Bond University

DOCTORAL THESIS

Architecture of survival: the habitation of Antarctica through a biophilic lens.

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architecture of survival

the habitation of Antarctica through a biophilic lens

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Abstract

Shelter has always been a key quality in human constructed architectural interventions aiding in their survival. Antarctica presents a unique extreme environment which highlights this relationship and distils the design decisions around the structure down to their basic characteristics. While this environment might seem distant and unrelatable, aspects are becoming part of the new normal for common habitable locations around the world, from climatic patterns to social isolation. Investigating the history of building in this extreme environment illustrates how humans have adapted their shelters over time and what agents were employed or harnessed to enable that evolution.

It is this fundamental facet that this research explores: the history of human developed shelter in Antarctica and how nature has played a role in the architectural interventions aimed towards survival in the harsh environment. Nature in an inescapable part of life in Antarctica and plays a significant role in the development of structures. The view of 'nature' within this setting reflects both the immediate surroundings, as well as the value the inhabitants have given relatable elements the natural elements of 'home'.

The relationship between human-nature connection stems from human behavioural patterns that facilitate shelter and protects through the built environment has been identified as 'biophilic design'. A basis of design made up of attributes which recognise aspects of those patterns that are integrated contemporary building practices to further foster an appreciation and understanding of the nature environment to cultivate healthier spaces to work and live. It is this classification system of biophilic design that forms the framework of analysis of shelters and structures in Antarctica for this research.

Through a case study methodology, six examples of buildings ranging from the history of human habitation in Antarctica are explored through a triangulation of data collection that uses archival research, documentation, and interviews. The buildings selected are Robert F. Scott's Hut at Cape Evans, Douglas Mawson's Hut, Australia's Casey Station, United Kingdom's Halley VI, and the United States of America's McMurdo Station and Amundsen-Scott South Pole Station. Though stemming from an Anglo cultural background, they represent significant periods in the relatively short Antarctic history and illustrate different scales, building practices, material technology, and location within the continent. Beyond reviewing and reporting the history of the cases, they are then analysed based on the experiences and attributes of biophilic design to investigate how it has been integrated, providing a common set of characteristics that are relevant to human welfare to provide a framework.

Through this research, it was seen that practicality of the building elements that promote human survival through the biophilic attributes and how they were incorporated into the buildings of Antarctica. However, conditions of the time period of construction categorised what was considered 'practical.' Unexpected bureaucratic and technological aspects were found to be as much, if not more of, a barrier than the Antarctic environment, itself. Concluding this analysis, possibilities going forward to incorporate successful elements into future Antarctic structures are identified, respecting considerations found in the cases. Beyond the limited population of the southernmost continent, which the majority of the world will never visit, these elements can be employed to facilitate survival of similar situations. This could range from once-in-a-lifetime climatic events evoking characteristics of Antarctic weather patterns to the social isolation experienced during the Covid-19 pandemic.

Keywords

Amundsen-Scott South Pole Station

Antarctica architecture

Biophilic design

Casey Research Station

Explorer Huts

Halley VI Station

Mawson Huts

McMurdo Base

Scientific Research Stations

Scott's Hut – Cape Evans

Declaration by Author

This thesis is submitted to Bond University in fulfilment of the requirements of the degree of Doctor of Philosophy (Architecture).

This thesis represents my own original work towards this research degree and contains no material that has previously been submitted for a degree or diploma at this University or any other institution, except where due acknowledgement is made.

Full name: Katelyn Patricia Carter Hudson

Signature

Date: 18.06.2020

Research Outputs

Published and Presented Conference Abstracts

Hudson, K.P.C.' Dwelling in Darkness: the evolution of architectural interventions in the Antarctic night '. Digital presentation, Island Dynamics – Darkness Conference, Nuuk, Greenland, 2020. *cancelled due to Covid-19

The explorers of the Heroic Age of Exploration faced months devoid of sunlight during the Antarctic winter. Of all the aspects the extreme environment challenged them with, the early huts were least equipped to respond to darkness, rather prioritising the need for shelter from temperature and weather. Over the following century building design developed to consider this, as the relevance of the psychological role diurnal cycles play in inhabitants' wellbeing became highlighted. The most recent stations look at the concept beyond something to combat or overcome, but an aspect to incorporate with attributes that enhance the lives of those residing in the prolonged night. Six cases ranging 103 years illustrate this progression; from Robert Scott's Terra Nova Hut to the British Antarctic Survey's Halley VI. A broad examination of how the building form has evolved from shunning or ignoring the matter to embracing it, whether that was through intentional design decisions or how the inhabitants themselves have taken measures into their own hands. Biophilic design provides a framework to structure this investigation, considering the innate human affinity towards light from a contrasting angle.

Hudson, K.P.C. 'Biophilic Design in Antarctica: connecting to nature through architecture'. Digital presentation, SCAR POLAR2020, Tasmania, Australia, 2020. *cancelled due to Covid-19

Humans developed the built environment through a series of behavioural patterns interacted with natural aspects necessary to provide shelter and protection from their surroundings. These practices have continued to innately be utilised and identified as 'biophilic design'. This research investigates how those elements have been utilised in one of the few climates where it is particularly pertinent, requiring humans to still rely on buildings purely for the basic purpose of survival, Antarctica. Through a case study framework, six examples of buildings ranging the history of human habitation in Antarctica will be explored; Robert F. Scott's Hut at Cape Evans, Douglas Mawson's Hut, Australia's Casey Station, United Kingdom's Halley VI, and the United States of America's McMurdo Station and Amundsen-Scott South Pole Station. Not only do they represent significant periods in the relatively short Antarctic history, but they illustrate different scales, building practices, material technology, cultural backgrounds, and location within the continent. The cases will be then analysed based on the elements and attributes of biophilic design to investigate how it has been integrated. The result of this research gains greater insight *into biophilic design regarding residential architecture, as well as tracking building practices concerning occupant wellbeing.*

Hudson, K.P.C.' Emergence of Antarctic Biomimicry: potential for an interdisciplinary approach to building design '. Digital presentation, SCAR POLAR2020, Tasmania, Australia, 2020. *cancelled due to Covid-19

Antarctic architectural expression has evolved from pure, basic shelter, to space-age capsules that crawl around the ice. Though separation and buffer from the natural environment have remained. Not only for basic survival that the extreme climate requires but from familiar building and design practices. The direction that station design has progressed opens the door for other approaches that discover how other aspects of that natural environment have existed in Antarctica. Biomimicry is a design practice that was identified by the scientist Janine Benyus in the mid-1990s; endeavouring to study and learn from strategies employed in nature and how they can be incorporated to solve problems. It built upon the biomimetic work of Otto Schmitt and is included in Stephen Kellert's biophilic design attributes. Applications range from design, materials, optics, systems, etc., but this research focuses on the potential for architectural design. To date, there has been no completed architectural intervention that has used biomimicry in Antarctica. Investigating two published conceptual works from 2014; the snowflake greenhouse of the Venice Biennale and the student project: Transformable Antarctic Research Facility (iceberg), there is room for an interdisciplinary approach to biomimicry in future station design that goes beyond an aesthetical shell. Entailing interdisciplinary work of architects and engineers together with the scientists to learn from their research to study environmental, floral, and fauna adaptations that could merge into building design. This is a logical potential trajectory of the future of Antarctic Architecture.

Hudson, K.P.C. 'History of Architecture in Antarctica through a biophilic lens'. Digital presentation, Southern Exposure: Antarctic Research at the University of Canterbury, Christchurch, New Zealand, 2020.

Architectural interventions in Antarctica started with the huts of the Heroic Age of Exploration up to the Research station today; they are an integral aspect of existence in the extreme environment. A design concept that builds upon the survival techniques utilised in early human structures is called biophilic design; fostering a connection with the natural environment for the benefit of the occupants. This research explores six cases that span the history of human occupation of the continent and are analysed based on the attributes of biophilic design to investigate how natural elements of Antarctica or the source country have evolved and been incorporated to support habitation.

Hudson, K.P.C. 'Vernacular of Exploration: development of an architectural presence in Antarctica'. Digital presentation, SC-HASS – Antarctic Connections at the End of the World, Ushuaia, Argentina, 2019.

The earliest recorded human occupants that inhabited the continent of Antarctica were the men of the Heroic Age of Exploration. In the lack of an endemic culture, they were given a blank slate to formulate the image of what it meant to live in the Antarctic. The resulting paradigm reflected the demographic makeup of these early expedition parties. Antarctica was viewed at the time as one of the last terrestrial frontiers. Men could be men; they could prove themselves against the raw elements, affording them the opportunity to conquer the unknown. Despite an expressed interest, women were not included in the early explorations. They did not crack into the all-boys club at the scientific research stations as active participants at the earliest in the late 1950s and as late as the mid-1990s in some instances. The structures constructed would have to manifest those male-centric beliefs and not the cushy Edwardian trappings of home. However, these were still civilised men with the need to show their dominion, display their mastery of this wild untamed wilderness. It was this latter aspect which is expressed in the architectural interventions, but on their terms and from their cultural background. There are distinct themes found in the documented shelters that correlate to the traditional vernacular architecture of the supporting countries.

Anything constructed can't persist in Antarctica without taking the extreme environmental conditions into consideration. Beyond their occupants' values, the buildings had to contend with intense cold, winds, and drifting snow. Which was compounded by the tremendous isolation of the continent restricting access to building materials and difficulty of transportation. As a result, the prefabricated huts that were brought with some of the expeditions were designed with the primary function of shelter and survival interlaced with aspects of the men's' principles. This is best illustrated in the records of improvised emergency shelters, where specific rituals or organisation are upheld.

This paper investigates the architectural form; how it was influenced by these philosophies and how these core beliefs of the explorers have continued to inform contemporary design. Beyond the natural limitations of Antarctica, it is those initial colonising attitudes that created further restrictions on the building design and execution. In turn, the resulting architectural interventions have been utilised to maintain that explorative paradigm of what it means to live in Antarctica.

Hudson, K.P.C. 'Illuminating Antarctic Architectural Interventions: adaptation of Halley VI Station to mitigate natural daylighting challenges'. Digital presentation, Island Dynamics – Darkness Conference, Svalbard, Norway, 2019.

Early habitation of the Brunt Ice Shelf often meant an existence devoid of natural daylight. The most recent of the Halley stations endeavours to circumvent issues inherent with this and take advantage of some of the opportunities it affords. Located 75°35' South is a string of futuristic pods that forms the sixth iteration of the British Antarctic Survey's architectural occupation, which became operational in 2013. The site frequently faces high winds, drifting snow, constantly moving ice shelf for a substrate, as well as prolonged summer light and seemingly perpetual *winter dark. During the winters the inhabitants face the challenge of potentially over a hundred days of complete darkness while being completely cut off from outside support. Advances in technology, in addition to a shift in the conception of what constitutes an "Antarctic Station", allowing Hugh Broughton Architects to develop a concept for a station which prioritised the wellbeing of the human occupants, beyond simply designing a shell to fill the basic need for survival. The British architectural firm won the design competition conducted by the British Antarctic Survey in 2004 utilising techniques similar to the elements outlined in Stephen Kellert's concept of biophilic design; accommodating inherent human affinity towards nature within the built environment. These embrace both the surrounding endemic features as well as applying characteristics that are more attuned to the inhabitants' natural habitats. Much of Broughton's efforts were around combating the confined lifestyle and darkness which winter brings.*

Hudson, K.P.C.' Biophilic Design in Architecture,' *Antarctic Times* (Winter 2018).

Hudson, K.P.C. 'Human occupation of the extreme south'. Digital presentation, Bond University People x place matter/s symposium, Queensland, Australia, 2018.

Hudson, K.P.C. 'Ecological Architecture of Antarctica: the usage of natural building materials'. Poster presentation, SCAR/IASC POLAR2018, Davos, Switzerland, 2018.

Today the building industry has a strong impetus and emphasis on sustainable building, a prevalent aspect of which is the use of endemic materials. What happens when the natural resources available aren't what is traditionally considered usable or practical? Throughout the history of building practices in Antarctica, there has been minimal employment of materials that are available despite knowledge of the vernacular architectural practices in Arctic regions. Snow and ice are an ever-present consideration in Antarctica, whether the structure interacts with drifting snow defensively, treating it as a negative quality, an impediment, or embraces it as a secondary building material and potential insulator. Recent research stations, in contrast to many of the older stations and huts, have been more cognizant of what impact they have on natural surroundings, which has resulted in more creative and innovative structures, including one proposal which incorporates snow as a primary building material. An interpretive-historical study of the building practices provides cultural and environmental insight into why this practice wasn't utilised more as well as the successes and failures.

Ethics Declaration

The research associated with this thesis received ethics approval from the Bond University Human Research Ethics Committee. Ethics application number 0000016100

Copyright Declaration

No published manuscripts were included for publication within this thesis.

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Missy and Libby – for their frequent correspondences reminding me of home.

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Dr. Spencer Leinweber – mentor (UHM)

Sue Donnely – mentor (GSGWM)

Frank Henry – mentor (FLLWSA)

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[1] Unless otherwise noted, graphics developed by author

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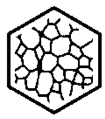
List of Abbreviations

Australian Antarctic Division	AAD
Australian Antarctic Expedition	AAE
Australian Antarctic Building System	AANBUS
Alternating Current	AC
Engineering firm, formerly Faber Maunsell	AECOM
Australian National Antarctic Research Expeditions	ANARE
Antarctic Treaty Secretariat	ATS
Antarctic Treaty System	ATS
Australia	AUS
British Antarctic Expedition	BAE
British Australian and New Zealand Antarctic Research Expedition	BANZARE
British Antarctic Survey	BAS
Council of Managers of National Antarctic Programs	CONMAP
Direct Current	DC
Global Positioning System	GPS
Heroic Age of Exploration	HAE
Heating, Ventilation, and Air Conditioning	HVAC
International Geophysical Year	IGY
International Polar Year	IPY
First IPY, 1882-1883	IPY I
Second IPY, 1932-1933	IPY II
Third IPY, 1957-58, commonly known as IGY	IPY III
Fourth IPY, 2007-2009, referred to in this research as IPY	IPY IV
International Space Station	ISS
Lesbian, Gay, Bisexual, and Transgender	LGBT
National Aeronautics and Space Administration (USA)	NASA
National Science Foundation (USA)	NSF
Restorative Environmental Design	RED
Replacement Station	REPSTAT
Russia	RUS
Scientific Committee on Antarctic Research	SCAR
SCAR Standing Committee on the Humanities and Social Sciences	SC-HASS
Scott Polar Research Institute	SPRI
Tongue and Groove	T&G
United Kingdom	UK
United States	US
United States of America	USA
United States Antarctic Program	USAP
Union of Soviet Socialist Republics	USSR
World War II	WW II

Icon Glossary[2]

Icon	Identification
	Aerodynamic
	Age
	Air
	Alien
	Angular
	Animal
	Antarctic Treaty Secretariat
	Aquarium
	Atrium
	Audio
	Aurora Australis

Icon	Identification
	Balance
	Balconies/Deck
	Barometric Pressure
	Biomimetics
	Biomimicry
	Blue
	Boundaries
	Brown
	Building Skills

[2] Icons developed by author to illustrate experiences, attributes, and examples of biophilic design for analysis.

	Building : Environment
	Bunks

Icon	Identification
	Change
	Change, Age, Patina of time
	Chimney Effect
	Clerestory
	Colonnades
	Colour
	Colour Temperature
	Community
	Computer Display

	Connection to the Environment
	Constructed Landscape
	Cooking
	Corridors

Icon	Identification
	Courtyards
	Cultural
	Curved
	Death
	Desalinisation of Sea Water
	Details
	Direct Connection to Nature
	Diversity
	Dogs

	Doors
	Drafts
	Durability
	Eating/Food

Icon	Identification
	Ecological
	Elevators
	Endemic
	Entry Areas
	Escalators
	Events
	Experience of Space and Place
	Exterior
	Facades

	Feeders
	Fire
	Fire – Physical
	Forests

Icon	Identification
	Fountains
	Foyers/Lobby
	Fractals
	Furnishing
	Gardens
	Geographical
	Grasslands
	Greys
	Greens

	Green Roof
	Green Walls
	Historical
	Humidity
Icon	Identification
	Hydraulics
	Hydroponics
	Hygiene
	Ice
	Ice Sheet Movement
	Identity
	Images
	Indirect Connection to Nature
	Individual Building

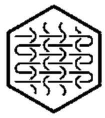
	Individual Occupants
	Individuals : Building
	Information Richness
	Integrating Parts to Create Wholes
Icon	Identification
	Intensity
	Interiors
	Landscapes
	Light/Artificial
	Light/Sunlight
	Linking
	Literal
	Maintenance
	Maps

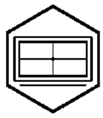
	Materials
	Mathematical Properties
	Mental Wellbeing
	Mobility
Icon	Identification
	Modular
	Multiple Buildings
	Narrow Rooms
	Natural Geometries
	Night
	Operable Windows
	Oranges
	Organised Complexity
	Painting/Artwork

	Paths
	Patina
	Patio/Porches
	Patterns
Icon	Identification
	Perpendicular
	Phi
	Photo
	Place
	Plants
	Planters
	Ponds
	Ponies/Mule
	Proportion

	Prospect and Refuge
	Purples
	Rainwater Spouts
	Recycling
Icon	Identification
	Reds
	Reflectivity
	Roads
	Rooms
	Salt Water
	Scientific
	Sculpture
	Shade
	Shapes & Forms

	Shape
	Shelter
	Sight Lines
	Simulated Light and Air
Icon	Identification
	Size
	Skylight
	Smell
	Snow
	Space
	Spirals
	Stairs
	Swales
	Symbolic

	Tactile
	Temperature
	Textiles
	Texture
Icon	Identification
	Toilets
	Transitional Spaces
	Transitory Population
	Translucent
	Vents
	Values
	Video
	Views
	Walks

	Water
	Waterfalls
	'Weather' – classification by Kellert, may be referred to as climate
	Wetlands
Icon	Identification
	Windows
	Wood
	Yellows
	Zones

Chapter 1: Introduction

1.1 BACKGROUND AND CONTEXT

'…at the frontier the environment is at first too strong for the man.'

— Frederick Jackson Turner[3]

Architecture has served humans over the years as a power relationship, artistic expression, display of values, but at heart – shelter. This intervention in history has allowed the spread of the human race to occupy, survive, and thrive in any imaginable environment on earth. While this enterprise initially began with structures that were tuned to the local environment, advances in building practices, material technology, and curiosity for conquering the unknown made this possible in places that were previously not a consideration.

This approach to architecture also developed a disconnect between humans and their environment, making them less aware of their surroundings, making them less equipped to cope with the natural world. The impact buildings had on the environment increased; material consumption and waste, the size and scale of the structures, depletion of the land itself, and so much more. As much as people like to think they are above it, they are part of the ecosystem and are affected by these things just as much. This relationship has become emphasized as earth is facing extreme weather events and climatic conditions, against which traditional building practices are not necessarily adapted to shelter.

Antarctica illustrates a concentrated view of this development of architectural interventions from basic shelter to permanent habitation structures. The initial rudimentary accommodations have evolved over a relatively short period of time due to the harsh natural environment, and increased human awareness of their impact on the last minimally touched continent, amongst other technological advances. Investigating the existing structures that are in this extreme environment can provide a guide for the practice of architecture that can aid occupants in survival of similar conditions.

Tracking the historical evolution of architectural interventions of Antarctica complementary to the purpose of survival of survival and shelter is accomplished with the framework of biophilic design. The attributes of which build upon the human/nature relationship, principles of biophilic design

[3] Turner, Frederick Jackson, "The Significance of the Frontier," *The Frontier in, 4merican History (1920* (1893).

connect users to their environment to better their wellbeing as well as encourage stewardship of it. These approaches track back to human behavioural patterns developed in vernacular architecture of early humans.

The use of biophilic design as a tool of analysis is an extension of the researcher's prior doctoral research, *Holistic Dwelling*, which was a more pragmatic investigation into human behavioural patterns influence on the built environment. Investigating how biophilic design, environmental psychology, and Chinese geomancy (*feng shui*) overlapped in residential design to create habitation that was more attuned to the users' needs.[4] Geographically *Holistic Dwelling* focused on Northern New England in the United States, the researcher's home environment.

While there is a geographically significant divide between Northern New England and Antarctica, there are aspects of the latter's climate that are found in the endemic weather patterns of the former prompting the researcher's interest in the southern polar regions. Beyond the climatic considerations, habitation of Antarctica is distilled down to the essential need for protection, impacting the design decisions, influencing the overall building form and construction. The remoteness and inaccessibility of the sites also intensify the prioritisation designers and inhabitants face in choosing what to incorporate or bring. The one theme that unites all the buildings in this hostile setting is that of survival.

Architecture in Antarctica is less documented and researched than its polar counterpart. When most people think of Antarctica, they picture a frozen wasteland subjected to harsh winds, freezing temperatures, snow, and ice. However, as discussed, not even Antarctica is free of human intrusion. Built structures weren't added to its landscape until the late nineteenth/early twentieth century. It was at this time that what is known as the Heroic Age of Exploration commenced with bases for expeditions, notably to conquer the geographic South Pole. These were comparatively rudimentary wooden structures, designed to be temporary, and many of which have succumbed to the environment. Scientific interest in the possibilities of research being conducted in the south polar regions prompted what has become the original scientific research stations built for use during the International Geophysical Year. These have led to over one hundred building sites for explorers' huts, scientific research stations and bases, whaling stations, and a few military instalments that reside in Antarctica today in various states of habitation.

A critical part of the built environment of Antarctica can illuminate how to cope with isolation and remotes. Now, more than ever, the built environment has taken on a renewed importance for humanity. With a global pandemic, many countries have a shelter-in-place order, meaning that

[4] Hudson, Katelyn, "Holistic Dwelling: Integrating Biophilic Design, Environmental Psychology, and Feng Shui" (University of Hawaii at Manoa, 2013).

people are experiencing their homes for more than just the typical nights and weekends. To see how the attributes of biophilic design are incorporated into this extreme in ways that engage, stimulation, and encourage the occupants' wellbeing can enable people to adapt their existing environment or develop future structures that are prepared for extreme conditions – whether that is from the climatic or sequestration.

1.2 PURPOSE

1.2.1 Research Questions

The research explores and answers the following questions:

Preliminary Question

How has shelter evolved in Antarctica?

Antarctica presents an environment that requires shelter throughout the entire year. There is no potential for outsiders to land on shore, evaluate their surroundings, and develop a plan for protection as they acclimate to or find a need in their new environment. The need is immediate and dire. This prompts forethought and planning into how the shelter is intended to be achieved, from the earliest structures to the most recent, which is a unique approach to an architectural evolution. These methods of building design and construction have developed and advanced over three significant periods of building activity over the history of human occupation of Antarctica.

Factors that contribute:

Prior experiences – the progression of time provides an increase in precedents for expeditions and governing organization to learn from and adapt any proposed structures from what has been observed and learned.

Material Technology – the building history in Antarctica spans just over a century, which has seen significant advances in material science during hostilities like WWI, WWII, and the Cold War, resulting in races for superiority around technology and science.

Transportation – similarly what is described above impacted the ability, type, and security of vessels that could convey people, supplies, equipment, and building materials to Antarctica.

Awareness – culturally, predominantly Anglo in origin, there has become a greater understanding and shift towards a more conscientious approach to the environmental impact that humans have upon Antarctica.

Secondary Question

How has nature been incorporated within architecture in Antarctica?

Nature in Antarctica is an inescapable presence; aspects of the natural environment are what prompt the necessity of shelter. This could be said of vernacular architecture in any location, the resulting forms and construction and developed based on the specific resources, climate, and culture and reflect the surrounding environment. This is where Antarctica presents a difficult situation, it is continent almost entirely devoid of traditional natural materials and minimal animal and plant life. The climate is inhospitable to humans with intense winds and severe cold rendering some typical building practices not practical or feasible. Therefore, one aspect of this question pertains to how natural elements of **Antarctica** have been incorporated within architectural interventions, if at all.

From a cultural perspective, there is no documented evidence of pre-existing culture found in Antarctica. Yet, as predominantly Anglo explorers and scientists developed their bases and stations, they brought with them characteristics of their own cultures, using their own building techniques and materials to construct these buildings. The remoteness, cost of transportation, and demands of the climate distilled the design decisions down to the most essential and crucial elements, eliminating anything that might be purely aesthetic. However, a secondary facet of this research question examines how the natural aspects of the **source county** have been incorporated. For the inhabitants, this would be imperative, bringing components of their home with them to such an inhospitable and isolating climate to make a little corner of it more familiar.

Tertiary Question

How has natural elements aided in the survival of the occupants through shelter?

Vernacular architectural interventions were developed to help humans survive in environments. The study of these behavioural patterns and the resulting built forms has become known as biophilic design. The characteristics of the structures were developed based on the need to withstand predatory attacks and different climatic considerations. Constructed shelter became a tool which enabled humans to expand their range beyond the warmer savannah-like habitats to cover six of the seven continents. The extended range of humanity's territory consistently requires humans to adapt to changing environmental conditions; recently this has further been challenged with severe climatic events that continue to be described as 'once in a lifetime' which have tested the suitability of the available refuges. This shift brings those early behaviour patterns for survival back to the forefront of concerns to support the human safety and wellbeing, using the attributes of biophilic design provides a framework of analysis as described in Chapter 3 – Research Design - Theoretical Framework of Cases.

Summary

With the consideration of the Secondary and Tertiary questions, the climate has a significant impact on the buildings, their form, materiality, and the ultimate success. This feat is regardless of whether natural elements are incorporated in the buildings as queried in the Secondary question, the impact they have on the building is like nowhere else on earth. Emphasising the need to address the primary question as extreme weathers become more prevalent. The primary question ties the latter two together and provides potential indicators of where building design can proceed forward by looking at the trends of the past.

1.2.2 Preliminary Hypotheses

Based on the existing literature, the following were preliminary hypotheses.

- Shelter in Antarctica has evolved to be more suited their extreme environment based on information and experiences gleaned of previous structures.
- Nature plays a vital role in human habitation of Antarctica
- Aspects of the inhabitants' origins, geographically and culturally integrated into the stations and huts.
- Building designs are a product of the climatic considerations and natural features of the surrounding environment.

Characteristics of these shelters can be used to inform buildings around the world facing similar climatic challenges.

1.3 SIGNIFICANCE, SCOPE, AND DEFINITIONS

1.3.1 Significance

Once-in-a-lifetime weather event are becoming more frequent and climatic patterns have been tracking with more intensity, bringing attributes of extreme environment to the rest of the world. With a focus specifically on the extreme environment that Antarctica presents, dangerously cold temperatures, high winds, prolonged isolation, this research investigates how architecture and nature have played a role in human survival. Studying the development of cases in Antarctica provides a roadmap for the built environment to advance, adjust, or adapt to similar conditions.

While human survival generally stems from a foundation in physical shelter from the climate and weather, the mental well-being of the occupants has become recognized as valuable. Nature has been proven to play a significant role in both, having positive and antagonistic attributes for humans. These qualities are intensified in Antarctica with an environment that is perceived as harsh and alien. This apparent trait and the geographic challenges faced distils the decisions made in the architectural design process down to its essence. During the research, the influence that the isolation has on life in Antarctica and the built environment became inescapable. Studying how the cases embrace, mitigate, or cope with that aspect became particularly prevalent in light of the global epidemic with 'stay-at-home' orders. This brings a broader meaning to 'survival'. It is more of the mental survival and how the built environment can contribute to it, rather than limiting the concept to survival against natural elements.

This research also furthers the exploration of the attributes of biophilic design in alternative climates. The use of biophilic design as an evaluative tool is not new, however examining the incorporation of nature within a case located in an extreme environment in its totality is new ground. This approach provides valuable, critical insight into the merits or short falling of the cases selected.

1.3.2 Scope

This study focuses on examining the development of the architectural interventions of humans from Anglo cultures concerning wellbeing and survival in Antarctica. Antarctica was selected as the extreme environment, narrowing the focus of the research in a manner that refines the essence of what constitutes shelter. It presents a finite timespan of human occupation, lacking any recorded pre-existing culture or vernacular architecture. This insight will provide a more comprehensive view across the period of the Anglo occupation of Antarctica into how the concept of shelter has evolved. Additionally, this investigation will explore biophilic design in a more profound view regarding residential design as well as its viability in an alien environment.

Biophilic design is employed to facilitate that process as a framework and to structure the analysis. The instinctual aspect found in the principles of biophilic design allows for the exploration of concepts that were not intentionally incorporated. This is critical for structures located in remote, punishing locations that prevent anything beyond perfunctory shelters, such as Antarctica.

To accomplish this investigation, case studies of six structures that are still standing and host/hosted year-round occupation in Antarctica will be analysed based on the framework of the attributes and experiences of biophilic design. The cases are selected from the three primary building periods of Antarctica and have comparable aspects within their structures.

1.3.3 Definitions

Antarctica

Antarctica is the southernmost continent in the world. The Antarctic Treaty System defines 'Antarctica' as encompassing any land and ice shelf south of the 60th parallel south (60°S latitude). The focus of this research is on the continent itself, and the adjoining ice shelf, not the surrounding or subantarctic islands.

Biophilic Design

Biophilic Design is a recently developed multidisciplinary concept in the field of architecture which endeavours to create opportunities within buildings that foster a connection with the natural environment. The framework developed and categorised throughout this research primarily employs the classifications identified in the 2018 publication *Nature by Design* for analysis. Unless otherwise noted, when used in text 'biophilic design' refers to this model.

Extreme Environment

The classification of an 'extreme' environment is one which temperature, accessibility, resources, or climatic considerations make survival difficult for humans or other animals. These are often classified as polar regions, deserts, oceans, and high-altitude regions. The extreme environment that is the focus of this research is that of Antarctica – a cold desert with potential for high winds, prolonged circadian rhythms, intense cold temperatures, and remoteness. For this research, unless otherwise specified, 'Antarctica' and 'extreme environment' are used interchangeably.

Human/Humans

Homo sapiens. This research focuses on human occupants. However, the primary emphasis is on humans stemming from Anglo cultures with cases selected from Australia, the United Kingdom, and the United States of America. This partiality towards humans of Anglo cultures extends to the perception of the terminology and construction of biophilic design in the analysis of the cases, i.e. 'nature' is intended to be reflective of what humans in Anglo cultures identify as nature.

Living Spaces

The spaces of structures being researched are based on the areas/rooms of the Heroic Age of Exploration Huts. This is to facilitate more straightforward cross-analysis between the cases, as well as narrow the focus with the larger stations. Each case has a structure which functions as a cafeteria/mess hall, kitchen, recreational/lounge space, bathing facilities, and dormitories or sleeping areas. Scientific research buildings or areas, storage, or support structures are not directly included as the primary concentration of the research but may be referenced.

1.4 THESIS STRUCTURE

This thesis is structured as follows:

Literature Review

The review of existing literature is broken into two section. The first explores the existing literature on the humanities and social science research in Antarctica. This portion also surveys how architectural research has been represented in that area of research as well as provides an overview of how architecture has fit into Antarctica in general. The second section investigates biophilia and biophilic design, the publications that make up the foundation of those concepts, and the existing use of biophilic design as a tool for analysis. Beyond the identification of gaps in both areas of study, this chapter ascertains where there is a potential overlap between the history of architecture in Antarctica and biophilic design.

Research Design

The method undertaken to achieve this research is named within this chapter – Case Study. The approach of triangulation through data collection is elaborated upon, as well as the epistemology, ontology, and two stage approach of analysis directing the research. Within the section on 'Case Recruitment', which cases were chosen and what the parameters used to for selection is identified. This chapter is also where limitations are discussed, which heavily influence the data collection and case recruitment, though not to the detriment of the research.

Review of Architectural History of Cases

The Review chapter serves two purposes within the overall thesis: background description of the cases and the first phase of analysis. Each case is illustrated through text and floor plans to provide a basis of understanding for the reader prior to breaking them down based on the inclusion of the attributes of biophilic design within the structures. This latter application is what comprises the first phase of analysis, allowing for further comparison in the following chapter by identifying what is applicable within the framework of biophilic design.

Results

Within the Results Chapter, it commences with the potential natural elements of Antarctica are identified for inclusion in the architectural interventions per biophilic design. Based on the initial findings in the Review Chapter's the framework of six cases are considered in their totality. Graphically and textually, each attribute is broken down and to scrutinise what was utilized to facilitate it's integration, what natural features it took advantage of, where those features originated, track the changes, and examine why some potentially were not incorporated.

Conclusions

The synthesis of the research is found in the last chapter with a summary of the analysis of the previous two chapters. Structured through the attributes of biophilic design, identification of potential approaches towards the incorporation of natural elements to aid in human survival in Antarctica.

Chapter 2: Literature Review

There are two aspects of the research addressed in this literature review; the history of architecture in Antarctica and biophilic design. The former looks into the existing body of Humanity and Social Sciences of Antarctic research which includes the history of the human occupation of the continent, historical preservation of existing structures, and study that specifically pertains to the field of Architecture. The latter delves into the background of biophilic design and the previous application as a tool of analysis.

While these two topics appear to be disparate, they both relate to the overall theme: human survival through architectural interventions. The following chapter is organized into two separate sections since there is no existing academic overlap. However, it is identified where gaps in the existing bodies of knowledge are that this research fills and expands. It also introduces how the two topics can be partnered, one as a framework to analyse the other which is further explored in Chapter 3 Research Design.

2.1 ANTARCTICA

2.1.1 Background on Humanities and Social Science Research in Antarctica

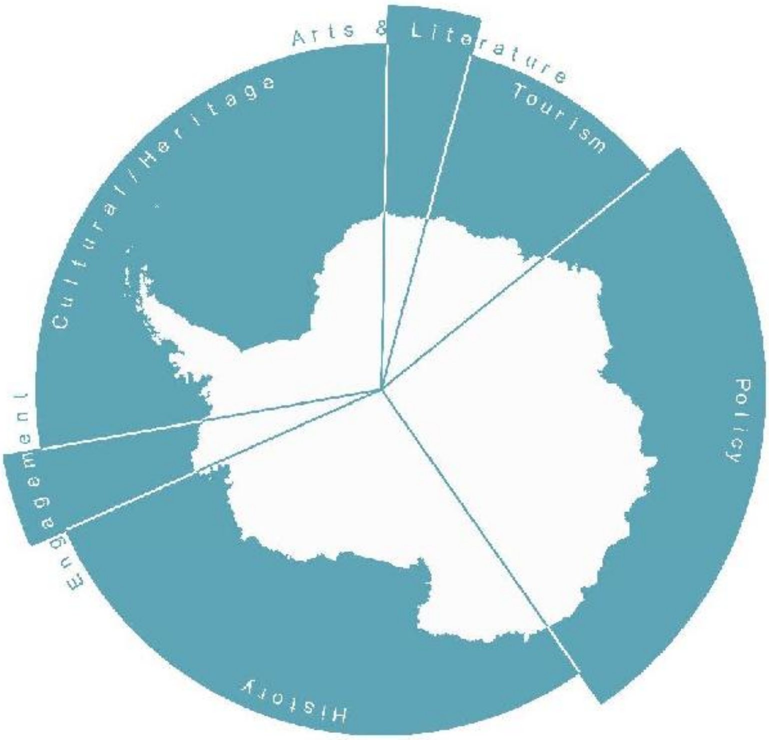


Figure 2-1 SC-HASS 2019 Conference Presentation Categories[5]

The largest, body of research from Antarctica is in the field of science; the organisation of which has been overseen by the Special Committee on Antarctic Research (SCAR[6]) since the International Geophysical Year. This thesis does not touch upon those primary fields, other than to rely upon their scientists requiring shelter; rather, it focuses on a newer branch of SCAR. In 2018, various groups within SCAR came together to formally recognised as the Standing Committee on the Humanities and Social Sciences (SC-HASS[7]), it is predominantly here that relevant research is sourced. Policy and politics have always been a focus of discussion and study, ranging from sovereignty to the ATS to international borders today. A newer significant concentration is tourism, how that is happening in Antarctica, the growth, the impact, and the management. Historic recording, documentation, and analysis have been continual since the Heroic Age, though the Preservation and some of the more critical examinations have occurred more recently. Anthropological, socio-cultural, and other humanities-based studies have also started to have a growing presence within the research landscape of Antarctica.

[5] Graphic by Author
[6] "Scientific Committee on Antarctic Research," Scott Polar Research Institute, University of Cambridge, scar.org.
[7] "Scar Standing Committee on the Humanitites & Social Sciences (Sc-Hass)," Scientific Committee on Antarctic Research, antarctica-hasseg.com/.

The following subsection discusses the main areas of humanitarian and social science research. It explores the significant researchers, the background of the topics, and primary themes. There is also a critical look at how it relates to architecture and built environment if there are any possible gaps in the research.

Governance and Politics

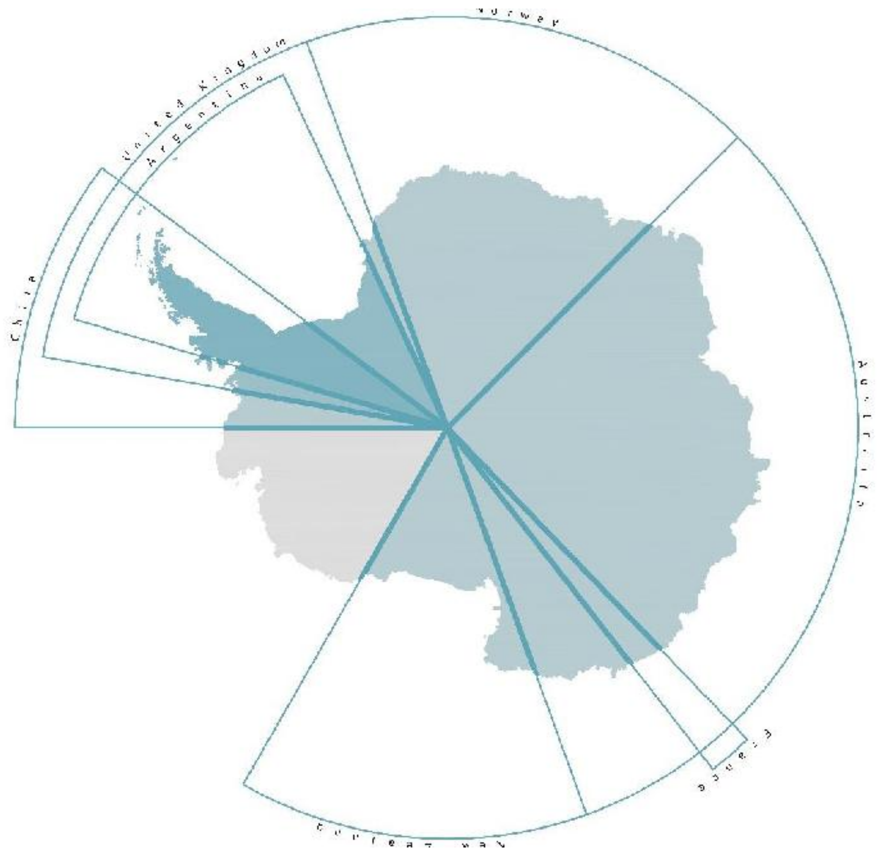


Figure 2-2 Sovereignty Claims in Antarctica[8]

The most established of the areas of research in the Humanities and Social Sciences is that of governance and policy. This primarily stems from Antarctica lacking its own independent governments and employing the Antarctic Treaty Secretariate instead as an agreement between countries with interests in Antarctica. Interest in the geopolitical makeup of Antarctica has always been central to human existence on the continent. The obstacle with the resources is the inherent bias that is found within the documents, that combined with the sheer amount of research available makes an in-depth overview of a herculean task. This portion of the literature review endeavours to provide a glimpse into the history of Governance and Politics and the literature available from a variety of perspectives, but is by no means exhaustive.

During the HAE, many of the expeditions were used to claim territory, as well as exploration. There was little push back for land claims with no existing population inhabiting the

[8] Graphic by Author

continent.[9] This lack of oversight can be seen with several overlaps in the resulting sovereignties at the time of the signing of ATS (Figure 2-2). As discussed in Demographics, there is a certain elitism seen in who claimed sovereignty during this time; whether that was financial (United Kingdom, Norway, France) or geographical (Chile, Argentina, Australia, New Zealand).

It was through the more international organisation to develop the IGY, that pressure was put on an overarching governance structure be formulated. An International Trust Territory was proposed, but the original sovereignties pushed back question who it was designed to protect.[10] As nearby countries, Australia and South Africa were concerned about the USSR presence south of them during the Cold War period leading up to the IGY.[11] India also expressed concerns about ensuring the demilitarisation of Antarctica, having gained independence from Great Britain.[12] The result was the signing of the ATS by the participating countries of the IGY.

There are several publications which explore the whole process, implications, and the execution of the ATS over the years.[13] There has been criticism of the US, its involvement and facilitating the ATS.[14] The perception of the US role in the IGY and disregard for existing sovereignties, scepticism regarding a lack of territorial claims despite a heavy presence leading up to the IGY.[15] In general, concerning the sovereignties, the ATS acknowledges them to the effect of not acknowledging them, placing them on hold where they were during the IGY, which some have viewed as a reward.[16]

The fairness of the development of the ATS was called into question in 1982 by Malaysia. Their premise was that the geopolitical composition of the global community had significantly

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[9] Dodds, Klaus, *Geopolitics of Antarctica: Views from the Southern Oceanic Rim* (Wiley-Blackwell, 1997); Stephens, Tim, "The Antarctic Treaty System and the Anthropocene," *The Polar Journal* 8, no. 1 (2018).
[10] Dodds, *Geopolitics of Antarctica: Views from the Southern Oceanic Rim*.
[11]Beck, Peter J, *The International Politics of Antarctica (Routledge Revivals)* (Routledge, 2014). Dodds, *Geopolitics of Antarctica: Views from the Southern Oceanic Rim*.
[12] Chaturvedi, Sanjay, "India and the Antarctic Treaty System: Realities and Prospects," *India Quarterly* 42, no. 4 (1986).
[13] For example: Joyner, Christopher C and Theis, Ethel R, *Eagle over the Ice: The Us in the Antarctic* (Univ Pr of New England, 1997); Pyne, Stephen J., *The Ice: A Journey to Antarctica* (Seattle, Washington, USA: University of Washington Press, 1998); Dodds, K. J., "Post-Colonial Antarctica: An Emerging Engagement," *Polar Record* 42, no. 220 (2006); Dodds, Klaus J, *Pink Ice: Britain and the South Atlantic Empire* (IB Tauris, 2002); Barber, Laurie and Selby, Michael, "The Search for an Alternative Strategy: New Zealand and the Antarctic," *The Round Table* 72, no. 288 (1983); Chaturvedi, "India and the Antarctic Treaty System: Realities and Prospects."; *The Polar Regions: A Political Geography* (John Wiley & Sons in association with the Scott Polar Research Institute, 1996); Collis, Christy and Stevens, Quentin, "Modern Colonialism in Antactica: The Coldest Battle of the Cold War," (2004); Portella Sampaio, Daniela, "The Antarctic Exception: How Science and Environmental Protection Provided Alternative Authority Deployment and Territoriality in Antarctica," *Australian Journal of Maritime & Ocean Affairs: Challenges for Antarctic Governance in the Early Twenty-First Century* 11, no. 2 (2019); Herr, Richard A and Davis, Bruce W, *Asia in Antarctica* (Centre for Resource and Environmental Studies, 1994); *The Antarctic Treaty Regime : Law, Environment, and Resources*, ed. Gillian Doreen Triggs, Studies in Polar Research. (Cambridge, Cambridgeshire ;: Cambridge University Press, 1987); *Antarctica : Legal and Environmental Challenges for the Future*, ed. Gillian D. Triggs and Anna Riddell (London: British Institute of International and Comparative Law, 2007); *Australia and the Antarctic Treaty System : 50 Years of Influence*, ed. M. G. Haward and Tom Griffiths (Sydney: University of New South Wales Press, 2011); *Antarctica in International Law*, ed. Ben Saul and Tim Stephens, Documents in International Law (Oxford: Hart Publishing, 2015); "Reform the Antarctic Treaty," *Nature (London)* 558, no. 7709 (2018).
[14] Joyner and Theis, *Eagle over the Ice: The Us in the Antarctic*.
[15] Pyne, *The Ice: A Journey to Antarctica*.
[16] Dodds, "Post-Colonial Antarctica: An Emerging Engagement."

shifted in the intervening decades. They posited the original signatories and their priorities (primarily Euro-American) did not represent the global concerns as a whole that the United Nations would be a better governing organisation.[17]

There is some criticism along Malaysia's line of thinking, between the connection of financial elitism, science, and the politics of Antarctica. There are differences between 'full members' and signatories of the ATS, primarily being a significant scientific presence in Antarctica. That is primarily interpreted as a scientific research station,[18] which would only be achievable for a country with enough financial backing for its Antarctic program. Also, despite the intention that Antarctica is a peaceful continent, devoted to scientific endeavours and international cooperation, it has come under question the political aspects of the research. From early mapping being used as territorial claims[19] to the use of scientific research stations as a passive battle for an international presence during the Cold War[20], and today politicising the environmental protection of Antarctica[21].

Overall the early research is primarily Euro-American focuses, as were the major players. In his 2005 paper analysing the concept of 'post-colonialism' in Antarctica, Klaus Dodds called for a need for broader research from other countries to develop a more comprehensive understanding outside of the potential bias of Europe or the US[22]. An earlier example is a collection of essays on the political environment of Antarctica, including Asian researchers in 1994.[23] When examining the emphasis of recent publications, a broader international focus on various policy, governance, geopolitical aspects of Antarctica has advanced in the last decade.[24]

There is a significant gap in the research as far as a critical analysis of policy with regard to the built environment of Antarctica. The Madrid Protocol, in particular, significantly impacts

[17] Barber and Selby, "The Search for an Alternative Strategy: New Zealand and the Antarctic."; Jayaseelan, Sumitra, "Development of Malaysia's Position in Antarctica: 1983 to 2017," *The Polar Journal: Special Issue: The Asian View on Polar Research* 9, no. 1 (2019).
[18] Chaturvedi, *The Polar Regions: A Political Geography*.
[19] Dodds, *Pink Ice: Britain and the South Atlantic Empire*; Portella Sampaio, "The Antarctic Exception: How Science and Environmental Protection Provided Alternative Authority Deployment and Territoriality in Antarctica."
[20] Collis and Stevens, "Modern Colonialism in Antactica: The Coldest Battle of the Cold War."; Musto, Ryan A., "Cold Calculations: The United States and the Creation of Antarctica's Atom-Free Zone *," *Diplomatic History* 42, no. 4 (2018).
[21] Portella Sampaio, "The Antarctic Exception: How Science and Environmental Protection Provided Alternative Authority Deployment and Territoriality in Antarctica."; Summerson, Rupert and Tin, Tina, "Twenty Years of Protection of Wilderness Values in Antarctica," *The Polar Journal: The 20th anniversary of the entry into force of the Madrid Protocol* 8, no. 2 (2018).
[22] Dodds, "Post-Colonial Antarctica: An Emerging Engagement."
[23] Herr and Davis, *Asia in Antarctica*.
[24]Colombo, Andrea, "International Co-Operation in Antarctica: The Influence of Regional Groups," *The Polar Journal: Special Issue: The Asian View on Polar Research* 9, no. 1 (2019). Ferrada, Luis Valentín, "Five Factors That Will Decide the Future of Antarctica," *The Polar Journal* 8, no. 1 (2018); "Latin America and the Antarctic Treaty System as a Legal Regime," *The Polar Journal: Latin America and Antarctica* 9, no. 2 (2019); Howkins, Adrian and Lorenzo, Cristian, "Latin America and Antarctica: New Approaches to Humanities and Social Science Scholarship," ibid.; M. Roura, Ricardo, Steenhuisen, Frits, and Bastmeijer, Kees, "The Shore Is the Limit: Marine Spatial Protection in Antarctica under Annex V of the Environmental Protocol to the Antarctic Treaty," *The Polar Journal: The 20th anniversary of the entry into force of the Madrid Protocol* 8, no. 2 (2018); Nicklin, Germana, "Turning Attention to the Layered and Dispersed Access Management System of the Antarctic Treaty System," *The Polar Journal: Latin America and Antarctica* 9, no. 2 (2019); Novas, Mariano A., "Antarctic Governance of Biological Resources: The Argentine White Genome Project," ibid.; Zhang, Lulu et al., "Reforming China's Polar Science and Technology System," *Interdisciplinary Science Reviews: Interdisciplinary research and its impacts: from Entropy to Education in the work of Alan Wilson* 44, no. 3-4 (2019).

station operation, impact on the environment, and ultimate disposal. It would be in this area where potential policy around the implementation of aspects of biophilic design would be applicable. This gap is not the focus of this research, but analysis and interpretation of the Madrid Protocol do impact the history of the buildings.

Demographics

Ethnic Diversity

Historically, those engaging in activities in the Antarctic were white and European. During the Heroic Age of Exploration, the only exceptions were the Japanese Antarctic Expedition[28], Australasian Antarctic Expedition[29], and transition of Omond House (Scottish National Antarctic Expedition) to Orcadas Base (Argentina's National Office of Meteorology)[30]. Mawson's Australasian Expedition was also making their claims and discoveries in the name of the King of Great Britain, which leaves one expedition that was not affiliated with Europe.

Figure 2-3 World Map – countries participating in the Heroic Age of Exploration[25]

Through the IGY and signing of the ATS, the majority of participants remained white, European based countries. Beyond the HAE participants, the USA and USSR joined, along with Chile and South Africa. Occupation in Antarctica is expensive unless a nation had a significant reason to participate; sovereignty interest, political motivation, scientific research, etc., it is logistically challenging to justify a presence in Antarctica. This is a contributing factor to ethnic diversity during this time.

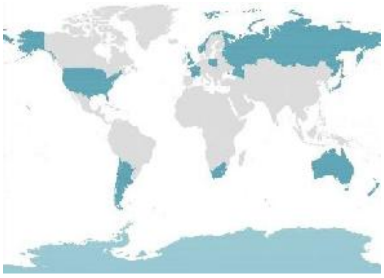

Figure 2-4 World Map –signatory countries to the Antarctic Treaty Secretariat[26]

The potential country participation can be tracked by following nations joining the ATS. There is still strong membership from Europe and North America, Asia and South America have increased their presence. One notable exemption from Antarctic involvement is Africa, South Africa remaining the only participant.

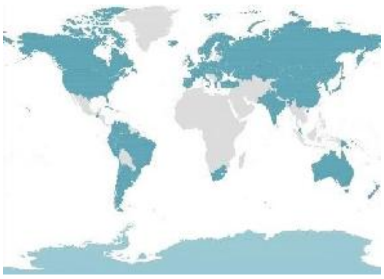

Figure 2-5 World Map – Antarctic Treaty Secretariat members 2012[27]

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[25] Graphic by Author
[26] Graphic by Author
[27] Graphic by Author
[28] Susan, Barr, "The Japanese Antarctic Expedition in 1912: A Summary of Lectures Given at the Norway-Japan Society and the Mariners Society in Oslo, 2012," *Antarctic Record* 57, no. 2 (2013).
[29] Mawson, D., "Australasian Antarctic Expedition, 1911-1914," *Geographical Journal* 44, no. 3 (1914).
[30] "Antarctic Station Catalogue," (Council of Managers of National Antarctic Programs, 2017).

Documentation, discussion, and analysis of these demographics are not readily available. Specific information regarding the racial or ethnic composition of the stations is also not a topic that has been published. There are beginning to be more studies which analyse policy, history, and heritage from a South American perspective.[31] The South African program has also recently become the focus of several studies which highlight the residual impact the apartheid had on the racial structure of the population of their station.[32]

Overall, the general focus of research has been a continuation of the same emphasis of the HAE, European/Caucasian/White based. However, there is beginning to be South American (primarily Chilean and Argentinean)[33] and South African[34] research which delves into their own history, culture, and politics concerning Antarctica. Tracking the publication dates, research that specifically investigates and critically analyses non-anglo ethnical demographics is minimal and just beginning to grow. This partially stems from a hesitancy of "challenging" or "questioning" one's heroes, which needs to be done and can be accomplished in a respectful manner aware of standard practices of the time and painting a more discerning picture of what is Antarctica.

Gender

For as brief a period that Antarctica has had contact with humans, the amount of time women have had access is significantly shorter. While it is believed that many of the commercial whaling vessels potentially brought wives and companions within sight of the continent, it wasn't until 1935 when Caroline Mikkleson accompanied a landing party from her husband's voyage.[35] This inclusion illustrates what the conventional narrative for female involvement for the next several decades; domestic companionship was. An accessory to the male pursuit.

This paradigm developed was not for lack of fascination, even going back to the Heroic Age of Exploration, women expressed eager interest in joining Shackleton's expedition as well as Mawson's 1929 BANZARE receiving twenty-five applications and the 1937 British Antarctic Expedition obtaining 1300.[36] None were accepted. It wasn't until 1947 that the first women

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[31] Fontana, Pablo Gabriel, "A Hut Too Far: History of the Argentine Ventimiglia Shelter on Peter," *Polar Research* 37, no. 1 (2018); "Between the Ice of the Orkney Islands: Filming the Beginnings of the Antarctic Overwintering Tradition," *The Polar Journal: Latin America and Antarctica* 9, no. 2 (2019); Howkins, Adrian and Lorenzo, Cristian, "Latin America and Antarctica: New Approaches to Humanities and Social Science Scholarship," ibid.; León Wöppke, Consuelo, "The Chilean Army's Participation in the Nation's First Antarctica Expedition," *The Polar Journal* 2, no. 2 (2012); Tahan, Mary R., *The Life of José María Sobral : Scientist, Diarist, and Pioneer in Antarctica*, Springer Biographies (Cham: Springer International Publishing, 2017).

[32] Lavery, Charne, "Antarctica and Africa: Narrating Alternate Futures," 55, no. 5 (2019); *Antarctica and the Humanities*, ed. Peder Roberts, Lize-Marié Van der Watt, and Adrian Howkins, Palgrave Studies in the History of Science and Technology (London: Palgrave Macmillan UK, 2016).

[33] Fontana, "A Hut Too Far: History of the Argentine Ventimiglia Shelter on Peter."; "Between the Ice of the Orkney Islands: Filming the Beginnings of the Antarctic Overwintering Tradition."; Howkins, Adrian and Lorenzo, Cristian, "Latin America and Antarctica: New Approaches to Humanities and Social Science Scholarship," ibid.; León Wöppke, "The Chilean Army's Participation in the Nation's First Antarctica Expedition."; Tahan, *The Life of José María Sobral : Scientist, Diarist, and Pioneer in Antarctica*.

[34] Lavery, Charne, "Antarctica and Africa: Narrating Alternate Futures," *Polar record* 55, no. 5 (2019).

[35] Blackadder, J., "Frozen Voices: Women, Silence and Antarctica," *Antarctica: Music, Sounds and Cultural Connections* (2015).

[36] Ibid.; Seag, Morgan, "Women Need Not Apply: Gendered Institutional Change in Antarctica and Outer Space," *The Polar Journal* 7, no. 2 (2017).

wintered over on the continent, once again Edith Ronne and Jennie Darlington came accompaniment to their husbands.[37]

Women first began being admitted to this "boys only club" in 1969 for the United States Antarctic Program[38] and late 1970s for the Australian Antarctic Division. The latter's first female winter-over-er was due to the potential closure of the Macquarie Station because of the lack of being able to find a male doctor to oversee the station for the winter.[39] It took BAS much longer to integrate their stations which was prompted by legislation regarding gender equality. Women weren't permitted until 1983 on a limited number of stations, all of which weren't fully integrated until 1994, meaning the BAS was able to qualify as an equal opportunity employer in 1996.[40] This does not necessarily reflect the universal delayed inclusion of women; a female scientist was hosted at a USSR station during the IGY.[41]

There is a common belief amongst research as to why it took so long for these countries to integrate their stations despite standard practices in their source countries. Scholars highlight the early belief that the inclusion of women would somehow be perceived to undermine the significance of the male conquest. If a delicate Victorian woman could endure the same environment as the likes of Scott and Shackleton, it would diminish their achievements.[42]

A distinct difference between the genders in Antarctica is the impulse to conquer. While women are just as competitive as men, it is not displayed at the same level as the early race to the South Pole between Amundsen, Shackleton, and Scott. Despite her distinction, Caroline Mikkleson rarely talked about her time in Antarctica.[43] The first women to the South Pole arrived by plane, which they agreed to step off arm-in-arm at the same time to avoid the race to be "first".[44] A notable work of fiction by Ursula Le Guin depicts an earlier all-female exploration to the South Pole in which they leave no trace behind.[45]

In 2017 a longitudinal study by Aspa Sarris was published which interviewed fourteen women returning to Australia after living and working at stations over fifteen years. The continued gender gap was highlighted, which also was reflected in a schism between the scientists and workers. Many of the women fell into the former group, which tends to lean towards a different cultural, academic background compared to the trade workers. When asked for qualities the women felt those following in their footsteps should have; the qualities they

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37 Sarris, A., "Antarctic Station Life: The First 15 Years of Mixed Expeditions to the Antarctic," *Acta Astronautica* 131 (2017).
38 Rosner, Victoria, "Gender Degree Zero: Memoirs of Frozen Time in Antarctica," *a/b: Auto/Biography Studies* 14, no. 1 (2014).
39 Sarris, "Antarctic Station Life: The First 15 Years of Mixed Expeditions to the Antarctic."
40 Seag, "Women Need Not Apply: Gendered Institutional Change in Antarctica and Outer Space."
41 Lewander, Lisbeth, "Women and Civilisation on Ice," *Cold Matters: Cultural Perceptions of Snow, Ice and Cold. Umeå: Umeå University and the Royal Skyttean Society* (2009).
42 Blackadder, "Frozen Voices: Women, Silence and Antarctica."; Rosner, "Gender Degree Zero: Memoirs of Frozen Time in Antarctica."; Sarris, "Antarctic Station Life: The First 15 Years of Mixed Expeditions to the Antarctic."
43 Blackadder, "Frozen Voices: Women, Silence and Antarctica."
44 Rosner, "Gender Degree Zero: Memoirs of Frozen Time in Antarctica."
45 Leane, E., "Placing Women in the Antarctic Literary Landscape," *Signs* 34, no. 3 (2009).

discussed fall in the more typically "male" category and detracting from more "female" ones, for example, "don't wear your heart on your sleeve".[46]

While gender studies in Antarctica are not the primary focus of this research, it was the study into the history of BAS, which emphasised the impact it has on architecture. Morgan Seag wrote in her paper *Women Need Not Apply* that one of the primary reasons BAS was able to push integration off for as long as they did was a lack of infrastructure for women to live at the stations. They did not have the restroom for women. It was as they continued to update the stations to maintain their integrity as a relevant research organisation that the BAS was forced to incorporate facilities that would accommodate both genders.[47]

It is worth noting that the gender of the researchers on this topic is predominantly female. Also, the documents that have been published in peer-reviewed journals focus primarily on the inclusion of women in European, Commonwealth, and United States Stations.

As discussed in this section, the majority of the population of Antarctica is made up of adult men and (now) women; however, two bases on the peninsula established settlements for families to habitat. Esperanza Base (Argentina) and Villa Las Estrellas (Chile) developed Antarctic stations which accommodated the men working as well as their wives and children, babies have been born at both stations. While there has been research into the cultural history and makeup of these two communities, the availability is limited to Spanish and not currently translated into English. More recently, a researcher, Nelson Llanos, who is interviewing and documenting the early life of the women at Villa Las Estrellas.[48]

Sexual Orientation

There are no formal academic studies published and readily available the analyse the demographic makeup or culture of the sexual orientation of the population of Antarctica at this time. Some anecdotal evidence has emerged over the last five years. Several events gained media attention, generally organised found in connection with US groups.

There has been at least one 'Pride' event held at McMurdo Station in 2018[49] and more recently at the Australian bases as well[50]. The article that reported on the event elaborated on experiences, concerns, and difficulties the winterover occupants faced. While the members had worries going in, it did not prevent them from applying and pursuing life and work in Antarctica. Occupants did not describe any issues, harassment, or hostility, that there is more flexibility on the part of all parties. What is described is an atmosphere where sexual orientation is less of a priority in everyday life.[51] A memoir by Gretchen Legler agrees with this,

[46] Sarris, "Antarctic Station Life: The First 15 Years of Mixed Expeditions to the Antarctic."
[47] Seag, "Women Need Not Apply: Gendered Institutional Change in Antarctica and Outer Space."
[48] Llanos, Nelson, "Housewives at the End of the World. Chilean Women Living in Antarctica, 1984-1986," *The Polar Journal: Latin America and Antarctica* 9, no. 2 (2019).
[49] Nichols, James Michael, "Antarctica Was Just Declared 'the World's First Lgbt-Friendly Continent'," *Huffpost*, 22/03 2016.
[50] , January 19, 2020, https://twitter.com/ausantarctic/status/1328849594558476288?lang=en.
[51] Miksche, Mike, "Queers Making History at the End of the Earth," *Logo*, 23/05 2018.

where she documents her time as part of the Artist in Residence Program at McMurdo. During this time she also describes her growing relationship with a fellow expeditioner in the early 2000s.[52]

In 2016 Antarctica was declared the first LGBT-friendly continent, with the peace flag being "raised" on its shores.[53] While this is a commendable gesture, with no permanent population, the ATS has not outlined any specific LGBT rights. Legal rights are governed by the occupant's home nation, not by their geographic location within Antarctica; but by the sovereignty on the continent or ownership of the research base/station inhabiting.[54]

Summary

Overall, within the primary existing fields of study in Antarctic research, there is some relationship to architecture and the built environment. Research that is entirely dedicated to architecture in Antarctica is discussed below in Section 2.2.3 Related Research. What is found investigating the general body of knowledge finds the built environment being brought in to illustrate or bolster arguments, that ranges from the narration of history, illuminating social inequalities, to the protection of the environment. As can be seen with this, architecture can be a very useful tool to promote one's agenda; however, architecture can also be studied for what it has to offer on its own.

2.1.2 General History concerning the Built Environment

Looking at the extent of human habitation, they spread from warmer climates to occupy almost all the continents. This range was made possible through migratory patterns to take advantage of seasonal temperate weather, the use of natural resources to develop protection through clothing and architectural interventions, and the technology to get from one location to another. Antarctica remained one of the few places uninhabited for the majority of human existence. The extreme climate, as well as the lack of natural resources partner to create an environment that is not welcoming to humans. Antarctica is the only continent not to have a documented pre-existing culture, with Europeans making the first recorded landfall relatively recently in the early 19th century. Despite these challenges, people have developed structures in Antarctica over the last hundred and fifty years to support exploration and scientific research. These aspects make Antarctica an ideal environment to investigate biophilic practices as they relate to survival.

The first impetus for venturing down towards Antarctica was for whaling and sealing. This practice dates back to the 1790s when vessels would hunt for fur seals, in under three decades the population was hunted close to extinctions prompting the focus to turn to elephant seals. Whaling began around the turn of the 20th century. This industry prompted permanent

[52] Legler, Gretchen, *On the Ice: An Intimate Portrait of Life at Mcmurdo Station, Antarctica* (Milkweed Editions, 2005).
[53] Nichols, "Antarctica Was Just Declared 'the World's First Lgbt-Friendly Continent'."
[54] "The Antarctic Treaty," (Washington, D.C.: Conference on Antarctica, 1959).

infrastructure to be constructed on surrounding sub-Antarctic islands, and value in sovereignty beginning to show.[55]

This research, however, focuses on the three significant, influential periods impacted the structures on the content of Antarctica. The earliest being the Heroic Age of Exploration when the first explorers' huts were built. A relatively quiet period after that was followed by the International Geophysical Year (IGY), which prompted a flurry of construction to support the new scientific research being conducted. The most recent, the fourth International Polar Year (IPY IV) brought a conscientiousness to building and the surrounding environment as well as the introduction of aestheticism to the structures and the use of architects in the design process.

Heroic Age of Exploration

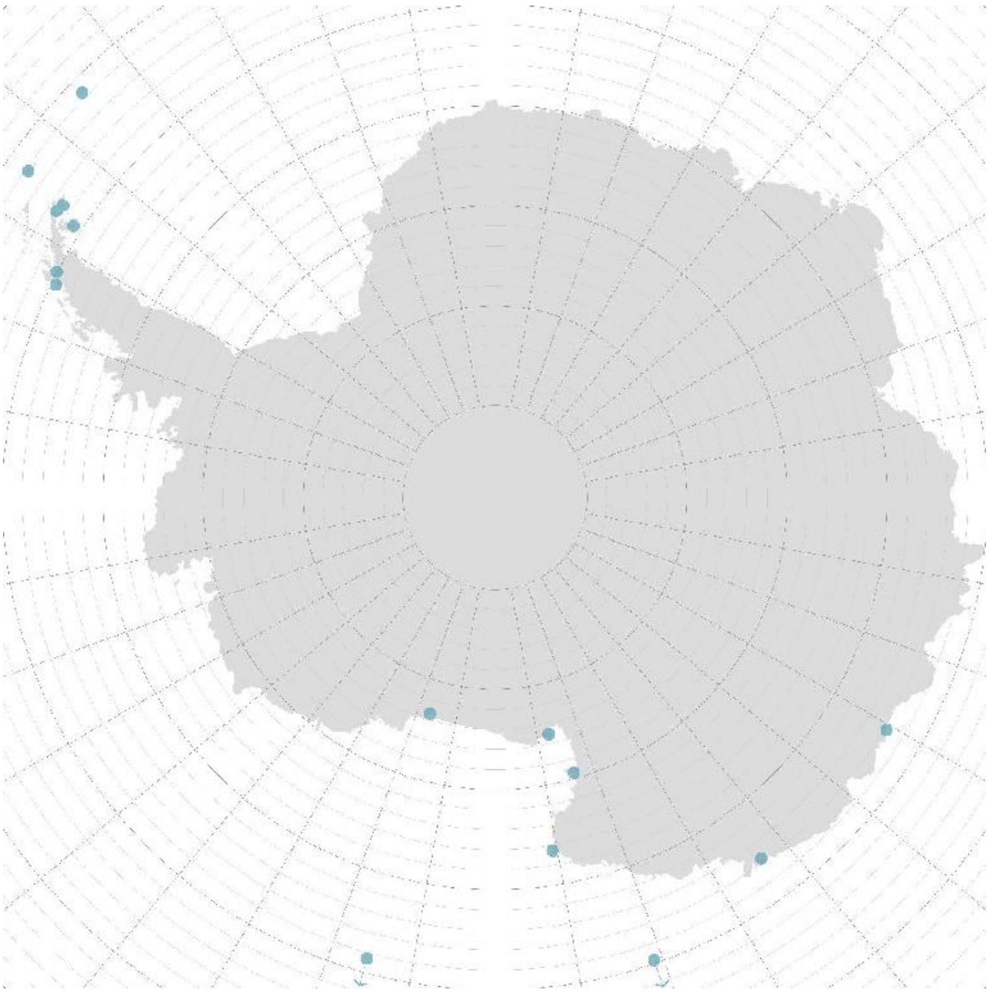

Figure 2-6 Map of Antarctica – building sites during the Heroic Age of Exploration[56]

During the Heroic Age of Exploration, which is typically defined by the first exploration in 1899 and ends with Ernest Shackleton's death on his last expedition in 1922, teams developed bases

[55] "History," Commission for the Conservation of Antarctic Marine Living Resources, https://www.ccamlr.org/en/organisation/fishing-ccamlr.
[56] Graphic by Author

from which to launch their journeys. For some, the ship they travelled in served as the primary shelter, others brought prefabricated buildings to be constructed on the continent. These structures fall within three major building types according to Michael Pearson, which is endemic of their national origins; Scandinavian, British, and Australian.[57] Unfortunately, only six of the original huts still stand in reasonable condition today. The others have since succumbed to the weather, snow, or calved off into the sea.

The more notable expeditions are those which endeavoured to reach the geographic South Pole. These parties include two attempts by Robert Falcon Scott (second one achieving his goal), one by Ernest Shackleton, and the successful attempt by Roald Amundsen, earning him distinction as the first man to conquer the South Pole. Not all expeditions were undertaken for the pure achievement of obtaining this victory. Shackleton later attempted to cross the entire continent, the disastrous failure of which earned him as much renown for his heroism as Scott and Amundsen. Concurrent to Scott's second attempt, Douglas Mawson launched his own expedition to map a significant portion of the continent. Most of these men made multiple trips to Antarctica, serving on other expeditions before conducting their own. Many of the expeditions also included a heavy scientific component, uncovering as much of the unknown continent as they could.

In addition to investigating the continent, the Heroic Age of Exploration prompted the establishment of sovereignty by the countries conducting or funding the expeditions. By the end of the Heroic Age of Exploration, land claims had been made by Argentina, Australia, Chile, France, New Zealand, Norway, and the United Kingdom, some of which overlap.[58]

Much of the information about early buildings can be found in the personal diaries of men who inhabited them. For some expeditions, this is limited to that of the leader[59], but in subsequent years other members have published their own experiences as well. The majority of these allowed the authors to reflect and modify their entries before publishing. A notable exception is Scott's last diary which was posthumously published after it was recovered from his final camp upon his return from the pole.[60]

The inclusion of a darkroom appears to be relatively standard in the building designs, allowing for there to be photographic evidence of life in the huts. Frank Hurley[61] (Mawson-1912) and

[57] Pearson, Michael, "Expedition Huts in Antarctica: 1899–1917," *Polar Record* 28, no. 167 (1992).
[58] "The Antarctic Treaty."; Collis and Stevens, "Modern Colonialism in Antactica: The Coldest Battle of the Cold War."
[59] Amundsen, Roald and Chater, Arthur G., *The South Pole; an Account of the Norwegian Antarctic Expedition in the 'Fram' 1910-1912 — Volume 1* (2002); Mawson, Douglas, *The Home of the Blizzard Being the Story of the Australasian Antarctic Expedition, 1911-1914* (2004); Shackleton, Ernest, *South! : The Last Antarctic Expedition of Shackleton* (Santa Barbara, CA, USA: Narrative Press, The, 2000); Shackleton, Ernest Henry Sir, *My South Polar Expedition* (2003).
[60] Scott, Robert Falcon, *The Voyage of the 'Discovery'*, ed. Edward Adrian Wilson and H. T. Ferrar (London: John Murray, 1905); Scott, Robert Falcon and Jones, Max, *Journals Captain Scott's Last Expedition*, ed. Max Jones, Oxford World's Classics (Oxford: Oxford University Press, UK, 2006).
[61] Hurley, Frank, *Australasian Antarctic Expedition 1911-1913*, Accessed September 28, 2017, https://www.nla.gov.au/pictures/frank-hurley-antartic-photographs.

Herbert Ponting[62] (Scott-1911) both served on expeditions in which they documented the surrounding environment, the hut, expeditions, and the lives of the men. Ponting also made a video recording as part of Scott's last expedition. The two men's work has been analysed in relation to one another, Ponting's being more posed and structured while Hurley's are more relaxed and casual.[63] The photographs provide less filtered documentation of the buildings themselves than the diaries.

The huts were not designed to be lasting monuments or initially intended for return use. Their purpose was purely utilitarian, to provide shelter for the span of the expedition. They weren't necessarily stripped bare and abandoned; teams typically secured the door shut, left a few supplies (just in case), and departed. Therefore, it was when explorers came back years later; they found the structures in relatively sound shape. The dry climate prevented extensive moisture damage, and the cold temperatures preserved materials that would typically rot or deteriorate.

The surviving huts, fall predominantly under two organisations' jurisdiction for conservation. Mawson's hut has had work conducted by the AAD, supplemented by Project Blizzard and Mawson's Hut Foundation. The remaining huts; Borchegvik, Discovery, Shackleton, and Scott, are overseen by the New Zealand Antarctic Heritage Trust, though since these were the result of expeditions from the United Kingdom, there is a sister organisation, the United Kingdom Antarctic Heritage Trust. As part of the conservation efforts to mitigate primarily snow and ice damage, the organisations released reports documenting the existing conditions with proposed work to be conducted for the individual buildings.

[62] Ponting, Herbert, *British Antarctic Expedition 1910-13*, Accessed September 28, 2017, https://www.spri.cam.ac.uk/picturelibrary/catalogue/bae1910-13/.
[63] Mundy, Robyn, "Pioneering Antarctic Photography: Herbert Ponting and Frank Hurley," *The Polar Journal* 4, no. 2 (2014).

International Geophysical Year

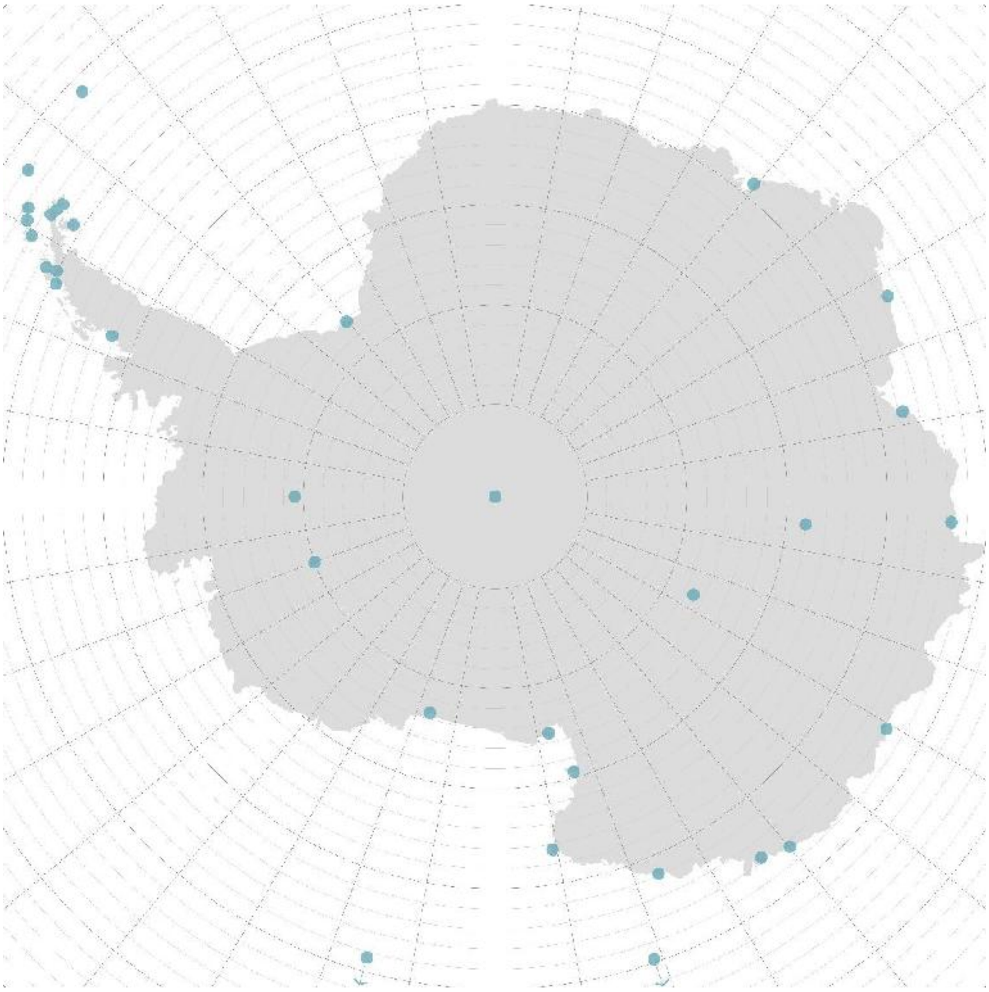

Figure 2-7 Map of Antarctica – building sites up through the end of the IGY[64]

From the end of the Heroic Age of Exploration and the 1950s, there was minimal exploration or contact with Antarctica. This lack of activity was partially due to World War II, before which the German government tentatively investigated establishing a base in the Norwegian claim.[65] After WWII, with the Cold War, the United States of America (USA) and the Union of Soviet Socialist Republics (USSR) began to develop an interest in the continent, with the USA establishing a series of military camps known as 'Little America'.

Previously several international scientific events were coordinated, the International Polar Years (IPY), the first being held in 1882-1883 and the second fifty years later in 1932-1933. With the approach of the twenty-fifth anniversary of IPY II, interest began to grow with advances in technology from WWII and the Cold War, in conducting another event. However, rather than just focusing on the two polar regions, a more extensive scope was implemented and relabelled the event as the International Geophysical Year (IGY), though it is acknowledged as

[64] Graphic by Author
[65] Summerhayes, C. and Beeching, P., "Hitler's Antarctic Base: The Myth and the Reality," *Polar Record* 43, no. 224 (2007).

IPY III. The IGY was intended to last from 1957-1958, with twelve countries established over 60 stations in Antarctica.[66]

This event brought the most significant influx of building that has occurred on the continent. Akin to the explorer's huts, these structures were not intended to last longer than the IGY, however many evolved to become the first permanent habituated stations. The event marked a significant transition from the strategic military potential of the Cold War to the principal public focus on peaceful scientific practice. After the success of the IGY, the ATS was signed in 1959 and went into effect in 1961. The general purpose is to maintain the governance of the continent with the original focus from the IGY. The original twelve countries that had previously claimed sovereignty were the signatories as well as Belgium, Japan, South Africa, the USSR, and the USA.[67](see Appendix B.1)

While the aims were scientific, most of the stations were built and supported through branches of their countries' military. Typically, these were the organisations with the equipment and resources to conduct this work. The early buildings were often military issued modular prefabricated structures that were adapted for the extreme climatic environment. The building materials were comparable to that of the Heroic Age, though plywood sandwich panels and insulated corrugated metal were frequently utilised as well.[68]

Eventually, as these buildings began to fail due to climatic pressures, erosion from the salt in the ocean air, or accidental fires, the structures were replaced using more advanced building practices. These buildings were built to withstand the environment, not aesthetics, which is visually evident in the practicality of the structures, lack of ornamentation or material finish.[69] Most of them are the product of engineering rather than architectural designs. Some stations developed masterplans for the overall organisation of future construction, however with funding, this was typically difficult to achieve, and construction was conducted on an ad hoc basis.[70]

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66 Collis and Stevens, "Modern Colonialism in Antactica: The Coldest Battle of the Cold War."; Klein, A. G. et al., "The Historical Development of Mcmurdo Station, Antarctica, an Environmental Perspective," *Polar Geography* 31, no. 3-4 (2008); United States Antarctic Program, "Mcmurdo Station Master Plan 2.1," ed. National Science Foundation (2015).
67 "The Antarctic Treaty."
68 Collis and Stevens, "Modern Colonialism in Antactica: The Coldest Battle of the Cold War."; Tin, T. et al., "Energy Efficiency and Renewable Energy under Extreme Conditions: Case Studies from Antarctica," *Renewable Energy* 35, no. 8 (2010).
69 Bowden, Tim, "Founding Davis and Casey Stations," *Australian Antarctic Magazine*, no. 22 (2012); Davis, Georgina A., "A History of Mcmurdo Station through Its Architecture," *Polar Record* 53, no. 02 (2017); MacKenzie, Rod, "From Wilkes to Casey," *Australian Antarctic Magazine*, no. 15 (2008); Nielsen, Hanne, "From Shelter to Showpiece: The Evolution of Scientific Antarctic Stations," *University of Canterbury Summer Research Project* (2013).
70 Bowden, "Founding Davis and Casey Stations."; Brooks, William D, "Elevated Station Design for the South Pole Redevelopment Project at Amundsen-Scott South Pole Station" (paper presented at the Cold Regions Engineering: Putting Research into Practice, 1999); Broughton, Hugh, "Halley Vi Antarctic Research Station," (2006); Davis, "A History of Mcmurdo Station through Its Architecture."; MacKenzie, "From Wilkes to Casey."; United States Antarctic Program, "Mcmurdo Station Master Plan 2.1."; Nielsen, "From Shelter to Showpiece: The Evolution of Scientific Antarctic Stations."; Pekin, Mark, "A Historical Appraisal of Structural Engineering Associated with Australian Antarctic Buildings" (paper presented at the Australasian Structural Engineering Conference 2012: The past, present and future of Structural Engineering, 2012); Shears, John, "Draft Comprehensive Environmental Evaluation: Proposed Construction and Operation of Halley Vi Research Station, Brunt Ice Shelf, Caird Coast, Antarctica" (paper presented at the Antarctic Treaty Consulative Meeting, 2005); Weale, Jason et al., "Elevated Building Lift Systems on Permanent Snowfields: A Report on the Elevated

It is during the evolution of these stations that different building approaches were explored, hoping to find a cost-effective, weather-resistant station which would have an extended life span. In contrast to the buildings of the Heroic Age of Exploration, which are standalone pieces, actively being conserved to reflect what they were like at the end of that era, the stations of the IGY continue to evolve, grow, and adapt to meet the changing needs of their populations. Many, becoming a collection of buildings to form a base, act comparably to a small town or city.

The stations from this era fall into a written resource gap between the two other identified periods. They lack the notoriety of the explorer's huts and don't have the appeal of the latest cutting-edge showcase stations. However, owing to their longer lifespan, there is significant documentation of life at the station through blogs and books.

Tangential to documentation relating directly to the station's architecture, recently more information about the impact existing stations have on the surrounding environment have surfaced. Attention has been paid to the largest station on the continent, McMurdo. Georgina Davis has written extensively about the sustainability of McMurdo Station and explored what further could be done to mitigate its physical and ecological footprint.[71] In the private sector with Terrapin Bright Green, Davis has begun a series of blogs which looks at attribute are broadly present in the buildings of Antarctica.[72]

Building Lift Systems in Polar Environments Workshop," (Engineer Research and Development Center Hanover NH Cold Regions Research and Engineering Lab, 2014).

[71] Davis, Georgina Amanda, "A Study of Remote, Cold Regions Habitations and Design Recommendations for New Dormitory Buildings in Mcmurdo Station, Antarctica" (2015).

[72] Davis, Georgina A. to Terrapin Bright Green, November 28, 2017, 2017, https://www.terrapinbrightgreen.com/blog/2017/11/biophilia_abiotic-environment/?utm_source=Website+Signups&utm_campaign=d3ab3d0967-November+2017+Newsletter&utm_medium=email&utm_term=0_83a051a21f-d3ab3d0967-107914601.

International Polar Year IV

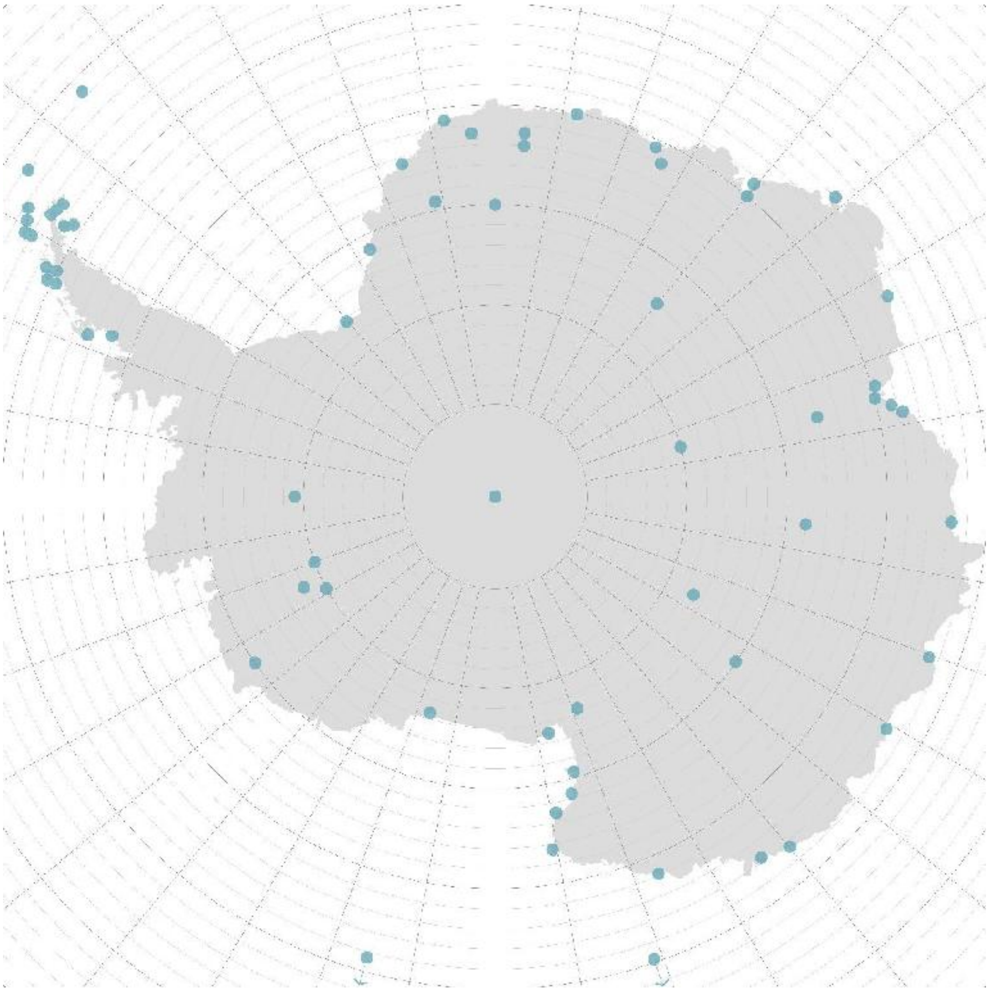

Figure 2-8 Map of Antarctica – building sites up through 2017[73]

Following the IGY the construction of new stations steadily increased, though with no comparable spurt of building that accompanied the IGY. After another twenty-five years, the International Council for Science and the World Meteorological Organization prepared for the fourth International Polar Year to be held 2007-2009. One of the themes of the research being conducted focused on the environment.[74]

Tracking the timeline of building construction[75], the IPY IV also became an apparent prospective deadline for both new stations and redesign of outdated ones. Visually this event also marked a point in building design when aesthetics began to become a consideration, transitioning from engineering to architectural based design[76]. This event also marked a point in building design when aesthetics began to become a consideration, transitioning from engineering to architectural based design. These stations utilise cutting edge material technology to develop showcase designs that reflect the importance of the research being

[73] Graphic by Author
[74] "International Polar Year 2007-2008," http://www.ipy.org/.
[75] "Antarctic Station Catalogue."
[76] Nielsen, "From Shelter to Showpiece: The Evolution of Scientific Antarctic Stations."

completed within the buildings, as well as creating a symbolic identity for the country and organisation running the station.

Since the IGY, Antarctic architecture has developed a niche market for a select few architectural firms who have developed a reputation for creating station designs over the last decade.[77] Ferraro Choi specifically has worked with the National Science Foundation for several decades designing buildings for the US stations. The novel designs proposed by these firms echo popular approaches and techniques being explored in regular practice today. These projects include reuse of prefabricated storage containers[78], NetZero buildings[79], relocatable modules[80], and using the natural environment to form the entire structure[81].

