

**ADAPTABLE ARCHITECTURE FOR A CHANGING COASTAL
ENVIRONMENT**

by

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ABSTRACT

Coastal erosion, population decline, and economic deterioration, in the rural coastal community of Sydney Mines, Cape Breton, are concerns upon which the provincial government is focused. This thesis explores how ideas of permanence, adaptation, and sacrifice can engage the prevailing erosion of both the coastline and community, in terms of the physical cliff face, population, and economy. Articulating methods of responding to the various conditions of erosion enables an evolving and didactic architecture, which can become a catalyst to stimulate the economy and create stability for the town. Strategies of site placement, as well as technologies of geological formation, historic mining practices, and adaptation approaches, explored in this thesis, provide examples of how prototypical architecture and programmatic insertions can create a viable solution to erosion in this coastal town.

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Acknowledgements go out to my family and friends for their continuous encouragement, love, and support over the past seven and a half years of my architectural education. I am particularly indebted to my parents for their unending assistance, patience, and understanding. Thank you Mom and Dad because, without you, this process could not have been accomplished.

CHAPTER 1: INTRODUCTION

Sydney Mines, aptly named for its rich mining culture, is abundant with histories. Some histories evolved from how geological processes formed multiple layers of loosely compressed sedimentary deposits susceptible to environmental erosion and rich with coal. Others have grown from how the Sydney Coal Field is abundant with snaking coal seams throughout the area, providing indigenous energy, economy, and a way of life for many communities. Still other histories have emerged from how the removal of mining and industry has left the area in economic deterioration and population depletion.

This range of histories describes two areas of erosion threatening Sydney Mines that incorporate the environmental and socio-economic domains. Due to factors including climate change and industry loss, erosion is accelerating, putting towns at risk of becoming neglected places that are poorly populated. Without an innovative and adaptable approach to design and programme, the coastal area of Sydney Mines will face an extensive loss of habitable coastline in the future, as well as a significant socio-economic decline.

It is the belief of this author that the investment in Architecture and its programmatic components can help draw attention to coastal erosion to give secure solutions and economic stability. Where once stood dominating industrial infrastructure, now remains a scarred and forgotten landscape, slowly being eroded into the ocean. While considering the future of these erosion-worn mining sites, one must reflect upon the past, including the history of place, the role mining played in the creation of the community through infrastructure and planning rationale, and the geological importance, expressed by the energy that lay beneath the soil.

Socio-Economic Context

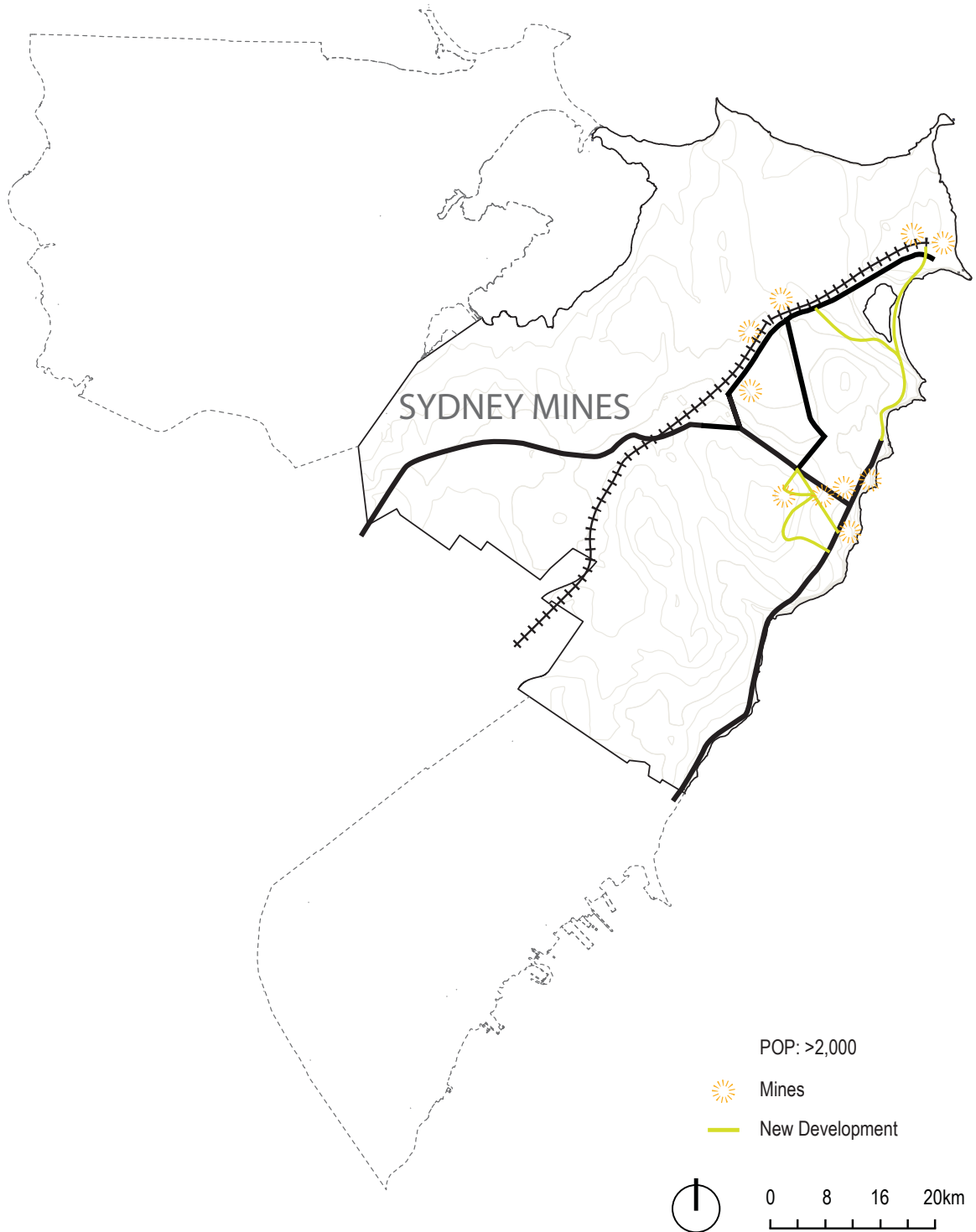
Sydney Mines: Settlement, Growth, and Loss

The town of Sydney Mines is positioned in the north-eastern reaches of Cape Breton at the entrance to Sydney Harbour on the Atlantic Ocean. It neighbours the transportation hub of North Sydney with its international harbour and ferry terminal to Newfoundland. It has a current amalgamated population of 14,135 people, and its developed land area measures twenty-six square kilometres, having a density of 528.4 inhabitants per square kilometre.