Following the theme previously identified above, the buildings around IPY IV were developed with sensitivity and conscientious approach towards the overall environment of Antarctica. The goals were to go above and beyond the conventions laid out by the Madrid Protocol for environmental design put forth by the ATS in 1991.[82] The agreement meant adapting green building technologies; not all of the traditional techniques are suitable for the extreme climate.[83]

Further attention was also paid towards the inhabitants' experience at the stations. The design briefs provided to the architects show that the emotional wellbeing of the inhabitants was stressed. This consideration includes elements like views, privacy, colours, material choices, ability to personalise spaces, natural daylighting, as well as simulation of diurnal patterns.[84] Much of this is based on observations of other stations and how the users reacted to the spaces.[85] Some of this shift has been met with criticism, that life in Antarctica shouldn't be pleasant or easy, that there should be a certain amount of hardship involved.[86]

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77 "Ferraro Choi," http://ferrarochoi.com/; "Hugh Broughton Architects," http://www.hbarchitects.co.uk/; "International Polar Foundation," http://www.polarfoundation.org/; "Bof Architekten," http://bof-architekten.de/en/; "Map Architects," http://www.maparchitects.dk/.
78 "Ferraro Choi".
79 "Bof Architekten".
80 "Hugh Broughton Architects".
81 "Map Architects".
82 "Protocol on Environmental Protection to the Antarctic Treaty," (Secretariat of the Antarctic Treaty, 1991).
83 Blake, David Michael, "The Construction of Halley Vi Station in Antarctica," in *Iscord 2013: Planning for Sustainable Cold Regions* (2013); Broughton, "Halley Vi Antarctic Research Station."; Ferraro Choi, "Sustainable Design Strategies for the Modernization of the Amundsen-Scott South Pole Station," http://ferrarochoi.com/publications/sustainable-design-strategies/; "Integrated Sustainable Design," http://ferrarochoi.com/publications/integrated-sustainable-design/; Nielsen, "From Shelter to Showpiece: The Evolution of Scientific Antarctic Stations."; Shears, "Draft Comprehensive Environmental Evaluation: Proposed Construction and Operation of Halley Vi Research Station, Brunt Ice Shelf, Caird Coast, Antarctica."
84 Broughton, Hugh, "Polar Research Facilities: Living in Isolation" (2016); Hugh Broughton Architects, "Halley Vi British Antartic Research Station," http://www.hbarchitects.co.uk/halley-vi-british-antarctic-research-station/; Ferraro Choi, "Sustainable Design Strategies for the Modernization of the Amundsen-Scott South Pole Station"; Shelton, Simon and Broughton, Hugh, "Antarctic Station Modernization: Future-Proofing Infrastructure," Antarctica New Zealand, https://www.scottbaseredevelopment.govt.nz/news-publications/antarctic-station-modernization-future-proofing-infrastructure.
85 Broughton, "Halley Vi Antarctic Research Station."; "Polar Research Facilities: Living in Isolation."; Ferraro Choi, "Sustainable Design Strategies for the Modernization of the Amundsen-Scott South Pole Station".
86 Schiermeier, Q., "Antarctic Stations: Cold Comfort," *Nature* 431, no. 7010 (2004).

As previously mentioned, these stations have a plethora of resources describing their architectural significance and innovation due to their aesthetic appeal. The architects of the buildings themselves also provide marketing materials highlighting the stations. Since these buildings are newer, they do not have the same extent of blogs and books documenting what it is like to reside at the stations. However, there are a few, and over time that will grow. With both the stations developed around the IPY IV and IGY, more recently there have been short videos providing glimpses into life at these structures.

Currently, there is evidence of all the diverse building techniques and styles in Antarctica in various conditions. The earliest stations, bases, and huts were built directly on the ground, as shown in Figure 2-9, either tied down with cables or pier type foundation driven into the ice or ground. As previously discussed, the primary issue found with this type was the structure being consumed by drifting snow; to resolve this, the next approach is illustrated in Figure 2-10. Using the natural snow and ice substrate to create a trench in which the station would be located. This structure too succumbed to the ground level increasing, making the trench deeper and potentially unstable. Surrendering to the problem of the drifting snow, Figure 2-11 demonstrates the tunnel type of station. In this briefly used approach, the buildings making up the station were located within a metal or insulated panel tunnel; however, the pressure of the shifting snow and ice damaged the structural integrity of these tubes, and the lack of natural daylighting was challenging for the inhabitants.

Figure 2-9 Ground Bearing Station

Figure 2-10 Trench Station

Figure 2-11 Buried Station

Figure 2-12 Dome Station

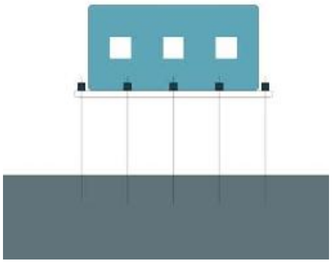

Figure 2-13 Elevated Station – Light

Figure 2-14 Elevated Station – Rigid

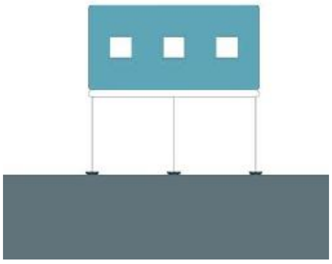

Figure 2-15 Mobil Station [87]

One of the more iconic stations from the end of the 20th century was the second iteration of the Amundsen-Scott South Pole Station. They utilised a dome, similar to Figure 2-12, to protect the buildings from the climate, similar to earlier issues, the dome itself began to be buried by the drifting snow causing structural concerns. A recent solution to this inherent problem of building in the Antarctic prompted the use of elevated platforms, Figure 2-13 and Figure 2-14. This approach has afforded the longest life span for the stations and is currently the most popular approach. Halley VI has taken the innovation even further by adapting the elevated station to incorporate skis instead of an embedded foundation system Figure 2-15, allowing smaller modules to relocate with the station perpendicular to the winds.

[87] Graphics by Author based on design principles from Nielsen, "From Shelter to Showpiece: The Evolution of Scientific Antarctic Stations."

2.1.3 Related Research

There has been minimal previous architectural research specifically in architecture in Antarctica[88] , and none has incorporated biophilic design towards gaining insight into human survival. However, there is ample information regarding the individual aspects of this research upon which to build.

The two most closely related publications are both dissertations which were completed within the last several years as parts of Doctorates of Philosophies for Departments of Architecture. They both utilise case studies as their primary research method to analyse buildings which are in extreme environments:

Georgina Davis at Texas A&M studied McMurdo Station in Antarctica. Her research specifically investigates energy efficiency, occupant satisfaction and comfort, as well as minimising the impact the structure has on the surrounding site. The culmination of this was recommendations in architectural and HVAC designs for a new dormitory building at the station. Through site visits and surveys, Davis developed a matrix framework that considered health & safety, psychological comfort & satisfaction of users, and functional & task performance. With her matrix, she evaluated the current station, the proposed master plan, and detailed what an 'idealised station' should contain.[89]

The second research focuses not on Antarctica, but the design process for architecture in extreme environments with an application in Space Architecture. Bringing her personal experience working on projects in the Arctic, Olga Bannova highlights the influence that this setting has on the requirements needed for habitation, restrictions on the building process, and what provisions should be taken for safety. In her work, Bannova makes a clear distinction between the architecture and building in the Arctic versus the Antarctic. It is with this difference; she studies examples of both. This research predominantly focuses on the exterior form of the building.[90]

While Bannova has continued her research with a focus on architectural design concerning outer space, Davis has remained concentrated on Antarctica. Recently she began a blog series with the biophilic design consulting firm, Terrapin Bright Green, identifying how the biophilia can be adapted for the alien environment of Antarctica. However, there are still strong ties to how her work can be applied in off-world living, similar to Bannova. While this blog is one of the few other examples of a cross-over between extreme environment and biophilic design,

[88] Bannova, Olga, "Designing for Extremes," (2016); Davis, "A Study of Remote, Cold Regions Habitations and Design Recommendations for New Dormitory Buildings in Mcmurdo Station, Antarctica."
[89] "A Study of Remote, Cold Regions Habitations and Design Recommendations for New Dormitory Buildings in Mcmurdo Station, Antarctica."
[90] Bannova, "Designing for Extremes."

Davis investigates this in relation to architecture in Antarctica in totality. Using the 14 patterns of Biophilic Design, she picks specific individual examples that display them.[91]

The research proposed to be conducted departs from these two examples in several ways. It delves deeper into the role of natural elements that promote human wellbeing from an Anglo cultural perspective. This tactic, in turn, provides insight into the behavioural patterns, humans, from Anglo cultures developed for survival and how it has been interpreted in a more contemporary setting with an environment that is significantly different from the savannah origins, which creates a cultural aspect that neither prior researchers focused. Multiple case studies will also provide a strong base to view the patterns and formulate a conclusion based on the observations rather than hypothesising a proposal and providing recommendations for future designs.

[91] Davis Biophilia in an Abiotic Environment.

2.2 BIOPHILIC DESIGN

2.2.1 Historical Background

Today, the built environment bears little resemblance to the early rudimentary shelters of humanity. However, the motivation behind the development of those shelters and contemporary structures remains the same, survival. No matter what the aesthetics, buildings serve one essential purpose, to protect the inhabitants, to provide refuge and sanctuary. Given this connection between the two apparently different structures, it is important to understand the experiences and patterns of humans, primary of anglo cultures, have developed towards that end to create architecture that supports our existence.

Over time, humans expanded their range of habitation, and what the built environment was designed to protect them from evolved to reflect various climates, social structures, and building materials and methods. Increasingly these changes removed humans from their natural surroundings, shielding them from potential harm, but also buffering them from the benefits that having contact with nature provides. Consequently, our homes, workplaces, schools, stores, etc. have instinctively developed to contain components that simulate these natural aspects. Many interdisciplinary studies have investigated these experiences and what impact they have upon the users, which has become known as biophilic design.

Figure 2-16 Relationship of Biophilia/Biophilic Design[92]

Fromm

The basis for biophilic design comes from the concept of biophilia. The first use to the term 'biophilia' was used by the social psychologist and sociologist Erich Fromm in his book *The Heart of Man.* Breaking the word down to its literal Latin roots, *bio* – life and *philia* – love, Fromm defines biophilia as the love of life. He foils this with necrophilia, the love of death, which this publication dwells upon more extensively, but notes that humans are more naturally inclined to strive towards life rather than death.[93]

Fromm's use of *biophilia* is focused more on a it as a psychological orientation. His work presents a foundation for what the phrase has come to represent, but in itself it is a much more reductive view of how it is perceived now. As Chomsky commented on Fromm's work in general, it is 'pretty superficial'[94], a sentiment that is an apt description of *biophilia* in relation to this research. Considering the breadth of Fromm's publications and contribution to his field,

[92] Graphic by Author
[93] Fromm, Erich, *The Heart of Man* (New York, New York, USA: Harper & Row Publishers Inc., 1964).
[94] Barsky, Robert F, *Noam Chomsky: A Life of Dissent* (Mit Press, 1998).

not fulling exploring a small concept that is not a substantial psychological theory that is attributed to him, the concept being less fleshed out or explored in his work is understandable.

Biophilia

The more notable use of the term was in a publication of the same title by the Harvard biologist Edward O. Wilson.[95] He expounded upon Fromm's identification of human preference towards living features or life, stating that the connection stems from a more profound, inherent link that humans have acquired over time as they evolved and is a vital part of our personal mental development. Wilson based this conclusion from his previous studies into sociobiology[96], which was not as widely accepted as his work on *biophilia*. Beyond the conceptual aspect, *biophilia* had a deeper impact, becoming an ecological charge to the audience to conserve nature to preserve the human-nature relationship. The idea being, if humanity wishes to continue to survive and thrive as a species, it needs to take a critical look at its impact on the surrounding environment.

The criticism *Biophilia* garnered was focused on early lack of broad cultural scope to the research. The target audience, and much of the initial research, concentrated on industrialised communities and their specific connection to nature. It is appealing to view Wilson's *biophilia* as a comprehensive approach to human-nature connection quiddity. In today's more culturally, socio-economic, and gender inclusive academic environment, a broader investigation of how *biophilia* is represented in alternative, less anglo focused setting has been a common criticism. This does not necessarily invalidate Wilson's theory and research; it is a point of awareness going forward with this potential bias and how it has been used to structure subsequent research.

Another criticism of *Biophilia* that relates to the relevancy of use in this research, is a lack of actionable pathway to achieve the ecological stewardship. It was in his next work that Wilson began to assemble interdisciplinary research towards this goal. Partnering with Stephen Kellert, an ecologist, to edit the compilation *Biophilic Hypothesis*[97], researchers were invited to contribute chapters that explored their previous research and how it related to *biophilia*.

With Kellert's contribution on the relationship people have beyond the human-nature connection is further elaborated upon. He identifies nine patterns of typical interactions. (see Appendix A.1) (1) **Utilitarian**, the physical aspects that nature provides humans, usually pertaining to food or security. (2) An unfiltered, **naturalistic** contact with nature. (3) The **ecological-scientific** study of the natural world through traditional empirical methods. (4) The

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[95] Wilson, Edward O., *Biophilia: The Human Bond with Other Species*, 1996 ed. (Cambridge, Massachusetts, USA: Harvard University Press, 1984).
[96] *Sociobiology: The New Synthesis* (Cambridge, Massachusetts: Harvard University Press, 1975); *On Human Nature* (Cambridge, Massachusetts, USA: Harvard University Press, 1978); *Genes, Mind and Culture: The Coevolutionary Process* (Cambridge, Massachusetts: Harvard University Press, 1981).
[97] Kellert, Stephen R., "The Biological Basis for Human Values of Nature," in *The Biophilia Hypothesis*, ed. Stephen R.; Wilson Kellert, Edward O. (Washington, D.C.: Island Press, 1993).

physical, **aesthetic** attractiveness that nature possesses. (5) Emblematic representations often found **symbolically** represented in language and communication. (6) The **humanistic** connection of our personal experiences and emotional bonds. (7) The **moralistic** and ethical concerns humans retain. (8) Humanities desire to have **dominionistic** control over nature. (9) A **negativistic** aspect of the natural world evoked from feelings of fear or aversion.[98]

These nine human-nature patterns, begin to form a format that allows for analysis of a situation, project, case, etc. It also further opens up the theory of *biophilia* for a wider consideration of the human nature-connection. While this stems from that initial culturally anglo point of view of nature, describing the connections as broader interactions it allows for a more comprehensive inclusion of alternative connections.

Kellert used these patterns as a basis to highlight the struggle that modern society has cultivated with maintaining a connection with nature despite the existing practices that exploit natural resources to incorporate them aesthetically into our lives. It was with this observation that he and others then developed the model that he became the figurehead for; biophilic design.

Biophilic Design

Kellert & Other Frameworks

The seminal book of the same title was another interdisciplinary collaborative work.[99] It is with Kellert's contribution to the book that the authors' bridge the gap between the abstract discussion about biophilia and a tool that can be utilised to foster the human-nature connection, the built environment. This approach was a logical place to focus since buildings have become a natural habitat for humanity. Humans now engage with the buildings and structures with which we surround ourselves similarly to how our ancestors connected to the outdoors, nature, plants, and animals.[100] The foundation for *Biophilic Design* comes from a three-prong defence: the theory of the new concept[101], the documented science and benefits[102], and the practical application[103]. Each of these sections relate and build upon one

[98] Kellert, Stephen R.; Wilson, Edward O., *The Biophilia Hypothesis* (Washington, D.C.: Island Press, 1993).
[99] Kellert, Stephen R.; Heerwagen, Judith H.; Mador, Martin L., *Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life* (Hoboken, New Jersey, USA: John Wiley & Sons, Inc., 2008).
[100] Salingaros, Nikos A.; Masden, Kenneth G., "Neuroscience, the Natural Engironment, and Building Design," in *Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life*, ed. Stephen R.; Heerwagen Kellert, Judith H.; Mador, Martin L. (Hoboken, New Jersey: John Wiley & Sons, Inc., 2008).
[101] Benyus, Janine, "A Good Place to Settle: Biomimicry, Biophilia, and the Return of Nature's Inspiration to Architecture," ibid.; Kellert, Stephen, "Dimensions, Elements, and Attributes of Biophilic Design," ibid.; Mador, Martin L., "Water, Biophilic Design, and the Built Environment," ibid. (John Wiley & Sons Inc.); Salingaros, Nikos A.; Masden, Kenneth G., "Neuroscience, the Natural Engironment, and Building Design," ibid. (John Wiley & Sons, Inc.); Wilson, Edward O., "The Nature of Human Nature," ibid. (John Wiley & Sons).
[102] Frumkin, Howard, "Nature Contact and Human Health: Building Evidence Base," ibid. (John Wiley & Sons, Inc); Loftness, Vivian; Snyder, Megan, "Where Windows Become Doors," ibid. (John Wiley & Sons, Inc.); Louv, Richard, "Children and the Success of Biophilic Design," ibid.; Moore, Robin C.; Cooper Marcus, Clare, "Healthy Planet, Healthy Children: Designing Nature into the Daily Spaces of Childhood," ibid.; Orr, David; Pyle, Robert Michael, "The Extinction of Natural Experience in the Built Environment," ibid.; Ulrich, Roger S., "Biophilic Theory and Research for Healthcare Design," ibid.
[103] Beatley, Timothy, "Toward Biophilic Cities: Strategies for Integrating Nature into Urban Design," ibid.; Bender, Tom, "Bringing Buildings to Life," ibid.; Berkebile, Bob; Fox, Bob; Hartley, Alice, "Reflections on Implementing Biophilic Design," ibid. (John Wiley & Sons, Inc); Bloomer, Kent, "The Picture Window: The Problem of Viewing Nature through Glass," ibid.

another in more of a collaboration, as has the following research. This strengthens the research, in sharp contrast to other aspects of environmental psychology, which has been observed to be less of a partnership between disciplines and more oppositional.[104]

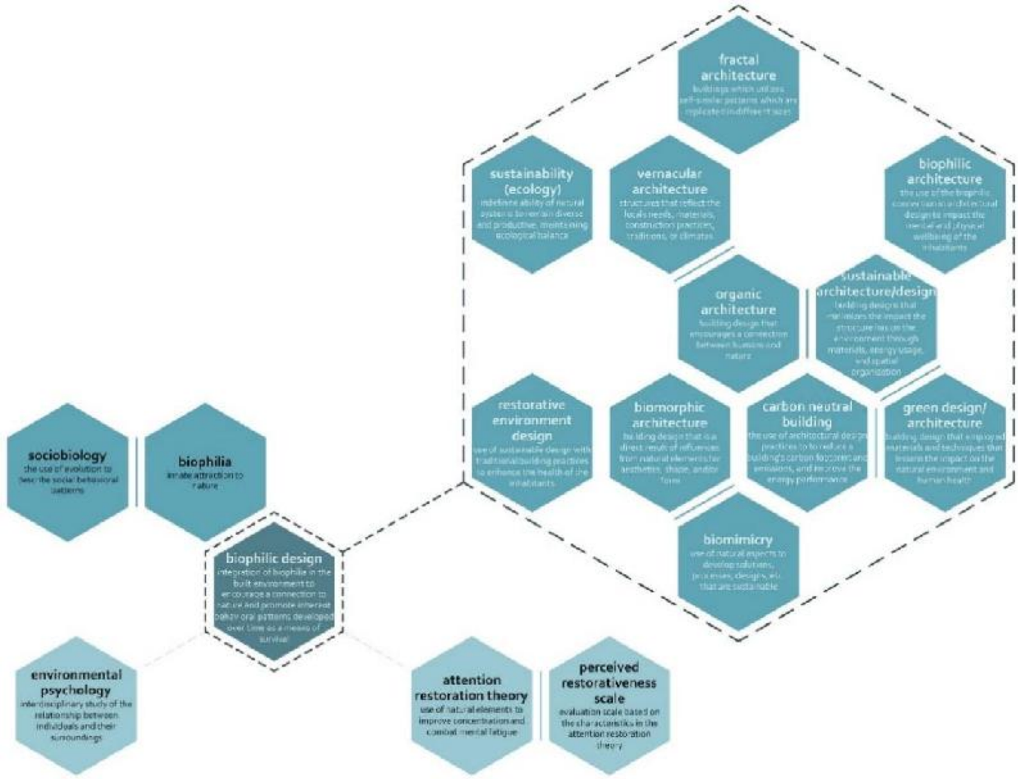

Figure 2-17 Biophilic Design and Related Concepts[105]

Kellert's contribution to *Biophilic Design* built upon his earlier work which had close ties to the environmental psychology and Restorative Environmental Design (RED). This model was one of the first studies that investigated the beneficial traits of traditional green building practices beyond the impact it had on the natural environment, by considering the wellbeing of the inhabitants as well. The three components of which are; environmental stress, coping, and restorative environments. These individual pieces build upon one another, investigating what difficulty or challenges are presented to the users, how they adapt to them, what materials and resources are utilised to meet the demands, and the process employed to restore what was expended in the process.[106] The relationship this has to his later work can be seen, these theories acting as a foundation, but lacking an impetus or motivation for them to be applied.

(John Wiley & Sons, Inc.); Cramer, Jenifer and Browning, William, "Transforming Building Practices through Biophilic Design," ibid.; Fisk, Pliny, "The Greening of the Brain," ibid.; Heerwagen, Judith H.; Gregory, Bert, "Biophilia and Sensory Aesthetics," ibid.; Hildebrand, Grant, "Biophilic Architectural Space," ibid. (John Wiley & Sons, Inc); Kieran, Stephen, "Evolving an Environmental Aesthetic," ibid. (John Wiley & Sons, Inc.); Rose, Jonathan R. P., "Green Urbanism: Developing Restorative Urban Biophilia," ibid.; Wilson, Alex, "Biophilia in Practice: Buildings That Connect People with Nature," ibid.

104 Hudson, "Holistic Dwelling: Integrating Biophilic Design, Environmental Psychology, and Feng Shui."

105 Graphic by Author

106 Hartig, Terry; Bringslimark, Tina; Patil, Grete Grindal "Restorative Environmental Design: What, When, Where, and for Whom?," in *Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life*, ed. Stephen R.; Heerwagen Kellert, Judith H.; Mador, Martin L. (Hoboken, New Jersey: John Wiley & Sons, Inc., 2008); Powell, R. B., Kellert, S. R., and Ham, S. H., "Antarctic Tourists: Ambassadors or Consumers?," *Polar Record* 44, no. 230 (2008).

The primary contribution of Kellert's in the theory section of *Biophilic Design* is a guiding set of attributes that enhance the human-nature connections, primarily from the standpoint of Anglo cultures. These strategies are a culmination and reflection of the rest of the research in the book, not a standalone theory; each attribute is elaborated upon based on the evidence presented. While Kellert approaches the subject from a predominantly Anglo cultural preconception, there are gestures towards that of other cultures; citing influences from early humans in the savannahs of Africa or using Asian examples. These attributes are characteristics of building design that range from readily apparent properties that have always been used, though perhaps not necessarily in relation to nature, i.e. colours, patterns, views, to intuitive properties that have been neglected or integrated unknowingly, i.e. prospect and refuge, nonlinear pathways,[107] (for the full list see Appendix A.2.) All of these attributes fall within the nine patterns that Kellert previously identified, though he synthesised these into six primary elements; environmental features, natural shapes & forms, natural patterns & processes, light & space, place-based relationships, and evolved human-nature relationships.[108]

It is the partnering and expansion of the initial nine interaction patterns of *The Biophilia Hypothesis*[109] with more tangible aspects of the built environment and relationships that introduces a strong semblance of a rubric. The ease with which that framework of elements and attributes can be adapted to specific function is illustrated by Terrapin Bright Green and McGee & Marshall-Baker's *Biophilia Matrix.*[110](see Appendix A.5 & A.6) The former is an approach for how to incorporate biophilic attributes into the architectural designs in general and the later is more specific towards developing a tool of analysis for existing conditions. These are both are interpretations of the existing biophilic design principals specific to their audiences.

It is at the point that the more theoretical patterns of the human-nature relationship is applied to examples is when the cultural scope is potentially narrowed unintentionally by cultural bias. While the attributes of Kellert's work are board and encompassing, there is still the underlying anglo bias of what is considered desirable or acceptable in a building. This carries through much of the subsequent adaptations. Similar to Wilson's work this does not invalidate biophilic design as a basis for framework, but this criticism is a quality of the research to take into consideration.

[107] Kellert, *Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life*.
[108] Kellert, *The Biophilia Hypothesis*.
[109] Ibid.
[110] Browning, William, Ryan, Catherine, and Clancy, Joseph, "14 Patterns of Biophilic Design: Improving Health & Well-Being in the Built Environment," (New York: Terrapin Bright Green, 2014); McGee, B. and Marshall-Baker, A., "Loving Nature from the inside Out: A Biophilia Matrix Identification Strategy for Designers," *HERD* 8, no. 4 (2015).

In his last publication[111], Kellert continued to refine and develop the concept of biophilic design, with much broader applications than his previous work both historically and culturally. Using the foundation formed in *Biophilic Design*[112] and *The Biophilia Hypothesis*[113], Kellert distilled the elements down to three overarching experiences, and the attributes streamlined to twenty-five (see Appendix A.3). The experiences take a broader look at how humans connect to nature; directly or indirectly, and how they interact with space or the sense of place in experiential ways. Reducing the attributes to almost a third the original number, Kellert did not eliminate attributes; rather, they became more comprehensive. For example, instead of eight attributes relating to 'light', there is one attribute which covers the characteristics of the original eight.[114] This shift allows for more critical analysis of buildings and creative solutions, where the seventy-plus could become simply a checklist or be overwhelming. The expanding of the definitions of the attributes allows for them to be more culturally inclusive, inviting more interpretation to build within the framework of biophilic design.

Along with the new structure Kellert proposes in *Nature by Design*[115], in the descriptions of the attributes, he highlighted historical and contemporary examples of how the attributes have been utilised. This approach lends itself to have greater weight, illustrating practical applications, not theoretical discussions. This is not as detailed as a rigorous post-occupancy evaluation, the success of the interventions is not explored, and it is not an exhaustive investigation. It is to this aspect that this research endeavours to add. There is a lack of applications which explore challenging environments and how biophilic attributes have been incorporated or solutions found where they have been challenged.

Popular Study Areas

While biophilic design can be applied to the field of architecture in general, there are specific areas in which more extensive research has been undertaken. One of the earliest studies conducted that is affiliated with biophilic design investigates the benefits of natural views within hospitals, notably by Roger Ulrich.[116] Valentine Seymour has corroborated Ulrich's hypothesise in her own exploration of how the human-nature relationship impacts their physical health.[117] A more generalised review of healthcare facilities tied the aspects of the indoor environment that impacts the health and wellbeing of the patients. The authors do not base their research in biophilic design, but the results of their findings parallel the principles.[118]

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111 Kellert, Stephen R., *Nature by Design : The Practice of Biophilic Design* (New Haven: Yale University Press, 2018).
112 Kellert, *Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life*.
113 Kellert, *The Biophilia Hypothesis*.
114 Kellert, *Nature by Design : The Practice of Biophilic Design*.
115 Ibid.
116 Loftness, "Where Windows Become Doors."; Salingaros, Nikos A.; Masden, Kenneth G., "Neuroscience, the Natural Engironment, and Building Design," ibid.; Ulrich, Roger S., "Biophilia, Biophobia, and Natural Landscapes," in *The Biophilia Hypothesis*, ed. Stephen R.; Wilson Kellert, Edward O. (Washington, D.C.: Island Press, 1993); "Biophilic Theory and Research for Healthcare Design."
117 Seymour, V., "The Human-Nature Relationship and Its Impact on Health: A Critical Review," *Front Public Health* 4 (2016).
118 Salonen, Heidi et al., "Physical Characteristics of the Indoor Environment That Affect Health and Wellbeing in Healthcare Facilities: A Review," *Intelligent Buildings International* 5, no. 1 (2013).

Most of the work has looked at the totality of healthcare design and how it can be improved to create calmer, more welcoming spaces.[119]

McGee and Marshall-Baker have specifically tailored the attributes of biophilic design to create what they have identified as a Biophilia Matrix (see Appendix A.6), which can be used to strategize inclusion of features within children's healthcare facilities.[120] Further research into the benefits of gardens in children's hospitals has been conducted in Australia.[121] Both of these papers found a positive correlation between the inclusion of natural elements which aligned with Ulrich earlier work which further emphasised the mixed-methods study of the playrooms provided for children in healthcare facilities.[122]

Another focus of research is educational spaces which examine the impact current school design and layout has on students' ability to learn, how natural elements improve the learning environment, and how those can be integrated for more successful spaces.[123]

The performed workspace studies relate to worker efficiency, job satisfaction, and stress levels, primarily relating to natural views and daylighting.[124] One of the few longitudinal studies published that focuses on biophilic design are in the health benefits that natural elements have in the workplace.[125] This study entailed a two-year collaboration between the University of Western Sydney and an office environment for a local construction company. Beyond improved satisfaction with the work environment, Gray and Birrell found the inhabitants experience lower stress, higher morale, and greater collaboration. They have continued to gather data as the space continues to be utilised.

The principles of biophilic design have also been considered on the larger scale of urban design. Aspects can be seen in the work of early 20th century urban planner, Patrick Geddes, where he created dynamic designs that were created to evolve.[126] Another early adopter of the attributes that make up biophilic design is Ian McHarg, who published his philosophies in his book *Design with Nature*.[127] The American Institute of Architects adapted their

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[119] Kellert, Stephen R. and Finnegan, Bill, *Biophilic Design the Architecture of Life*, *Architecture of life* (Oley, Pa.: Bullfrog Films, 2011); Nyrud, A. Q., Bringslimark, T., and Bysheim, K., "Benefits from Wood Interior in a Hospital Room: A Preference Study," *Architectural Science Review* 57, no. 2 (2014).

[120] McGee and Marshall-Baker, "Loving Nature from the inside Out: A Biophilia Matrix Identification Strategy for Designers."

[121] Reeve, Angela, Nieberler-Walker, Katharina, and Desha, Cheryl, "Healing Gardens in Children's Hospitals: Reflections on Benefits, Preferences and Design from Visitors' Books," *Urban Forestry & Urban Greening* 26 (2017).

[122] Weinberger, N. et al., "Child Life Specialists' Evaluation of Hospital Playroom Design: A Mixed Method Inquiry," *Journal of Interior Design* 42, no. 2 (2017).

[123] Cramer and Browning, "Transforming Building Practices through Biophilic Design."; Louv, Richard, "Children and the Success of Biophilic Design," ibid.; Moore, Robin C.; Cooper Marcus, Clare, "Healthy Planet, Healthy Children: Designing Nature into the Daily Spaces of Childhood," ibid.

[124] Loftness, Vivian; Snyder, Megan, "Where Windows Become Doors," ibid.; Mangone, G. et al., "Bringing Nature to Work: Preferences and Perceptions of Constructed Indoor and Natural Outdoor Workspaces," *Urban Forestry & Urban Greening* 23 (2017).

[125] Gray, T. and Birrell, C., "Are Biophilic-Designed Site Office Buildings Linked to Health Benefits and High Performing Occupants?," *Int J Environ Res Public Health* 11, no. 12 (2014).

[126] Batty, Michael and Marshall, Stephen, "Thinking Organic, Acting Civic: The Paradox of Planning for Cities in Evolution," *Landscape and Urban Planning* 166 (2017).

[127] McHarg, Ian L., *Design with Nature*, 25th anniversary ed. ed. (New York: J. Wiley, 1992); Yang, Bo and Li, Shujuan, "Design with Nature: Ian Mcharg's Ecological Wisdom as Actionable and Practical Knowledge," *Landscape and Urban Planning* 155 (2016).

Regional/Urban Design Assistant Team program in 2005 to have a sustainable sister program, the Sustainable Design Assessment Team. Both interventions bring an interdisciplinary group to visit an area to hear from leaders, stakeholders, and citizens before compiling a roadmap with guidelines, the latter geared towards a more sustainable community.[128]

It has been shown that even in urban environments, people prefer if they have naturalistic and organic elements which are helped if the city itself is viewed as its own ecosystem.[129] Unlike the application of biophilic design in architecture, urban design rarely offers a ground-up approach. Instead, the designers are working with existing communities, and researchers analyse how these elements can be integrated.[130] Several case studies of existing city designs have been analysed to assess their applications. el-Baghdadi and Desha studied Portland, Chicago, Toronto, Berlin, and Singapore, highlighting the economic benefits of biophilic urbanism as an incentive for a more ecological approach to cities.[131] Two other case studies specifically considered the heat island effect that plagues urban development and how that can be mitigated through biophilic principles applied to existing buildings or for developing green spaces within the urban context.[132]

Going back to the basis of the human-nature connection, survival, little research has been conducted investigating how that is found in residential architecture today. One of the few works that explore this was previously mentioned in the introduction. In *Holistic Dwelling*, Hudson investigated how biophilic design could be incorporated in residential projects to develop designs that are more attuned to the specific clients' needs and background.[133] This research reflects one of the few studies looking at aspects of home design and layout, not merely how the house fits within the community as a whole. The geographic focus of this research is northern New England, USA, and the intent is a more pragmatic examination into architectural design practice.

2.2.2 Summary and Implications

Biophilic design is a relatively young branch of human behavioural study in architecture. Still, it has proved to have a wide range of resulting research in a variety of fields and is continually evolving. There has been significant work on healthcare, education, and work environments,

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[128] "Sustainable Design Assessment Team Program (Sdat)," American Institute of Architects, https://www.aia.org/pages/2901-sustainable-design-assessment-team-program-sd:61.

[129] Beatley, "Toward Biophilic Cities: Strategies for Integrating Nature into Urban Design."; Kellert, S., "Biophilic Urbanism: The Potential to Transform," *Smart and Sustainable Built Environment* 5, no. 1 (2016); Rose, "Green Urbanism: Developing Restorative Urban Biophilia."

[130] Beatley, Timothy and Newman, Peter, "Biophilic Cities Are Sustainable, Resilient Cities," *Sustainability* 5, no. 8 (2013); Reeve, A. C. et al., "Biophilic Urbanism: Contributions to Holistic Urban Greening for Urban Renewal," *Smart and Sustainable Built Environment* 4, no. 2 (2015).

[131] el-Baghdadi, Omniya and Desha, Cheryl, "Conceptualising a Biophilic Services Model for Urban Areas," *Urban Forestry & Urban Greening* 27 (2017).

[132] Revell, G. and Anda, M., "Sustainable Urban Biophilia: The Case of Greenskins for Urban Density," *Sustainability* 6, no. 8 (2014); Soderlund, J. and Newman, P., "Biophilic Architecture: A Review of the Rationale and Outcomes," *Aims Environmental Science* 2, no. 4 (2015).

[133] Hudson, "Holistic Dwelling: Integrating Biophilic Design, Environmental Psychology, and Feng Shui."

the focus of the research on the occupant wellbeing being tied productivity, efficiency, and performance. Within the realm of academic research, personal dwellings have not had similar attention paid. Outside of academic journals, the presentation of biophilic design is similar to other 'style', decorating guides, or fads in architecture rather than the studied rational approach that *Biophilic Design* and *Nature by Design* laid out. The benefits tied to wellbeing in the other environments can be extrapolated and also be valuable for dwellings. Being able to feel safe in one's abode, to be able to relax and recharge is an essential aspect of life and survival in modern society.

Academically, there has been no criticism of biophilic design. Many of the original collaborators on the initial publication, *Biophilic Design* were seasoned researchers, coming to their theories and conclusion from years of fine-tuning their hypothesis and observation, stemming and learning from some highly criticised earlier work. The study of biophilic design has been additionally bolstered by the interdisciplinary approach to the field. The primary criticism comes from outside academia. It is a very young theory, which could lend itself to the argument that it is untried. There is also the perception which follows many aspects of sustainable building design – it is too expensive. Though by partnering sustainability with physical and mental health benefits, biophilic design helps soften the potential price tag.[134]

The most significant criticism that has independently been observed through this literature review is the inherent potential anglo bias. This predisposition is found around what is considered nature or the built environment, though not the fundamental human-nature relationship in the basis for biophilia and biophilic design. Seeing the more comprehensive path that research is taking with biophilic design, this is a diminishing gap. For this research, the anglo focus is mirrored in the Antarctic cases selected, while it is an acknowledged possible limitation it fits within the existing boundaries discussed in Chapter 3: Research Design.

The use of biophilic design as a framework is well established through the existing literature, documentation, and professional practice. It was first developed to create a set of guidelines of what should ideally be incorporated within the built environment to foster the human-nature connection. While this is geared towards new construction or renovations, it also creates an outline for a rubric, matrix, or framework of analysis of existing structures. It is this latter function of biophilic design that this research uses.

[134] Birrane, Alison, "Why You Can't Afford to Ignore Nature in the Workplace," https://www.bbc.com/worklife/article/20161125-why-you-cant-afford-to-ignore-nature-in-the-workplace?referer=https%3A%2F%2Fen.wikipedia.org%2F; to The Impact and Benefits of Biophilia in the Workplace, January 17, 2021, https://www.coalesse.com/blog/the-impact-and-benefits-of-biophilia-in-the-workplace/.

2.3 SUMMARY AND IMPLICATIONS

While both biophilic design and the built environment of Antarctica have been relatively well researched, there are significant gaps within the supporting body of knowledge and little evidence of any cross-pollination between the two. The proposed research endeavours to help fill that gap with the aid of the two topics with biophilic design supporting the analysis of the history of architecture in Antarctica.

Humanities and social sciences initially began as a small corner of Antarctic research, with the primary focus on the hard sciences, it has grown larger, encompassing a broader view of life, policy, and history. Within this field, architecture and the built environment occupies a more isolated or tangential space. The existing research either touches upon buildings in relation to a larger concept or argument, or focuses upon individual separate aspects or structures. This research begins to explore that gap by investigating the built environment as a whole, spanning a broader amount of time, though still with in parameter that are elaborated upon in the Research Design chapter.

The concept of biophilic design has become a well-established theory, and the philosophies behind the attributes have been thoroughly investigated through ecology, human behavioural studies, environmental psychology, anthropology, and architectural theory. While the application of biophilic design in healthcare, educational facilities, urban design, and within the workplace have been explored, the use in human living habitations has not been as thoroughly researched. This proposed study has the added specificity regarding how the attributes were developed around survival in a place of alien isolation, and that is still applicable today.

Research Questions

- *How has shelter evolved in Antarctica?*
- *How has nature been incorporated within architecture in Antarctica?*
- *How has natural elements aided in the survival of the occupants through shelter?*

The review of the existing literature led to the research questions identified and discussed in the Introduction Chapter. How the purpose of the questions relates to the summary of the literature review findings is as follows:

Delving further into the history of architecture in Antarctica

Individual explorers' huts and research stations have been studied, though not many and not often in relation to other structures. Publications specifically for the explorers' huts are primarily for preservation purposes, while the research stations are primarily from a sustainable design perspective, either making recommendations or highlighting their aspects. This study breaks down the structures and analyses how they incorporate the attributes of biophilic design, drawing parallels between the buildings, considering if the approach to design evolved, learning from the precedents, and examining whether some aspects were more successful than others, in terms of survival.

Increasing the awareness of architectural solutions in extreme environments

Media outlets are covering stories of 'once in a lifetime' climatic events with increasing frequency; cyclones, hurricanes, blizzards, droughts, tornados, etc. The architectural response has not kept up with these new challenges. The few responses outside of Antarctica to creating resistant architecture without considering biophilic design typically results in bland, unappealing concrete bunker type structures. Taking a critical look at the application and identification of biophilic design in relation to early human survival provides insight into the direction architectural practices should take. Antarctica provides an ideal setting for case studies to analyse structures and Anglo human habitation in an extreme environment which reflects weather patterns that are now being found in other parts of the world; intense wind speeds, dangerous temperatures, drifting snow, and isolation.

Expanding the understanding of biophilic design

Research and publicised application of biophilic design have predominantly focused on healthcare, education, and workspace design. This research concentrates on the residential conditions of the Antarctic huts and research stations; dormitories, recreational, dining, kitchen, and living facilities, the 'home' aspect of Antarctic life. We spend much of our time in our homes, making the application of biophilic attributes being included in this setting is no less important. Residential functions also afford more opportunity and need for customisation of biophilic design to an individual's preference for it to be successful. It is not the aim to analyse biophilic design itself, rather utilise it as a tool of analysis, as has been its function is research with other applications. The extending this usage to residential conditions in Antarctica expands upon the understanding of biophilic design in alterative environments and settings.

Chapter 3: Research Design

3.1 METHODOLOGY AND RESEARCH DESIGN

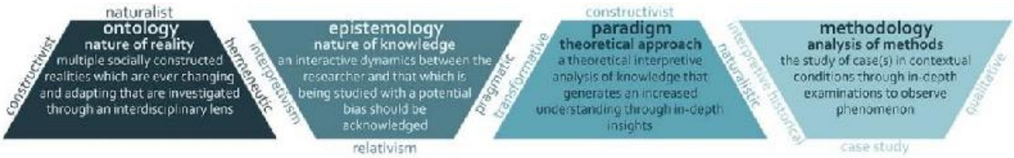

Figure 3-1 Research Design[135]

3.1.1 Methodology

The primary structure for the proposed research follows that of a case study,[136] which is supported with methods of triangulation through data collection.[137] This tactic fills the gap in the literature of both architecture in Antarctica and expands upon the use of biophilic design as a tool of analysis while tying the two together to explore how architectural interventions have incorporated natural elements which promote human existence in inhospitable environments.

In their text, *Architectural Research Methods*, Groat and Wang identify seven strategies towards conducting architectural research; interpretive-historical, qualitative, correlational, experimental/quasi-experimental, simulation & modelling, logical argumentation, and case studies. While the overarching structure for this research is a descriptive and explanatory multiple case study[138], the information on cases themselves rely on data collected through techniques found in interpretive-historical and qualitative research, providing a triangulation of methods to support the primary methodology. With the research aiming to investigate the use of biophilic design within buildings, the case study framework allows for specific cases to be selected to illustrate these attributes, while maintaining a finite obtainable scope of work. The initial stage of the case study is descriptive; the cases are illustrated and expressed within a real-world context to provide a base understanding of each building before moving onto the second stage. The explanatory aspect of the case study then illuminates how biophilic attributes have been integrated within each case, awareness into why that was done, and how those aided in resilience and comfort of buildings.

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[135] Graphic by Author

[136] Yin, Robert K., *Case Study Research : Design and Methods*, Fifth edition. ed. (Los Angeles: SAGE, 2014). and Sarvimäki, Marja, *Case Study Strategies for Architects and Designers : Integrative Data Research Methods*, ed. ProQuest (London: Taylor and Francis, 2017); Aksamija, Ajla, *Research Methods for the Architectural Profession* (Routledge, 2021).

[137] Groat, Linda N. and Wang, David, *Architectural Research Methods*, ed. David Wang, 2nd ed., Architectural Research Methods (Chichester: Wiley, 2013).

[138] Yin, *Case Study Research : Design and Methods*.

This method of managing case study research is described as the 'four pillars and a roof' approach acknowledged in Sarvimäki's *Case Study Strategies for Architects and Designers* was initially identified in the field of International Business by Pauwels and Matthyssens[139] for use in multiple case studies is applicable for this research. This tactic is also encouraged for architectural research in Aksamija's recent publication *Research Methods for the Architectural Profession*.[140] As identified in the Case Recruitment section of this chapter, the sampling for the case study spans the 120-year history of the habitation of Antarctica. The cases selected represent the three significant building periods, as well as different scales, assemblies, design approach, and nationalities of building in Antarctica for habitation.

Prior to Sarvimäki's publication, the primary resource focused on case studies was by Robert Yin, and focuses on social science research, though many of his techniques are applicable in architectural research as well. There are a variety of sources of evidence recognised for case studies to utilise, Yin, highlights six types, including documentation, interviews, archival records, direct observations, participant-observation, and physical artefacts.[141] The primary sources for this research are documentation, archival records, and interviews, and the triangulation of the data is further discussed below.

A logical approach to the analysis of the Antarctic cases is pattern matching[142], utilising biophilic design as an established set of patterns to identify aspects of the architecture interventions in Antarctica. It is better categorised as a specific type of pattern matching, which Yin highlighted as its own technique, namely, explanation building. The six buildings selected to form the case study create a series that represents the architectural history of Antarctica, which allows for the comparison of the hypotheses over time. Cross-Case Synthesis can be utilised for strengthening conclusions made from the research, how this specifically occurs through two stages is reviewed in the Analysis Section.

The overarching 'roof' that Pauwels and Matthyssens characterised is the validation of the research through the juxtaposition and iteration of the data collected. This multi-supported approach helps to negate the primary criticism that case study methodology faces. Rather than relying upon a singular method of observation or data collection, which has been reproached for potential bias or lacking repeatable results, tackling a case study with multiple data collection techniques, some which are considered traditional research methods in themselves, aids is mitigating the potential or perceived short-comings of case study research.

139 Pauwels, Pieter; Matthyssens, Paul, "The Architecture of Multiple Case Study Research in International Business," in *Handbook of Qualitative Reserch Methods for International Business*, ed. Rebecca; Welch Marschan-Piekkari, Catherine (Cheltenham, UK: Edward Elgar, 2004).
140 Aksamija, *Research Methods for the Architectural Profession*.
141 Yin, *Case Study Research : Design and Methods*.
142 Ibid.

Figure 3-2 Research Process[143]

Phases of Research

The following provides a synopsis of the proposed work for this study

Phase 1 – Preliminaries

The initial phase of research encompasses early work that has been conducted in composing the Confirmation Report: research design, ethics application, and establishing a document management system. This phase extends beyond the proposed Confirmation of Candidature to encompass the ongoing work of the Literature Review, which continued through all phases.

Phase 2 – Archival Research

Building upon the initial information gathered in the Literature Review of Phase 1; this phase included more in-depth analysis and study of primary source documents, articles, and design documents. With the older explorers' huts, this involved traditional resources; diaries, newspaper articles, scholarly papers, and preservation reports. For the stations, similar secondary source material is available, however more contemporary versions of diaries, inhabitant blogs illustrate daily life.

[143] Graphic by Author based on Wright, A. and Wright, Lt, "The Sage Handbook of Qualitative Research (3rd Ed.)," *European Journal of Marketing* 40, no. 9/10 (2006).

Fieldwork included in this phase was conducted at archives and organisations internally relevant to the cases. National Archives, Libraries, Antarctic Governing Organizations, heritage trusts, and foundations were visited in Australia, New Zealand, the United Kingdom, and the United States.

Phase 3 – Interviews

While most data was gathered during Phase 2, the initial plan for the research called for interviews of professionals who have worked on the buildings. The goal of the interviews was to gain additional resources from these professionals, including plans, renderings, and photographs. For a sample of the interview questions, please see Appendix D1. Further elaboration on how this functioned is discussed below in Research Design.

Phase 4 – Site Visit

The initial planning for the research optimistically included the potential for a site visit to Antarctica for in-person observations of the cases. It was preferred that this research would include a site visit to Antarctica to observe the Stations and Huts. Realistically visiting all six stations and huts would not be possible, issues were elaborated upon in Research Design. The lack of experience was supplemented with virtual tours of Scott's Hut and Halley VI. During a fieldwork trip to Hobart, the replica of Mawson's Huts was toured.

Phase 5 – Analysis

All phases are proposed to overlap, analysis of the research gathered was ongoing as it was collected to aid in the focus of the investigation. The basis for analysis is to use the attributes of biophilic design to organise the data gathered for the six buildings. Once all data assembled the final analysis, and a review of previous work was undertaken. Data Analysis is further elaborated upon in Analysis below.

Theoretical Framework of Cases

Most literature that discusses case study as a research method recommends developing a theoretical framework to facilitate data collection. Another researcher who has written extensively about the use of case studies in social science research, Robert Stake, recommends outlining the primary 'issues' that each case displays, stating that these provide insight into the context of each case, be it political, social, historical, or personal.[144] Stephen Kellert's attributes and experiences of biophilic design were proposed to create this framework. The initial plan was to utilise the six elements and seventy-two attributes outlined in *Biophilic Design*[145] to do so. The elements would create the structure of the research, to allow for a more holistic approach to data collection rather than focusing on the seventy-attributes and simply pigeon hole observations or develop a checklist. During the archival research phase, a new

[144] Stake, Robert E., *The Art of Case Study Research* (Thousand Oaks: Sage Publications, 1995).
[145] Kellert, *Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life*.

book on Kellert's classification of biophilic design was published[146]. With three experiences and twenty-five attributes, it is much more streamlined. Some redundancy with using the original for classification was lessened by combining some attributes and elements. The new difference in categorisation and properties of the experiences also allowed for a more in-depth analysis. There was a clear difference between what an element was versus an attribute; they comprised of descriptive relationships rather than being 'super attributes'.

3.1.2 Research Design

Due to the nature of the research, the approach focuses on qualitative data collection, not quantitative or experimental.

Data Generation

For case studies, Yin identifies six possible types of data collection; interviews, documentation, direct observation, participant observation, archival records, and physical artefacts[147]. The primary techniques employed in this research are the examination of documentation, archival record, interviews, and observations.

Documentation and Archival Record

The documentation reviewed included personal documents; the diaries of explorers and expedition team members as well as the contemporary equivalent, blogs, of the inhabitants at the stations. Media coverage, newsprint and televised, of the expeditions and stations were also be considered. Governmental and professional documents available to the public or upon request were also used; primarily from governing organisations for the cases and the websites for the architects who designed the contemporary structures.

Interviews

Interviews were broken into two categories; design professionals and preservationists. The interviews were intended to provide more in-depth knowledge of the buildings themselves and the design decisions behind specific aspects. The interviews, unfortunately, did not go as intended. The majority of attempts to conduct interviews were met warmly, but with a lack of follow-through. The two organisations that participated fully provided ample and critical information for the corresponding cases. What data was gathered, however, was more of an extension of Documentation and Archival Record rather than having unique qualities to Interviews.

Site Visit

A site visit to the identified cases was identified as a beneficial addition to the evidence collection. However, the possibility of a site visit was remote (see Limitations); therefore, the research was designed to compensate for that and did not rely exclusively upon potential data

[146] Kellert, *Nature by Design : The Practice of Biophilic Design*.
[147] Yin, *Case Study Research : Design and Methods*.

gathered in that manner. If a trip were able to happen, it would not have been possible to visit all of the cases.

Observations

To supplement what would have been beneficial with a Site Visit, remote observation provides a limited experience of the cases. Photographs, floor plans, 3D tours of two stations and videos of the stations were used to observe the conditions of the structures and provide insight into the experience of being in them.

3.2 CASE RECRUITMENT

There are amazingly over 100 sites of explorers' huts, military bases, whaling stations, and scientific research stations and bases south of 60° latitude, using this classification of land and ice masses located in this area to define 'Antarctica' (see Appendix B2 & B3). The following is the process that was used to narrow down that field to obtain the final six structures to study (for graphic representation of process see Appendix C). The basic building information, the subsequent aspect was considered:

- The building must still be standing and habitable
- Permanent, year-round use (for scientific research stations and bases)
- significant preservation (for explorer's huts)

While this significantly narrowed the field, a quick survey of available literature specific to individual buildings provided additional criteria:

- Governing Organization has a webpage for the Station/Hut/Base
- Peer-reviewed sources are available
- Primary sources are available
- Quantity of other sources (other websites, books, newspapers, etc.)
- English sources are readily available

Looking at the three significant periods in Antarctic history, two buildings from each were then identified:

- Heroic Age of Exploration
    1. Scott's Hut – 1911 – Cape Evans – Antarctic Heritage Trust
    2. Mawson's Huts – 1912 – Commonwealth Bay – Mawson's Hut Foundation
- International Geophysical Year
    3. McMurdo Station – 1956– Ross Island – United States Antarctic Program
    4. Casey Research Station – 1964 – Vincennes Bay – Australian Antarctic Division
- International Polar Year (IV)
    5. Amundsen-Scott South Pole Station – 2003 – Geographic South Pole – USAP
    6. Halley VI – 2012 – Brunt Ice Shelf – British Antarctic Survey

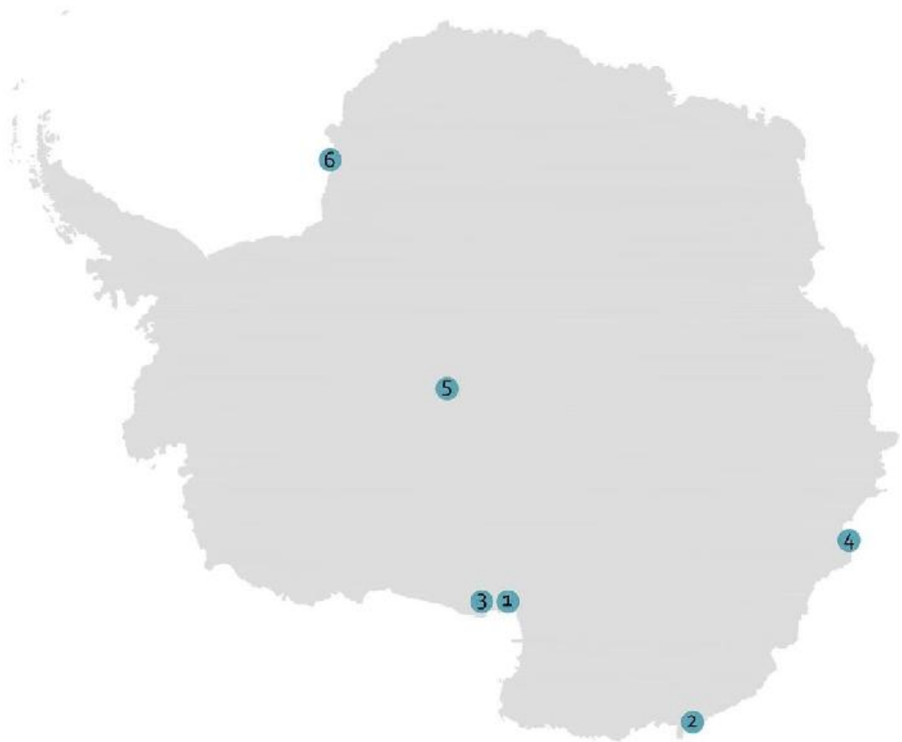

Figure 3-3 Map of Antarctica – Stations Identified for case studies[148]

[148] Graphic by Author

Figure 3-4 Scott's Hut – Hut at Cape Evans Walkers[149]
(courtesy National Science Foundation)

Figure 3-5 Scott's Hut – Cape Evans in Snow[150]
(courtesy National Science Foundation)

[149] Lucibella, Mike, *Hut at Cape Evans Walkers,* 2015, Photograph. National Science Foundation, Accessed June 11, 2020, https://photolibrary.usap.gov/PhotoDetails.aspx?filename=hut-at-cape-evans-walkers.jpg.
[150] *Cape Evans in Snow,* 2015, Photograph. National Science Foundation, Accessed June 11, 2020, https://photolibrary.usap.gov/PhotoDetails.aspx?filename=cape-evans-in-snow.jpg.

Figure 3-6 Sir Douglas Mawson's Hut in East Antarctica.[151]
CC BY-SA 4.0

Figure 3-7 Mawson's Huts - historic[152]
(CC BY-SA 4.0 – courtesy Museums Victoria)

[151] Collins, Kimberley, *Sir Douglas Mawson's Hut in East Antarctica,* Photograph. Creative Commons, Accessed June 12, 2020, https://search.creativecommons.org/photos/cf600a49-f63a-473a-a3bb-f1a82f541057., reproduced under a CC BY-SA 4.0 Creative Commons Licence.

[152] *Explorers near the Entrance at the 'Old Hut',* Photograph. Museums Victoria, Accessed June 12, 2020, https://collections.museumsvictoria.com.au/items/1735074., reproduced under a CC BY-SA 4.0 Creative Commons Licence.

Figure 3-8 McMurdo Station – Building 155[153]
(courtesy National Science Foundation)

Figure 3-9 McMurdo Station - overall[154]
(courtesy National Science Foundation)

[153] Hood, Elaine, *Building 155 Storm,* 2013, Photograph. National Science Foundation, Accessed June 11, 2020, https://photolibrary.usap.gov/PhotoDetails.aspx?filename=Building155_entrance2.jpg.
[154] *Mcmurdo,* 2020, Photograph. National Science Foundation, Accessed June 11, 2020, https://photolibrary.usap.gov/PhotoDetails.aspx?filename=2020Jan6-McMurdo-2.jpg.

Figure 3-10 Casey Station – Red Shed[155]
CC BY-SA 4.0

Figure 3-11 Casey Station – overall.[156]
CC BY-SA 4.0

[155] Tapson, Natalie, *Red Shed Casey Station,* Photograph. Creative Commons, Accessed June 14, 2020, https://search.creativecommons.org/photos/d84437ff-b7d2-40ff-b1c8-9869c04bc3f4., reproduced under a CC BY-SA 4.0 Creative Commons Licence.
[156] *Casey Station,* Photograph. Creative Commons, Accessed June 14, 2020, https://search.creativecommons.org/photos/9fcf3a6f-9385-48ee-a02f-e7573ee713cb., reproduced under a CC BY-SA 4.0 Creative Commons Licence.

Figure 3-12 Amundsen-Scott South Pole - Entrance[157]
(courtesy National Science Foundation)

Figure 3-13 Amundsen-Scott South Pole[158]
(courtesy National Science Foundation)

[157] Hood, Elaine, *Amundsen-Scott South Pole Station,* 2013, Photograph. El Station Entrance, Accessed June 11, 2020, https://photolibrary.usap.gov/PhotoDetails.aspx?filename=ElStationEntrance3.jpg.
[158] Whitmore, Colin, *Amundsen-Scott South Pole Station,* 2018, Photograph. National Science Foundation, Accessed June 11, 2020, https://photolibrary.usap.gov/PhotoDetails.aspx?filename=2018Nov21-Amundsen-Scott-South-Pole-Station-2.jpg.

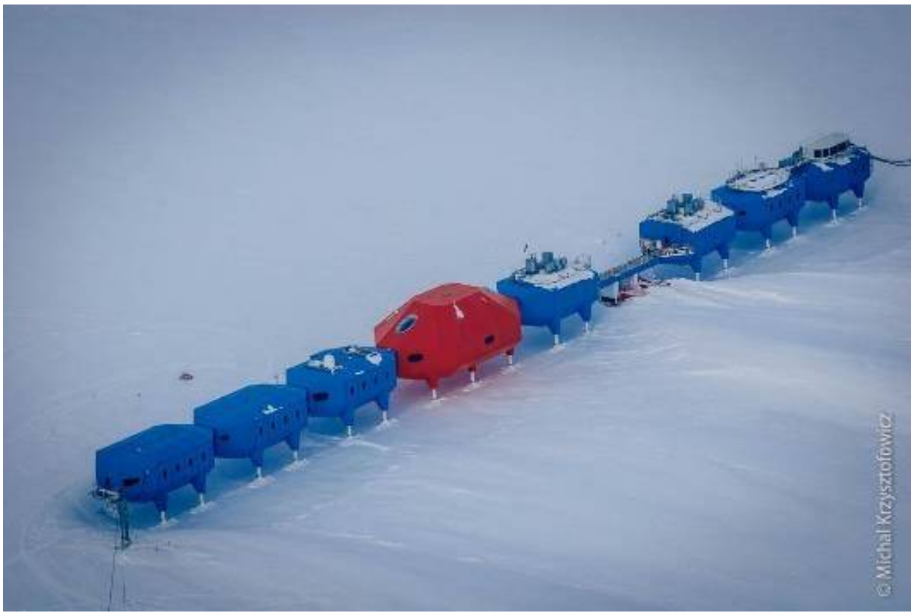

Figure 3-14 Halley VI – Brunt Ice Shelf[159]
(used with permission from M. Kryzsztofowicz)

Figure 3-15 Halley VI - night[160]
(used with permission from M. Kryzsztofowicz)

3.3 RESEARCH PARADIGM

The typical approach employed in qualitative case studies is the constructivist paradigm. This model is built upon a subjective epistemology which not only believes that individuals construct their realities through their own experiences, but also acknowledges research

[159] Krzysztofowicz, Michal, *Halley Vi from Above,* 2014, Photograph. Beautiful Ocean, Accessed June 11, 2020, http://beautifulocean.org/albums/halley-station-1/content/halley-vi-from-above/.
[160] *Moon Halo,* 2014, Photograph. Beautiful Ocean, Accessed June 11, 2020, http://beautifulocean.org/albums/project-antarctica-366/content/moon-halo-4/.

interpretation of their research is influenced by their own experiences as well.[161] The constructivist/naturalist/hermeneutic ontology also supports this theory. Architectural research often employs interdisciplinary approaches, using the different lenses to investigate multiple socially constructed realities that are ever-changing and evolving and formulate the overall conclusions. This approach mimics the interdependent approach of the architectural design process that continually refers to a design brief that may evolve while moving forwards towards a conclusion.[162]

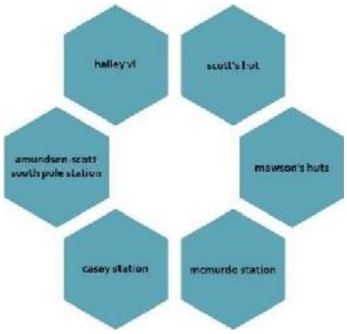

Figure 3-16 Cases Selected

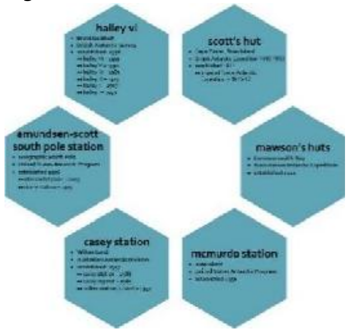

Figure 3-17 Stage Two - overall analysis

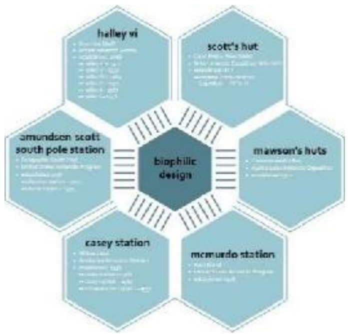

Figure 3-18 Stage One - description and identification of biophilic attributes[163]

3.4 ANALYSIS

The data analysis for this research is organised into two stages; individual case description and cross-case analyses. The analysis is identified as being conducted during Phase 5 of the Research Process. The staged approach was identified by Heidi Lauckner in an effort to "balance the intricacies and detailed richness of the individual cases with the aim of generating an abstract theoretical framework"[164].

The first stage focuses on each case individually, in this instance: each structure. The goal is to create the 'rich, thick descriptions' that is the asset of qualitative case studies[165], which allows the audience to view the totality of the building prior to an explanation of its experiences in terms of biophilic design. This stage is what comprises Chapter 4.

The second stage critically investigates the incorporation of biophilic design over the six cases and with the overall development of the structures. This is to understand what aspects have been prevalent throughout the history of human habitation in Antarctica, what has been changed, adapted, and potentially answer why this occurred. This last stage takes a detailed look at how the biophilic design attributes were incorporated in terms of their original behavioural patterns.

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[161] Lauckner, H., Paterson, M., and Krupa, T., "Using Constructivist Case Study Methodology to Understand Community Development Processes: Proposed Methodological Questions to Guide the Research Process," *Qualitative Report* 17, no. 13 (2012); Sarvimäki, *Case Study Strategies for Architects and Designers : Integrative Data Research Methods*.
[162] Penn, Alan, "Architectural Research," in *Advanced Research Methods in the Built Environment*, ed. Andrew Knight and Leslie Ruddock (Oxford: Wiley-Blackwell, 2008).
[163] Graphics by Author
[164] Lauckner, Paterson, and Krupa, "Using Constructivist Case Study Methodology to Understand Community Development Processes: Proposed Methodological Questions to Guide the Research Process."
[165] Sarvimäki, *Case Study Strategies for Architects and Designers : Integrative Data Research Methods*; Yin, *Case Study Research : Design and Methods*.

3.5 ETHICS AND LIMITATIONS

Ethics

Ethics application number 0000016100 has been opened and approved. This research is reliant upon information gathered through interviews with Architects and Historic Preservationists. It is the intent to follow Bond University's guidelines to protect participants. Documents submitted as part of the ethics application are in Appendix E.

Limitations

Site Visit

Typically, with architectural research, particularly with a case study, it is considered crucial to visit the site physically. This act garners the researcher first-hand experience of the structure and its surroundings. However, access to conducting fieldwork in Antarctica is severely restricted with few options, which present their own potential problems.

Accommodations in Antarctica is limited to the scientific research stations, rooms at which, are not available to rent. The only opportunity to spend significant time on the continent or at the research stations is to secure either the National Science Foundation's Antarctic Artists and Writers Program (United States of America) or the Australian Antarctic Arts Fellowship. Both would provide transportation and accommodation at either countries' research stations, travel to other stations from there is possible. Each program only selects a few recipients each year.

Another prospect would be to join a scientific research team as a support member. This approach was taken by another PhD candidate from the United States, focusing her research on architecture; however, she was able to join a team from her own University. Bond University does not have an active Antarctic program, and other Universities generally prioritise their own students before seeking outside members.

The last possibility was not ideal. There are tourism opportunities via cruises that stop at several research stations and explorers' huts. It would not allow the same access as the two fellowships/programs do and would require significant private funding to participate. While participation is not competitive, the time at a site would be short, and only one building would be available for access.

It was with these considerations that during the Confirmation of Candidature, Bond University did not require a site visit take place during this research. However, it is important to note there may be limitations to the outcome of this research due to a lack of first-hand experience of the sites. It is also emphasised in Chapter 6, that this opens up the potential for further research if the opportunity arises to conduct a site visit.

Language

Noted under Case Recruitment is the need for a substantial number of sources available in English for a case to be considered. The researcher is limited by only being fluent in English, literate in Latin, and lacking the funding for translations. While this constraint did aid in narrowing the filed for case recruitment, it does present a bias within the research towards Anglo cultures, representation of 'shelter', response to Antarctica, and the interpretation of the biophilic constructs.

Interviews

As mentioned in Research Design, some difficulty and limitation in the Interview portion of data gathering occurred. There is always a possibility with interviews that participants could be unwilling or reluctant to participate. With several interactions, another aspect was potentially impacting the ability to gather data this way – governmental discretion. With the majority of the cases being run and controlled by governmental organisations, there was a reluctance to share information, floor plans, etc., with an international researcher due to potential confidentiality. Being a United States citizen with research being conducted at an Australian institution provided a stumbling block for both US, Australian, and United Kingdom interviewees. This was not the case universally; two key contacts provided essential resources to this research. In this situation, it was decided to focus on the available data, which was more than adequate than trying to unravel the bureaucratic issue.

Chapter 4: Review of Architectural History of Cases

4.1 INTRODUCTION

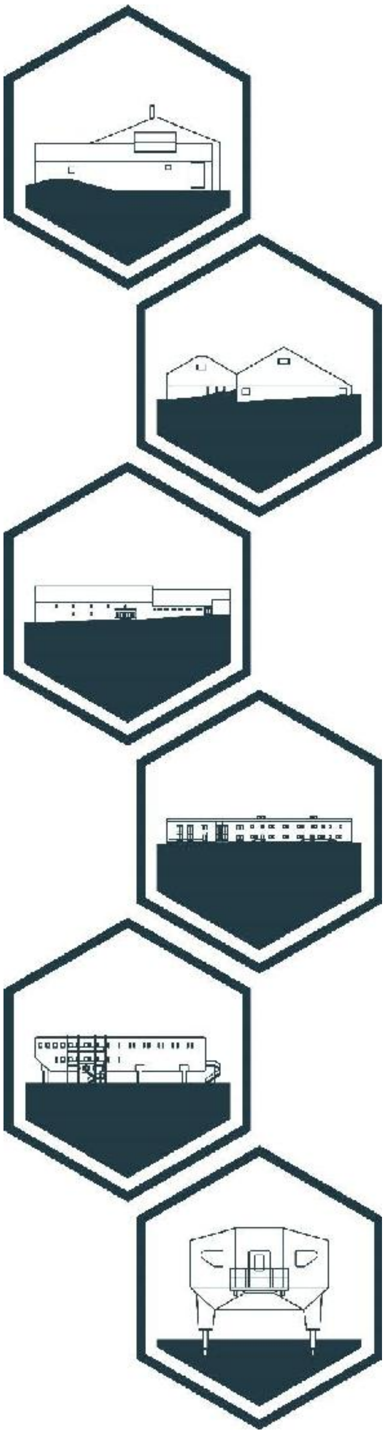


Figure 4-1 Cases being reviewed

The following chapter provides an in-depth review and detailed description of the selected cases. It is intended to provide a foundation of understanding upon which an analysis can build.

The structures are discussed in chronological order; Scott's Hut, Mawson's Huts, McMurdo Station's Building 155, Casey Station's Red Shed, Amundsen-Scott South Pole Station, and Halley VI. The historical context and background of the structure are addressed, including an exploration of the conditions at each site. To familiarise the reader with the buildings themselves, a detailed walkthrough of the building(s) that are being analysed for this research at each of the bases or stations, provides the fabric from which the analysis references later.

Concluding each case is the raw classification of attributes of biophilic design found in each structure (following the same element and attribute organisation laid out by Kellert). This identification is provided to illustrate the inclusion, or lack thereof, of biophilic qualities within the isolated cases, specific to the time period, location, cultural practice, etc. Further critical discussion and evaluation of these qualities are found in Chapter 5. The analysis in that chapter also investigates and tracks this discussion as a whole, how it progressed or regressed over time with shifting priorities, abilities, and goals.

4.2 SCOTT'S HUT

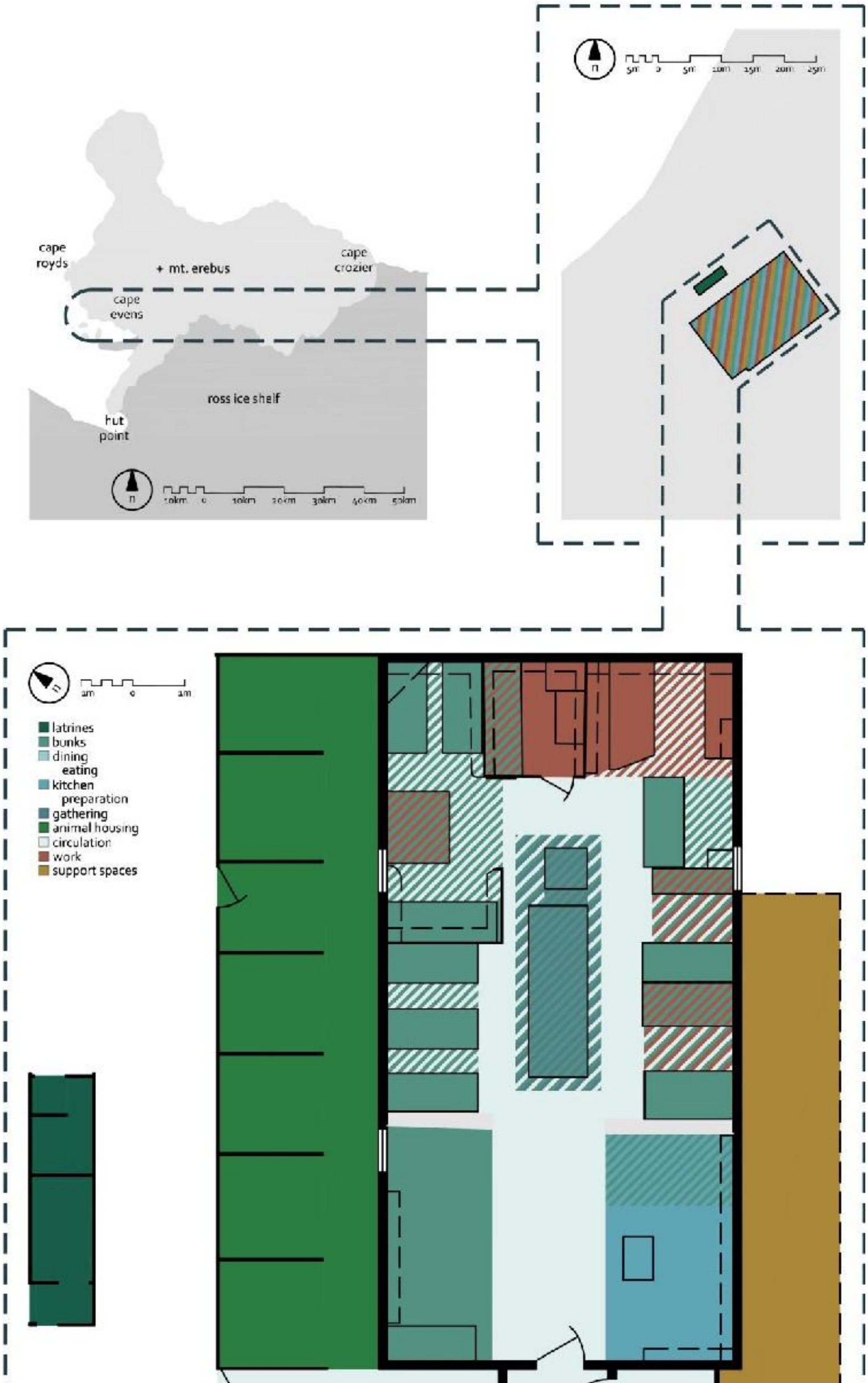


Figure 4-2 Scott's Hut – Site, Orientation, Floor Plan[166]

4.2.1 Sources

Within Chapter 4 and Chapter 5, much of the material presented is from examinations of archival research. Where applicable, specific references are cited. General observations and analyses are from the diaries of expeditioners[167], conservation reports[168], photographs[169], and 3D models[170]. Any particular item is referred to explicitly if applicable.

4.2.2 Background

The earliest structure studied here is affiliated with Captain Robert Scott's British Antarctic Expedition (1910-1913). This was Scott's second expedition to Antarctica, his first being the National Antarctic Expedition (1901-1904), with the Discovery Hut being constructed at Hut Point on Ross Island. The goals of the BAE were to conduct scientific experiments, expand upon the biological and geological understanding of the continent, but primarily to win the race to the geographic South Pole.

Before landing in Antarctica, the Expedition started from London, making stops in Cape Town, South Africa, Melbourne, Australia, and Lyttelton, New Zealand. It was at this last stop that they conducted a trial erection of the prefabricated huts which had been brought on the Terra Nova from London. This exercise proved useful, and they were able to procure replacement parts when they found some issues with the size and number of members.

The main building for the winter quarter was located at Cape Evans on Ross Island in January 1911. There were several other smaller parties with structures affiliated with them; the Northern Party at Cape Adare and the Western Party at Granit Harbour and Inexpressible Island, however, this research will focus on the main hut at Cape Evans. Built-in soon after making landfall, it housed 25 men the first winter and 13 the second. They used the hut for

[166] Graphic by Author – developed from Antarctic Heritage Trust's Conservation Plan

[167] Cherry-Garrard, Apsley, *Worst Journey in the World : A Tale of Loss & Courage on Scott's Antarctic Expedition* (Santa Barbara, CA, USA: Narrative Press, The, 2000). Evans, E. R. G. R., "The British Antarctic Expedition, 1910-13," *Scottish Geographical Magazine* 29, no. 12 (1913). Mill, Hugh Robert, "The Antarctic Expeditions of 1911-12," *The Geographical Journal* 39, no. 5 (1912). Levick, George Murray, *Antarctic Penguins a Study of Their Social Habits* (2011). Ponting, Herbert, *With Scott in the Antarctic* (Glouchestershire, United Kingdom: Amberly Publishing, 1922). Priestley, Raymond E, "Work and Adventures of the Northern Party of Captain Scott's Antarctic Expedition, 1910-1913," *The Geographical Journal* 43, no. 1 (1914). Richards, R.W., *The Ross Sea Shore Party 1914-17* (Norwich, United Kingdom: The Erskine Press, 1962). Shackleton, Ernest, *South* (New York, New York, USA: Carroll & Graf Publishers, 1999). Scott and Jones, *Journals Captain Scott's Last Expedition*. Taylor Taylor, Griffith, "Physiography and Glacial Geology of East Antarctica," *The Geographical Journal* 44, no. 4 (1914); *Antarctic Adventure and Research* (London, United Kingdom: Forgotten Books, 2015); *With Scott: The Silver Lining* (London, England: Forgotten Books, 2015).

[168] Antarctic Heritage Trust, https://www.nzaht.org/. Cochran, Christopher; and Trust;, Antarctic Heritage, *Conservation Plan, Scott's Hut, Cape Evans : British Antarctic Expedition, 1910 - 1913, Ross Island, Antarctica*, Scott's Hut, Cape Evans (Christchurch, N.Z.: Christchurch, N.Z. : Antarctic Heritage Trust, 2004).

[169] Erskine, Angus and Savours, Ann, "Scott's Last Voyage: Through the Antarctic Camera of Herbert Ponting," *The Geographical Journal* 141, no. 2 (1975); Ponting, *British Antarctic Expedition 1910-13*; *The Great White South* (New York: Cooper Square Press, 2001); *With Scott in the Antarctic*., Scott, Robert Falcon, *Scott's Last Expedition Volume I* (2004)., Nigel Watson, Jane Ussher, *Still Life: Inside the Antarctic Huts of Scott and Shackleton* (Australia: Murdoch Books, 2012).

[170] "Scott's Hut Virtual Tour," Google Maps, https://www.google.com/maps/@-77.6361805,166.4173336,2a,75y,39.88h,93.5t/data=!3m7!1e1!3m5!1sAfGF5tFC13NdN-ql2yHC8Q!2e0!6s%2F%2Fgeo0.ggpht.com%2Fcbk%3Fpanoid%3DAfGF5tFC13NdN-ql2yHC8Q%26output%3Dthumbnail%26cb_client%3Dmaps_sv.tactile.gps%26thumb%3D2%26w%3D203%26h%3D100%26yaw%3D129.23318%26pitch%3D0%26thumbfov%3D100!7i13312!8i6656 https://www.antarctic.eu/wp-content/panoramas/panotouren/cape_evans/Cape_Evans.html.

shelter from the elements, where general domestic activities could occur as well as providing space for each of the expedition members. Throughout the expedition, they conducted scientific observations, made plans and prepared the equipment and supplies for the South Pole journey, and on the periphery, housed the ponies, donkeys, and dogs.

Late in October 1911, the team along with additional support members set out for the South Pole. 17 January 1912, Scott, with four other men, reached the geographic South Pole only to discover that Roald Amundsen has made it there a little over a month earlier. He had left the remains of Polheim, their camp, with a letter stating their achievement, and the Norwegian flag. Scott's team began the return journey a few days later, all members of the team perished with the last diary entry that Scott made being on the 29th of March.

The remaining member at the hut waited for Scott's arrival; several men journeyed out to try to meet them. However, by April 1912, they had given up hope. The following spring a team went out, found the final camp, and built a snow cairn to commemorate the men. In January 1913, the Terra Nova returned to pick up the remaining members of the team from Cape Evans. The men left the hut stocked with supplies for future expeditions.

It was only a few years later that these proved useful when the Ross Sea Party of Ernest Shackleton's Trans Antarctic Expedition (1914-1917) were accidentally abandoned on Ross Island. This expeditionary party was there with the intent of laying depots for the second half of Shackleton's Expedition. They were unaware of the loss of the Endurance, forcing the expedition to be aborted. It was their original plan to take two summers laying the depots, spending the winter aboard their ship, the Aurora as previous expeditions had done. However, a blizzard pushed the ship out and prevented it return to pick up ten men stranded on Ross Island. After foraging between Cape Royds with Shackleton's earlier Nimrod Hut, Scott's Discovery Hut at Hut Point, they settled into the Terra Nova Hut at Cape Evans. When these men left in 1917, they closed up the Terra Nova Hut, which was not visited for another three decades.

4.2.3 Site Conditions

The original intent of the British Antarctic Expedition was to locate the main winter quarters at Cape Crozier on the eastern part of Ross Island. This site was chosen from Scott's previous experience on Ross Island, he described it as 'comfortable', with ice available to melt for freshwater and snow for the dogs and ponies. The snowy slopes and exposed rocky areas provided opportunities for the men to ski and walk. Also, for scientific exploration, a significant portion of the expedition, afforded possibilities to study the adjacent Great Barrier as well as access to the rookeries of Adélie and Emperor penguins. Scott was also interested in the proximity to Mount Terror and other peaks for ascension and observations. His primary deciding factor was the convenience for the expedition's ultimate goal, this area on the island provided a more direct route to the Southern Road. Scott's desire for this location was further elaborated by Ponting in his diary, identifying that Mount Terror and the surrounding foothill would also provide further shelter for the camp.

A small landing party from the Terra Nova was launched to investigate potential sites. The waves in the area prevented even mooring the whaleboat to consider the surrounding area. Several men also noted the height of the Great Barrier at Cape Crozier, dwarfing even the Terra Nova. Despite his confidence in the site, Scott determined that it would take too long and be too dangerous for the ship to continue to search for a safe place to anchor the Terra Nova, and then logistically how to unload the supplies.

Continuing with the search for an appropriate site, the Terra Nova moved farther into McMurdo sound, around towards the western side of Ross Island. His earlier Discovery Hut was located within this same area at Hut Point, an option he firmly ruled out. However, due to warmer summer conditions, more of the coast of Ross Island was accessible. Pulling once again from knowledge from the previous expedition, Scott proposed they land at a cape which they had called the Skuary. The site had shallow bays on either side that would have a more extended period as frozen, providing a more convenient transportation route to his path to the South Pole. Similar to his original plans with Cape Crozier and Mount Terror, Mount Erebus and its foothills provided shelter for the site. With its selection, Scott renamed it Cape Evans after his second in command, Lieutenant Edward Evans.

The surroundings of the Hut are illustrated by Scott and his men in their diaries. The substrate of the site was composed of volcanic rock, olivine kenyte, which was described as being broken down into a sand-like texture from weathering. Most of the exposed earth was dark brown or black. However, Evans elaborated stating that there were also earth reds, yellows found in the area. Differing site substrate significantly impacts how building foundations are formulated, which will be seen within the different cases. Having exposed rock that was not 'ice-rich' allowed Scott to utilise bearers in direct contact with the rock below it, without worrying that the substrate would significantly shift with expanding and contracting ice.

The site for the winter camp was adjacent to Home Beach and North Bay for ease of unloading from the Terra Nova. The camp provided a seascape to the north of the hut of the open water in the warmer months dotted with icebergs and frozen sound in winter. The latter being far from a stagnant white sheet was visually broken up with clear and snow-covered ice with varying textures. With the former, the temperatures created streams of snow and ice melt, even, as described by Taylor, a small waterfall, which was freshwater. Visually this created a tempered dynamic view in contrast to the typically static scene presented by surrounding hills and mountains. Beyond the visual aspect, the proximity to open water afforded the ease as mentioned earlier for transportation while during the colder months similar advantage of allowing for transportation over the frozen surface to access the Southern Road. The shift between liquid and solid water would also present different auditory conditions for the site. With Taylor's waterfall and Scott's description of running snowmelt, this would create the familiar tinkling noise of water running across ice or rocks. In the winter, shifting ice generates more eerie reverberation as it expands, contracts, interacts with other slabs of ice. There is also, in between, while the ice is breaking into increasingly smaller pieces, the chiming sound as waves push them together. These are only a few examples of the auditory aspects that the different water condition presented the site.

The most prominent feature of the site was the view of Mount Erebus to the east of the winter camp. Several men harkened images of Mount Fuji, mainly when the crater was obstructed by the steam cloud. This is due to the volcano being more horizontal in form than vertical and desire to relate this alien environment to something familiar. When visible, the cloud provided a quick observation of the wind direction, indicating that the prevailing winds came from every direction but westward. The steam cloud provided more than just visual interest to the repose of the mountain; it gave relevant information regarding wind. Depending on where the cloud was trailing the wind direction could be interpreted. Other views from the site included Wind Vane Hill to the South providing shelter for the hut and to the west farther off in the distance, on the other side of McMurdo are the Trans Antarctic Mountains as described in the Conservation Plan for the hut. The unintentional side effect of nestling the hut in the pseudo valley of Cape Evans compared to Scott's previous Hut Point was a restriction of direct sunlight. Surrounding hills brought sunset earlier and pushed sunrise later despite maintaining the same light conditions in the sky.

There are other structures affiliated with this expedition located at Cape Evens as well as a few other locations in the area. These will not be the focus of this research but are identified here. In addition to the primary hut, there are various shelters for scientific observations including a magnetic hut, meteorological screen, and on Wind Vane Hill an instrument shelter as well as a memorial cross to commemorate those who perished from the Ross Sea Party during the Imperial Trans-Antarctic Expedition. There is a latrine located close to the main hut. In addition to built structures, ice caves were dug in a nearby glacier for meat storage as well as some scientific experiments. Also, remains of a stone structure, erected as a test of the building technology by Cherry-Garrard for his planned journey to Cape Crozier. The Northern Party also constructed a smaller structure near Borchgrevink's Hut at Cape Adare, upon the return journey they excavated an emergency shelter in a snow cave on Inexpressible Island.

4.2.4 Building Development

The basic form of the hut is relatively simple, a rectangle with a gabled roof. Overall dimensions vary slightly between Scott's Diary and the measurements of the preservation team documenting the existing structure for the 2004 Conservation Plan. Scott writes that the length and width are 50 feet by 25 feet, and the wall height at the eaves is at 9 feet. The Plan lists 15.415m long, 7.795m wide, and an interior-side wall height of 2.45m, they also further detail the central ridge at the gable ends at 4.3m. The longer axis of the structure is North-East/South-West, to maintain consistency with the existing written accounts of the hut, it will be referred to as E/W with the elevations corresponding.

The exterior of the hut is clad in weatherboard; horizontal tapered boards that lap one another to aid in the prevention of wind/rain penetration. This was just the outermost layer of a sandwich of materials. Working towards the interior; the weatherboards were installed directly over Gibson quilting, insulation that is comprised of dried and shredded seaweed that is quilted in jute sacking. This outer insulative barrier was affixed to tongue and groove (T&G) boards on the exterior of the primary wall framing. On the other side of the studs, the framing is another layer of T&G boards, which another layer of Gibson quilting is installed, and the final finished interior face is vertical T&G boards. To further prevent drafts from penetrating the interior, the kenyte gravel was piled around the lower edges of the exterior walls. Scott discusses this having to be reapplied after the first winter due to the elements eroding that natural seal. He also had any of the extra fodder and fuel stacked around the walls to create added insulation.

As discussed above, the floor structure of the hut was supported on bearers that rested directly on the existing gravel substrate, which Scott describes as being manually levelled. Floor joists span the bearers, on which are the four layers of materials that make up the floor. Two layers of T&G floorboards with Ruberoid are the primary elements, with a green linoleum for the interior space.

The roof utilised similar materials as the wall and floor structures. Overall it was supported by four trusses, which were spanned by purlins. On the interior side of these, the ceiling was finished with T&G boards; the trusses exposed, creating a cathedral ceiling. To the exterior, there is an additional layer of T&G boards on which is a layer of 2ply Ruberoid. Between that and another layer of 3ply Ruberoid is Gibson quilting for insulation. This outermost layer was held in place with timber battens.

There are three windows in the hut, itself; two small and higher windows on the north elevations and a moderately larger one on the south; specific location with regard to the interior will be discussed later. The plan of the hut shows this to be mirrored; photographs and

Scott's description verify the Conservation Plan's drawings. When the stables were rebuilt before a second winter, three windows were added and a new annex. The windows did not provide any additional light to the interior of the hut.

Several additions were made over the two initial years that the hut was occupied. The first of which was a cold porch, which had provided shelter for entry during the expedition's first year. It was a small addition the took users through a second door before entering the main interior of the hut, creating an airlock. There was an acetylene plant located within this space, adjacent to the two doors.

Along the northern side of the hut, stables for the ponies were constructed. The first winter, the walls were crude; utilising bales of fodder as well as blocks of coal. Prior to the second winter with the addition of seven mules replacing the ponies, more substantial wooden walls were built. The stables also held a stove which burned blubber to cook food for ponies and mules as well as dogs. The roof of this area was lower sloping, connecting to the exterior wall and lower than the eaves of the hut, allowing for the two smaller windows to get natural daylighting to the interior living quarters. There are small windows on the eastern and western walls to provide light. In addition to the first open entry near the cold porch, there are two doors on the northern side of the stables which lead out to the latrine.

The latrine itself is separately located of the conglomeration of hut/stables/annexes. It is a simple wooden structure, built from a leftover packing crate in which one tractor arrived. The latrine itself was segregated between the 'officers' and the 'men', entrances for each class is on either end. Within, there are three cubicles for the occupants,

The storekeeper for the Expedition, Henry Bowers, constructed a small annex on the southern side of the hut. The location allowed easy access to supplies from the primary entrance of the hut. This can be seen in some of Ponting's early photographs of the hut with a simple continuation of the roofline on the southwestern corner.