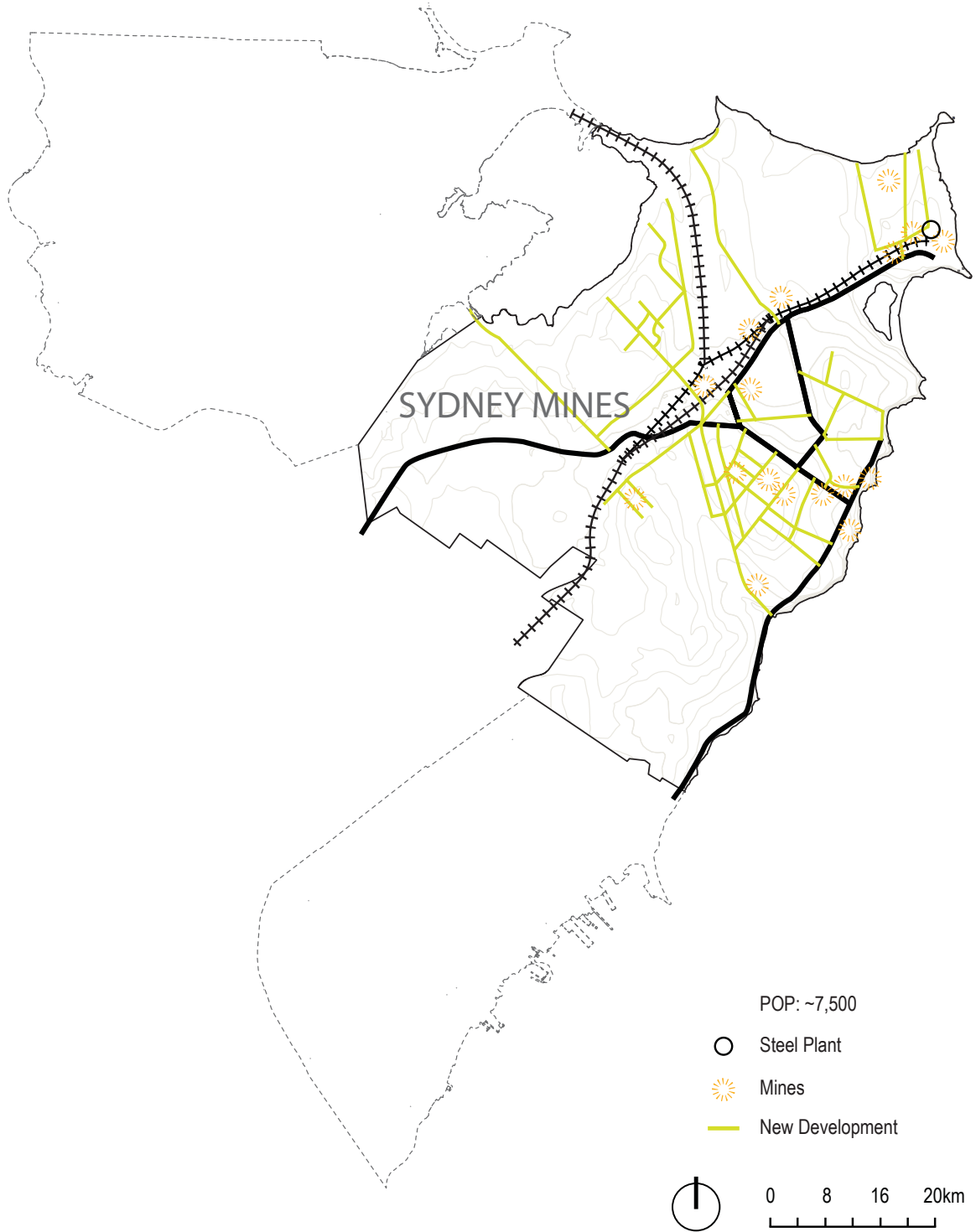
Sydney Mines was first settled when coal was discovered and colonization was encouraged by Lieutenant Governor J.F.W. DesBarres. By 1854, several new mines were opened, including Jacob and Queen Pit, which indicated the positive potential future of the town. Infrastructural necessities, such as sewer, water, electricity, and paved streets were established when the steel plant was opened, in 1902, connecting much of the town to the mines. By 1931, population reached a peak of 9,100 people, the highest recorded census number achieved, due to industry success. The town was booming, with many businesses opening, including a bank, retail stores, and a hotel, as well as a church. The closure of Princess Colliery, in 1975, marked an end to coal mining in the area, and brought about the gradual socio-economic decline of Sydney Mines.

In 1995, Cape Breton Regional Municipality was formed, which established fewer municipal centres in Cape Breton. The historic Sydney Mines was dissolved, amalgamated with the surrounding towns of North Sydney and Florence, and new boundaries drawn. This effectively more than doubled the town's population and area. The population and subsequent services are diminishing due to the deflated economy and social structure.

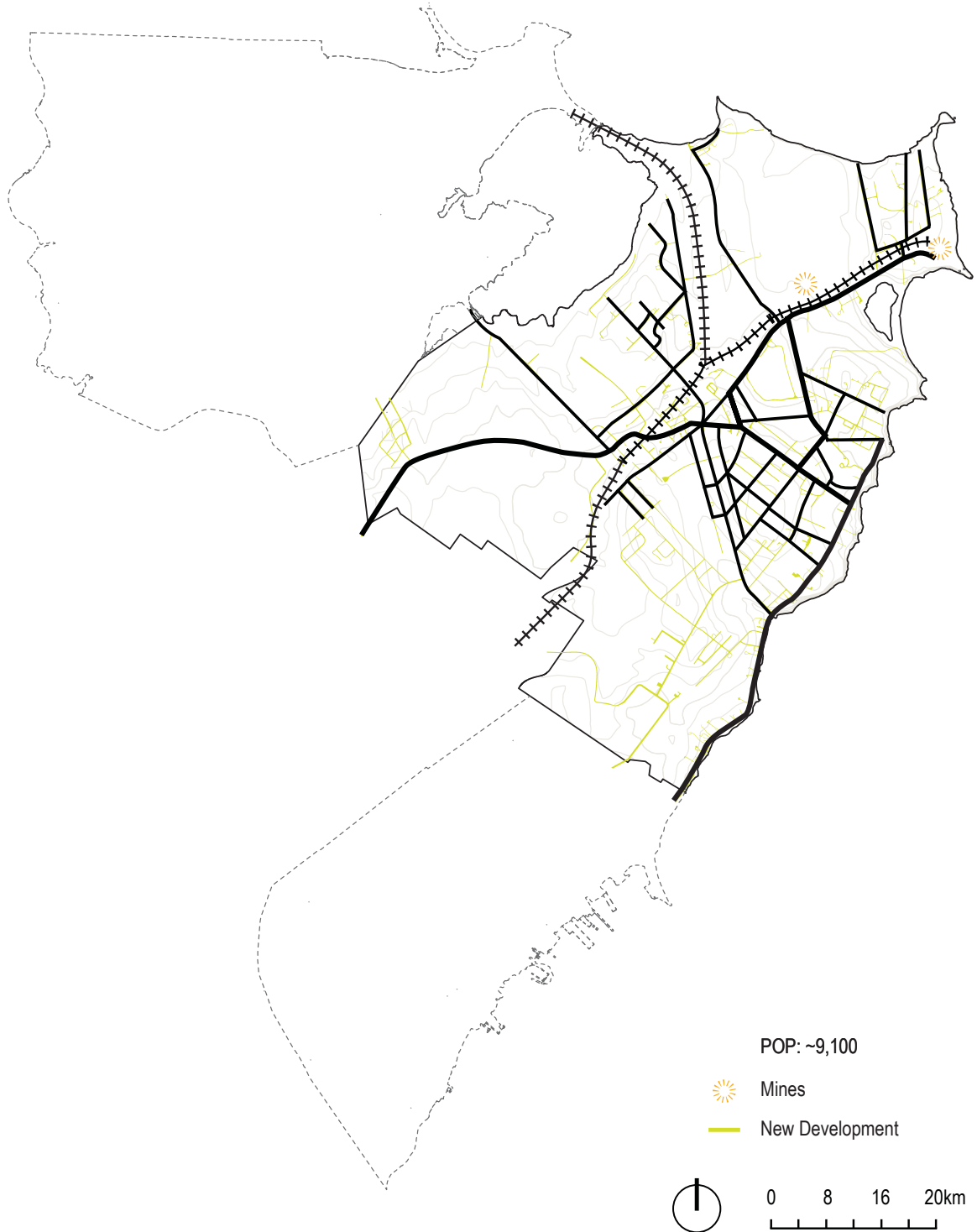
Mining defined the development and settlement patterns of Sydney Mines. Infrastructure catered to the development of the mining network with roads and tracks to connect the industry to the harbour. Pocket settlement occurred, with worker housing appearing in radial patterns around the mines and along the major routes connecting the mines. Growth was contained due to the bordering cliffs defining Sydney Harbour to the north and east. A range in economic status within the town resulted in a variety of building styles from pre-fabricated trailer homes, to wealthy mine-owner homes, to standard subdivision style homes. Today, the town is bounded by ocean cliffs to the east and north, industrial development to the south, and Big Pond to the west. Mining properties, scarred and in remediation processes, dot the town and, coupled with erosion, provide a unique scenario for development along the cliffs. With the loss of industry, homes are being abandoned rather than developed as the population declines.



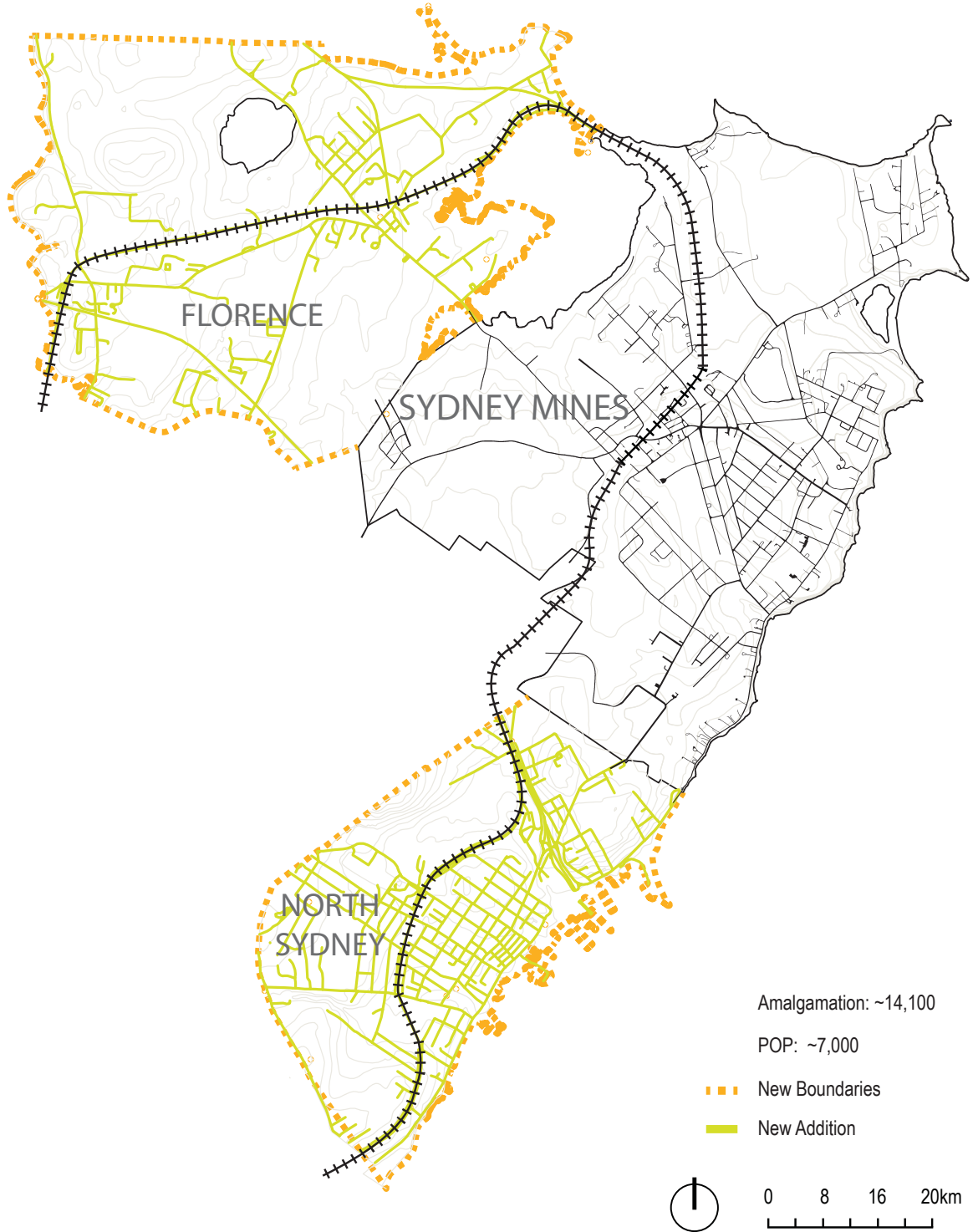
Settlement and Growth of Sydney Mines in 1864. Few roads and train tracks connected mines to one another and North Sydney shipyard, data from the Department of Energy, Mines, and Resources.