The final early addition to the hut was a more extensive Annex during at the same time the stables were reconstructed. This structure stretched the length of the western façade, enclosing the entrance to the stables and Cold Porch. Along with windows on the stable side of the annex, there is another closer to the new entrance door. At this time, the primary entry door to the hut was removed, leaving the Cold Porch door remaining. Similar to the rebuilt stables, the annex is a wooden structure with vertical board and batten.

The interior of the primary part of the hut is a single open space without any structural divisions. This space was separated into two primary areas; the messdeck for the 'men' and the wardroom for the 'officers', maintaining that military division that can be seen in several other structures. The only other formal division of space is in the wardroom to create cubicles for Scott and the darkroom.

The first space encountered after entering through the cold porch is the messdeck. This area provided living space for non-commissioned and support members of the expedition as well as the galley. It comprised of almost the first two bays when one first entered the hut. Provisions boxes were utilised to form a bulkhead which separated the messdeck from the wardroom. On the southern end of this space is the galley with the cooking stove, which also provided heat. The walls of the galley have numerous shelves for storage of various supplies. This was also contained the sleeping spaces for three of the men. On the northern end are bunks for the remaining five support members of the expeditions. It is in this area that one of the smaller northern windows provides potential natural daylight.

The remainder of almost 2/3rds of the hut is what is known as the Wardroom. The perimeter of the space was separated into individual sleeping and working spaces for Officers or Scientists of the Expedition. Centrally located is a large communal table and towards the eastern end of the space, a second stove, cast iron used for heating and at one time had an ice melt tray.

Starting in the north-west corner of the Wardroom, are the accommodations that became known as the Tenements. Five men set up their series of bunks, perpendicular to the exterior wall, with the central one consisting solely of an upper bunk to allow for a small work and storage space to be shared beneath it. Further storage was created with shelves along the exterior wall and the bulkhead. To create the bunks, the men built wooden frames and legs supporting the metal beds brought with them. Scott assigned the five men that area after identifying their budding friendship on the Terra Nova.

On the south-facing wall is a series of bays where the scientists on the expedition inhabited. These were broken up generally into disciplines; geology, biology, meteorology, and physics. Similar to the Tenements, the men here employed wooden structures to customise their living spaces. However, for the scientists, developing space that also contained their research and experiments was a priority and were afforded a little more space to do so.

Moving along the south wall, west to east the following describes each of these niches. The geology bay comprised of two bunks perpendicular to the exterior wall, with one tucked up against the bulkhead. Three men stayed here with one of the bunks allowing for a work/storage space. Between bunks along the wall, the men installed a desk and a series of shelves to augment their space. To create a sense of privacy for the occupants, boards were installed along the bunk ends, also between the eastern bunk and its neighbour creating informal partitions. The geology bay had further privacy with a curtain hung up between the bunks to allow for the potential of seclusion for the inhabitants from the rest of the hut. Griffith Taylor, one of the occupants, described a study that conducted looking at the temperature difference between the bunks. From the floor to the top bunk, they recorded a 10°C change. Taylor, the lower bunk occupant, noted that while the upper bunk was warmer, the lower had better ventilation.

The neighbouring bay's focus was on biology. Within this space, there is a set of bunk beds adjacent to the partition with the geology space. Unlike their neighbours, the two men kept their space open to the rest of the hut. It was noted in several others' diaries the care and attention that they put into their space. The men took the time to create turned caps on the top of the posts of the bunk and staining the wood to give it a darker appearance. They also constructed a functional set of drawers on which the lower bunk sat on. Like others, they affixed shelves within their bunk spaces to provide further storage. Opposite the bunk was a workbench for the biologists. Adjacent to the workbench is part of the larger southern window, shared with the meteorology table.

The meteorologists and physical laboratory are the remaining defined bays along the southern wall. The previous bunks have been oriented with their shorter end along the exterior wall; the two inhabitants of this area took a different approach. Their bunk is independent of the walls; instead, it is perpendicular, with east/west orientation, aligned with the outer corner of the biology workbench. To create some separation from their neighbours, the men installed canvas in the frame of the bunk. This allowed for the other half of the window to provide light to workspace for the meteorology. Also, let the remaining three walls (south and east exterior walls and the southern wall of the darkroom) form the physical laboratory. Along the shared wall of the darkroom is the primary workbench for the space. There is a break in the vertical T&G on the eastern wall where it has been covered over with horizontal boards indicating where the weather box is located on the exterior. The walls of this bay have multiple shelves for storage of equipment and materials.

Prominently located on the eastern back wall of the Wardroom is the darkroom. Ponting constructed this using timber dedicated for the room and leftover Ruberoid to eliminate any light. This wraps the lower ceiling for the darkroom, which was then used for storage. Facing the main interior of the Wardroom is the entry door to this space with a small window next to it. Within the darkroom, Ponting set up a workbench and equipment for developing photographs. Walls contained shelves for materials and equipment. He devised a bed which folded up during the day to allow for more work area. Ponting only utilised this for the first winter, the second winter without his presence, a hole was cut in the floor for gravitation measurements to be conducted without leaving the hut. During the Ross Sea Party's stay, a small religious shrine was set up by clergyman and party member, Arnold Spencer-Smith. This space was described as 'palatial' in several accounts of it by others.

Tucked in the north-east corner of the Wardroom are the living spaces for Edward A. Wilson and Lieutenant Edward Evans. Their corner is tucked in between the north wall and the darkroom, with beds running parallel to each running east/west. On the eastern and southern walls are mounted shelves with books and medical supplies. The prominent location of their accommodations reflects their roles on the expedition; Lt. Evans as second in command and Wilson as the Chief of the Science Staff and medical doctor.

The part of the hut was occupied by the expedition leader, Scott. Located on the northern wall between the Tenements and Wilson/Evans corner, a cubical was constructed to provide privacy on the western and southern sides. Tucked away in it was Scott's bed, above which is a lower ceiling for his cubicle. Multiple shelves line the two partition walls, and lower shelf extends along the exterior wall. The remaining window provides natural light for his space, particularly for the large chart table which separates his bed and that of Wilson and Evans.

The building systems are relatively simple for the hut. Heating was provided by the two stoves; the cooking stove in the Messdeck and the heating stove in the Wardroom. The primary fuel used by the expedition was Crown Patent Fuel blocks. Rather than straight coal, these blocks were made up of waste coal with pitch that is moulded into the final block form. There was a smaller heating stove that operated with blubber was in the easternmost stall of the stables; it also allowed the men to prepare food for the ponies and dogs. Ponting also discusses bringing a small mobile stove which he used in his darkroom while preparing the photographs, and the door was shut.

Compared to many of its contemporaries, this hut was very well ventilated with the ability to control it as well. Both of the stoves vented up to a central roof vent. Scott discusses how they were able to adjust the ventilation of the hut based on the interior activities and the exterior climatic conditions. He describes 'suitable holes' which allowed the cooler natural draughts to enter the hut, introducing fresh air. A secondary set of these would then let the warmed return air back outdoors using natural convection. In the section where he details this process, Scott highlights the importance of fresh air for the hut. There is an additional vent within the darkroom ceiling.

The primary light source for the hut was in the form of acetylene lamps. The generation of which came from the acetylene plant on the cold porch. There is some documentation in the diaries of the men utilising candles or integrating candle holders into their personal spaces.

There was no plumbing in the traditional sense, per se. Water for bathing and cooking was obtained by melting ice. The only formal sink in the hut is the lead-lined sink in the Darkroom. Ponting set up a 30-gallon tank on the roof of the darkroom; daily he would collect and melt ice to then funnel into the tank. This gravity-fed water for photographic plate washing with a tap, it is unclear where the waste pipe is released. The only restroom facilities are the latrines to the north of the hut as previously discussed.

For entertainment, Scott set up a routine. He encouraged the men to spend times outside the hut when possible, setting up a schedule for exercising the animals. They also held mid-day football matches outdoors. The men explored the surrounding area for their scientific experiment, Scott described many of his own solo wanderings. Inside the hut, men brought books with them and shared them amongst each other. The popularity of the games that were brought was also noted; they included two chess sets, backgammon, and draughts. Several men brought their own musical instruments, and the Expedition had a pianola and a gramophone for added enjoyment. Unfortunately, it does not appear that anyone was satisfactorily able to play the piano. However, they were able to supplement their Sunday services with the musical offerings. Scott also set up a lecture series with each of the men based on their expertise, often focusing on the application of such in polar regions.

Overall there were no significant conflicts documented between inhabitants of the hut during its two-year occupation.

4.2.5 Preservation

Shackleton's Ross Sea Party were the last expedition to inhabit the hut in 1913 since then it has remained unoccupied. Discussions around the preservation of the HAE huts began around the same time as planning for the IGY.[171] However, it was not until 1987 that the Antarctic Heritage Trust was formed in New Zealand, a charitable trust which has overseen the conservation of the historic sites in within their sovereignty around the Ross Sea Dependency. An investigation into the sites was started in 1999 with a conservation report for Scott's Hut (Cape Evens) published in 2004. The goal was to stabilise and repair the existing hut in its current form with the least amount of disturbance or damage to the existing fabric, not restore it to a particular period.[172] Work began in 2008 on the conservation and was completed in 2015 with ongoing maintenance being conducted to sustain the structure.[173]

[171] Evans, Sherrie-Lee et al., "Historic Huts; Remove, Repair or Restore?," *Syndicate report, Graduate Certificate in Antarctic Studies, University of Canterbury Reports, listed but not available online: http://www. anta. canterbury. ac. nz/courses/gcas/reports. shtml* (2004).
[172] Cochran and Trust;, *Conservation Plan, Scott's Hut, Cape Evans : British Antarctic Expedition, 1910 - 1913, Ross Island, Antarctica*.
[173] Antarctic Heritage Trust.

4.2.6 Integration of Biophilic Attributes

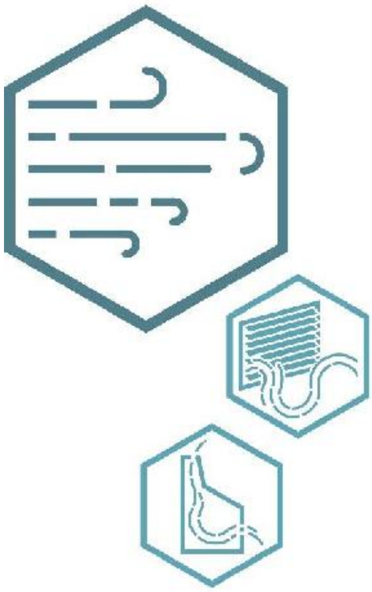
Direct Experience of Nature

Robert Scott had the benefit of previous first-hand Antarctic exploration, an intimate knowledge of what environment he would be dealing with, and how to prepare his shelter for such. The natural surroundings were not viewed as a component to be incorporated into the building to foster a closer connection; rather, it was an element to be kept out, to shield against, to shun. This disconnect is a common thread through the following attributes; this was also hampered by a lack of designated site during the planning phase.

Light

To take advantage of the natural daylighting during the summer months, the hut has several multi-pane windows. There are two smaller windows on the northern façade to allow in the potential direct sunlight. These bring light to Scott's private cubicle where he had a chart table set up and into the men's personal area of the Mess Deck. Ambient skylight can enter the main hut through a medium-size window on the southern side. Illumination from this window was shared between the biology and meteorology bunks. In preparation for the second winter, when the surrounding annex and stalls were more formalised, three new windows were added in the east and west walls.

Air



The occupants relied on a natural ventilation system to create a comfortable dwelling. This was done through what Scott describes as a series of holes that worked with a roof ventilation system. Cooler fresh air was brought in through these holes, and if temperature or wind speed was a factor, they could be shut. The air was circulated through natural convection, and ventilation was facilitated through a roof system. The building was relatively airtight without much mention of draughting. The tightness was achieved through the multiple layers making up the wall system and mounding the loose rock around the base of the hut to prevent draughts coming through the floor. The rocks had to be re-piled the following spring.[174]

Water

There are no active hydraulic systems within the hut. Rather, the process of procuring fresh water required multiple steps and more awareness of the consumption or use as well as an appreciation for obtaining it. Ice from the nearby glacier was collect and then melted in the galley for general utilisation; ranging from cooking and drinking to laundry, cleaning, and bathing. It was often typical for grooming habits to be lax, though not wholly rejected, this was an adventure, and some rugged manliness was to be expected. The only "traditional" sink is a gravity-fed basin in the Darkroom.[175]

[174] Scott, *Scott's Last Expedition Volume I*.
[175] Ibid.

Plants

There is no inclusion of plants or plant material from the site into the hut or knowingly brought from abroad for any reason other than foodstuff. There is no recorded evidence of live plant material being brought to the hut; any other presence will be addressed in other sections, i.e. materials, texture, etc. While the technology to allow for plant growth existed at the time (greenhouses or hothouses), the hut's primary function of shelter did not prioritise the inclusion of live plantings for aesthetics, mental health, or fresh food. The materials would have been difficult to transport as well.

Animals

Natural specimens of the surrounding wildlife became integrated with the scientific research portions of the hut. Representations or depictions of endemic animals were not integrated into the hut design. Another way that inhabitants interacted with wildlife was as a food source. Penguins and seals were used to supplement the food supplies were brought for the expedition.

Ponies, mules (second winter), and dogs were the only regular, dynamic, live animal interactions the men had available all year. Both the ponies and dogs were brought down to Antarctica for aid in transportation. Scott facilitated the connection with these animals through scheduled exercise or familiarisation between the men and the animals with whom they would be working. The ponies were housed in an adjacent stable annex to the main living quarters. A discussion of potential imagery of animals is below.

Landscapes

When siting the hut, there was no attempt to incorporate the terrain into the building design or recreate familiar landscape elements from the men's' source countries. There is no evidence of "giving back" any of the site based on the footprint of the hut. The physical impression that the expedition made at Cape Evans was not limited to the hut and the immediate site, with artifacts, smaller architectural interventions, structural experiments in broader surroundings. These were not practices or considerations at the time.

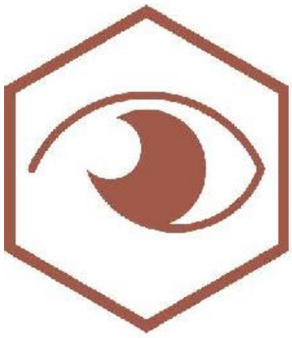
'Weather'

The hut was located taking an Antarctic setting and environment into consideration. Proximity to the open water was necessary for transport, not just to the ship, but also once it froze over in the winter it allowed for exploration of the surrounding area over the ice. The hut was tucked between natural hills and against Mount Erebus for protection from the elements and allow the inhabitants' opportunities to study and survey them.

While the actual site for the hut was unknown, Scott also facilitated the design of a hut to be more attuned to the climatic conditions based on his previous expedition. The main conditions that had to be combated were wind, temperature, and snow. The external envelope of the hut had multiple layers of materials in differing orientations to create a tight seal and avoid draughts. Additionally, the perimeter was piled with loose gravel to seal the foundation space. The Annex and Stables also provided additional protection and insulation from the climate for the central hut. The temperature of the hut was maintained by two coal stoves with a ventilation system to help with control.

However, the majority of the efforts were made to keep the climate out and not necessarily connect the inhabitants to it. The windows were not oriented for the occupants to take stock of the exterior conditions before exiting. Though the hut was not so well insulated that they were able to escape the sounds of the climate; wind, snow, melting water could be heard by the occupants potentially indicating the climate.

Views



The hut itself is not designed to take advantage of any of the surrounding views; it was prefabricated for an unselected site. While there are windows, they are not oriented to provide views for the occupants.

Fire

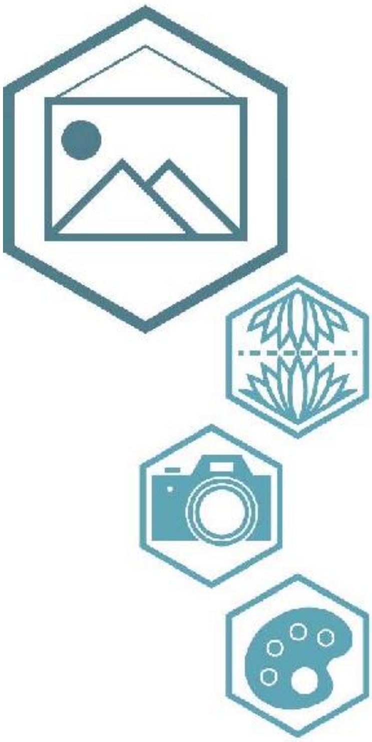
Despite the proximity to natural aspects of fire - Mount Erebus, there was not noted volcanic activity that impacted the hut or was integrated within the design. During the designing of the hut, Scott did not intend to have the final site be at the base of Mount Erebus.

Fire is present in the hut as the heat sources and the generation of the lighting. The heat was provided principally by two stoves were fuelled by waste coal fuel blocks. There was also a smaller stove modified to burn seal blubber. Interior lighting for the hut was provided by open flames, either candles or fixtures burning acetylene, which was created by an acetylene plant on the front porch. While this was simple and rudimentary compared to the contemporary technology of the time, a lack of infrastructure as one of the earlier inhabitants of Antarctica prevent the use of the "modern" technology.

Indirect Experience of Nature

The straightforward, practical design and construction of Scott's Hut is demonstrated through the opportunities for indirect experiences with nature. The attributes are found in aspects of the building that are integral to its basic structure, not added on for aesthetic or well-being value. There is some visual ornamentation found in the men's personal spaces and belongings to bring elements of home with them to this frozen foreign environment.

Images



Some men customised their individual bunks with personal photographs. In the historical images from Ponting, these photos mostly depict loved ones can be seen in the men's spaces, including Scott's cubicle. Documentation of the hut's existing condition shows additional displays of personal images with a series of dogs mounted on a sheet.[176]

Throughout the first winter, a lecture series included projected photographs Ponting brought to of his travels around Asia, some of his Antarctic photographs were included in the other men's more scientific lectures as well.[177]

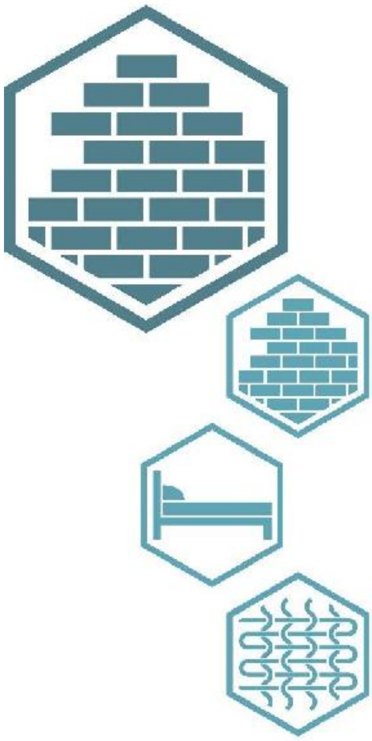
One unexpected source of imagery in the hut is from the supplies and storage crates. Some of the labels had vivid illustrations and logos, often showing what is within the container, potentially plant or animal-based.[178]

One participant, Edward A. Wilson, of the expedition has been particularly lauded for his watercolour paintings of the Antarctic landscape, flora, and fauna relating to his scientific studies. It is unclear if these were displayed within the hut, within his workspace, or kept within his papers, or if other men engaged in or displayed their own creative explorations similarly. However, his drawings brought awareness and artistic

[176] Nigel Watson, *Still Life: Inside the Antarctic Huts of Scott and Shackleton*.
[177]Scott, *Scott's Last Expedition Volume I.*, Ponting, *With Scott in the Antarctic*; Taylor, *Antarctic Adventure and Research*.
[178] Nigel Watson, *Still Life: Inside the Antarctic Huts of Scott and Shackleton*.

documentation of the Antarctic environment back to the United Kingdom after his death on the return from the South Pole.

Materials



Beyond the mounded kenyte[179], the materials utilised in the construction of the hut were brought with the BAE. The primary building material was wood; Scots Pine, Spruce, and Fir for the various elements. [180] The use of foreign materials stemmed from a lack of familiarity or acceptance of the endemic natural resources as viable building fabric. The men constructing the structures were primarily not skilled tradesmen, resulting in utilising materials that were easier to assemble.

Wood was the primary material found internally as well, with the majority of the furniture and partitions being constructed from it. A departure was the bunks were a metal frame/springs that the men then built wooden frames around to customise their spaces. The other natural material found within the space was not one employed in the hut construction, animal skins were used in the apparel and equipment of the men for when they ventured out on their sledging expeditions. Sleeping bags of reindeer skins and Finneskoe boots adapted from Lapland also made of Reindeer skin, and grass for insulation could be seen through the hut for storage or out for repairs.[181]

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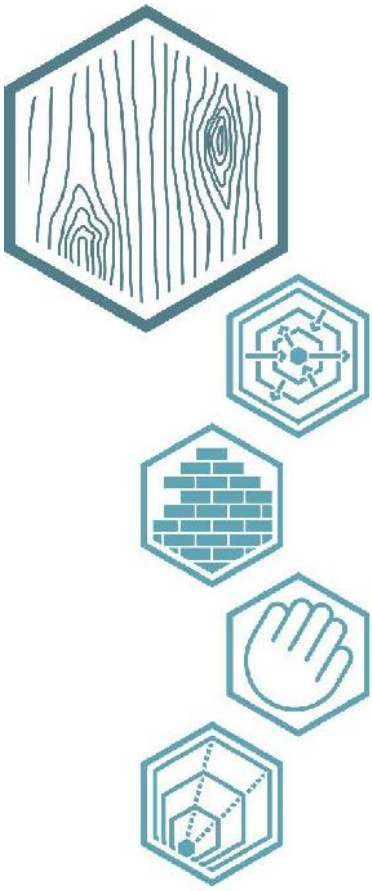
179 Scott, *Scott's Last Expedition Volume I*.
180 Ibid., Cochran and Trust;, *Conservation Plan, Scott's Hut, Cape Evans : British Antarctic Expedition, 1910 - 1913, Ross Island, Antarctica*.
181 Scott, *Scott's Last Expedition Volume I*., Cochran and Trust;, *Conservation Plan, Scott's Hut, Cape Evans : British Antarctic Expedition, 1910 - 1913, Ross Island, Antarctica*.

Texture



There are subtle differences in the texture with the overwhelming use of wood for the hut's primary building material, primarily from the orientation of the T&G on the interior of the structure. The majority of wooden furnishing elements are horizontal in nature: bunks, boxes of the bulkhead, the table, chairs, shelves. The wall and ceiling panelling contrasts this with verticality. The orientation changes, along with various sizes and scales that these applications utilise creates a sense of depth for what could be a monotonous uniform material. The use of wood also creates warmth, familiarity, and tangibility to the aspects that are made from it.[182]

Colour

Beyond the natural colours of the wooden interior, there is some colour introduced to the space that can still be seen in the hut.[183] The primary wooden fabric of the hut was left untreated, giving it very subtle differences. There was only one instance where it was noted that wooden elements were stained to achieve the desired effect; within the Biology nook. Inhabitants there stained their bunks so they would mimic a darker mahogany shade. The significant injection of colour to the building is found in the bulkhead and labels on the supplies. Additionally, the men's belongings and expedition equipment provided subtle colour to the space. The floor broke up this neutral surround of

[182] Nigel Watson, *Still Life: Inside the Antarctic Huts of Scott and Shackleton*.
[183] Ibid.

wood; a linoleum was laid that grounded the space with dark olive green.[184]

Shapes and Forms

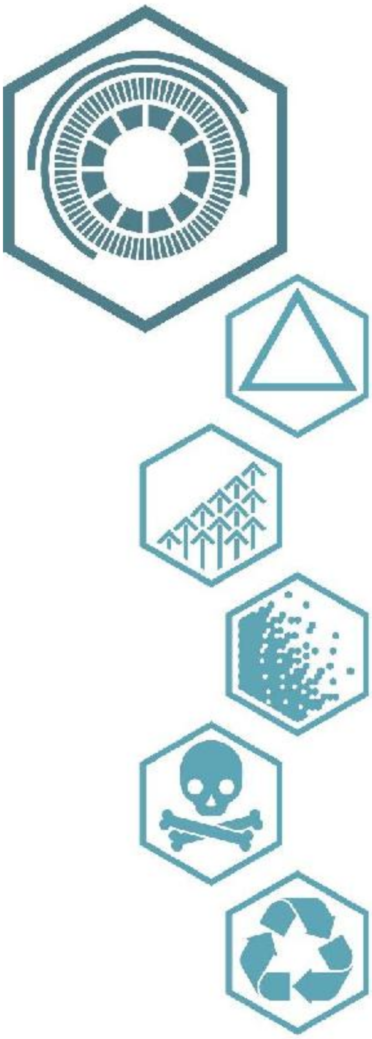
The geometric form of the hut and interior layout is rectilinear. The simplistic form partially results from the skill level of the men constructing it as well as limitations of the building materials.

Information Richness

There is a very restrained depth to the fabric of the hut. While the materiality is relatively similar, the wood itself is not a completely uniform material. The grain of wood presenting minimal intricacies differing from piece to piece. The various materials found within the space also presents a tangible richness; from the various types of bedding to the sledging expedition equipment and gear. These softened the harder surroundings, including the rigid aspects beyond the hut's infrastructure; metal elements and appliances, scientific equipment, and supply stores. Visually, while each of the men was given the same basic furnishings for their personal spaces, how they inhabited and chose to organise their bunks kept the hut from being homogenous. A lack of diversity is what makes this a weaker attribute within Scott's Hut.

[184] Cochran and Trust;, *Conservation Plan, Scott's Hut, Cape Evans : British Antarctic Expedition, 1910 - 1913, Ross Island, Antarctica*.

Change, Age, and the Patina of Time



Using any building materials of the time within an extreme environment opened up the hut to the expected wear from the exposure to winds and snow. The exterior cladding slowly was eroded by those elements. As previously noted, the kenyte buffer was replaced due to being swept away by the wind of the first winter.

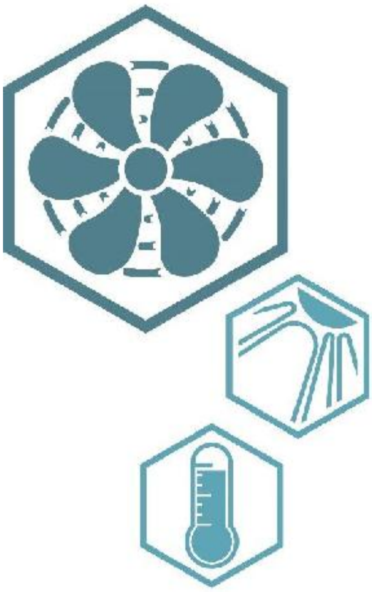
The interior of the hut also developed a darker patina from the stoves, which was particularly noted after the Ross Sea Party's occupation.[185] While the hut was occupied, there was minimal damage due to the ice freeze/thaw cycle noted, primarily around the hole cut in the floor of the Darkroom for the magnetic observations during the second year. The drifting snow and ice accumulation was also negligible. Several observations of ice in the interior of the hut, and when it was found, it was promptly resolved.[186] As is the case with the Darkroom during the first year, Ponting employed a small stove to heat the room when developing to stave this off.

Natural Geometries

Natural geometries were not a priority in the design process of the hut, due to the practical and simplistic character of the shelter as well as limited material technology available and skill level of the men constructing the structure.

[185] Shackleton, *South! : The Last Antarctic Expedition of Shackleton*.
[186] Ponting, *The Great White South*; Scott, *Scott's Last Expedition Volume I*.

Simulated Natural Light & Air



For the majority of winter months, light for the hut was provided by acetylene lamps and candles during the period of 24 hr darkness. Ventilation systems were in place for the stoves and the hut in general, relying on natural convection ration than using mechanical means. However, none of this was designed to mimic the natural processes in any way. While Scott did maintain a plan for "day" use of the lighting during the winter[187], it was for practical purposes and did not follow diurnal fluctuations or the transition of sunrise/set. So while artificial light and temperature are provided within the hut to make it functional, they were not employed in a method to create a simulation of the circadian rhythms or temperature cycles of Great Britain.

Biomimicry

Biomimicry was not a priority in the design process of the hut.

[187] *Scott's Last Expedition Volume I.*

Experience of Space and Place

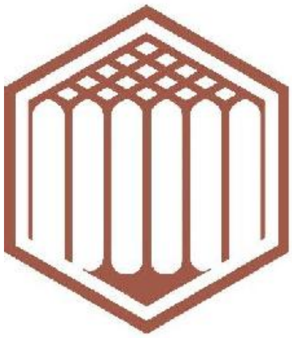
Antarctica's environment makes the Experience of Space and Plance inescapable, which prompted the existence of Scott's Hut for a successful expedition. While any type of structure is needed to winter-over in the extreme environment, Scott's social and military background, as well as a drive to conquer the Pole created a unique culture to the layout and arrangement of the hut.

Prospect and Refuge

The hut is a form of refuge for the inhabitants creating shelter from the climatic conditions of Antarctica. Inside, the men were able to create personal spaces with their individual bunks. There are varying levels of connectivity to the central gathering area of the Wardroom. The bunks were clustered together primarily based on disciplines; most were oriented with the narrow ends of the bunks presented to the central space. However, Meteorology/Physics prioritised their workspaces being located against the exterior wall and used their bunk as a division. The most private of these belong to the ecologists. They blocked off ends of the bunks and installed a curtain as a door to their cubby. The men with the higher ranks; Scott, Wilson, and Evans, were afforded retreat through architectural elements. The latter two had their bunks tucked between the exterior wall and the Darkroom. Scott had one of the few independent planned walled pseudo-rooms with his own cubical sheltering two sides with a third against the exterior wall. What all these personal spaces allowed was the controlled privacy or refuge for men spending months in close quarters, but also prohibiting total isolation. The reasoning for this is discussed below in *Organised Complexity*.

Figure 4-3 Hierarchy of Scott's Hut: building to zones to bunks

Organised Complexity

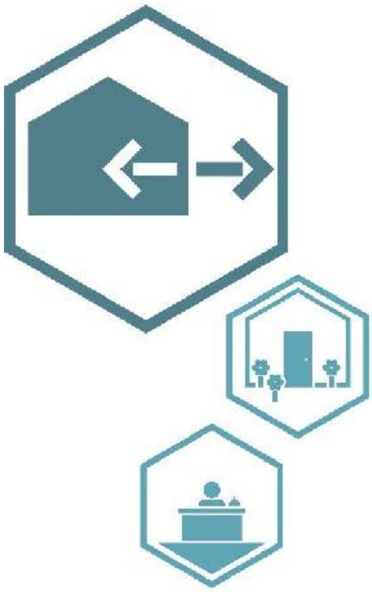


For organized complexity, the interior of the hut certainly displays a significant amount of complexity but lacks the balance that this attribute seeks. The amount of equipment for the expedition combined with the small scale of the interior and the personalization of the men's personal spaces creates a rich, diverse, and detailed space within the wardroom. This impression is particularly illustrated in photographs of Scott's birthday and the midwinter celebrations, where that central communal space has not only what is previously described, but is also decked out with Union Jacks and buntings for the festivities. A lack of cohesive arrangement is what contributes to the imbalance. However, a unified composed scheme to decoration or organization of the interior of the hut was not a priority or consideration for the expedition.

Mobility

With such a small space for the men to share, mobility is a potential issue, the organisation discussed above prompted the basis for which circulation was arranged. The simple layout of the hut allows for ease of movement with central access through the Mess Deck, which then splits around the focal table in the Wardroom. Off from this primary circulation, are the secondary paths for personal spaces, workspaces, the Darkroom, and the Galley. With such small habitable space, much of the wardroom circulation doubles as seating clearance around the central table, which is a common occurrence in a structure with a compact footprint.

Transitional Spaces



With the initial hut design, a small room to create a transitional space between the interior and the exterior environment. What was called the Cold Porch was a small room with two doors at right angles to each other. This space shelters the interior of the hut from direct contact with the outdoor conditions, with one door at a time being able to be opened. The renovations and fortification of the Stables and Annex created a larger space for this transition to occur. The Cold Porch still existed, but the interior door was removed. The Annex allowed for more room between the exterior door and the Cold Porch door.

Internally, with the rank style organisation, the hut contains several "gateway" transition points which reinforce that structure as one move through what would otherwise be an almost entirely open space. The first is the opening in the bulkhead, to indicate the shift from the Mess Deck to Wardroom. Each of the personal bunk spaces has a range of transitional points to designate "their" spaces.

Place

The hut fosters a connection to both the physical and social sense of place for the men.

Geographic – Since the final site for the winter quarters of the expedition was not selected during the design phase; specific geographic features were not incorporated into any planning. In a more broad sense, simply the siting of the structure on Ross Island, McMurdo Sound, Antarctica, itself, contributes to aspects of the hut to be able to combat those extreme climates.

Ecology – From a scientific research point of view, the biodiversity and ecology of the specific site were important, but this was not reflected architecturally.

History – being one of the earlier architectural contributions to the continent, there was not a significant historical connection to the site. It was more happenstance how close it was to Scott's previous Discovery Hut.

Culture – Each winter created a unique shared experience for those men. It can be seen how the hut instilled a sense of communal culture for the specific individuals staying there. The men established their own segmented "territories", and they later documented their pride in the customizations they undertook in their published diaries, as described in 4.2.4 Building Development.

The hut becomes a finite whole to contend with the extreme environment that the Antarctic climate presents. Unfortunately, that means is it does not interact with the neighbouring environment in a manner which connects the occupants to natural surroundings. When the hut was constructed, the climate was viewed as something to be kept out. The majority of previous attributes which could foster a connection was either incorporated within an indirect way or most often found with ties to life at home rather than Antarctica.

4.3 MAWSON'S HUTS

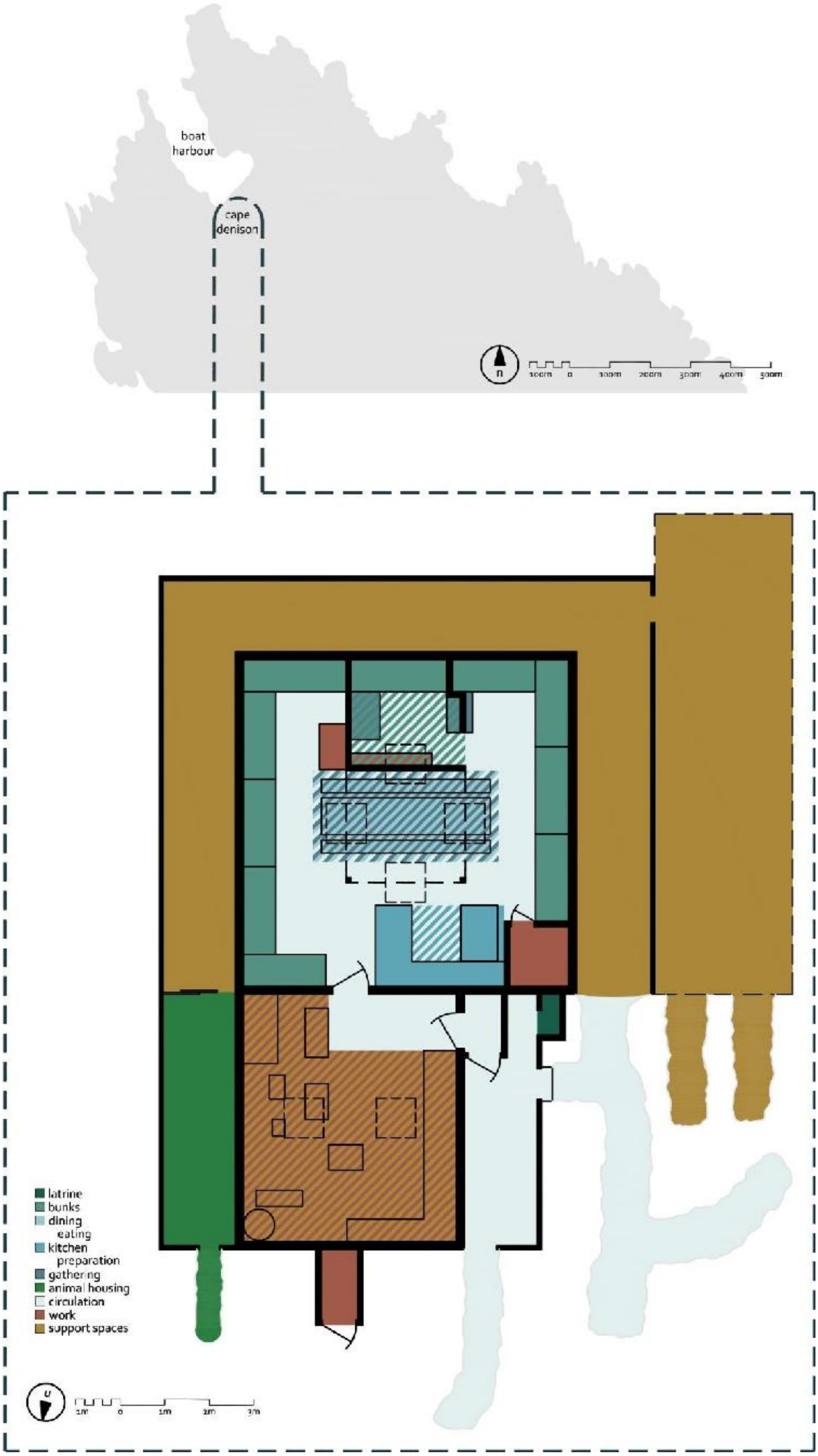


Figure 4-4 Mawson's Huts – Site, Orientation, Floor Plan[188]

4.3.1 Sources

Within Chapter 4 and Chapter 5, much of the material presented is from examinations of archival research. Where applicable, specific sources are cited. General observations and analyses are from Mawson's diary[189], conservation reports[190], photographs[191], and a site visit to the replica museum in Hobart, Tasmania[192]. Any specific item is referred to particularly if applicable.

4.3.2 Background

The foil that is being investigated to Scott's *Terra Nova* Hut is Mawson's Huts from his Australasian Antarctic Expedition (AAE: 1911-1913). The huts are the last of the architectural interventions created during the Heroic Age of Exploration that remain today. This expedition was conducted by Dr Douglas Mawson and was his second time in the Antarctic, having joined Ernest Shackleton on his *Nimrod* Expedition. Initially, Mawson had approached Scott to operate as a satellite party during the BAS. Scott counter-offered with an invitation to Mawson to join the main party; he lacked the room and resources to support the additional research not already outlined in his programme. This offer included a place on the Scott's South Pole sledging team; however, he was disappointed when Mawson turned him down.

Mawson's interest in Antarctica was beyond the pursuit of the geographic pole. Preferably with his geological background and his prior experience locating the magnetic pole during the *Nimrod* Expedition, Mawson wanted to concentrate on further study of that pole as well as expanding the geographic mapping of the continent, specifically the area directly south of Australia. The AAE was also organised to include telegraphy, meteorology, and geology.

Mawson's background also lent a different approach and organisation to the AAE that differed from Scott and Shackleton. The latter two both approached their expeditions from their military backgrounds. As an expedition leader, Mawson's academic and scientific background led to a more relaxed and egalitarian expedition, this was neither better or worse than his contemporaries' approach, but is reflected in the huts' design and layout, which will be discussed later.

The AAE presented a unique expedition to the Heroic Age of Exploration. The makeup of the men was the first to be predominantly Australian. Mawson, himself, was born in England, but he was raised and educated in Australia. Other nationalities included several men from New Zealand, the United Kingdom, and Switzerland. The expedition has been firmly identified as Australian; the Commonwealth of Australia had recently become a Federation. The Union

[188] Graphic by author – deleloped from Australian Antarctic Division's 2013 Site Management Plan
[189] Mawson, Douglas Sir, *The Home of the Blizzard Being the Story of the Australasian Antarctic Expedition, 1911-1914* (2004).
[190] "Mawson's Huts Foundation," https://www.mawsons-huts.org.au/; Australian Antarctic Division, *Mawson's Huts Historic Site Management Plan 2013-2018* (Kingston, Tasmania: Australian Antarctic Division, 2013).
[191] Hurley, *Australasian Antarctic Expedition 1911-1913*; Hurley, Frank, Dixon, Robert, and Lee, Christopher, *The Diaries of Frank Hurley, 1912-1941*, ed. Robert Dixon and Christopher Lee (London ; New York: Anthem Press, 2011).
[192] Site visit to replica of Mawson's Hut in Tasmania August 2018

Jack was flown along with the Australian flag, and claims were made for the United Kingdom. However, Mawson was establishing Australia's presence, and this was later allocated as Australia's sovereignty when the UK handed control over in 1933.

The expedition left Australia on the *Aurora* in December 1911. They stopped to establish the first base of the expedition on Macquarie Island. This station was to be principally used as a relay station for radio messages, overseen by George Ainsworth. The main winter quarters were established by Mawson at Cape Denison in the Commonwealth Bay; this included what will be focused on in this research; Mawson's Huts. A third smaller station was set up further west on the Shackleton Ice Shelf in Queen Mary's Land for further scientific research under Frank Wild.

Due to a delay in locating a suitable site for the main base, the main sledging journeys occurred during the second summer in 1912-1913. Many of these worked towards charting the coastal areas of Adelie Land, King George V Land, and Queen Mary Land. They also furthered scientific exploration in geology, meteorology, biology, and marine science. With Mawson's previous discovery of the magnetic pole, there was a focus on geomagnetism.

When planning for the AAE, Mawson's proposal was for a single winter. He proposed utilising the second summer for the majority of exploration and being relieved by the *Aurora* at the end of that season, 1913. Mawson's own eastern sledging team was not able to make it back to the Winter base during the scheduled time. This delay was due to difficulty on his return journey, which unfortunately resulted in the loss of Mawson's two companions, with his return to Cape Denison occurring within hours of the *Aurora* leaving. A small group of men had stayed back to wait for Mawson's return. The weather conditions prevented the ship returning, and they spent the second winter in the huts. During this time, they continued monitoring the observations from the previous winter.

It was not until December 1914 that the *Aurora* was able to reach Cape Denison and pick up the remaining men. At that point, the huts were shut and not visited until Mawson returned with his British, Australian, New Zealand Antarctic Research Expeditions (BANZARE) in 1929-1931. They visited the site and stayed in tents nearby, entering the huts through one of the skylights. No one has inhabited the huts since Mawson, and the remainder of the AAE left in 1914.

4.3.3 Site Conditions

The focus of the Australasian Antarctic Expedition drew the *Aurora* along the coast directly south of Australia. Seventy-five years before Mawson's expedition the French explorer Dumont D'Urville had claimed this for his country naming it Adelie Land. However, this claim was made without setting foot on land, D'Urville remained aboard his ship, which is how Mawson viewed the territory still open for a claim by land. Part of the intent of the Expedition was to map this area, expanding the British claim in Antarctica. For Mawson, the magnetic pole also held personal importance due to his involvement in Shackleton's *Nimrod* expedition. At the same time as Shackleton endeavoured to reach the geographic pole, Mawson and two other men successfully located the magnetic pole in 1909. In the introduction to his diary, Mawson discussed his hopes to further explore the coastline near that pole, directly south of Australia. Another aspect of the Expedition that influenced potential site locations was the plan to set up wireless communications between the various huts and Macquarie Island station. The farther away the main winter quarters were from Macquarie would impede this.

After setting up their station on Macquarie Island, the *Aurora* made its way down to the main continent. Mawson's original plan was to set up three huts along the coast, but the longer they travelled West along the coast to find suitable sites, the less time they would have to establish the bases. The farther they went also put more distance between them and Macquarie Island and the magnetic pole. With this in mind, Mawson decided to combine the largest and smallest prefabricated huts for what would become the primary winter quarters. He also felt that this would strengthen the scientific work being conducted at this base. The final location for this was at what Mawson designated as Cape Denison at the tip of Boat Harbour, Commonwealth Bay. What drew them to the area was the presence of exposed rock to allow for the hut to be erected.

Unfortunately, the *Aurora* could not get close to Cape Denison, so unloading the ship was an arduous process. The difficulty was contributed by the climate. The initial day that Mawson and several men investigated the site, it was a clear summer day which he was familiar with from his previous experience. However, he notes that after dropping some supplies at the site, as evening approached, the wind began to pick up, and the temperature dropped. This began a pattern of days where they would be unable to move between the site and the ship due to the extreme weather, trapping men at either location. After living at Cape Denison for a month, Mawson noted how different the conditions were between Cape Royds and where he had selected. The site was frequented by almost endless series of gale-force winds and has been dubbed the windiest place on earth at sea level.

The extreme conditions were due to a lack of more significant topographical elements (hills, mountains, volcanos, etc.) to protect the site, it backed up against the continental ice cap bringing that consistent southern wind. This natural aspect becomes the dominant feature along Commonwealth Bay. The Cape itself is a small 1.5 km projection of rock, moraine, and topped with ice and flanked on either side by ice cliffs. It is made up of a series of south-southeast/north-northwest ridges, the largest of which sheltered the huts. Some lakes are located within these ridges as well that develop with water from glacial melt. The view to the north is that of the sea across Boat Harbour.

The wind was the principle natural attribute of the site, impacting and overwhelming the other characteristics as well. Frequent blizzards made conditions dangerous with katabatic winds maxing out often over 100 km per hour. It brought loose snow, which caused extreme drifting conditions in and around the site. The wind chill also dropped the already cold temperatures at Cape Denison. Within Boat Harbour, the air currents created choppy conditions with the unfrozen sea during the summer months.

Availability of wildlife for study and consumption was also a positive attribute of the site. During the summer months, there were colonies of penguins, various types of petrels, and skua. The mammalian visitors come from the ocean and included seals. While they were studied, a crucial purpose of seals and penguins was for sustenance for both men and dogs. This practice was typical of early Antarctic expeditions; harvesting was aided by wildlife not familiar with humans, especially as predators.

There is some plant life present at this site. The AAE and Mawson's subsequent BANZARE expeditions different types of lichen were identified amongst the rocks around the site. In the melt lakes and streams during the summer months are host to non-marine algae.

The geological makeup of Cape Denison was detailed by Mawson, as the expedition geologist. He describes the nearby rocks as predominantly gneiss, a high-pressure/high-temperature metamorphic rock with a banded texture. These bands consisted of schist and the occasional veins of quartz. Mawson also found the occurrence of the gemstones: beryl, tourmaline, and garnet, as well as coarser deposits of mica. There were also metals present as well; iron, copper, and molybdenum.

In addition to the combined huts, they constructed several other smaller structures. At the Cape Denison site, there was a magnetograph house, absolute magnetic hut, transit hut, and the infrastructure for the wireless masts. These were relatively rudimentary and provided basic shelter for those conducting the readings and the equipment itself. The last prefabricated hut was taken farther west along the Adelie Land Coast and located at Shackleton Ice Shelf, under the leadership of Frank Wild. However, this structure no longer exists.

4.3.4 Building Development

The two structures that make up the huts are a very contained geometric form. Mawson's goals when detailing out his priorities in shelter design was that the resulting structures respond to the site condition, specifically the hurricane winds and the extreme cold of Antarctica. Practically thinking, he also wanted the structures to be easy to carry down with them and simple to erect once a site was selected. To achieve this, Mawson thought a pyramidal form on a square base would be best; that this form would create the least resistance to the wind.

Mawson took his idea to Alfred Hodgeman, a draughtsman and member of the expedition, who drew up technical drawings of the four huts. Four different companies from around Australia manufactured the prefabricated kits. For the main winter quarters, the larger was from George Hudson & Son in Sydney, and the smaller was from the Messer's Anthony in Melbourne. The delay in site selections forced the modification of these original two independent huts to be conjoined due to the revised expedition plans, forming what is called Mawson's Huts.

The larger living hut was 7.32 m square with the smaller workshop hut being 5.49 m by 4.88 m. The floor was smaller than Mawson had initially intended, rather than having the entire "living space" contained within the footprint of the roof. This offset created a 1.52 m overhang with a thinner exterior wall as a veranda around the huts. The space allowed for the portion where the roof was lower to become a secondary area. Along the exterior wall, the store boxes were stacked, stepping up to reach the roof edge, further emphasising the pyramidal form; eliminating vertical exterior faces for further wind resistance.

Exterior walls and roof structure were constructed in the same manner, framing with Oregon timber.[193] On either side of the framing were Baltic pine T&G boards with two courses of tarred paper for windproofing. Waterproofing was not considered for the roof fabric due to the lack of anticipated rain. The roof and walls of the veranda were similarly constructed, but with T&G boards only on the outer face.

Extra insulation for the interior living space came from the double wall of the veranda, the stacked store boxes, and eventually the drifted snow which came to engulf the lower structure and portions of the roof during the winter months. There is some evidence that the straw type material from the packing boxes may have been used at some point as an insulation material. There is further indication that there was improvised caulking from scrap cloth.

Challenges were found when constructing the foundation; the temperature presented difficulties to the expedition members. Even with the relatively flat rocky ground that was selected, moving of larger rocks was still required. The substrate itself required the use of dynamite to blast holes for what Mawson identified as "stumps", what would be more commonly identified today as footings. These were approximately 1 meter deep. To place the dynamite steel rock drills were used to boreholes in the stone, which were continually having to be repaired and sharpened. An aspect of this process that was problematic was the lack of material to tamp in the dynamite, instead of the traditional earth or clay, penguin guano worked. The dynamite had to be kept warm with the men's body heat. Once the stumps were in place, the cold also prevented the use of concrete to secure them. Instead, wedges affixed the stumps, between them, the space was also filled in with additional boulders.

[193] Australian Antarctic Division, *Mawson's Huts Historic Site Management Plan 2013-2018*.

Expecting the drifting snow, Mawson took the approach of locating all the windows for the huts in the roof. The position allowed them to remain unimpeded by the elements. Each had their own shutter for protection. In the living hut, there were four windows, one on each of the roof planes. For the smaller workshop hut, there were only two on each of, the longer sides of the pyramidal roofs.

With the combination of the two huts, the entrance sequence became more complicated. The primary entrance is through the western veranda of the Workroom. The winter entrance is on the western face, while the summer one is on the northern façade. In the back corner of the veranda is a small cold porch, this acts as an airlock entry into the Workroom itself. Centred on the southern wall of the Workroom is the only door to the living hut. To access the surrounding verandas, one must leave the huts. In the winter, tunnels were constructed to enable this due to the drifting snow. A hatch was installed in the corner of the roof in the Workroom veranda to provide an alternative exit.

In the middle of the workroom veranda is a cellar trapdoor, which led to an excavated space below the Workroom. It was used for frozen storage of meat – mutton they brought with them or penguins and seals that had been harvested after arriving. This cellar space was what Mawson mused about being the safest location if the huts succumbed to the hurricane-force winds.

The overhang of the roof, forming the verandas allowed the expedition to utilise this unconditioned space. As previously mentioned, the veranda directly to the west of the Workroom was primarily used as an entrance space. The latrine for the huts was also located next to the cold porch. Along the western side of the huts, the space next to the living area was used for biological store, directly adjacent outside the perimeter of the huts' was a hanger for an air tractor constructed out of packing cases and tarpaulin. The entrance for the hanger is located in the southernmost corner of the biological store. Around the southern end of the huts is where the food was stored with general storage wrapping around the eastern façade. The final part of the verandas is a space for the expedition Greenland dogs to stay. The animal housing was on the eastern side of the Workroom. One other addition to the huts form was a small aurora observatory on the northern side of the Workroom.

The original intention for the huts was to merge the work and living area within a single space; as was done at the Macquarie Base and Western Party. However, the reorganisation of the expedition due to time constraints prompted the combination of the largest and smallest huts, which allowed Mawson to designate one room for habitation and the smaller as a workshop. This organisation creates a more egalitarian layout to the living space with the only hierarchy in bunk designation being Mawson's cubical. The only other formal division of the space was that of the darkroom.

Once one enters through the cold porch, the first space encountered is the Workroom. Along the western wall, wrapping the northern corner is an 'L' shaped workbench for the mechanics as well as biology and geology. Above the bench are a series of shelves for equipment, materials, and specimens related to the use below. The eastern side of the space was occupied by an AC & DC generator, the wireless operating equipment, as well as a lathe and sewing machine. A little north of the centre, there is a stove to provide heat for the area.

The larger square living space is entered through a door slightly off centre on the northern wall. Three of the surrounding walls are lined with double bunks for the men. Due to the span of the hut, four central columns support not just the trusses, but also form a platform for storage. Underneath this is the primary gathering space; a 5.5m dining table with two benches.

Directly to the right upon entering the space is the galley. This was a simple cooks table and a worktop, identified in A.J. Hodgeman's plans as a dresser. Above these were several shelves for dishes and stores. Completing the 'U' shaped galley was the stove. Not only was for cooking, melting water, but it was the primary heat source for this portion of the huts.

Tucked in the northwest corner, next to the galley was the Darkroom. This room was the expedition's photographer's (Frank Hurley) private workspace. The interior and exterior of the stud wall are lined with T&G boards, with an additional sheathing material to block any light further out. Much of the interior is taken up with surrounding workbenches and shelves for equipment, supplies, and materials. In the outermost corner is a small basin set flush with the workbenches to act as a sink. The Darkroom also has its own lowered ceiling to ensure control of the light conditions further.

Hurley's own sleeping space is directly adjacent to the Darkroom along the western wall. The bunks ran along the western, southern, and eastern walls, with one next to the entrance on the north. Each man's space was designated with their initials carved into the sideboard. They were arranged double height with the head/foot butting each other, which lessened the intrusion to the central space. They were relatively simple construction from wood, with blocking to support horizontal slats along the exterior wall. The interior is picked up by a system of supports and joists. Other than the change in orientation, pillow and mattress position, location of the vertical supports, it was documented in the Management Plan that there were partitions to designate the individual spaces.

One section of the bunks in the huts became known as Hyde Park Corner. The group inhabiting that corner comprised several of the international expedition members; Xavier Mertz (Switzerland), Frank Bickerton (Britain), Belgrave Ninnis (Britain), and Cecil Madigan (Australian). Ninnis and Mertz were Mawson's two sledging party members who did not survive their expedition to King George V Land. This Corner was in the southeasternmost corner, afforded more privacy due to being pinched between the exterior wall and that of Mawson's room.

The only remaining portion of the huts is that of Mawson's own living space. There are thinner walls which extend and surround a smaller private cubical, utilising the southern-most columns for support. There is a small doorway opening in the north-eastern corner. A partial roof covers his room. Within his space, Mawson had a simple single wooden bunk, table & chair, and shelving. He kept some equipment in his room for timekeeping and monitoring weather. He also put up some decorative prints within his room, which further personalised it. Directly adjacent his doorway was a small library that backed upon a more public library for the rest of the hut inhabitants. Similarly, on the opposite side of his cubicle's northern wall were shelves for storage near the dining table.

The building systems for the huts are reasonably minimal and straightforward. The heat for the huts was provided by the stoves located in the Workroom and the Galley. The fuel utilised was anthracite coal briquettes, but if a higher temperature were required quickly seal blubber would be burned. The interior temperature was kept close to 4.5°C for comfort and economy of fuel.

There is no active ventilation system. Mawson does not write about incorporating one during the planning process. He does address a lack of need due to drafting that came through the huts with excessive wind. Both of the stoves did have their own chimneys for ventilation directly to the outdoors. There is one instance that was noted when the chimney became blocked by drifting snow, and the interior began filling with smoke until one of the men went up and manually dug it free.

The artificial lighting for the huts was in the form of acetylene lamps. The plant for this was located just off the side of the storage platform away from the galley. This technology was a common practice for portable lighting sources. During the summer months, natural daylight could illuminate the interior through the skylights. The workroom had two skylights on either side of the ridgeline, while the Living quarters had four on each of the faces of the pyramidal roof. This orientation allowed for light to enter around the storage platform above the dining table. Mawson's cubical roof had an opening to also let the natural light into his own space. Each window was also outfitted with shutters.

There was no plumbing system in place in the huts. Any water that was to be used for cooking or personal hygiene came from melted snow or ice. The latter was restrained, and the men grew beards to help mitigate the waste of water for shaving. The only sink like equipment found within the huts was the basin in the Darkroom for preparing photographs. The waste from the sink drained through the north wall. The drain was adjacent to the latrine, a rudimentary pit type restroom facility.

Entertainment for evenings and the long winter came from a variety of sources. The huts was appointed with the MacKellar Library, named for its donor, which gave the men additional reading material beyond what they had personally brought. It was noted that the books on polar expeditions were particularly popular. For music, they had a gramophone and a small organ. The men put on plays written by Hurley and would tell tales of their previous adventures. They also published a newspaper *The Adelie Blizzard*.

The initial intent for the huts was that they would provide adequate shelter for one winter only, luckily the lifespan lasted much longer. During the winter of 1912, struts were added to help strengthen the rafters against the almost constant wind force. For the second winter, some changes were made. Only seven men were living within the huts, compared to the previous 18, which allowed for some modifications to be made to make life more comfortable. Particular attention was made towards further weatherproofing by adding black paper, scrap canvas and bagging to help windproof the eastern and western walls. A canvas sheet was also added to the windward side of the pyramidal roof. With fewer occupants, several bunks were converted for storage, allowing for food stores to be brought inside for ease of access. The radio equipment was also moved to where the bunk on the northern wall was located. The dining table was cut in half to create more space centrally.

4.3.5 Preservation

Preservation efforts for Mawson's Huts has not been as straightforward as that for those on Ross Island. There have been multiple public and private organizations involved in the preservation of the building as well as an early passionate debate about what should occur. This ranged from preservation *in-situ* to relocating the entire structure to a museum in Australia or even building a protective dome around the site.[194]

The initial internal snow and ice removal began in the 1970s by ANARE teams; the magnitude of infiltration had increased at some point in the late 1950's early 60's. It was during the process that the preservation *in-situ* was favoured with the inclusion of a heritage management plan. While challenging, preservation would pose less logistical issues than relocating. Not the least of which involved concerns around how the building fabric would transport and then acclimate to a more temperate environment.[195]

While this beginning of remediation was taking place, the site was listed as historic through several organizations. This included the Antarctic Treaty and Register of the National Estate,

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[194] Hughes, Janet, "'In Situ' Conservation Versus Relocation: The Case of Sir Douglas Mawson's Huts in Antarctica," *Historic Environment* 8, no. 1/2 (1991). Evans, Sherrie-lee, "Icy Heritage–Managing Historic Sites in the Antarctic: Pristine Wilderness, Anthropogenic Degradation or Cultural Landscape?," *The Polar Journal* 1, no. 1 (2011). Collis, Christy, "Mawson's Hut: Emptying Post-Colonial Antarctica," *Journal of Australian Studies* 23, no. 63 (1999).

[195] Hughes, "'In Situ' Conservation Versus Relocation: The Case of Sir Douglas Mawson's Huts in Antarctica."; Powell, Stephen, "Heroic Huts and Beyond: Managing Australia's Historic Antarctic Heritage Places," (2007). Evans, "Icy Heritage–Managing Historic Sites in the Antarctic: Pristine Wilderness, Anthropogenic Degradation or Cultural Landscape?."

both of which restricted preservation rather than relocation. Half of the preservation efforts have been conducted by the ANARE or the AAD; the other half was conducted by private groups, including Project Blizzard and Mawson's Huts Foundation.[196]

The continued intense winds had worn away the basic fabric of the building while the continued snow and ice loads strained the internal structure. There has been extensive work conducted to lessen the impact of these issues. Some of the early interventions have needed to be remediated or repaired again. This was to maintain the historic fabric of the building. It also worked to continue the use of like-materials; primarily found in the over-cladding of the exterior.[197]

While there were still a surprising number of artefacts found in good condition, much of the equipment in the workroom was taken back with the AAE in 1913 to be sold and help pay back the debt of the trip. Also, some souveniring occurred during the 1931 BANZARE trip. However, there have been efforts made to preserve what was left.[198]

4.3.6 Integration of Biophilic Attributes

Direct Experience of Nature

There are many commonalities between the two HAE huts and their approach to the integration of biophilic attributes. Mawson drew upon his prior experience on Shackleton's expedition to design a structure that would be adept at providing shelter based on the climate. Rather than fostering a relationship between the men and natural surroundings, the huts separate the two for protection and refuge. How the following direct experience attributes were incorporated illustrates this.

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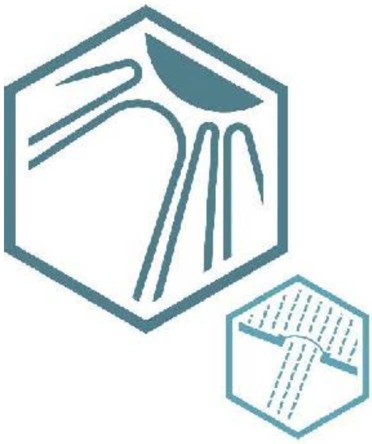
[196] "Icy Heritage–Managing Historic Sites in the Antarctic: Pristine Wilderness, Anthropogenic Degradation or Cultural Landscape?."; Powell, "Heroic Huts and Beyond: Managing Australia's Historic Antarctic Heritage Places."
[197] Splettstoesser, John, "Centennial of Historic Huts in Antarctica: A Tourism Attraction," *Tourism Recreation Research* 25, no. 2 (2000); Powell, "Heroic Huts and Beyond: Managing Australia's Historic Antarctic Heritage Places."; "Weather Beaten Hut Given Extra Protection," *Australian Antarctic Magazine*, no. 13 (2007).
[198] "Heroic Huts and Beyond: Managing Australia's Historic Antarctic Heritage Places."; Killick, David, "Century-Old Artefacts Uncovered at Mawson's Huts," *Australian Antarctic Magazine*, no. 30 (2016).

Light



With regards to natural light, Mawson took an approach significantly different than Scott. The huts have windows oriented to take the best advantage of the natural daylight during the summer, skylights in the roof rather than traditional wall-mounted windows. They were each outfitted with shutters for protection during the dark, snowy, and windy winter months. Having skylights creates more generalised ambient lighting for the interior of the huts.

In the Living Space, there are four skylights, one each of the sloped roofs. Spaced out, these allow the natural illumination to go around the central storage platform and provide light for the rest of the space. Mawson's cubicle with its lowered roof has part of that substructure removed to allow for the sunlight's penetration. The Workroom has two skylights perpendicular to the more extended north-south ridge of the roof.

The surrounding entry veranda, dog habitation, and storage do not have any formal windows for sunlight. Instead, there are unimpeded openings on the north face that could potentially allow for daylight during the summer months when they are not blocked by snow.

Air

Natural ventilation was provided by unintentional means, unlike Scott's Hut. The huts were not airtight, and the high wind speeds created plenty of involuntary and at times, undesired natural ventilation. Draughts were a continual issue for the occupants. Beyond providing fresh air, the draughts also brought in ice crystals and snow.[199]

[199] Mawson, *The Home of the Blizzard Being the Story of the Australasian Antarctic Expedition, 1911-1914*.

Once winter settled in and accumulated snow had sealed the holes causing the drafts, the wind was still a regular part of the men's lives. Even if they did not leave the structure, there was an ever-present auditory reminder. The sound of the howling wind was an ever-present reminder of where they were living.[200]

Water

Due to the fundamental nature and location of the huts, like Scott's Hut, there are no active hydraulic systems. The process of obtaining liquid water involved melting snow or ice on the galley stove. Also similar to Scott's expedition, conservation efforts were observed; limiting the men's traditional toilette routine and eliminating shaving. The primary use was for cooking, consumption, and cleaning. The only formal sink-type equipment is found in the Darkroom, which is a simple basin to pour melted water with a drain to the outside.[201]

However, Mawson noted that water became an unexpended presence during the spring months when the huts defrosted, the melting frost and snow ran along with the interior of the walls and dripped from the ceiling.

Plants

The design of the huts does not consider endemic plants. If any of the lichens were brought into the huts, it was as a scientific specimen for observation. This was for the same reasons as Scott's expedition; it was not prioritised as an essential element of the expedition.

[200] Ibid.
[201] Ibid.

Animals

The primary attention of the incorporation of animals within the huts can be seen in the formal housing provided for the Greenland dogs. The veranda on the eastern side of the workshop was portioned off for their use. The inclusion of local animals came either for scientific research or more commonly as food.[202]

Landscapes

Akin to Scott's approach to the landscape, Mawson did not attempt to mitigate the impact of the huts on the surrounding environment or to recreate any familiar landscape elements in or around his structure. This was not a practice of the time, therefore not a consideration.

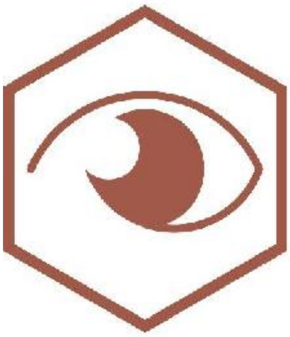
However, Mawson did engage with the site to create natural protection from the southern continental winds. Pushing the larger hut closer to a rocky outcropping and then placing the smaller hut in the leeward side of the larger hut created a windbreak.

[202] Ibid.; Australian Antarctic Division, *Mawson's Huts Historic Site Management Plan 2013-2018*.

'Weather'

The climate was a primary factor for Mawson when developing the concept for his base design, a key reason the huts was successful. Similar to other areas of Antarctica, the weather conditions that had to be combatted were temperature, snow, and wind. However, unique to Cape Denison was the almost continual presence of hurricane-force winds. The overall building form Mawson developed was to combat wind and drifting snow. While it follows the same overall shape and form of Scott's Discovery Hut, it was modified to suit the climate. The pyramidal roof form was chosen to minimise any vertical faces for the wind to push against, the store boxes were stacked around the exterior of the veranda façade to have a similar effect. The drifting snow against the exterior also created additional insulation for the inhabitants and once established, a windbreak. The verandas, in turn, also created buffers from the conditions. The central portion of the huts has a veranda on all sides except the northern, the leeward side. The interior was conditioned to 4.5°C (40°F) by two coal-burning stoves to combat the extreme outdoor temperatures.

Views



With the lack of the traditional vertical windows which Scott's Hut has, the huts is not designed to take advantage of the surrounding views with the skylights. When conceived and prefabricated, the site had not been selected, so any potential view could not be taken into consideration.

Fire

The fire was used within the huts for two principal purposes; heat and light, like Scott's Hut. The heat came from coal-burning stoves located in the Workroom and the Galley. The latter was a cooking range for meal preparation as well as a heat source. They would occasionally burn seal blubber, but that was in situations where heat was required quickly rather than steadily. The lighting during the winter months and night was provided by fixtures burning acetylene.[203]

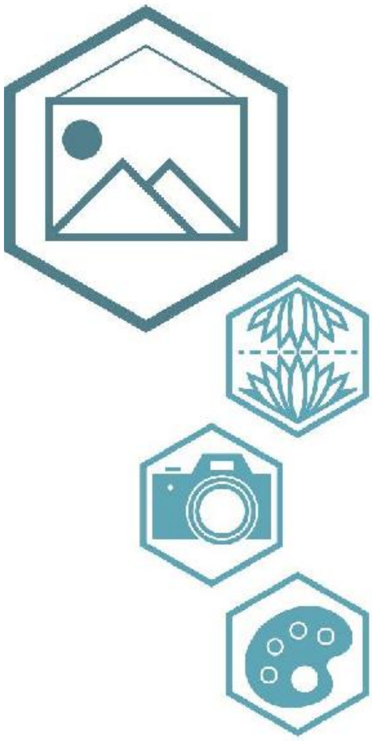
St. Elmo's fire was also observed around the equipment in the Workroom. During blizzards and storms, lightning-like charges could be seen around the equipment, typically this was a blue hue and caused much amusement for the inhabitants.[204]

Indirect Experience of Nature

The following describes what is intended to be indirect experiences, which builds upon many of the direct experiences which were integrated indirectly. With the practical aspect of Mawson's Huts, many of these attributes are found within parts of the structure which would fundamentally provide this connection. It is also a pivotal point in which it can be seen which aspects were brought to remind the men of 'home' and opportunities to see how individuals customized their spaces.

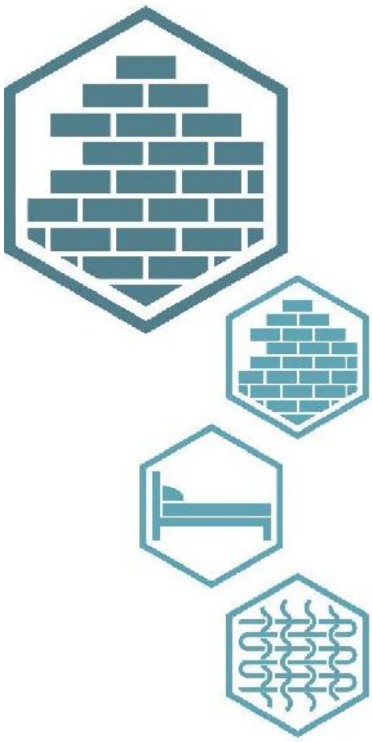
[203] *Mawson's Huts Historic Site Management Plan 2013-2018*; Mawson, *The Home of the Blizzard Being the Story of the Australasian Antarctic Expedition, 1911-1914*.
[204] *The Home of the Blizzard Being the Story of the Australasian Antarctic Expedition, 1911-1914*.

Images



The men in the huts customised their individual bunks with personal images and photographs. In the replica of the huts in Hobart, Mawson's room has a print of Jean-Honoré Fragonard's *The Swing*. This print depicts a rococo painting showing a natural scene with greenery and general frivolity, an antithesis to the Antarctic environment, creating a small visual escape from the extreme environment and a tie to home and family. Another source of imagery within the huts came from the labels on the supplies; these had illustration and logos and added visual stimulation to the space.

Materials

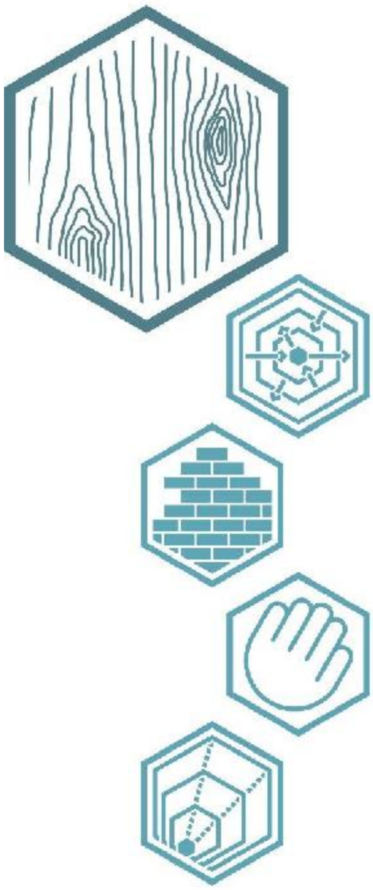


The permanent building fabric that makes up the huts were brought to Antarctica by the AAE as was typical during the HAE. The primary material for the structure is wood Oregon timber and Baltic pine. The bunks are entirely constructed on-site from wood, not metal as was used in Scott's Hut.

Similarly, much of the other furnishings in the huts are also wooden. The huts were not devoid of metallic elements with exposed fasteners, shelving supports, and the stoves being metal. The bedding material was natural fabric, with the heavier blankets appearing to be woollen. Their sleeping bags for the sledging trips were made from reindeer skins.

A key difference with the building fabric in Mawson's Huts versus Scott's was the use of a natural resource, snow. Drifting snow provided an insulative layer for the exterior of the huts through winter months; however, in the summer this was lost when it melted.

Texture



With the primary building material being uniformly wood, the interior has a fairly consistent appearance. T&G boards along the wall are laid horizontally, which is also picked up by the horizontality of the bunks, giving the space a broader feeling. The boards on the ceiling are laid perpendicular. The angles of the roof and the exposed supports create a different condition to the materials.

Colour

The colour of the natural wooden interior is quite monotonous. The Baltic pine boards have a subtle difference of colour with regard to the grain. The various types of wood also offer restrained nuance to the brown tones of the space. Relief from this colour comes from the materials, supplies, and personal effects of the men. Their bedding was a neutral blue-grey, on the walls behind were posted personal images. On the shelves, the books, cooking supplies, and various equipment and utensils also introduced a variety of colours to the huts.

Shapes and Forms

The geometric form of the huts and the interior layout is rectilinear with two almost perfect squares butting against one another. This is due to one of the same reasons as Scott's Hut, material limitations. The designer of the huts was a member of the expedition and oversaw the onsite modifications of the two huts joining to become one, creating a more complex structure than Scott's Hut. The general skill level of the men building the huts was about equal, leading to the same basic carpentry techniques being employed.

Information Richness

Upon first consideration, the interior of the huts is quite unvaried and straightforward; with the overwhelming presence of Baltic pine boards and the retrained relief of personal effects and supplies. Hurley's photographs of the interior show a different story. Just looking at the primary material and how it has been employed. The boards lie perpendicularly; walls horizontal, ceiling vertical. This, with the variations of each board, creates a subtle difference which disrupts the uniform material. The exposed wooden trusses of a different species on the ceiling also break up the expanse. Hurley shows that this was necessarily an open vast wooden box, many of his photographs showing various flags, equipment, gear, laundry hanging from the rafters. Midwinter dinner shows the storage platform festoon in the Union Jack and Australian flags with one of the posts wrapped with the commonwealth star showing prominently.

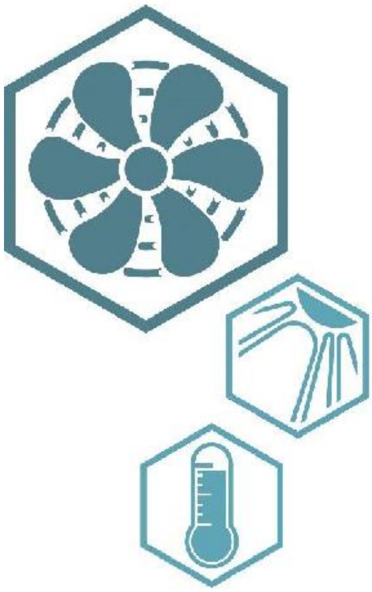
Change, Age, and the Patina of Time

Similar to other structures built during the HAE, Mawson's Huts were only occupied for a short period, and not intended to be habitable longer than a few years. During the expedition, there is little documentation regarding wear to the building. However, looking at the condition of the huts today, the primary wear comes from the wind upon the wooden exterior. Combined with any grit, ice, or snow, the wind eroded the pine boards, further exposing the natural grain of the wood. This wear was not a problem for the structure until after the AAE vacated the huts, as well as snow and ice-penetrating the interior of the huts which posed significant structural issues and prompted the preservation efforts.

Natural Geometries

Natural geometries were not considered in the design process of the huts. The same limitations that constrained Scott's Hut were behind this with Mawson as well. The men building the structures were not necessarily skilled labourers which prompted simplified structures and the material technology at the time did not promote complex designs.

Simulated Natural Light & Air



The light for the huts came from acetylene lamps during the winter months period of 24-hour darkness. As was typical with other Expeditions, the light wasn't conditioned to simulate the natural diurnal cycles as discussed in Scott's Hut. The only ventilation system that was installed within the huts were chimneys for the two stoves; there was no additional active system for fresh air.

Biomimicry

Biomimicry was not a priority in the design process of the huts.

Experience of Space and Place

This element is ever-present in Antarctica, particularly with the harsh conditions at Commonwealth Bay. Mawson's Huts was well designed and provided the shelter, which was the essential aspect of the structures. This protection, however, does create a bit of a separation that is often found within buildings in Antarctica. Mawson's Huts also provided a relaxed approach to the rigid organization of Scott's expedition.

Prospect and Refuge

The huts are an essential part of the successful habitation of Antarctica. In the interior affords individuals their own refuge within their bunks. Having the longer face of the bunk to the central gathering "public" space of the huts still provides a connection. However, within the overall complex of the huts, various areas that allow for "away" space for groups or individuals. Spaces within the verandas, the Workroom, and the snow tunnels that were dug during the winter. Inside the living hut, the storage platform provides a sense of security or refuge with its lowered ceiling. Similarly, Mawson's room provided him with his own personal space while still not being completely cut off from the rest of the life within the huts.

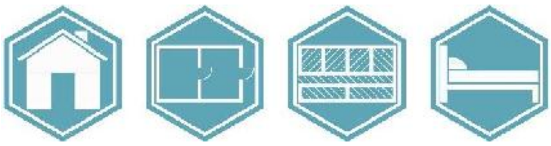
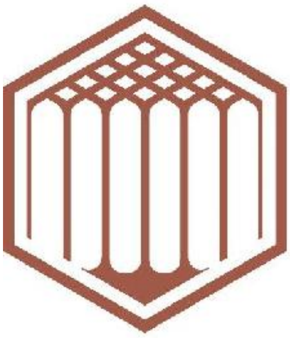


Figure 4-5 Hierarchy of Mawson's Huts: building to rooms to zones to bunks

Organised Complexity

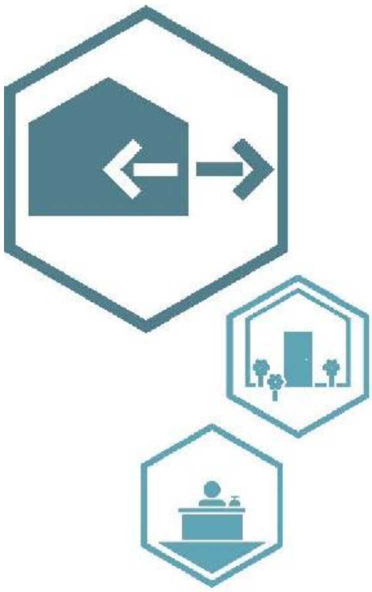


Similar to Scott's Hut, Mawson's Huts while rich in objects; expedition gear, personal possessions, scientific equipment and books, there was a lack of organization and balance to relate to this attribute fully. So while it does provide a visual contrast to the subtlety of the natural environment, there is nothing orderly about it and can be overwhelming.

Mobility

The basic layout of the huts is formed around the central gathering area. The primary circulation comes in through the entry veranda taking a turn in the Cold Porch to enter the Workshop. The main path there occupies the south-east corner before accessing the main living hut. It runs along the front of the bunks in a 'U' shape before wrapping into Mawson's cubicle. The egress to the site became difficult with drifting snow in the winter months; this prompted the use of tunnels around the huts and a roof hatch for a formal exit.

Transitional Spaces



The transitional sequence for the huts is more elaborate than Scott's Hut. As described above, entering the main living space from the exterior required passing through four doors/doorways, maintaining the level of conditioning within each space. The entry veranda offered the lowest insulative value and was used for circulation with the outhouse adjacent. A formal airlock entry similar to Scott's Hut is in the small cold porch leading to the workroom. The south-east corner of that space is a continuation of the transition from the cold porch to the final door entering the indoor space of the living hut.

Place

Geography – The physical sense of place is unavoidable at Cape Denison, and for the huts to be effective, they had to react to it. Mawson drew upon his prior experience with Shackleton's *Nimrod* expedition when outlining the attributes the huts should have. While the conditions were different between the *Nimrod* Hut and Cape Denison, it provided Mawson with a closer understanding of Antarctica as a place.

Ecological – Specific ecological systems were not a consideration when designing the huts, due to its ultimate location being unknown. However, for scientific research, they wanted to be located within a diverse location. While the primary goal of the expedition was mapping, there was also interest in various other sciences, including biology, geology, which related to the ecological make-up of the site.

Cultural – the huts had a communal culture for the expedition members, between the two winters, there was a different shared experience for the members. Part of the basis for this collective culture comes from the selective nature of the expedition. Only those with a shared interest would make an effort to apply to join, and then Mawson could choose from those members who could work well together.

Historical – Being the first to make landfall at Cape Denison, there was no local historical culture from which to draw. The men were aware of traditions, practices, and cultures of previous Antarctic and Arctic explorations. Some of these were from personal experiences or from documentation of others', some of this was incorporated into the expedition.

Integrating Parts to Create Wholes

As shown with the previous attributes, there is a disconnect between the huts and the natural environment, where biophilic design endeavours to foster the integration and understanding of inhabitants to the surrounding ecosystem. Mawson's huts does get closer to this with the drifting snow becoming an important insulative layer and the resulting snow tunnels around the formal structure. Otherwise, nature and the site conditions are something that is kept out of the building, to protect the occupants.

4.4 MCMURDO STATION

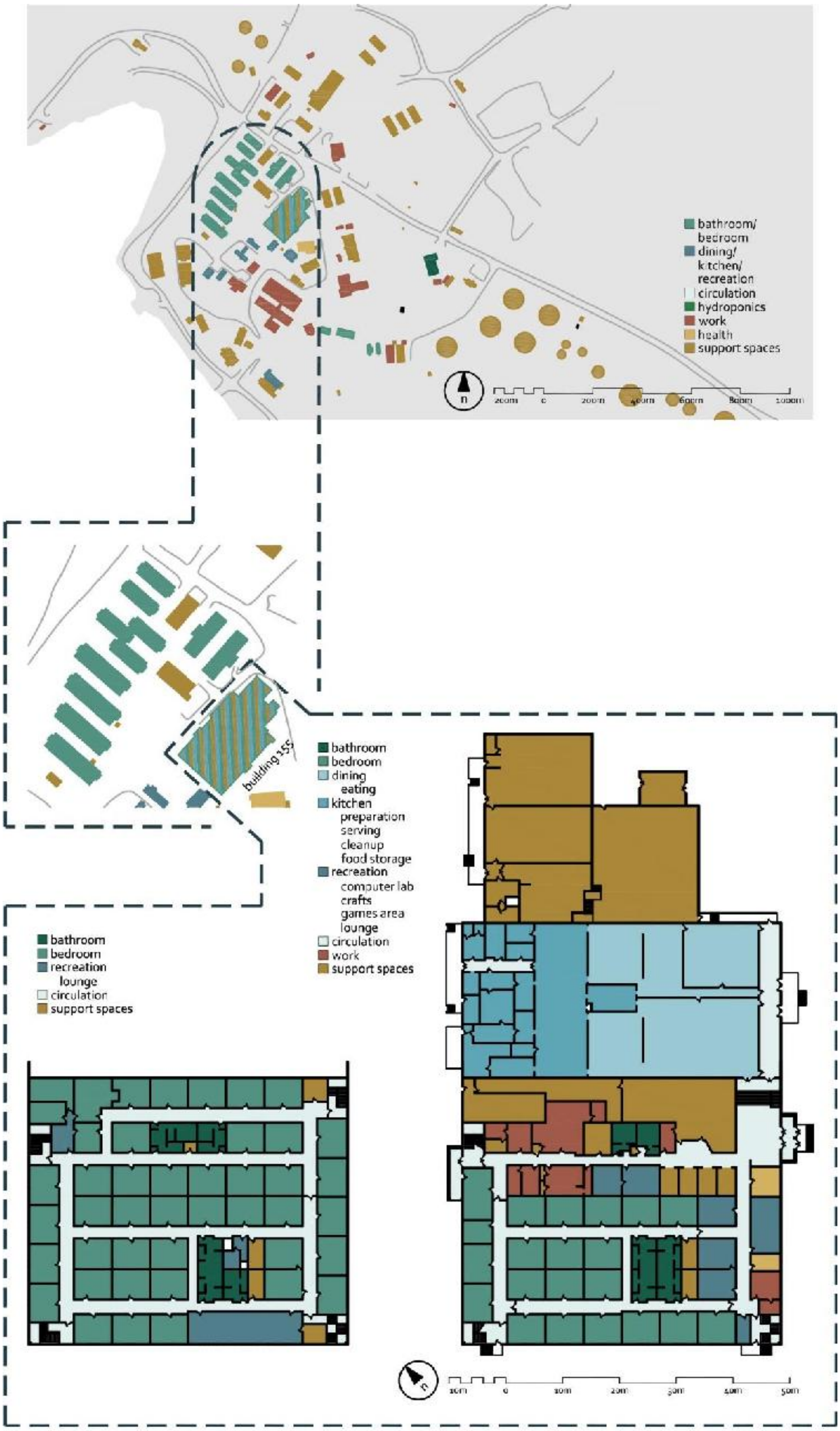


Figure 4-6 McMurdo Station's Building 155 – Site, Orientation, Floor Plan[205]

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[205] Graphic by Author – developed from GIS floor plans and NSF Master Site Plan

4.4.1 Sources

Within Chapter 4 and Chapter 5, much of the material presented is from examinations of archival research. Where applicable, specific sources are cited. General observations and analyses are from floor plans[206], master plan[207], photographs[208], blogs[209], and youtube videos[210]. Any specific item is referred to specifically if applicable.

4.4.2 Background

McMurdo has become the largest station in Antarctica and was developed by the United States of America in 1956 on Ross Island as one of the seven stations the USA built for the IGY. While not involved in the earlier Heroic Age of Exploration, the IGY did not mark the beginning of the USA's interest in Antarctica. Prior to this, the US Navy under the guidance of Admiral Richard E. Byrd had tried to establish smaller stations around the continent during Operation Deep Freeze and mapped significant portions of Antarctica. For the IGY, the US Navy was once again tasked supporting and establishing the stations.[211]

There is one aspect of McMurdo Station that was noted while reading articles about the base, its location. As previously discussed the USA has no claim to sovereignty, therefor McMurdo is located within New Zealand's claim. There is a clear division in thinking about this. One, predominantly from authors originating in the USA, that either does not acknowledge the other claims or does not see the claims as a barrier towards other international station developments. The other stance has almost resentful overtones that the USA feels that they are above the existing sovereignty claims and can just come in and establish bases wherever they wanted. The United States is not the only country to follow this practice. The USSR also established new stations prior to the ATS without having sovereignty. Before the IGY, there

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[206] Turner, R., Palmer, C., "Mcmurdo Station Master Site Plan," (National Science Foundation2007)., "Mcmurdo Gis Floor Plans," ed. Cline Alan.
[207] "Mcmurdo Station Master Plan 2.1," National Science Foundation, https://future.usap.gov/master-plan/mcmurdo-master-plan-page/.
[208] "Building 155 Galley," FourSquare City Guide, https://foursquare.com/v/building-155-galley/4efa34760039deea019448a4; "Mcmurdotimes," Flickr, https://www.flickr.com/photos/mcmurdotimes-com/with/6874137121/; Spindler, Bill, "Amundsen-Scott South Pole Station," https://www.southpolestation.com/; "Image of Mcmurdo Station," https://compote.slate.com/images/511985a0-36fd-450a-a6f5-59a53899cab3.jpg; "Mcmurdo Station," Science Magazine, https://www.sciencemag.org/sites/default/files/styles/article_main_large/public/images/McMurdoStation.jpg?itok=AnKi3xhP.
[209] to Icecube in Ice Antarctic Telescope, June 09, 2020, 2012, https://www.polartrec.com/expeditions/icecube-in-ice-antarctic-telescope-2012/journals/2012-12-08-0; to Daily Life in Antarctica, June 09, 2020, 2012, https://ciresblogs.colorado.edu/antarcticuavs/2012/09/01/daily-life-in-antarctica/; to A Space Science Guy's Blog, June 09, 2020, 2015, https://spacewx.wordpress.com/category/antarctica/; Dudzik, Caitlin, June 09, 2020, 2015, https://antarcticaadventures.wordpress.com/tag/gluten-free/.
[210] "Heart of Mcmurdo Station - Building 155 (Must Know!)," youtube, https://www.youtube.com/watch?v=P65wO-4nQbw; "Summer in Antarctica," youtube, https://www.youtube.com/playlist?list=PLNH_RpzkiN34O6HxUVn1P-x52HCmV9JJp; "Jobs in Antarctica," youtube, https://www.youtube.com/playlist?list=PLNH_RpzkiN37lCE2AZTcUuM90kDvPVQ8r.
[211] Collis and Stevens, "Modern Colonialism in Antactica: The Coldest Battle of the Cold War."; Collis, C. and Stevens, Q., "Cold Colonies: Antarctic Spatialities at Mawson and Mcmurdo Stations," *Cultural Geographies* 14, no. 2 (2007); Davis, "A History of Mcmurdo Station through Its Architecture."; Dodds, K. J., "Post-Colonial Antarctica: An Emerging Engagement," ibid.42, no. 220 (2006); Ferraro, Joseph, "Development of a Remote Station Architecture - Mcmurdo Station, Antarctica," Ferraro Choi, http://ferrarochoi.com/publications/development-of-a-remote-station/; Klein et al., "The Historical Development of Mcmurdo Station, Antarctica, an Environmental Perspective."; United States Antarctic Program, "Mcmurdo Station Master Plan 2.1."

is evidence that during World War II the German government claimed a portion of Norway's sovereignty known as New Swabia.[212]

For prior United States Antarctic expeditions, Little America had been used for supply aircraft to land. This was not deemed acceptable by the US Navy for the International Geophysical year due to the ice shelves continual movement and calving. Also, to be able to support the South Pole Station effectively, larger wheeled aircraft would need to be utilized rather than the lighter ski-based ones.[213]

The location that the United States selected for their proposed airbase was positioned in New Zealand's sovereignty and right next door to the proposed New Zealand Scott Station. This raised questions with the organizers of the International Geophysical Year of how the two bases would work together, could this become one singular co-operated base, etc. Since McMurdo was intended as a support airbase only, it was ultimately not viewed as detracting from Scott Station.[214]

4.4.3 Site Conditions

McMurdo Station was located at Hut Point for logistical reasons rather than climatic or aesthetical. With the original intent for the station being support for the other planned scientific research stations, McMurdo needed to be sited in an easily accessible area but also have the closest proximity to the other sites, particularly the South Pole Station. Plans initially called for a land-based airstrip, which partially facilitated the site selection.