Settlement and Growth of Sydney Mines in 1914. Steel Plant opened in 1902 at Princess Colliery. New roads provide access to worker housing. Train tracks added to Florence, data from the Department of Energy, Mines, and Resources.



Settlement and Growth of Sydney Mines in 1964. Only one mine opened, Princess Colliery, and the coal washing plant. Population beginning to decrease from highest recorded populus in the 1930s, data from the Department of Energy, Mines, and Resources.



Settlement and Growth of Sydney Mines in 2014. No operating coal mines in the area. Sydney Mines was amalgamated with North Sydney and Florence in 1995, data from Google maps.

Mining and Energy: Industry in Sydney Mines

The Sydney Coal Field, for nearly three-hundred and fifty years, was the pillar of coal mining operations, supporting industrial Cape Breton and many Islanders, their families, and communities during this time. Coal operations began in 1672, when a French explorer and prospector, Nicholas Denys, identified Cape Breton's immense coal deposits. It wasn't until 1720, however, that coal mining began to fuel the imperial fortress at Louisbourg on the south-east coast of Cape Breton Island. Decades later, in 1766, coal harvesting began in Sydney Mines by using iron bars to pry coal from the exposed coal seams along the cliffs between Swivel and Cranberry Point.¹

Mining began in Sydney Mines, in 1784, and a wharf was constructed for coal shipment in North Sydney, and the Mines (Sydney Mines) was founded. At this time, roads were trails, housing was primitive, and profits were slight.

In 1820, forty-two men were employed in mining. From then onwards, mining operations flourished throughout north-eastern Cape Breton, and subsequently, the mining towns grew. Over the life of mining in the Sydney Coal Field, over one-hundred mines were in operation, from Florence to Port Morien, more than any other field in Nova Scotia.² Sydney Mines produced seventeen percent of the coal mined in the area, the third largest producer on the Sydney Coal Field.³ The rich coal deposits supported the quick advancement of the Industrial Revolution through colonial Great Britain, and provided energy for many other industries, which developed locally, including steel.

1 Hugh Fletcher, *Descriptive Note on the Sydney Coal Field* (Ottawa: S.E. Dawson, 1900), 3.

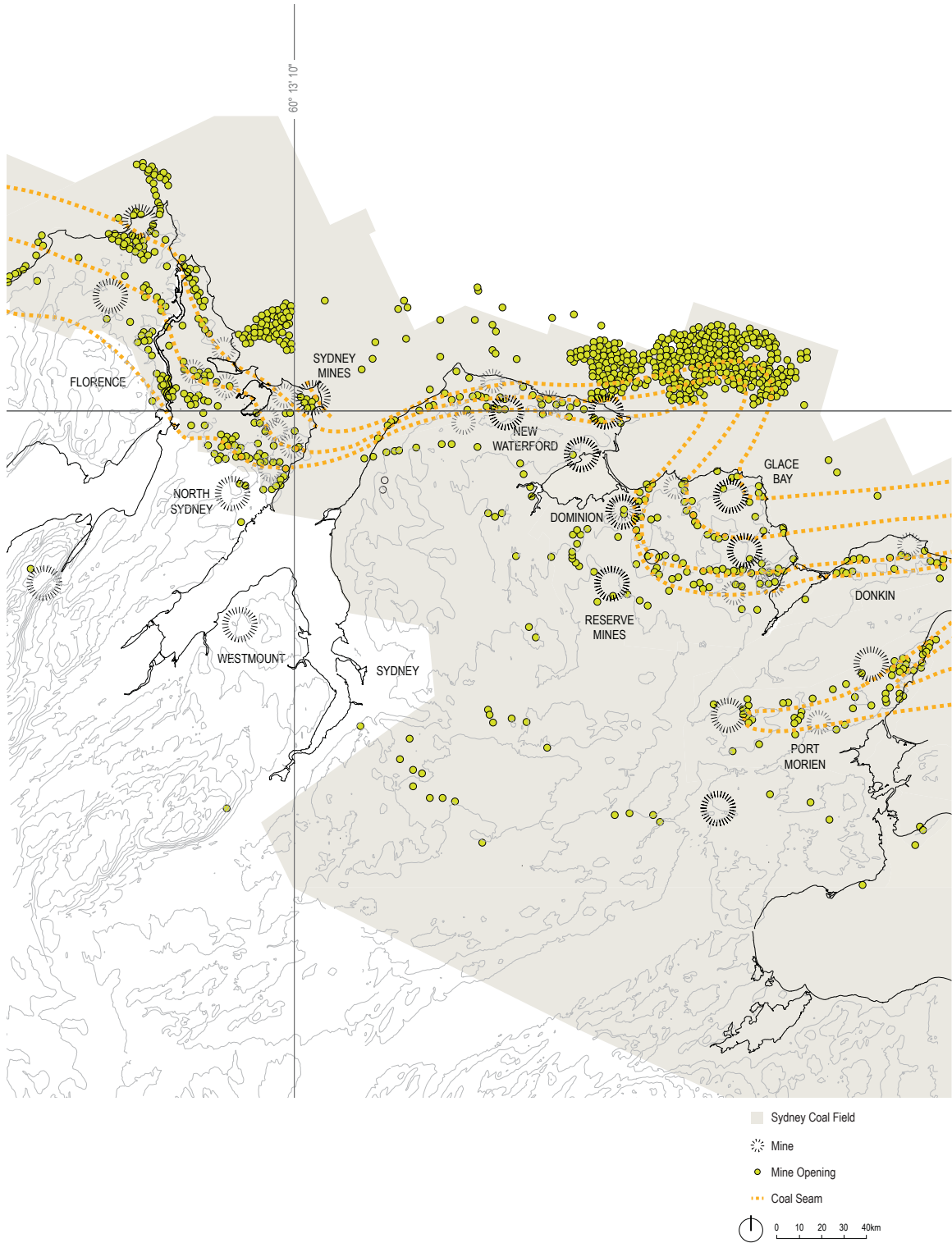
2 John H. Calder, *Coal in Nova Scotia* (Halifax: Canadian Cataloguing in Publication Data, 1985) 38.