Hut Point, near Captain Scott's *Discovery* Hut, was ideal. However, considering the same issues that Scott faced on his 1911 voyage, the Cape Evans Hut site was selected as a backup, being farther slightly farther north. To everyone's relief advances in maritime transportation technology and with some work on the part of the ice breakers, Hut Point was feasible.[215]

This station was one of the first two constructed by the United States for the International Geophysical Year. It also was one of the most extensive infrastructure endeavours constructed in the history of Antarctica. Designed to serve over 300 men, its impact on the surrounding landscape was much more significant than previous explorers huts, stations, or bases.

The ground was described as 'granite-like permafrost', but despite that, the chosen site was graded to accept the coming structures.[216] The types of substrate present different challenges for building upon them. The ideal terrain to build on is ice-free bedrock. However, even with

[212] Summerhayes and Beeching, "Hitler's Antarctic Base: The Myth and the Reality."
[213] Belanger, Dian Olson, *Deep Freeze* (Sebastopol: University Press of Colorado, 2011).
[214] Ibid.
[215] Ibid.; Foster, M. J. N., "Operation Deepfreeze-I," *Geographical Journal* 123, no. 1 (1957).
[216] Belanger, *Deep Freeze*; Foster, "Operation Deepfreeze-I."

exposed bedrock, there is the potential for layers of ice to have formed underneath it. When that melts, it alters the surface stability.[217] From the description of 'granite-like permafrost' it is unclear the specific makeup, but no documented issues with melting ice.

The landscape features are similar to those described at Scott's Hut; they are both located on the south-western side of Ross Island, about 25 km as the crow flies[218]. The station is located further south than Cape Evens at the tip of Hut Point Peninsula, which locates Mt. Erebus to the north-east.

4.4.4 Building Development

The first accommodations were tents that were set up around Scott's Discovery Hut at Hut Point while the station was constructed. The structures the US Navy brought with them to be used for the IGY were similar in purpose and concept to those employed by the earlier explorers. They weren't intended to be permanent; they were basic shelters to protect the inhabitants. At the same time, they carried out their research, and they were prefabricated systems that were brought to Antarctica for assembly.[219]

Three different types of structures comprised the early station. One of which was corrugated metal Quonset Huts, which were constructed from curved metal panels which could be joined to suit a variety of needs. This building type was used in various climates by the US military around the world; here, the panels were augmented with additional insulation. As with most of these building types, the interior was free of supporting walls allowing the structures to be divided up in whatever manner was required. The downside of the Quonset hut was the curved exterior walls did not allow for windows to be placed along the length of the building.[220]

Jamesways were similar in concept to the Quonset hut but differed in materiality. The curved form was made up of wooden ribs that were then covered in insulated double-walled canvas. While the Jamesways lessened the need for steel, they were more of a fire hazard. However, the lightweight design was less problematic to transport. There are still a few of these at McMurdo today.[221]

The final building type was a modular plywood structure known as Clements huts or T-5. They were constructed from simple 1.22m x 2.44m insulated plywood panels and wood or steel

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[217] Incoll, Phil, "An Overview of Antarctic Buildings and Services for Administrators, Scientists and Engineers" (University of Technology 1990).
[218] "Mapmyrun," Under Armour, https://www.mapmyrun.com/routes/create/.
[219] Collis and Stevens, "Cold Colonies: Antarctic Spatialities at Mawson and Mcmurdo Stations."; Davis, "A History of Mcmurdo Station through Its Architecture."; Klein et al., "The Historical Development of Mcmurdo Station, Antarctica, an Environmental Perspective."; United States Antarctic Program, "Mcmurdo Station Master Plan 2.1."
[220] Davis, "A History of Mcmurdo Station through Its Architecture."; Ferraro, "Development of a Remote Station Architecture - Mcmurdo Station, Antarctica"; United States Antarctic Program, "Mcmurdo Station Master Plan 2.1."
[221] Davis, "A History of Mcmurdo Station through Its Architecture."; Ferraro, "Development of a Remote Station Architecture - Mcmurdo Station, Antarctica"; United States Antarctic Program, "Mcmurdo Station Master Plan 2.1."

trusses for the roof. The appeal for the T-5 was that it was easily assembled with only a few men and little specialized tools. The panels themselves could be connected together to form various sizes, and different panel types (window, door, and plain) be arranged to accommodate different layouts. The typical T-5 was configured to be 6.1m x 14.6m. There is one of the original T-5 building from the 1960s in use at McMurdo Station today.[222]

The layout for McMurdo was very militaristic; the 34 buildings were set up along 'streets' in very orthogonal orientations, a parade ground, and chapel. The separate buildings were spaced away from each other as seen in other remote military bases to avoid the potential threat of fire spreading. While this layout might not seem harmonious with the climate, the buildings themselves were oriented with consideration to the prevailing winds per guidelines set out by the Army and US Naval Civil Engineering Laboratory manuals.[223]

The initial plan was to dismantle buildings after 1958. With the success of the research conducted, McMurdo continued operation with some temporary structures continuing use into the 1970s. After the ATS implementation in 1961, it prompted changing the name to what it is known by today, McMurdo Station. The purpose of the base also transitioned from an airfield to a permanent station.[224]

With this transition, the approach to building changed as well. Rather than the earlier temporary structures, the US Navy employed steel clad and framed building similar to the T-5, but known as Robertson Buildings. While not very aesthetically exciting or different than the T-5, they were better insulated and allowed for more customizable interior layouts. This building approach was still evident in more recent structures, most notably in the three-storey dormitory buildings constructed in the 1980s.[225]

In 1970 the United States National Science Foundation (NSF) assumed control of McMurdo Station, with the US Navy ceasing all support in 1993. While many of the early militaristic influences can still be seen in the station, overall layout began to move away from the strict geometry. Throughout the 1970s as new buildings were constructed, they aligned more closely with the topography of the site. Their locations were chosen for ease of construction and convenience of level ground.[226]

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[222] Davis, "A History of Mcmurdo Station through Its Architecture."; Ferraro, "Development of a Remote Station Architecture - Mcmurdo Station, Antarctica"; United States Antarctic Program, "Mcmurdo Station Master Plan 2.1."
[223] Collis and Stevens, "Modern Colonialism in Antactica: The Coldest Battle of the Cold War."; Collis and Stevens, "Cold Colonies: Antarctic Spatialities at Mawson and Mcmurdo Stations."; Davis, "A History of Mcmurdo Station through Its Architecture."; United States Antarctic Program, "Mcmurdo Station Master Plan 2.1."
[224] Davis, "A History of Mcmurdo Station through Its Architecture."; United States Antarctic Program, "Mcmurdo Station Master Plan 2.1."
[225] Davis, "A History of Mcmurdo Station through Its Architecture."; Ferraro, "Development of a Remote Station Architecture - Mcmurdo Station, Antarctica".
[226] Davis, "A History of Mcmurdo Station through Its Architecture."; Ferraro, "Development of a Remote Station Architecture - Mcmurdo Station, Antarctica".

The station has developed to comprise of around 100 buildings, which cover almost 50 acres. Until recently, there has been limited focus on the organisation of laying out the station, building being constructed on an 'as need' basis. McMurdo can be home to over 1000 Summer inhabitants and has a winter population between 200-300 members. It has a very different feeling than many of the other stations in Antarctica, more of an urban feeling that has been described some as an old United States Western frontier town. [227]

Briefly, McMurdo's power was augmented by a nuclear power plant, affectionately nicknamed 'Nukey Poo'. In the 1960s the cost of the diesel-generated power was fairly expensive since the US had successfully installed smaller nuclear power plants at other military bases around the world, they developed one on the outskirts of McMurdo Station. Throughout its short lifespan, the plant was plagued by smaller issues, and in 1972 it was decommissioned and dismantled over the next three years. The infrastructure and contaminated surrounding area were shipped back to the United States for disposal. [228]

McMurdo Station today is a collection of independent buildings which encompassing anything from maintenance structures, offices, dormitories, laboratories, to bars or the lone church at the station.[229]

Due to the climate, all the services are above ground, including the water, sewer, telephone and power lines.[230]

Despite being run by the NSF for over forty years, there is still elements of McMurdo that show its military roots. The dining facility at Building 155 still has separate sections, the E side (enlisted) and O side (officers) at which anyone may eat. Housing is still separated by the occupation and status of those living at the station. There are dormitories for staff, aircrew, scientists, and apartments for NSF personnel. This segregation harkens back to how Scott maintained structure within his Terra Nova hut.[231]

Beyond just a "galley", Building 155 acts a central hub for those living at McMurdo Station. It houses a store, photo and computer labs, the station's radio and televisions stations, the

[227] Collis and Stevens, "Cold Colonies: Antarctic Spatialities at Mawson and Mcmurdo Stations."; Davis, "A History of Mcmurdo Station through Its Architecture."; United States Antarctic Program, "Mcmurdo Station Master Plan 2.1."
[228] Collis and Stevens, "Modern Colonialism in Antactica: The Coldest Battle of the Cold War."; Davis, "A History of Mcmurdo Station through Its Architecture."; Klein et al., "The Historical Development of Mcmurdo Station, Antarctica, an Environmental Perspective."; Ramana, MV, "The Forgotten History of Small Nuclear Reactors," *IEEE Spectrum* 52, no. 5 (2015); Wilkes, Owen and Mann, Robert, "The Story of Nukey Poo," *Bulletin of the Atomic Scientists* 34, no. 8 (2015).
[229] Stone, E., "Cold Comfort (Mcmurdo Station in Antarctica)," *American Scholar* 77, no. 3 (2008).
[230] Alvine, Joe, "Policy and Science of Geothermal Heat Use at Mcmurdo Station, Antarcrtica," (2010).
[231] Collis and Stevens, "Modern Colonialism in Antactica: The Coldest Battle of the Cold War."; Davis, "A History of Mcmurdo Station through Its Architecture."

offices for the newspaper, and resident life offices. Other services provided there include a barber, library, and artificially lit sunroom.[232]

Several dormitories are located around the station to accommodate the large summer population. Throughout the summer the majority of rooms are kept at double occupancy, which minimizes any hope of solitude or privacy. Beyond the occupation division mentioned above occupation, assignments are also made based on the number of months spent in Antarctica, priority being given to those who have wintered over. Descriptions and images evoke images of aging college dormitory facilities.[233]

Intermingled in these very hard resilient buildings is a wooden structure that is known as the 'Chalet'. Built in 1970, it houses the National Science Foundation's headquarters. The design evokes a feeling of a Swiss ski lodge, using wooden cladding and deep eves on a pitched roof to achieve this. The headquarters is one of the few times at McMurdo that aesthetic form alongside functionality as well as a conscious nod to a vernacular architectural form that is complementary to the surrounding natural landscape, albeit from a different hemisphere.[234]

Another building at McMurdo that stands out is the Chapel of the Snows. The original Chapel was constructed by volunteers from material left over after the initial shelter construction. That original form was renovated over time to include a steeple and stained glass windows. After a fire in 1978, it was rebuilt a little over a decade later.[235]

Building 155

There are several buildings at McMurdo used for housing occupants. However, the structure that is the focus of this research is Building 155. The usage of Building 155 is more similar to the multipurpose function of the other cases, versus the singular dormitory focus of the other options at the station. Building 155 was constructed in 1969 to consolidate dining, housing, and recreational activity into one more massive structure. The location of the building is along the original axes of the military layout of the original station.

Building 155 is broken down into three main zones; a two-story dorm and lounge space, the dining and kitchen, and then support areas to the northeast. The primary public entrance is along the eastern façade, with emergency exits along the south, and utility access along the west. A vestibule transitions occupants of the station to a central lobby area inside Building 155. There are handwashing stations directly adjacent to the main doors to promote health

[232] Collis and Stevens, "Cold Colonies: Antarctic Spatialities at Mawson and Mcmurdo Stations."; Davis, "A History of Mcmurdo Station through Its Architecture."
[233] Collis and Stevens, "Cold Colonies: Antarctic Spatialities at Mawson and Mcmurdo Stations."; Stone, "Cold Comfort (Mcmurdo Station in Antarctica)."
[234] Collis and Stevens, "Cold Colonies: Antarctic Spatialities at Mawson and Mcmurdo Stations."
[235] Ibid.

within the station.[236] Stairs to the right lead up to the galley and subsequently to the second floor. Additionally, monitors within this space provide information for the arrivals and departures of flights for user reference.

The corridor that follows the trajectory of the entrance is lined with information about life and activities at McMurdo. This is also where general housing management offices are located. There is also coat storage, communal computer labs, restrooms, and the station store. The other more public corridor in this section of the building is to the left of the entry lobby, along this segment are several lounges, radio station offices, craft room, and barber. The remainder of the first floor is dedicated to shared dormitory rooms. Two halls create a square parti with the previously described corridors. Additional hallways break the housing section in a figure-eight configuration with rooms along the exterior perimeter, a block of interior rooms and a block with the men's and women's bathrooms. In each corner, stairs are leading to outdoors as well as the second story of the housing section.

The second story has a similar layout to the floor below it. However, there are less public use spaces. It is dedicated to shared dorm rooms with two pairs of gendered bathrooms and a sauna. There is one larger lounge space in the south-eastern corner. From videos and photographs, the bedrooms are outfitted similarly to standard college dormitories. Furniture is customizable for users with beds, dressers or wardrobes, and sometimes a desk and chair. These are rugged construction, often with wood-like aspects.

The galley and kitchen round out the remainder of the building that is being focused on for this research. Within the dining area, still referred to as the galley, there are two main areas, a holdover from the military origins of McMurdo with separate facilities for officers versus enlisted men. There are skylights to help naturally illuminate this larger area during the summer months. Furniture is simple, typical cafeteria-style round and rectangular wooden tables in clusters.[237] In between the standard commercial kitchen and the dining is the serving area. There are various options within the serving area with a grill, deli, and dessert stations as well as providing takeaway options.

4.4.5 Future Consolidation

Over the life of McMurdo Station, there have been many attempts to formulate Long Range Development Plans. Many of the earlier efforts lacked funding and were not fully implemented; most buildings were replaced or built on an 'as need' basis. Recently, however, there has been a more organized focus on developing and adhering to a formal master plan

[236] Dudzik Antarctica Adventures; "Heart of Mcmurdo Station - Building 155 (Must Know!)".
[237] Antarctica Adventures.

for the station. The most current iteration is the *McMurdo Station Master Plan 2.1*, which was published in 2015.[238]

Creating a unifying image is a primary goal. As described in the previous section, the buildings that make up the fabric of McMurdo represent almost the entire history of the station. They are in varying conditions, made up of different materials, have different styles, appearances, and shapes. The NSF wanted to develop a set of design parameters going forward that reflects the scientific endeavours conducted there, showing strength and permanence.[239]

Whatever design is implemented must be adaptable. To promote energy efficiency, the NSF requires future building(s) to be able to accommodate the summer population, but also be comfortable and sensible for the smaller winter inhabitants. Additionally, environmental stewardship is a prominent focus going forward, working with building orientation to take advantage of passive daylighting opportunities and using high-performance materials to create the building envelope.[240]

In response to occupant comfort, the NSF wants opportunities that promote communal well-being to be considered. In addition to the benefit of natural lighting, designers should consider the surrounding views while siting any future buildings as well.[241]

While the Master Plan outlines these recommendations, a key component is a design proposal for restructuring the central core of the station. This plan centralizes the central services, fire/medical, trades, field and science support closer to the existing lodgings. Many of the larger and more recently constructed buildings that formerly housed those functions are repurposed to consolidate the support elements.[242]

4.4.6 Integration of Biophilic Attributes

Direct Experience of Nature

There is a significant difference between McMurdo and the previous HAE cases that potentially would foster a more significant direct experience with nature, prior knowledge and habitation of the site. The site for McMurdo was scouted before the establishment of the base. The station had been running for less than a decade before Building 155 was constructed, therefore, potentially, with greater familiarity engenders greater connect. Not so. Building practices, while more advanced, were still focused on the primary goal of shelter. Many of the incorporations of direct experiences are integral to the basic building fabric. They are used in

[238] Davis, "A History of Mcmurdo Station through Its Architecture."; United States Antarctic Program, "Mcmurdo Station Master Plan 2.1."
[239] "Mcmurdo Station Master Plan 2.1."
[240] Ibid.
[241] Ibid.
[242] Ibid.

methods that promote an indirect connection, buffering the occupants from what was still perceived to be a hostile environment.

Light

As the largest structure analysed, Building 155 prioritized natural light differently. Due to its size, the dorm area does not have the ability for similar organizational layout, resulting in internal bedrooms without any windows. This does not pose as much of an issue due to the vastly different circadian rhythms of Antarctica. It was noted that many inhabitants who do have a window developed various self-constructed methods of blocking out the overabundance of sunlight during the summer months.[243] In the dining area, there are skylights to bring natural light further into the space. The other housing buildings at McMurdo Station have their communal spaces with larger windows oriented towards the water. Building 155 is older and lacked the same consideration in planning; instead, windows are on a uniform grid within the panelized system.

[243] Davis, "A History of Mcmurdo Station through Its Architecture."

Air

Atypical of contemporary building practices in Antarctica, there are operable windows in some of the buildings at McMurdo. Which do get used, they compensate for heating/cooling issues, not natural ventilation.[244] It is unclear why this design decision was made, but it allows occupants to control the temperature of their rooms, suiting their individual needs. This is a reflection of an ineffective heating/cooling and ventilation systems. The aging of the structures has prompted 'do-it-yourself' shading devices that often incorporate insulation or draft prevention from inefficient or leaky windows.[245]

Water

Potable water is provided to the station through desalinization of seawater with a reverse osmosis system from the McMurdo Sound, differing from the other cases studied. Due to the population size, this is more efficient and less damaging to the surrounding environment than snow/ice melt. It is still an energy-intensive process, which was previously lessened by the nuclear power plant. The station struggles with the water demand during peak occupancy, summer, and water rationing is employed. As fixtures need to be replaced, water-saving versions are used as alternatives to help lower the overall consumption.[246]

[244] Ibid.
[245] Ibid.
[246] Ibid.

Plants

There is a separate greenhouse located at McMurdo Station. Comply with the Madrid Protocol; the plants are grown hydroponically. Artificial lighting is also used to provide an appropriate diurnal cycle for productive plant growth.[247] The plants grown are used to supplement the food for the station's inhabitants and provide fresh produce during the winter months.

Animals

Due to the Madrid Protocol, there are no animals presently included in the stations planning. However, previously sled dogs were housed there, and some non-endemic animals were used for scientific observations. There were also rumours of a mouse stowaway and a pet hamster smuggled onto the base.[248]

Landscapes

When siting McMurdo Station, there was no documented effort to mitigate the impact their structures had on the surrounding landscapes similar to that of the HAE. There are also no recreated landscapes that mimic what occupants are familiar with from their source country. The Madrid Protocol prevents this to protect the endemic landscape from potential invasive species. With the protocol, there has been more of an effort to restore landscape when buildings are no lingered used. Also, with the proposed station consolidation, the goal is to have less of an impact on

[247] Kuenning, Kris, "Green Antarctica: Station Greenhouses Produce Fresh Food, Feel-Good Environments," National Science Foundation, http://www.spaceref.com/news/viewpr.html?pid=13724.
[248] Headland, R. K., "History of Exotic Terrestrial Mammals in Antarctic Regions," *Polar Record* 48, no. 02 (2011).

the site. Though in doing so, further separating the occupants from the landscape.

'Weather'

As with the other cases, the climate is viewed as an attribute to be resolved through architecture, and a solution is found with the building envelope. With a station made up of multiple buildings, the wind and drifting snow create further considerations as well. The structures are separated to mitigate wind tunnels and drifting snow; they are spaced out also to avoid the spread of fire. However, as elaborated on in the Site Conditions and Building Development sections, the overall organization and orientation of the buildings is not a reflection of the natural elements. There are windows near the entrances, which allows occupants to visually see the conditions prior to exiting, so they can be prepared.

Views

Common to contemporary building practices, access to views of the surrounding environment was prioritized for communal spaces in the accommodation buildings at McMurdo Station. This can be seen with the staggered setting of the other housing buildings, allowing their lounges to have a view over McMurdo Sound as the buildings step down along the topography. However, as previously discussed, Building 155 does not appear to have aimed to located windows or orient the building to frame specific views.

Fire

For safety reasons, there is no presence of open flames or fire within the station. Any combustion is contained within the plant rooms or mechanical buildings.

Indirect Experience of Nature

The incorporation of Indirect Experiences at McMurdo are more diverse than that of the HAE. Ease of transportation aided in more 'luxury' items beyond that of pure shelter. These attributes primarily tie back to the United States and with individual interventions, precisely where they are from in the US. While there are some instances where attributes relate to the Antarctic environment, it is often where that is inescapable. Frequently the building is reacting to the aspect rather than incorporating it. More regularly, the occupants are striving to create a sense of familiarity within an alien environment, to develop a sense of home for themselves temporarily.

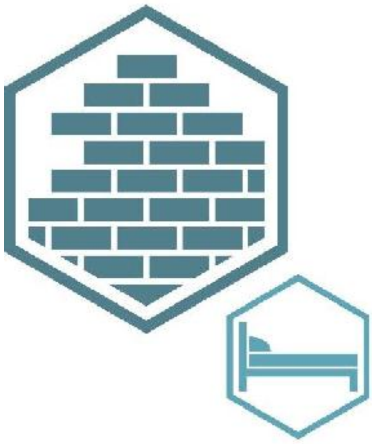
Images

The USAP runs a fellowship program which invites artists and writers to experience what life is like in Antarctica. The buildings at McMurdo have benefited from this with works of art remaining at the station. Inhabitants have also contributed to public displays, which includes Antarctic landscape panoramas.[249] These images help to bring awareness and connection to the natural environment where the inhabitants are living.

Within the living spaces similar to what was discussed in the HAE, inhabitants can customize their rooms with personal images, which appear to also flow out into the corridors, creating seasonal identities for specific areas.

[249] Davis, Georgina A., "A History of Mcmurdo Station through Its Architecture," ibid.53 (2017).

Materials



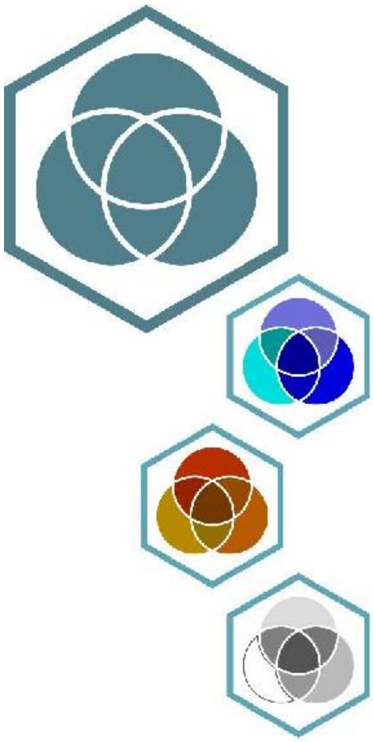
Following what has been observed in previous cases, endemic natural materials were used to construct the station. There is no documented description of the materials utilized in the lodgings at McMurdo Station; however, from observing videos and photographs, the primary factor in selecting materials is durability. The construction appears to be typical commercial construction with standard materials, typical of the IGY and later stations; painted wallboard, metal door frames, tile, rubber skirting, linoleum-type flooring in high traffic areas, and low pile carpet in others. While this is a familiar material palette for the occupants, it is mostly devoid of natural materials from the source country, the only inclusion of wood appears to be in furniture.

Texture

This section is limited similarly to the *Materials* section. There is a uniformity to the textural properties of the materials that make up the basic fabric of the accommodation buildings. One significant instance is in the use of flooring, a transition from transitory or circulation space to that of more sedentary (lounges or dining) or personal areas (bedrooms). Also introducing another texture, which brings specific attention to this area, is the tile backsplash behind the handwashing station. While this was done for pragmatic waterproofing, the difference in wall treatment highlights this as an area of importance.[250]

[250] "Handwashing," Antarctic Arctic Files, https://antarcticarctic.files.wordpress.com/2012/10/handwashing.jpg.

Colour



The interior colours of the accommodation buildings are neutral, generally warmer tones; however, in the common areas of Building 155, there is a distinctive grey/blue scheme. Any personal decoration or works of art augment the existing palette. The exteriors of the buildings are similarly earth tones with tans and browns, though recently Building 155 was repainted to be a brilliant blue.

Shapes and Forms

The overall rectilinear form of the buildings offers no connection to organic characteristics. The shape is derived from the use of prefabricated panels for ease of transportation and construction. While advances in material technology, the ability to transport materials, and skilled labour had shifted since the HAE, the climate and limited building season still made buildings constructed from a 'kit-of-parts' the most practical.

Information Richness

The layers of the other attributes work together to create an ever-changing interior environment for the occupants of McMurdo Station. The basic palette of the building fabric is very neutral and institutional, often compared to that of a University8888888 dormitory; practical and durable. It is through the interventions of those living there that depth and identity begin to form.

They don't necessarily complement each other, but they develop a habitation pattern that is expressed through ornamenting the public face of the personal space.

Change, Age, and the Patina of Time

Differing from the HAE huts, which were viewed as temporary, the infrastructure at McMurdo is designed to have a longer lifespan. The materials and building techniques were selected to support that and slow the aging and wear process. However, weathering to buildings is inevitable in the Antarctic environment. As is typical, the buildings at McMurdo are subjected to freeze/thaw cycles, ice, high winds, and salt air from proximity to McMurdo Sound. The material selection has developed to attempt to withstand these natural processes; however, as illustrated by the window issue discussed in the *Air* section, maintenance is a continual process to keep the buildings habitable.

Natural Geometries

There is no evidence that natural geometries were considered in the planning of the living accommodations at McMurdo Station. While they do generally follow a grid form, as discussed later, it is based on building material and ease of transport rather than natural sequencing.

Simulated Natural Light & Air

The accommodations at McMurdo rely on artificial lighting to be functional. The bedrooms are outfitted with overhead lighting and individual desk lamps for task lighting. The remainder of the spaces relies on overhead light fixtures. This lighting is stagnant, not programmable to simulate diurnal cycles; some occupants bring their own solar clocked to resolve this lack of control.[251]

As discussed in the *Air* Section, there is a significant amount of unintentional natural ventilation, making some spaces prone to drafts. This aids in what is found in the non-drafty areas as inadequate artificial ventilation. It is unclear what contributes to this issue, but it was alluded to a lack of updated infrastructure or adequately sized equipment.[252]

Biomimicry

Biomimicry is not an acknowledged source of inspiration for the buildings at McMurdo; from observation, it does not appear to be incorporated in any way.

Experience of Space and Place

Life in Antarctica it is almost impossible not to be aware of where one is living, especially with a multiple building station like McMurdo. While the relationship between occupants and natural surroundings is similar to the HAE, there are many ways that it changed. Material advances enabled more efficient buffering from the conditions, but it also allowed for more indirect opportunities for connections. McMurdo is also uniquely sited in an area of Antarctica that is rich in history and culture of the HAE.

[251] "A History of Mcmurdo Station through Its Architecture."
[252] Ibid.

Prospect and Refuge

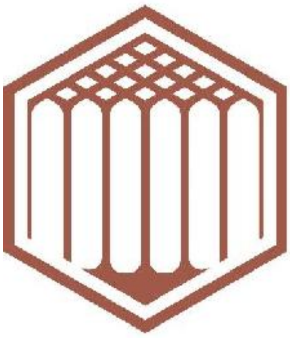
When siting McMurdo, the priority was accessibility. What this entailed was locating near water for boat access as well as hopes of locating an ice landing strip for planes. This consideration sited the station adjacent to open water which tucked it up between two valleys, providing both natural prospect and refuge. The former being the view of approaching transportation, weather conditions, surrounding environment, while the latter offers physical geographic protection behind the station. Within the living buildings, the views towards the sea are cultivated by orienting the buildings and having larger windows to take advantage of them in the common spaces.[253]

The interior manifestation at McMurdo station is dealt with similar to a University dormitory, more looking at public versus private. The majority of the bedrooms at McMurdo are semi-private[254], shared by at least two people, meaning that their "personal" area is contained within their bunk or bed space. In all of the buildings, there is at least one common lounge space, for communal socialization and gatherings. Within Building 155, there is a broader spectrum to the public spaces in terms of size and function.

Figure 4-7 Hierarchy of McMurdo Station's Building 155: station to building to zones to rooms to bunks

[253] Ibid.
[254] Ibid.

Organised Complexity



Within Building 155, there is some complexity and some organisation; however, there is little overlap between the two, creating a lack of balance this attribute desires. The living portion of the building has plenty of diversity and detail with the occupants' customization and informational posters in the primary corridor. These decorations don't have an overarching configuration to order them, which can lend itself to a more hectic feeling. Conversely, the dining areas are much more structured, but then it lacks the visual stimulation that is craved in the Antarctic with a muted natural pallet.

Mobility

For the majority of the living buildings, the circulation pattern is straightforward, employing a double-loaded corridor to allow the bedrooms to have an external window. Building 155, due to is size does not follow the same pattern as the other living buildings at the station. In the bedroom areas, circulation spaces are kept internally, allowing for access to exterior windows for occupied rooms. The stairwells are predominantly in the corners, with external egress points. Internally the corridors figure-eight around banks of internal bedrooms, bathrooms, and communal spaces. The dining is laid out more open, allowing the area to be reorganized as needed. The adjacent kitchen is broken up into smaller rooms suited to their usage with circulation by allowing controlled access.

A difficulty that was noted with the circulation spaces within the station was the size of the hallways. Using standard dimensions for the width of a corridor becomes an issue when the people using it are bundled up in multiple thick layers for the extreme cold.[255]

Transitional Spaces

Even with advances in material technology and building practices, airlock entrances are still used to transition occupants from the outdoors to the indoors. Differing from the huts of the HAE, there are multiple entrances to each other the buildings for safety and security purposes, not all of them have their own vestibule. Saving space, only the formal entrances are equipped with such; other emergency exits are often combined with a stairwell, which is typical construction in the USA.

The transition from the outdoors to the indoors is more complicated than that of the huts, particularly in Building 155. The entry vestibule leads to a handwashing station to mitigate the transmission of sickness through the station. Following is a series of coatrooms for the outdoor gear to be stored before entering the mess hall.

Internally the typical dorm building with a simple layout has public versus private transitional spaces; between dorm rooms and the common areas. Again, Building 155 is a bit more intricate. The building, itself, is broken into three main zones separated by changes in elevation and doors. These are the private dorm space with some common areas, operational and station-wide communal functions, and then the kitchen and mess hall.

[255] Ibid.

Place

Geographical – As discussed in the *Landscape* Section, McMurdo's location is tied to its very existence. McMurdo was initially just a supply depot to support the other stations during the IGY, with very little scientific activity planned. However, partially because of the geographic properties it developed into the largest station in Antarctica. McMurdo has maintained a connection to its roots as a gateway to the USAP. Scientists and crew members pass through the station prior to progressing to Amundsen-Scott.

Ecological – The ecological features of the site are similar to that of Scott's Hut, making it an appealing site for scientific research. The climate on Ross Island presents a variety of Antarctic flora and fauna. Located near Mount Erebus expands upon the geological possibilities, as well as glaciology studies.

Cultural – While many stations/expeditions/huts have an individual identity, McMurdo has developed a clear cultural characteristic. As described in 4.4.4 Building Development, McMurdo has gained a reputation as evoking the feeling of an old US western frontier town, not entirely lawless, but less structured, ready to let loose when not working hard. A larger population base (1,200 in the summer) has fostered unique developments of subset social groups. Within the buildings themselves, the subset groups often ornament their areas of residence as described in the *Information Richness* Section.

Historical – Ross Island is steeped in Antarctic history, going back to the Heroic Age of Exploration with Shackleton's and both of Scott's Huts located there. McMurdo's own history starts with the first large scale contemporary occupation of the continent for the IGY. The station itself is located quite close to Scott's *Discovery* Hut and still has remained from early

Jamesway huts lingering. Some of the history is on display in Building 155 near the Galley with display cases showing artefacts and equipment from days past.

Integrating Parts to Create Wholes

Continuing from the HAE, Building 155 lacks a connection which integrates the occupants to the greater natural environment. Similarly, the structure's primary purpose is to shelter the occupants, which creates a buffer but also isolates them. This can be seen in the previous attributes have been incorporated in a more indirect method, and favouring the inclusion of natural aspects from 'home' rather than from Antarctica.

4.5 CASEY STATION

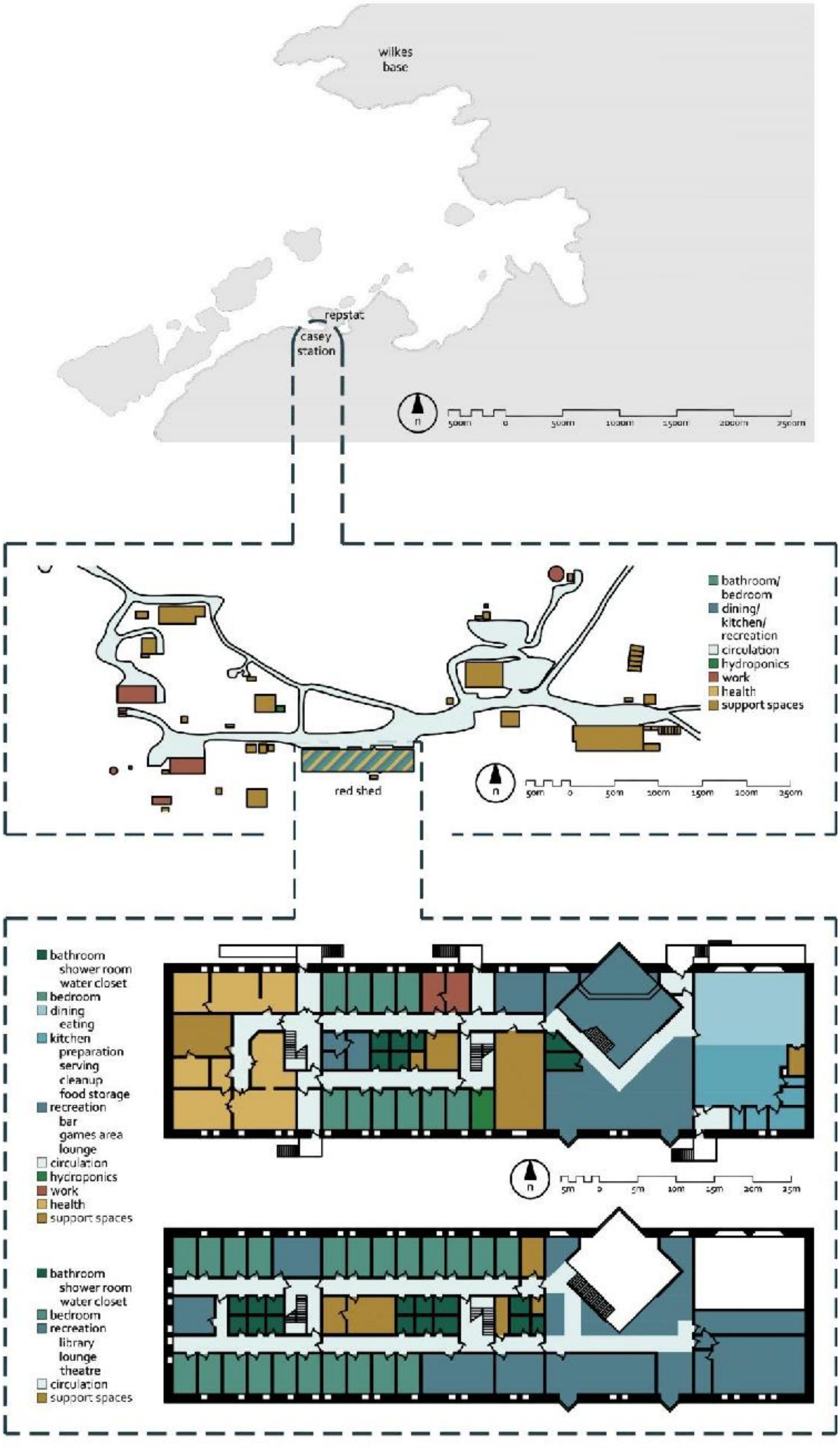


Figure 4-8 Casey Station's Red Shed – Site, Orientation, Floor Plan[256]

4.5.1 Sources

Within Chapter 4 and Chapter 5, much of the material presented is from examinations of archival research. Where applicable, specific sources are cited. General observations and analyses are from floor plans[257], photographs[258], AAD blog[259], and youtube videos[260]. Any specific item is referred to specifically if applicable.

The plans for this analysis were generated from Incoll's paper *The Influence of Architectural Theory on the design of Australian Antarctic Stations*.[261] These were conceptual design plans, not the final construction documents, differences in the plans and the finished design observed in video or photographs are noted. To preface that, in a 2019 video[262] it appears that additions have been made to the east and west wings of the Red Shed, without the specific design plans of these additions available they will not be included within the analysis.

4.5.2 Background

The station at Vincennes Bay has gone through several different identities and ownership shifts. It was initially called Knox Coast during the planning of the International Geophysical Year, but soon became known as Wilkes Station.[263] Later after transferring from the United States to the Australians, it went through two renovations and name changes from REPSTAT to what it is called today, Casey Station.

Wilkes was not originally a station that the United States was planning on developing. However, it was politically motivated. With a series of Soviet stations located in Australian sovereignty, the United States positioned Wilkes as a buffer between Mawson Station (AUS) and Mirny Station (RUS). Before development and signing of the ATS, concerns were expressed regarding sovereignty and territory grabbing during the IGY by countries without claims. So while the Australians were grateful for Wilkes' location, they also wanted to ensure that IGY parties were aware that they were located within their territory. This did not always

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256 Graphic by Author – developed from Incoll's The Influence of Architectural Theory on the design of Australian Antarctic Stations

257 Incoll, Phil, "The Influence of Architectural Theory on the Design of Australian Antarctic Stations," (Australian Construction Services, 1990).

258 Jolley, Dianne to Twitter, June 09, 2020, 2017, https://twitter.com/drdiannejolley/status/939799857140658177; McBride, Kerry to The Crafting Pint, June 09, 2020, 2016, https://craftypint.com/news/1288/Cold_As_Ice_Brewing_In_Antarctica; Standaloft, Brett, June 09, 2020, 2012, http://brettinantarctica.blogspot.com/; Rowarneleith to Casey Station, June 09, 2020, https://rowarneleith.wordpress.com/casey-station/.

259 to This Week at Casey, June 09, 2020, 2020, https://www.antarctica.gov.au/news/stations/casey/.

260 AntarcticStreams, "2020-04-18 Casey Station Antarctica," Youtube, https://www.youtube.com/watch?v=ho-KVWMTc0g; Shaw, Stuart, "'Casey's Back' - Antarctic 48hr Film Festival 2017 - Casey Station," Youtube, https://www.youtube.com/watch?v=6NV-Ne79HNw; AusAntarctic, "Living at Casey Station, Antarctica," Youtube, https://www.youtube.com/watch?v=t6aPVAe3k5I; Compagnoni, Tom, "Antarctica - a Week at Casey Research Station," HuffPost Australia Youtube, https://www.youtube.com/watch?v=_jdcLNRiHCA.

261 Incoll, "The Influence of Architectural Theory on the Design of Australian Antarctic Stations."

262 Compagnoni, "Antarctica - a Week at Casey Research Station".

263 Bowden, Tim, *Antarctica and Back in Sixty Days* (Sydney, AUS: ABC Enterprises, 1991).

sit well with the other parties involved. During the IGY and with the ATS, the United States, in particular, emphasized the lack of recognition of sovereignties.[264]

Similar to McMurdo, construction on buildings at what is now known as Casey Station was completed for the IGY. Though, while McMurdo has grown in an additive process, Casey Station had developed in a different manner. Known initially as Wilkes Station, the base was established as part of the USA's research during the IGY. It was made up of Jamesway huts and Clemsons, unsurprisingly the same building types as McMurdo and only took 17 days to set up.[265]

Soon after the IGY, the USA gave custody of the station to the AAD (AAD) in 1959. There is some interpretation as to how this occurred; whether the USA abandoned Wilkes Station[266], if it was gifted to Australia[267], or the USA 'wanted out' and Australia saw the opportunity to gain an additional station[268]. For the early part of Wilkes post-IGY history, it was shared between the Australians and USA; there was some dispute over flag precedence, which nations' should be flown higher. An egalitarian solution resolved the issue with two flag poles. Due to the initial siting of the station resulted in it being almost completely buried in snow each winter.[269]

4.5.3 Site Conditions

The location is on the edge of the Antarctic Circle, meaning that the site faces different conditions than others, namely seasons and less extreme daylighting. The presence of open water also promotes warmer temperatures at the station. Which means that there is a thaw period in the spring and summer frequently has temperatures above freezing. While this might seem delightful in comparison to the rest of the cases, Vincennes Bay experiences similar katabatic winds as Commonwealth Bay and severe winter storms.[270] These both present design challenges, building materials which can withstand regular free/thaw cycles, combat drifting snow, and cope with high winds.

The preliminary evaluation of the surrounding landscape by the meteorologist Rudolf Honkala was described as desolate and sterile, comparing it to a lunar landscape. He revised his assessment as he observed the variety of plant and animal life in the area.[271] There are a variety

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[264] Belanger, *Deep Freeze*.
[265] "Cultural Heritage at Casey," Australian Antarctic Division: Leading Australia's Antarctic Program, http://www.antarctica.gov.au/about-antarctica/history/stations/casey/casey-cultural-heritage; Bowden, "Founding Davis and Casey Stations."; Lazer, Estelle, "Antarctic and Sub-Antarctic Cultural Heritage," (2006).
[266] Clark, Linda and Wishart, Elspeth, "The Frozen Face: Using Oral Histories in Museum Exhibitions," *Oral History Association of Australia Journal, The*, no. 18 (1996).
[267] "Wilkes Station," Australian Antarctic Division: Leading Australia's Antarctic Program,, http://www.antarctica.gov.au/about-antarctica/history/stations/wilkes.
[268] Bowden, "Founding Davis and Casey Stations."
[269] "Cultural Heritage at Casey"; "Casey Station a Brief History," Australian Antarctic Division: Leading Australia's Antarctic Program,, https://www.antarctica.gov.au/about-antarctica/history/stations/casey/; "Founding Davis and Casey Stations."
[270] Belanger, *Deep Freeze*.
[271] Bowden, *Antarctica and Back in Sixty Days*.

of plants available at Casey station due to its longitude. There are several species of moss, liverwort, and lichens. Also found are terrestrial and snow algae. The moss beds, in particular, relate to ancient penguin colonies, feeding off the fertilizer of the residual guano.[272]

The ground at Vincennes Bay differs from many other sites in one fundamental way; it is not ice-rich. The soil fond there is a combination of gravel, moraine, and rocky outcrops, which allows for any building to be constructed directly on the ground without the worry of the same heat loss and melting ice that other areas present.[273] It is also classified as 'ice free', which, with the temperature swings at Casey Station means that building foundations do not have to accommodate the expansion and contraction of freezing and thawing ice.[274]

During Operation Highjump it was noted that Vincennes Bay would be an ideal location for a future station. Beyond this recommendation, the siting was more political than scientific or climatic, as discussed above. The site was initially accessed by icebreaker, with the intent of developing an airstrip.[275]

The original site was in what was thought was a sheltered valley on a rocky outcropping.[276] However, this site was eventually abandoned due to drifting snow causing structural damages to the station.[277] The snow did not completely melt during the summer months, the remaining snow would compress and freeze to ice during the winter and would be added to with the drifting snow.[278]

REPSTAT was developed with a different approach. Using an elevated station with a north-south orientation, the intention was to avoid drifting snow. The site emphasized this, rather than being in a valley, it was located on a promontory. The leading edge of the structure was oriented into the wind was curved with a walkway contained within the uninsulated connecting structure. [279]

In a reaction to the failure of a singular connected REPSTAT, Casey Station was developed as a series of a cluster of individual buildings. Their primary orientation is with the longer axis parallel to the drifting snow.[280] These are situated on low rocky outcroppings further inland from where REPSTAT was located.[281] The site is close enough to the open water for access to the ice breakers, and also near the Wilkes Aerodrom for air support.

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[272] "Casey: The Daintree of Antarctica," Australian Antarctic Division: Leading Australia's Antarctic Program,, http://www.antarctica.gov.au/about-antarctica/wildlife/plants/casey-the-daintree-of-antarctica.
[273] Nelson, Lisa, "Human Habitation in Antarctica" (1991).
[274] Incoll, "An Overview of Antarctic Buildings and Services for Administrators, Scientists and Engineers."
[275] Belanger, *Deep Freeze*.
[276] Ibid.
[277] Nelson, "Human Habitation in Antarctica."
[278] Smith, GDP, *Design and Development of Australian Antarctic Stations and Buildings* (Department of Supply, Antarctic Division, 1972).
[279] Incoll, "The Influence of Architectural Theory on the Design of Australian Antarctic Stations.", Smith, *Design and Development of Australian Antarctic Stations and Buildings*.
[280] Incoll, "The Influence of Architectural Theory on the Design of Australian Antarctic Stations."
[281] "Location of Casey Station," Australian Antarctic Division: Leading Australia's Antarctic Program,, https://www.antarctica.gov.au/living-and-working/stations/casey/living/location/.

4.5.4 Building Development

Wilkes Station

For the International Geophysical Year, the United States developed the Wilkes Station in 1957. Very similar to that of early McMurdo and Amundsen-Scott, these were temporary structures, not intended to function longer than the event needed.[282] They were timber-framed panelled buildings with plywood sheathing and fibreglass wool insulation. A key distinction for the occupants was the roominess of the living and working spaces in comparison to the other Australian Stations.[283] Once Australia formally took over the station in 1959, they used the existing structures until they were structurally unsafe.[284]

Outlined by the ATS, sites that are pre-1958 qualify for automatic protection, which covers the Wilkes Station. It was considered an excellent example of IGY architecture since it is one of the few remaining that is the most intact. Despite that, there does not appear to be an effort made to preserve Wilkes Station. The buildings were documented by Linda Clark and Elspeth Wishart in the 1980s and 1990s, including interviews with former inhabitants. It is unclear who has jurisdiction over the site if it belongs to the USA or Australia. The site itself is almost completely covered and filled with snow and ice, emerging only in the rare warm summer.[285]

REPSTAT

During 1964 construction began on what would officially be known as Casey Station, though it became commonly known as REPSTAT (replacement station). Abandoning the Wilkes site as it was further buried in the snow, the new station stretched away from the coast in a linear fashion. Their goal with the new design was to create a complex that would resist drifting snow better while avoiding potential fire hazards.[286]

The buildings themselves were made up of insulated panels that were the standard practice of the AAD, identified as the Post Tensioned Box. The exterior of the panel had a metal layer for resilience; the interior surface could be customized based on the use of the building. The joints between the panels were sealed with rubber gaskets, creating a weak point in the building envelope, ultimately leading to the failure of this station. Once the gasket fails, it was impossible to replace or repair. These panels were strung with steel cables at floor and roof,

282 "Wilkes Station".
283 Smith, *Design and Development of Australian Antarctic Stations and Buildings*.
284 "Wilkes Station".
285 Clark, Linda, "Isolation: A Management Issue.[Management of Isolated Historic Sites and Buildingspaper Presented at the Australia/Icomos. Conference (1994: Launceston)]," *Historic Environment* 12, no. 3-4 (1997); Clark and Wishart, "The Frozen Face: Using Oral Histories in Museum Exhibitions."; Evans, Sherrie-lee, "Heritage at Risk," (2007); Lazer, "Antarctic and Sub-Antarctic Cultural Heritage."
286 "Cultural Heritage at Casey"; "Casey Station a Brief History"; "Changing Demands," Australian Antarctic Division: Leading Australia's Antarctic Program, http://www.antarctica.gov.au/about-antarctica/history/stations/history-of-australias-antarctic-buildings/changing-demands; Bowden, "Founding Davis and Casey Stations."; MacKenzie, Rod, "From Wilkes to Casey," ibid., no. 15 (2008).

which were tighten to secure panels together. The interior structure in the panels was timber-framed, which allowed for customization for windows and doors.[287]

The structures were elevated 2 m above the ground on a steel framework. For additional stability, guy wires were used to resist the winds. Each building was separated from the other by a distance of 7 m for fire protection. The elevated design made for colder floors and additional noise and movement with the wind.[288]

The most distinct element of this station was the device utilized to mitigate the extreme winds and snow building up at the site. Developed through wind tunnel testing, the eastern side of the line of buildings had a rounded corrugated metal profile connected to the exterior. This tunnel-like-structure connected most of the buildings, creating protected circulation space.[289]

While this external tunnel technique did provide the desired deflection and enhanced the ability to move between the buildings, it quickly developed its own problems. A blizzard nine months after its completion blew away multiple sections of the panels making up the tunnel. Also, being external to the building envelope, it was unheated. It was noted that expedition members, after a shower, would have frozen hair upon returning to their rooms after travelling through the tunnel.[290]

While this new station incorporated modifications based on prior experience with the similar building practices employed by the AAD at the other two Australians, as previously mentioned, REPSTAT eventually closed due to issues with the buildings. However, this was a significant point in AAD building practices in Antarctica, REPSTAT was the first larger scaled building project for the AAD. Rather than relying on the expedition members to complete building projects, a group of tradesmen were employed to complete the work over several summers, a significant shift away from the building practices established during the Heroic Age of Exploration. This additional expense meant that the neighbouring Davis Station was closed during that time to pay for the construction.[291]

The primary issues that developed at REPSTAT were primarily moisture based. The metal stilts supporting the structures began to rust. Water vapour built up on the interior began to

[287] "Cultural Heritage at Casey"; "Post Tensioned Boxes," Australian Antarctic Division: Leading Australia's Antarctic Program, http://www.antarctica.gov.au/about-antarctica/history/stations/history-of-australias-antarctic-buildings/post-tensioned-boxes; Incoll, Phil, "The Development of Australian Antartic Building Types" (paper presented at the The First International Offshore and Polar Engineering Conference, 1991); MacKenzie, "From Wilkes to Casey."; Pekin, "A Historical Appraisal of Structural Engineering Associated with Australian Antarctic Buildings."
[288] "Casey Station a Brief History"; Incoll, "The Development of Australian Antartic Building Types."; MacKenzie, "From Wilkes to Casey."; Pekin, "A Historical Appraisal of Structural Engineering Associated with Australian Antarctic Buildings."
[289] "Cultural Heritage at Casey"; Bowden, "Founding Davis and Casey Stations."; Incoll, "The Development of Australian Antartic Building Types."; MacKenzie, "From Wilkes to Casey."; Pekin, "A Historical Appraisal of Structural Engineering Associated with Australian Antarctic Buildings."
[290] Bowden, "Founding Davis and Casey Stations."
[291] "Changing Demands"; AURORA AUSTRALIS, "Davis Station Turns 50," (2007); Bowden, "Founding Davis and Casey Stations."; Incoll, "The Development of Australian Antartic Building Types."

rust the panels where the gaskets had failed. Also, the location of the station contributed the rust and breakdown, being close to the ocean, the salt from the sea spray proved to be corrosive. After 19 years, construction began again in at a nearby site for the new Casey station, which is still used today.[292]

Since Casey Station evolved by entirely moving to a new site each time it was rebuilt, the issue of Heritage or Preservation arises. The protocol for historic sites has been laid out by the ATS. [293] Unfortunately, at the time of the decommissioning of REPSTAT, the ATS required all non-habitable buildings to be dismantled and removed. So none of the original structure exists, which is generally acknowledged as a loss for the cultural heritage of Casey Station. That treaty obligation has since been modified to accept those nations can preserve recognized historical landmarks. Clark and Wishart did document this building as well in 1992 before its complete demolition.[294]

Casey Station

Casey Station today is more similar to the cluster layout of McMurdo, though much smaller. In the summer months, the station has 150-160 expeditioners and dwindles to about 20 for the winter. Of the three Australian Antarctic Research Stations on the continent, this is the largest.[295] Compared to other stations, it is relatively easy to access, being only a four-hour flight from Hobart, Tasmania and then another four-hour drive.[296]

The newer building technique used by the AAD is known as the Australian Antarctic Building System Prefabricated System. The buildings were designed to be larger, but with reduced numbers to lessen the footprint of the station. Site considerations, such as prevailing winds and drifting snow, should be observed to avoid doors and windows being blocked by snow. Repairs should be able to be completed easily to the extent that an entire panel could be replaced without dismantling the structure. [297]

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[292] "Casey Station a Brief History"; Bowden, "Founding Davis and Casey Stations."; Pekin, "A Historical Appraisal of Structural Engineering Associated with Australian Antarctic Buildings."
[293] Evans, "Heritage at Risk."
[294] Clark, "Isolation: A Management Issue.[Management of Isolated Historic Sites and Buildingspaper Presented at the Australia/Icomos. Conference (1994: Launceston)]."; Lazer, "Antarctic and Sub-Antarctic Cultural Heritage."
[295] Dapin, Mark, "What's Life Really Like for Australians Working in Antarctica?," *The Sydney Morning Herald*, 3 Decembe 2016.
[296] "Living at Casey," Australian Antarctic Division: Leading Australia's Antarctic Program, http://www.antarctica.gov.au/living-and-working/stations/casey/living; Phillips, Nicky, "Life at Antarctica's Casey Station," *The Sydney Morning Herald*, 1 March 2014.
[297] "The Beginnings of Aanbus," Australian Antarctic Division: Leading Australia's Antarctic Program, http://www.antarctica.gov.au/about-antarctica/history/stations/history-of-australias-antarctic-buildings/beginnings-of-aanbus; "Aanbus Modular," Australian Antarctic Division: Leading Australia's Antarctic Program, http://www.antarctica.gov.au/about-antarctica/history/stations/history-of-australias-antarctic-buildings/aanbus-modular; "Foundations and Lifestyles," Australian Antarctic Division: Leading Australia's Antarctic Program, http://www.antarctica.gov.au/about-antarctica/history/stations/history-of-australias-antarctic-buildings/foundations-and-lifestyles; Incoll, "The Development of Australian Antartic Building Types."; Strange, Carolyn, "Reconsidering the "Tragic" Scott Expedition: Cheerful Masculine Home-Making in Antarctica, 1910–1913," *Journal of Social History* 46, no. 1 (2012).

Buildings needed to provide accommodations for expedition members that were more comparable to what personnel at similar research stations in Australia would be provided. This included smaller details like acoustical attenuation, to avoid the previous complaints of noise during blizzards. It also extended to more aesthetic elements of the design, taking advantage of natural views and more appealing interior finishes and layouts. There is a great effort to provide single rooms for expeditioners, doubling up only occurs on a short-term basis during the summer months, a recent addition in 2016 helps with this.[298]

The primary living accommodation at Casey Station is known as the Red Shed, due to its exterior colouring (all the buildings at the station are colour coded based on their use). It houses the library, kitchen, dining, lounge, and a presentation room in addition to housing and bathrooms. There is also a sauna and spa for the expeditioners. Expedition members have also established a small onsite brewery. The social structure at the station is less restricted than at McMurdo, while the inhabitants are not working. The rooms are not segregated by occupation.[299]

In addition to the buildings, there are recreational opportunities around Casey Station as well. A cross country ski loop has been established behind the station. In 2012 a pair of expeditioners endeavoured to create their own marathon that involved a runner and a skier going from the station to the Antarctic Circle. In 2017 another pair of expeditioners decided to test the field manual's guidelines on building an emergency igloo, which one of them stayed in overnight. Another enterprising expeditioner built an outdoor theatre out of a snowbank, complete with a projection screen and seating [300]

Many of the experienced expeditioners promote the natural entertainment that can be found in the local penguin population or dynamic of the shifting snow and ice while noting that the newer inhabitants are more connected to technological entertainment with their

[298] "Foundations and Lifestyles"; "Living at Casey"; Frydenberg, Josh, "New Antarctic Accommodation Facility at Australia's Casey Research Station," news release, 2016; Incoll, "The Development of Australian Antartic Building Types."; Robertson, James, "Cold Comfort in Antarctica at Casey Station," *The Sydney Morning Herald*, 18 December 2013; Strange, "Reconsidering the "Tragic" Scott Expedition: Cheerful Masculine Home-Making in Antarctica, 1910–1913."

[299] "The New Designs," Australian Antarctic Division: Leading Australia's Antarctic Program, http://www.antarctica.gov.au/about-antarctica/history/stations/history-of-australias-antarctic-buildings/the-new-designs; "Living Accommodation," Australian Antarctic Division: Leading Australia's Antarctic Program,, http://www.antarctica.gov.au/living-and-working/station-life-and-activities/living-accommodation; Dapin, "What's Life Really Like for Australians Working in Antarctica?."; King, Kevin, "The 2011 Resupply Voyage to Casey Station, Antarctica," *Australian Journal of Maritime & Ocean Affairs* 4, no. 4 (2012); Phillips, "Life at Antarctica's Casey Station."; Robertson, James, "Cold Comfort in Antarctica at Casey Station," ibid., 18 December 2013; Rowarneleith.

[300] "Ice Marathon," Australian Antarctic Division: Leading Australia's Antarctic Program, http://www.antarctica.gov.au/news/2012/ice-marathon; "School's Virtual Visit to Casey Research Station," Australian Antarctic Division: Leading Australia's Antarctic Program,, http://www.antarctica.gov.au/news/2014/schools-virtual-visit-to-casey-research-station; Pash, Chris, "The Mystery of the Igloo at Australia's Casey Station in Antarctica," *Business Insider Australia*, 1 May 2017; Robertson, "Cold Comfort in Antarctica at Casey Station."

smartphones. People can also get away from the main base to vacation at smaller huts in the surrounding area.[301]

Also at the station is a hydroponic greenhouse. It produces fresh vegetables and fruits to supplement the supplies brought by the expeditions in the winter months. The inclusion of a greenhouse is not an unusual practice; Casey Station has had some form of plants or greenhouse since 1969. Though what is allowed is strictly regulated by the ATS to avoid the potential spread of invasive species.[302]

Red Shed

The Red Shed has undergone a variety of renovations and additions, which can be seen in photographs. This description, however, covers the initial conceptual designs, as seen in the floor plan earlier in this section.

In this plan, there are five entrances, with their own set of stairs leading up to a platform directly in front of the door. Internally, the entrances lead users through a cold porch to isolate the tempered indoor air from the outdoors. It also provides an area for putting gear on or taking it off before entering or exiting the building.

Starting with the entrance in the north-west corner, it leads to the primary communal gathering spaces. Inhabitants of Casey Station come into the main lounge, bar, and games area. To their left is the dining hall and kitchen, the latter which has its own entrance for deliveries. The lounge is sunken down a step and on a 45° angle to the primary geometry, creating a separate space that is still open to the rest of the space. It is in this lounge that the original plans had a fireplace, planters, and discussed the potential for fish tanks in the AAD stations.[303] This is shown as a double-height space in the plans and has a stair along one edge.

The opposite, the western end of the building, has the medical suite on the first floor. In the middle are a series of dorms along the north and south exterior walls, and a pair of offices and the hydroponics greenhouse. Hallways create a circuit through this area with stairs at either end and encompassing a sauna, showers, and toilet rooms.

On the second floor, on the eastern end of the building, are more communal gathering spaces; smaller lounges, a library, crafting areas, projector room. The remainder of the second floor is similar to the first floor but more widespread. Dorms line the north and south walls, with the central circulation creating a route that includes the stairs from below with clerestory

[301] "School's Virtual Visit to Casey Research Station"; Dapin, "What's Life Really Like for Australians Working in Antarctica?."
[302] "Living at Casey"; Bamsey, Matthew T et al., "Design of a Containerized Greenhouse Module for Deployment to the Neumayer Iii Antarctic Station" (2014); King, "The 2011 Resupply Voyage to Casey Station, Antarctica."; Robertson, "Cold Comfort in Antarctica at Casey Station."
[303] Incoll, "The Influence of Architectural Theory on the Design of Australian Antarctic Stations."

windows. In the middle of the hallway, there are the showers, toilet rooms, and support spaces.

4.5.5 Integration of Biophilic Attributes

Direct Experience of Nature

During the design phase, there were more significant documented attempts to develop direct experiences with nature at Casey Station compared to the other cases. The intention was to bring aspects that are familiar to the occupants to evoke a feeling of 'home' in their temporary habitation. Logistics, policy, safety, and practicality were the typical reasons that prevented this, as described below. Otherwise, the approach to direct experiences is very similar to that of the other cases, attributes incorporated in practical and logical manners, connecting users to the exterior environment through indirect means.

Light

The Red Shed at Casey Station was designed to take the best advantage of the northern light. The central lounge and the dining space are both double height with significant glazing allowing for natural sunlight to penetrate further into the spaces.[304] The organisation of spaces around the perimeter of the building prioritises window allocation to communal spaces and bedrooms. Spaces that require more privacy or that natural lighting would not necessarily be beneficial are kept to the interior; shower rooms, water closets, laundry facilities. The stairwells, while also in the internal core of the building, have skylights to provide natural daylighting.

[304] Ibid.

Air

There is no incorporation on natural ventilation in the station; measures are taken to keep the cold air out, including airlock entries, as is typical of contemporary buildings. Fresh air is brought through vents and tempered before distribution.

Water

Water is generated by treating snow and ice melt in a melt cavern. Water-saving measures are in place for conservation in personal usage.[305] At Vincennes Bay, water is not just part of life in terms of consumption or everyday use. The location of the station creates a different relationship with water than the other stations, more controversial with corrosion from the sea salt spray, which was a significant contributor to the decommissioning of REPSTAT. During the planning phase of the AANBUS system, there was a proposal for an aquarium in the central lounge space. However, due to the Madrid Protocol, this was not feasible.

305 "Keeping Antarctic Stations Water-Wise," Australian Antarctic Division: Leading Australia's Antarctic Program, http://www.antarctica.gov.au/news/2018/keeping-antarctic-stations-water-wise.

Plants

In the initial floor plans, there are planters generously located through the main lounge space of the Red Shed for psychological benefits. Some concern was expressed about what plants could be brought down and growing methods with the restrictions of the Madrid Protocol. How that was resolved is not discussed, but photographs show greenery, it is unclear if they are real or fake. Also on the ground floor of the Red Shed is a hydroponics facility to provide fresh vegetables and herbs during the winter months.[306]

Animals

Due to the Madrid Protocol, there are no animals directly included in the station planning. There is some incorporation of animals in imagery, as discussed later. During the planning phase, including an aquarium for the AAD Lounges was considered. However, this was rejected because of the Protocol.

306 "Hydroponics," Australian Antarctic Division: Leading Australia's Antarctic Program,, https://www.antarctica.gov.au/living-and-working/stations/amenities-and-operations/food/hydroponics/.

Landscapes

Similar to McMurdo Station, there are restrictions as to the inclusion of recreation of natural landscape elements from Australia. However, the evolution of restoration for landscape can be seen through the three stations that have been located at Vincennes Bay. Before the Madrid Protocol, when Wilkes Station was decommissioned in favour of REPSTAT, the structures were simply abandoned and can still be seen today. Due to the climate at the site, the structure does not succumb to drifting snow or get pushed out to sea with ice flows. When the shift from REPSTAT to Casey Station occurred, the decommissioned station was dismantled and removed from the site per requirements outlined in the Protocol. What this allows is the natural landscape to reclaim that area and hopefully eventually regrow.

'Weather'

When locating Casey Station, the landscape was also a significant consideration. With the infrastructure already in place near Vincennes Bay, it was logical to locate the new station there. However, the AAD wanted to avoid the issues found with Wilkes Station being located in a sheltered valley becoming buried[307] and REPSTAT's elevated design to combat the drifts making the wind's prevalence more problematic[308]. The orientation and organisation of the cluster of buildings that makes up Casey Station are prompted by the prevailing winds and studying drifting snow patterns. This also prompted the location of doors and other projections to keep them clear of drifts. Wind conditions also prompted the combination of proposed

[307] "The Influence of Architectural Theory on the Design of Australian Antarctic Stations."; Incoll, Philip, *Aanbus: The Creation of a Building System for Antarctica* (Commonwealth of Australia, Department of Housing & Construction, 1980).
[308] Incoll, "An Overview of Antarctic Buildings and Services for Administrators, Scientists and Engineers."

living and sleeping structures into the Red Shed with concerns for fire safety.[309] However, the decision to have other buildings kept individual and unconnected, causing inhabitants to exit the Red Shed to get to where they are working, was an intentional choice. The connecting tube system that REPSTAT employed was found to isolate the users from their environment and believed to be the cause of lower productivity and morale.

Views

Elaborating further on the use of larger windows within the central lounge and dining spaces from the *Light* section, another reason for their usage was for views.[310] The northern orientation not only provided natural light, but it also had a view towards the open ocean where occupants could keep a lookout for the relief ship.[311] The number of windows is also a reaction to what had previously been in REPSTAT. This previous iteration had windows only oriented in the eastern façade due to the design of the station, creating a lack of diversity in view potential.[312] The Red Shed allows for different views throughout the building in various rooms to three cardinal directions. Beyond traditional windows, the isolated stairwells in the centre of the station also have clerestory windows to provide light and awareness of the external conditions to users, though not a specific view.[313]

[309] "The Influence of Architectural Theory on the Design of Australian Antarctic Stations."
[310] "An Overview of Antarctic Buildings and Services for Administrators, Scientists and Engineers."
[311] "The Influence of Architectural Theory on the Design of Australian Antarctic Stations."
[312] Incoll, *Aanbus: The Creation of a Building System for Antarctica*.
[313] Incoll, "An Overview of Antarctic Buildings and Services for Administrators, Scientists and Engineers."

Fire

Similar to other contemporary stations, Casey does not have any open flames; however, the initial floor plans include a fireplace on the ground floor lobby. For safety reasons, this was eliminated in the final construction.[314]

Indirect Experience of Nature

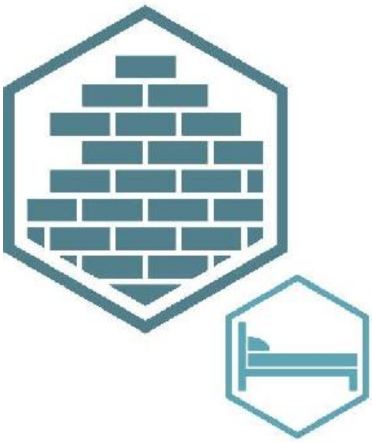
There are more practical examples of Indirect Experiences of Nature than Direct found in Casey Station's Red Shed. Though, some of the previously discussed attributes have characteristics which were incorporated through indirect methods. Many of these attributes are utilized to take advantage of the Antarctic environment in practical, useful ways. They are more commonly seen as a primary source of including natural elements typical of Australia within the buildings.

Images

Similar to McMurdo, maintaining a connection to the surrounding environment as well as reminding the occupants of familiar scenes of 'home' can be seen in videos of the common spaces. There is a mixture of images that depict the surrounding Antarctic environment, often relating to the scientific observations and artwork or photographs of the Australian bush.

[314] "The Influence of Architectural Theory on the Design of Australian Antarctic Stations."

Materials



As is typical with the majority of structures in Antarctica, there are no endemic materials incorporated into the design of the station. The interior wall finishes within the AANBUS system are primarily painted plasterboard.[315] From videos and photographs showing the communal spaces, this is augmented with wood trim and fixtures bringing natural materials into the building. Within these spaces, panelling is employed liberally to highlight specific areas, such as the games area's dartboard wall and the bar.

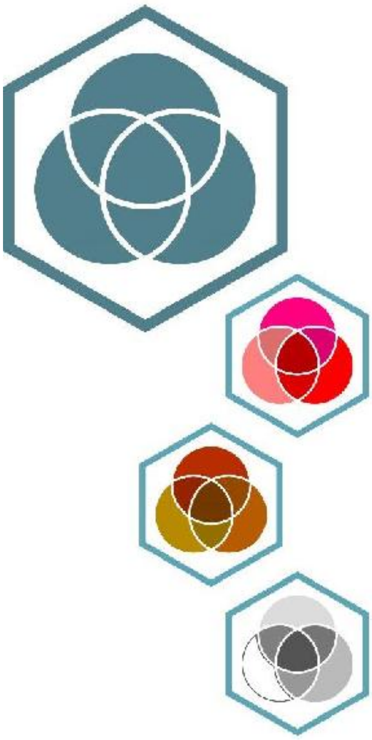
The flooring is similarly focused on resilience with the main circulation path being what appears to be a linoleum type of cover. Carpeting is also utilised in more stationary areas. Neither of these looks to be natural materials.

Texture

The use of materials shows a thought towards how texture could create depth within the common spaces. Woodgrain inherently brings more complexity and a tangible sense to a surface versus gypsum wallboard. Wood panelling is applied to and create smaller gathering areas within the main lounge. The choice to use carpeting also contributes towards the over the physical feeling of the space.[316] The decision to use what might be considered a less robust material was done for psychological purposes,[317] which goes back to the biophilic design connection between having something soft underfoot relating to the feeling of natural ground covering.

[315] Incoll, *Aanbus: The Creation of a Building System for Antarctica*.
[316] Compagnoni, "Antarctica - a Week at Casey Research Station".
[317] Incoll, "The Influence of Architectural Theory on the Design of Australian Antarctic Stations."

Colour



The interiors of the station have a warmer colour palette to bring warmth to the interior psychologically. This effect is achieved with almond coloured plasterboard, golden-hued wood, and other furnishings that complement that feeling.[318] In 2019 the Red Shed was under refurbishment, photographs showing the progress indicates the use brighter colours, precisely one corner which celebrates the State of Origin Ruby match with a red Queensland wall versus a blue New South Wales wall.[319]

Exterior colours were also a conscious choice for each of the buildings. The Australian stations have a distinct colour coding based on the purpose of the structure. For the living facilities, it is red, ergo the nickname the Red Shed. This colour selection comes not from any tie to the endemic natural environment or that of Australia. Rather it is meant to evoke the feeling of an American barn settled into rolling snowy hills.[320]

Shapes and Forms

The overall form of the Red Shed does not mimic or complement more organic and natural forms. The long rectilinear form is a reaction to the weather patterns, which is discussed further in the *Place* attribute, as well as the utilization of a penalization system developed by the AAD, AANBUS. There is one element that breaks up the perpendicular geometry of the building, the main lounge space. This space is oriented 45° from the surrounding rooms or areas; this pivot point aids in the creation of a central circulation hub for the station while

[318] "An Overview of Antarctic Buildings and Services for Administrators, Scientists and Engineers."
[319] "This Week at Casey: 13 September 2019," Australian Antarctic Division: Leading Australia's Antarctic Program, https://www.antarctica.gov.au/news/stations/casey/2019/this-week-at-casey-13-september-2019/.
[320] "The Influence of Architectural Theory on the Design of Australian Antarctic Stations."

working within the parameters of the panelling system.[321]

Information Richness

The layering of different materials, textures, plant foliage, and colours over a varied geometric form creates a depth and interest to the common areas of the Red Shed. Wooden elements highlight specific areas; doors, the bar, the games area, while the almond coloured paint provides relief from the space becoming too visible busy. This is also true for the flooring, where texture and colour inform users subtly of the purpose for the space. Plantings create a natural aspect for the inhabitants that evokes a calming feeling of the environment of 'home'. With the main lounge space angled at 45°, it separates it away from the rest of the area without walls; however, it is stepped down, lowering it a bit to emphasise the division further. That angle does more than partition the space, having the windows at a different angle creates a different sun condition than the majority of the exterior walls.

[321] Ibid.

Change, Age, and the Patina of Time

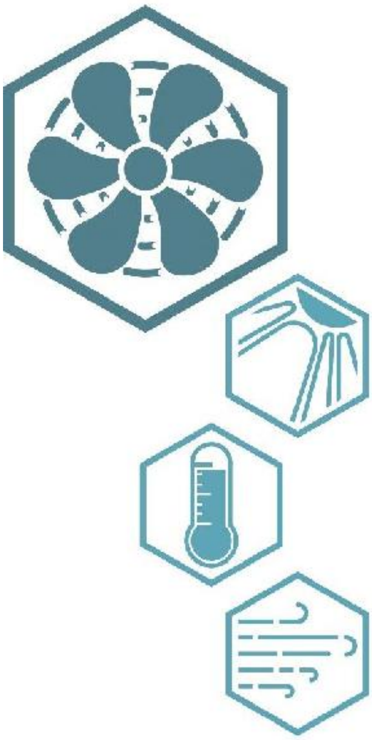
At Vincennes Bay, there are unique conditions that contribute to this attribute, though most are similar to issues found at McMurdo and the huts of the HAE. However, the station is designed to withstand this, which historically has not been successful and led to decommissioning. As with the majority of the sites around Antarctica, material erosion from excessive wind and abrasive snow or ice particulates is an issue and accumulation of drifting snow. Wilkes Station was quickly buried by the drifting snow in the valley where it was built, leading to the construction of REPSTAT. The metal sheeting succumbed to corrosion from sea spray, breaking down the material. The buildings also have to be able to withstand a more significant freeze/thaw cycle, which can breakdown the materials. However, this is not embraced as an aesthetic or desirable design feature in this environment.

Natural Geometries

There is no documented evidence that natural geometries were a consideration when designing Casey Station. The underlying pattern or repetition that informs the overall form is founded on a modular system based on building materials.[322] The reasoning to continue to utilize these panel systems is the same as the previous cases, the difficulty of transportation and conditions under which the structures are constructed.

[322] Incoll, *Aanbus: The Creation of a Building System for Antarctica*.

Simulated Natural Light & Air



The Red Shed is outfitted with artificial lighting to enable the building to be usable during the prolonged periods of darkness through the winter. The external lighting considers safety but also works not to impede atmospheric observations.[323]

It is unclear the specifics of the ventilation system, though there is no natural ventilation (openable windows, direct venting, etc.) to aid in this process. With such tight buildings, simulated air is essential to habitable conditions, and there is a discussion regarding the prevention of snowdrifts hindering vents.[324]

Biomimicry

No documentation shows any inspiration from biomimicry was incorporated into the design of Casey Station.

Experience of Space and Place

The awareness that one is living in Antarctica is difficult to avoid. Historically, however, REPSTAT unintentionally did just that, isolating the occupants from the outside environment, to what the AAD believed, was to their detriment. The current iteration of Casey Station took measure to overcome that, which can be seen through the following attributes.

[323] Incoll, "An Overview of Antarctic Buildings and Services for Administrators, Scientists and Engineers."
[324] Ibid.

Prospect and Refuge

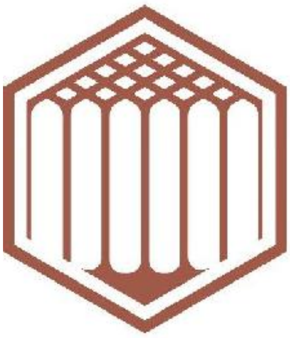
Using the surrounding environment for refuge is difficult in Antarctica, as seen by the early Wilkes Station. In an attempt to gain some shelter in a small valley, the station was covered by collecting drifting snow. The buildings, instead, provide this protection for the inhabitants, as is the case with the current Casey Station. Located with sightlines towards the water to see incoming supply ships, it takes advantage of siting for natural prospect as discussed in the *Views* section.

Internally, the Red Shed provides a variety of levels of refuge for the inhabitants, socially. The rooms are designed for individual occupants, with a few smaller lounges that can be used as shared accommodations if needed. Throughout, there are numerous spaces for smaller gatherings or specific activities; library, crafting room, darkroom, theatre. While providing these opportunities, AAD wanted to ensure that the inhabitants would not isolate themselves in their rooms. The circulation hub is centralised on the main lounge, to get from the rooms to the mess hall once must cross through this communal space.[325] Even within the larger space that the main lounge occupies, it is broken into smaller areas with the sunken gathering zone being complemented with the bar and recreation areas.

Figure 4-9 Hierarchy Casey Station's Red Shed: station to building to zones to rooms

[325] "The Influence of Architectural Theory on the Design of Australian Antarctic Stations."

Organised Complexity



The Red Shed, similar to McMurdo, fall short on the biophilic intention of organized complexity. There are complexity, diversity, and details found within furnishings and decorations of the main lounge area, but there is a lack of balance or organization. The physical architecture of the space contains these interventions to designated areas, but they can feel frenzied.

Mobility

The internal circulation of the Red Shed is designed to allow for maximum daylight opportunities for rooms that it would benefit. Similar to McMurdo's living buildings, this circulation system takes advantage of a double-loaded corridor to utilize the space efficiently. This organisation creates an internal corridor that wraps around service spaces, bathrooms, water closets, and vertical circulation. For fire protection, this is sectioned off with periodic doors. Which also allows for zoning of the spaces based on uses, sound level, and occupation numbers. There are two stairs centrally located stairs within the bedroom area, and one within the main lounge to facilitate movement between the two floors.

Transitional Spaces

The Red Shed has a more consolidated approach to transitional spaces than that of McMurdo. There are five entrances; each equipped with a cold porch larger than that of the HAE huts. This space provides an area for the users to don gear and create a buffer between the Antarctic climate and conditioned interior of the building rather than simply to be passed through. From the plans, there is no identifiable coatroom like McMurdo has.

Internally, as previously discussed, the main lounge acts as a transitional space between the more public areas of the Red Shed and that of the separate dorm rooms.

Place

There is a distinct identity with the AAD in Antarctica.

Geographical – The geographic features of the site were the impetus for the very existence of Casey Station. Then, Wilkes Station, Vincennes Bay was selected for the rocky outcroppings and the ease that would give to developing the built environment. Those same geographical features have created distinct identities for the three architectural solutions for habitation at the site. The current iteration is more mindful of the issues that the previous ones encountered, from siting to orientation towards wind direction as described previously.

Ecological – Being on the edge of the Antarctic Circle, Casey Station has a broader ecological spectrum while still being located on the main part of the continent. This site informs the type of research conducted at the station, which in turn is a draw for researchers to base their expeditions there.

Cultural – The AAD has developed a distinctive architectural, cultural identity for their Antarctic stations. The history of Casey Station, described below, engenders a different cultural identity. With three disparate iterations of the station, there is a younger feel to the station, despite the current buildings being of the same vintage as that of Davis and Mawson Stations. However, the overall social makeup of the stations is very similar, since the population is cultivated through a selective process. Those not interested in living in that environment are significantly less likely to apply for the opportunity, which automatically develops a shared mindset of the inhabitants.

Historical – There is a varied relatively short history of the occupation at Vincennes Bay. Going back to the Heroic Age with Mawson's exploration, this began a close tie between Australia and Antarctica, which resulted in possession of the most substantial sovereignty claim at the time of the IGY. At this time, with the whole continent "open" for research station location, Australia paid close attention to the siting of bases within their territory. [326] Despite initially being a US base, Wilkes Station was situated strategically for the Australian's to provide a buffer between their Davis Station and a proposed Russian base.

Beyond sitting, there is an existing historic building fabric that also creates a historical sense of place to Casey Station. The original base was never dismantled, and a discussion regarding the preservation of the buildings has been ongoing. While the image of REPSTAT is markedly tied to Casey Station, the structure was dismantled with the construction of the current Casey Station. In videos,[327] there appears to be paraphernalia that commemorates prior expeditions within the main lounge. It is unclear if there is anything related directly to the stations themselves.

Integrating Parts to Create Wholes

As with the previous cases, the Red Shed does not necessarily foster a deep connection between the occupants and the surrounding environment to provide a greater understanding of one's place within the ecosystem. The building's primary purpose is to shelter the occupants. This separation can be seen through the preference of indirectly incorporating natural elements that are more familiar to Australia rather than Antarctica.

[326] Belanger, *Deep Freeze*.
[327] Compagnoni, "Antarctica - a Week at Casey Research Station"; "Antarctica: Life at Casey Station," Youtube, https://www.youtube.com/watch?v=WMNwfvVLOkI.

4.6 AMUNDSEN-SCOTT SOUTH POLE STATION

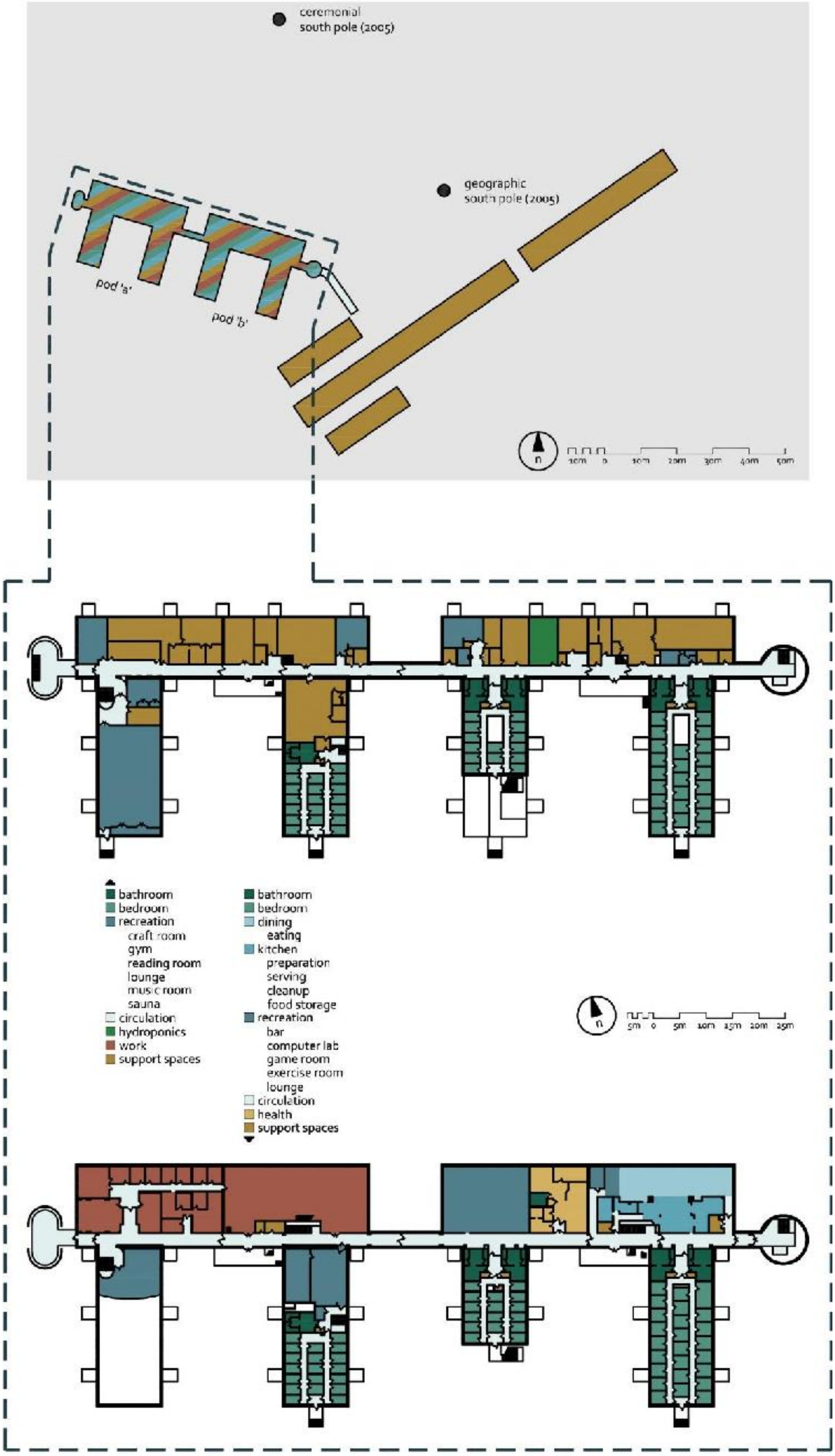


Figure 4-10 Amundsen Scott South Pole Station – Site, Orientation, Floor Plan[328]

4.6.1 Sources

Within Chapter 4 and Chapter 5, much of the material presented is from examinations of archival research. Where applicable, specific sources are cited. General observations and analyses are from floor plans[329], master plan[330], blogs[331], photographs[332], and youtube videos[333]. Any specific item is referred to specifically if applicable.

4.6.2 Background

The original station for Amundsen-Scott South Pole Station[334] was part of the USA infrastructure for the IGY, established in 1956. It was perceived as a significant component of the USA's "claim" on Antarctica with the site being located within 1000 meters of the geographic South Pole. The station is one of two that have been continuously inhabited since the IGY, not on the coast.[335]

4.6.3 Site Conditions

The location for Amundsen-Scott is unique, the geographic south pole. There are several purposes behind this site selection, both scientific and political.

Paul Siple, a scientist, Antarctic explorer, and first commander of the station, stated that the idea for a station at the Geographic South Pole came from the scientific side. The US IGY scientific community was interested in weather conditions and opportunities six months of darkness would provide. It would also neatly tie up the three chains of research geographically located on the globe for the IGY. With his prior experience, he was cautious about the potential hazards and climatic conditions.[336]

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[328] Graphic by Author – developed from NSF Overall Building Layout and plans provided by Ferraro Choi

[329] Turner, R., Palmer, C., "Overall Building Layout Plan," (National Science Foundation2005)., Ferrari, J, "South Pole Station Modernization Elevated Station," (Ferraro Choi1999).

[330] Ferraro Choi, "Master Plan for the South Pole Redevelopment Project," http://ferrarochoi.com/publications/master-plan-for-the-south-pole-redevelopment-project/.

[331] Brunt, Kelly to Notes from the Frield, June 09, 2020, 2020, https://earthobservatory.nasa.gov/blogs/fromthefield/2020/01/03/happy-new-year-from-amundsen-scott-south-pole-station/; Lowitz, Amy to Weblogarithms, June 09, 2020, 2016, http://amylowitz.com/SouthPole/posts/stati onTour.html; Nayak, Michael, June 09, 2020, 2018, https://www.michaelnayak.com/blog; , June 09, 2020, 2019, https://blogs.scientificamerican.com/observations/the-last-good-gig-a-summer-at-the-south-pole/; Spindler, "Amundsen-Scott South Pole Station".

[332] "Amundsen Scott South Pole Station," Wikimedia Commons, https://commons.wikimedia.org/w/index.php?search=Amundsen+Scott+South+Pole+Station&title=Special%3ASearch&go=Go&ns0=1&ns6=1&ns12=1&ns14=1&ns100=1&ns106=1; Ward, Paul, "Oae's Amundsen-Scott Station at the South Pole," Cool Antarctica, https://www.coolantarctica.com/Community/OAE_south-pole.php; "National Science Foundation,," https://www.nsf.gov/.