3 Louis Frost, "History of the Sydney Coal Field," *Mining History Nova Scotia*, March 12, 1964, <http://www.mininghistory.ns.ca/lfrost/lfintro.htm>.

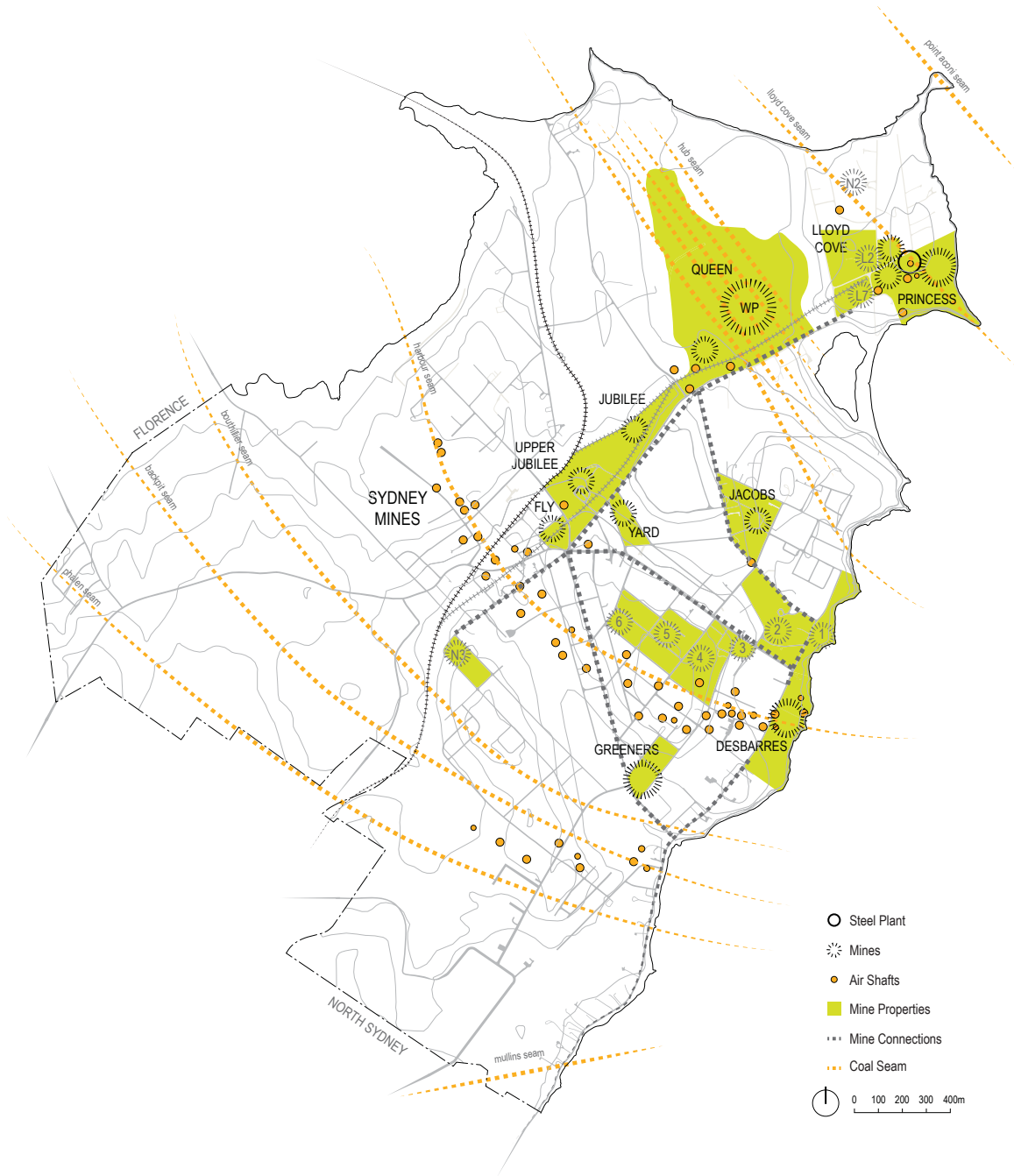
The introduction of the steel plant, in 1902, stimulated an economic boom in Sydney Mines, which generated town prosperity. Blast furnaces and coke ovens were also erected to smelt iron in the town. With the increase in demand of both coal and steel development in the beginning of the 20th century, and the investment of large amounts of capital, Sydney Mines became one of the foremost industrial centres on the North American continent.⁴ Eighteen years later, in 1920, the steel industry went into recession and the steel operations at the Sydney Mines Plant shut down.

The last coal mine in Sydney Mines, Princess Colliery, closed down operations in 1975. One year later, the last load of coal was removed and the closure reached completion in 1977. The mine operated as a tourist attraction for several years, but was completely shut down with the closure of the mine. In 1983, the supporting Coal Washing Plant was closed, marking an end of industry in Sydney Mines.

4 Sydney Mines Heritage Museum, "Town," January 11, 2014, <http://sydneyminesh heritage.ca/heritage-museum/town/>.



Coal extraction operations across north-eastern Cape Breton following the Sydney Coal Field, data from Louis Frost, "History of Sydney Coal Field."



Coal extraction operations and steel production in Sydney Mines over the history of the town, data from Louis Frost, "History of Sydney Coal Field."

Loss of Industry: Deteriorating Economy and Disappearing Population

Beginning in the 1950s, mining operations sharply declined due to increased pressures in the marketplace created by an abundance of inexpensive imported oil, and the high costs of extraction and transportation of coal.⁵ For these reasons, it has been the Government of Canada's policy to systematically close coal mine operations, dismantle and remove the infrastructure, fill the pits and shafts, and remediate the landscape. This has effectively erased thousands of employment opportunities provided by the industrial giants, as well as their associated infrastructure that defined the landscape.