[333] Donenfeld, Jeffery, "Amundsen-Scott South Pole Station Antarctica Tour," Youtube, https://www.youtube.com/watch?v=P5lQ9DCXIbs; Miller, Kate, "Tour of South Pole Station," PolarTREC Youtube, https://www.youtube.com/watch?v=vrPiVT23MhA&t=5s; "Amundsen-Scott South Pole Station Tour!!," Youtube, https://www.youtube.com/watch?v=2bNRNqaKxZ8.

[334] To be referred to as Amundsen-Scott

[335] "Amundsen-Scott South Pole Station," *Issues In Science And Technology* 17, no. 3 (2001); Ananthaswamy, Anil, "Comment: South Pole Science Gets Luxurious New Base," (2008); Gunderson, EK Eric, *From Antarctica to Outer Space: Life in Isolation and Confinement* (Springer Science & Business Media, 2012); Nielsen, "From Shelter to Showpiece: The Evolution of Scientific Antarctic Stations."

[336] Siple, Paul, *90 South* (New York: G.P. Putnam's Sons, 1959).

Building on an ice shelf, even the ice cap that is over the main body of the continent presents some challenges. The primary of which is stability; ice shelves are always moving, cracking, melting to form rivers, etc. The South Pole, being part of the ice cap, has less movement than the other case studied in this research located on an ice shelf, Halley Station.[337]

There is a lack of mountains, hills, or other changes in topography at the South Pole. The ice cap around that point is a flat expansive plain of ice and snow. Photographs show this is broken up naturally by the gentle forms made by drifting snow and artificially by the tracks left by people and their vehicles.

There is no familiar or identifiable animal life at the South Pole. The combination of a lack of resources or food with a harsh environment makes it inhospitable to the other wildlife, more commonly found in Antarctica. Temporary natural visitors are few and far between. There is one recorded instance of a bird flying past the Amundsen-Scott Station; it is assumed to be a skua.[338]

Flora, near the station, is similarly hampered by the climate. The temperatures, winds, and lack of precipitation inhibit the natural growth of plant life. The impact of cold-desert is predominantly seen in this regard in the interior of the continent.

Unique out of the cases in this research, Amundsen-Scott is not located near open water. With the extreme temperatures, the only means of obtaining liquid water is through melting ice or snow. Being a cold desert, this also means that the air is quite dry, and there is not a significant amount of new snowfall each year. All of these conditions make the South Pole the most challenging site of the cases.

4.6.4 Building Development

International Geophysical Year

Typical of the USA's structures from the IGY period, the station was comprised of Jamesway huts and the other prefabricated buildings employed by the US Navy. As the station evolved in the early years, these temporary structures were replaced with panelized buildings with protective corrugated steel arches, until the mid-1970's this housed thirty-three men for year-round research.[339]

Being in the centre of the continent, the original Amundsen-Scott Station began to experience different issues than other stations. The predominant of which was snow drifting. While it is an arid climate without as much snowfall as one might think, there are intense winds that cause drifting. The shelters that were built for the IGY were soon buried in snow. Initial efforts

[337] Incoll, "An Overview of Antarctic Buildings and Services for Administrators, Scientists and Engineers."
[338] Burton, Adrian, "Skua Going South," *Frontiers in Ecology and the Environment* 13, no. 10 (2015).
[339] Brooks, "Elevated Station Design for the South Pole Redevelopment Project at Amundsen-Scott South Pole Station."; Ferraro Choi, "Master Plan for the South Pole Redevelopment Project"; Nielsen, "From Shelter to Showpiece: The Evolution of Scientific Antarctic Stations."

were made to battle this by building an adjacent connected structure at the new ground level. This developed a series of interconnected pods which slowly stepped downwards into the snow. [340] Today this network of structures still exists, though it is estimated that it is completely consumed under over 8 meters of snow.[341]

Geodesic Dome

In 1975, the iconic next generation of the Amundsen-Scott Station was completed. To combat the drifting snow, the new station employed the same technique of corrugated steel arches to protect support structures, but for the main living and scientific buildings, a large dome was constructed. This geodesic dome, modelled after Buckminster Fuller's principles, was 51 m in diameter.[342]

The dome was successful in resisting the driving snow compared to the arches. However, the uneven weight of the snow on the exterior began to cause structural issues within the structure. The dome also eventually became buried in snow, which had to be cleared periodically and could only be accessed through a dug out tunnel.[343]

Beyond the climatic challenges this site provided, the primary problems, and what led to the need for a new station sooner than anticipated, originated with the initial planning of the station. The dome station was not designed to house any more people than the original station. With the vast research opportunities, the geographic south pole provided, the population of the station at its closure was around 150 people, five times what the building was designed to accommodate.[344]

Additional people were housed in tents, Hypertat huts, and resurrecting the historic Jamesway huts during the summer months to supplement the sheltered structures in the dome. One inhabitant described his room, which was located several hundred meters away from the main

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[340] Brooks, "Elevated Station Design for the South Pole Redevelopment Project at Amundsen-Scott South Pole Station."; Nielsen, "From Shelter to Showpiece: The Evolution of Scientific Antarctic Stations."

[341] Ananthaswamy, "Comment: South Pole Science Gets Luxurious New Base."; Brooks, "Elevated Station Design for the South Pole Redevelopment Project at Amundsen-Scott South Pole Station."; Nielsen, "From Shelter to Showpiece: The Evolution of Scientific Antarctic Stations."

[342] Behar, M, "Cold Rush Welcome to the South Pole, Where the Coolest Science Outpost on Earth Is Being Built Atop 9,000 Feet of Solid Ice," *WIRED-SAN FRANCISCO-* 10, no. 7 (2002); Ferraro Choi, "Elevated Station Design for the South Pole Redevelopment Project at Amundsen-Scott South Pole Station," http://ferrarochoi.com/publications/elevated-station-design/; "Master Plan for the South Pole Redevelopment Project"; Mason, JSB, "Photovoltaic Energy at South Pole Station," *ANTA504. Graduate Certificate in Antarctic Studies. Christchurch, New Zealand* (2007); Nielsen, "From Shelter to Showpiece: The Evolution of Scientific Antarctic Stations."

[343] Ananthaswamy, Anil, "Interview: Living It up at the South Pole," (2009); Behar, "Cold Rush Welcome to the South Pole, Where the Coolest Science Outpost on Earth Is Being Built Atop 9,000 Feet of Solid Ice."; Brooks, "Elevated Station Design for the South Pole Redevelopment Project at Amundsen-Scott South Pole Station."; Ferraro Choi, "Master Plan for the South Pole Redevelopment Project"; Mason, "Photovoltaic Energy at South Pole Station."; Nielsen, "From Shelter to Showpiece: The Evolution of Scientific Antarctic Stations."; Slavid, Ruth, *Extreme Architecture* (Laurence King London, 2009).

[344] Ardanuy, Philip E et al., "Antarctic Exploration: Proxy for Safe, Sustainable Exploration of the Moon and Mars" (paper presented at the 1st Space Exploration Conference: Continuing the Voyage of Discovery. Orlando, Florida, 2005); Behar, "Cold Rush Welcome to the South Pole, Where the Coolest Science Outpost on Earth Is Being Built Atop 9,000 Feet of Solid Ice."; Ferraro Choi, "Master Plan for the South Pole Redevelopment Project"; Marty, J. W., "The Construction Challenges," *Civil Engineering* 70, no. 12 (2000).

dome, as more akin to a large closet and having little to no privacy from the adjoining seven rooms.[345]

Consolidated Elevated Station

It was in the early 1990s that the NSF began to work towards replacing this station with a newer building. They held a conference to explore what the best solution for the specific climatic needs would entail and hired the architectural firm, Ferraro Choi and Associates, in 1992 to execute the results. Construction on this structure began in 1999, with the difficulty that the remote site presented combined with the requirement that the transition between the two stations should be seamless, and have an opening to coincide with the IPY IV in 2008.[346]

The first notable aspect of the new Amundsen-Scott Station is that it is elevated 3 meters above the ground. At the time of its construction, three other elevated stations were built with various levels of success. Casey Station's REPSTAT iteration, as previously discussed, the German Filchner Station, which had to be abandoned as the surrounding ice shelf began calving, and the United Kingdom's Halley V, which at the time was still inhabited, to be discussed in the section on Halley VI.[347]

Learning from issues in the precedents, Amundsen-Scott was designed on a platform that enabled the entire structure to be lifted an entire storey twice in its life so that as the substructure was buried in snow, the habitable portion could remain above the snow. This proved to be helpful when the snow substrate began to compress under the load of the building during construction.[348]

The construction of the station was partially dictated by the site location. The majority of Antarctic stations are located near the ocean, which makes the delivery of materials slightly easier. For Amundsen-Scott, however, materials were shipped over 160,000 kilometres (10,000 miles) from California to McMurdo Station and then flown to the Pole. Not just the

[345] Behar, "Cold Rush Welcome to the South Pole, Where the Coolest Science Outpost on Earth Is Being Built Atop 9,000 Feet of Solid Ice."; Ferraro Choi, "Master Plan for the South Pole Redevelopment Project"; Fox, D., "Antarctic Dreams Learning What You're Made of at the Bottom of the Earth," *Virginia Quarterly Review* 92, no. 2 (2016).

[346] Ferraro Choi, "Elevated Station Design for the South Pole Redevelopment Project at Amundsen-Scott South Pole Station"; Mason, "Photovoltaic Energy at South Pole Station."; Nielsen, "From Shelter to Showpiece: The Evolution of Scientific Antarctic Stations."

[347] Behar, "Cold Rush Welcome to the South Pole, Where the Coolest Science Outpost on Earth Is Being Built Atop 9,000 Feet of Solid Ice."; Ferraro Choi, "Elevated Station Design for the South Pole Redevelopment Project at Amundsen-Scott South Pole Station".

[348] Ananthaswamy, "Interview: Living It up at the South Pole."; Behar, "Cold Rush Welcome to the South Pole, Where the Coolest Science Outpost on Earth Is Being Built Atop 9,000 Feet of Solid Ice."; Ferraro Choi, "Elevated Station Design for the South Pole Redevelopment Project at Amundsen-Scott South Pole Station".

logistical consideration with the distance, the size of the prefabricated units were restricted by the interior of the plane.[349]

The station is comprised of two C-shaped pods, two stories high and connected by a long central corridor. Originally it was intended to be three pods, but funding only covered two. The hydraulic jacking system allows for minor adjustments due to uneven settles to be made between the two pods. The pods themselves are designed with chamfered edges towards the prevailing winds to increase the aerodynamics of the building.[350]

On either end of that central spine are connections to the outdoors and the rest of Amundsen-Scott station. The eastern end has a set of enclosed stairs and freight elevator leading down to the support stations below the snow. The opposite is a viewing platform on the upper level and an entrance platform on the lower. Starting on that end, there is a vestibule to transition users from the outdoors into the station

The corridor, itself, is a long straight line. For safety, there are doors to separate the two pods and sections within the pods. Also visually breaking up the corridor are sections of colour. Textured rubber tiles are used on the walls with various colour combinations for different parts of the station, particularly around intersecting hallways. The floor is the same rubber tiles but in a more universal darker shade. This texture diversity is found in the other halls, with smaller horizontal patterning on those walls.

The main body of the 'C' shape is on the northern side of the corridor. The lower level is primarily used for the support spaces; mechanical services, electrical services, maintenance, etc. There are several recreational spaces, primarily in the corners of this area for the occupants. Centrally located in the eastern pod are a growth chamber and a sauna. What has been dubbed the South Pole Food Growth Chamber, is a small contained unit within the station where a limited number of vegetables can be grown. The hydroponic greenhouse is overseen by the University of Arizona, developed by the Sadler Machine Company, and designed by NASA.[351] These two spaces are commonly referenced in many blogs and videos as to their importance for occupants, particularly during winter. They provide areas that allow inhabitants a chance to connect back to familiar aspects of home; be it plant life, the natural

[349] Ananthaswamy, "Interview: Living It up at the South Pole."; Behar, "Cold Rush Welcome to the South Pole, Where the Coolest Science Outpost on Earth Is Being Built Atop 9,000 Feet of Solid Ice."; Nielsen, "From Shelter to Showpiece: The Evolution of Scientific Antarctic Stations."

[350] Ferraro Choi, "Elevated Station Design for the South Pole Redevelopment Project at Amundsen-Scott South Pole Station"; Nielsen, "From Shelter to Showpiece: The Evolution of Scientific Antarctic Stations."

[351] Ananthaswamy, "Comment: South Pole Science Gets Luxurious New Base."; Patterson, RL et al., "Description, Operation and Production of the South Pole Food Growth Chamber" (paper presented at the International Symposium on Advanced Technologies and Management Towards Sustainable Greenhouse Ecosystems: Greensys2011 952, 2011); Slavid, *Extreme Architecture*.

wood smell, or permeating warmth. These spaces are small, so this can be done in more intimate groups or as a solitary activity.

On the southern side of the central corridor are where the four legs branch off. All except for the westernmost are utilized to house the occupants. Each leg has men's and women's bathrooms off of the hall leading from the corridor. This then splits into a double-loaded corridor with individual dormitory rooms along the outside, and a few in the middle with no exterior windows. The rooms are small, typical of a University dorm room. They are furnished with an elevated bed with storage beneath, a desk, chair, bureau, and armoire. The floors are carpets; walls are a muted taupe, task, and ambient light help to mitigate the prolonged night or lack of windows. In the rooms with windows, they are provided with blackout shades for the 24hr light through the summer. There are enough private rooms to house up to 150 people, and each room has new technological considerations with ethernet and telephone ports.[352]

The last, western-most leg contains more recreational spaces for the occupants. The majority is taken up with a double-height gymnasium that hosts various sports; basketball, volleyball, as well as a projector screen for movie viewing. There is also a music room on the ground floor and exercise equipment on a second level balcony that overlooks the court below. Connecting the two levels in this leg is a stair at the entrance near the central corridor.

The housing 'legs' have similar layouts and functions on the second level. Each one has a secondary emergency exit with a vestibule at the southern end. The western-most housing leg has additional recreational and support spaces. This was designed to create a safe-haven in the case of an emergency. It can be closed off from the rest of the station and support any occupants until rescue is possible.

The second floor of the main parts of the pods has the scientific area and the logistical and management offices for the station in the western pod. The eastern side is the remaining living spaces, with an ample lounge space, medical facilities, the kitchen and dining hall. On either end of the long central corridor are connections to the rest of the site. The western side has an outdoor viewing platform and a stair leading to the ground, and the opposite is a stair to the undergrown support spaces along with a freight elevator. Internally, along that central spine, there are stairs adjacent, connecting the two levels of the station. There are also two outdoor platforms which are accessed for smoking.

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[352] Ananthaswamy, "Comment: South Pole Science Gets Luxurious New Base."; "Interview: Living It up at the South Pole."; Behar, "Cold Rush Welcome to the South Pole, Where the Coolest Science Outpost on Earth Is Being Built Atop 9,000 Feet of Solid Ice."; Ferraro Choi, "Elevated Station Design for the South Pole Redevelopment Project at Amundsen-Scott South Pole Station".

Aligning with the overall environmental goals the ATS outlines, as well as the focus of the IPY IV, Amundsen-Scott was designed to consider environmental impact. Elevating the station consequentially lessens the footprint of the station which factored into that decision. Ferraro Choi endeavoured to design a building that was adjusted to its unique environment. While studies into the Arctic and even coastal Antarctic buildings could be helpful, the polar plateau presents its own restrictions and assets.[353]

The architects also prioritized the effect the interior of the station would have on its inhabitants. Recognizing that the winter population of approximately 50 would have little opportunity to leave the station, Ferraro Choi sought to bring in or simulate natural lighting. With the windows, they designed blinds and removable panels for the inhabitants to be able to control the glare and heat loss and accommodate personal preferences. They also enabled the private rooms to have their temperature and lighting controls. When selecting finishes, they utilized ones with low VOCs. They used interlocking modular flooring, colours, and other finishes to identify different areas of the buildings and break up potential monotony.[354]

4.6.5 Integration of Biophilic Attributes

Direct Experience of Nature

Where Amundsen-Scott is located offers less and more extreme natural aspects to incorporate than the other cases. Architectural characteristics that are inherently found in the basic functional building are often means of directly connecting to nature, however in this situation that does not happen. These connecting to these attributes are done through indirect methods and often relate to aspects found in the US, rather than Antarctica.

Light

Creating a natural feeling with daylighting was valued in the design process. The majority of the living spaces; recreational, dining, bedrooms, are along external walls allowing them to have windows for direct natural light during the summer months. There are a small number of internal bedrooms that do not benefit from this, similar to Building 155 at McMurdo Station. There are also blackout shades to block the light when too abundant. When selecting the internal finishes bright,

[353] "Sustainable Design Strategies for the Modernization of the Amundsen-Scott South Pole Station"; Nielsen, "From Shelter to Showpiece: The Evolution of Scientific Antarctic Stations."
[354] Ferraro Choi, "Sustainable Design Strategies for the Modernization of the Amundsen-Scott South Pole Station".

light-coloured, reflective paint was selected to facilitate the spread of the light further into the spaces.[355]

Air

The inclusion of natural air is addressed at Amundsen-Scott, similar to the other contemporary cases, artificially. Due to the extreme climate of the Antarctic desert plateau, there are no operable windows and construction is kept tight to avoid drafts. Fresh air is tempered before distribution. There are several opportunities for occupants to take direct advantage of the outdoor air with an observation deck and smaller decks for smoking.

Water

With no liquid water sources naturally available, water for the station is provided through snowmelt, with a snow well. It is used throughout the station in a conserved manner with schedules and limits on laundry and showering.

355 Ibid.

Plants

A growth chamber is on the lower level of the eastern module, similar to the Stations of the IGY. The plants grown there are purely for food growth and closely monitored for potential invasive species that would violate the Madrid Protocol. The psychological benefits of the greenery are not just limited to the inside of the chamber. Windows in the corridor look into the planting space with a seating area in an outer room. The growth chamber not only offers a visual connection to plants but in the cold desert, provides a small humid[356] escape reminding users of a more familiar climate.

Animals

As with the other stations occupied post-Madrid Protocol, there is no animal presence factored into the building design. Previously, there have been non-endemic animals at the station for scientific purposes, including hamsters.[357] There is a lack of endemic wildlife available for incorporation, but the skua that flew past the station in 2011 is often noted.[358]

Landscapes

The approach to this aspect tracks the same way as it did with Casey Station. The earliest structures from the IGY, even before with the camps from Amundsen and Scott, succumbed to drifting snow. Once no longer occupied, they were abandoned but not dismantled. At that time, there was no thought to the impact of or interaction with the landscape on the Plateau. When

[356] Miller, "Tour of South Pole Station".
[357] Headland, "History of Exotic Terrestrial Mammals in Antarctic Regions."
[358] Burton, "Skua Going South."

the current iteration of the station was developed, the central part of the dome station was dismantled per the Madrid Protocol, and the landscape settled back to what it was before the structure is there.

While this station is elevated it is not to minimize the impact on the landscape in an ecological conservation sense, instead with the inevitable drift accumulation, there are hydraulic jacks to lift the station up twice over its anticipated lifespan. [359]

'Weather'

Following the trend of the other cases, the climate is approached as something to be kept out. The building envelope is designed to do just that, keep the cold, the wind, the snow out, while allowing the interior to be adequately conditioned. Beyond the building envelope, the overall architectural form has been developed to work with the primary conditions encountered at the South Pole. Rather than fight the wind, the cross-section mimics a foil shape to direct the wind around the building passively. The wind that travels beneath the elevated station has an increased speed due to compression from the shape of the underside building form. This effect pushes the resulting snowdrifts further away from the building.[360]

[359] Ferraro Choi, "Elevated Station Design for the South Pole Redevelopment Project at Amundsen-Scott South Pole Station".
[360] Ibid.

Views

As discussed in the earlier section on *Light*, the exterior wall has a significant number of windows to let in natural lighting. This intervention also allows for views of the surrounding landscape. While these are relatively uniformly placed, there is a higher frequency or doubling up within communal spaces. The regularity is a reflection upon what is available for views at the South Pole plateau as well as the natural light conditions. The only focus for specific views is human-made, such as the airstrip. On the western end of the station is an observation platform which looks in that direction, the lower section is partially sheltered.

Fire

For safety concerns as with all the other contemporary cases, open flames are not included within the building.

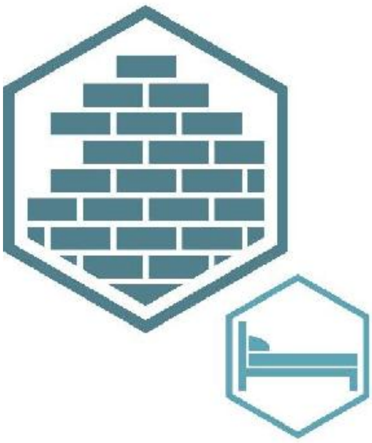
Indirect Experience of Nature

As with the other cases, it is easier for Amundsen-Scott to connect with natural aspects indirectly. With some creativity and advances in materials, what is found in the indirect experience attributes are more innovative and stimulating for the occupants. There is still a disconnect between the inhabitants and that natural Antarctic environment, and a tie to the source country's natural aspects is tenuous, showing a lack or prioritization. The shift between the IGY examples and Amundsen-Scott shows the potential for stronger connections in the future.

Images

From video tours[361] of the interior of the station, the central corridor has been used to incorporate images and information about Antarctica. There are areas with the history of the station and ties to the original discovery of the South Pole. These contribute to the attribute *Place*, below by bringing context to an interior environment which can be devoid of connection to the outside world.

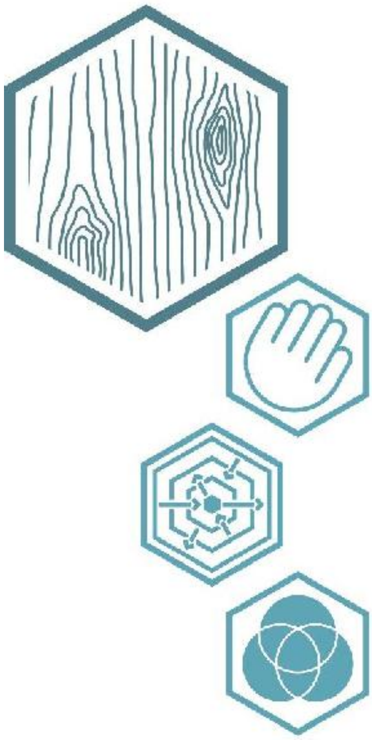
Materials



In general, similar to contemporary stations, Amundsen-Scott has imported material that is durable and synthetic. With the heavy wear from equipment and externally from the weather, utilizing stronger, more resilient materials minimizes the need to replace elements, also reducing waste.

[361] Donenfeld, "Amundsen-Scott South Pole Station Antarctica Tour"; Miller, "Tour of South Pole Station".

Texture

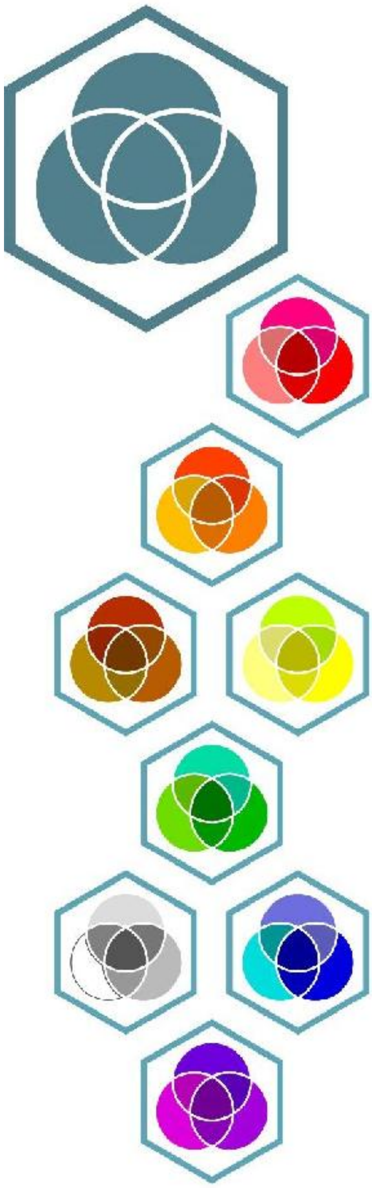


Amundsen-Scott approaches wall surfaces differently than the other cases discussed. As covered in the *Materials* section above, durability is a priority for the contemporary structures; however, Amundsen-Scott used panelling systems internally, which brings a tangible aspect to the walls. As seen in videos[362], the primary material is a wrap of the rubber flooring tiles with small numbs. Secondary material is a modular system but with a horizontal linear profile. The combination of these two creates a more dynamic space where it could become institutional without sacrificing the need for robust materials.

With flooring, Amundsen-Scott employs a similar approach. In the high traffic areas, the rubber tiles and other resilient floor is utilized. While, in the most sedentary or private spaces, carpet tiles have been applied, creating a calmer warmer atmosphere.

[362] Donenfeld, "Amundsen-Scott South Pole Station Antarctica Tour"; Miller, "Tour of South Pole Station".

Colour



Most of the walls of the station are light, bright reflective materials to aid in illuminations. The rubber tiles described in the *Texture* section are quite colourful. Alternating pseudo checkerboards of various colours give context to where one is located within the station. The colours range from primary and secondary colours to greys, black, and browns. Not only does this create a more playful atmosphere and takes away from a potentially stagnant and uniform feeling, but it creates a differentiation between the walls and the floors. The floors were designated a darker colour.[363]

363 Donenfeld, "Amundsen-Scott South Pole Station Antarctica Tour".

Shapes and Forms

The overall elements which create the form of the modules are similar to the other contemporary stations, prefabricated panels. The use of these panels prompts rectilinear internal spaces and overall geometry like the other stations. Though, Amundsen-Scott developed several departures to this perpendicular paradigm in the external components. On the eastern and western sides, there are curvilinear elements; a round vertical circulation tower and observation deck. Also, for aerodynamics, there is an angled slope connecting the second-floor overhang to the setback first floor to create the foil shape described earlier.

Information Richness

Looking at the previous attributes, Amundsen-Scott builds upon them to create a more vibrant and user-friend space out of what could potentially be generic and institutional. The best example is to look at how colour, material, and texture was layered to liven the central corridor with the rubber tiled walls. Colour providing vibrancy and wayfinding, the material is applied in an unusual yet practical manner, and the nubs of the tiles create a visual texture as well as a palpable one.

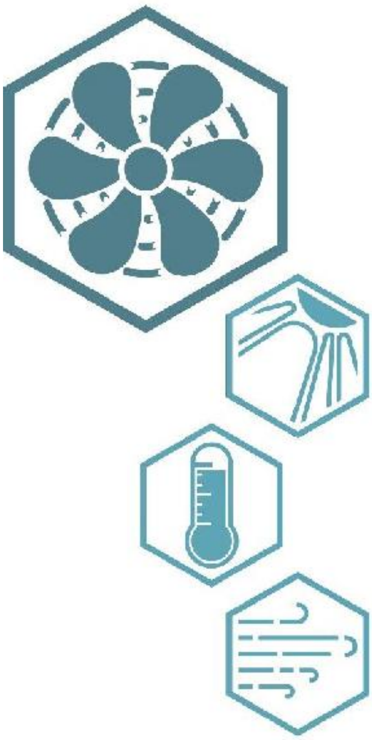
Change, Age, and the Patina of Time

The station is still relatively young, so there is no documentation as to how the materials are performing and potentially wearing. However, a key design feature of the overall concept of Amundsen-Scott focuses on this attribute. The hydraulic jacking of an elevated station is to combat the continual accumulation of drifting snow. Amundsen-Scott is designed to do this only a few times, restricted by technology and practicality, but it will prolong the effective use of the station.

Natural Geometries

As discussed in several other attributes, the overall geometric form of the station follows a rectilinear grid pattern similar to the IGY cases. There are three significant departures from this, which are slightly more organic, following their distinct functions of vertical transportation.

Simulated Natural Light & Air



As seen with the other cases, buildings must supply artificial lighting and ventilation to permit the building to be safely occupied all year. Amundsen-Scott utilizes typical lighting systems for ambient and task lighting with individual switching to allow users greater control over their own spaces.[364]

With the heating of the station primarily controlled through radiant or hydronic methods, the need for artificial ventilation is reduced. Ventilation is specific to the needs of a space, whether it is due to equipment of the function.

Biomimicry

Similar to the other stations, Amundsen-Scott does not incorporate principles of biomimicry in the design.

Experience of Space and Place

As with the other cases, awareness living at the South Pole environment is inescapable. This site presents some of the more divergent qualities for occupants, be it the diurnal patterns, temperatures, lack of flora and fauna, and more. Similar to the other cases, Amundsen-Scott takes measures to mitigate that, prioritizing evoking feelings of home over embracing aspects of the natural surrounding. The South Pole also has particular importance regarding the sense of 'place', with significance culturally and historically to the continent.

[364] Ferraro Choi, "Sustainable Design Strategies for the Modernization of the Amundsen-Scott South Pole Station".

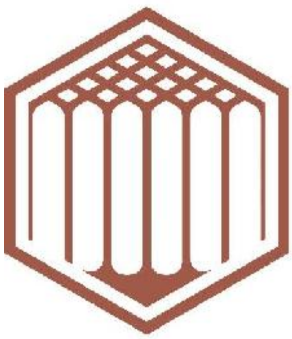
Prospect and Refuge

The geographic South Pole offers little opportunity for shelter or views in the vast flat expanse of the central continental plain. Therefore, it is dependent upon artificial means to provide that shelter and afford opportunities for prospect. While the primary purpose of elevating the building was to avoid the drifting snow, but it also provides a better view of the surrounding area.

The internal layout also addresses the personal need for this attribute for the inhabitants. Having three of the wings contain the bedrooms keeps them isolated from the communal spaces. The bedrooms are designed to used by a solitary occupant, providing a personal, private domain with a door. Outside of the sleeping areas, various types of communal areas are along the central spine of the station allowing for different functions and sizes of gatherings.

Figure 4-11 Hierarchy of Amundsen-Scott: building to zones to rooms

Organised Complexity



In contrast to the previous cases, Amundsen-Scott begins to integrate the aspects of organized complexity, but in a very subtle way which does not fully connect to the biophilic intention of the attribute. With the physical textural and colour incorporation of the corridor and hallways, details are created, diversity through the space, while the patterns formed create an organized balance. However, the detailing is very subtle with the horizontal profiles in the hallway and the uniformity of the raised bumps on the rubber tiles. What this does illustrate is how durable materials can be pushed towards achieving this attribute.

Mobility

The internal circulation is straightforward and contributes to the organization of the entire structure. Linking the whole station is a long corridor that acts as a central spine. From this, rooms branch directly or off secondary hallways. The configuration creates simple and easy to navigate. A combination of single and double-loaded corridors is utilised for efficient use of the external walls for natural daylighting.

Within the station, there are four stairs for vertical transportation. Two are centrally located in each module, and on the western side, there is an additional stair near the gymnasium and the athletic room. The fourth stair is outside of the modules in a separate tower and includes a freight elevator. This tower serves more than the two levels of Amundsen-Scott, travelling down below the ice to support spaces.

Transitional Spaces

As is typical in building practices in colder climates, Amundsen-Scott utilizes air lock vestibules to facilitate the transition to the indoors from the outdoors at the observation deck on the western side of the building and the exits at the end of each of the wings. These are smaller than those found in the more contemporary cases, serving simple as a gap to isolate the interior of the building from external conditions, not doubling as additional storage or a space to clad oneself in outdoor gear.

Four doors noticeably lack the airlock vestibules. These are located centrally in each of the modules. These lead out to smoking decks for the inhabitants.[365] While there is no room for a formal vestibule, the transmission of external conditions is somewhat mitigated with a strip curtain.

Internally, there are transitional spaces between the public living, working, support areas and that of the private personal rooms. While not environmentally necessarily, it creates more separation between the communal and private, also allowing for a level of security. The design of these pseudo-antechambers allows for a division between the bathrooms and the bedrooms. Doors that lead to the former have access to janitorial closets within the passageway between the main corridor and the hall for the bedrooms.

[365] Donenfeld, "Amundsen-Scott South Pole Station Antarctica Tour".

Place

Geographical – The very existence of Amundsen-Scott is due to the geographic south pole. Otherwise, the central Antarctic plateau offers little in terms of geographical features to connect. The building form reacts to the physical aspects that the plateau presents; orientation to the wind and foil shape.

Ecological – While the plateau offers unique ecological aspects, it is not what prompted the siting of the station. As previously discussed, the natural characteristics are viewed more as something to overcome, such as drifting snow prompting a raised structure with hydraulic jacks.

Cultural – Similar to other contemporary stations, there is a specific cultural identity to the occupants to the station purely due to the remoteness of the site. People with like values are more apt to seek out work at Amundsen-Scott, which engenders an identity to the population. This case has a uniqueness compared to the others, with it being the only research base located at the south pole.

There is also a political side to the culture of place for Amundsen-Scott. With the south pole representing the convergence point of the sovereignties, the siting of a USAP base here, a country without any territorial claim on the continent, has elicited a range of opinions. These views range from attempting to maintain neutrality at the pole during the IGY to interpreting it as a display of dominance.

Historical – There are strong historical ties to the geographic south pole, which are celebrated within the building. There are displays in the station which commemorate the race to the pole, highlighting Raoul Amundsen's success. Throughout the corridor, there are also artefacts and paraphernalia that tracks the station's life at the pole since the International Geophysical Year.

Integrating Parts to Create Wholes

Similar to the other cases, the efforts that the building makes to shelter the occupants also isolates them from Antarctica's natural environment.

4.7 HALLEY VI

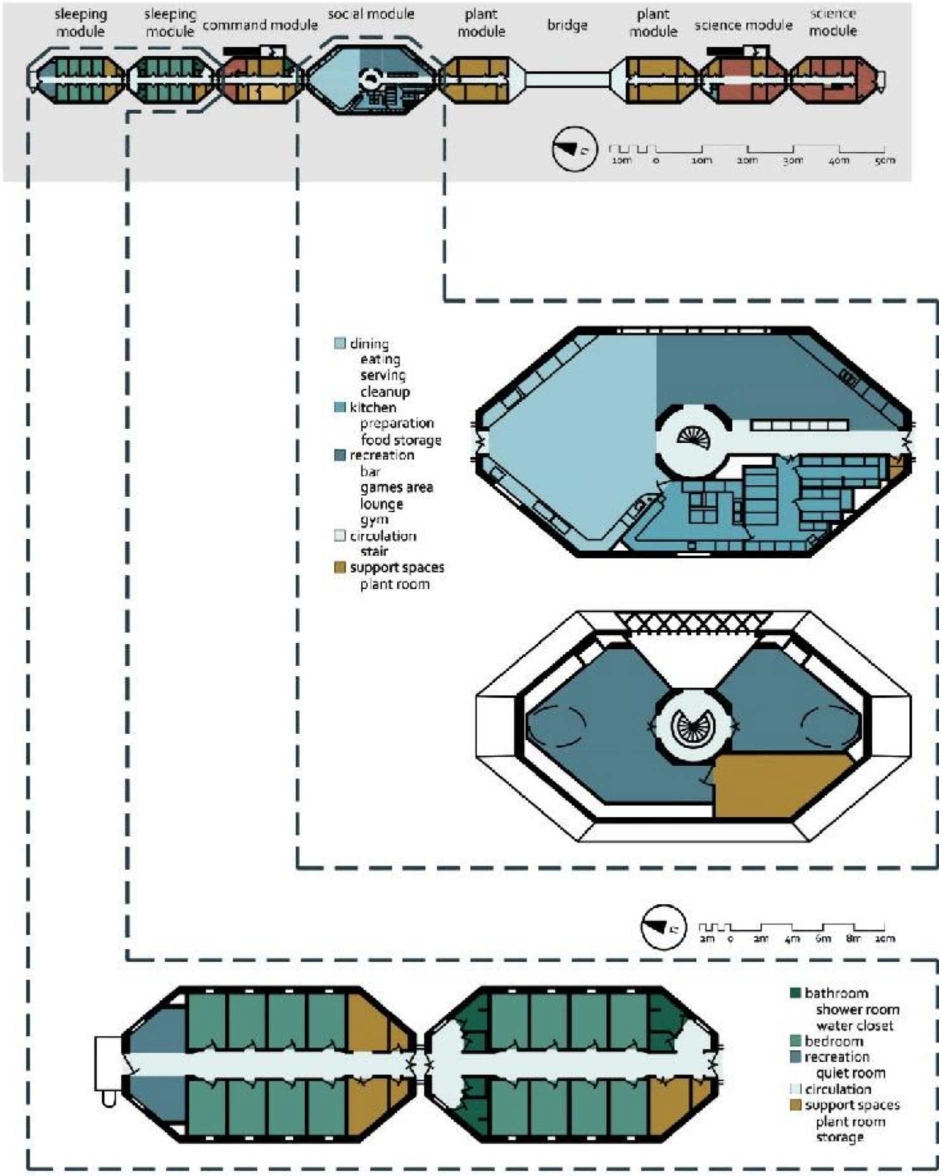


Figure 4-12 Halley VI – Site, Orientation, Floor Plan[366]

[366] Graphic by Author – developed by plans provided by Hugh Broughton Architects

4.7.1 Sources

Within Chapter 4 and Chapter 5, much of the material presented is from examinations of archival research. Where applicable, specific sources are cited. General observations and analyses are from floor plans[367], photographs[368], blogs[369], 3D tour[370], and youtube videos[371]. Any specific item is referred to specifically if applicable.

4.7.2 Background

The Brunt Ice Shelf has been the site of the Halley Stations since the IGY, Halley I was built in 1956. This has proved to be a challenging site on which to maintain a structure. The ice shelf is floating and flows at a rate of 400 metres per year towards the ocean, where it then breaks up into icebergs. The surface of the ice shelf increases anywhere from 1 to 1.5 metres a year from accumulated snow and drifting.[372]

Even with these challenging locations, the British Antarctic Survey (BAS) has maintained its southern-most station in the same location. Research at the Halley Stations has garnered significant contributions to atmospheric information, specifically towards the hole in the ozone. Other studies undertaken at this relatively small station include meteorology, glaciology, and seismology. The continued presence of the BAS has allowed many studies to be conducted continuously since the IGY.[373] Halley is also one of two stations to be built directly on an ice shelf.[374]

4.7.3 Site Conditions

Similar to Amundsen-Scott, Halley VI is constructed on an ice shelf. Though not an ice cap, it is an ice sheet that is pushed out past the coast, essentially floating on the surrounding ocean. The Brunt Ice Shelf is pinched between two glaciers on the Caird Coast.

The characteristics of the site are very comparable to what is described in Amundsen-Scott. The surrounding area is a vast plain of snow-covered ice, with winds coming from the continent drifting the snow. The latter was the primary cause of the failure of the previous

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367 "Halley Vi Antarctic Research Station Plans," (Hugh Broughton Architects).
368 Krzysztofowicz, Michal, "Michal Krzysztofowicz Photography," https://beautifulocean.org/; Morris, James, "Antarctica - Halley," https://www.jamesmorris.info/portfolio/halleyvi/; "Image Collection," British Antarctic Survey,, http://www.photo.antarctica.ac.uk/external/guest.
369 to Ramblings to and from Antarctica, June 09, 2020, 2019, http://esorekim.blogspot.com/; to Step inside the Halley Vi Antarctic Research Station, June 09, 2020, 2017, https://cornerofthecabinet.com/2017/04/04/virtual-tour-inside-the-halley-vi-antarctic-research-station/; Krzysztofowicz, Michal, June 09, 2020, 2017, https://antarcti.co/; Evans, David Vaynor, June 09, 2020, 2008, http://antarctic-diary.blogspot.com/2008/01/halley-vi-coming-on-nicely.html; to Tag Archives: Halley, June 09, 2020, 2018, https://basclub.org/tag/halley/; to Blog Section: Halley, June 09, 2020, 2018, https://basclub.org/tag/halley/.
370 Krzysztofowicz, Michal, "Halley 360," https://halley360.antarcti.co/.
371 "Walkthrough of Halley Vi," Youtube, https://www.youtube.com/watch?v=3B3pHpz_fbE; "Inside Halley, the British Statioin in Antarctica," Youtube, https://www.youtube.com/watch?v=X3LnyNus7vI; "Halley Vi Research Station," Youtube, https://www.youtube.com/watch?v=dhR-JZLtzvQ.
372 Blake, "The Construction of Halley Vi Station in Antarctica."; Broughton, "Halley Vi Antarctic Research Station."; Shears, John, Downie, Rod, and Pasteur, Liz, "Proposed Construction and Operation of Halley Vi Research Station, Brunt Ice Shelf, Antarctica. Draft Comprehensive Environmental Evaluation (Cee)," (2005).
373 Broughton, "Halley Vi Antarctic Research Station."
374 "Polar Research Facilities: Living in Isolation."; Schiermeier, "Antarctic Stations: Cold Comfort."

stations. Some aspects differ from the South Pole. While there is a lack of flora, the proximity to the coast and open water does provide some fauna. Penguins, petrels, and other sea birds common to Antarctica have colonies or visit the area regularly. Additionally, there is access to sea life with seals, whales, and orcas frequenting the waters nearby.[375]

This proximity to the open ocean was vital for early access to the site by an ice breaker. While an ice runway is nearby for aeroplanes, sea access is still needed for support.

Some of the challenges that were averted with Amundsen-Scott are more significant at the Brunt Ice Shelf. The movement of the ice is greater with ice shelves compared to the ice cap; the sheet of ice is continually being pushed out towards the sea.[376] Some of the preceding stations that were not removed can be seen buried as the ice sheet breaks off into the ocean.[377] This creates a base for structures that is not stable, prone to cracking and shifting.

Another problem the Brunt Ice Shelf presents as a site is cracking. With this inevitable progress towards the ocean, the ice breaks and cracks along the edges where ice is moving at different speeds. These cracks can spread across the ice shelf, causing ice calving, and the formation of icebergs. The current Halley VI is in threat of this occurring with two cracks/chasms growing more rapidly than typical and threatening to join and break off a significant amount of the ice shelf.[378] Because of this, Halley VI has relocated further away from the cracks and temporarily shut down for the winter seasons, when emergency relief would be difficult.

4.7.4 Building Development

Halley I & II

Similar to other stations built during the IGY, Halley I was a rudimentary wooden structure that soon was buried in the snow. During the IGY, Halley I was overseen by the United Kingdom Royal Society, in 1959 it was transferred to the BAS. As with the early Amundsen-Scott and Wilkes Stations, as Halley I succumbed to the snow, tunnels were dug to gain continued access to the building. By 1968 the structure was under over 14 metres of snow was causing enough structural damage for the station to need to be abandoned.[379]

Halley II was built in 1967 and was similar construction to Halley I, though with a steel frame rather than heavy timber. Instead of one single structure, seven huts were erected, once again,

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375 "Halley Vi Research Station," British Antarctic Survey, https://www.bas.ac.uk/polar-operations/sites-and-facilities/facility/halley/.
376 Incoll, "An Overview of Antarctic Buildings and Services for Administrators, Scientists and Engineers."
377 Alsop, Andrew, "Halley Iii," https://www.bbc.com/news/magazine-35717932.
378 "Brunt Ice Shelf Movement," British Antarctic Survey, https://www.bas.ac.uk/project/brunt-ice-shelf-movement/; "Countdown to Calving at Brunt Ice Shelf," NASA, https://earthobservatory.nasa.gov/images/144563/countdown-to-calving-at-brunt-ice-shelf.
379 Broughton, "Halley Vi Antarctic Research Station."; Shears, Downie, and Pasteur, "Proposed Construction and Operation of Halley Vi Research Station, Brunt Ice Shelf, Antarctica. Draft Comprehensive Environmental Evaluation (Cee)."; Weale et al., "Elevated Building Lift Systems on Permanent Snowfields: A Report on the Elevated Building Lift Systems in Polar Environments Workshop."

directly on the surface of the ice shelf. Six years later, Halley II was vacated for the same reasons.[380]

Halley III & IV

The next two iterations of the Halley Station developed a different approach. Accepting the idea that the buildings would inevitably be consumed by the snow, the stations were contained within tubes. Halley III was a series of single-storey prefabricated wooden structures in a 6-metre steel tube and was used for eleven years. The warmth from the conditioned tube, as well as the pressure of the snow accumulation, warped the tube. One of the more iconic images of the station's history shows Halley III emerging at the edge of the ice shelf as it calves off.[381]

Halley IV utilized a larger tube, 9 metres, which allowed for two-storey buildings, and the tube was constructed from insulated plywood panels. The weight of the snow began structurally damaging the tube within four years of its construction. This station only lasted nine years and was replaced by Halley V in 1992.[382]

Halley V

Halley V took a different approach that was becoming more popular in Antarctica, elevated stations. Four of the buildings that made up the station were located on elevated platforms with steel legs. The remaining two buildings were on skis and could be towed to new locations. The platforms could be jacked up to keep the buildings above the rising snow surface. The technology at the time made this a laborious process that involved annually bringing a team of steelworkers to come down to cut and weld on new realigned legs. This difficulty was coupled with the moving ice shelf warping the piers. It was the impending threat of the calving ice shelf that prompted the BAS to begin developing a new station in 2004.[383]

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380 Broughton, "Halley Vi Antarctic Research Station."; Shears, Downie, and Pasteur, "Proposed Construction and Operation of Halley Vi Research Station, Brunt Ice Shelf, Antarctica. Draft Comprehensive Environmental Evaluation (Cee)."; Weale et al., "Elevated Building Lift Systems on Permanent Snowfields: A Report on the Elevated Building Lift Systems in Polar Environments Workshop."

381 Broughton, "Halley Vi Antarctic Research Station."; Shears, Downie, and Pasteur, "Proposed Construction and Operation of Halley Vi Research Station, Brunt Ice Shelf, Antarctica. Draft Comprehensive Environmental Evaluation (Cee)."; Weale et al., "Elevated Building Lift Systems on Permanent Snowfields: A Report on the Elevated Building Lift Systems in Polar Environments Workshop."

382 Broughton, "Halley Vi Antarctic Research Station."; Shears, Downie, and Pasteur, "Proposed Construction and Operation of Halley Vi Research Station, Brunt Ice Shelf, Antarctica. Draft Comprehensive Environmental Evaluation (Cee)."; Weale et al., "Elevated Building Lift Systems on Permanent Snowfields: A Report on the Elevated Building Lift Systems in Polar Environments Workshop."

383 Broughton, "Halley Vi Antarctic Research Station."; Shears, Downie, and Pasteur, "Proposed Construction and Operation of Halley Vi Research Station, Brunt Ice Shelf, Antarctica. Draft Comprehensive Environmental Evaluation (Cee)."; Weale et al., "Elevated Building Lift Systems on Permanent Snowfields: A Report on the Elevated Building Lift Systems in Polar Environments Workshop."

Halley VI

Instead of the typical institutionally designed building, they held a competition for the design of Halley VI. This process is a significant change between the post-IPY stations and early structures; bring aesthetics into consideration by utilizing design professionals. The design competition brought in 86 entries from seven different countries. A final three were selected to develop their concepts, which included a site visit. The ultimate winner was Hugh Broughton Architects and Faber Maunsell (now known as AECOM).[384]

The design brief focused on the environmental impact of the station and the well being of the inhabitants. The overall objects for the project highlighted the Environmental Protocol outlined by the ATS, hoping to minimize the impact the station has on its surroundings. The station itself needed to create a safe and comfortable environment for the inhabitants, accommodating the extreme weather at the Brunt Ice shelf. The brief also expanded to ask that the station create a stimulating workplace and habitation. It should be able to house 52 people in the summer and 16 through the winter. The BAS also wanted a station that would last up to 20 years instead of previous stations, which averaged about a 10-year lifespan.[385]

Halley VI is designed to be an elevated mobile station, made up of smaller modules that are linked together to form the whole structure. The legs which hold the individual modules up can be hydraulically moved up and down. This innovation enables the station to 'climb' out of the rising snow, with additional support each leg is lifted individually, the hole that it just vacated is filled in by a bulldozer and tamped down, the leg then lowers back down to settle on the ground. The module is then raised up to be at the same level as its neighbours.[386]

The modules can also be unhooked from each other and relocated. The legs rest on skis to spread the weight of the structure out, but also allowing the individual modules to be towed inland and the entire station be repositioned as the ice shelf shifts. A recent crack that is known as Chasm 1 was estimated to threaten the location of Halley VI, so a relocation effort was made in 2016. Another crack, the Halloween Crack, which is moving much quicker than Chasm 1,

[384] Abley, I. and Schwinge, J., "Architecture with Legs (Project Redsand)," *Architectural Design* 76, no. 179 (2006); Broughton, Hugh GK, "Antarctic Research Stations: Parallels for Interplanetary Design" (paper presented at the Proceedings, 40th International Conference on Environmental Systems, American Institute of Aeronautics and Astronautics, 2010); Broughton, "Halley Vi Antarctic Research Station."; Fry, C., "Lab in a Cold Climate," *IEE Review* 51, no. 4 (2005); Shears, Downie, and Pasteur, "Proposed Construction and Operation of Halley Vi Research Station, Brunt Ice Shelf, Antarctica. Draft Comprehensive Environmental Evaluation (Cee)."

[385] Broughton, "Polar Research Facilities: Living in Isolation."; "Halley Vi Antarctic Research Station."; Shears, Downie, and Pasteur, "Proposed Construction and Operation of Halley Vi Research Station, Brunt Ice Shelf, Antarctica. Draft Comprehensive Environmental Evaluation (Cee)."

[386] Broughton, "Polar Research Facilities: Living in Isolation."; "Halley Vi Antarctic Research Station."; "A Mini Module for Remote Science Research in Cold Regions," (SAE Technical Paper, 2007); Holden, Constance, "Architecture for the South," *Science* 309, no. 5735 (2005); Blair, Scott, "Global Project of the Year: Halley Vi Antarctic Research Station. (Cover Story)," *ENR: Engineering News-Record* 274, no. 3 (2014).

has forced Halley VI to be evacuated for winter 2017. It is intended to evaluate Halloween Crack and its trajectory in summer 2017/2018 and potentially relocate Halley VI again.[387]

There are two primary forms of modules that make up Halley VI, seven smaller blue modules, and a singular larger red one. The eight modules are connected together with flexible links. The Architects studied how trains were coupled together in colder climates. This allows for the modules to be uncoupled for transportation. It also has a tight assembly, but flexible enough that changing in the substrate won't impact the structure.[388]

The smaller blue modules can house different purposes; there are two devoted to scientific labs, two for the generators and plant functions which are connected by a service bridge, a single command module, and two for sleeping. These latter ones each have eight small rooms which have two bunks. They also have restroom facilities and a small seating area. The service bridge serves two purposes. In the case of a fire, the bridge creates a break, and each side can support inhabitants until they are rescued. It also forces those researching in the science modules to go outside to connect to the natural environment that surrounds them.[389]

The larger red module contains the main living spaces in the two-storey space. The architect kept the first floor fairly open to allow for the space to be rearranged based on the needs of the fluctuating population between summer and winter. Central to the module is a helical stair that brings the users to the second floor where a gym, library, and lounge are found.[390]

To combat Seasonal Affective Disorder, the designers took particular care with the materials, colour, and layout of the living modules. Colours were selected to break up the potential sterile monotony of the interiors, each module reflecting different schemes. Around the helical stair, cedar panels were installed to bring natural warmth, texture, and odour to the space. Since the modules are arranged in a straight line, subtle changes in the width of the central corridor, as well as the height, break up the monotony. There are also large windows whenever the space allows, and for the three months of almost complete darkness, LEDs project natural circadian rhythms.[391] Even the colours of the overall station, the string of blue modules broken

[387] Broughton, "Polar Research Facilities: Living in Isolation."; "Halley Vi Antarctic Research Station."; Blair, "Global Project of the Year: Halley Vi Antarctic Research Station. (Cover Story)."; Dockrill, Peter, "Gigantic Ice Crack Threatens British Antarctic Station," *Aurora Journal* 36, no. 2 (2017); George, Alison, "Have Skis, Will Travel," *New Scientist* 227, no. 3028 (2015); Weale et al., "Elevated Building Lift Systems on Permanent Snowfields: A Report on the Elevated Building Lift Systems in Polar Environments Workshop."

[388] Broughton, "Polar Research Facilities: Living in Isolation."; "Halley Vi Antarctic Research Station."; "A Mini Module for Remote Science Research in Cold Regions."; Jones, D. H. and Rose, M., "Measurement of Relative Position of Halley Vi Modules (Morph): Gps Monitoring of Building Deformation in Dynamic Regions," *Cold Regions Science and Technology* 120 (2015).

[389] Broughton, "Polar Research Facilities: Living in Isolation."; "Halley Vi Antarctic Research Station."; "A Mini Module for Remote Science Research in Cold Regions."

[390] "Polar Research Facilities: Living in Isolation."; "Halley Vi Antarctic Research Station."; "A Mini Module for Remote Science Research in Cold Regions."

[391] Broughton, "Antarctic Research Stations: Parallels for Interplanetary Design."; Broughton, "Polar Research Facilities: Living in Isolation."; "Halley Vi Antarctic Research Station."; Slavid, *Extreme Architecture*; Holden, "Architecture for the South."

with the larger red social hub against the white snow background, evokes the colours of the Union flag.[392]

Hugh Broughton Architects describe how they viewed the station; "We consider Halley VI to be a visitor to Antarctica, not a resident."[393] They were not designing a station that is intended to last forever; they intended to create a building that would have minimal impact on its surroundings and not leave a lasting impression once it was removed. This partially stems from requirements in the initial design brief that asked the designers and engineers to consider how decommissioning would take place. That was part of the impetus behind the prefabricated modular elements; ease of replacement and demolition.[394]

Other passive environmental measures were taken when siting the station, which is ever-evolving since the station is movable and can modify their approach each time the station is relocated. The initial layout has the linear string of modules perpendicular to the prevailing winds for snowdrift mitigation.[395]

The construction process also was conducted in an environmentally sensitive manner, or at least as much as it could be at its location shipping materials to the site.

The water for the station is provided by melting snow and ice. This energy-intensive process is alleviated by using excess heat from the bioreactor sewage treatment system. The reliance upon water has been lessened by limiting the duration and frequency of showers and utilizing vacuumed drainage system that was based on what is typically found on ships and submarines.[396]

The station is furnished with low energy equipment to lower the electrical demand. The exterior envelope was insulated against the environment to diminish the heating requirements. This enabled Halley VI to avoid using traditional renewable energy systems since these do not always function reliably in Antarctica. Much of the mechanical and electrical systems are controlled by a building management system to optimize them. This arrangement also enables the station to be run with less support staff than the typical station.[397]

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[392] Slavid, *Extreme Architecture*.
[393] Broughton, "Halley Vi Antarctic Research Station."; "A Mini Module for Remote Science Research in Cold Regions."
[394] "Halley Vi Antarctic Research Station."; "A Mini Module for Remote Science Research in Cold Regions."; Shears, Downie, and Pasteur, "Proposed Construction and Operation of Halley Vi Research Station, Brunt Ice Shelf, Antarctica. Draft Comprehensive Environmental Evaluation (Cee)."
[395] Broughton, "Polar Research Facilities: Living in Isolation."; "Halley Vi Antarctic Research Station."
[396] Blake, "The Construction of Halley Vi Station in Antarctica."; Broughton, "Antarctic Research Stations: Parallels for Interplanetary Design."
[397] Blake, "The Construction of Halley Vi Station in Antarctica."; Shears, Downie, and Pasteur, "Proposed Construction and Operation of Halley Vi Research Station, Brunt Ice Shelf, Antarctica. Draft Comprehensive Environmental Evaluation (Cee)."

4.7.5 Integration of Biophilic Attributes

Direct Experience of Nature

As seen in the previous cases, Halley VI was not designed to facilitate a direct connection with the natural environment. However, the designers do take more innovative measure to connect the occupants indirectly with the attributes described in biophilic design as 'direct'. This also includes creating opportunities to relate to the natural aspects of Antarctica.

Light

Halley VI prioritised the inclusion of natural sunlight whenever possible. The bedrooms in the sleeping modules are each outfitted with small portal windows. Additionally, at the entrance area to each of those modules have larger viewing windows. In the larger social module, the first floor has a double-height space with translucent panels wrapping the vertical and angled planes. To provide natural lighting on the second floor of the social module are cockpit rooflights, bubble-like skylights in the angled ceiling of the library and gym. Through the central circulation spine of the station, there are light tubes that augment artificial light sources.

Differing from contemporary cases, Halley VI also took measures to consider how to mitigate too much light or the empty eerie feeling of the darkness. The translucent panels in the living module are used higher, where the view is not practical to act as a screen or filter. With the cockpit rooflights and the bedroom portal windows, they are equipped with blackout shades to allows for control by individual users.

Air

As with the other cases discussed, measures have been taken to avoid natural air infiltration.

Water

With no natural potable water easily accessed, water generation is through snowmelt. The melt tanks are located under the connector bridge between the Plant Modules, which house a water treatment centre. Facilities within the station are designed for water savings to lessen the load. Toilets utilise a vacuum drainage system, and showers have time limitations and frequencies, which is often the case at stations.

Plants

Early concepts included a hydroponic greenhouse to augment winter food sources, but this did not make it through to the final design. The reason why it was not discussed.[398]

[398] Slavid, Ruth, *Ice Station : The Creation of Halley Vi : Britain's Pioneering Antarctic Research Station* (Zurich: Park Books, 2015).

Animals

Due to the Madrid Protocol, there are no animals in the station

Landscapes

There is very little in terms of the landscape directly surrounding Halley VI that engages the inhabitants; rather, the significance lies with the possible scientific research. Like Amundsen Scott, Halley VI is an elevated station. However, this is to prolong the life of the station, not out of ecological respect to the site. The history of the station's interaction with the surrounding landscape tracks that of Amundsen Scott and Casey Station, with structures before the Madrid Protocol being abandoned. With the nature of an ice shelf, eventually carried to the edge and calved off into the ocean. After the Protocol, the stations were dismantled and removed from the continent for disposal.

Recreating natural landscapes from the source country is also not a possibility, with the same restriction as the other cases of the Madrid Protocol. Also, the climate of the ice shelf would not easily support foreign plantings. As discussed in the *Plant* section, there is no internal greenery at this station.

'Weather'

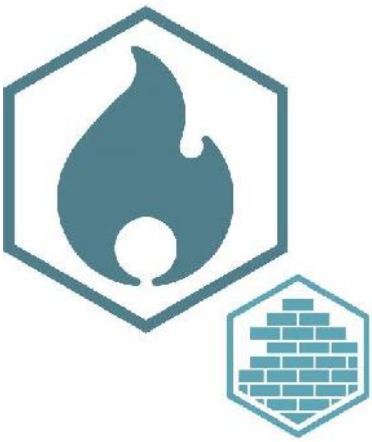
The combination of the Ice Shelf and Antarctic climate create a unique set of climatic conditions challenges that Halley VI overcame based on learning from the prior five iterations. Wind, snow, and temperature are the most significant. Halley VI's design addresses explicitly the combination of wind and snow with hydraulic legs that support the modules. Individually, the modules can "climb" out of the snowdrifts. One leg at a time lifts, the snow is ploughed and compacted below before it lowers down again. Each module is relocatable to combat the steady movement of the ice out towards the ocean. Each leg rests on skis, which allow the modules, when uncoupled, to be towed to a new location. These two systems are intended to work together to extend the lifespan of the station where the previous versions failed.

The wind direction dictates the orientation of the string of modules. With this severe weather, Halley VI still connects the inhabitants to the outside with plentiful windows and an observation deck within one of the science modules. Direct experience within the conditions is unavoidable while living and working at the station. Inhabitants must cross the service link bridge to access the scientific modules, which is not enclosed.

Views

The inclusion of a significant number of windows has previously covered their relevance for allowing natural light and for monitoring weather patterns. They have the added benefit of providing views of the surrounding views and bringing an awareness of where the inhabitants physically are. Different from the previous cases, Halley VI is a mobile station; therefore, windows cannot be located for specific views; instead, they are oriented for other attributes of the environment. Most windows are at eye level to allow users to view the expanse of the ice shelf and have an awareness of the exterior conditions since there are not any substantial geological elements. On the second floor of the social module in the gymnasium and lounge/meeting room are the cockpit rooflights, which are specifically intended to provide the inhabitants with a view of the aurora australis during the winter months.

Fire



The same as the previous IGY and IPY cases, there are no open flames present in the living spaces, and any combustion takes place away from these areas. However, fire was employed symbolically at the heart of Halley VI. The cedar veneer panels were specified to evoke a feeling of warmth central to the social module[399]

[399] Ibid.

Indirect Experience of Nature

Similar to the other cases, Halley VI has a stronger indirect connection with nature and favours natural aspects that are reminiscent of the UK rather than Antarctica. Comparable to Amundsen-Scott, innovative materials, technologies, and creative thinking leads these attributes to be more successful and valuable regarding the intention of biophilic design. The diverse efforts discussed in the previous section also impact the indirect attributes.

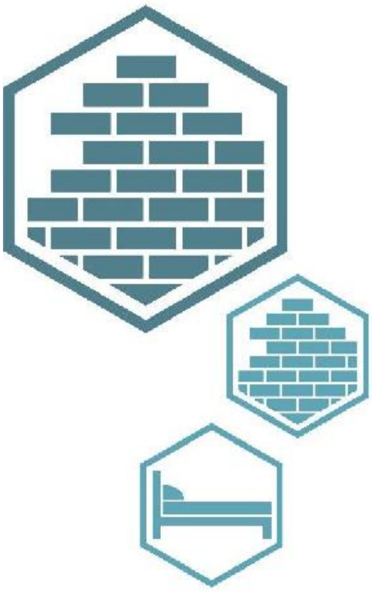
Images

The interior of the station is quite sleek with the formal inclusion of imagery contained to the historical display in the living module. In Halley360[400], some expedition member's artwork can be seen on the lower level surrounding the circular stair. A more unceremonious continuation of the historical display can be seen on the face of storage closets in the dining area; these range from related expedition images and what appear to be photos from home. There are several other instances in the communal spaces which primarily depict Antarctic related images, whether historical or natural providing context to the setting.

In the sleeping, modules are designed for inhabitants to be able to personalise their own spaces. The wall behind the desk allows for temporary mounting with pushpins. Observed in pictures, often this is utilised to display personal photos of friends, family, or home. Some more creative occupants have more elaborate and creative uses slightly for this displaying crafts or handiwork, bringing a sense of familiarity.

[400] Krzysztofowicz, "Halley 360".

Materials



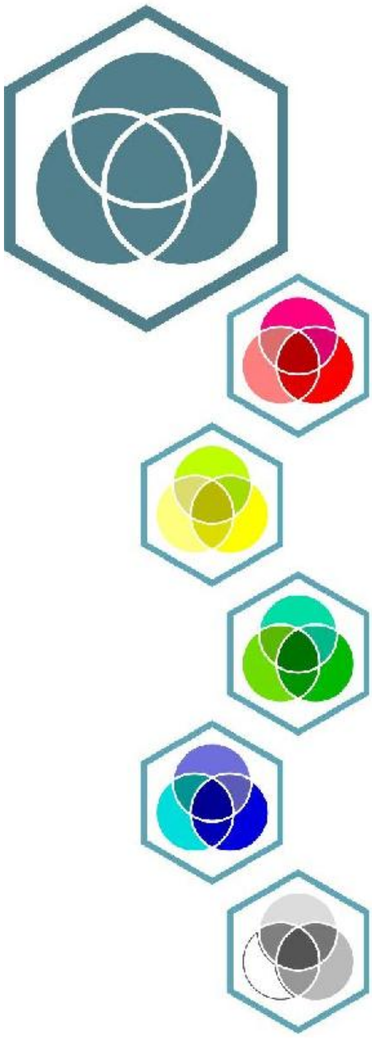
There are no endemic materials incorporated in the design of Halley VI, as seen in the previous cases. Instead, the materials were all imported explicitly for the construction of the station. The most common material found on the interior for cladding is fermacell, a type of gypsum board. The majority of other materials utilised are of similar synthetic durability; metal, plastic, vinyl, rubber, etc.

There are highlights of natural materials that the inhabitants would more readily relate to, primarily wood found in the living and sleeping modules. The most significant amount is centred around the circular stair, in the living module; the drum is lined with Lebanese cedar panels, the stairs themselves have wooden treads and a cherry handrail. The next significant installation is the wooden panel wall which a dartboard is mounted upon in the bar area. In the bedroom, the desks and shelves bring a warm natural brightness with blond wooden surfaces.

Texture

As described above, the majority of materials have a smooth texture for durability and ease of cleaning. One instance that illustrates how texture has incorporated those two attributes but also provided variety is with the flooring. There are two predominant types of flooring inside the station; round stud rubber flooring and carpeting. While they maintain a consistent colour between the two, they are employed in different locations based on the use of the space and the amount of through traffic. Shared spaces with many people moving through and transitional areas from the indoors to outdoors have more robust rubber flooring. Where the spaces that are more sedentary, quiet, home-y have the carpeting, providing softer muffled conditions for the sleeping modules and recreational spaces (bar and second floor of the living module).

Colour



A colour psychologist was consulted for the design of the Halley VI to create a dynamic and engaging space to live and work. The palette does not have grounding with earth tones, instead endeavoured to create an identity for each module. The overall red and blue exterior scheme was intended to partner with the surrounding white to evoke the feeling of the Union Jack. Inside light, bright colours were selected. The flooring is a vibrant blue colour, grounding the space, while the wall colour throughout the majority of the station is a bright off white. Intense pops of colours greet users to the various modules, the sleeping modules have lime green, while the command and science module use yellow. Within bedrooms, colours are kept subtler, with the same blue as the carpet wrapping to the desk wall and a muted golden for curtains on the bunks. Beyond a bright red chair, the rest of the space and furniture are the same off-white colour from the rest of the station.

Shapes and Forms

Halley VI does not inherently incorporate any naturalistic or organic forms. The modules and spaces within them are octagonal and rectilinear. The angles of the modules are not strictly 45° but have a similar quality. Like the previous cases, Halley VI is made up of prefabricated elements with commonality in the overall shape of the modules. This does not lend itself towards having curved or natural forms. However, for aerodynamics, the outside of the station is smoother, lacking harsh corners, which does give it a more organic feeling, as discussed in *Natural Geometries*.

Information Richness

Halley Vi is a relatively simple, straight forward, clean line building. However, the attributes are layered together to create a subtle diverse richness. For example, how Mobility, Organized Complexity, and Colour complement one another to facilitate wayfinding and ease of differentiation between modules. Added to that, Prospect & Refuge connects the users to the outdoor spaces within the circulation areas.

Another instance is the circular stair. Here, a dynamic spiral form grows out of a primarily orthogonal space to connect the two levels. The material selection of cherry wood and glass gives a lightness to a relatively enclosed concept. Furthermore, the Lebanese cedar panelling brings a sensory depth, evoking a warmth to the centre of the station, a tangible softness in contrast to the gypsum boards, delivering the earthy cedar scent to a foreign natural environment devoid of familiar smells to the occupants.

Change, Age, and the Patina of Time

Materials were selected for their resilience and have not had any documented wear over the six-year life of the building. As with Amundsen Scott, it will be seen how these newer technologies, materials, and approaches stand up over time. However, the building is designed with a finite lifespan. With the prior experience at the Brunt Ice Shelf, it is accepted that someday Halley VI will need to be replaced.

Natural Geometries

There are two key aspects of Halley VI that relate to standard natural geometries; spirals and aerodynamic forms. The latter is seen in the overall shape of the individual modules. In concept sketches,[401] the architect has noted that the 'units must appear aerodynamic'. There is no further elaboration on if they need actually to be aerodynamic, which would aid in extending the lifespan of the building. The resulting shape is comparable to the rounded cubicle form of some fish and seed pods.

The vertical transportation drum occupies the proverbial centre to the station in the living module. A spiral stair is used to resolve the issue moving between floors in a condensed floor plan. While the stair is a simplistic version of a spiral, it does relate and allude towards the more sophisticated versions; snail shells or fern fiddleheads.

[401] Ibid.p.20

Simulated Natural Light & Air

Artificial lighting is essential for life at Halley VI due to the extreme diurnal cycles at the Brunt Ice Shelf. In the sleeping modules, this was done in a way that complements or simulate the natural light. In the central corridor, alternating with the light tubes are recessed can lights; an artificial lighting intervention creating the same effect as the natural light. A more sophisticated system which simulates natural light is the sunlamps in each bunk. These are lights that can be set to mimic sun rising for the occupant, and individualised to preferences. The sunlamps were intended to help combat seasonal affectedness disorder that can be prevalent in these regions.

Common amongst the contemporary cases, there is an artificial ventilation system which tempers the outdoor air for fresh air.

Biomimicry

There is no documented evidence that biomimicry was employed in the design process or the resulting station.

Experience of Space and Place

While Halley VI is designed to be in tune with the challenges that the extreme environment and site present, it does not fully connect the inhabitants to the natural surroundings. The station does take further steps than many of the other cases to do so, but still not to the level that biophilic design endeavours to have. There are a distinct history and culture around the BAS's occupation of the Brunt Ice Shelf that Halley VI embodies.

Prospect and Refuge

The Brunt Ice Shelf provides minimal natural elements that can aid in creating refuge for any architectural interventions. One could argue that drifting snow creates a form of protection, but this has been more of a hindrance than an asset. Earlier versions of the station show that while the snow does promote this condition, it also eliminates any potential for prospect aspect of this attribute and being buried in snow proved to be problematic for building materials.

As discussed in the Views section, windows are crucial in this environment to provide a connection to the exterior. This is particularly emphasised with creating an opportunity for fostering a sense of prospect; a relationship with the natural surroundings from a sheltered space. The architect makes a specific note about the cockpit rooflights offering the opportunity to experience the surroundings from the warm protection of the interior of the station, with the reasoning behind the clear glass of the atrium allowing for views of the 'Antarctic wilderness'.[402]

Within the station, the concept of refuge can also be viewed from an individual inhabitant's perspective. There is an assortment of spaces that allow for varying levels of privacy. The aptly named social module houses the areas designated for the larger group gatherings, the communal living spaces; with the bar, dining, and games are on the lower level and a lounge and gym on the upper. Sleeping modules at the end of the station contains more private living areas. The pair of modules include small seating areas for two or three people, the bedrooms, and the bathrooms. The bedrooms have separate bunks for occupants; in summer each room houses two expeditioners, winter allows for solo habitation. During shared summer months, the bunk is

[402] Ibid.

intended to create a secluded, personal, pseudo customizable space. Curtains provide separation; the alarm light elaborated upon in Simulated Natural Light is wall mounted for each bunk, and space for personal items to create more of a feeling of home.

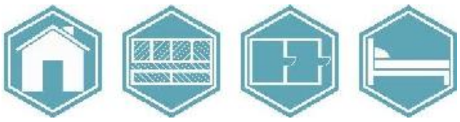
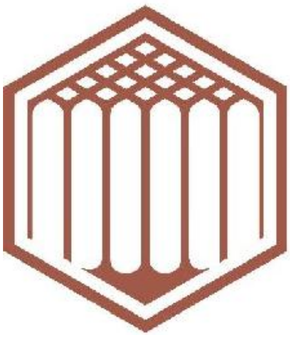


Figure 4-13 Hierarchy of Halley VI: building to zones to rooms to bunks

Organised Complexity



Halley VI has a very sleek space-age-like interior and exterior. This aesthetic does not relate to what biophilic design classifies as organised complexity. Ornamentation is minimal, with much of the surfaces kept smooth for durability.

Mobility

This station uniquely has two types of mobility considered with its design. As previously discussed, the building itself is mobile. Individual modules can be disconnected, pulled on their built-in skis, relocated, and reassembled at the desired final location. The intent of this was to combat the shifting ice shelf, but it has also been employed recently to avoid cracks forming in the ice shelf.

With the central corridor, parti mobility is relatively simple between the eight modules. The arrangement also logically follows the general use of each module, with the sleeping modules paired together, separated from the social module by the command module. The remaining four modules are devoted to the science and plant rooms. The treatment of the central spine in each is different, whether that is through colour, ceiling height, corridor width, or partition existence. These techniques are all employed to aid in wayfinding within the relatively small station.

Transitional Spaces

There are two main entrances to Halley VI, though vestibules attached to the command module and one of the science modules. These are small spaces primarily devoted to exterior mobility equipment (skis, sleds) and two doors. The larger of these rooms exit outside with the smaller opening into a boot room where general outdoor gear and clothing put on in preparation and stored when not in use.

The internal arrangement has more clear individual transition points than other cases with the configuration of a linked series of pods. As one travels through the station, there is a clear beginning, middle, and end to each module as is described in *Mobility* above.

Place

Inhabitants live an isolated remote life in and around Halley VI. However, it still does engender a sense of place specific to the Brunt Ice Shelf both physically and socially.

Geographical - The Brunt Ice Shelf's lack of significant stagnant geographical features is what defines life there. As discussed in the *Landscapes* section, the lack of mountains, trees, hills, or other landmarks creates a windswept snowfield atop the ice shelf. The wind and drifting snow are then what Halley VI has reacted to in a unique sense for this station. Primarily this is achieved through orienting the string of modules partnered with its ability to climb out of drifting snow.

Ecological - Conditions of the ecological system inherent in an ice shelf have also built upon the geographic attributes in moulding the final form of Halley VI. The resolution was elaborated upon in the

Mobility section. The Brunt ice shelf continually moves towards calving into the ocean, taking anything on or in it steadily towards the edge of the shelf. The act of moving the station brings an acute awareness of this condition to those living there.

Cultural - Living in Antarctica provides a community both on and off the continent with a limited number of people with similar experiences. The unique nature the location of the station provides further comradery between inhabitant; past and present. Shared experiences of the challenges and encounters of living on an ice shelf form a bond with the inhabitants and extend to a remote kinship after they have left the ice.

Historical - Halley VI has a long historical connection to the Brunt Ice Shelf, going back to the planning of the International Geophysical Year. The physical evidence of the previous five stations has either been buried by drifting snow and calved into the ocean or dismantled and removed. However, within the living module, there is a display illustrating the history of expeditions at the Halley Station. Engaging in primary scientific research also connects the inhabitants to the base historical purpose of the Halley Stations.

Integrating Parts to Create Wholes

Halley VI is one of the more innovative cases concerning associating the building with its site. However, many of these aspects are not designed to connect the occupants and nature, or they provide opportunities to appreciate the surroundings in a controlled manner indirectly. This does not directly lend itself to an appreciation of one's place within the ecosystem of Antarctica, instead maintaining that buffer, found in all of the cases, prioritizing shelter.

4.8 SUMMARY

Each case presents its own incorporation of biophilic attributes, primarily in passive manners. While they were designed independently of one another, patterns within the development and inclusion emerge as the cases are viewed chronologically. This highlights the inherent characteristics of biophilic design and illustrates the priorities fostered withing building in an extreme environment. In the following chapter, these patterns are acknowledged and described to provide a fuller picture of the evolution of architectural interventions in Antarctica.

Chapter 5: Results

5.1 BIOPHILIC DESIGN IN ANTARCTICA

Biophilic design was conceived within the constructs of the developed world with a temperate climate. While it has grown to take a global climatic and socio-economic approach to the experiences and attributes, much of it is still challenged by such an extreme environment that Antarctica presents. An environment where the natural reaction to the outdoors is to shut the door purely for survival. It is a climate where humans require architectural interventions to be able to exist. The following section identifies in a general sense what Antarctica has to offer the attributes of biophilic design.

5.1.1 Direct Experience of Nature

The extreme environment of Antarctic presents complexities and limited opportunities for inhabitants to have direct experiences with the natural elements. The following discusses the possible opportunities.

Sunlight

A variety of natural daylight conditions occur throughout the continent. The most extreme of these consists of one sunrise and one sunset each year. Nearly all portions of the continent have a period of 24-hour darkness in June and 24-hour daylight in December/January.

Air

The air is breathable, and there are natural breezes and wind patterns. However, the average temperature for the majority of the continent infrequently rises above 0°C throughout the year; the average annual temperature across the cases is -21.4°C. Combined with extreme winds in some locations makes natural ventilation unfeasible and potentially detrimental to the structures and inhabitants.

Water

Water is found naturally on the continent of Antarctica in two common states; liquid and solid. During the warmer summer months, oceanic and sea ice in the coastal areas melts and creating open water near shore. More prevalent is the presence of solid-state liquid in the form of snow and ice. These are present universally on the continent and in some areas is the only occurrence of water.

Plants

Limited plant life thrives on the continent of Antarctica. The most widely found in the coastal regions are mosses, lichens, algae, and liverwort. The lack of vegetation is due to the harsh climate, and there are portions of the continent where no plants are present. Though there is evidence of rich jungle flora during the time of Pangea, it does not directly relate to the climatic conditions of Antarctica today. The Madrid Protocol restricts non-endemic plants to avoid damaging the surviving horticulture of Antarctica.

Animals

All endemic fauna found in Antarctica are associated with the surrounding water, which similar to the flora means areas of the continent have nothing naturally living there. Animals typically found in the coastal regions include sea birds, penguins, seals, and whales. The Madrid Protocol addresses the importation of non-native species, such as sled dogs, to protect the existing environment. Any alien or exotic species are banned from being brought intentionally to Antarctica.

Landscapes

Antarctica is considered to be a cold or polar desert. With no significant period with temperatures above freezing, snow rarely melts in the centre of the continent, distinguishing this ecosystem from the tundra. These conditions can be found in the polar regions as well as in high altitudes. The natural terrain in Antarctica is quite varied. Snow covers much of the continent, and the footprint significantly expands with ice shelves. However, coastal areas have exposed rocks, mountains, and glaciers. There is one significant mountain range, the Transantarctic Mountains, which bisects the continent.

'Weather'

The extreme characteristic of life in Antarctica primarily is the what biophilic design describes as 'weather'. The majority of the Continent rarely sees temperatures above freezing. Being a cold desert, climatic patterns exhibit little precipitation but are coupled with the harsh, severe winds, the loose fine snow obstructs visibility and buries anything with drifts.

Views

A variety of landscape scenes are afforded the inhabitants of Antarctica depending on their location. Views range from wide expansive views of the ice shelves and Antarctic plane. Cutting through the continent and ringing the perimeter are mountain ranges breaking up the topography. There is also the surrounding ocean and wildlife to add to the adjacent scenery.

Fire

Despite being such a frigid climate, there are several volcanos found around the continent. Beyond that, fire is a necessity for survival in Antarctica, ergo with the inclusion of humans, there is a presence of fire or heating.

5.1.2 Indirect Experience of Nature

Indirect experiences of the surrounding environment may provide more palatable opportunities for the inhabitants. It indeed allows for greater access to representations or the alteration of nature to suit an indoor setting. This element of biophilic design is also a point where the symbolism of what is selected can be analysed and affords the chance for inhabitants to include elements from their own natural habitat. Opportunities to engage with the Antarctic environment in the manner are illustrated below.

Images

Photography was included in many of the early expeditions, capturing still and moving images and documenting early life, the natural environment and wildlife in Antarctica. This practice has continued; several Antarctic governing bodies have instituted programs that support expanded arts/writing activities as well. Curiosity, conservation, education, and scientific research has also contributed to a significant amount of video footage of the nature of Antarctica. Personal images allow for inhabitants to individually customise their spaces and potentially incorporate aspects of their own environmental background.

Materials

Natural building materials are limited in this environment; the most available resources are snow, ice, stone, and seaweed. Typically the materials used for construction come from overseas; this presents an opportunity for the inclusion of natural building materials from the source country.

Texture

In biophilic design, the texture goes beyond just the feel or touch of materials to include the other senses as well. Tangibly the endemic building materials can be integrated. The directly including views of the aurora australis or simulating the effect not only provides a visual rhythm but also combining the natural colours of the lights. Non-tangible aspects of texture include auditory experiences. Sounds range from the raucous penguin colonies; calls beached seals to subtler noises of the wind, the reverberations of cracking ice, the tinkling breakup of ice at the edge of the shore.

Colour

Antarctica is often thought of as a vast white expanse, despite being host to a veritable rainbow of natural colours. The snow and ice present varying shades of blue and white, while exposed rock and earth offer blacks, browns, yellows, and reds. The snow also reflects any light display from sunrise and sunset. During the 24 darkness of winter, the natural light display of aurora australis treats the few residents to a diverse range of colours in the phenomenon.

Shapes and Forms

Frozen crystalline patterns are the closest associated with forms endemic to Antarctica. These can form complex shapes and geometries ranging from snowflake and ice crystals to icebergs, crevasses or ice caves. These latter larger elements can begin to develop attributes similar to columnar supports or natural arches and domes that are familiar to other climates. More organic forms come from flora and fauna; their actual appearance or attributes, movement patterns, behaviour.

Information Richness

The perception of the environment initially can be quite homogenous. However, Antarctica has a variety of natural elements that come together beyond snow and ice. The topography includes large mountain ranges, volcanoes, the continental plateau, snowmelt lakes, and more. There are limited plant and animal life, both on land and in the ocean, that foster a dynamic and changing ecosystem. With the unique extreme environment, all of these elements have aspects that complement one another to be able to endure and subsist.

Age, Change, and the Patina of Time

Antarctica presents an ever dynamic and changing environment. Winds wear away at stationary material with sand and snow particles. Drifting snow caused by the winds also buries any vertical structure. Both create an active element to buildings as the materials are organically broken down and eventually need to be replaced or fortified.

Natural Geometries

The aspects of the environment of Antarctica present a multitude of natural geometries. Fractals or fractal-like aspects make up the structure of snowflakes and frost/ice patterns. The inherent tendency of nature to follow the geometries embodied in the Fibonacci sequence and the Golden Ratio is consistent here as well; ranging from plant growth, shells, penguin markings, etc.

Simulated Natural Light & Air

With the challenges outlined under Sunlight and Air, it is essential to supplement the natural attributes. During winter, lighting can mimic diurnal cycles and conversely in the summer shades can aid in developing a favourable sleeping environment. Mechanical systems are necessary, frequently required to foster healthy and sufficient ventilation within buildings. For both of these elements, it is typical to utilise characteristics that are similar to those of the inhabitants' source country.

Biomimicry

Biophilic design distinguishes the difference between biomimicry and biophilic design with the former studying how natural aspects have altered overtime versus the methods people have utilised to acclimate to their surroundings. How plant and animal life have adapted to survive in the extreme environment of Antarctica, ice formation, or many other processes can potentially serve as useful source material for biomimicry. Particularly studying the cold climate resilience of flora and fauna and investigating if that can be integrated into material technology or architectural form and function.

5.1.3 Experience of Space and Place

Living in Antarctica, the awareness of the location of ones' habitation is almost inescapable. For an architectural intervention to be successful, it is forced to acknowledge this and integrate considerations into the overall design. This goes beyond responding to the need for shelter or reacting the climatic considerations; integrating historical and cultural aspects as well.

Prospect and Refuge

The general environment of Antarctica presents perilous and hazardous setting for humans, primarily from temperature and winds, despite a lack of predatory animals. The extreme environment prompted the requirement for architectural interventions as a protective refuge. With that satisfied, inhabitants can foster a greater appreciation of the natural environment which surrounds them.

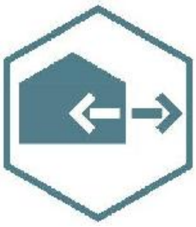
Organised Complexity

The natural environment of Antarctica does provide a canvas of detail and diversity. There are a variety of textures, forms, and patterns to be found in the snow, ice, rock, water, flora, and fauna. However, it is very subtle and muted to an outside perspective, which forms the biased perception of Antarctica is that of a vast snowswept landscape.

Mobility

The climate of Antarctica can make mobility between separate buildings complicated, particularly in the winter. The severe cold requires specific equipment to insulate individuals. Intense winds cause physically moving to be difficult; this also creates a hazard with drifting snow obscuring visibility and making unaided movement an issue.

Transitional Spaces



For shelter to be effective in Antarctica, the built environment must provide a sanctuary from the exterior elements. Intermediary spaces that facilitate the transition of inhabitants from outdoors to indoors creates additional control. This buffer can be to acclimate the inhabitant, don/discard the appropriate gear, or establish a further barrier between the climate and the temperate interior.

Place

Antarctica has a short, but rich human heritage integrated into its natural environment, predominatly from an Anglo perspective. Attempts at colonisation began with the Heroic Age of Exploration, establishing the culture of adventure and discovery. Layered on this was the quest to be the first to reach the geographic south pole, developing a mystique and significance around that point. Beyond the significant players (European) in this competition, countries geographically close to Antarctica joined the sovereignty land grab up until the International Geophysical Year. However, establishing a presence in Antarctica is exceptionally difficult due to the climatic considerations as seen in previous attributes. The ecological in tandem with the geographic constraints play an essential role in need and construction of shelter, making the architectural interventions a unique reflection upon their settings.

Integrating Parts to Create Wholes

Ecosystems thrive when encompassing functional interconnected parts. Flora and fauna have explicitly adapted to the harsh climatic conditions. Those conditions are specific to their unique setting on the continent, developing particular patterns. It is from these aspects that buildings can relate to their sites to connect the occupants to where they are living.

5.2 ANALYSIS

5.2.1 Overall Development

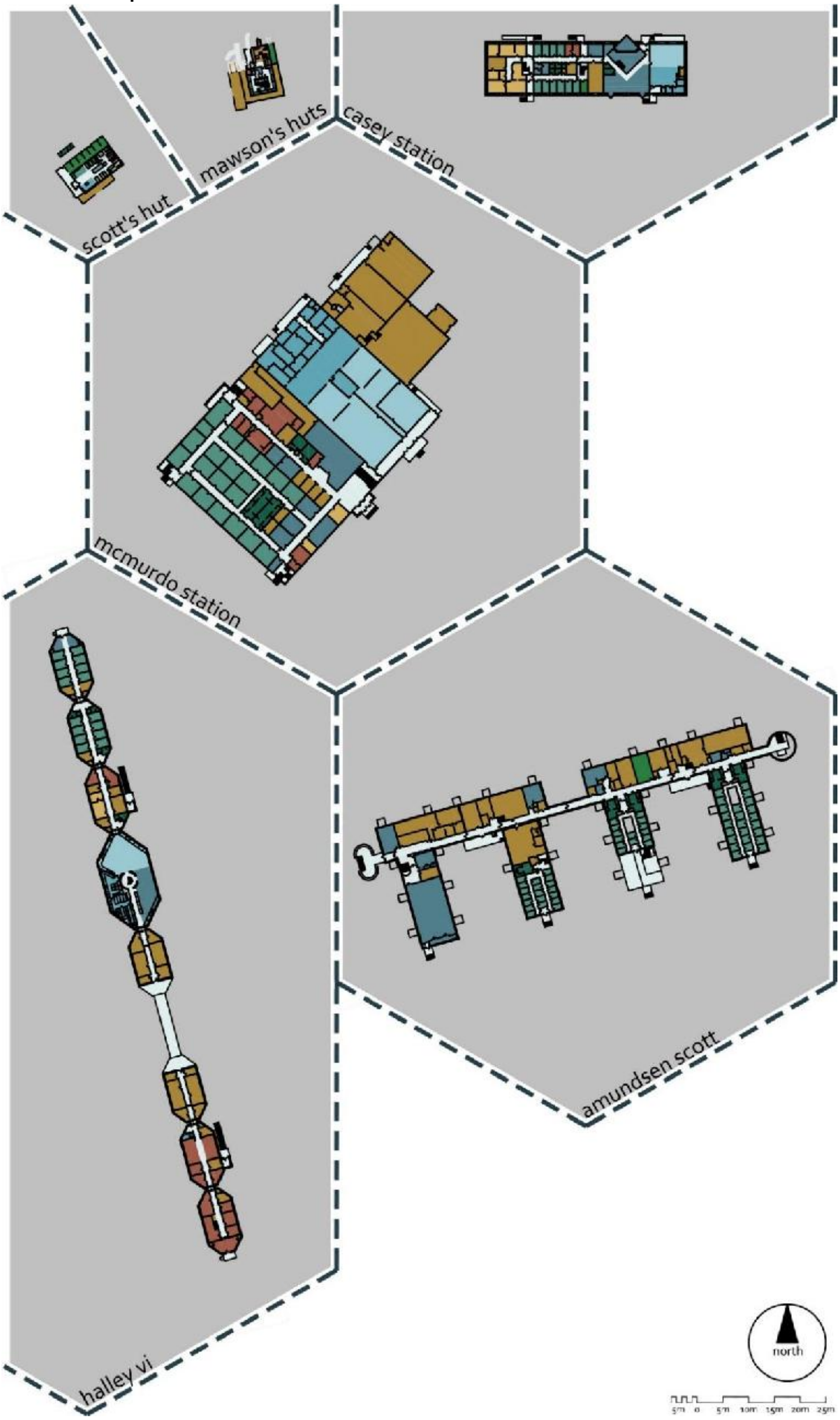


Figure 5-1 Comparison of Scale and Orientation of Case Ground Plans[403]

[403] Graphic by Author

Table 5-1 General Overview of Cases

	Scott's Hut	Mawson's Huts	McMurdo Station Building 155	Casey Station Red Shed	Amundsen-Scott	Halley VI
Location	Cape Evens Ross Island (1)	Cape Denison (2)	Hut Point Ross Island (3)	Wilkes Land (3)	Geographic South Pole (3)	Brunt Ice Shelf (3)
GPS Coordinates	77°38'10"S 166°25'04"E (4)	67°00'31.6"S 142°39'39.7"E (5)	77°50'53.5"S 166°40'06.3"E (3)	66°16'54"S 110°31'39"E (3)	90°S 0°E (3)	73°34'24.56"S 25°28'1.05"W (3)
Operational Period	year round (1)	year round (2)	year round (3)	year round (3)	year round (3)	year round (3)(6)
Accessibility	sea (1)	sea (2)	air and sea (3)	air and sea (3)	air (3)	air and sea (3)
Year Built	1911 (1)	1912 (2)	1955 (3)	1957 (3)	1957 (3)	1957 (3)
Population						
Summer			1000+ (3)	99 (3)	150 (3)	70 (3)
Winter			153 (3)	20 (3)	49 (3)	17 (3)
Beds	25 (1)	18 (2)	1200 (3)	99 (3)	150 (3)	52 (3)
Max. Capacity	25 (1)	18 (2)	1200 (3)	99 (3)	153 (3)	52 (3)

Notes
(1) data from Scott's Diary
(2) data from Mawson's Diary
(3) data from COMNAP - Antarctic Station Catalogue
(4) data from GeoHack - tools.wmflabs.org
(5) data from GeoHack - tools.wmflabs.org
(6) Halley VI was designed as a year round station, cracks in the ice shelf have prompted the station's closure during winter for safety

Table 5-2 Climatic Comparison of Cases

	Scott's Hut	Mawson's Huts	McMurdo Station Building 155	Casey Station Red Shed	Amundsen-Scott	Halley VI
Temperature (1)						
Summer	-10°C	-6°C	-10°C	-3°C	-21°C	-10°C
Autumn	-22°C	-17°C	-22°C	-13°C	-58°C	-24°C
Winter	-25°C	-17°C	-25°C	-15°C	-63°C	-28°C
Spring	-10°C	-8°C	-10°C	-6°C	-42°C	-12°C
Daylight (2)						
Summer	20:08:56	17:11:37	20:08:56	16:45:30	21:40:38	20:02:59
Autumn	1:41:22	5:27:56	1:41:22	5:51:11	0:00:00	2:31:00
Winter	4:08:13	7:33:42	4:08:13	7:49:42	2:40:00	5:13:37
Spring	22:24:18	19:32:27	22:24:18	19:15:33	24:00:00	22:18:42
# of 24hr day	119	37	119	24	183	107
# of 24hr night	116	0	116	0	182	102

Notes

(1) data generated from historical records at legacy.bas.ac.uk

(2) data generated from 2018 records at esrl.noaa.gov/gmd/grad/solcalc

Table 5-3 Spatial Comparison of Cases

	Scott's Hut	Mawson's Huts	McMurdo Station Building 155	Casey Station Red Shed	Amundsen-Scott	Halley VI
Area (1)						
Total Station	253.7m²	250.2m²	32750m² (2)	8000m² (2)	16107m² (2)	2000m² (2)
Total Case Building	131.1m²	203.7m²	7965.9m²	2316.5m²	6172.6m²	2250.9m²
animal	55.0m²	12.1m²	- - -	- - -	- - -	- - -
bathroom	7.5m²	0.6m²	259.1m²	71.4m²	239.9m²	181.4m²
bedroom	55.2m² (3)	24.6m² (9)	2221.0m²	304.5m²	735.6m²	33.7m²
circulation	82.1m² (4)	46.6m² (10)	1432.3m²	447.6m²	1422.0m²	388.1m²
dining	10.7m² (5)	19.6m² (11)	763.9m²	82.0m²	129.3m²	155.0m²
health	- - -	- - -	41.9m²	137.2m²	119.0m²	34.2m²
kitchen	14.1m² (6)	7.0m² (12)	597.3m²	78.0m²	109.9m²	89.9m²
plants	- - -	- - -	- - - (16)	9.3m²	48.3m²	- - -
recreation	10.7m² (7)	21.0m² (13)	576.4m²	523.1m²	865.6m²	243.2m²
support spaces	29.5m²	131.2m² (14)	1446.9m²	137.1m²	893.5m²	438.5m²
work	22.8m² (8)	36.1m² (15)	254.9m²	19.1m²	587.2m²	275.0m²

Notes

(1) data generated from scale drawings, for sources see diagrams in Chapter 4
(2) from COMNAP - Antarctic Station Catalogue
(3) shared with – circulation, kitchen, work
(4) shared with – bedroom, dining, recreation, work
(5) shared with – circulation, recreation
(6) shared with – bedroom
(7) shared with – circulation, dining
(8) shared with – bedroom, circulation
(9) shared with – circulation, recreation, work
(10) shared with – bedroom, dining, kitchen, recreation
(11) shared with – circulation, recreation
(12) shared with – circulation
(13) shared with – circulation, dining
(14) shared with – work
(15) shared with – support spaces
(16) Hydroponic greenhouse located in separate building

5.2.2 Biophilic Design in Architectural Interventions in Antarctica

Direct Experience of Nature

Light

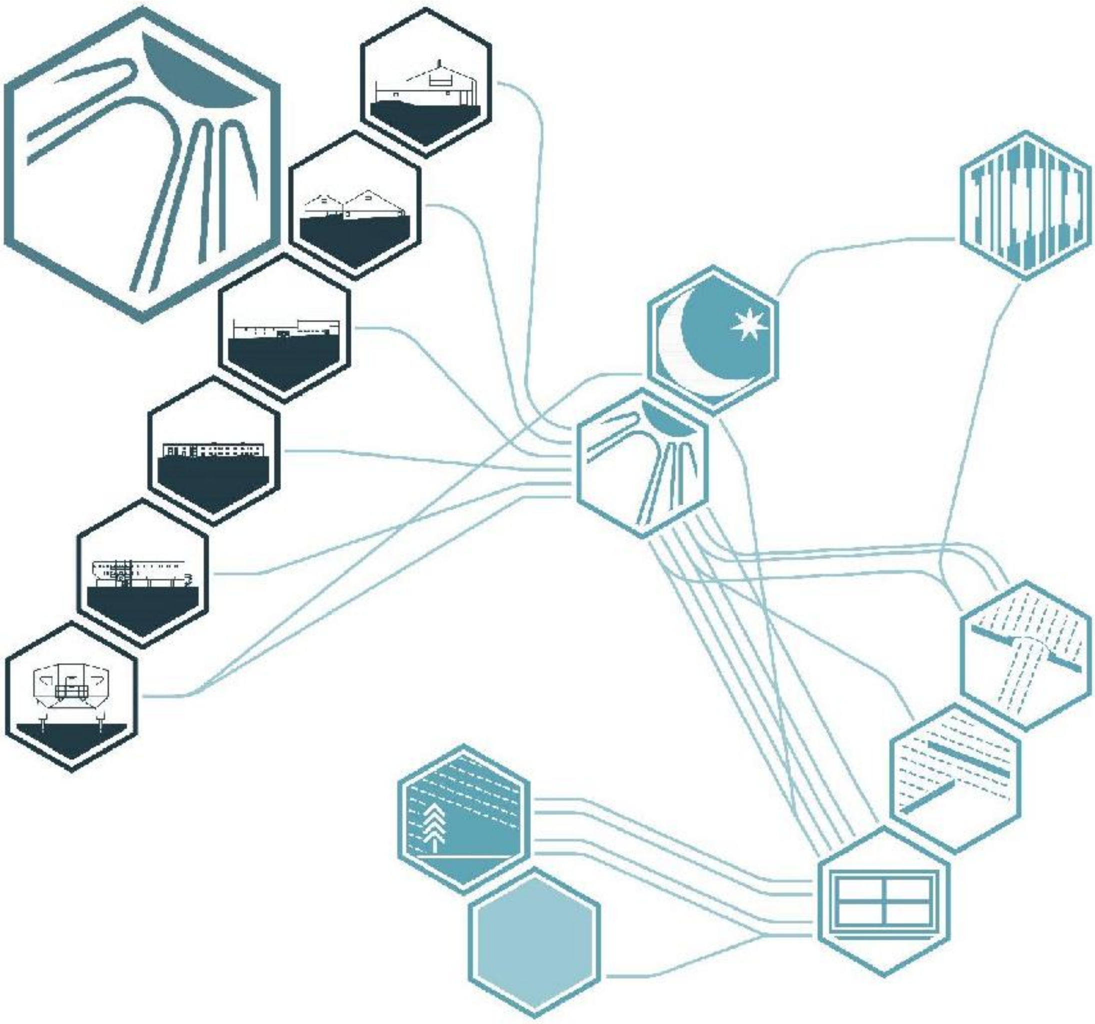


Figure 5-2 Light Analysis

One of the more disparate endemic qualities of life in Antarctica is natural light; the overabundance or lack thereof with prolonged periods of 24 hr daylight or darkness. Despite this difference, the majority of the cases utilise ordinary windows to bring natural light to the occupants. However, in many instances, shades have been provided (IPY) or improvised (McMurdo) to combat excessive and unwanted light.

The overall layout of the stations has been designed to take advantage of allocating windows to spaces which would benefit from natural light. Skylights and clerestory windows provide ambient lighting at McMurdo and Casey Stations for the dining room and vertical circulation respectively. Mawson also used skylights as the only natural light source in his huts. Due to the insulative double-shell concept with verandas along the perimeter, this was the only way to get natural light to the internal living and working spaces.

The most innovative approach to challenges of natural light comes from Halley VI, where the architects thought not only of the lighting conditions but also the darkness. Typical windows with blackout shades are found throughout the station. In corridors, there are solar tubes to illuminate the central windowless areas. In the social pod has a large double-height window wall, which during the summer would provide a significant amount of natural light. In the winter months, the glass becomes is eerie, dark, reflective. The designers used a frosted glass for the upper portions, above the line of sight, diffusing the summer light and lightening the winter darkness.

Halley VI is the only case to consider the aurora australis in the design. "Cockpit" skylights on the second floor of the social module are designed to be able to view these in the conference room/library and exercise room.

The interventions designed to take advantage of the natural sunlight have slowly responded to the unique conditions in Antarctica. Natural light is a crucial part of human life according to biophilic design. Not only does it offer illumination and heating, but movements of the sun provides the consistent circadian rhythm, how it tracks through the sky allows for cardinal direction orientation, and the intensity affords information about the climatic conditions. All of this can be accessed through a simple window; however, many of those customary patterns are different in Antarctica. As has been seen, allowing for user control, creates more comfort and well being for the occupants, permitting them to tailor the light conditions to their needs. Particularly true of the extended 24hr days. Biophilic design encourages manipulating the light beyond the flat conveyance typical windows create. Halley VI demonstrated the beginnings of this possibility through translucency and solar tube utilising the excessive light in a regulated manner effectively within spaces that benefit from the natural lighting offset. What is often forgotten during the long winter night is the aurora Australis, natural dynamic light shows which add depth to a prolonged period that lacks traditional stimulation. None of these situations is completely foreign to human habitation. Looking to the opposite Pole, around the arctic circle are similar conditions and further creative adaptations could be studied there.

Air

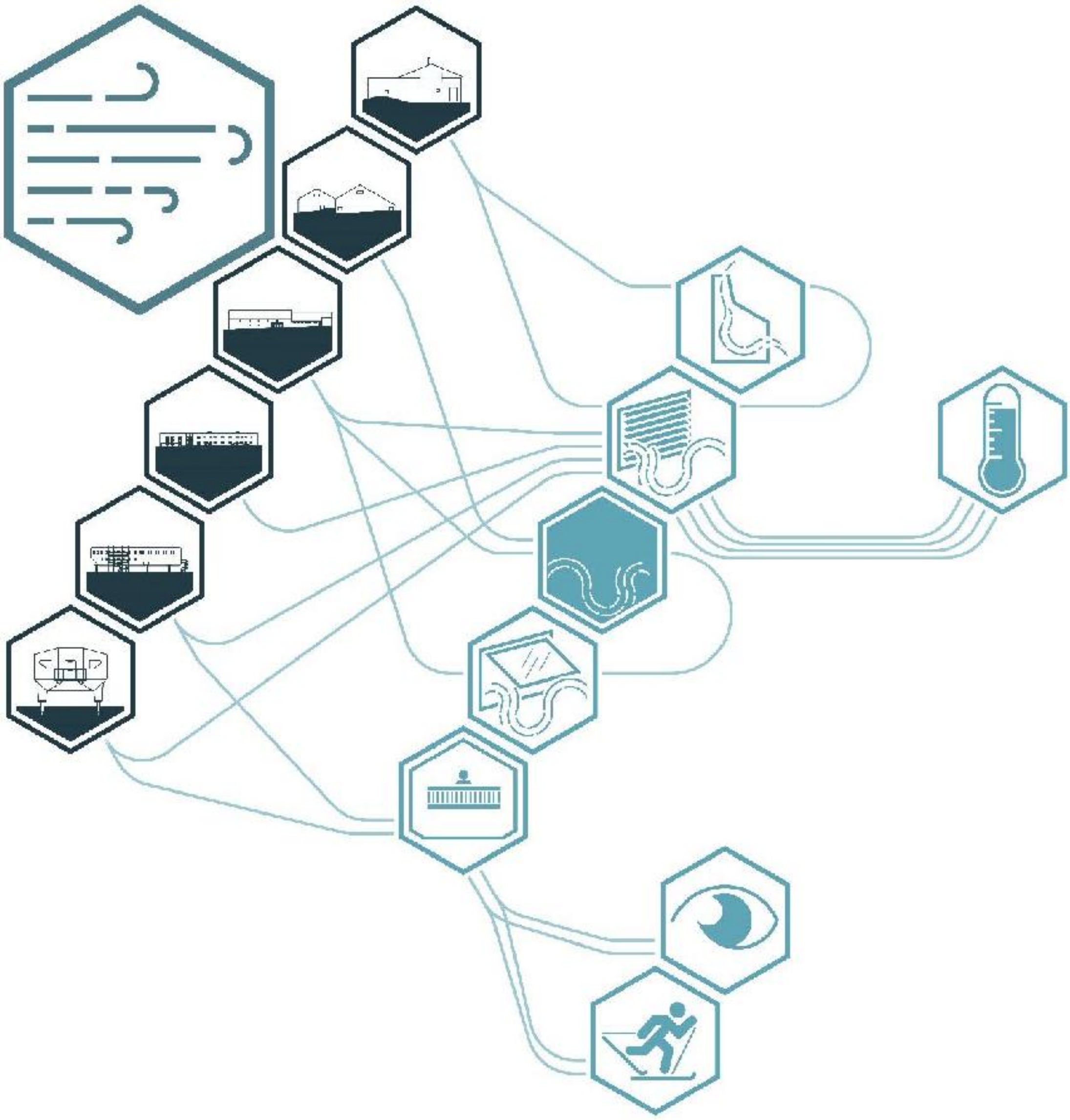


Figure 5-3 Air Analysis

The attribute of air is a basic building block of human life. Biophilic design highlights the importance of the role air plays in connecting occupants to the atmospheric conditions of the natural environment. However, the climate of Antarctica does not lend itself to this practice. Scott's Hut is the only case that intentionally brought in untempered external air. This practice was to introduce fresh air and utilised convection through the chimney effect to facilitate air transfer.

The later stations combined heating and fresh air delivery into one system, conditioning the external air brought in through vents. Unfortunately, this takes away the encoded information regarding the external conditions, which is lauded in biophilic design. Though, with the extreme characteristics of the climate, it would be counterproductive to bring the cold air directly into a tight building designed to keep the elements out.

With Mawson's Huts and McMurdo, there is an aspect that still provides this – drafts. This is not viewed as a positive by the occupants. There are other secondary means in the IPY cases by which the inhabitants can encounter the surrounding conditions. In Amundsen-Scott there is a partially sheltered observation deck. Halley VI also has a bridge section separating the living pods from the working pods, ensuring that those working and living in the Station have to 'commute' outside each day.

An effective approach to atmospheric awareness is through connecting with the surrounding air, bringing not just a temporal understanding, but other sensorial; smell, feel, movement. With extreme temperatures and harsh winds that are endemic to Antarctica, the inclusion of such has been challenging. The majority of the times that interior direct contact with airflow was not an issue due to a flaw in the overall building system; largely, drafts from not early construction and mitigation for ineffective heating systems. Due to the conditions and more significant role the building envelope plays in the habitation of Antarctica, internal inclusion of connecting to air is better addressed under Simulated Natural Light and Air. Externally, the development of areas that allow for relating to the outdoors has created opportunities that foster an awareness of the conditions. This is achieved primarily through circulation and decks; interventions that still permit there to be a level of shelter or protection for the occupants. These are more ancillary methods, not the core integral approaches often outlined in biophilic design.

Water

The existence of water in Antarctica, in its solid-state – snow or ice presents some challenges to the biophilic attribute of water and requires the fundamental conservation of it as a resource. The examples identify[404] both indoor and outdoor applications are challenged by the climate as well as political obstacles. The majority of the year extreme cold prevents the inclusion of reconstructed landscapes, such as wetlands, ponds, or fountains to be designed. This is also compounded by the restrictions of the Madrid protocol[405] conserving the natural flora and fauna by restricting the inclusion of non-native species. Annex II is specifically what prevented the planned inclusion of an aquarium in the lobby of the AAD projects.

The indirect examples of interaction with water recognized in biophilic design; images, video, and audio can be found in limited instances in the Cases. With the rudimentary construction and use of snow as an insulative material in Mawson's Huts, Mawson noted the sound of trickling water in his diary[406] with the summer thaw. What is more readily found in the cases is water in its solid-state. Views of snow and ice from windows, or also in the IGY and IPY examples, images of it through illustrations of science being conducted.

[404] Kellert, *Nature by Design : The Practice of Biophilic Design*.
[405] "The Protocol on Environmental Protection to the Antarctic Treaty," (2009).
[406] Mawson, *The Home of the Blizzard Being the Story of the Australasian Antarctic Expedition, 1911-1914*.

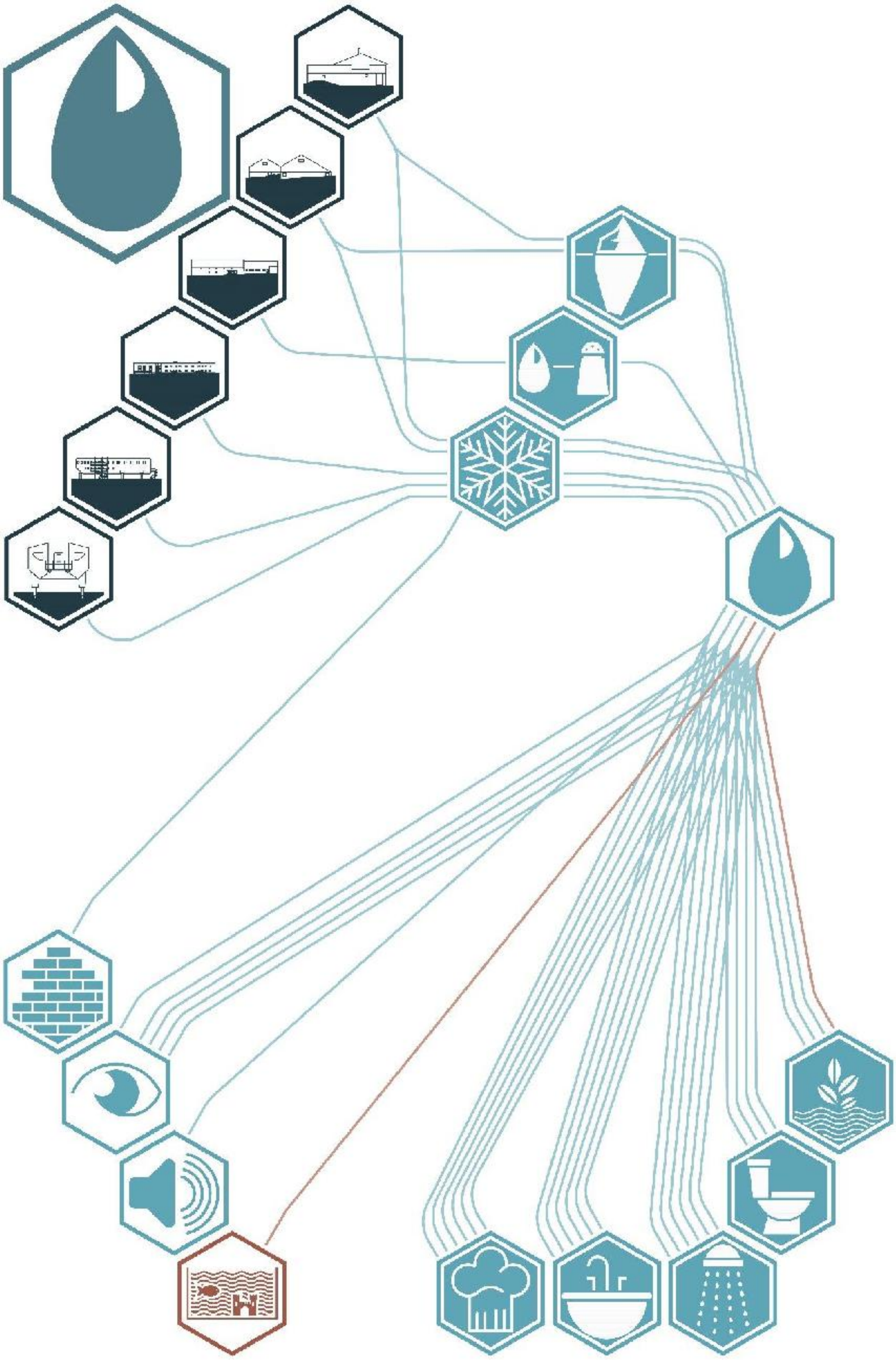


Figure 5-4 Water Analysis

When the perspective of what water is shifts states, it changes how occupants directly interact with it. This is overtly seen in Mawson's use of water as a building material, but it also alters the relationship with the fluid form where required. To survive, humans are reliant upon liquid water, in Antarctica this requires additional effort to achieve potable water, engendering more cognizant use.

The majority of the cases use simple snow and ice melt to generate water. The HAE simply heated it up using their cooking stove, IGY and IPY have developed more complex methods ranging from using a melt bell to melt tanks to cope with the higher demand. McMurdo is unique in cases with their water generation is through desalinisation of nearby seawater. While desalinisation requires more electrical power, generated with diesel generators and wind turbines[407], due to the greater population at McMurdo and resulting demand, it is the more efficient approach.

All the cases managed this precious resource in the same manner – restriction, as a result of the electrical consumption required to generate usable water. With the more straightforward systems of the HAE huts, use of water was minimised for anything other than cooking, occasional hygiene, and the darkrooms, as described in the Review Section. The prioritisation of the darkrooms was to generate images to market the expedition for funding. There was a different cultural expectation of what it meant to be an 'explorer'; the men were expected to tolerate certain 'hardships' and grow the best beard they could.

With the IGY and IPY, the buildings involved more infrastructure, such as flushing toilets, showers, and laundry. These still face restrictions as to the quantity or duration of usages. A less extreme cultural expectation regarding personal hygiene and beard growth is still present, but showers are encouraged. McMurdo has prioritised this with prominent handwashing stations to prevent the spread of disease.

Halley VI shows the greatest shift away from purely limiting access to water, which many of the stations are following. Many of the fixtures specified have a high efficiency to minimise the waste of water and the recycling of greywater[408]. They also employed vacuum toilets[409] to increase this efficiency as well.

One unexpected ancillary interaction with water is a direct result of the aforementioned Madrid Protocol – hydroponic greenhouses. The benefits of the greenhouse itself are discussed in the Plants section. Foreign soil, which may contain contaminants, is banned under the same reasoning as inhibiting non-endemic flora and fauna, which has resulted in hydroponic gardens. Indirectly the occupants are benefitting, not from the direct contact water, but rather the product of what the enriched water creates.

[407] to Power Up: What Keeps Mcmurdo Going, May 06, 2020, 2013, https://scienceroadshow.wordpress.com/2013/01/26/power-up-what-keeps-mcmurdo-going/.
[408] "From the Jobsite: Moving Halley," Armacell, https://local.armacell.com/en/armacell-germany/references/moving-halley/.
[409] to Lifting the Lid of Antarctic Toilets, May 06, 2020, 2012, http://esorekim.blogspot.com/2012/02/lifting-lid-on-antarctic-toilets.html.

Plants

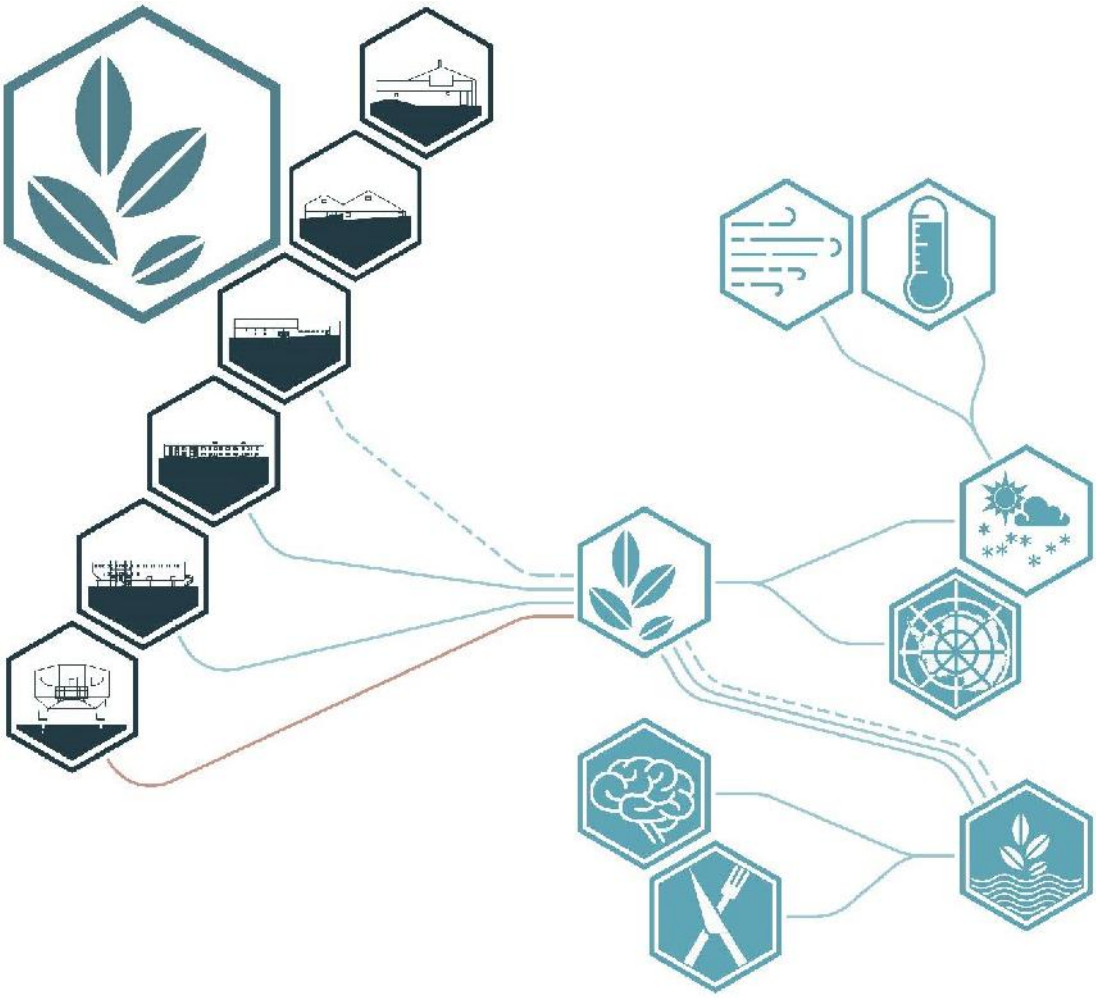


Figure 5-5 Plants Analysis

Due to climatic conditions, there is very little diversity of plant life in Antarctica and difficult for any alien flora to survive. This is further reinforced by restrictions in the Madrid Protocol[410] to protect the endemic ecosystem from invasive species. The climate was a primary factor in a lack of plant life at the HAE structures; the inclusion of plants for a variety of purposes was not a priority to the expeditions. Mawson and Scott were more focused on observations of the Antarctic environment, not biological experiments with foreign materials.

Current plant life found at Stations is kept within strict adherence with the Madrid protocol. While the climate and regulations still prevent outdoor gardens, all the IGY and IPY Stations developed plans for hydroponic interior chambers. Halley VI had to cut this from their final designs; it is assumed that this was due to budget restraints. In Casey and Amundsen-Scott these are integrated directly within the buildings studied. McMurdo has a separate building for its gardens.

[410] "The Protocol on Environmental Protection to the Antarctic Treaty."

Casey station specifically identified the psychological benefits of having greenery during the planning phase, intending to have open-air planters in the common spaces, but the restrictions of the Madrid Protocol prevented the use of live plants. This mental well-being component is secondary to the inclusion of flora within the station but exploited for the occupants' enjoyment. The primary function of the growth chambers is to provide fresh vegetables to supplement the supplies brought to the station.

The limitations imposed severely limits the effectiveness that the few inclusions of plants and greenery have upon the occupants of the stations. Where biophilic design encourages the inclusion of native plantings, the minimal lichens and moss would most likely not engender the same positive response that is intended due to the non-indigenous nature of the population itself. The policy restricted growth chambers also do not elicit the desired connection with their hydroponic setting being artificial. Further, multi-sensory inclusions like the cedar panelling in Halley VI could bolster the lack of accessibility for this attribute through Images, Materials, and Texture.

Animals

Today, the Madrid protocol prevents the inclusion of alien animals from residing at the station for scientific, companionship, or transportation, historically the most common reason for animals in Antarctica. Architecturally in the IGY and IPY show little formal inclusion of animals other than images and artwork promoting the scientific research or in the personalisation of individual spaces.

During the HAE, animals were essential for survival. Scott brought dogs and ponies/mules, and Mawson dogs. Spaces adjacent to the main living quarters at each base were given to housing the animals. While their primary purpose was to aid in transportation, they also provided a dynamic element to life at the base, especially through winter. A significant portion of many of the diaries comments on the antics of the animals.

An aspect of endemic wildlife that became part of life at the HAE bases is as a source of food. Penguin and seal were used to supplement the food stores during the winter.

Throughout the IGY, alien animals were still permitted in Antarctica; their primary function was still that of transportation. Stow-aways and several scientific experiments have been documented.[411] These, however, do not promote a connection with those living at the stations. As discussed in the Water section, Casey Station had planned aquariums for a communal space, purely for the psychological benefit this would provide the occupants though this was not feasible with the Madrid Protocol.

An aspect that has often been noted at stations located near penguin colonies is sound and smell, though this has not been incorporated or fostered in the designs. Reviewing the

[411] Headland, "History of Exotic Terrestrial Mammals in Antarctic Regions."

documentation of the cases, one can see the importance of the presence of animals, even if it is the unfamiliar endemic fauna. Amundsen-Scott has no permanent or even transitory animal population nearby, but there is a significant amount of anecdotal records about the one time a skua flew over the station. The excitement around a unique occurrence illustrates the deprivation occupants can feel. Similar measures, as discussed in Plants, could be taken to lessen the difficulty in effectively incorporating animal attributes.

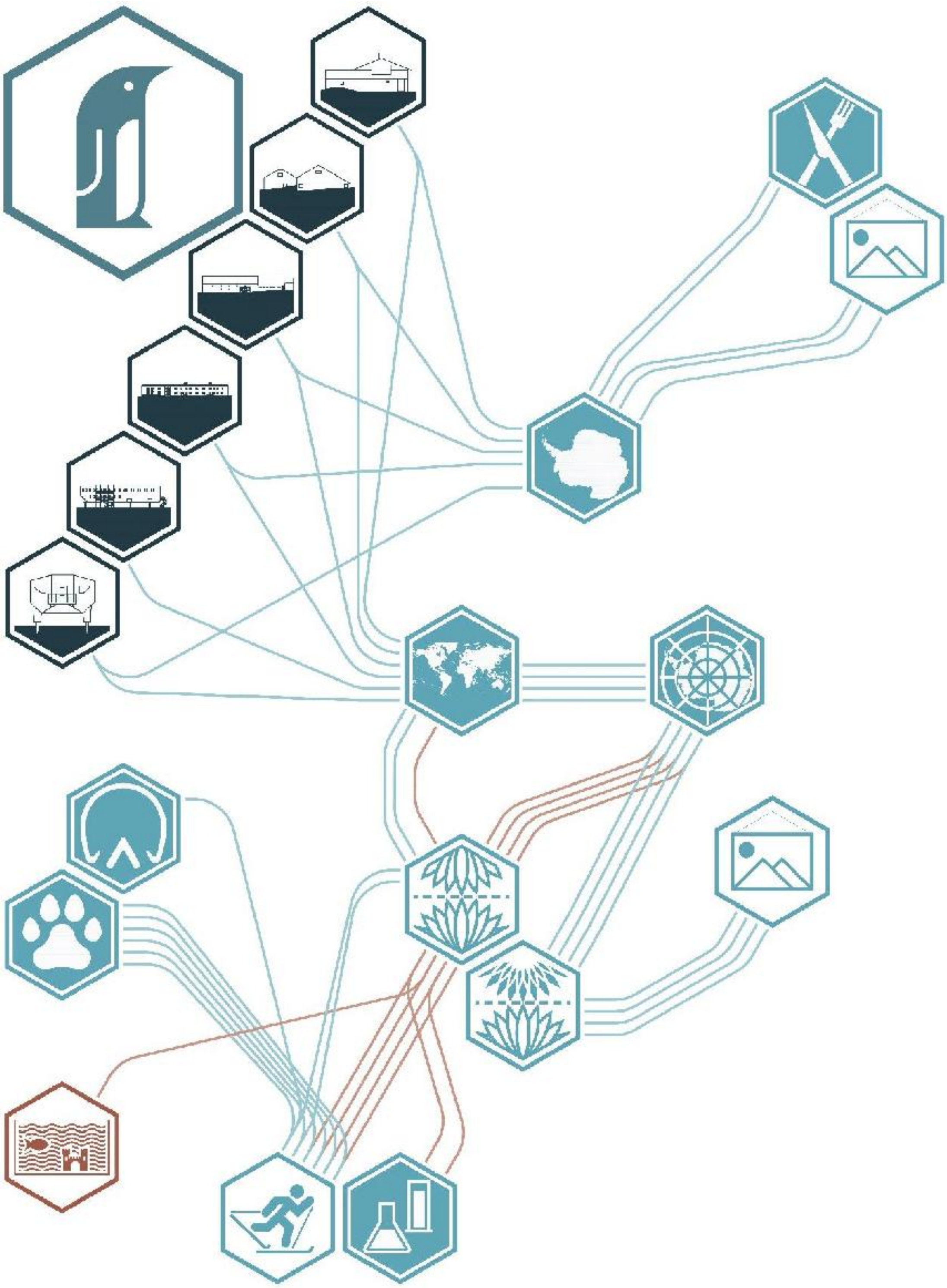


Figure 5-6 Animal Analysis

Landscapes

Figure 5-7 Landscape Analysis

What is commonly considered landscape design has not been incorporated into habitation in Antarctica. The extreme environment prevents the reconstruction of familiar landscaping that is often ascribed to this attribute; wetlands, forests, etc. The Madrid Protocol also restricts the flora and fauna that can be brought to Antarctica as described in the Plants section. The Protocol moreover outlines the protection of endemic natural areas, preventing the creation of Antarctic landscaping by manipulating regional natural elements.

The inevitable temporary nature of contemporary structures is also covered in the Madrid Protocol. Previously decommissioned buildings could be left to succumb to the natural elements. Now they must be dismantled and disposed of off the continent. This impacts the natural landscape in a few ways. With careful planning, the new station could be located in the same footprint as the old one, minimising the impact on virgin ground. If that isn't feasible, once the old structure is removed, the land where it was can slowly be reclaimed by the Antarctic environment.

During the HAE, before the Madrid Protocol, consideration of the surrounding landscape was not a priority. The huts were not intended to be permanent structures, so the possibility of cultivating the landscape was not discussed in any documentation of the expedition preparations.

The Antarctic landscape resists permanent interventions, which has developed stations that have a more minimal footprint to prolong the life of the building, which is further discussed in the 'Weather' section. A solution was found, the elevated station. They allow the bulk of the structure to be above ground level, thus have less of a direct impact on the ground or ice. There is still some disturbance due to shifting wind patterns, but it separates two components that fight against one another: snow and building. While this does, in fact, separate the occupants from the landscape, but it also affords a unique opportunity for another connectivity to the ever-shifting environment. Most elevated stations are designed to be jacked; the whole building lifted in reaction to changes in the environment. This distinctive solution creates a more dynamic aspect of what are normally stationary buildings.

The need for this separation for survival is a decision which needs to evaluate the necessity for it to occur. In instances such as Halley VI and Amundsen-Scott, it is the only way to prolong the lifespan of the building and keep the occupants above the drifting snow. However, the stations have taken advantage of promoting a connection to the landscape in other manners as discussed in other attributes. It is the case of REPSTAT, that elevated stations should be approached with caution. A critical complaint that was highlighted in 4.5.4 was that the occupants never had to leave the structure, which the designer of AANBUS sought to remedy with Casey Station being separate buildings that follow the topography.

In so far as biophilic design has developed the attribute 'Landscape', it is severely challenged by the environment and policy of Antarctica. The harshness of the existing landscape creates more of an adversarial relationship between the building and surroundings. Even with the growth cambers inside, as discussed in the Plants section, the Madrid Protocol does not allow them to create anything that could be associated with 'landscape'. Rather they would fall under what is identifies in biophilic design as "superficial decoration rather than a meaningful experience of the natural world."[412] However, this is the best that is available. It would take significantly more resources and money than is currently allocated for this attribute to be explored and executed effectively.

'Weather'

Humans have relied on awareness of climatic patterns for survival before the use of architectural interventions. The conditions that Antarctica presents are extreme and often foreign, which lends to the isolation or buffering of the occupants. Despite this, opportunities to connect with or have an awareness of the climate has been incorporated.

There is some history with structures that endeavoured to create sequestered stations, with little to no interaction with the exterior. Casey Station's REPSTAT was a series of modules connected with a single linear enclosed walkway. Occupants' wellbeing and productivity suffered significantly[413], which was attributed to being cut off from the environment. It was frequently referred to when redeveloping the AAD stations.

A simple solution has been to create conditions that require occupants to leave their living quarters and go outside to get to their workspaces. This was specifically designed into Casey and Halley VI. McMurdo, being a multi-building station, also inherently requires the movement between buildings. The logic behind that choice was due to the size of the population, connecting occupants with their surroundings is a side benefit.

[412] Kellert, *Nature by Design : The Practice of Biophilic Design*. p. 42
[413] Incoll, "The Influence of Architectural Theory on the Design of Australian Antarctic Stations."

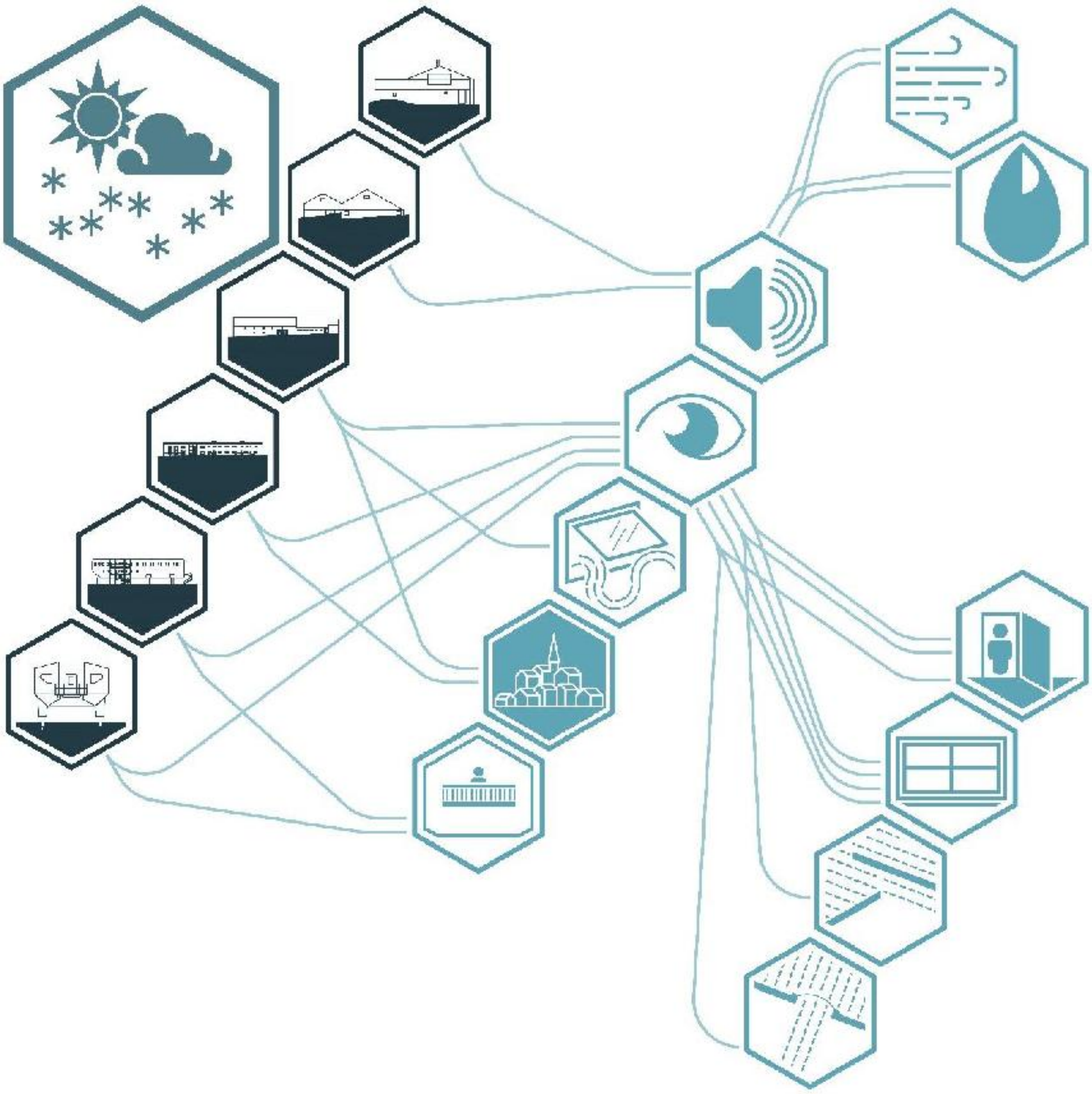


Figure 5-8 'Weather' Analysis

This does not mean that Amundsen-Scott, as a singular structure, does not engender an awareness of the external conditions; it is just more passive than physically exiting the building. All the stations in the IGY and IPY were cognisant of use of windows to view the conditions. Casey also included clerestory windows in the internal stairs for this reason.[414] Many located windows near the cold porches to enable inhabitants to appropriately dress for the conditions.

The HAE did not take these same considerations towards their building design; it was more geared towards function and keeping the elements out. Material technology made windows a weak point for heating and drafts. However, with these limitations, it also meant that there was not the same level of insulation that the contemporary research stations have. This is manifested more in an auditory awareness of the wind, storms, and melting snow dripping.

[414] Ibid.

There is a shift towards stations with a smaller footprint, which often means singular structure construction similar to Halley VI and Amundsen-Scott. Maintaining a connection to and recognition of the exterior conditions is significant to occupant wellbeing, as illustrated in REPSTAT. This is increased by the technological advances in materials which create more of a conditioned and buffered interior, further separating inhabitants from their surroundings. The more passive techniques; using windows for views or decks, can be employed to foster this relationship without compromising the important shelter component of these stations.

Views

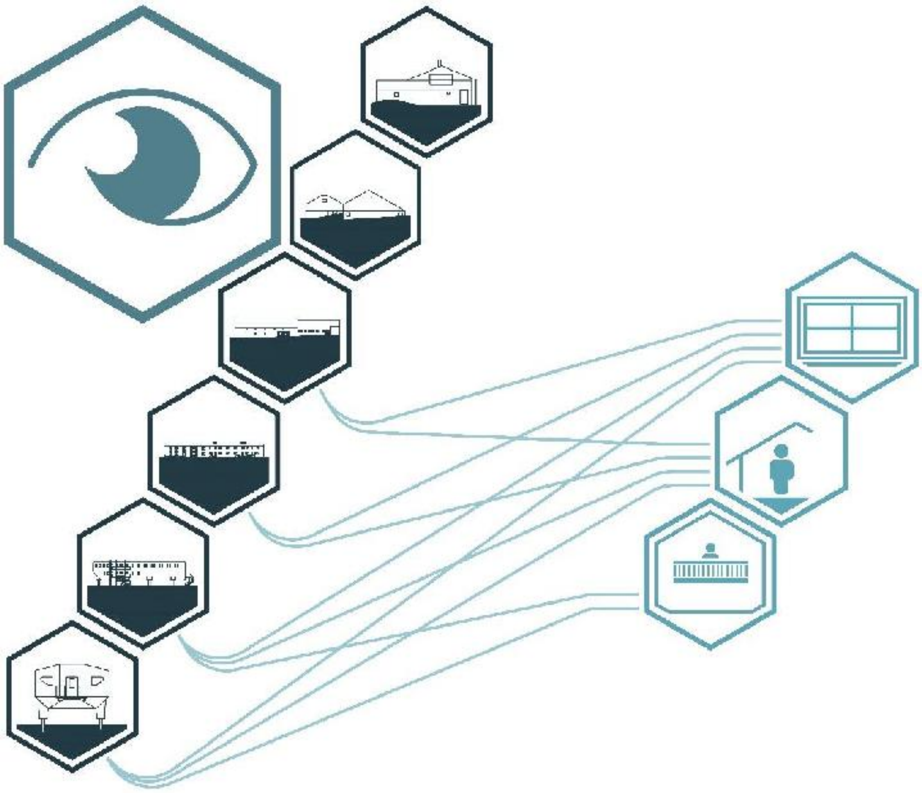


Figure 5-9 Views Analysis

Views are a very useful attribute in Antarctica to connect the inhabitants to their natural surroundings. Biophilic design recommends facilitating vistas from a place of safety for the user to reduce anxiety and stress. In Antarctica, this primarily means from inside, protecting the occupants from the elements. However, this does divorce the observer from the full immersive experience. While the visual aspect of the view can be observed, this attribute can have further depth when layered with other attributes which lend themselves to direct outdoor opportunities for views. While the traditional approach of indoor viewing is still the most prevalent, there are a couple of cases which provide protected immersion viewing as well.

For the huts of the HAE, they did not know where the final site of the structures would be. As a result, during the design phase, views were not a consideration. Mawson's Huts eliminates the potential all together by using skylights only.

In the IPY and IGY cases, views of the surroundings were prioritised for communal areas; lounges and dining. While this is more of a limited connection to the natural world, it does maintain awareness and appreciation of where they are living within a controlled environment. Halley VI and Amundsen-Scott also have decks which create a more immersive viewing experience.

The bedrooms in McMurdo and Amundsen-Scott without windows distinctly lack an opportunity for views. It has been noted that these rooms are not considered less desirable than the ones with windows. Primarily, this is because the circadian rhythms are counter to the sleeping patterns of the occupants and so shades are constructed to block out the unwanted sun or eerie darkness. The windows and the exterior walls mean that these spaces are less insulated than the internal rooms. However, the lack of a view within them is a crucial aspect of occupants' long-term wellbeing. Even if they keep their window blocked, that is their choice, and they can pull up the shade or remove the obstruction to look out their window, allowing them control over their personal space. Occupants are not restricted to their quarters, and can freely move about the station to connect to views in other spaces, but this is an important consideration when laying out the living areas of the stations.

Fire

Due to the technology available in such a remote location, fire was a critical attribute to general habitation during the HAE. In both cases, centralised coal stoves were used for cookie and heating the living areas. The artificial lighting was also using open flame with candles or acetylene lamps.

With the IGY and IPY safety became the overarching fear regarding open flames and difficulty fire fighting in the Antarctic climate. The AAD had designed fireplaces in the main lounge for psychological comfort but did not build them due to safety concerns. Halley VI took steps to incorporate a symbolic gesture of fire with the red cedar panelling in the central stair of the social module.

All four of these instances of the use or attempted use of fire show a commonality – the central hearth. They are located in the major communal gathering space for each of the buildings. The hearth concept is a basic building component since early human habitation, so it is natural to see the pattern continued through to these cases.

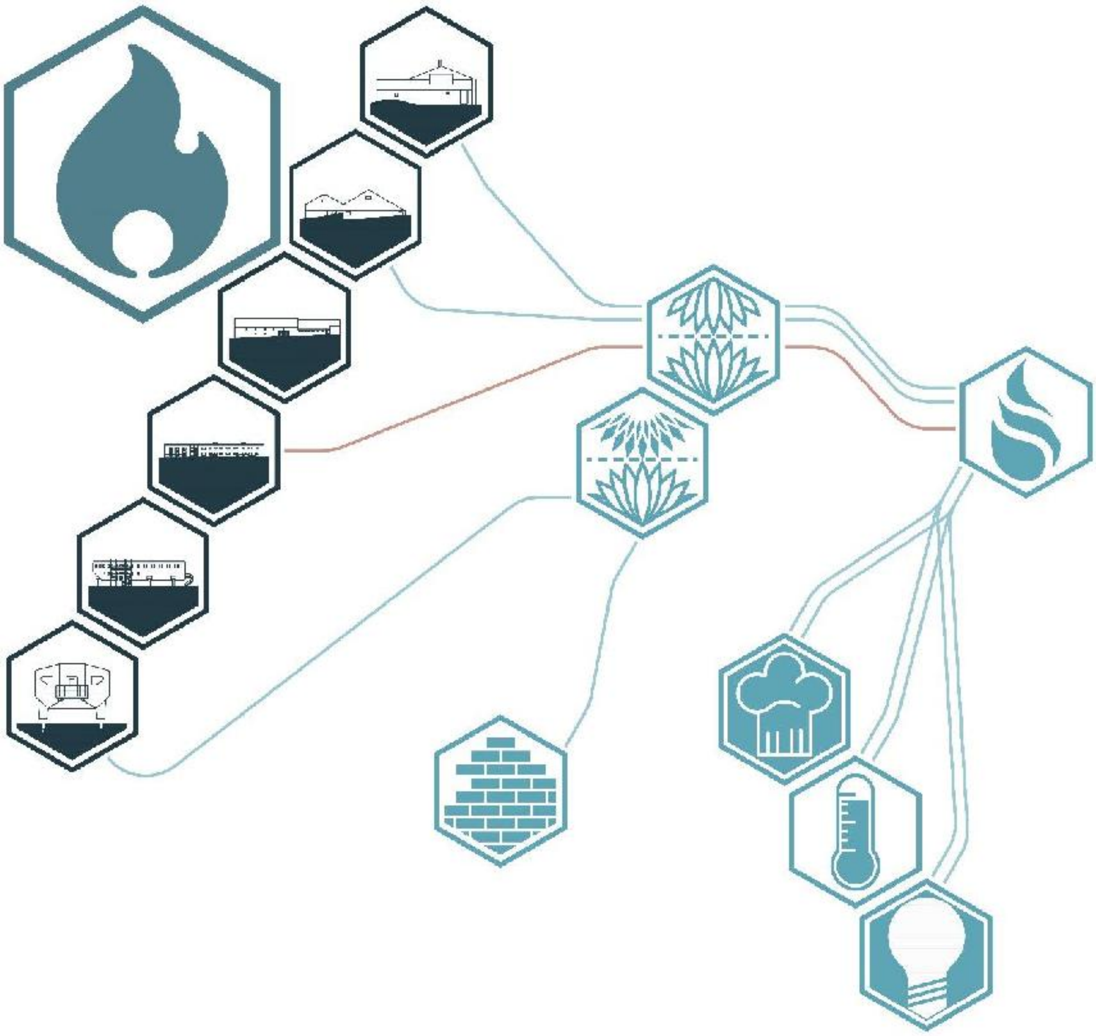


Figure 5-10 Fire Analysis

Summary

The attributes categorised under the direct connection to nature should foster a closer relationship between the occupant/building and the natural surroundings. Regrettably, the harshness and the unfamiliarity with the extreme environment does not lend itself towards this. Many of the attributes, when they focus on aspects of Antarctica, do so in an indirect method, i.e. views through windows, images of fauna, etc. This certainly isn't beneficial towards biophilic design's goal of developing the link to one's immediate ecosystem. However, this is not an ecosystem that humans are adapted to survive unaided.

Addressing the incorporation of direct connections with nature from the occupants' source countries and environments. This creates a familiar, relatable sanctuary within a surrounding that is perceived to be hostile. Simply that scenario generates indirect or simulated methods of inclusion as well. The Madrid Protocol further constrains direct connections primarily with potentially invasive alien aspects, though as limits disturbing the endemic environment.

The inherent nature of this element within biophilic design, that despite the challenges and constraints attempts have been made to include the majority of the direct connection attributes. Are they incorporated within the most effective manner? No, but advancement can be tracked through the history; buildings integrating features that are more attuned to the users' well-being in alignment with connecting to both Antarctica and home.

Indirect Experience of Nature

Images

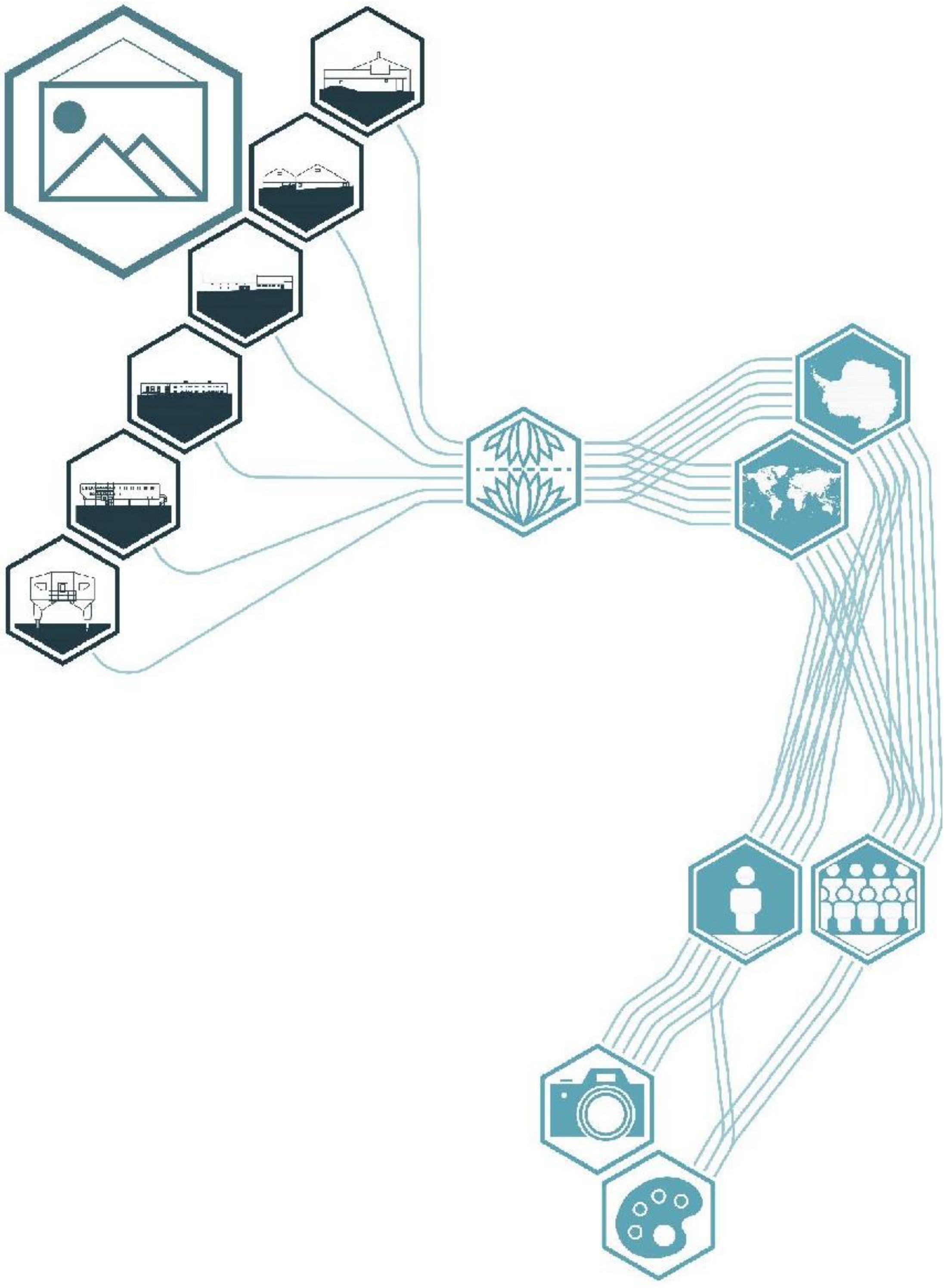


Figure 5-11 Images Analysis

There are two clear approaches to the inclusion of imagery in the cases, public and personal. Both have benefits and shortfalls in terms of what is outlines as key biophilic components in images. For images to be effective, they should be plentiful and varied, display an assortment of experiences that humans can relate to, and cultivate a common theme as a whole.

Personal spaces have universally been an area for individual customisation throughout the cases. Regardless of whether it is a room or a bunk, occupants have incorporated images or decorations to express their values, backgrounds, and personality. The images may not directly show views of nature, but evoke a feeling of the home environment or have aspects of the natural setting in the periphery. Without a permanent presence, these interventions allow the users to create a space that is territorially theirs. These images can give a sense of calm with their familiarity and potentially natural aspects. Important in fostering a space for the user to recharge in a foreign environment. While these personal installations have the potential to touch upon all of biophilic design's key components, there is no guarantee to do so.

Communal, public spaces are often much more cultivated in their approach to imagery. In the HAE, there are very few images that do not directly relate to the expedition; maps, sketches, photographs of the reigning monarch, within their central gathering space. A continuation of the culture of exploration, decoration or imagery would be considered an element of domesticity.

For the scientific research stations, there are two primary types of images; historical and scientific. All the IGY and IPY cases have sections highlighting the history of the station and the expeditioners living there. If there is additional imagery, often it relates to the research being conducted or the neighbouring regions. This brings a sense of awareness to one's location, though research posters may not be the most relatable method. In a few cases, Casey for example, have some posters show views of the Australia rainforest and outback to bring a connection to home into the main lounge.

The common spaces are where a concise and considered image installation could be developed to foster a more abstract connection to Antarctica. Right now, other than the historical portion, the organisation seems haphazard and insufficient. While there is a formality to the communal imagery, it lacks intentionality. In McMurdo, there is a mixed mural from a visiting art fellow, which was developed collaboratively with the station's inhabitants.[415] Similar projects could be formally developed and organised throughout the communal spaces to provide less overt and more conceptual connections to what they can see outside the window.

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415 Cortada, Xavier, "Antarctic Mural and Painting," https://cortada.com/2007/AntarcticMuralAndPainting.

Images are also an attribute that can be used to create connections that are lacking in Direct Connection to Nature; both to the environment of Antarctica and occupants' source country. Specifically, those attributes that are limited by the Madrid Protocol like Plants and Animals. Beyond simply including images, painting, or murals of the subjects, stylisation, patterns, symbology, or themes could be incorporated to connect the occupants with elements that are more familiar to them.

Materials

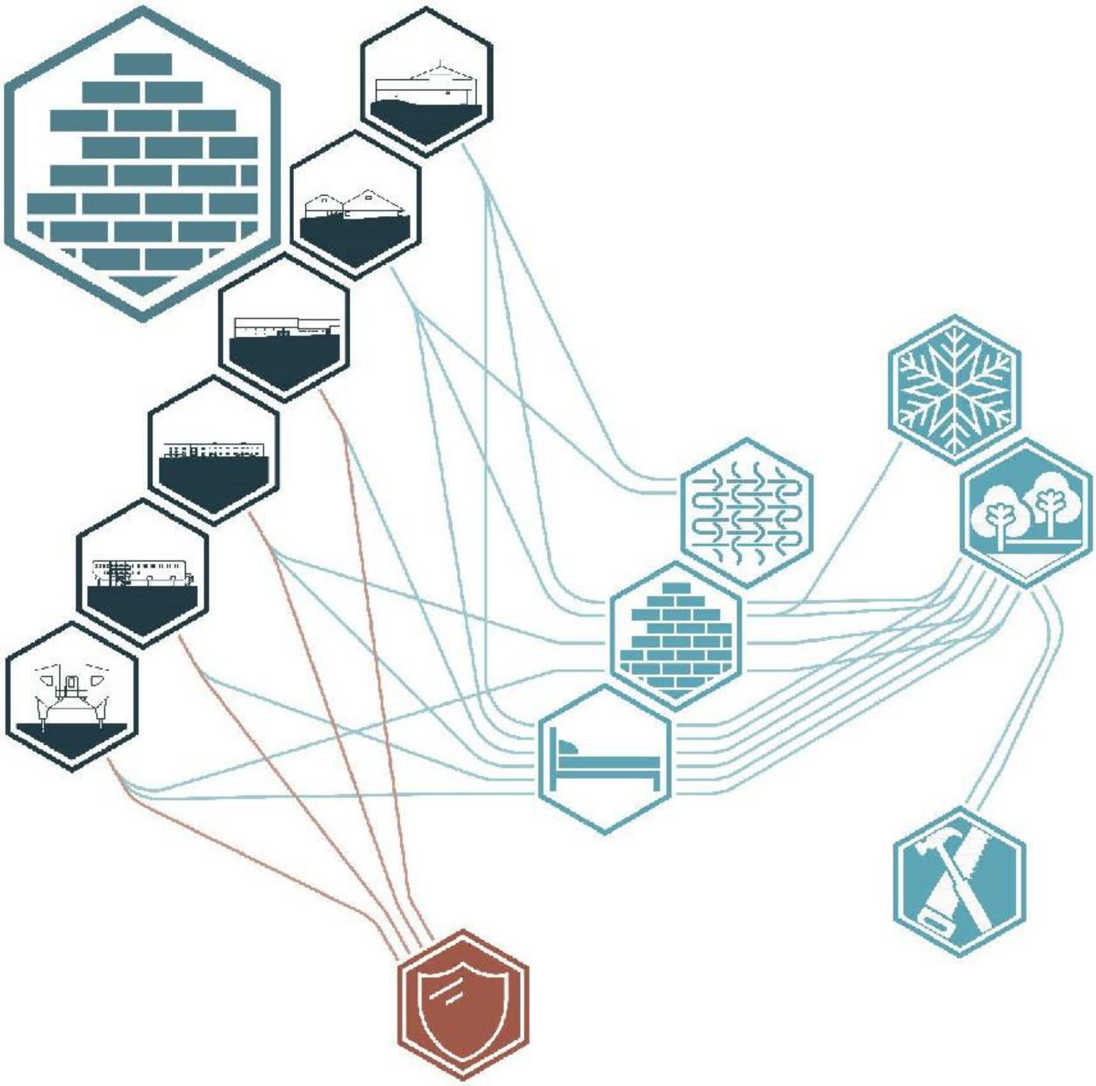

Figure 5-12 Materials Analysis

Materials are a valuable method to indirectly connect users with nature and natural surroundings in a controlled manner. Unfortunately, Antarctica does not have material resources that are typically used in building construction; with no trees available for timber and endemic stone only being used in emergency shelters. The only instance of local natural material used in the cases is Mawson's use of snow as an extra insulative layer.

What this attribute affords is the possibility to incorporate natural materials from the occupants' source country to evoke familiar feelings of home. During the HAE, this was a natural byproduct of common and straightforward building construction of the time. The structures and much of the interior was built from timber by those who would live there.

The perceived weakness of this construction is the deterioration that timber sustains from wind bourn aggregates. Biophilic design identified this as a benefit, a temporal connection for users and is elaborated upon in the Change, Age, and Patina section. However, this prompted future architectural interventions to select more durable materials. With cases from the IGY and IPY, the majority of materials have been processed from their natural states to be longer-lasting and more resilient. These structures see a significant amount of wear from a transient population that has different gear and living patterns than typical construction sees, to enable the buildings to function affordably over time, hard-wearing materials were prioritised.

This does not mean that the IGY and IPY stations are devoid of any natural material; it just is not an integral part of the building fabric. Many of the furnishings are wooden, bringing a bit of relaxedness to the living spaces. Timber is also found as a highlighting material in Casey and Halley VI. They utilised it in communal areas to emphasise certain usages. In Halley VI, significant use of cedar was in the central circular stair to create feelings of warmth and texture.

With timber being the more commonly used natural material, this connects back to a more passive inclusion of plants. Timber also, as shown in Halley VI, affords depth and multi-sensory experience for users as discussed in Information Richness. To relate to the Antarctic environment, most natural materials still present difficulty: snow and ice. However, stone could potentially be incorporated within the station in a variety of conditions. The Madrid Protocol does not overtly prohibit this depending on the scale of application. Though, if this were considered to create a 'significant change in the…environments'[416], the stone used does not need to be sourced directly from Antarctica. Materials that are similar in texture, colour, and makeup could be utilised. It is an inherently durable material, bridging the gap between occupants and the natural resources Antarctica with a material that is still familiar to them from home.

Texture

Texture brings sensory stimulation to a building. In the cases, it is most often used in combination with wayfinding to provide additional passive information to the users. It is done in an integral approach; becoming more intentional and effective over time.

During the HAE, with a more utilitarian approach to design, the aspect of texture comes from properties characteristically found in the materials being used. Mainly the primarily building fabric – timber. While the material was almost universally used for the Huts, numerous uses

[416] "The Protocol on Environmental Protection to the Antarctic Treaty."

utilised the timber on assorted scales or orientations and wore differently, preventing it from being too uniform.

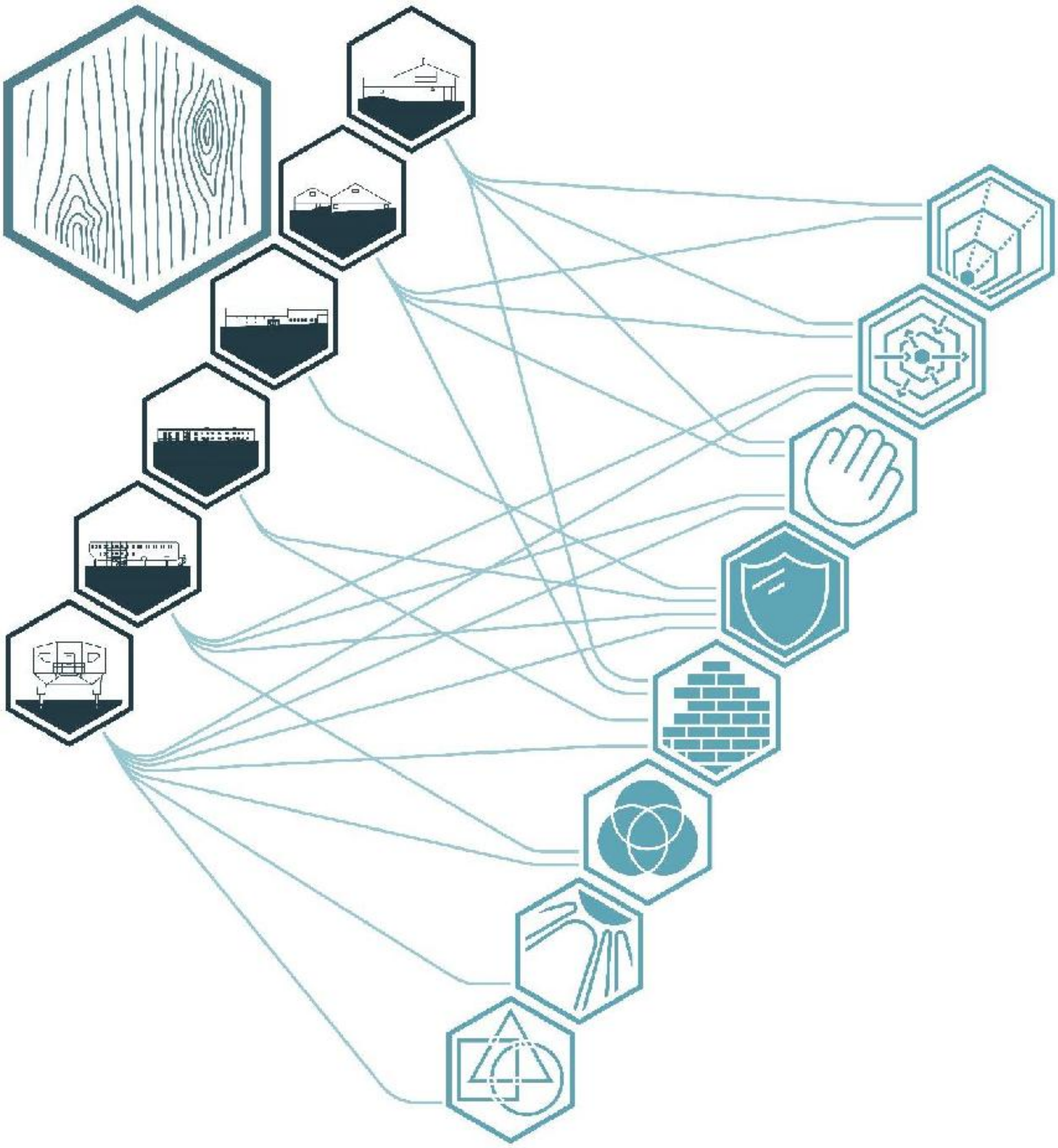

Figure 5-13 Texture Analysis

This use of natural materials resulting in natural texture did not carry through to McMurdo and Casey Stations. The need for more rugged materials led to the use of smoother, more uniform installations. However, this does not remove these cases from the characterisation of Texture in biophilic design. Humans relate smooth, soft, or gentle textures with a feeling of security, in contrast to rough with potential danger. So while the designs lack a more overt diversity, they still evoke a calm protective feeling. Casey Station, in particular, has shown a shift with this in renovations, with more colour and natural texture being incorporated to highlight areas of interest, creating a visual texture for the users.

More significant efforts to create a diversified textural presence is seen in the IPY cases, specifically geared towards wellbeing. The use of colours, physical material texture, use of natural light, shapes of spaces all come together to create a more dynamic and stimulating internal environment. This is seen specifically in two examples of the IPY. At Amundsen-Scott, the wall treatments have a physical and colour diversity that provides information about where one is in the station but also breaks up potential stagnant corridor conditions. Halley VI's central spiral stair barrel is lined with cedar veneer panels. Use of a natural material that provides visual diversity in the wood grain and colour, a tactile texture from the natural finish, and an olfactory sensation with the fragrant cedar smell.

A consistent illustration of how texture has been integrated into the IGY and IPY is in the flooring. A variety of flooring types; carpet, tile, vinyl, timber, has been used throughout the scientific research stations. This is often done in conjunction with the use of an area; more high traffic areas have more hard-wearing flooring. This combines a subtle change in texture underfoot with spatial awareness.

Overall, diversity in materials can be utilised to enhance the texture-based experience of a building. This is imperative in Antarctica when so much time is spent indoors, and the surrounding environment lacks what humans of Anglo cultures typically affiliate with stimulation. Halley VI's use of cedar shows how one component can touch on many qualities of texture, yet still fit within the functional and practical requirements of life in Antarctica.

Colour

There is a definitive evolution with the incorporation of colour within buildings in Antarctica. Cases from the HAE and IGY include colours that are fundamentally part of the materials being used. With the HAE this resulted in natural tones from the wooden cladding. IGY utilised more contemporary and durable materials developing a neutral palette of greys and browns. However, the shift from a singular structure to multi independent building stations introduced the use of colour on the exterior for identification purposes. With the transition during the IPY cases back to singular structures, the use of colour was similarly interpreted internally. Halley VI and Amundsen-Scott, with long central corridors, used colour as wayfinding tools for internal mobility.

The Antarctic environment presents a very subtle colour palette, monotonous compared to what occupants are accustom. Incorporating colour within the architecture is a step towards creating visual stimulation to ameliorate the conditions. When designing Halley VI, a colour specialist was consulted to develop a concept that would foster this.[417] As the non-historic stations are renovated, they too are integrating colour as a feature within common spaces as

[417] Slavid, *Ice Station : The Creation of Halley Vi : Britain's Pioneering Antarctic Research Station*.

seen in Casey Station's recent modifications.[418] It is a relatively simple solution to enhance the interior of the buildings and create an exciting environment, one that is moderately easy to modify in the future. It also aids in the identity of the different stations, whether that is national pride with the colours of the Union Jack making up the exterior of Halley VI or the other distinctive colours to represent different nations' stations.

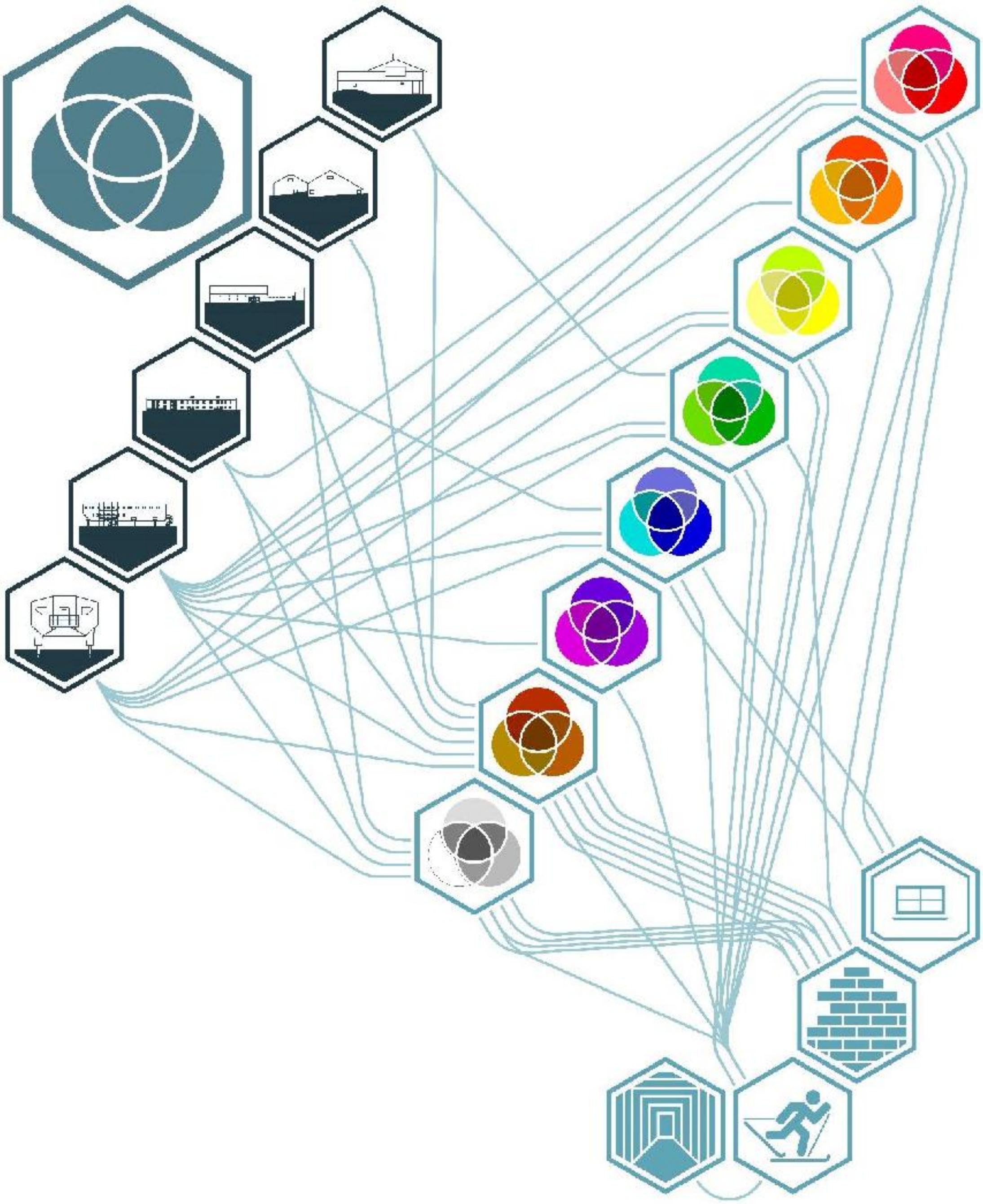

Figure 5-14 Colour Analysis

[418] to It's All Happening, May 06, 2020, 2019, http://www.antarctica.gov.au/living-and-working/stations/casey/this-week-at-casey/2019/this-week-at-casey-13-september-2019.

Shapes and Forms

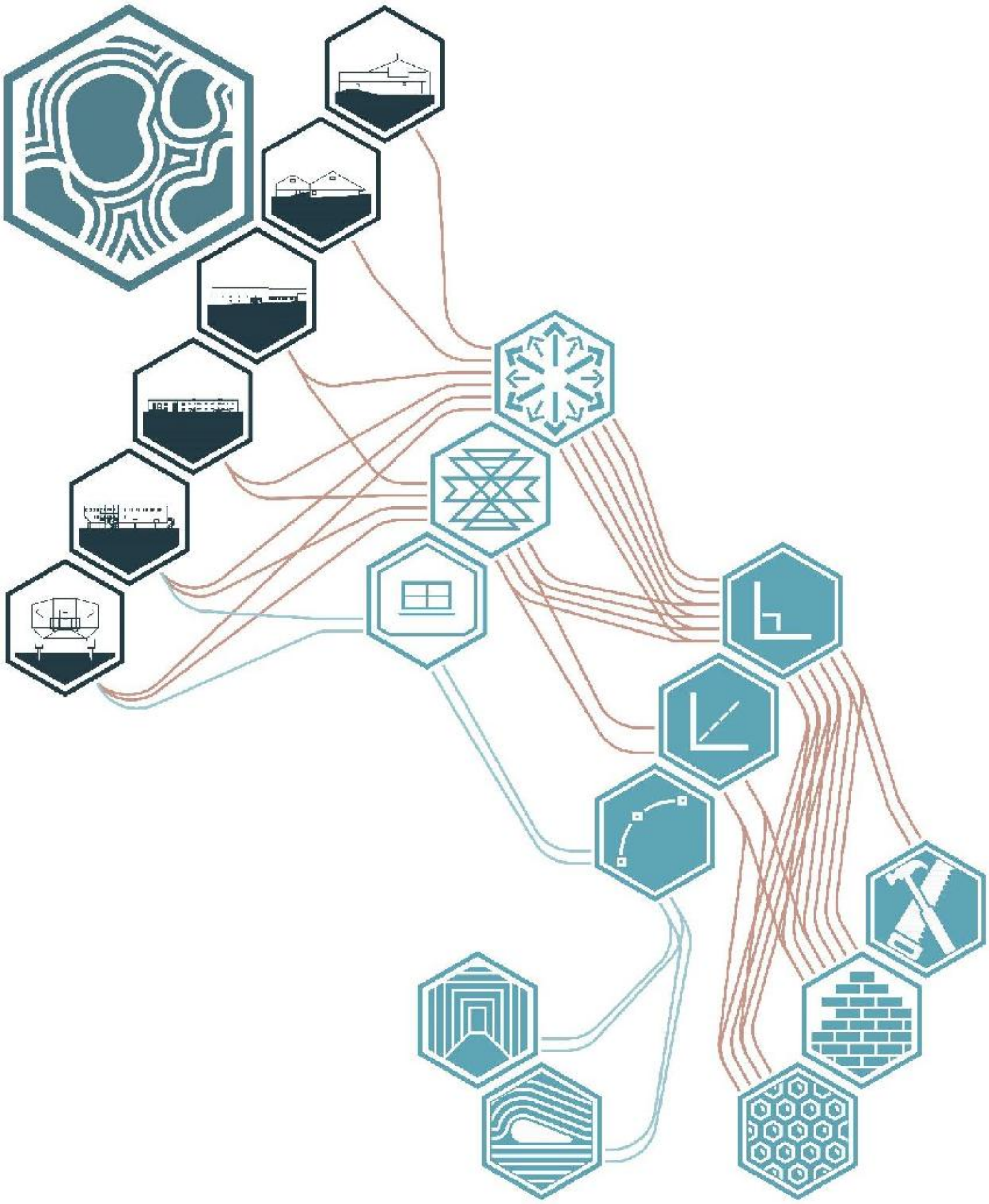

Figure 5-15 Shapes and Forms Analysis

The incorporation of organic shapes and forms has been limited in the majority of the cases analysed. Organic shapes are an opportunity to introduce interpretations of natural aspects of the local or source countries' environments to a building. This creates spaces that are more dynamic, creative, and engage the occupants. It is especially important to include this in spaces that will be inhabited for prolonged periods and with a surrounding environment that lacks the mental stimulation with which the users are familiar.

In the earliest Huts, the materials and skills of the builders were a significant factor in the rectilinear form. Cultural practices at the time meant that this was potentially not even a consideration in the planning process. When one needed long term non-emergency shelter, one built a hut with four perpendicular walls and a peaked roof. Throughout the history of western colonisation that was the practice and it continued into the polar regions.

With the IGY, ease of transportation and building technology had improved, but the stations were primarily constructed from modular systems. That practice has continued through the IPY as well. These panelisation systems do not lend themselves to organic shapes; the internal layouts are primarily still perpendicular. However, with the IPY stations, we start to see the overall shape of the building, taking on an aerodynamic form. Elevated stations necessitate that the form has to be considered on all sides. Through observation of previous structures and further testing, both Amundsen-Scott and Halley VI developed curved bottoms to mitigate the drifting snow.

Internally, the IGY and IPY have long double-loaded corridors, which is identified and described as creating "largely lifeless settings"[419] according to biophilic principles. In McMurdo's Building 155, the largest of the cases, videos of the interior show networks of hallways which become labyrinth-like in their uniformity. Halley VI took a subtle approach to relieve that feeling. Along the length of the central spine, as one moves from one pod to the next, the width of the hallway changes, enlarging around the entrance. The height also increases in the central part. These are subtle changes, and mostly linear in form, but they create an undulating and dynamic feeling through what could be a stagnant section of the station.

It is within the circulation that Halley VI and Amundsen-Scott both experiment with curvilinear forms. The only connection between the two levels of the social module in Halley VI is a circular stair, concisely spiralling within a barrel of cedar. On the first level of Amundsen-Scott near the gymnasium, the stair's mid-landing is a half-circle with the top and bottom landings having curved forms guiding users from the central spine into the stairwell. Circulation is a logical starting place to incorporate curved forms. People rarely walk in perpendicular manners, rather rounding off corners and moving in more fluid ways. Focusing curves in this area won't fight existing behavioural patterns or make furnishing the space difficult. Also, in the case of Halley VI's spiral stair, it helped save on floor space.

[419] Kellert, *Nature by Design : The Practice of Biophilic Design*. p. 72

Information Richness

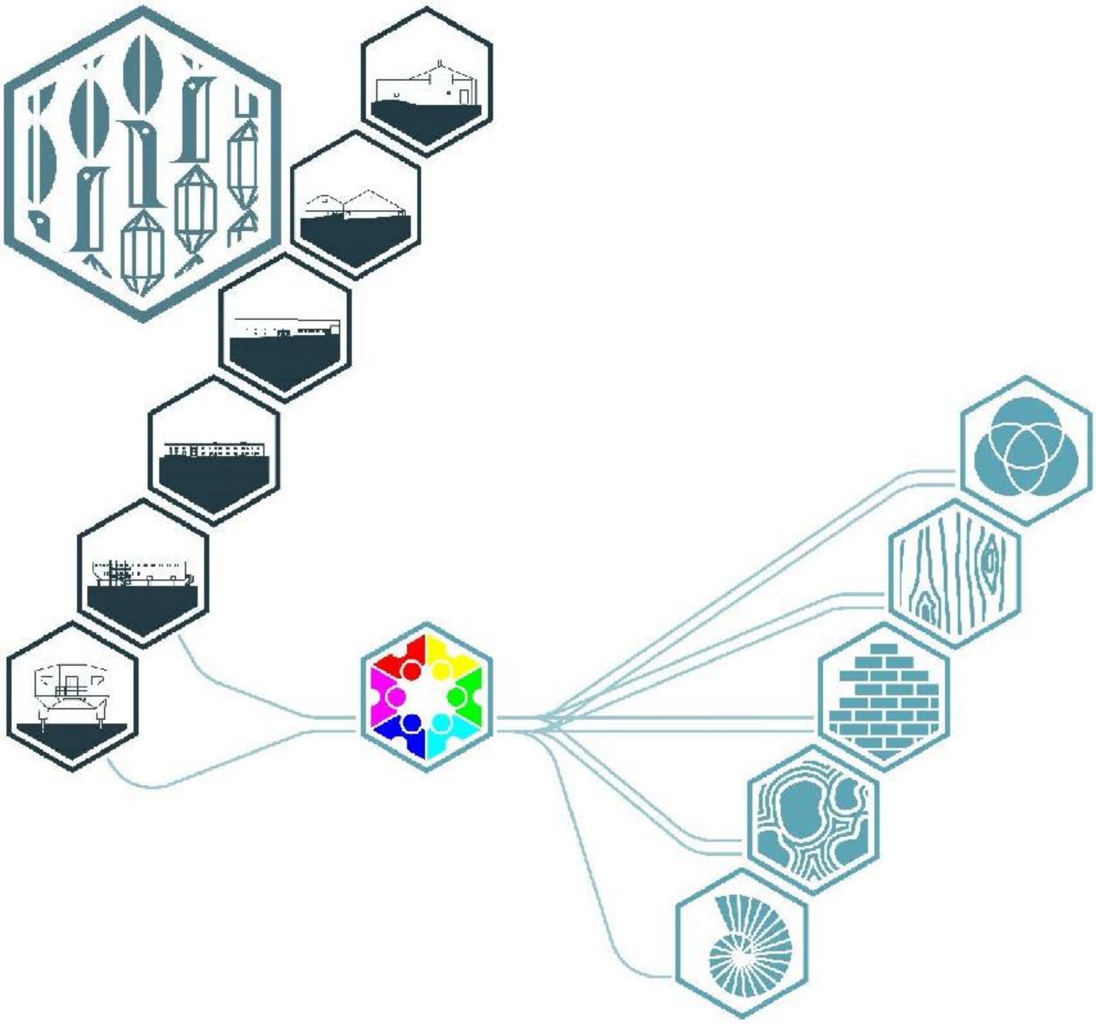

Figure 5-16 Information Richness Analysis

Much of this attribute is discussed as aspects in others; information richness is the complement of the others creating depth to the design. Unfortunately, many of these; natural geometries, natural materials, shapes & forms, texture are weaker attributes in many of the cases leading to information richness also not being a strong quality.