Since the closure of the coal mines and steel plant, Sydney Mines has suffered socially and economically. With the last mining operations terminating in 1975, the economy of Sydney Mines, like many mining towns on the island, has been negatively impacted by the departure of industry, and is challenged by high unemployment rates. People are leaving Sydney Mines to head, typically, to the Halifax Regional Municipality, or Western Canada, in search of employment and a way to sustain themselves. In the past decade, over 2,100 people have left Sydney Mines, marking a twelve percent decrease in population.⁶ This steady reduction indicates an out-migration of a younger, well-educated age group, which has resulted in lower birth rates and an aging demographic. If Sydney Mines is to survive as a viable entity, innovative solutions are necessary to reverse this trend.

5 Calder, *Coal in Nova Scotia*, 41.

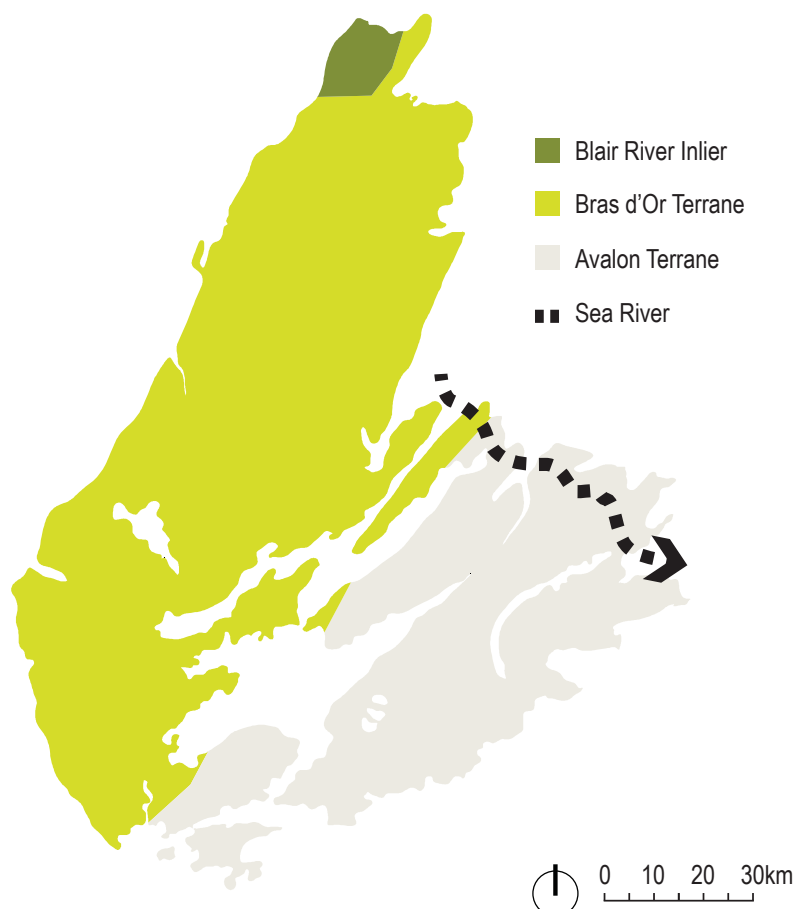
6 Statistics Canada, "Census Profile," October 13, 2013, <http://www12.statcan.gc.ca/census-recensement/2011>.

Environmental Context

Geological Origins: A Description of the Geological Process Over Time

Between 1500 to 700 million years ago, the oldest rocks of the Blair River inlier were formed during the collision of continental plates that resulted in the supercontinent Rodinia. During the time of Rodinia, a broad, subsiding floodplain, can be traced by its effect on the formation of the Sydney Coal Field.

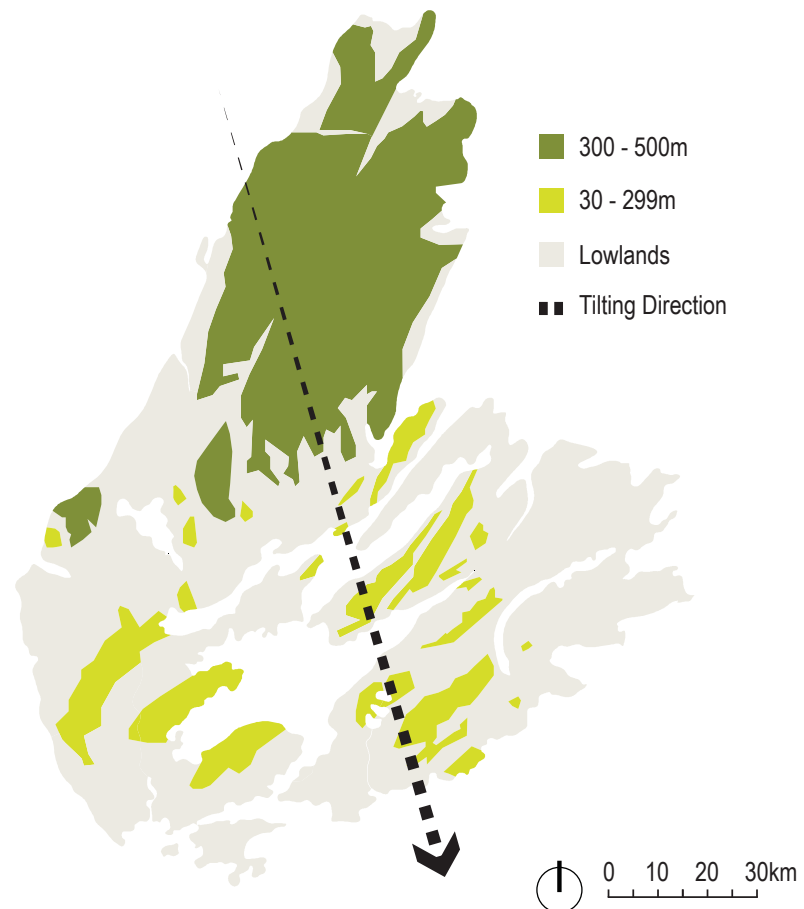
Rodinia broke up into smaller continents and started migrating, giving rise to the volcanic rocks of the Avalon terrane between 750 to 450 million years ago. Sedimentary rocks were laid down, which were later intruded with igneous rocks, forming the Bras d'Or terrane. The Bras d'Or terrane and the Avalon terrane were driven together as the ocean closed and the landmasses collided.



The three terranes of Cape Breton and the historic sea river, data from Parks Canada.

Between 450 to 360 million years ago, further continental collisions sandwiched the three terranes to form the core of Cape Breton. Three terranes make-up Cape Breton Island and include: the Blair River inlier, found at the north-west tip, composed of the oldest rocks known in the Maritime Provinces; the Bras d'Or terrane, found at the northern half of Cape Breton, a series of sedimentary and volcanic rocks, began forming off the north-west coast of South America; and the Avalon terrane, found at the southern half of Cape Breton, a volcanic rock that first began forming on the north-west coast of Africa.