With the HAE, there is a lack of diversity in the building materials, creating more subtlety to the materials, texture, and colour. The available materials and skills prevented more complex natural geometries beyond a pragmatic grid pattern. It is in the men's own areas that some depth and details are found within their customisation. With limited space in the huts and in the ship transporting all the supplies and men, the structures were practical and focused purely on shelter, not creating a stimulating interior environment.

A similar pattern follows through with McMurdo and Casey Stations. Their basic goal is also protection from the environment. As structures with a longer lifespan, they are looking towards the durability and longevity of materials. As discussed this minimises the inclusion of natural materials, textures, and colours. The introduction of panelised construction also restrictions the shapes & forms and natural geometries. However, with prolonged occupation, the stations are continually evolving and incorporating these aspects to create more diverse spaces geared towards the inhabitants well being.

The IPY has made the best use of properties found in this attribute. Halley VI and Amundsen-Scott have incorporated multiple other attributes, layering them in balanced manners to create interior spaces that are stimulating for the occupants. This still occurs on a more constrained level than one might see in their source countries, due to constraints of building in Antarctica, but is in sharp contrast to what the seemingly alien natural surroundings are to them.

Change, Age, and the Patina of Time

If there is one attribute which flourishes in the Antarctic environment, it is this one. As has come up as a challenge in numerous other sections, it is, so far, impossible to construct an enduring structure. This is because of the high winds, drifting snow, abrasive ice particles, and in some instances, corrosive saltwater deteriorates or bury anything that is constructed. All of the cases embraced this reality in their designs. The contemporary structures endeavour to prolong the life of the buildings with more durable, often man-made materials, but even the IGY cases are showing wear with varying degree of mitigation through maintenance. Not enough time has elapsed to know how the IPY stations will fare, but with hydraulic elevated stations their goal is to delay the submerging of the structures in snow. However, even Halley VI acknowledges that it is a temporary structure, despite having the most sophisticated survival strategies.

The HAE, embraced the inevitable demise of their shelters, only designing them to survive a few years. However, when leaving both expeditions left their behind supplies, in case of future expeditions requiring emergency shelter. This is what happened with Scott's Hut when the Ross Sea Party of Shackleton's Trans Antarctic Expeditions were unexpectedly stranded for a winter. Scott's Hut took on a new life for the men and ensured the majority of them survived.

This attribute connects the occupants to their surroundings, though this is not necessarily viewed as a positive; old drafty windows in McMurdo for example. This perceived inconvenience brings a continual awareness of what it means to live in Antarctica. There has been some criticism that the newer station keeps the inhabitants too isolated, that it is not 'rugged enough'. To be able to embrace this attribute in more of a controlled manner would facilitate more appreciation from the users.

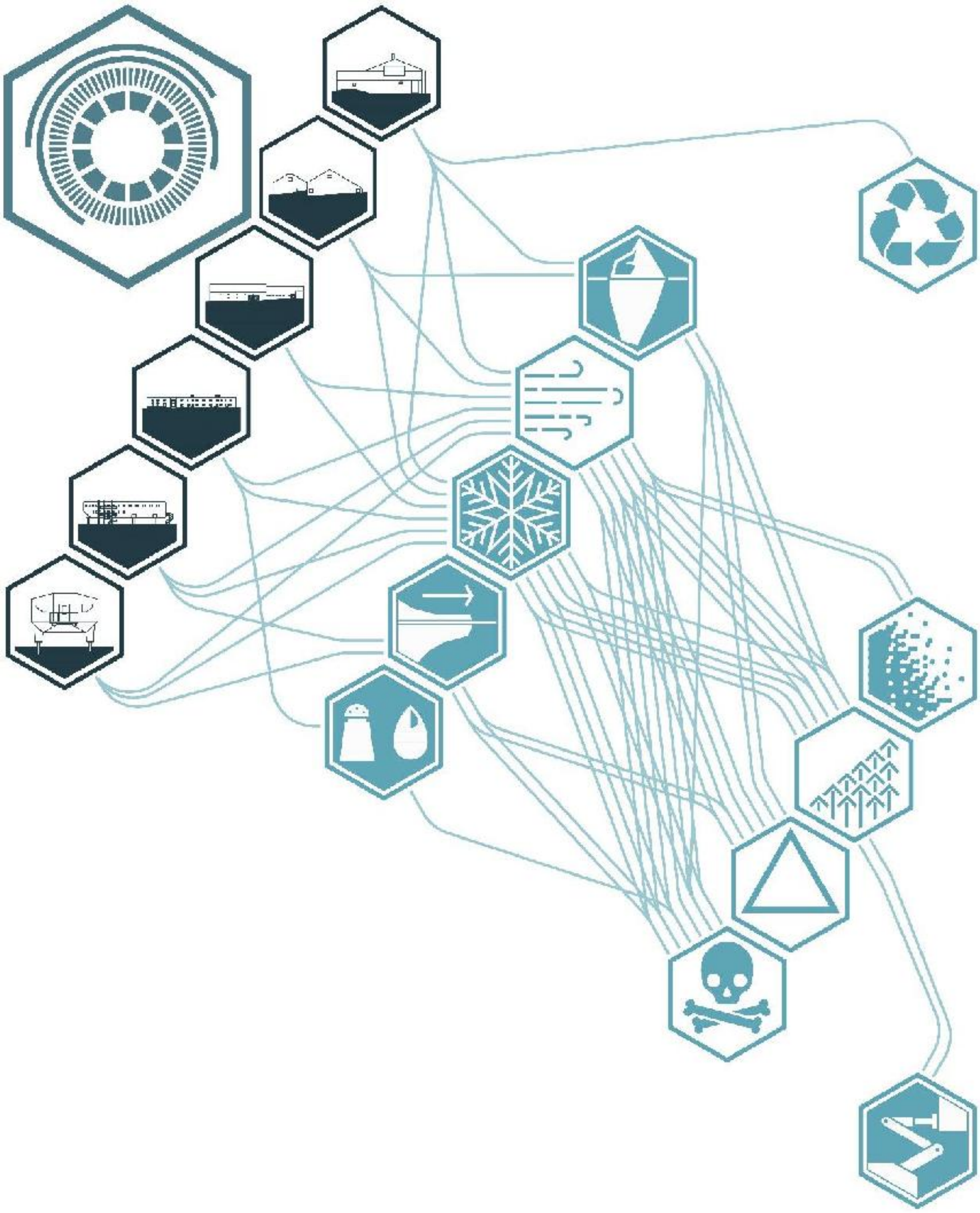

Figure 5-17 Change, Age, and the Patina of Time Analysis

Natural Geometries

Figure 5-18 Natural Geometries Analysis

All of the cases use a grid-based system for the overall building geometry. This organisation is not based on natural mathematical properties as outlined in biophilic design. Rather it is developed from material and panelisation system constraints. While it does create a balance, coherence, and harmony that designing around this framework fundamentally has, it lacks variety. Using natural geometries, such as fractals or the golden ratio, creates a system that can comprehensibly work on a variety of scales or orientation.

Many of the aspects of this attribute are mirrored in Organised Complexity and Shapes & Forms. The lack of organic nature to the above description is what takes away from geometry inherent in the cases, though there is some indication in the more recent stations. The cases of the IPY begin to make gestures in this direction with curvilinear forms and spirals. It is within a very contained and controlled manner, which gives insight into how these attributes could be included further. The concern that a lack of balanced diversity brings can be seen in the long institutional hallways of the IGY stations. Even within a rectilinear plan, the proportions can be subtly manipulated within the guidelines of the aforementioned natural geometries to create a more stimulating internal environment.

Simulated Natural Light & Air

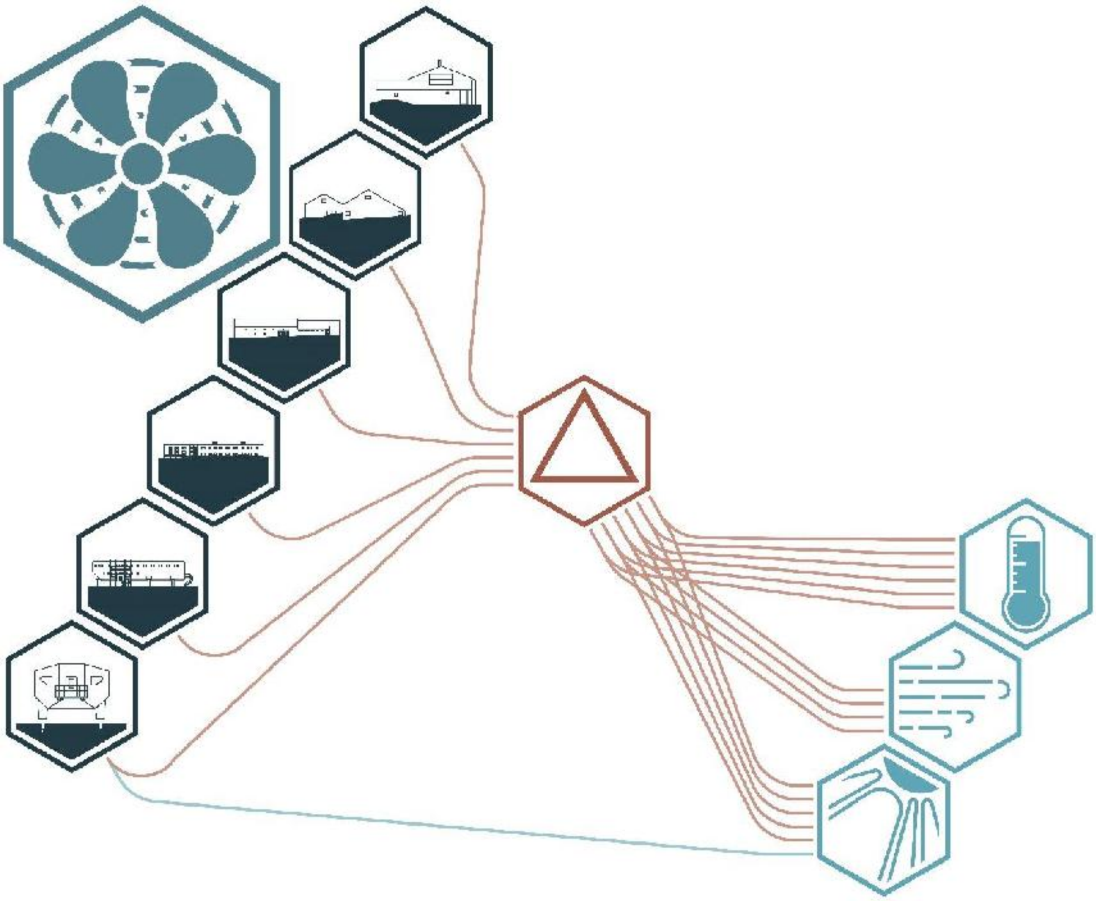

Figure 5-19 Simulated Natural Light and Air Analysis

Artificial light and ventilation are essential for survival; the accuracy of simulating the appropriate conditions for the inhabitations has been a developing process. During the HAE and the IGY, the approach to this issue was simple and practical. The four cases employed common technology conventional for their respective time that was reasonable for the remote environment. It was noted that recent occupants would frequently bring their own solar clocks to moderate the prolonged day or night and customise the lighting to their personal preferences. This approach was formalised within Halley VI with sunlamps built into each bunk. Overall there is a shift to, in personal spaces, facilitate the means to create simulated lighting experience. The overall approach is still artificial lighting for safety and function purposes.

There is no documented evidence showing a similar development with simulated air. In the HAE, the goal was to purely introduce fresh air to the interiors. Mawson did this through drafts, Scott having tighter construction employed a system that used convection to introduce fresh and release stale air. With artificial ventilation system during the IGY and IPY, stations temper fresh incoming air and distribute it throughout the buildings. This is often on a station-wide system, and occupants do not have individual control of their spaces.

Both the artificial air and light systems could be designed to create a more diverse and varied interior environment. As discussed in the Air section, the ventilation systems could be tuned to be more diverse to be closer to a natural environment or allow the users control of their own spaces to foster an atmosphere that is closer to what they consider home. Similar to light, Halley VI has incorporated a lighting system to mimic that of their natural light, which creates a more stimulating environment using a system that would need to be in place regardless.

Biomimicry

Figure 5-20 Biomimicry Analysis

Universally throughout the six cases studied, biomimicry has not been employed in the architectural designs. Biophilc design identifies biomimicry as integrating animal adaptations into the buildings, versus the human-oriented evolution of biophilic design. Looking at the goals of the HAE, to study the natural environment, it is logical that they would not have the requisite knowledge to incorporate biomimicry. Though this is not the only aspect holding the early explorers back, culturally, that was not the practice at the time. While knowledge of endemic habits was less known, other cold climate adaptations of the natural environment were more familiar, though with the cultural perspective at the time, not considered.

This disconnect between the study of the natural environment, learning from adaptations, and practical architectural application has continued through the IGY and IPY. Typical building practices are relied upon instead. With more recent station design and construction, that envelope is being pushed with technological and material advances, opening the door to the potential incorporation of biomimicry. This is particularly feasibly with the scientific underpinning to existence in Antarctica; the knowledge is readily available.

Outside of the cases studied, conceptual designs are beginning to integrate hollow attempts of biomimicry; Venice biennale snowflake greenhouse[420] or the transformable Antarctic research facility by a student at the Studio Hadid Vienna[421]. Both approach elements in an aesthetic manner, taking the overall form of the natural source and incorporating it into the form of their building. Further investigation into more in-depth properties of the sources can result in designs that are potentially more successful is the Angle human-nature connection and sustainability, making it more marketable, but this illustrates the initial growth of biomimicry in Antarctic architecture.

Summary

With indirect connections to nature, the aspects that were challenging in direct connection come to fruition. For characteristics of Antarctic and source country environment, it more feasible for incorporation within the buildings in this manner. Practicality becomes an underlying theme throughout this element. Due to limitations of accessibility for construction and the cost of building in Antarctica, the resulting buildings have a functional and sensible commonality. Again, it can be seen over time how these attributes have been incorporated with greater awareness and creativity; materials technology, ease of transportation, and prioritisation of the quality of life of the occupants contributed towards this.

[420] Kozyr, Alexey, "Antarctic Polar Gallery Mack," http://archikozyr.ru/projects-eng/pr_02.php.
[421] Radu Pop, Sergiu, "Transformable Antarctic Research Facility," Behance, https://www.behance.net/gallery/18655835/Transformable-Antarctic-Research-Facility.

Experience of Space and Place

Prospect and Refuge

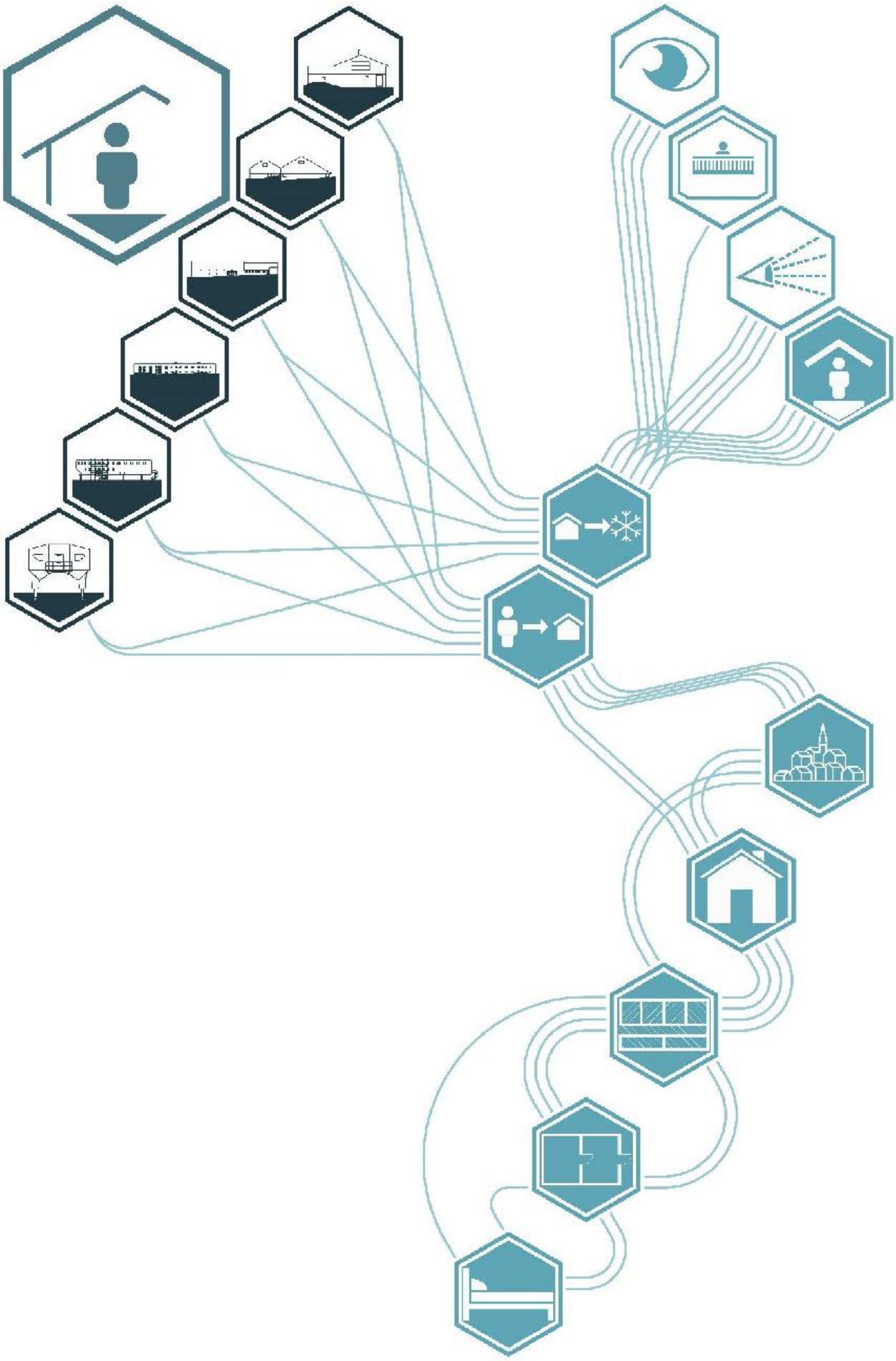

Figure 5-21 Prospect and Refuge Analysis

This research has approached 'Prospect and Refuge' two ways; building to environment and individual to building, due to the two distinct approaches the environment engenders.

The building's relationship to the environment has the concept of refuge fully embraced in all the cases analysed. As has been previously discussed, shelter is required for year-round human existence in Antarctica. Despite the different building materials, practices, and technologies, the building envelope for all six cases were effective in creating a safe, secure environment for the occupants.

The prospect portion varies, creating an imbalance for the cases. With the HAE, it was not a priority, talked about in the views section, with an unknown final destination it is impossible to architecturally take advantage of potential vistas. The concept of prospect is also approached differently in Antarctica. The attribute is originated around the need to monitor potential threats and opportunities. Without much by way of observable threats (i.e. predators), the IGY and IPY cases focus their prospect around opportunities, specifically transportation opportunities. Travel is difficult to Antarctica, so many communal spaces have views of the runways or where the ships 'dock'.

Halley VI specifically took efforts to create unique measures to afford internal opportunities for the inhabitants to enjoy natural aspects of Antarctica. Amundsen-Scott similarly has an external observation deck. The climate does not lend itself to typical building components that lead themselves to prospect. For that reason, any aspect is weighted more with a value on refuge.

With the individual occupant's connection to the building, there are varying levels of prospect and refuge within the structures. The simplistic, basic forms of the HAE huts left the majority of the men with only a bunk space as refuge. The level of privacy that afforded ranged from completely open as in Mawson's Huts to curtained off clusters of bunks in the geology corner of Scott's Hut. The former had a more elaborate configuration of spaces, rooms, and tunnels to seek out quiet space compared to Scott's. The latter, with the break up of disciplines into groups in the interior, their 'territory' served as their work and personal space more clearly delineating each area, also allowing each section to control their level of connection to the main space.

Beyond the HAE, the research stations became more complex with multiple buildings and more typical building forms. Within the IGY cases, to address prospect, the overall layout of the Red Shed and Building 155 are designed to filter the occupants through a common area between their quarters and the dining facilities. This allows for information gathering and also potential socialisation to avoid inhabitants from isolating themselves. Similarly, Amundsen-Scott and Halley VI employ a similar concept, through with a less overt parti due to more types of spaces being housed within the singular building.

When it comes to refuge within the IGY and IPY, there is a split as to what level of 'personal space' an occupant has. This split goes beyond the age of station or the governing country. In Halley VI and McMurdo, rooms are shared by two occupants. Halley VI has curtained off built-in individual bunks, where McMurdo has customisable University dorm-like furniture. Amundsen-Scott and Casey both offer individual rooms for the occupants. These are small, but afford the comfort of a door to designate one's personal space. Consideration seems to be around area and population of the stations. McMurdo is the largest in terms of population, so it would be logical to prioritise the available number of beds over individual personal space. Despite having a significantly smaller population, Halley VI is similarly concerned about area over personal space. It is noted, during the winter months with the extreme isolation and 24 hr darkness, both stations limit the residency to one person per room.

Overall, refuge has been approached thoroughly concerning the building's relationship to the Antarctic environment, creating a structure that provides adequate shelter for the occupants. Internally, this has evolved to accommodate human to building aspect more effectively with respect to Anglo cultural perspectives. The character of communal life at the stations can be difficult with various personalities and stress the environment can put on occupants, having their own personal space to recoup in is just as important as the physical shelter of the building. All of the cases are designed for individual rooms during the winter months to aid this; with Casey and Amundsen-Scott housing occupants in single rooms year-round. Halley VI mitigates this with sheltered individual bunks within a double room.

Prospect has been an effective method of connecting occupants with indirect methods of connecting with the surrounding environment in the later cases; establishing views from sheltered and protected spaces with windows or decks. These, however, don't necessarily take advantage of the natural surroundings and as previously described often focus more on transportation. A shift in this can be seen with Halley VI cockpit windows, designed to view the aurora australis. Providing similar opportunities would engender a closer relationship with Antarctica.

Organised Complexity

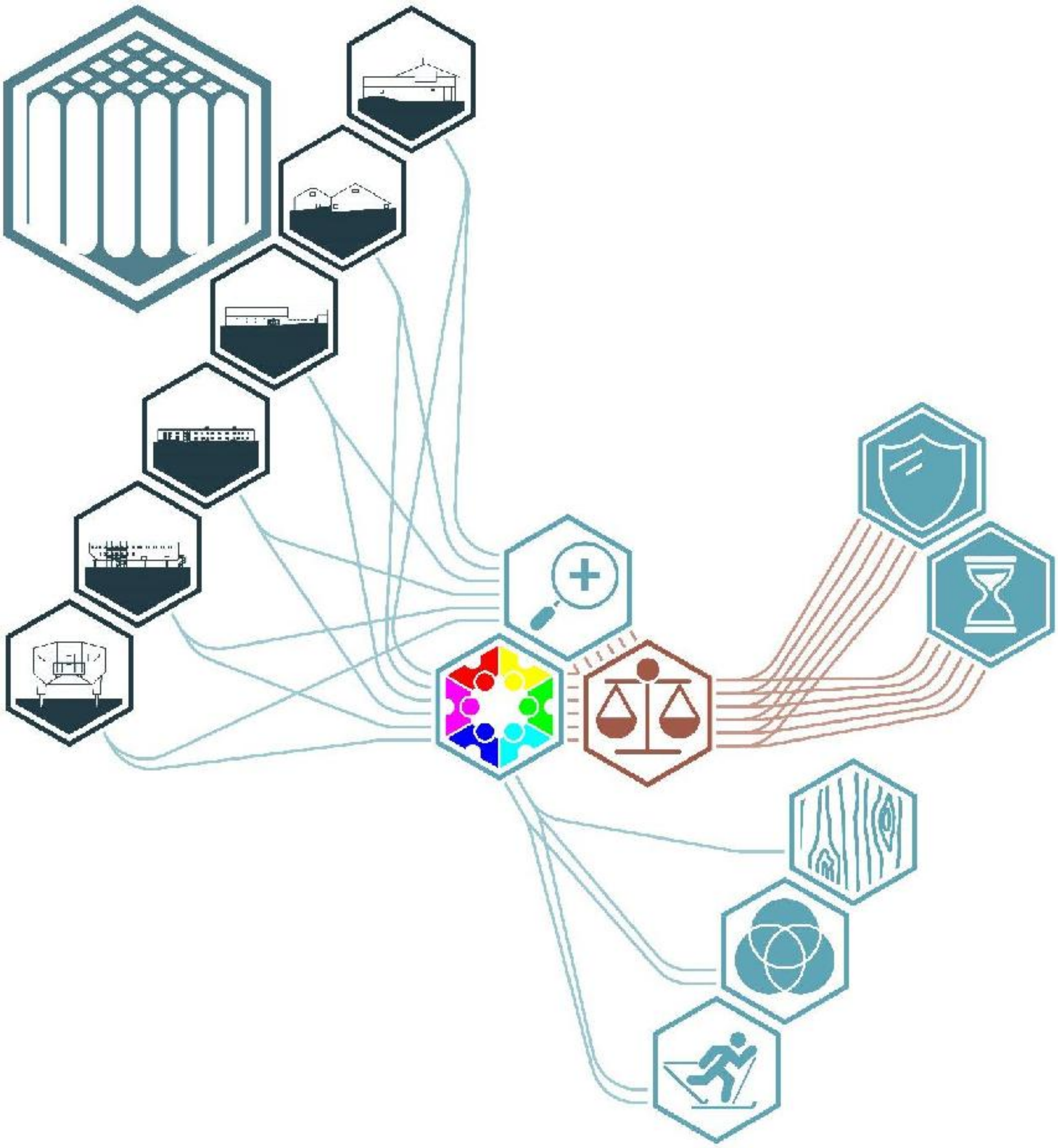

Figure 5-22 Organised Complexity Analysis

Two aspects of building in Antarctica impede more effective use of organised complexity: durability and temporary occupancy. This attribute typically is seen in rich, but structured components or details within building design, often decorative. As discussed in the materials and texture section, a primary goal is longevity for the life of the building which does not lend itself to ornamentation. However, illustrated in the cases, humans from an Anglo cultural background, naturally embellish their surroundings to personalise them. The HAE demonstrate this particularly with their midwinter celebrations: men's personalised exposed bunks, expedition equipment, layered with a variety of celebratory flags. While this brings the detail and depth, it lacks the organisation or structure to avoid a chaotic feeling, granted this was not an everyday occurrence.

This similar uneven balance of 'organised' and 'complexity' can be seen in the IGY as well. With a more distinct emphasis on durability, much of the building features are kept simple and functional. The population is a transitory one; the living spaces have to cope with bulky equipment, tracking in bits of the ecosystem, potentially bored winter-over occupants, delicate materials or decoration would not withstand the type of this type. Not just internally, but ornamentation on the exterior of the buildings would have a difficult

The majority of examples of organised complexity stem from long developed cultural values and storytelling. While Antarctica has its own unique culture, it is not one that has a continual, consistent arc. However, in customising their own spaces, some occupants have created diverse, creative, and artistic interventions to designate their areas. This is where the latter obstacle comes into play because there is no permanent population; the occupants, their interests, their values, and their mode of expression is continually changing from season to season. A lack of formal structure governs these self-expressions, once again potentially falling into this disorganised territory.

The newer stations, and updates to the older ones, have begun to use subtle interventions with the permanent infrastructure which get to this more balanced state. This is predominantly around wayfinding and colour. Both Halley VI and Amundsen-Scott have employed colour to provide a subtle clue to the occupants where they are located within the station. Amundsen-Scott, particularly, utilises textured rubber panels at main intersections along the central spine of the station. Each is a checkboard of two colours and limited to the immediate area near the junctions, keeping this at a manageable and coherent scale. These panels are also textured, which brings a bit of diversity to that installation. With both of these examples, while they are light-handed, they create diversity within the interior of the station. That tempered approach prevents it from becoming cluttered or overwhelming as the HAE's celebratory decorations had the potential to be. With such a seemingly stark, foreign environment of Antarctica adding too much to the interior can easily disrupt that balance and become over-stimulating.

Biophilic design specifically identifies that "complexity signals an environment of ample resources and opportunities."[422]. A recent study found that the human brain physically undergoes changes due to the isolation and perceived environmental monotony in Antarctica.[423] This emphasises the need to incorporate this attribute into the habitable spaces. Not only does it create stimulation for the occupants, but it harkens to that relationship to a healthy, safe environment.

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[422] Kellert, *Nature by Design : The Practice of Biophilic Design*. p. 91

[423] Stahn, Alexander C. et al., "Brain Changes in Response to Long Antarctic Expeditions," *The New England Journal of Medicine* 381, no. 23 (2019).

Mobility

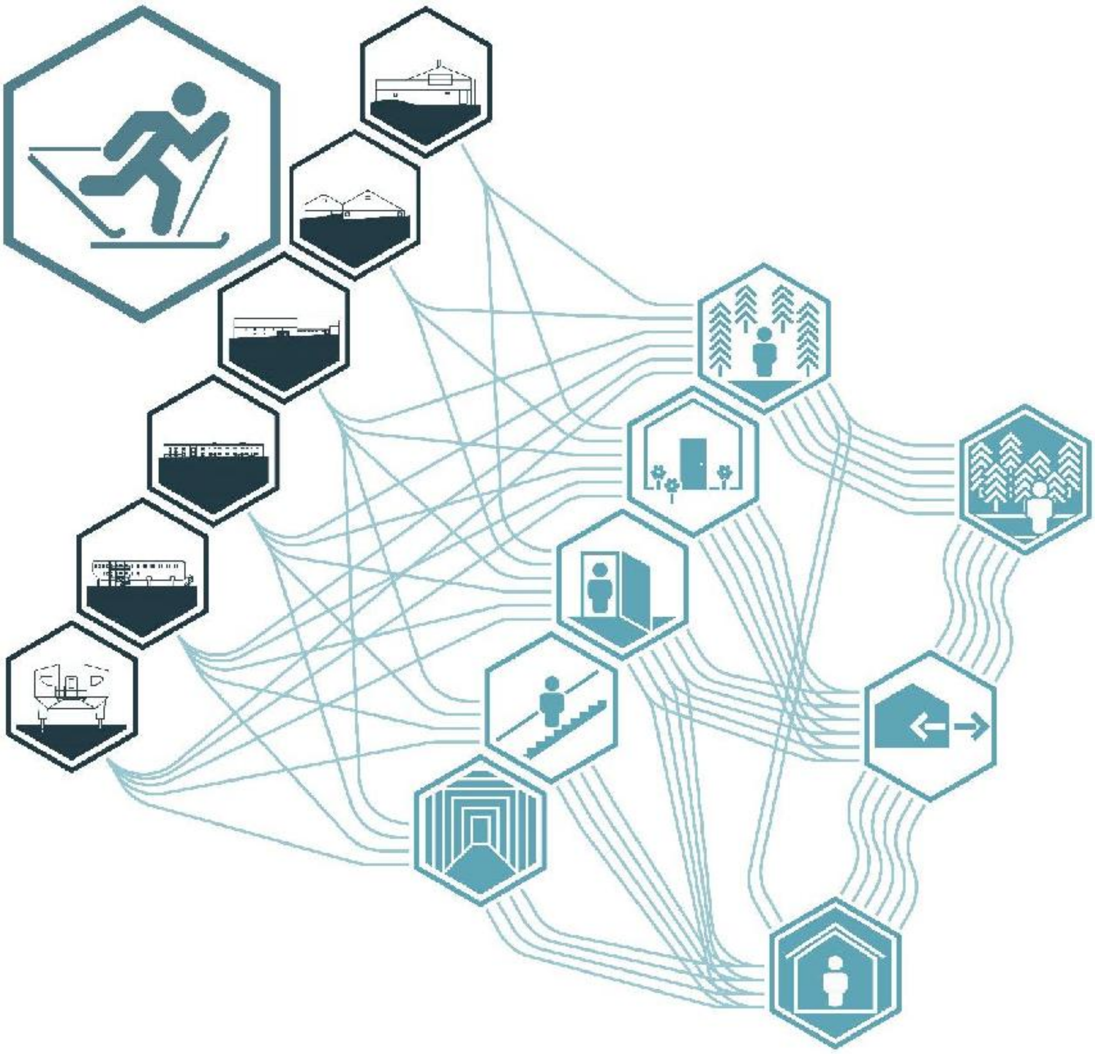

Figure 5-23 Mobility Analysis

All of the cases utilise well-defined and effective circulation, which is the primary focus of the biophilic categorisation of 'mobility'. With a transient population, the buildings need to be easy to navigate with a significant portion of the occupants change each year. Ease in mobility cuts down on anxiety and stress in a foreign environment.

Starting with the entrance to the buildings, each clearly distinguishable. With the IGY and IPY, the primary entrances are denoted by stairs or steps leading up to the cold porch. While this is partially due to the construction of the stations, it distinctly indicates the primary entry points. The HAE did not have that same overlap between floor height and entrance, however, Mawson's and Scott's huts both one entry point. Mawson experienced difficulty once the station was buried in drifting snow and an entrance was made in the roof. He noted in his diary that occasionally men would miss the hatch during storms.

Externally, circulation is less formalised. Instead of having extensive infrastructure, the stations use pathways in the snow, ice, or rock base for circulation paths. These pathways are oriented around the layout of existing structures. Once again, the HAE was more simplistic in their lack of vehicles for transportation needing official roadways. Mawson during the winters created a network of tunnels through the snow to get to other parts of his immediate structure. Similarly, Amundsen-Scott has a tunnel system to support service infrastructure remaining from the dome station.

Internally the HAE both have a fairly circular circulation pattern around their central gathering table. Due to the size of the structure and simplicity of the over parti, the circulation is likewise straight forward. Often portions are usurped by seating around the table or with storage and maintenance of equipment. While there lacks formal designation of dedicated circulation space, it is clear where users are supposed to move.

As previously discussed, IGY and IPY formed their circulation around access to natural light. Using a double-loaded corridor concept kept spaces that would benefit from daylight on the external wall. In McMurdo and Casey, a loop concept is to economise the prioritisation of light. In Casey, this is kept as an uncomplicated loop with intermediary crossing points. McMurdo is slightly more complicated with blocks within blocks, which allows the building to be larger and serve more occupants; however, it has noted the spaces aren't wide enough for all the winter gear to navigate.[424] Amundsen-Scott and Halley VI both employ a central spine parti, which allows them to isolate different zones through their modular stations.

How mobility has been used to navigate stations is quite logical and straightforward. There are many parts of life in Antarctica that can create stress for the inhabitants. With an unfamiliar and sometimes hostile natural environment, prolonged shared habitation with the same isolated community, having an interior environment that is simple to navigate and easy to familiarise oneself with can help ease apprehensions.

Mobility can also be used to explore the opportunities for physical exercise at the structures. With the HAE huts, it was more limited during the winter months, summers were used for exploration, and as such, the men were outside the majority of the time. During the rest of the year, they were encouraged to get outdoors whenever possible and exercise the animals. With the IGY and IPY, dedicated athletic facilities were designed within the case building (IPY) or in a separate structure (IGY). They all still encourage outdoors exercise, supplying skis for transportation as well as recreation, and some stations holding running races. The opportunity to stay physically active is an important component of overall occupant wellbeing.

A unique approach to the concept of mobility found in Halley VI is that the building itself can move. One of the adaptations of the station, the pods are designed to uncouple and be tugged by tractors one at a time to relocate the structure. This is part of the strategy to extend the

[424] Davis, "A Study of Remote, Cold Regions Habitations and Design Recommendations for New Dormitory Buildings in Mcmurdo Station, Antarctica."

building life, as discussed in this research, has allowed the station to 'run away' from encroaching cracks in the ice shelf.

Transitional Spaces

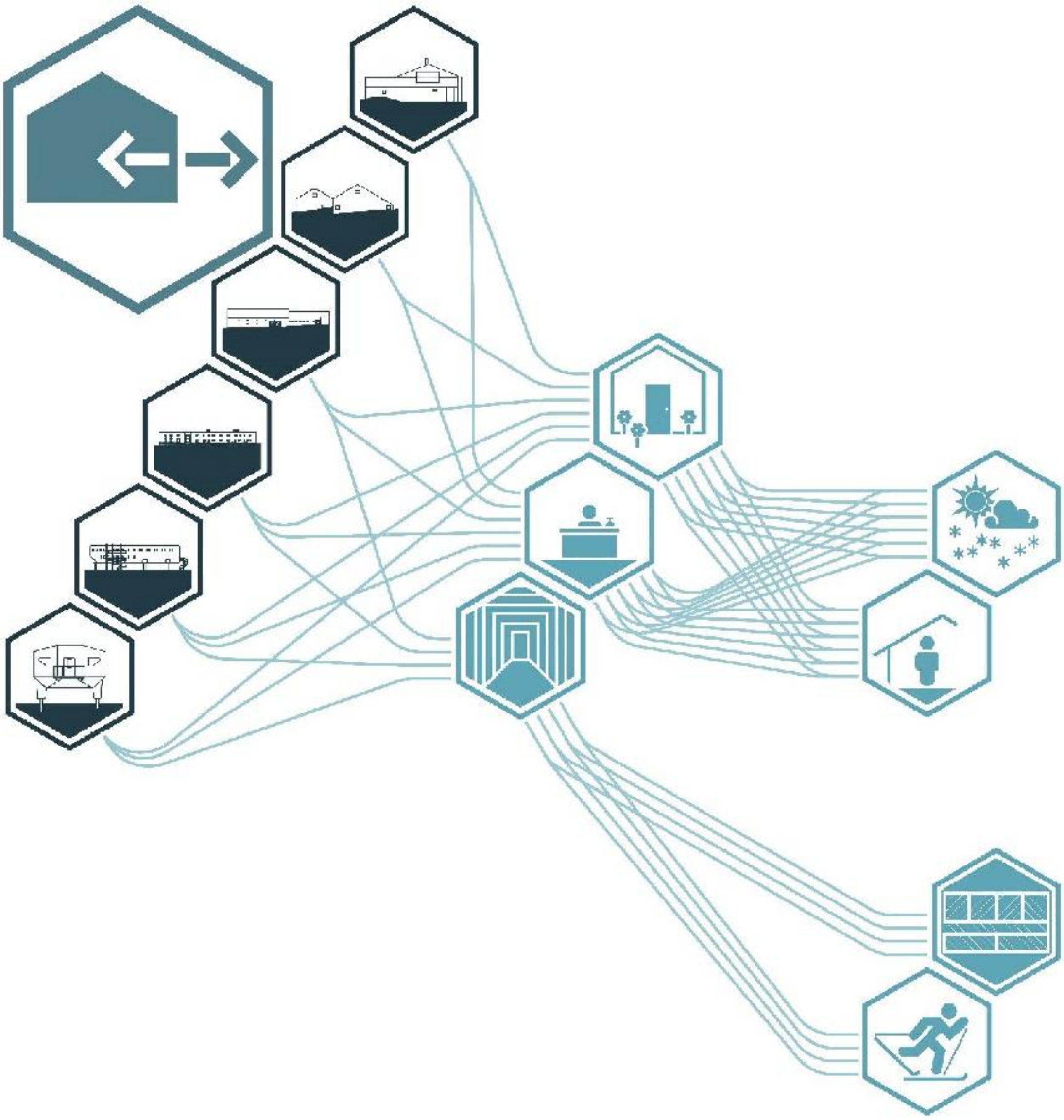

Figure 5-24 Transitional Spaces Analysis

One common feature through all six of the cases is the use of this attribute to climatically protect the tempered interior spaces. Each uses a cold porch or airlock entry at the transition point from indoors to outdoors. A tool, that if designed effectively, will act as a buffer between the heated internal spaces and the harsh cold and wind surroundings. It also acts as a staging ground to don the gear needed for outside, to not only physically, but mentally prepare oneself to go out into the extreme environment. There is generally an open area for a pseudo lobby/entry on both sides of the cold porches, which allows the user to pause, and observe their surroundings before proceeding.

Internal transitional spaces have been treated differently between the periods. All of the cases are mixed-used; with living, eating, sleeping, and sometimes work spaces all under one roof. In the HAE, with areas often having multiple purposes, the designations between each are less formal. There are very few internal doors in both cases; simpler gateways are used to indicate a change in use or status. Cases from the IGY and IPY create clear usage 'zones' for different purposes. These are connected through a series of corridors and often delineated by formal doorways, even if the doors may remain open.

The continued use of transitional spaces as the cases studied have are essential for successful habitation in such an extreme environment. They are basic, practical aspects of architectural design which create a buffer between interior and exterior conditions. Also, with the shift towards singular building stations, it denotes clear changes of function within the structure. This latter helps orient the occupant towards effective use of the space and facilitates an ability to relax in the living spaces more fully.

Place

Developing a sense of place within a building relates directly to the surrounding setting, in this situation, Antarctica. Often engendering an emotional attachment for the occupants to the inhabited environment, through geographical, ecological, historical, and cultural connections. As seen in many of the other attributes, this is not so simple in Antarctica. Some aspects lend themselves easily to fostering this connects, but others challenge it.

Geographical – There is a significant connection to qualities that relate to the geography of Antarctica. This is underlined by the scientific emphasis behind the occupation of the continent. It also means that inhabitants select where to locate themselves based on their research concentration and what is available concerning that in specific areas. With the HAE, the observations were broader due to the originality and a lack of existing information, denoting that the whole continent could be considered valuable. With the IGY and IPY, the research is more focused on the flora, fauna, climatic conditions, geological attributes, etc. available at or near the stations.

Ecological – Patterns in ecological connections are similar to that of geographical, following the scientific nature of the anglo human Antarctic occupation. Ecological systems are less diverse in Antarctica compared to the typical human environment. But there is a broad range of conditions that appeal to various occupants based on their chosen research focus and direct their temporary settlement at one station or another. A key aspect at five of the cases, Scott's Hut, Mawson's Huts, McMurdo, Casey, and Halley VI, independent of scientific research, is water access. A connection to the water is important for ease of transportation. While many of the contemporary sites now have a runway for military planes to fly occupants down, ice breakers are still used for transportation of people and supplies.

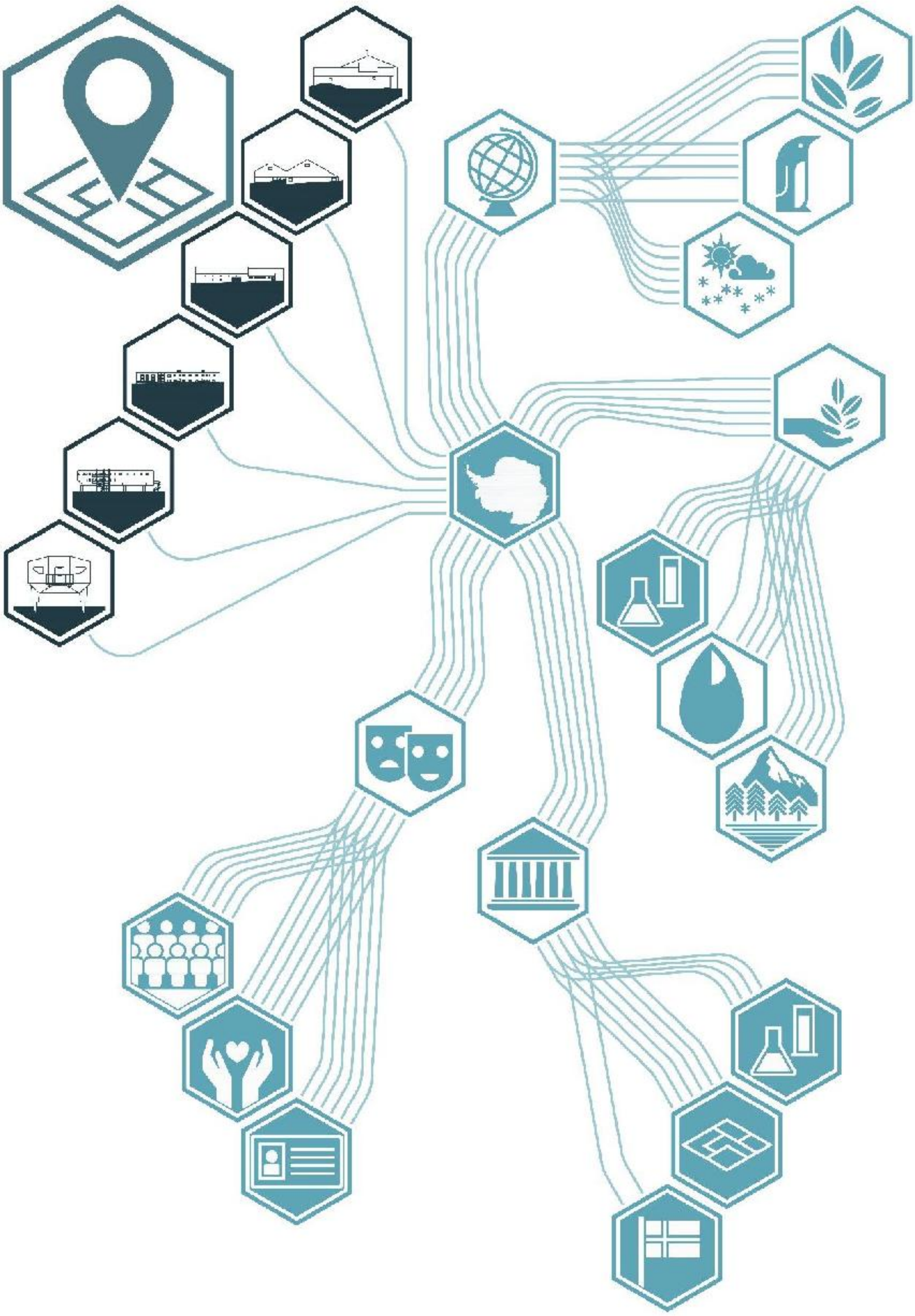

Figure 5-25 Place Analysis

Historical – Documented human interaction in Antarctica is brief compared to the rest of the world, with recorded first sighting being two hundred years ago. The cases studied, spanning the history of human occupation, have varying strength of historical connections. Both

Mawson and Scott used previously mapped areas to pre-select the general area of where they were intending to construct their structures. Their goal was to conduct new scientific research and exploration, so locating their bases near or around previous expeditions was not their objective. Prior to the IGY, further mapping provided more comprehensive information which could be utilised for site selection. All four contemporary cases were initially constructed during that time period. They were located not so much for historical significance, but rather logistical and political reasons. The stations continued to be developed, renovated, and reconstructed through the IPY and today for their historical significance. They have developed their own historical narrative and importance over their lifespan due to events (conquering of the South Pole), long term research (atmospheric research at Halley VI), and ties to the IGY (Wilkes Base), to name a few examples.

Cultural – Culture is a characteristic that is usually developed by a group through shared values, experiences, traditions over time. All the cases are comprised of temporary, transitory populations; no group of expeditioners are the same year to year. However, there is an extensive procedure to live and work at one of the stations; a similar application process was in place during the Heroic Age. Ensuring that no one accidentally stumbles upon life there, that the population is vetted for interest, compatibility, and values. While it is not the organic method most cultures develop, it does create a clear commonality in the inhabitants that rolls from one year to another.

Integrating Parts to Create Wholes

Figure 5-26 Integrating Parts to Create Wholes Analysis

This attribute is an amalgamation of building characteristics to connect the occupants with their surrounding ecological environment with more personal awareness. This is a challenge in Antarctica, which is seen in many of the other attributes. There is a disconnect from the environment, stemming from the belief that it is a hostile element to be fought and kept out. There is some reality to this, temperatures are regularly below freezing at the Cases and some of the highest winds recorded.

Thus, the more indirect connections with nature have more success being employed; images, simulation, materials, etc., which are not as effective. Primarily this has been the inclusion of sources from the inhabitants' home environment. While it potential develops a comforting familiarity, it also engenders further separation from the natural surroundings. If, as has previously been mentioned, the indirect connections could turn some of their focus towards incorporated sources with Antarctic facets, which could provoke a deeper connection with the endemic environment. Touching back on the example given in the Materials section, these don't have to be aspects or characteristics that are completely alien to the inhabitants. Stone is a common building material in the three governing organisations' countries, but if that stone had characteristics of the local geology, it could link a familiar material with the natural environment.

Summary

It is within this element, the experience of space and place that the separation between the Antarctic environment and the built environment is seen. Yet, over time, the awareness of the user impact on the surrounding environment became more conventional, which is a goal of biophilic design. This is partially due to the self-selection process of the occupants, the scientific focus of life, and restrictions outlined in the Madrid Protocol. The general cultural view on what it means to occupy Antarctica has become more conscientious.

5.2.3 Reflections

Kellert's Lessons Learned

Effective biophilic designs evoke a variety of responses based on inherent values found in nature

Emotional attachment is key

Experiential engagement and immersion are necessary

Direct and indirect contact with nature, as well as a satisfying experience of space and place, enhance a design's biophilic appeal

A strong sense of attachment to place an essential part of biophilic design includes both physical and social dimensions

A building or landscape should be experienced as part of a functional and integrated whole

Successful biophilic design enhances health, productivity, and wellbeing

Effective biophilic design contributes to the ecological resilience and integrity of the natural environment over time

Ideally, biophilic design motivates people to sustain, retain, and restore their structures, and places

Successful biophilic design contributes to a perception of beauty and harmony

(Kellert, Stephen R., *Nature By Design: The Practice of Biophilic Design* (New Haven: Yale University Press, 2018) pg.

Overall, looking at biophilic design's goal to encourage the inherent love of nature that humans of anglo cultures possess, use that affinity to develop more conscientious, sustainable building and living practices, Antarctica presents challenging conditions. If one approaches biophilic design as a checklist where all twenty-five attributes have to be present for a structure to fulfil the overarching objective, then all cases in this study have failed. However, that is not the premise that biophilic design is founded upon. Each attribute must be measured based on its feasibility, not just for the climatic considerations but also for how it aids in the occupant well-being. That is where the challenges of the Antarctic climate comes to the forefront. Despite that, it is seen how there is some license in the incorporation of direct attributes in indirect manners, particularly critical to a building within a foreign environment.

The foreign, unfamiliar, and isolating environment of Antarctica does not lend itself to the direct inclusion within the built environment. Occupants often endeavour to surround themselves with reminders of home; including natural facets, not entirely creating their own homeland - microclimate within the stations. That practice does not stimulate a connection to the Antarctic environment for the occupants in the manner Kellert and others have outlined; instead, it would seem to drive a further wedge between the two. Incorporating many aspects of the endemic natural environment of Antarctica into biophilic design's attributes is to welcome some of the more hostile climatic conditions into the building envelope. This is counterproductive to the fundamental, essential purpose of the building to provide shelter.

Beyond structures constructed in an environment that has minimal related able natural elements for biophilic design to draw from, there are the additional policy restrictions. In what is probably a unique situation, there is a non-endemic human population that administratively regulated from integrating aspects of their own environment or incorporating potentially familiar properties of the Antarctic. A scenario which is certainly not a potential challenge that is discussed in biophilic design publications. Inherently, the Madrid Protocol aims to enforce the ecological conservation that biophilic design endeavours to promote, but as previously described, also inhibits the presence of biophilic experiences.

While there is some back and forth in prioritising effective incorporation on natural elements within the built environment, it can be seen such a balance is even more difficult in Antarctica. Nevertheless, attributes of biophilic design are still found inherently incorporated within the cases studied. The success of which has become stronger as the technology and transportation developed and more creative solutions were explored. This does lend itself to the stereotype that biophilic design comes with a certain price tag. A facet of biophilic design that is particularly challenging for architectural interventions in Antarctica is the presupposition that a building warrants the 'luxury' of some of the considerations. In a remote, budget and resource conscious environment, practicality is vital and where many of the missing attributes fall under that extravagance category. The more successful integrations of biophilic design are when they are in functional, utilitarian applications.

Despite all the challenges, due to the self-selective transitory population, the connection to the environment that biophilic design endeavours to establish is still realised. People choose to live, and work in Antarctica because of what it is, what it has to offer. With the remoteness, selection process, and scientific focus, potential habitants have to make a conscious decision, be fully aware of the conditions and climate. Especially with return occupants, there is an inherent attraction to the hostile environment and which lends itself to biophilic designs underlying purpose of fostering a sustainable connection.

Chapter 6: Conclusions

6.1 SUMMARY

The final chapter of this thesis discusses the research findings previously presented, contributing factors that have shaped architectural interventions in Antarctica throughout the history of human habitation on the continent and the patterns that were uncovered through in the analysis. The research questions are revisited and reflected upon in light of the research findings, potential applications of which are outlined in a matrix of biophilic experiences. The chapter is wrapped up with the limitation encountered during research, where overcoming those could take future research, as well as other potential avenues where this study could grow.

6.1.1 General Discussion

Antarctica presents a unique set of environmental, geographical, and cultural conditions for architecture to develop. Almost every aspect of typical human of Anglo culture habitation is a challenge in Antarctica, requiring an intervention of some form to allow them to exist in that climate, for further sustained occupation an architectural solution is essential. The built environment provides the infrastructure for shelter from the temperature, wind, drifting snow, and simulated lighting to mediate the periods of prolonged daylight and night. Over the comparatively brief history of architecture in Antarctica, these have evolved from being rudimentary, purely pragmatic, enabling a secure but not extravagant existence to expand with consideration of the fundamental essentials but in a manner that enhances the occupants well being, though are not considered by any means luxurious as compared to source country standards.

Through the analysis of the six cases; Scott's Hut, Mawson's Huts, McMurdo's Building 155, Casey Station's Red Shed, Amundsen-Scott South Pole Station, and Halley VI, that practicality came through in the framework of biophilic design characteristics, illuminating priorities and the incorporation of natural aspects of the buildings. All the structures were met by the extreme environment and alien natural setting of Antarctica; technology allowed biophilic attributes to be more readily integrated. Over time, the thought of who occupies the buildings and for how long also impacted the inherent inclusion of aspects geared towards more than physical survival when planning for non-temporary structures was created to accommodate larger and more diverse populations.

The results indicated a stronger presence of indirect connections to nature and inclusion of direct connections in an indirect manner. There is a weaker link to natural elements of

Antarctica with the importation of materials and typical building practicals of the source countries, also occupants customising their personal spaces to remind them of home. However, it is the unique quality of a temporary population that bonds the inhabitants to the ecology of Antarctica.

With the components of this study, there are two primary accomplishments from the research. This is the first comprehensive architectural history of Antarctica that analyses the building development over time. Previous studies have focused on individual stations, governing organisations, or periods. This presents a broader spectrum history; investigating cases that spanned from the early Heroic Age huts to space-age-esque station of the fourth International Polar Year. These cases were developed by the Australians, British, and the United States, and ranged in scale, size, and population, which provides a more complete picture of what the architectural possibilities are in Antarctica.

Secondly, within biophilic design, this research takes the approach outside of its familiar environment to investigate that impact. Biophilic design has been studied predominantly across the other six continents and more habitable ecosystems. Also, within a historical context, this research flips the typical approach. Here, it is the cases being analysed in totality by the biophilic attributes, rather than picking and choosing cases to support the principles of biophilic design. This tactic has enabled a more creative examination of examples of the attributes, to view their interpretation in Antarctica over the history of building. It is ultimately expanding upon what biophilic design means within the context of an extreme environment and use as a framework of analysis.

What has ultimately resulted is a tool of analysis for both architectural history and biophilic design research. It breaks a building down into biophilic attributes, identifies the traditional examples before examining adaptations the designers or inhabitants have created to cope with specific conditions. This then reflects upon the attributes and the overarching three experiences to understand how the structure interacts with the surrounding environment. With this approach, comparing or weighing examples is more easily achieved, considering their priorities, period, or cultural considerations. A graphic language was developed around this process to aid in illustrating the relationships, endeavouring to make the research findings more accessible and appealing to a broader audience.

It is important to develop architecture that is attuned to the wellbeing of the occupants for survival; biophilic design promotes this in a manner that is cognisant of nature while connecting the indoors to the outdoors. The challenges that Antarctica poses towards this means it is important to ensure the properties of the biophilic attributes are incorporated. The buildings need to create spaces that are dynamic and stimulating for the occupants during prolonged periods isolated indoors due to inhospitable weather in a climate lacking familiar natural processes. The structures offer not only physical shelter for survival but also prompts a respite for mental health.

While it is commonly thought that the conditions in Antarctica are alien and irrelevant to the rest of the world, characteristics are becoming more prevalent throughout the more temperate climates. These observations are not limited to extremely cold climates; many of the approaches can be extrapolated or reinterpreted for any environment that does not lend itself to human habitation. The architectural adaptations observed, themselves, are not so revolutionary that they are impractical or inappropriate in other settings, and can be readily adjusted to retrofit buildings to aid coping with changing climatic situations.

An element of life in Antarctica that biophilic design compensates for is that of isolation. During the majority of winter months, stations and huts are/were cut off from logistical support from the rest of the world. Even today, with modern technology, transportation is either dangerous, difficult, or impossible. The inhabitants remain with their shelters to provide refuge as well as stimulation and familiarity to a dark, cold, potentially hostile environment. At the beginning of this research, it was far fetched that a relatable scenario existed. With the global Covid-19 pandemic; mandatory self-quarantining and shelter-in-place orders have isolated inhabitants within their own homes. How the structures in Antarctica inherently employed biophilic design to develop interior environments can inform interventions that accommodate this potential going forward. Spaces that are vibrant, dynamic, fostering a sense of comradery, and a much-needed connection to the natural environment beyond what can be seen from a window.

6.1.2 Patterns

Throughout the analysis, several patterns were uncovered to provide insight into the inclusion or prevention of biophilic design's attributes in Antarctic architecture. These patterns also mirror significant shifts in how the building designs have developed over time. Through these, a strategy to cognitively tailor biophilic design to this extreme environment can be developed.

Madrid Protocol

A significant challenge to directly connecting to nature is the Madrid Protocol, regardless of endemic or alien elements. Aspects of the surrounding landscape are protected under the Protocol, preventing the inclusion within the buildings. More significantly, it also precludes the construction or inclusion of familiar features of home; such as constructed landscapes, gardens, plants or animals, to prevent invasive species. This was not a consideration with the HAE and early IGY, prior to the Protocol. However, the implementation of alien elements was not executed in ways that complement biophilic design. With understanding proceeding, the purpose behind the Protocol is founded in an effort for ecological conservation of the natural environment in Antarctica, as such should be respected. While this inhibits attributes of biophilic design, it does lend itself to the overall intent.

Practicality

Throughout the majority of examples of the attributes in the cases, a common thread of practicality connects them. Many of the attributes are present purely due to the fact that the basic characteristics of typical building practices happen to facilitate them. Windows - if a building has a window, it allows natural daylight to come in, as well as provide views which will enable 'weather' [climate] observation and prospect & refuge, bonus points if the window looks out onto a penguin colony. This is not a negative quality to the design, but it does illustrate how to approach incorporating the attributes that are lacking in the cases; integrate them into the fundamental building components.

Individual Customisation

Another prominent theme regarding the establishment of biophilic attributes in the cases is with the customisation that individuals make to their own spaces. To varying degrees, there is a public face that is more structured and ordered within the cases, generally around the communal spaces. It is within the personal spaces or rooms where the occupants have the freedom to tailor their surroundings to suit themselves, that another level of inclusion of biophilic design has potential. This focuses around aspects of the occupants' source environment being integrated into their habitation, rather than that of Antarctica. But this promotes control for the inhabitants, which not only provides them with comfortable, familiar personal territories, also relieving the stress of being in a foreign and potentially hostile environment.

6.1.3 Contributing Factors

Beyond the underlying patterns that informed the inclusion of biophilic attributes, there are also overarching contributing factors that impact the architectural design in general.

Time Period

The most logical relationship to emerge is based on when the structures were built. Depending on what time period over the 102-year history, these cases cover, different attributes are seen incorporated. With the HAE, what is seen was inherent to the basic properties of the buildings being constructed, there was no conscious thought to augmenting the designs to include aspects that are seen a frivolous to the men's heroic exploration. Culturally, the inclusion of nature or human wellbeing, beyond the necessary physical, was not recognised as critical to the expedition. Thus, what is seen in the HAE, is a pure stripped-down version of how biophilic design is integrated into a shelter of a foreign, extreme environment.

With the IGY, there is a lot that has changed which allows for more attributes to emerge in buildings. While the purpose behind structures was similar to the HAE, basic physical shelter, culturally expectations as to what that meant had shifted. Advances in transportation to Antarctica made it easier to bring in the building materials. While initially the stations of the IGY were not intended to be permanent, the two cases studied were established after it was decided to have a lasting presence. That fundamentally changes how a building is developed. These structures also were serving a greater population than that of the HAE. However, building technology had advanced, and the combination of the last three characteristics sees the inclusion of more synthetic materials.

It is with the IPY that a cognisant approach to designing for the inhabitants' wellbeing becomes more consistent. Universally, each rebuilding, regardless of IPY or IGY, the governing organisations' endeavour to learn from the precedents to develop accommodations that are more in tune with what the users need, the longevity of the structure, and impact on the surrounding environment. While not acknowledged, this brought the building more in line with the attributes of biophilic design.

Technology

Naturally, with the difference in time between the three time periods studied, technology played a significant role in the changes in the buildings, in a variety of different ways.

Changes in material technology considerably altered the approach to building design. With the HAE cases, the majority of the building materials were natural; timber and insulation developed from seaweed. Developments in insulative materials impacted design strategies, allowing for more tempered interiors and complex designs. The technology behind the building practices evolved as well. While the basic concept of the structures constructed of prefabricated parts has remained constant through the cases, but the sophistication of the process improved; creating tighter buildings, more efficient connections, and allowing for more innovating shapes. With these material and building advances, it has allowed the architect-backed designs the freedom to experiment. Comparing the writings from the architect of Casey Station to that of Halley VI, the initial concepts of the AANBUS designs were held back by questions and logistical issues. Halley VI, the resources were more readily available to push the envelope within the same constructs.

A significant driver in the evolution of architecture in Antarctica is the technology behind transportation to the continent. During the HAE, the men and supplies were carried south by steam-powered wooden ships, limiting the size and weight of the materials brought down. It also had the potential to damage the material, as Mawson found with the warping of his timber by seawater. During the 40+ years between HAE cases and the IGY, aeroplanes became much more advanced and a feasible option for transportation to Antarctica. Without planes, the materials for Amundsen-Scott South Pole Station would have been carried over the continental plateau rather than airdropped. Large cargo military transport planes carry significantly more than the HAE ships and have a shorter travel time. Stations have continued to be serviced by ice breakers, and research vessels with icebreaking capabilities, the sections for Halley VI were shipped to the continent. As much as this aids in the construction of stations and life in Antarctica, rising temperatures have challenged this. The runways, constructed out of ice and snowpack, typically inaccessible during winter months and in recent summers occasionally warmed to the point of instability. Without more permanent infrastructure in place, as the AAD is planning[425], the stations will return to depending on ships for reliable transportation of building materials for coastal sites.

Economic/Stakeholders

Undertaking anything in Antarctica requires significant financial backing, which impacts all parts of architectural existence. With the HAE, there was governmental funding as well as private support, but post-expedition marketing and touring were intended to provide significant funding. Architecturally, this is seen in the priority that darkrooms were given as they produced marketing material. Also, with regard to archival sources for research, there was a greater number of expeditioners' diary available with Scott's expedition compared to Mawson's. Scott's death opened the window for the men to market their own publications. Mawson's diary is also much more cultivated and edited than Scott's posthumously published record.

With the IGY and almost all stations since they have been part of a governmental department focused on scientific research with military backing. That connection can be seen early on with standard prefabricated military structures. As that has faded to primarily transportation assistance, the buildings have taken on a more experimental and creative approach. However, this is all still constricted by the overall economic constraints of the governing organisation. Frequently, it comes down to a budgetary restriction which prompts a design prioritisation.

Mixed Gender Stations

One aspect that is a consideration in the stations and huts, though not specific to this research is the gender make-up of the buildings. Starting with the HAE, there is a masculine image of who is in the Antarctic. The population of the HAE was exclusively male, singular gender, which contributed architecturally to the more open layout of the huts. During the IGY, the overwhelming majority of the stations were also exclusively male; all of the cases studied initially were single-gendered. It took longer to shift and fully integrate the buildings than was standard back in the source country; women did not have full access to all stations all year until 1996 with the Halley stations being the last. Much of this harkens back to the masculine heroic image, but also military infrastructure and support of the stations. Often this came down to an architectural reason, bathrooms. Recently there has been an increase in research about the gender disparity that still exists; however, it is important to note that architecturally strides

[425] "Davis Aerodrome Project," Australian Antarctic Division, http://www.antarctica.gov.au/living-and-working/travel-and-logistics/aviation/davis-aerodrome.

have been made to provide gender-neutral or equal facilities for the occupants. It is pertinent when many of the underlying objectives of biophilic design are to develop architectural interventions that promote safe, comfortable, relaxing spaces for the inhabitants' wellbeing, that it does so for all the inhabitants. That women have a refuge when they still feel marginalised by the demographics, clothing, opinions about their career/research focus, and frequently still experiencing unwanted attention.[426]

6.1.4 Resolution

Research Questions

- *How has shelter evolved in Antarctica?*

Factors:

How have previous buildings informed the designs of later stations?

How has the approach to the climate changed with material advances?

How has improvement in transportation enhanced access to building materials?

How has an awareness of the building's impact on the natural environment developed over time?

- The initial huts of the Heroic Age were developed with minimal experience with the Antarctic Climate and were not intended to be permanent. Meaning they provided basic needs of shelter. Events throughout that era, the expedition leader, pulled from their prior experience to develop huts that were more successful than their predecessors. From the IGY onward, building practices built upon the observations of the failures and successes of buildings constructed prior to 1956. This was significantly aided in material advances, not just with the structures themselves, but with the ships they used to transport the supplies, and the new use of aeroplanes to access beyond the coastline and speed up the delivery time. Beyond structural engineering, environmental systems, and building envelopes struggling against the environment and climate, this has come to include the wellbeing of the occupants. The more recent stations are designed to create a stimulating interior to engage the occupants during long periods of confinement during the winters, as well as provide shelter. Finally, with the Madrid Protocol, there has been a significant shift in awareness that the human occupation has on the Antarctic environment. The HAE huts have what is now a historic sprawl of artifacts, not just from men but also from snow drifting and ice calving. The impact goes beyond the boundaries of the structures and exterior circulation. There was little regard to the conservation of flora and fauna; often, the fauna became a food supply. With the IGY, prior to the Madrid Protocol, this sprawl can still be seen at the older sites and likewise is considered historic. However, since the

[426] Meredith, Nash et al., ""Antarctica Just Has This Hero Factor…": Gendered Barriers to Australian Antarctic Research and Remote Fieldwork," *PLoS ONE* 14, no. 1 (2019).

Research Questions

- *How has nature been incorporated within architecture in Antarctica?*

- *How has natural elements aided in the survival of the occupants through shelter?*

Protocol, there is a greater effort to be more attuned to the surrounding effort, lessen the impact a station has, and have a plan in place for the removal of any abandoned structures.

- The primary source for natural elements comes from the governing organisation's source country. The most diverse application is often within the occupants' personal spaces, allowing for customisation based on preferences and backgrounds. The majority of connections to nature are indirect due to perceptions of the climate, restrictions of the Madrid Protocol, and ease of incorporation (materials, images, colour). When natural aspects of Antarctica are utilised, it is most often through unavoidable characteristics (light, tempered fresh air, views) or through depictions of natural elements of research conducted at the stations or huts.

- In the most basic sense, how architecture allows humans to survive is through shelter, the structures in Antarctica certainly provide that. There are some astounding records of emergency shelters constructed during the HAE, but for more sustainable long term dwelling, the huts and stations need to be able to provide effective refuge from the harsh climate, particularly for winter. The biophilic attributes come from patterns the humans developed to survive more hospitable climates, so it is natural to see them incorporated in Antarctica. Due to the difference in environmental conditions, biophilic design is often found in an indirect method, buffering the occupants from direct exposure which would potentially be detrimental to their health and safety. Beyond pure physical survival, mental stimulation and wellbeing also aid with the inherent inclusion of biophilic design, particularly in the more contemporary stations. Creating interior spaces that engage the occupants mentally helps them to mentally withstand the isolation and the subtler sensory pallet of Antarctica.

6.2 BIOPHILIC DESIGN IN ANTARCTICA

While not all of the attributes of biophilic design are incorporated in the cases studied, the potential is explored in Chapter 5 with the overarching analyses. The following table explores the possibilities of biophilic design in Antarctica to enhance human existence. Each attribute is broken down to summarize the significant likely challenges that were identified through the research. They are then followed up by solutions that were found to be successful in the cases. In several situations where attributes were not inherently integrated into the cases, prospective approaches are provided based on the intention of the description of biophilic design. Overall, this table represents the practical possibilities architecture holds for the physical and mental survival of occupants.

Table 6-1 Possible Opportunities to Incorporate Biophilic Design in Antarctica

	Existing Descriptions	Attributes	Antarctic Possibilities	
Direct Experience with Nature	facilitating the use of natural light within a space	Light	- challenge of unfamiliar circadian rhythms - customisable shading options for personal spaces - simulated light in personal spaces for sleep patterns - different window/glass treatment to mitigate light/darkness - natural daylighting in communal and circulation spaces keeps the occupants connected to setting	Direct Experience with Nature
Direct Experience with Nature	enabling natural ventilation to promote flow and movement to appeal to the different senses	Air	- high winds and extreme cold prevent direct use within buildings - variable temperatures to allow for user control - experience of 'outdoors' with decks and external circulation aids in environmental awareness	Direct Experience with Nature
Direct Experience with Nature	inclusion of water within a space that allows users the opportunity to experience its properties	Water	- water sources limited due to cold climate - used in a functional manner – cooking, hygiene - used for hydroponic gardening - potential to incorporate water features to mitigate cold desert air - possible use in indirect manners	Direct Experience with Nature

	Existing Descriptions	Attributes	Antarctic Possibilities	
Direct Experience with Nature	presence of endemic plants or plant material incorporated indoors	Plants	- limited by the Madrid Protocol and climate - hydroponic gardens provide food and vegetative experience - possible use in indirect manner: literal and symbolic	Direct Experience with Nature
Direct Experience with Nature	addition of elements that relate to animals; live ecosystem or representations	Animals	- limited by the Madrid Protocol - possible use in indirect manner: literal and symbolic - prioritise animals relevant to Antarctica in communal spaces	Direct Experience with Nature
Direct Experience with Nature	endemic plantings/ ecosystems surrounding the building that engage the users	Landscapes	- Madrid Protocol limits the impact stations can have on the surroundings - site buildings with respect of the existing topography - site buildings to work with climatic considerations (wind direction, drifting snow) - shelter exterior pathways to engage with the landscape but not inhibit mobility - foster opportunities to engage with surrounding landscape	Direct Experience with Nature
Direct Experience with Nature	a built environment that relates to the local qualities presented by the 'weather' and foster a relationship for inhabitants with conditions	'Weather'	- windows providing views of exterior conditions. - stations that promote occupants going outdoors; commuting, decks, etc - allow for limited multi-sensory awareness of conditions: sound	Direct Experience with Nature
Direct Experience with Nature	opportunity for inhabitants to connect with natural scenes from a protected/sheltered space	Views	- interior and exterior viewing opportunities - take advantage of natural surroundings for summer views, beyond transportation opportunities - promote alternative viewing opportunities; solar effects, aurora australis	Direct Experience with Nature
Direct Experience with Nature	controlled presence of fire or the interpretation of fire	Fire	- symbolic use of material and colour to create a warm feeling and evoke the spirit of fire	Direct Experience with Nature
Indirect Experience	depictions of nature or natural elements attempts to forge a connection with nature, potentially fanciful	Images	- allow for personalisation of individual space - organised communal integral imagery - prioritise relationship to Antarctica in communal spaces - literal and symbolic representation	Indirect Experience

	Existing Descriptions	**Attributes**	**Antarctic Possibilities**	
Indirect Experience with Nature	inclusion of natural materials applied in a variety of manners	Materials	- lack of reliable/accessible endemic natural materials - use materials that have similar properties to that found near the site (stone) - use natural materials from source country - use to highlight areas, add detail, in furnishings, textiles, artwork	Indirect Experience with Nature
	touch, form, and composition of aspects of the built environment and how they relate to each other	Texture	- variety of materials - utilise different colours, sizes, scales, shapes of materials - create visual, tangible, auditory stimulation through design - ensure balance	
	the use of colour, particularly natural or earth-toned within a space	Colour	- create visual stimulation to contrast muted external palette - can be used for wayfinding - develop a palette to bring the familiar theme: ground (darker), view plane (neutral), and sky (lightest).	
	naturalistic, organic shapes and forms incorporated into building design	Shapes & Forms	- aerodynamic shape for drifting snow - curved shapes in circulation to follow movement patterns - allow open communal spaces with flexible furniture for occupants to organise naturally	
	providing depth and diversity of patterns and textures that complements one another	Information Richness	- diversity through materials, colour, texture, shapes and forms - create a mentally stimulating, but not challenging indoor environment	
	the transformation of materials through time, wear, exposure, and adaptation	Change, Age, Patina of Time	- no building is permanent in Antarctica - Madrid Protocol mandates removal of structures - develop adaptable buildings that react to conditions - develop buildings that are flexible to the population needs	
	mathematical sequencing is found in nature providing predictable patterning	Natural Geometries	- design with coherent geometric patterns - aim natural mathematical geometries	

	Existing Descriptions	**Attributes**	**Antarctic Possibilities**	
Indirect Experience with Nature	artificial lighting or ventilation with attention paid to mimic the natural conditions	Simulated Natural Light & Air	- light simulates sunlight/sunset for circadian rhythms in personal spaces - customisable for individuals on different schedules - common areas that are 'open' all the time don't need simulated light but should have occupancy sensors to save on energy - simulated air should allow for customisation - variable airflow, temperature, humidity	Indirect Experience with Nature
Indirect Experience with Nature	designs that exemplify the features or functions of nature in a visual form rather than a direct illustrative reference	Biomimicry	- interdisciplinary work with scientists to identify adaptations of Antarctic nature and how it can be integrated into buildings, materials, or processes	Indirect Experience with Nature
Experience of Space and Place	aspects that allow for the unobstructed view of surroundings, as well as create a protective, secure environment	Prospect and Refuge	- protected views of surrounding natural environment - views of transportation - windows, sheltered decks - effective shelter from the climate - interior personal 'shelter' equating to individual rooms - variety of levels of socialisation in communal spaces - communal spaces that allow for casual observation while moving through building	Experience of Space and Place
Experience of Space and Place	elements or environments that have both an overarching organisation, but fosters detail, unpredictability, and interest	Organised Complexity	- use of: colour, materials, textures, images, shapes & forms, etc - planned design of communal spaces that employ attributes - diversity of attributes - balanced used of attributes - create visual and mental stimulation through design	Experience of Space and Place

	Existing Descriptions	Attributes	Antarctic Possibilities	
Experience of Space and Place	allowing effective and clear ability to move between spaces	Mobility	- facilitate foot traffic in buildings and stations - simple layout - clear wayfinding/identification - sheltered pathways outdoors (drifting snow) - accommodate equipment – larger than typical circulation - create opportunities for occupants to move around for physical exercise – athletic facilities - develop outdoor physical exercise – 'track', path, trails etc.	Experience of Space and Place
	areas between the built human environment and the natural outdoors	Transitional Spaces	- vestibules/cold porches! - space to don/doff equipment - be able to view outdoor conditions - 'gateways' to designate interior zones between uses	
	attachment to a setting or environments; cultural, historical, geological, ecological	Place	- show the scientific geographical/ecological significance - connect to the surrounding landscape/landmarks - design according to climatic patterns - incorporate flora/fauna - foster sense of community - build upon seasonal identities - celebrate station history - commemorate historical events - observe traditions	
	distinct smaller parts that combine to form a larger comprehensive entity	Integrating Parts to Create Wholes	- prioritise linking attributes incorporated to Antarctic aspects in communal areas - prioritise natural elements as sources for design	

This table is by no means exhaustive or stagnant. As is seen in this research is how humans of Anglo cultures shelter themselves in the Antarctic has shifted significantly over time, what people view as a requirement for habitation changes. Some of the possibilities are already standard within the stations today, some of it is still thought to be a luxury/unnecessary, much of it is dependent upon funding. It does provide a jumping-off point as to how biophilic design can be interpreted for an extreme environment, even a hostile environment where nature could be considered the enemy, and there isn't a history of conscious inclusion of biophilic principles, as is discussed in 6.4 Future Research. Now that what exists has been identified the next steps could range from critiques of the applicability of biophilic design, firsthand reactions of the occupants themselves, how other cold, extreme environments compare, or how this could potentially be executed.

6.3 LIMITATIONS

The scope of this study was limited by time and resources; the following describes these areas.

Site Visit – being able to visit the cases would have allowed for more intimate and comprehensive familiarity with the buildings and their surrounding site. Logistically working with five different organisations to facilitate site visits and the resources that it would require to undertake such, was above and beyond anything available for this study. Conducting research at a University without ties to existing Antarctic research made networking to join a research expedition difficult. Another drawback that became apparent was the organisational challenge of being a US citizen at an Australian University travelling to Antarctica. Future research around site visits is addressed below.

Cultural Scope – the cases selected for the study focused on English speaking source countries, resulting in cases developed by Australia, the United Kingdom, and the United States. Language is a considerable weakness when choosing from a global arena of cases. The case selection was limited to archival findings in either English or Latin and lacked the budget to hire translation of other sources. Future research considering cases with other cultural sources is addressed below.

Sampling response – initially, interviews were designed to have greater inclusion within the study. It was planned to utilise architects, design professionals, and preservationists to gain further, unpublished, insight into the cases. While several interviewees provided critical information that would otherwise not have been accessible, the majority did not respond or follow through on delivering content. Many of those cases concerned had the secondary sources to back up what would have been gained by direct responses.

6.4 FUTURE RESEARCH

The above limitations leave the door open for future research, the potential for that and other avenues of study is elaborated upon below.

Site Visit

Further study of the cases could be conducted with site visits to provide first-hand observations of the buildings themselves and the surrounding environment. Current plans, details, and vignettes could be developed that are specific to the aim of this research. Experiencing the site would also allow for a more in-depth awareness of the climate, which would benefit additional recommendations.

Elaboration

Individual aspects of this research can be isolated and investigated, not as part of a greater concept but by themselves. Examples of some approaches are discussed below.

Attributes

The attributes outlined by Kellert's biophilic design could be examined more in-depth within the context of Antarctica, separately or thematically. This would free the attributes for a more critical analysis rather than tying them to the overall construct of biophilic design. It also opens up the possibility for new attributes or the negation of the value of specific attributes within the extreme environment.

Characteristics

The traits and qualities identified in the cases could be researched further. There are many unique features of the population in Antarctica that impact the buildings and culture of the continent. Having no indigenous population means that any human presence is invasive and the environment is alien to the majority of the rest of the world, barring that of the North Pole region. The temporary nature of the inhabitants significantly affects the perception of ownership, occupation, and culture in Antarctica. There are two attempts at communities on the peninsula that could be investigated with regard to this, but even those do not have a permanent population of multiple generations.

Individual Interventions

How the occupants have personally adapted their habitats to suit their own needs illustrates where the building is not appropriately accommodating the needs of the occupants. Further investigation into this can, not only identify aspects of the buildings could be improved upon, but also surveying the personal resolutions can provide direction as to how that can be resolved. Conversely, if individual customisation is something which is desired, research into existing precedents provides insight into what materials should be provided to the occupants to do so.

Post Occupancy Evaluations of Antarctic Stations

The logical next step with this research is to see how the occupants in the habituated structures perceive the inclusion of attributes of biophilic design. This research investigates the design intent of the buildings and the finished product but does not always correlate with how users occupy the space. Developing a post-occupancy evaluation of the IGY and IPY stations that focuses on biophilic design would illustrate what level the attributes are recognised by those living in the structures. Two particular long-range cases would be of interest, McMurdo Station and Scott Base (New Zealand). Both have plans to undergo a significant re-design and upgrade to their architectural infrastructure, including the living accommodations. Three series of POEs could investigate the current conditions, the initial new station, and then after a few seasons track how the buildings are performing.

Cultural Representation through Antarctic Stations

The scope of this research limited the cases to stations and huts from the United Kingdom, Australia, and the United States. Further study could take the structure of biophilic design to analyse stations from other governing organisations to see how they approached building in Antarctica and incorporated natural elements. Particular interest would be countries with similar polar climates; Finland, Norway, or Russia.

Impact of changing environment on Antarctic Architecture

Recently, the Antarctic Peninsula gained attention for hitting a new temperature record at the Esperanza Base of over 18°C[427]. Historically, the peninsula is warmer than the main continent where the cases of this research are located; the average temperature is increasing greater as well. With Halley VI, the ski adaptations have allowed it to 'run away' from the increasing number of cracks in the ice shelf. None of the other stations are mobile and face potential difficulty with their infrastructure with these changes. Further research could be undertaken to investigate how the stations are acclimatising or how they could feasibly adapt to the new conditions to remain effective.

Arctic incorporation of Biophilic Design

A distinct attribute of the history of habitation in Antarctica is the lack of documented indigenous civilisation. Looking at the similar climate of the Arctic, the architectural history would go back to a vernacular base with the buildings and shelters of the Saami, Inuit, Aleut, Chukchi, Evenk, Khanty, Nenets, and Yupik[428]; ranging across Canada, Alaska, Scandinavia, and Russia. Vernacular architecture is inherently more climatically attuned, which would add another dimension to the research as well as examine if or how the precedent may have been incorporated. In addition to scientific research stations and indigenous populations, there are some established settlements which would provide more insight into permanent dwelling within an extreme environment.

Analysis of architectural intervention development

The framework of this research can be used as a tool of analysis to study architectural history. The most common approach is using historical examples to illustrate the attributes of biophilic design. This, however, takes the opposite stance, examining a singular historical case, or a series of cases, identifying the attributes that are incorporated within the cases, and

[427] Stone, Madeleine, "The Antarctic Peninsula Is Setting Heat Records. They Won't Stand Long," *National Geographic*, 18 February 2020.
[428] "Arctic Centre," University of Lapland, https://www.arcticcentre.org/EN/arcticregion/Arctic-Indigenous-Peoples.

expanding upon how they were utilised. Not only providing a different understanding of the historical precedents but expanding upon the knowledge of the practice of biophilic design.

Space, the [next] final frontier

A common application of architectural analysis in Antarctica is to utilise it for habitation in outer space. There are a variety of settings in outer space that include biophilic design within architectural intervention planning. However, the ethical basis of colonisation of untouched environments or planets is not necessarily encouraged through the underlying themes of biophilic design. One aspect of outer space habitation is a logical extension of this research, the evolution and development of the International Space Station. Many aspects of this research could be extracted to parallel research into the ISS. Comparison between Antarctic Research Stations and the ISS; looking at science-based habitation, also infrastructure-wise the impacts of tourism. Researching the history of space dwelling from an architectural point of view; initial conceptual plans from government organisations, early precedents like Mir and Skylab, delving into science fiction, and the proposed additions to the ISS. Also, seeing how/if biophilic design has influenced any aspect of the current or future infrastructure orbiting the earth. The thermosphere takes the challenges Antarctica presented to a further extreme. While Antarctica presented a foreign environment, there are still relatable aspects; they just might be more intense than those with which occupants are familiar or comfortable. There is nothing relatable around the ISS; lacking gravity, breathable air, relatable circadian rhythm, etc. the basic building blocks that are identified in biophilic design. It takes everything from the Antarctic setting and heightens it, which would be a fascinating case study.

Extreme/Remote Habitation

Closer to home, other extreme or remote architectural interventions could be used as cases to expand upon biophilic design, and its use as a tool of analysis. Similar to the ISS and the Antarctic research stations, there are other remote working/living conditions: oil rigs, lighthouses, coal mining facilities, submarines, etc. With these cases, not simply the integration of biophilic attributes in these unusual locations (on the water, remote coastlines, below ground, and underwater respectively). The impact that remoteness and alien environments have mentally on the occupants and how they facilitate work/life balance both at the facility but also when they return home. The second category of extreme or remote habitations is communities that have developed in isolated locations; the Faroe Islands, cliffside temples, secluded monasteries, Svalbard, Falkland Islands, Tristan da Cunha, Supai, Lukomir, Little Bay Islands and more. These are more than just places to work and live temporarily, separate from what "home" is for the occupants. These cases are communities and cultures, with their own identity that has developed over time with multiple generations passing down vernacular architecture that developed to their own environments. This could be a detached study which just analyses the individual cases, or including the source culture which leads to these remote communities and how that evolved into what is there today. Investigating how biophilic design was adapted to suit different conditions for evolving cultures and architectural identities.

Design Tool

The output for this research is qualitative, but with further analysis and detailing, a quantitative measure could be developed. A quantitative output could be used as a framework to build a design tool for evaluating existing buildings or proposing the potential effectiveness of future structures. It could also lead towards future adaptations for applications in other environments. The diagrams that accompany the analysis begins to touch on how this could be approached. With a closer look at individual attributes and a larger sample size, the qualitative data could be gleaned. This tool is a similar concept to the Natural Capital Project that the World Wildlife Fund has developed with Chinese Academy of Sciences, The Nature Conservancy, Stanford University, Stockholm Resilience Centre, and University of Minnesota. Part of this program is a software tool which models and maps various attributes of an ecosystem to enable decisions to be made specific to locations.[429] The United Nations Environment Programme World Conservation Monitoring Centre has similar resources available as well.[430]

[429] "The Natural Captial Project," World Wildlife Fund, https://www.worldwildlife.org/projects/the-natural-capital-project.
[430] "Environment Programme," United Nationals Programme World Conservation Monitoring Centre, https://www.unep-wcmc.org/.

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Appendices

Appendix A – Biophilic Design

A.1 Kellert's Typology of Biophilia Values[431]

Environmental Features	
Term	**Definition**
utilitarian	traditional employment of natural materials within the built environment and lives
naturalistic	fulfilment one gains from direct contact with nature which enhances inquisitiveness, connection to the outdoors, and development
ecologistic-scientific	knowledge and understanding through study of form, function, and interactions in nature
aesthetic	conventional physical attraction and interest of natural characteristics
symbolic	metaphorical use of natural components to communicate through language and expression
humanistic	love and affection one has for nature that encourages the sharing and bonding with others over that feeling
moralistic	ethical component of the connection to nature, through an affinity towards aspects of nature, a kinship and responsibility for its wellbeing is formed
dominionistic	ability to physically manipulate or subjugate nature, seeking to prove supremacy
negativistic	more adverse aspects of nature; phobias or elements that create distress or anxiety, which can lead towards the aversion or separation from nature

[431] Kellert, *The Biophilia Hypothesis*.