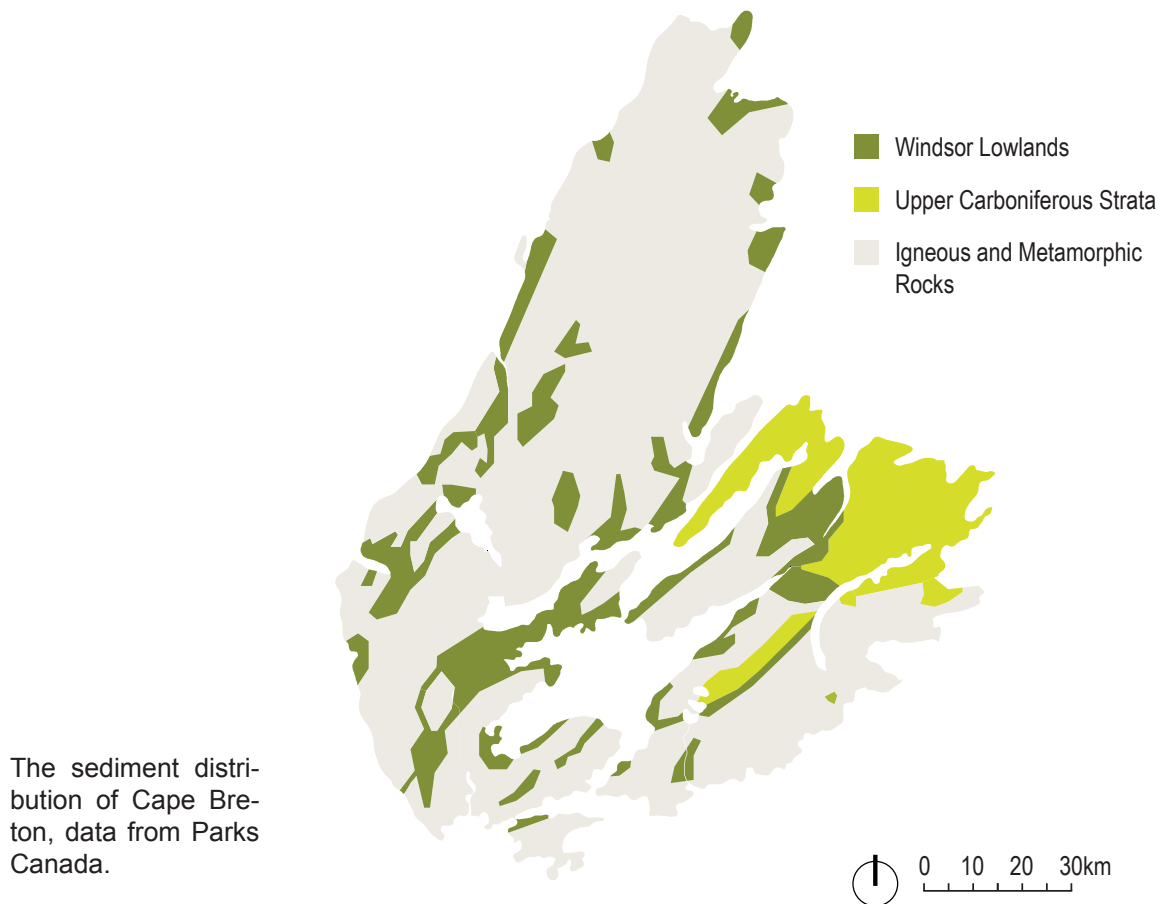
The tilting of the upland surface during this time period is indicated by the decreasing elevation of the upland blocks, from the Northern Plateau to the Atlantic coast. Tilting occurred due to the immense pressures of the colliding continents. The tilting of Cape Breton re-



The upland surfaces of Cape Breton, data from Parks Canada.

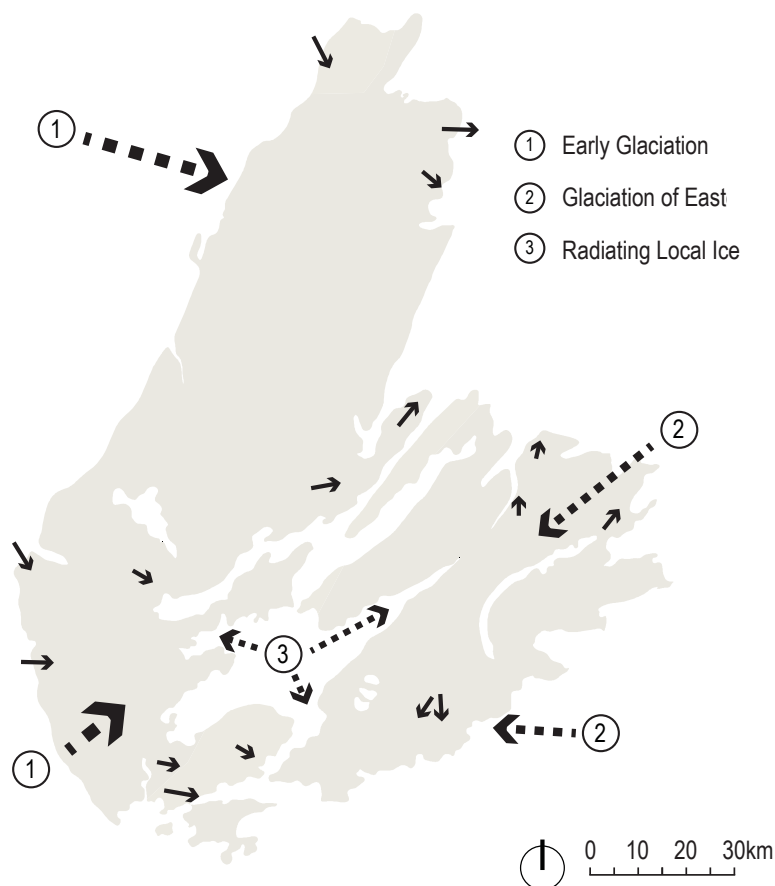
gion created an upland plateau and an inland plain. The land levelled, the tops of the upraised blocks were sheared off, and the underlying granite rocks were exposed.