A.2 Kellert's Biophilic Design Elements and Attributes[432]

Environmental Features

Attributes	Description
colour	the use of colour, particularly natural or earth toned within a space
water	the inclusion of water within a space
air	natural ventilation to promote flow and movement to appeal to the different senses
sunlight	natural light within a space (expanded upon later)
plants	presence of plants or plant material within the environment
animals	inclusion of animals in an area or representation of animals in ornamentation, materiality, forms etc.
natural materials	the use of organic natural resources over artificial materials
views and vistas	the opportunity for natural scenes that are relatable to human scale
façade greening	greener incorporated into vertical surfaces i.e. green walls or ivy-covered bricks, also horizontal areas i.e. green roofs
geology and landscape	creating a grounded connection with local geological structures
habitats and ecosystems	the incorporation of local natural environments
fire	the controlled presence of fire within a space

Natural Shapes and Forms

Attributes	Description
botanical motifs	the imitation of plant forms, visual characteristics, and arrangements
tree and columnar supports	elements the mimic forests or tree-like forms
animal (mainly vertebrate) motifs	reproduction of animalistic elements typically in a stylized form
shells and spirals	imagery and imitation of invertebrate from an ascetic point of view
egg, oval, and tubular forms	rounded forms in exteriors, gardens, embellishments
arches, vaults, domes	forms that resemble natural shapes both ornamentally and structurally
shapes resisting straight lines and right angles	organic curving, winding, twisting elements that resist orthogonal angles
simulation of natural features	simulation over replication of nature to be incorporated within spaces typically decoratively
biomorphy	designs that evoke a feeling of nature without directly referencing it
geomorphy	the inclusion of the local landscape within the space or a strong tie to the immediate site
biomimicry	designs that exemplify the functions of nature in a visual form rather than a direct illustrative reference

[432] Kellert, *Biophilic Design: The Theory, Science, and Practice of Bringing Buildings to Life*.

Natural Patterns and Processes	
Attributes	**Description**
sensory variability	changes and diversity of the elements interacted with sight, touch, taste, sound, or smell
information richness	environments that provide a depth of and variety of patterns and textures that relate to nature
age, change, and the patina of time	the transformation of materials through time, wear, and exposure
growth and efflorescence	changes of materials over time that evokes the feeling of age
central focal point	a dominant aspect within an environment to aid in navigability
patterned wholes	elements united to form an overall element through patterns, replications, tessellations, etc.
bounded spaces	areas that have clear defined borders, demarcations, or edges
transitional spaces	areas between the built human environment and the natural outdoors
linked series and chains	multiple linked spaces which draw users between built and natural environments
integration of parts to wholes	distinct smaller parts that combine to form a larger comprehensive entity
complementary contrasts	natural opposing elements that balance each other, i.e. high and low
dynamic balance and tension	static components that are dissimilar from each other that creates tension which generates a sense of strength and a more organic form
fractals	a variation on a theme or pattern through scale that are similar but not exact copies
hierarchically organized rations and scales	mathematically related parts composed together typically through size

Light and Space	
Attributes	**Description**
natural light	the inclusion of sunlight including the temporal attributes and colour spectrum
filtered and diffused light	having aspects that allow for the natural light to be controlled to alleviate potential negative affect such as glare
light and shadow	change and contrast exemplified in natural light through the day which gives depth to objects
reflected light	surfaces that bounce light to ease glare and draw light further into spaces
light pools	controlled lighting which entices users into spaces or aids in way-finding
warm light	light that is on the yellow/red/orange side of the colour spectrum creating a more welcoming area
light as shape and form	control of light to creating specific, desirable configurations
spaciousness	open and unimpeded environment
spatial variability	diversity within the shapes and sizes of areas
space as shape and form	environments that are manipulated to form specific configuration
spatial harmony	the blending of other attributes that complement each other to create more movement and comfort in a space.
inside-outside spaces	areas that have a direct connection to the outdoors while still providing shelter

Place-Based Relationships	
Attributes	**Description**
geographic connection to place	a link to significant landscape elements through orientation of the building and surrounding views
historic connection to place	a relationship to local culture and historic aspects
ecological connection to place	spaces that have a tie to local ecosystems and biogeographical elements
cultural connection to place	the union of the previous three attributes integrated into the character of the space
indigenous materials	locally sourced natural products
landscape orientation	thoughtful siting of the building that takes the surrounding environment and natural elements into consideration
landscape features that define building form	natural aspects of the site that manipulate or interact with the built form
landscape ecology	design and spaces that strengthens and supports aspects of the natural landscape
integration of cultural ecology	a collaboration of human ethnicity or values and landscape towards stewardship of the surrounding built and natural environment
spirit of place	the maturity of natural and built environments to become cherished over time and sustain the human-nature connection
avoiding placelessness	buildings need to reflect their surrounding environments and should not be interchangeable based on different locations and ecologies

Evolved Human-Nature Relationships	
Attributes	**Description**
prospect and refuge	aspects that allow for the unobstructed view of surroundings, as well as create a protective, secure environment
order and complexity	elements or environments that have both an overarching organization, but complexity brings in details, unpredictability, and interest
curiosity and enticement	inclusion of aspects that promote investigation, unknown, and curiosity
change and metamorphosis	the ability to evolve or grow over time that is dynamic
security and protection	spaces that evoke a feeling of safety or sanctuary, but does not isolate the inhabitants from the natural environment
mastery and control	the basic human desire to dominate nature
affection and attachment	the fondness and care for natural environments and aspects
attraction and beauty	the inclination to appreciate the appeal of nature
exploration and discovery	areas and spaces the encourage investigation of natural processes within themselves
information and cognition	design that promote the complexity of organic forms or ornamentation
fear and awe	the controlled incorporation of peril, components that have a sense of hazard, or provide a diminished sense of perspective for the users.
reference and spirituality	evoking a connection to creation that creates feeling of transcendence and creates a sense of companionship

A.3 Kellert's 2018 Biophilic Design Elements and Attributes[433]

Experience	Attributes		Description	Example	
Direct Experience of Nature	Light		facilitating the use of natural light within a space	windows	
				clerestory	
				atria	
				reflectivity	
				skylight	
	Air		enabling natural ventilation to promote flow and movement to appeal to the different senses	operable windows	
				vents	
				narrow rooms	
				chimney effect	
				balconies/decks	
				patio	
	Water		inclusion of water within a space that allows users the opportunity to experience its properties	fountains	
				aquarium	
				constructed wetlands	
				ponds	
				swales	
				waterfalls	
				rainwater spouts	

[433] Kellert, *Nature by Design : The Practice of Biophilic Design*.

Experience	Attributes		Description	Example	
Direct Experience of Nature (cont.)	Water (cont.)			images	
				video	
				audio	
	Plants		presence of endemic plants or plant material incorporated indoors	planters	
				greenwall	
				green roof	
				atria	
				gardens	
	Animals		addition of elements that relate to animals; live ecosystem or representations	images	
				audio	
				feeders	
				gardens	
				aquarium	
	Landscapes		endemic plantings/ecosystems surrounding the building that engage the users	constructed landscapes	
				wetlands	
				ponds	
				grasslands	
				forests	
				atria	
				gardens	

Experience	Attributes	Description	Example
Direct Experience of Nature (cont.)	Weather	a built environment that relates to the local qualities presented by the weather and foster a relationship for inhabitants with conditions	operable windows
			views
			porches
			courtyards
			skylight
			rainwater collectors
			sound
	Views	opportunity for inhabitants to connect with natural scenes from a protected/sheltered space	prospect/refuge
			porches
			decks
			windows
	Fire	controlled presence of fire or the interpretation of fire	fire
			colours
			materials
			temperature
Indirect Experience of Nature	Images	depictions of nature or natural elements, attempts to forge a connection with nature, potentially fanciful	symbolic
			literal
			photo
			computer
			video
			painting
			sculpture

Experience	Attributes	Description	Example
Indirect Experience of Nature (cont.)	Materials	inclusion of natural materials applied in a variety of manners	building materials
			furnishings
			textiles
			painting
			sculpture
	Texture	touch, form, and composition of aspects of the built environment and how they relate to each other	size
			shape
			tactile
			proportion
			Light
			Space
			colours
			sound
	Colour	the use of colour, particularly natural or earth toned within a space	reds
			oranges
			yellows
			greens
			blues
			purples
			browns
			greys

Experience	Attributes		Description	Example	
Indirect Experience of Nature (cont.)	Shapes & Forms		naturalistic, organic shapes and forms incorporated into building design	facades	
				spaces	
				patterns	
				furnishings	
				landscapes	
	Information Richness		providing depth and diversity of patterns and textures that complements one another	details	
				diversity	
				images	
				organisation	
				colours	
				texture	
				materials	
				shapes & forms	
				natural geometries	
	Change, Age, Patina of Time		the transformation of materials through time, wear, exposure, and adaptation	change	
				age	
				patina	
				death	
				recycling	

Experience	Attributes	Description	Example
Indirect Experience of Nature (cont.)	Natural Geometries	mathematical sequencing is found in nature providing predictable patterning	mathematical properties
			fractals
			phi
			spirals
	Simulated Natural Light & Air	artificial lighting or ventilation with attention paid to mimic the natural conditions	daylight conditions
			colour temperature
			intensity
			atmospheric conditions
			airflow
			temperature
			humidity
			barometric pressure
	Biomimicry	designs that exemplify the features or functions of nature in a visual form rather than a direct illustrative reference	biomimetics
			materials
			forms
			simulated light and air
Experience of Space & Place	Prospect and Refuge	aspects that allow for the unobstructed view of surroundings, as well as create a protective, secure environment	views
			porches
			decks
			courtyards
			colonnades
			sight lights

Experience	Attributes	Description	Example
Experience of Space & Place (cont.)	Organized Complexity	elements or environments that have both an overarching organization, but fosters detail, unpredictability, and interest	Details
			diversity
			coherent balance
			patterns
	Mobility	allowing effective and clear ability to move between spaces	boundaries
			walks
			paths
			roads
			corridors
			stairs
			doors
			elevators
			escalators
	Transitional Spaces	areas between the built human environment and the natural outdoors	entry areas
			foyers
			halls
			atria
	Place	attachment to a setting or environments; cultural, historical, geological, ecological	geographic
			historic
			ecologic
			culture

Experience	Attributes		Description	Example	
Experience of Space & Place (cont.)	Integrating Parts to Create Wholes		distinct smaller parts that combine to form a larger comprehensive entity	linking	
				boundaries	
				mobility	
				connection to the environment	

A.4 Kellert's Biophilic Design Comparison

Experience	Attributes	2008 Elements	2008 Attributes
Direct Experience of Nature	Light	Environmental Features	Sunlight
		Light and Space	Natural Light
		Light and Space	Filtered and Diffused Light
		Light and Space	Light and Shadow
		Light and Space	Reflected Light
		Light and Space	Light Pools
		Light and Space	Warm Light
		Light and Space	Light as Shape and Form
		Place-Based Relationships	Landscape Orientation
		Place-Based Relationships	Landscape Ecology
	Air	Environmental Features	Air
		Natural Patterns and Processes	Sensory Variability
		Place-Based Relationships	Landscape Orientation
		Place-Based Relationships	Landscape Features that Define Building Form
		Place-Based Relationships	Landscape Ecology
	Water	Environmental Features	Water
		Natural Patterns and Processes	Sensory Variability
		Place-Based Relationships	Landscape Features that Define Building Form
	Plants	Environmental Features	Plants
		Environmental Features	Façade Greening
		Natural Shapes and Forms	Botanical Motifs
		Natural Shapes and Forms	Tree and Columnar Supports
		Natural Patterns and Processes	Sensory Variability

Experience	Attributes	2008 Elements	2008 Attributes
Direct Experience of Nature (cont.)	Animals	Environmental Features	Animals
		Natural Shapes and Forms	Animal Motifs
		Natural Shapes and Forms	Shells & Spirals
	Landscapes	Environmental Features	Geology and Landscape
		Environmental Features	Habitats and Ecosystem
		Place-Based Relationships	Landscape Orientation
		Place-Based Relationships	Landscape Features that Define Building Form
		Place-Based Relationships	Landscape Ecology
	Weather	Environmental Features	Habitats and Ecosystem
		Place-Based Relationships	Landscape Orientation
		Place-Based Relationships	Landscape Ecology
		Evolved Human-Nature Relationships	Fear and Awe
	Views	Environmental Features	Views and Vistas
		Place-Based Relationships	Landscape Ecology
		Evolved Human-Nature Relationships	Security and Protection
		Evolved Human-Nature Relationships	Fear and Awe
	Fire	Environmental Features	Fire
		Evolved Human-Nature Relationships	Fear and Awe
Indirect Experience of Nature	Images	Natural Shapes and Forms	Botanical Motifs
		Natural Shapes and Forms	Animal Motifs
		Natural Shapes and Forms	Shells & Spirals
	Materials	Environmental Features	Natural Materials
		Natural Patterns and Processes	Sensory Variability
		Place-Based Relationships	Indigenous Materials

Experience	Attributes	2008 Elements	2008 Attributes
Indirect Experience of Nature (cont.)	Texture	Natural Patterns and Processes	Sensory Variability
	Colour	Environmental Features	Colour
	Shapes & Forms	Natural Shapes and Forms	Tree and Columnar Supports
		Natural Shapes and Forms	Shells & Spirals
		Natural Shapes and Forms	Egg, Oval, and Tubular Forms
		Natural Shapes and Forms	Arches, Vaults, Domes
		Natural Shapes and Forms	Shapes Resisting Straight Lines and Right Angles
		Natural Shapes and Forms	Biomorphy
		Natural Shapes and Forms	Geomorphy
		Light and Space	Space as Shape and Form
	Information Richness	Natural Patterns and Processes	Sensory Variability
		Natural Patterns and Processes	Information Richness
		Natural Patterns and Processes	Fractals
	Change, Age, Patina of Time	Natural Patterns and Processes	Sensory Variability
		Natural Patterns and Processes	Age, change, and the patina of time
		Natural Patterns and Processes	Growth and efflorescence
		Evolved Human-Nature Relationships	Change and Metamorphosis
	Natural Geometries	Natural Shapes and Forms	Shells & Spirals
		Natural Patterns and Processes	Patterned Wholes
		Natural Patterns and Processes	Fractals
		Natural Patterns and Processes	Hierarchically Organized Ratios and Scales

Experience	Attributes	2008 Elements	2008 Attributes
Indirect Experience of Nature (cont.)	Simulated Natural Light & Air	Natural Shapes and Forms	Simulation of Natural Features
	Biomimicry	Natural Shapes and Forms	Biomimicry
Experience of Space & Place	Prospect and Refuge	Evolved Human-Nature Relationships	Prospect and Refuge
		Evolved Human-Nature Relationships	Security and Protection
		Natural Patterns and Processes	Complementary Contrasts
	Organized Complexity	Evolved Human-Nature Relationships	Order and Complexity
		Evolved Human-Nature Relationships	Informational and Cognition
	Mobility	Natural Patterns and Processes	Central Focal Point
		Natural Patterns and Processes	Bounded Spaces
		Light and Space	Spatial Harmony
	Transitional Spaces	Natural Patterns and Processes	Transitional Spaces
		Natural Patterns and Processes	Linked Series and Chains
		Light and Space	Inside-Outside Spaces
		Place-Based Relationships	Landscape Ecology
	Place	Place-Based Relationships	Geographic Connection to Place
		Place-Based Relationships	Historic Connection to Place
		Place-Based Relationships	Ecological Connection to Place
		Place-Based Relationships	Cultural Connection to Place
		Place-Based Relationships	Landscape Ecology

Experience	Attributes	2008 Elements	2008 Attributes
Experience of Space & Place (cont.)	Place (cont.)	Place-Based Relationships	Integration of Cultural Ecology
		Place-Based Relationships	Spirit of Place
		Place-Based Relationships	Avoiding Placelessness
	Integrating Parts to Create Wholes	Natural Patterns and Processes	Patterned Wholes
		Natural Patterns and Processes	Integration of Parts to Wholes
		Light and Space	Spatial Variability

A.5 Terrapin Bright Green – Biophilic Design Categories [434]

Category	Pattern	Description
nature in the space	visual connection with nature	a connection with nature that is visual, i.e. an image, view, relying on sight
	non-visual connection with nature	a connection with nature that relies on the other four senses (touch, taste, smell, sound)
	non-rhythmic sensory stimuli	a connection to nature that is unpredictable, random, or impulsive
	thermal and airflow variability	changes within the temperature, flow, or humidity of air that follow natural characteristics
	presence of water	the inclusion of water within the environment, typically it is interacted with through sight, sounds, and/or touch
	dynamic and diffused light	light that is fluctuates with strength creating dynamic light and shadow that follows natural patterns
	connection with natural systems	correlation with natural rhythms that are typical of healthy local environments
natural analogues	biomorphic forms and patterns	shapes, patterns, or textures that are natural occurring or that are representative of natural aspects
	material connection with nature	the use of material and other natural elements that are specific to the local environment
	complexity and order	aspects that have a hierarchy that creates an intense sensory experience for the users
nature of the space	prospect	a view that is unrestricted that allows for observation and supervision
	refuge	a protective place in which an individual can remove themselves from an exposed environment or the primary occupation of a space
	mystery	partial appealing or fascinating views that lure individuals deeper into an environment to garner more information or greater access
	risk/peril	a perceivable danger or hazard that is paired with the possibility of protection

[434] Browning, Ryan, and Clancy, "14 Patterns of Biophilic Design: Improving Health & Well-Being in the Built Environment."

A.6 Biophilia Matrix Elements[435]

Environmental Features	
Attributions	**Description**
colour	the use of any colour
water	the use of any phases of water
air	the use of natural ventilation
plants	the inclusion of plants, live or dried
animals	the presence of animals
natural materials	materials that occur naturally and maintain their natural attributes
views and vistas	environments allowing observation natural scenes or landscapes
fire	controlled presence of fire that enhances colour, temperature, and movement

Natural Shapes and Forms	
Attributions	**Description**
botanical motifs	depiction of patterns or forms that are derived from plants or vegetation
tree and columnar supports	aspects that mimic attributes of trees or forests
Animals	images, symbols, or attributes that embody characteristics of animals
shells and spirals	depictions and inclusion of features of invertebrates
egg, oval, and tubular forms	inclusion of rounded forms, typically in decorative
arches, vaults, and domes	structural elements that simulate natural curved elements i.e. beehives, nests, etc. rounded or parabolic curvatures
shapes resisting straight lines	organic, twisting, winding, adaptive non-linear forms
simulation of natural features and biomorphy	a reproduction or imitation rather than a direct replication of a natural element, evokes a memory or feeling from the element
geomorphology	the replication or direct interaction with the surrounding landscape or geology within the interior
biomimicry	using nature as a direct model, through imitation or simulation that draw upon the purpose or utility of nature for inspiration

[435] McGee and Marshall-Baker, "Loving Nature from the inside Out: A Biophilia Matrix Identification Strategy for Designers."

Natural Patterns and Processes	
Attributions	**Description**
sensory variability and information richness	overlaying of multiple sensory experiences to create a complex experience that is intellectually stimulating
age, change, and the patina of time	the use of materials that are transformed over time through wear, growth, or exposure
central focal point	one primary element that draws the attention
patterned wholes	a singular element made up of smaller components which are organized in a patterned arrangement
bounded spaces	spaces that are defined with limits and demarcations, clearly expressed regions
transitional spaces	areas that are dedicated to moving or transitioning between spaces
linked series and chains	spaces directly interconnected sequentially
integration of parts to wholes	separate elements that together compose a whole entity
complementary contrasts	characteristics that are natural opposites that differ greatly, i.e. light and dark
dynamic balance and tension	differing characteristics that create a more organic form with tension creating a sense of robustness, resilience, or endurance
fractals	elements that have an analogous appearance independent of scale, geometrically self-similar, but not precise replications
hierarchically organized ratios and scales	patterns based on a progression of scale that are naturally occurring and pleasing, i.e. golden ratio, Fibonacci's sequence

Light and Space	
Attributions	**Description**
natural light	access to sunlight
filtered and diffuses light	non-direct access to natural light to reduce glare
light and shadow	modifications to the access of light that creates a variety of intensity
reflected light	that is bounced off other surfaces to promote further access to it
light pools	a series of light reflected on a surface to create mystery, drawing individuals between spaces
warm light	light that has properties of warmer colours; yellow, red, orange, that evokes a more welcoming, secure feeling
light as shape and form	manipulation of light to create a pleasing configuration
spaciousness	large unrestricted environment
spatial variability	a space or environment that provides different spatial experiences, i.e. light, scale, size
space as shape and form	areas that are designed to have a specific form or profile
spatial harmony	a feature within the spaces that creates a sense of commonality between them, making them related
inside-outside spaces	environments that are directly connected to the outdoors, but provides access to the interior

Place-Based Relationship	
Attributions	**Description**
geomorphic connection to place	the use of aspects from the local landscape and geographic properties within a space
historic connection to place	inclusion of historic elements or images
ecological connection to place	the inclusion of regional feature, i.e. mountains, bodies of water, etc.
cultural connection to place	the amalgamation of all three of the previous aspects
indigenous materials	use of materials that are locally sourced and prevalent naturally
landscape orientation and landscape features that define building form	the overall siting of the building or structure that is attuned to environmental conditions specific to that site or area

(evolved) Human-Nature Relationships	
Attributions	**Description**
prospect and refuge	spaces that allow an unobstructed view for observation and supervision, yet creates a protective place for the individual
order and complexity	aspects that have a hierarchy that creates an intense structured sensory experience for the users
curiosity and enticement	environments that promotes exploration, investigation, and creativity through experiences
change and metamorphosis	the modification or transformation over time

A.7 Biophilic Design and Related Areas of Consideration

Concept	Definition	Contributors	Date	Significance
Attention Restoration Theory	use of natural elements to improve concentration and combat mental fatigue	William James	1892	*Psychology: The briefer course*
		Rachel & Stephen Kaplan	1989	*The Experience of Nature: A psychological perspective*
		Stephen Kaplan	1995	*The Restorative Benefits of Nature: Toward an Integrative Framework*
Biomimicry	use of natural aspects to develop solutions, processes, designs, etc. that are sustainable	Otto Schmitt	1957	originated the term 'biomimetics'
		Janine Benyus	1997	*Biomimicry: innovation inspired by nature*
Biomorphic Architecture	building design that is a direct result of influences from natural elements for aesthetics, shape, and/or form	Geoffrey Grigson	1805	originated the term 'biomorphism'
		Alfred H. Barr	1936	*Cubism and Abstract Art*
		Antonio Gaudi	1878-1926	common theme throughout work
		Fariborz Sahba	1986	*Lotus Temple*
		Eero Saarinen	1962	*TWA Flight Center*
Biophilia	the love of life	Erich Fromm	1964	*The Heart of Man*
	innate attraction to nature	E.O. Wilson	1984	*Biophilia*
		Stephen Kellert & E.O. Wilson	1993	*the Biophilia Hypothesis*
		Peter Kahn & Stephen Kellert	2002	*Children & Nature: Psychological, Sociocultural, and Evolutionary Investigations*
Biophilic Architecture	the use of the biophilic connection in architectural design to impact the mental and physical wellbeing of the inhabitants	A. Almusaed & A. Almssad	2006	*Biophilic architecture: the concept of healthy sustainable architecture*
		Yannick Joye	2007	*Architectural lessons from environmental psychology: the case of biophilic architecture*
		Soderlund and Newman	2015	*Biophilic Architecture: a review of the rationale and outcomes*

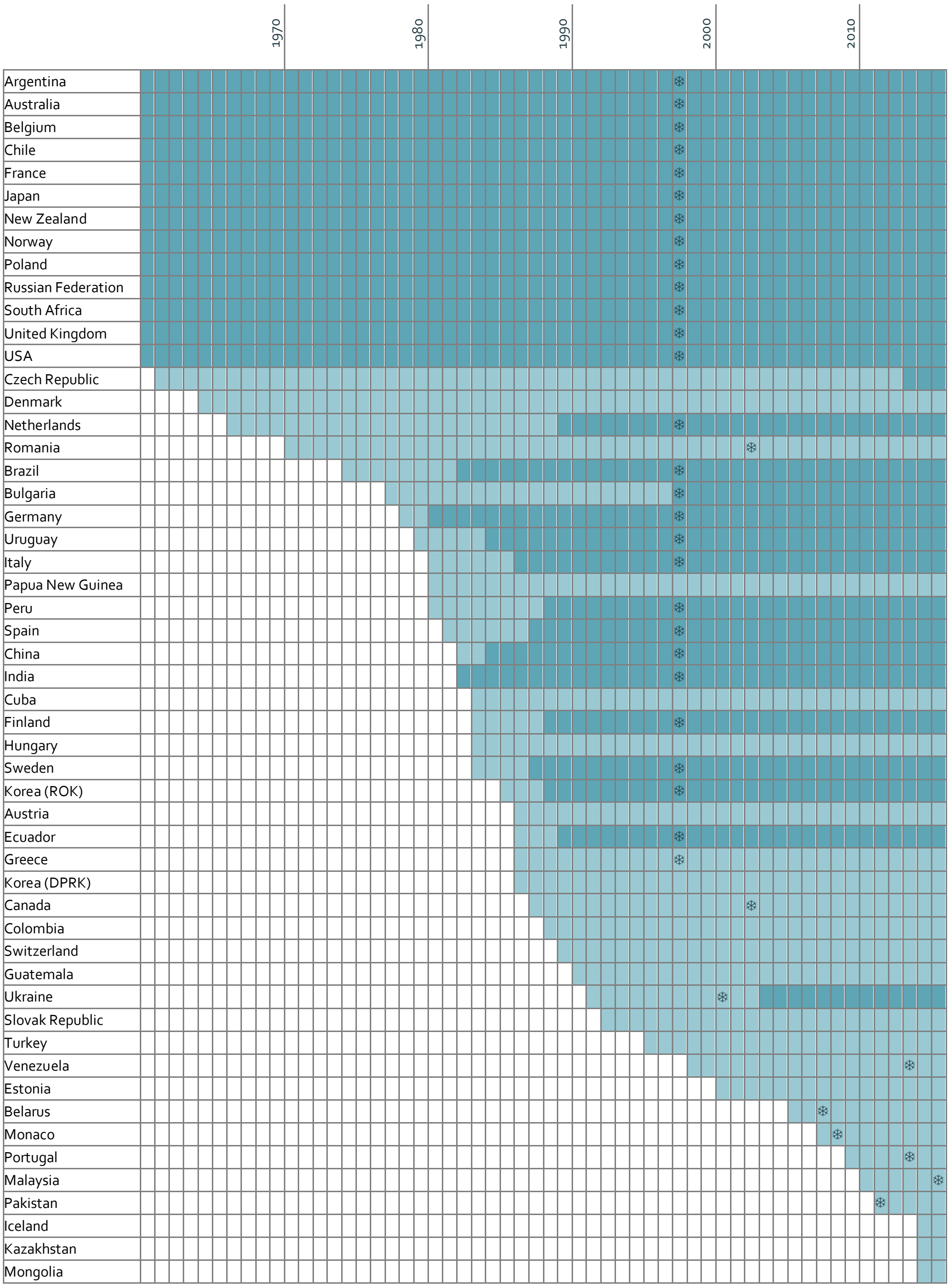
Biophilic Design	integration of biophilia in the built environment to encourage a connection to nature and promote inherent behavioural patterns developed over time as a means of survival	Stephen Kellert	2005	*Building for Life*
		Stephen Kellert, Judith Heerwagon, Martin Mador	2008	*Biophilic Design*
		Timothy Beatley	2011	*Biophilic Cities*
		Terrapin Bright Green	2014	*Biophilic Design Patterns*
Carbon Neutral Building	the use of architectural design practices to reduce a building's carbon footprint and emissions, and improve the energy performance	Edward Mazria	2002	Architecture 2030
		American Society of Heating, Refrigerating and Air Conditioning Engineers	2008	Vision 2020
		Pablo La Roche	2012	*Carbon-Neutral Architectural Design*
		Mandy Henk	2014	*Ecology, economy, equity: the path to a carbon-neutral library*
Environmental Psychology	interdisciplinary study of the relationship between individuals and their surroundings	Jakob von Uexküll	1927	*Theoretical Biology*
		Egon Brunswik	1934	*Wahrnehmung und Gegenstandswelt*
		Willy Hellpach	1935	*Geopyche* originated the term 'environmental psychology'
		Roger Baker	1965	*Explorations in ecological psychology*
Fractal Architecture	buildings which utilize self-similar patterns which are replicated in different sizes	Ron Eglash	1999	*African Fractals: Modern Computing and Indigenous Design*
		Yannick Joye	2006	*Symmetry breaking in fields as a methodology for three-dimensional fractal form generation*
		Richard Taylor	2006	*Reduction of Physiological Stress Using Fractal Art and Architecture*
		Hokky Situngkir & Rolan Dahlan	2009	*Fisika batik: implementasi kreatif melalui sifat fraktal pada batik secara komputasional*
		Xavier Vilalta	2013	*Architecture at home in its community*
Green Design/ Architecture	building design that employed materials and techniques that lessens the impact on the natural environment and human health	Ian McHarg	1969	*Design with Nature*
		Edward Mazria	1979	*The Passive Solar Energy Book*
		Bo Adamson & Wolfgang Feist	1969	Passive Haus Standard
		David Gottfried	1993	US Green Building Council
		David Gottfried	2002	World Green Building Council

Organic Architecture	building design that encourages a connection between humans and nature	Rudolf Steiner	1914-1935	practitioner of anthroposophic architecture
		Frank Lloyd Wright	1954	originated the term 'organic architecture'
		Frank Lloyd Wright	1957	*The New Architecture: Principles*
		Eric Corey Freed	1997	practitioner of organic architecture, founder of organicARCHITECT
		David Pearson	2001	*New Organic Architecture: The breaking Wave*
Perceived Restorativeness Scale	evaluation scale based on the characteristics in ART	Terry Hartin	1996	*Restorative Qualities of Favorite Places*
		Hartig, Evans, Korpela & Garling	1997	*A measure of Restorative quality in Environments*
		Peter Bowler, Florian Kaiser, and Terry Hartig	1999	*A Role for Ecological Restoration Work in University Environmental Education*
		Thomas Herzog, P. Colleen, Mary Macguire, & Mary Nebel	2003	*Assessing the restorative components of environments*
Restorative Environment Design	use of sustainable design with traditional building practices to enhance the health of the inhabitants	Stephen Kellert	2004	*Beyond LEED: From Low Environmental Impact to Restorative Environmental Design*
		Terry Hartig & Tina Bringslimark, & Grete Grindal Patil	2008	*Restorative environmental design: What, when, where, and for whom?* (in *Biophilic Design*)
		Victoria Derr & Stephen Kellert	2012	*Making Children's Environments "R.E.D.": Restorative Environmental Design and Its Relationship to Sustainable Design*
Sociobiology	the use of evolution to describe social behavioural patterns	John Paul Scott	1948	*Animal Behavior and Sociobiology*
		E.O. Wilson	1975	*Sociobiology: The New Synthesis*
		Noam Chomsky	1976	*Reflections on Language*
Sustainability (ecology)	indefinite ability of natural systems to remain diverse and productive, maintaining ecological balance	Ernst Haeckel	1866	originated the term 'ecology'
		George Bird Grinnell	1886	Audubon Society Founded (USA)
		Rachel Carson	1962	*Silent Spring*
		United Nations	1987	*Montreal Protocol*
		United Nations	2005	*Kyoto Protocol*

Sustainable architecture/ design	building designs that minimize the impact the structure has on the environment through materials, energy usage, and spatial organization	Brundland Report	1987	*Our Common Future*
		Natural Resources Defence Council	1993	Leadership in Energy and Environmental Design (LEED)
		Susan Maxman	1995	*Designing a sustainable facility to improve energy and environmental performance at the women's humane society*
		James Steele	1997	*Sustainable Architecture: Principles, Paradigms, and Case Studies*
Vernacular Architecture	structures that reflect the locals' needs, materials, construction practices, traditions, or climates	Bernard Rudofsky	1964	originated the term 'vernacular' for architecture
		Vernacular Architecture Forum	1980	*Buildings & Landscapes: Journal of the Vernacular Architecture Forum*
		Fathy, Hassan	1986	*Natural Energy and Vernacular Architecture: Principles and Examples, with reference to hot arid climates*
		Bashirul Haq	1994	*Battling the Storm - Study on Cyclone Resistance Housing*

Appendix B – Antarctica

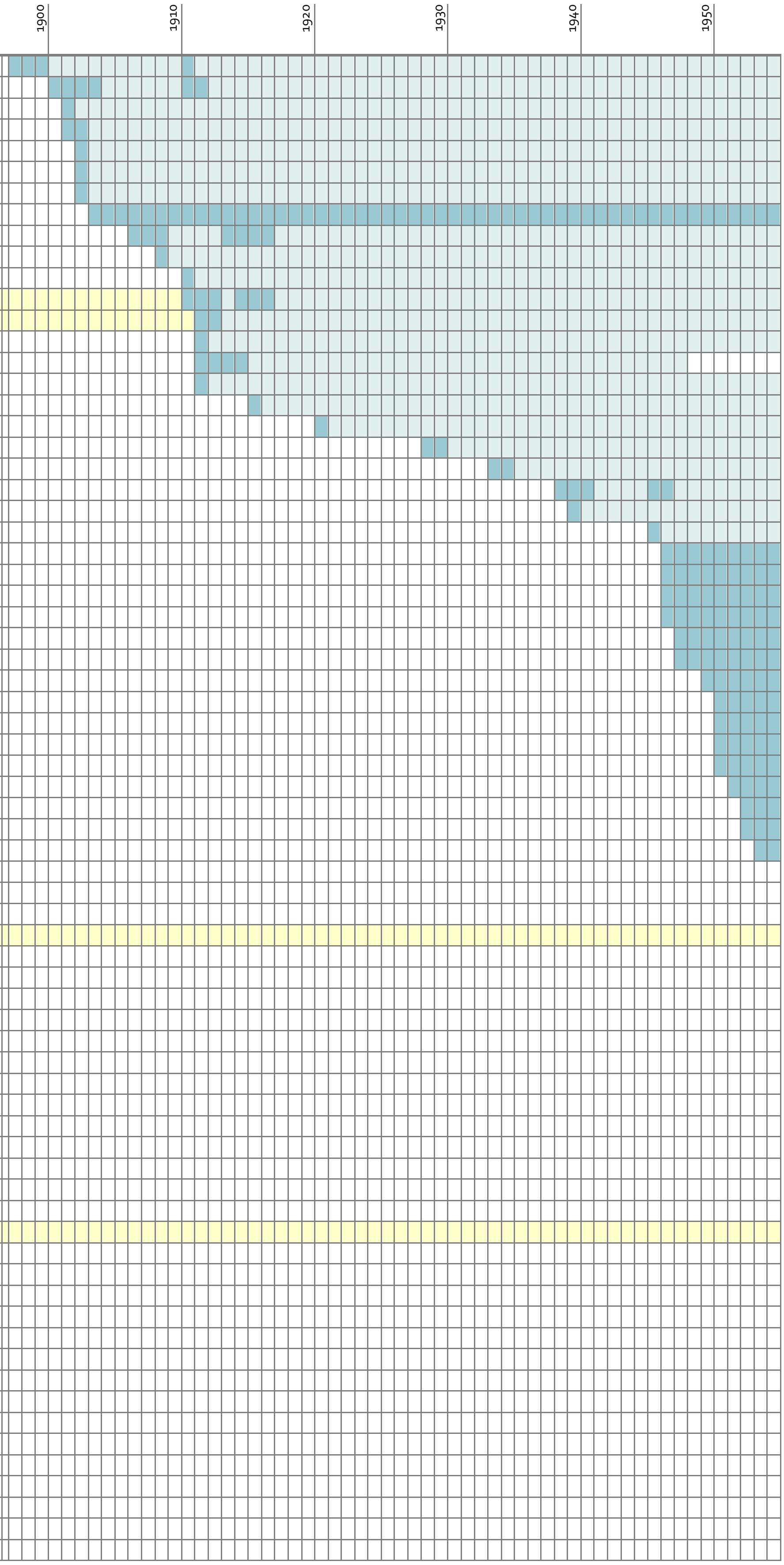
B.1 ATS Membership[436]



[436] Secretariat of the Antarctic Treaty, http://www.ats.aq/index_e.htm.

B.2 Overview of Architecture in Antarctica – Chronology

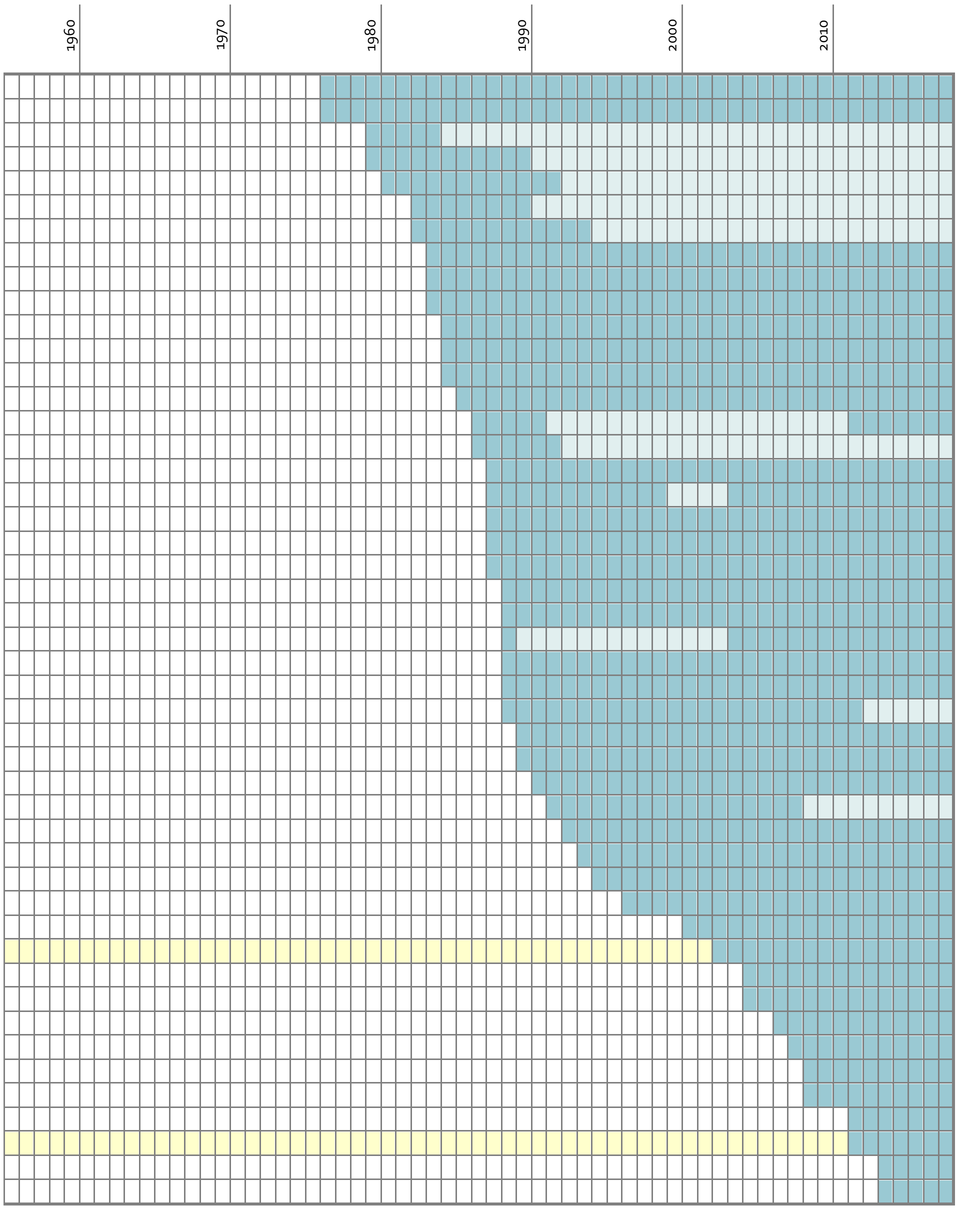
	Name
UK	Borchgrevink's Hut
UK	Discovery Hut
DE	Gauss Expedition Hut
SE	Nordenskiöld House
AR	Omond House
SE	Ruins of Stone Hut
SE	Ruins of Stone Hut
AR	Orcadas Base
UK	Shackleton's Hut
FR	Charcot Expedition
NO	Frammheim
UK	Scott's Hut
AU	Mawson's Huts
AU	remote hut
AU	Relay Station
UK	Ice Cave - North Party
UK	Shackleton Refuge
UK	Boat Hut
US	Little America I
US	Little America II
US	East Base
US	Little America III
US	Little America IV
AR	Melchior Base
CL	Prat Base
UA	Vernadsky
UK	Signy
AR	Deception Base
CL	O'Higgins Station
FR	St. Martin
AR	San Martin Base
AR	Almirante Brown
AR	Belgrano I Base
CL	Gonzalez Videla
AR	Camara Base
AR	Carlini Base
AR	Esperanza Base
AU	Mawson Station
FR	Dumont d'Urville
RU	Mirny Station
US	Little America V
US	McMurdo Station
US	Amundsen-Scott
AU	Davis Station
JP	Syowa Station
NZ	Hallett
NZ	Scott Base
RU	Vostok
RU	Komsomolskaya
US	Old Byrd
US	Ellsworth
AR	Matienzo Base
US	Byrd
RU	Novolazarevskaya
RU	Molodyyozhnaya
AU	Casey Station
AR	Sobral Base
US	Old Palmer Station
AR	Petrel Base
NZ	Vanda Station
UK	Halley II
RU	Bellingshausen
US	Palmer Station
AR	Marambio Base
CL	Montalva
JP	Mizuho
RU	Leningrad Skaya
UK	Halley III
UK	Rothera
US	Amundsen-Scott
AR	Primavera Base




1960
1970
1980
1990
2000
2010

	Name
AR	Belgrano II Base
PL	Arctowski
AR	Belgrano III Base
RU	Russkaya Station
DE	Neumayer-Station
IN	Dakshin Gangotri
UK	Halley IV
BR	Comandante Ferraz
FI	Aboa
UY	Artigas Base
CN	Great Wall Station
IT	Mario Zucchelli
JP	Asuka Station
RO	Law-Racovita Station
RU	Druzhnaya 4
	World Park Base
BG	St. Kliment Ohridski
RU	Progress Station
SK	King Sejong Station
ES	Juan Carlos I Station
SE	Svea
CN	Zhongshan Station
IN	Maitri Station
NO	Troll Station
PE	Machu Picchu Base
SE	Wasa
UK	Halley V
EC	Maldonado Base
ES	Gabriel de Castilla Base
PK	Jinnah
DE	Neumayer-Station II
NO	Tor Station
CL	Escudero Base
JP	Dome Fuji Station
SA	SANAE IV
DE	Kohnen Station
US	Amundsen-Scott
IT	Concordia Station
US	WAIS Divide Camp
CZ	Mendel Polar Station
DE	Neumayer-Station III
BE	Princess Elisabeth
CN	Kunlun Station
IN	Bharati
UK	Halley VI
CN	Taishan Station
SK	Jang Bogo Station

1900 1910 1920 1930 1940 1950


1960
1970
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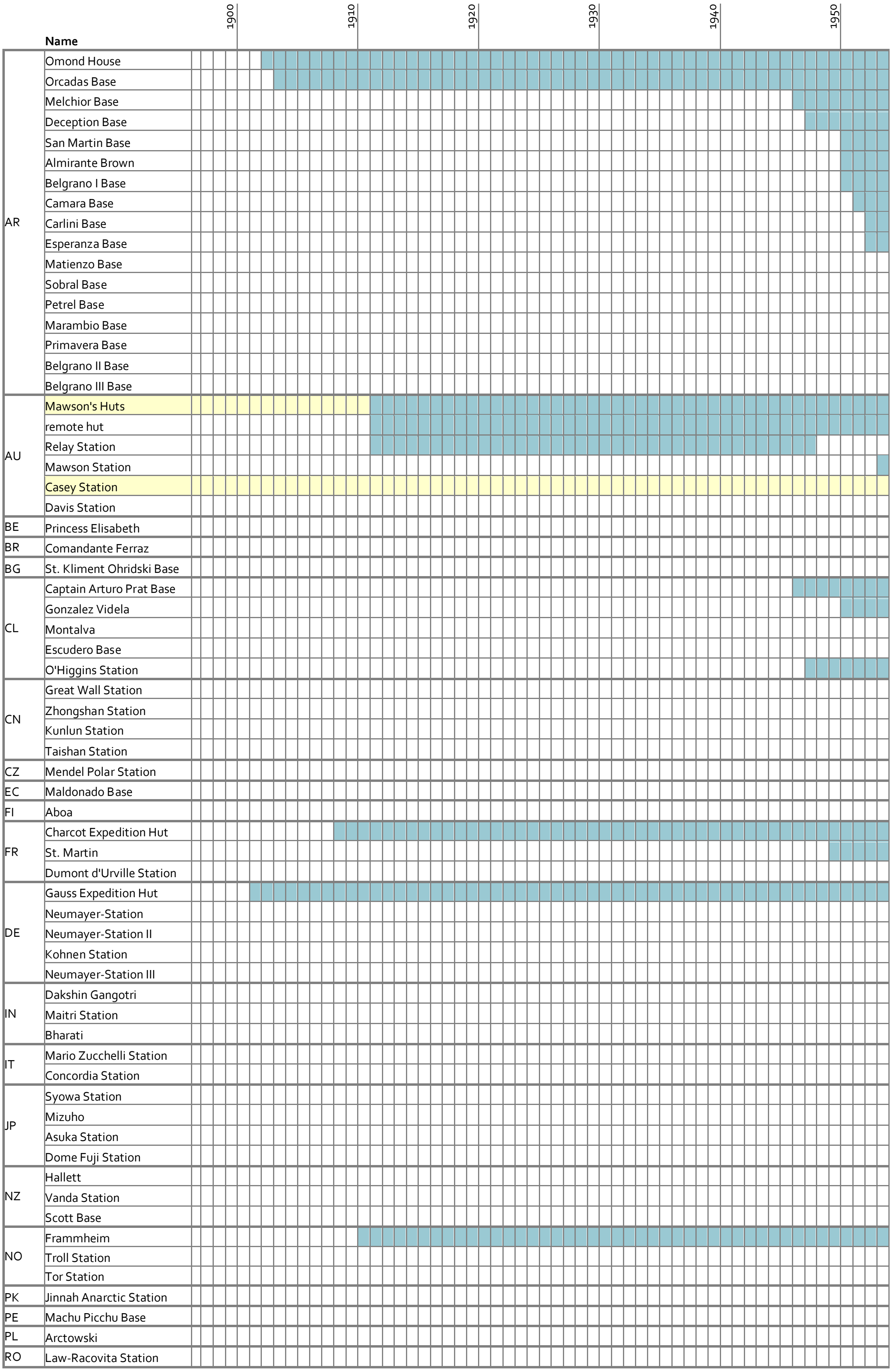
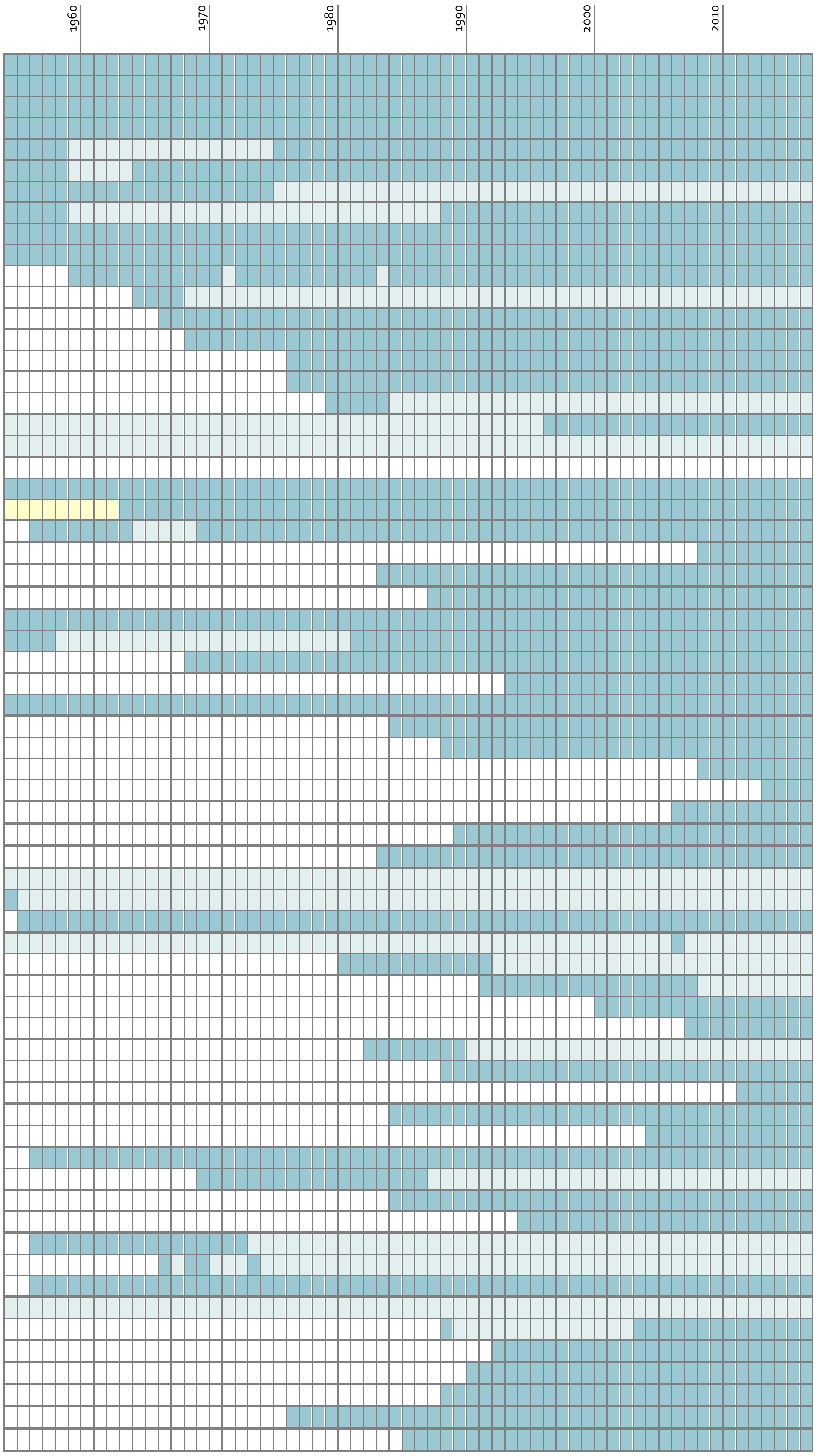
2010

B.3 Overview of Architecture in Antarctica – Country




1960
1970
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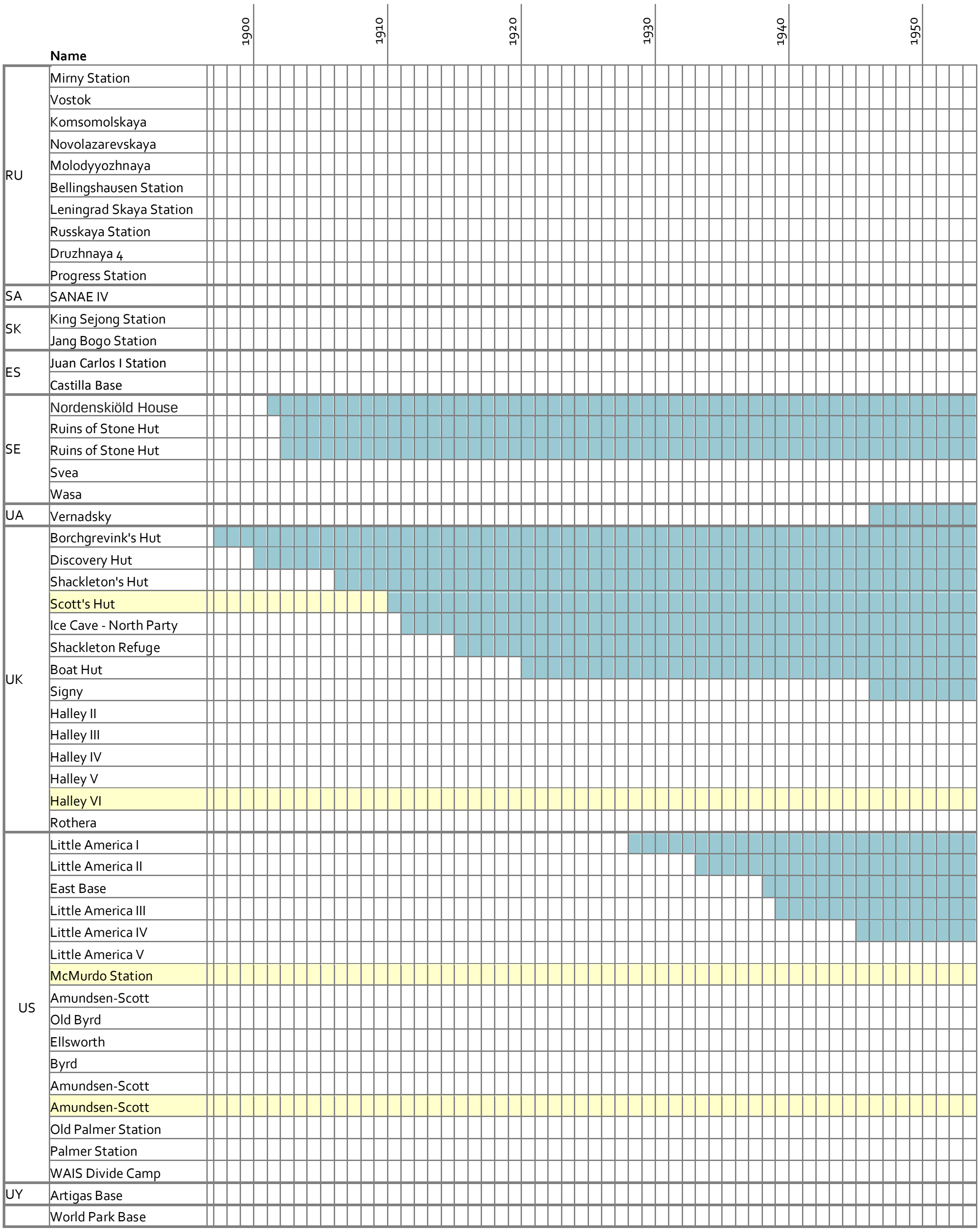

1900
1910
1920
1930
1940
1950
Name
RU
Mirny Station
Vostok
Komsomolskaya
Novolazarevskaya
Molodyyozhnaya
Bellingshausen Station
Leningrad Skaya Station
Russkaya Station
Druzhnaya 4
Progress Station
SA
SANAE IV
SK
King Sejong Station
Jang Bogo Station
ES
Juan Carlos I Station
Castilla Base
SE
Nordenskiöld House
Ruins of Stone Hut
Ruins of Stone Hut
Svea
Wasa
UA
Vernadsky
UK
Borchgrevink's Hut
Discovery Hut
Shackleton's Hut
Scott's Hut
Ice Cave - North Party
Shackleton Refuge
Boat Hut
Signy
Halley II
Halley III
Halley IV
Halley V
Halley VI
Rothera
US
Little America I
Little America II
East Base
Little America III
Little America IV
Little America V
McMurdo Station
Amundsen-Scott
Old Byrd
Ellsworth
Byrd
Amundsen-Scott
Amundsen-Scott
Old Palmer Station
Palmer Station
WAIS Divide Camp
UY
Artigas Base
World Park Base


1960
1970
1980
1990
2000
2010

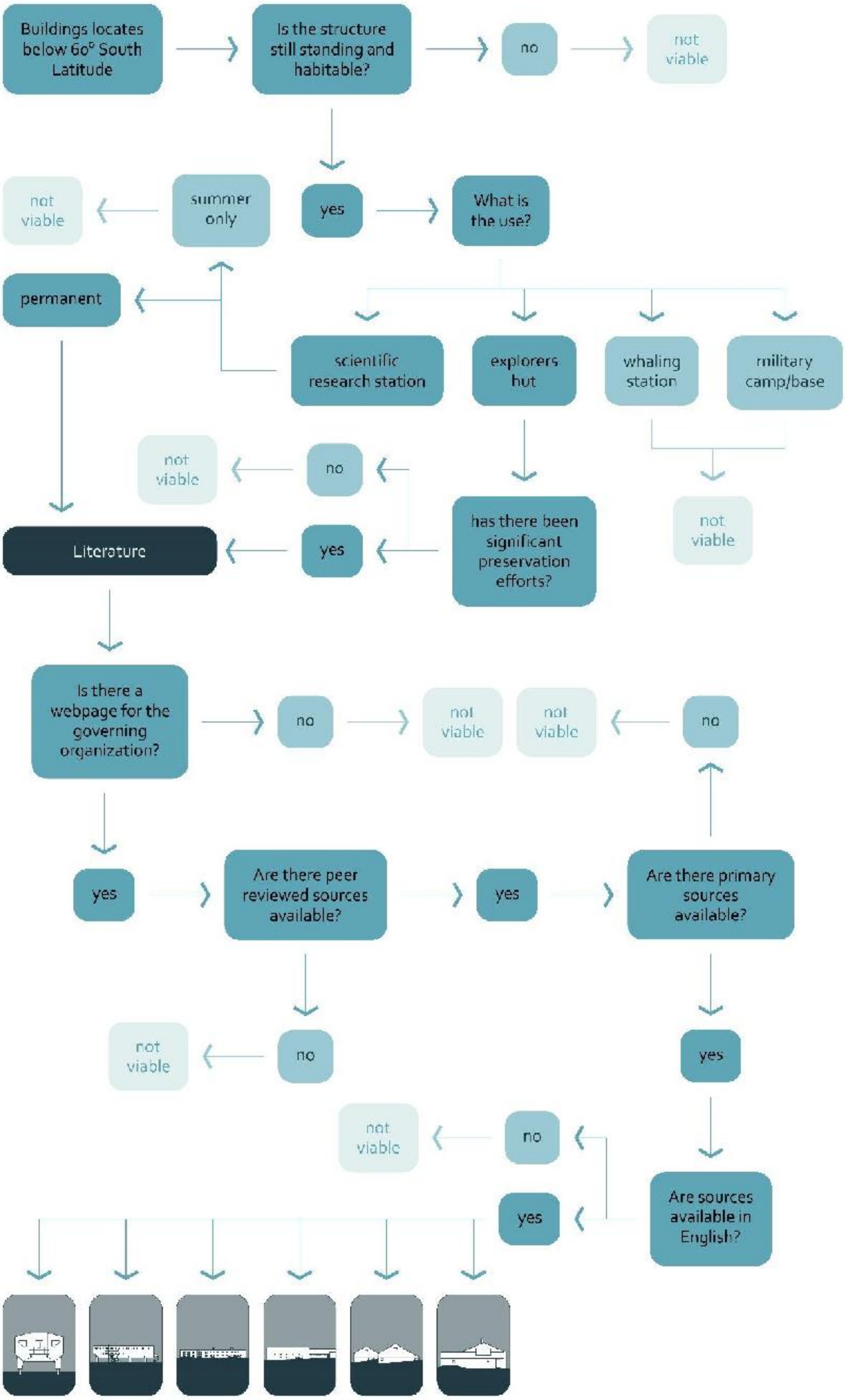
Appendix C – Case Selection

C.1 Case Selection Matrix

				Building Details					Literature Availability					
	Name	Location	Year	Permanent Station	Summer Station	Abandoned/ Demolished Station	Restored Explorers' Hut	Abandoned/ Ruined Explorers' Hut	Station/Foundation Website	Peer Reviewed Sources	Other Sources	Primary Sources	English Sources	Final Station/Hut Selection
AR	Omond House	South Orkney Island	1903											
	Orcadas Base	South Orkney Island	1904											
	Melchior Base	Mechior Islands	1947											
	Deception Base	Deception Island	1948											
	San Martín Base	Barry Island	1951											
	Almirante Brown	Antarctic Penisula	1951											
	Belgrano I Base		1951											
	Cámara Base	Half Moon Island	1952											
	Carlini Base	King George Island	1953											
	Esperanza Base	Hope Bay	1953											
	Matienzo Base	Graham Land	1960											
	Sobral Base	Filcher Ice Shelf	1965											
	Petrel Base	Dundee Island	1967											
	Marambio Base	Seymour-Marambio Island	1969											
	Primavera Base	Graham Land	1977											
	Belgrano II Base	Coats Land	1977											
	Belgrano III Base	Tierra del Fuego	1980											
AU	Mawson's Huts	Commonwealth Bay	1912											
	remote hut	Shackleton Ice Shelf	1912											
	Relay Station	Macquarie Island	1912											
	Mawson Station	Mac Robertson Land	1954											
	Casey Station	Vincennes Bay	1964											
	Davis Station	Princess Elizabeth Land	1957											
BE	Princess Elisabeth	Queen Maud Land	2009											
BR	Comandante Ferraz	King George Island	1984											
BU	St. Kliment Ohridsk	Livingston Island	1988											
CL	Captain Arturo Prat	Greenwich Island	1947											
	González Videla	Waterboat Point	1951											
	Montalva	King George Island	1969											
	Escudero Base	King George Island	1994											
	O'Higgins	Antarctic Penisula	1948											
CN	Great Wall Station	King George Island	1985											
	Zhongshan Station	Larsemann Hills	1989											
	Kunlun Station	Dome A	2009											
	Taishan Station	Princess Elizabeth Land	2014											
CZ	Mendel	James Ross Island	2007											
EC	Maldonado Base	Greenwich Island	1990											
FI	Aboa	Queen Maud Land	1984											
FR	Charcot Expedition	Petermann Island	1909											
	St. Martin		1950											
	Dumont d'Urville	Adelie Land	1956											
DE	Gauss Expedition Hut	Iles Kerguelen	1902											
	Neumayer	Atka Bay	1981											
	Neumayer-Station II	Atka Bay	1992											
	Kohnen Station	Queen Maud Land	2001											
	Neumayer-Station III	Atka Bay	2008											
IN	Dakshin Gangotri	Dakshin Gangotri Glacier	1983											
	Maitri Station	Schirmacher Oasis	1989											
	Bharati	Larsemann Hills	2012											
IT	Mario Zucchelli	Tera Nova Bay, Ross Sea	1985											
	Concordia Station	Dome C	2005											
JP	Syowa Station	East Ongul Island	1957											
	Mizuho	Mizuho Plateau	1970											
	Asuka Station	Queen Maud Land	1985											
	Dome Fuji Station	Queen Maud Land	1995											
NZ	Hallett	Hallett Peninsula	1957											
	Vanda Station	Lake Vanda	1967											
	Scott Base	Ross Island	1957											

	Name	Location	Year	Building Details					Literature Availability					
				Permanent Station	Summer Station	Abandoned/ Demolished Station	Restored Explorers' Hut	Abandoned/ Ruined Explorers' Hut	Station/Foundation Website	Peer Reviewed Sources	Other Sources	Primary Sources	English Sources	Final Station/Hut Selection
NO	Frammheim	Bay of Whales	1911											
	Troll Station	Queen Maud Land	1989											
	Tor Station	Queen Maud Land	1993											
PK	Jinnah	Sor Rendane Mountains	1991											
PE	Machu Picchu Base	Admiralty Bay	1989											
PL	Arctowski	King George Island	1977											
RO	Law-Racovita Station	Larsemann Hills	1986											
RU	Mirny Station	Davis Sea	1956											
	Vostok	Antartic Ice Sheet	1957											
	Komsomolskaya	Queen Mary Land	1957											
	Novolazarevskaya	Queen Maud Land	1961											
	Molodyyozhnaya	Thala Hills	1962											
	Bellingshausen	King George Island	1968											
	Leningrad Skaya	Oates Coast, Victoria Land	1971											
	Russkaya Station	Marie Byrd Land	1980											
	Druzhnaya 4	Princess Elizabeth Land	1987											
	Progress Station	Pryzdz Bay	1988											
SA	SANAE IV	Vesleskarvet	1997											
SK	King Sejong Station	King George Island	1988											
	Jang Bogo Station	Terra Nova Bay	2014											
ES	Juan Carlos I	South Bay	1988											
	Gabriel de Castilla	Deception Island	1990											
SE	Nordenskiöld House	Snow Hill Island	1902											
	Ruins of Stone Hut	Paulet Island	1903											
	Ruins of Stone Hut	Hope Bay	1903											
	Svea	Queen Maud Land	1988											
	Wasa	Queen Maud Land	1990											
UA	Vernadsky	Galindez Island	1947											
UK	Borchgrevink's Hut	Cape Adare	1898											
	Discovery Hut	Hut Point, Ross Island	1901											
	Shackleton's Hut	Cape Royds	1907											
	Scott's Hut	Cape Evans	1911											
	Ice Cave - North party	Inexpressible Island	1912											
	Shackleton Refuge	Elephant Island	1916											
	Boat Hut	Waterboat Point	1921											
	Signy	Signy Island	1947											
	Halley II	Brunt Ice Shelf	1967											
	Halley III	Brunt Ice Shelf	1973											
	Halley IV	Brunt Ice Shelf	1983											
	Halley V	Brunt Ice Shelf	1989											
	Halley VI	Brunt Ice Shelf	2012											
	Rothera	Adelaide Island	1975											
US	Little America I	Ross Ice Shelf	1929											
	Little America II	Ross Ice Shelf	1934											
	East Base	Stonington Island	1939											
	Little America III	Ross Ice Shelf	1940											
	Little America IV	Ross Ice Shelf	1946											
	Little America V	Ross Ice Shelf	1956											
	McMurdo Station	Ross Island	1956											
	Amundsen-Scott	Geographic South Pole	1956											
	Old Byrd	Marie Byrd Land	1957											
	Ellsworth	Tierra del Fuego	1957											
	Byrd	Marie Byrd Land	1960											
	Amundsen-Scott	Geographic South Pole	1975											
	Amundsen-Scott	Geographic South Pole	2003											
	Old Palmer Station	Anvers Island	1965											
	Palmer Station	Anvers Island	1968											
	WAIS Divide Camp	West Antarctic Ice Sheet	2005											
UY	Artigas Base	King George Island	1984											
	World Park Base	Cape Evans	1987											

C.2 Case Selection Flow Chart



Appendix D - Ethics

D.1 Interview Questionnaire

Name:

Firm:

Project Name:

Project Location:

Date of Project Completion

Why were you interested in working on this project?

What was the initial design brief?

What was asked for in the program? Did this change? Why?

If you conducted a precedent study at the beginning of the project what precedents did you use?

What was your general design approach for the project?

Please describe the overall design of the building:

Are there any cultural considerations taken for the inhabitants and their country of origin?

How was the climate taken into consideration?

Beyond climatic issues, what aspects tie this building to Antarctica?

Was sustainability a priority? If so, how was it incorporated?

Is there something creative or playful you were able to incorporate into the project?

Please supply the following information:

What materials were used in the follow elements of the building:

Element	**Material**	**Finish**
Structure		
Exterior Cladding		
Interior Wall Coverings		
Flooring		
Ceiling		
Built-ins/Cabinetry		
Furnishings		
Trim		

Please describe how/if the following attributes were used in the building:

Attribute		**How?**
Water – aesthetically	yes / no	
Water – utilitarian	yes / no	
Lighting – Artificial	yes / no	
Lighting – Natural	yes / no	
Lighting – Control (for artificial)	yes / no	
Lighting – Control (for natural)	yes / no	
Ventilation – Artificial	yes / no	
Ventilation – Natural	yes / no	
Heating System	yes / no	
Passive Heating	yes / no	

When designing the building was any of the following taken into consideration?

Item		**How?**
Natural Materials	yes / no	
Local Natural Attributes	yes / no	
Aging of Materials	yes / no	
Diurnal cycles	yes / no	
Surrounding Landscape	yes / no	
Views/Vistas	yes / no	
Overall geometry/grid pattern	yes / no	

Are you familiar with Biophilic Design or *biophilia?*

Is there anything additional you would like to say about this project?

If possible, can you provide floor plans, sections, elevations, renderings, or photographs?

Appendix E – Overview cross-referencing Biophilic Design and Antarctica

E.1 Potential Biophilic Characteristics Available at Cases

	Scott's Hut	Mawson's Huts	McMurdo	Casey	Amundsen-Scott	Halley VI
Light	Average Daily Sun: Summer - 20:09 hrs Fall - 1:41 hrs Winter - 4:08 hrs Spring - 22:24 hrs 24hr sun - 119 days 24hr night - 116 days	Average Daily Sun: Summer – 17:12 hrs Fall – 5:28 hrs Winter – 7:34 hrs Spring – 19:32 hrs 24hr sun - 37 days 24hr night - 0 days	Average Daily Sun: Summer - 20:09 hrs Fall - 1:41 hrs Winter - 4:08 hrs Spring - 22:24 hrs 24hr sun - 119 days 24hr night - 116 days	Average Daily Sun: Summer - 16:45 hrs Fall - 5:51 hrs Winter - 7:50 hrs Spring - 19:15 hrs 24hr sun - 24 days 24hr night - 0 days	Average Daily Sun: Summer - 21:40 hrs Fall - 0:00 hrs Winter - 2:40 hrs Spring - 24:00 hrs 24hr sun - 183 days 24hr night - 182 days	Average Daily Sun: Summer - 20:03 hrs Fall - 2:31 hrs Winter - 5:14 hrs Spring - 22:19 hrs 24hr sun - 107 days 24hr night - 102 days
Air	average summer temperature: -10°C average winter temperature: -25°C	average summer temperature: -6°C average winter temperature: -17°C	average summer temperature: -10°C average winter temperature: -25°C	average summer temperature: -3°C average winter temperature: -15°C	average summer temperature: -21°C average winter temperature: -63°C	average summer temperature: -10°C average winter temperature: -28°C
Water	liquid - Ross Sea solid - snow and ice	liquid - Commonwealth Bay, South Ocean solid - snow and ice	liquid - Ross Sea solid - snow and ice	liquid - South Ocean solid - snow and ice	solid - snow and ice	solid - snow and ice
Plants	algae, cyanobacteria, lichens, mosses	lichen	algae, cyanobacteria, lichens, mosses	mosses, liverworts, lichens, terrestrial and snow algae	- - -	- - -
Animals	Magellanic penguins, chinstrap penguins, Adelie penguins, gentoo penguins, king penguins, crabeater seal, fur seal, Weddell seal, right whale, humpback whale, skua	Adelie penguins, snow petrel, Wilsons storm petrels, south polar skuas, Weddell seals	Magellanic penguins, chinstrap penguins, Adelie penguins, gentoo penguins, king penguins, crabeater seal, fur seal, Weddell seal, right whale, humpback whale, skua	Adelie penguins, emperor penguins, elephant seals, leopard seals, Weddell seals, giant petrels, skuas, snow petrels	- - -	emperor penguins, snow petrels, giant petrels, diving petrels, storm petrels, white-chinned petrels, south polar skua, Weddell seals, minke whales, orcas

Landscape	Coastal - foothills, open water, exposed rock, glaciers	Coastal - low hills, open water, exposed rock, glaciers	Coastal - foothills, open water, exposed rock, glaciers	Coastal - low hills, open water, exposed rock, glaciers	Continent - ice/snow sheet	Ice Shelf - ice/snow sheet
Weather	Cold Desert - extreme cold, windy, low humidity, little precipitation	Cold Desert - extreme cold, windy, low humidity, little precipitation	Cold Desert - extreme cold, windy, low humidity, little precipitation	Cold Desert - extreme cold, windy, low humidity, little precipitation	Cold Desert - extreme cold, windy, low humidity, little precipitation	Cold Desert - extreme cold, windy, low humidity, little precipitation
Views	Mount Erebus and foothills, McMurdo Sound (open water and frozen ice)	Low hills on Cape Denison, Commonwealth bay (open water and frozen ice)	Mount Erebus and foothills, McMurdo Sound (open water and frozen ice)	Vincennes Bay (open water, frozen ice), the old Wilkes Base	expanse of the Antarctic plane	views of the expanse of the ice shelf
Fire	Mount Erebus is an active volcano	- - -	Mount Erebus is an active volcano	- - -	- - -	- - -
Images	Limited photographs, artwork, or imagery from previous expeditions near Ross Island.	- - -	Photographs, artwork, and imagery of Ross Island plentiful from previous expeditions and stations.	Photographs from previous exploratory expeditions.	Early photographs from Amundsen and Scott's race to the pole. Additional photographs, artwork, and imagery from IGY occupation.	Photographs, artwork, and imagery from IGY occupations.
Materials	Snow, Ice, & Rock	Snow, Ice, & Rock	Snow, Ice, & Rock	Snow, Ice, & Rock	Snow & Ice	Snow & Ice

	Scott's Hut	Mawson's Huts	McMurdo	Casey	Amundsen-Scott	Halley VI
Texture	*tangible* - ice, snow, water, large & small rocks, penguins, seals, wind *visual* - ", aurora australis, solar phenomena *taste* - saltwater, freshwater (snowmelt), penguin, seal *auditory* - native wildlife, ice on water, wind *smell* - ocean, penguins, seals,	*tangible* - ice, snow, water, large & small rocks, penguins, seals, wind *visual* - ", aurora australis, solar phenomena *taste* - saltwater, freshwater (snowmelt), penguin, seal *auditory* - native wildlife, ice on water, wind *smell* - ocean, penguins, seals,	*tangible* - ice, snow, water, large & small rocks, penguins, seals, wind *visual* - ", aurora australis, solar phenomena *taste* - saltwater, freshwater (snowmelt) *auditory* - native wildlife, ice on water, wind *smell* - ocean, penguins, seals, snow/cold	*tangible* - ice, snow, water, large & small rocks, penguins, seals, wind *visual* - ", aurora australis, solar phenomena *taste* - saltwater, freshwater (snowmelt) *auditory* - native wildlife, ice on water, wind *smell* - ocean, penguins, seals, snow/cold	*tangible* - ice, snow, wind *visual* - ", aurora australis, solar phenomena *taste* - freshwater (snowmelt) *auditory* - wind *smell* - snow/cold	*tangible* - ice, snow, penguins, wind *visual* - ", aurora australis, solar phenomena *taste* - freshwater (snowmelt) *auditory* - native wildlife, wind *smell* - penguins, snow/cold
Colour	white - snow, ice blue - snow/ice at night, sky, ocean browns - geological conditions pinks/greens - aurora australis warm tones - sunset/sunrise yellows - sun conditions rainbows - solar refraction in ice crystals	white - snow, ice blue - snow/ice at night, sky, ocean browns - geological conditions pinks/greens - aurora australis warm tones - sunset/sunrise yellows - sun conditions rainbows - solar refraction in ice crystals	white - snow, ice blue - snow/ice at night, sky, ocean browns - geological conditions pinks/greens - aurora australis warm tones - sunset/sunrise yellows - sun conditions rainbows - solar refraction in ice crystals	white - snow, ice blue - snow/ice at night, sky, ocean browns - geological conditions pinks/greens - aurora australis warm tones - sunset/sunrise yellows - sun conditions rainbows - solar refraction in ice crystal	white - snow, ice blue - snow/ice at night, sky pinks/greens - aurora australis warm tones - sunset/sunrise yellows - sun conditions rainbows - solar refraction in ice crystals	white - snow, ice blue - snow/ice at night, sky, ocean pinks/greens - aurora australis warm tones - sunset/sunrise yellows - sun conditions rainbows - solar refraction in ice crystals

Shapes & Forms	crystalline structures, organic forms derived from flora & fauna and snow shaped by wind	crystalline structures, organic forms derived from flora & fauna and snow shaped by wind	crystalline structures, organic forms derived from flora & fauna and snow shaped by wind	crystalline structures, organic forms derived from flora & fauna and snow shaped by wind	crystalline structures, organic forms from snow shaped by wind	crystalline structures, organic forms derived from fauna and snow shaped by wind
Information Richness	variety of materials, textures, colours, plants, animals, and landscape from which to draw	variety of materials, textures, colours, plants, animals, and landscape from which to draw	variety of materials, textures, colours, plants, animals, and landscape from which to draw	variety of materials, textures, colours, plants, animals, and landscape from which to draw	minimal - flat continental plateau variety comes from sun/moon conditions	variety of materials, textures, colours, and animals from which to draw
Change, Age, Patina of Time	wear from wind, corrosion from ocean salt, freeze/thaw cycle, drifting snow	wear from wind, corrosion from ocean salt, freeze/thaw cycle, drifting snow	wear from wind, corrosion from ocean salt, freeze/thaw cycle, drifting snow	wear from wind, corrosion from ocean salt, freeze/thaw cycle, drifting snow	wear from wind, drifting snow	wear from wind, freeze/thaw cycle, drifting snow
Natural Geometries	fractals - ice crystals golden ratio - plant growth, shells, animals	fractals - ice crystals golden ratio - plant growth, shells, animals	fractals - ice crystals golden ratio - plant growth, shells, animals	fractals - ice crystals golden ratio - plant growth, shells, animals	fractals - ice crystals	fractals - ice crystals golden ratio - animals
Simulated Natural Light & Air	- - -	- - -	- - -	- - -	- - -	- - -
Biomimicry	how life has survived in the extreme environment, changes in the ecosystem based on conditions	how life has survived in the extreme environment, changes in the ecosystem based on conditions	how life has survived in the extreme environment, changes in the ecosystem based on conditions	how life has survived in the extreme environment, changes in the ecosystem based on conditions	changes in the ecosystem based on conditions	how life has survived in the extreme environment, changes in the ecosystem based on conditions

	Scott's Hut	Mawson's Huts	McMurdo	Casey	Amundsen-Scott	Halley VI
Prospect and Refuge	Mount Erebus, foothills, ice caves, view of sea - mode of transportation	short hills, rocky outcroppings, view of sea - mode of transportation	Mount Erebus, foothills, ice caves, view of sea - mode of transportation	low hills along coast, view of sea - mode of transportation	- - -	- - -
Organized Complexity	snow, ice, rock, water, flora, fauna	snow, ice, rock, water, flora, fauna	snow, ice, rock, water, flora, fauna	snow, ice, rock, water, flora, fauna	snow, ice	snow, ice, water, fauna
Mobility	wind blowing objects penguins - shuffling/hopping/swimming/flying through water skuas/petrels - flying/hopping seals - swimming/galumphing whales - swimming orcas - swimming	wind blowing objects penguins - shuffling/hopping/swimming/flying through water skuas/petrels - flying/hopping	wind blowing objects penguins - shuffling/hopping/swimming/flying through water, skuas/petrels - flying/hopping seals - swimming/galumphing whales - swimming orcas - swimming	wind blowing objects penguins - shuffling/hopping/swimming/flying through water skuas/petrels - flying/hopping seals - swimming/ galumphing	wind blowing objects	wind blowing objects penguins - shuffling/hopping/swimming/flying through water skuas/petrels - flying/hopping seals - swimming/galumphing whales - swimming orcas - swimming
Transitional Spaces	- - -	- - -	- - -	- - -	- - -	- - -
Place	*Geographical* - extreme cold temperatures, high winds, excessive periods of light and dark, limited flora and fauna	*Geographical* - extreme cold, southern hurricane-force winds from, excessive periods of light & dark, limited flora and fauna	*Geographical* - extreme cold temperatures, high winds, excessive periods of light and dark, limited flora and fauna	*Geographical* - extreme cold temperatures, high winds, excessive periods of light and dark, limited flora and fauna	*Geographical* - extreme cold temperatures, high winds, excessive periods of light and dark, remoteness, geographic south pole	*Geographical* - extreme cold temperatures, high winds, prolonged periods of light and dark

Place (cont.)	*Ecological* - Mt. Erebus, lower surrounding hills, McMurdo Sound, Ross Sea *Cultural* - towards the end of the height of Edwardian polar expeditions *Historical* - two previous expeditions in the area	*Ecological* - lower surrounding hills, Commonwealth Bay *Cultural* - towards the end of the height of Edwardian polar expeditions *Historical* - no previous expeditions made landfall in the area	*Ecological* - Mt. Erebus, lower surrounding hills, McMurdo Sound, Ross Sea *Cultural* - developed as part of the International Geophysical Year *Historical* - three sites from the Historic Age of Exploration located in the area	*Ecological* - *Cultural* - developed as part of the International Geophysical Year *Historical* - no previous expeditions made landfall in the area, three stations have been constructed	*Ecological* - antarctic continental plateau *Cultural* - remoteness, current iteration part of the International Polar Year IV *Historical* - developed as part of the IGY, location for the finish of the race to the South Pole	*Ecological* - living on an ice shelf *Cultural* - current iteration part of the International Polar Year IV *Historical* - developed as part of the IGY, previous five stations inhabited the same location
Integrating Parts to Create Wholes	- - -	- - -	- - -	- - -	- - -	- - -

E.2 Biophilic Aspects Integrated in Cases

	Scott's Hut	Mawson's Huts	McMurdo	Casey	Amundsen-Scott	Halley VI
Light	widnows	skylights	windows, skylights, diy shading *bedroom without windows	windows, clerestory	windows, shades *bedrooms without windows	windows, skylight, shades, translucent glass
Air	chimney effect, ventilation	drafts	operable windows, leaky windows, ventilation	decks, ventilation	ventilation	ventilation
Water	snow, ice, open sea - generation through ice melt	snow, ice, open sea - generation through ice melt spring thaw	snow, ice, open sea - desalinization of sea water	snow, ice, open sea - generation through ice melt, spring thaw, sea salt spray	snow, ice - generation through melt, snow well	snow, ice - Generation through melt tanks
Plants	- - -	- - -	separate greenhouse accessible during winter months	planned planters in lounge, hydroponics facility	food growth chamber	hydroponic greenhouse (not built)
Animals	Ponies, donkeys, dogs, endemic biological samples	Greenland dogs, endemic biological samples	not currently permitted	not currently permitted	not currently permitted	not currently permitted
Landscapes	Open water access, mountain/hill shelter, natural scientific observation availability	Open water access, Antarctic continental plateau, rocky shoreline, natural scientific observation availability	open water access, ability to host an airstrip	melt lake, rocky outcropping, variety of plant and animal life, edge of Antarctic Circle	continental plateau - flat, drifting snow	ice shelf - effective for scientific observations; oceanic, atmospheric, extreme environment

Weather	sound	sound	windows, views, operable windows, multiple buildings	windows, clerestory, views, multiple buildings	building envelope, windows, decks	Pod form, windows, skylight, ,decks
Views	- - -	- - -	windows, common spaces, prospect/refuge - views towards transportation	windows, common spaces, prospect/refuge - views towards transportation	windows, observation deck, prospect/refuge, towards transportation	windows, cockpit rooflights, decks, prospect/refuge, towards transportation
Fire	Heating and artificial light through flame	Heating and artificial light through flame, St. Elmo’ s Fire	- - -	planned fireplace - not built	- - -	cedar veneer evoke a feeling of fire or warmth
Images	Personal effects, supply labels, lecturer series presentations	Personal effects, supply labels	artwork by artists in residence, inhabitant's artwork, research antarctic landscape panoramas, personal images	relating to relevant scientific research, some natural Australian imagry	Antarctic imagry in corridor, personal effects	personal effects, history corridor
Materials	endemic - none imported - natural wood, animal skins	endemic - snow imported - natural wood, animal skins	endemic - none imported - durable, synthetic, some wood	endemic - none imported - durable materials and wood highlights	endemic - none imported - durable, synthetic, some wood	endemic - none imported - durable materials, natural wood
Texture	Vertical/horizontal application of building materials, scale, size, touch	Vertical/horizontal application of building materials, scale, size, touch	durable	durable	durable, varied wall surfaces, different materials - indicating zones, sizes, colours	durable, varied, smooth wall surfaces, different materials - indicating zones, size, shapes, colours

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Colour	Natural browns – wood and furs, dark/black – metal objects, darkroom walls Additional colours – supply/material packaging and labels	Natural browns – wood and furs, dark/black – metal objects, darkroom walls Additional colours – supply/material packaging and labels	neutral, augmented by personal customization with images, exterior blue	exterior - red, shift to bright interiors, augmented by personal customization with images	exterior - dark grey interior - bright primary in public areas, darker floors, bright/light in areas without windows	exterior - red & blue interior - blue floors, light bright walls, light ceilings
Shapes & Forms	simple, rectilinear - due to building skills	simple, rectilinear - due to building skills	modular rectilinear - ease of construction and transport	modular rectilinear, 90°, 45° - ease of construction and transport	rectilinear, aerodynamic, external curved elements, curves in circulation	octagonal pod forms; 90°, angles, curves in circulation
Information Richness	wooden building fabric, wooden furniture, metal appliances, various equipment, supplies, sounds	wooden building fabric, wooden furniture, metal appliances, various equipment, supplies, sounds	personal ornamentation layered ontop of uniform base fabric	change in material, texture, ceiling height, floor level, angles	colour, texture, materials, shapes & forms, natural geometry	colour, texture, materials, shapes & forms, natural geometry
Change, Age, Patina of Time	patina - blackening from burning seal blubber change/age - weathering of wood from conditions	change/age - weathering of wood from wind conditions death - eventual destruction from elements	change/age - weathering from wind, ice, freeze/thaw cycle inevitable death of building	change/age - weathering from wind, ice, freeze/thaw cycle, corrosion from sea spray inevitable death of	change - hydrolics inevitable death of building	change - hydrolics, skiis inevitable death of building
Natural Geometries	- - -	- - -	- - -	- - -	- - -	- - -

Simulated Natural Light & Air	provide light & tempered air - not simulated	provide light & tempered air - not simulated	overhead & task lighting, inadequate ventilations, heated air, not simulated	artificial lighting & ventilation, air temperature, not simulated	artificial light, minimal isolated ventilation, not simulated	artificial lights, ventilation, air temperature, simulated sun lamps
Biomimicry	- - -	- - -	- - -	- - -	- - -	- - -
Prospect and Refuge	shelter building : zones : bunks	shelter building : rooms : zones : bunks	shelter, line of sight, views station : building : zones : rooms : bunks	shelter, line of sight, views station : building : zones : rooms	shelter, line of sight, views, decks building/station : zones : rooms	shelter, line of sight, views, decks station : building/pod : zones : rooms : bunks
Organized Complexity	- - -	- - -	- - -	- - -	- - -	- - -
Mobility	interior paths, entry, doorways	interior paths, entry, doorways, snow tunnels	exterior - paths interior - entries, doors, stairs, corridors	exterior - paths interior - entries, doors, stairs, corridors	interior - doorways, stairs, entries, corridors	interior - doorways, stairs, entries, corridor external - pods on skiis to relocate station
Transitional Spaces	entry "lobby" space, cold porch	entry "lobby" space, cold porch	corridors, entry "lobby" - vestibule	corridors, entry "lobby" - cold porch	corridors, entry "lobby" - vestibule	corridors, entry "lobby" - vestibule
Place	Geographical - attuned to weather conditions, learned from previous expeditions, scientific ties to plants, animals, weather Ecological - science, access to water, access to continent	Geographical - attuned to weather conditions, learned from previous expeditions, scientific ties to plants, animals, weather Ecological - science, access to water, access to new terriroty	Geographical - close to water and air transport, scientific ties to flora, fauna, weather Ecological - access to broad spectrum Antarctic ecology, water access, landscape	Geographical - rocky outcroppings, prevailing winds, drifting snows , scientific ties to flora, fauna, weather Ecological - edge of the antarctic circle, water access, landscape	Geographical - wind orientation, drifting snow, scientific ties to weather Ecological - jack-able for drifting snow, science	Geographical - orientation selected to react to the winds and drifting snow, scientific ties to animals and weather Ecological - transitory to react to the moving substrate science

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Place (cont.)	Cultural - shared Antarctic values, communal culture formed through close quarters Historical - adding to the Polar exploration narrative	Cultural - shared Antarctic values, communal culture formed through close quarters Historical - adding to the Polar exploration narrative	Cultural - significant population creating "frontier town", shared Antarctic values Historical - HAE, IGY+, science available, role in the IGY	Cultural - scientific community, shared Antarctic values Historical - Wilkes Station/REPSTAT, IGY+, science available	Cultural - location at the Geographic South Pole, Sovereignty, shared Antarctic values Historical - race for the South Pole (Amundsen & Scott), role in the IGY	Cultural - identity as an 'ice station', shared Antarctic Values Historical - connection to previous 5 stations, continuity of scientific work
Integrating Parts to Create Wholes	disconnected from intentional integration of building to nature	disconnected from intentional integration of building to nature	disconnected from intentional integration of building to nature	disconnected from intentional integration of building to nature	disconnected from intentional integration of building to nature	disconnected from intentional integration of building to nature