Great thicknesses of sands and silts were washed in from surrounding areas of the uplands around 340 to 250 million year ago, and were laid down on top of the earlier deposits on the lowlands. Dark, fine-grained sandstones defined the strata composition.



From 250 to 65 million years ago, Cape Breton subsided uniformly so that the sea level stood 25- to 50-metres higher than present day, causing much of the coastline to be submerged, flooding low areas in the centre of the Island such as Bras d'Or Lake. This caused further peat to be compressed into coal.

The glaciation of Cape Breton in three stages, data from Parks Canada.



The glaciations occurred in three stages, approximately two million years ago, which included an overriding early glaciation, retreating ice of the eastern lowland areas, and local ice radiating out towards the coast from one main centre at Bras d'Or Lake.

During the Carboniferous time period, the most significant time period to the Sydney Area, the geological process created the Morien Group formation. This formation is composed of compressed layers of fluvial mudstone, shale, siltstone, sandstone, and coal measures. The geological processes also formed the Sydney Coal Field, which acted as the stimulus of mining in Cape Breton.⁷

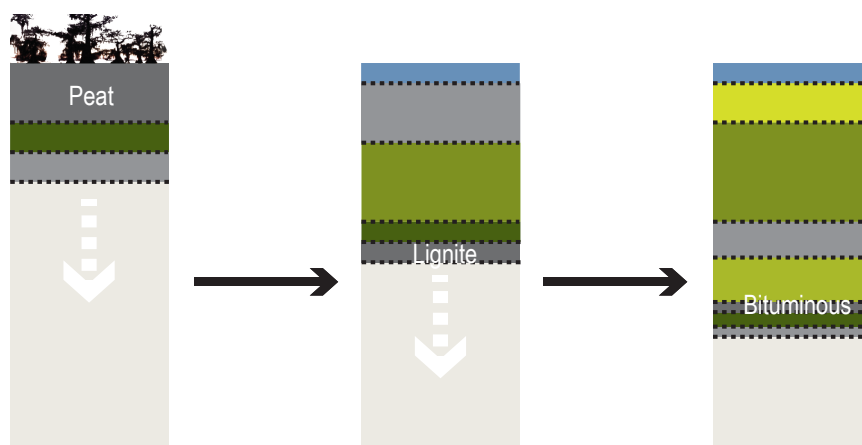
⁷ Parks Canada, *A Billion Years of Change: The Formation of Cape Breton Island*, August 6, 2008, <http://www.pc.gc.ca/pn-np/ns/cbreton/natcul/natcul1/a/i.aspx>.

Albert E. Roland, *Geological Background and Physiography of Nova Scotia* (Halifax: Ford Publishing Co., 1982), 295.

The Formation of Coal

The supercontinent of Rodinia hosted several winding sea rivers, which delineated subsiding floodplains. The floodplains ran parallel to the present-day coastline, cutting into the deposits on one side, and allowing vegetation to grow on the other. Over time, inorganic sediment deposits amassed and buried the vegetation. Compaction, layering, and partial decay of the vegetation created peat, which was formed by the accumulation of organic materials in swampy conditions, with high water levels and inadequate drainage causing stagnant water and oxygen-poor conditions. In order for peat to be transformed into coal, deposits of organic materials were required to be buried between four to ten kilometres by collected inorganic sediments. This typically occurred at coastal conditions where shoreline migration due to sea level rise submerged the coal swamp.⁸

The process of peat turning into lignite, and after further compression, becoming coal, data from Stephen Marshak, "Squeezing Power from Stone: Energy Resources," *Earth - Portrait of a Planet*.



The layering of these deposited sediments caused pressure and compression that transforms the peat into lignite, and further into coal. It takes roughly between seven and twenty-seven metres of peat to form a one-metre layer of bituminous coal. This represents

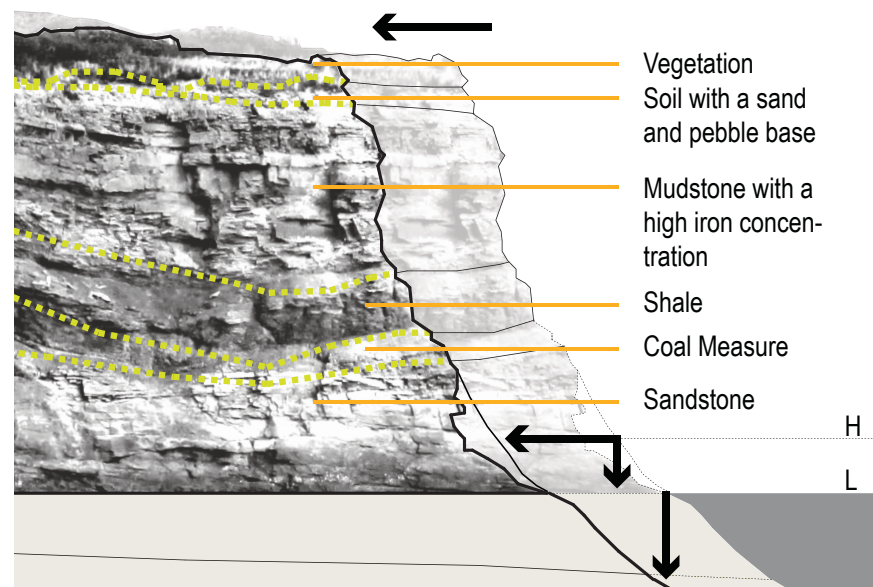
⁸ Stephen Marshak, "Squeezing Power from Stone: Energy Resources," *Earth - Portrait of a Planet* (New York: W. W. Norton & Company, Inc., 2012), 483.

the accumulation of plant debris over 6,000 to 9,000 years.⁹ This layering can be seen in the sequence of sediment deposit seams that interlay with other sedimentary strata such as sandstone, shale, and limestone. This layering of the sedimentary strata deposits is what makes the geological formation susceptible to coastal erosion.

Definition of Coastal Erosion

Coastal erosion is the process of exposed coastal cliffs being continually battered upon and worn away by the ocean and weather, resulting in landward movement of the shoreline. It is a naturally occurring process that consists of the continuous breakdown of rock and sedimentary particles. Within Atlantic Canada, coastal erosion happens as a result of the action of a number of controls.

Typical erosion of the cliff face due to the sedimentary composition, data from Robin Davidson-Arnott and Jeff Ollerhead, *Coastal Erosion and Climate Change*.



These controls include: exposure, sediment type, tides, weather and climate, and human activities. These factors play a large role in the rate and acceleration of erosion on the shoreline.

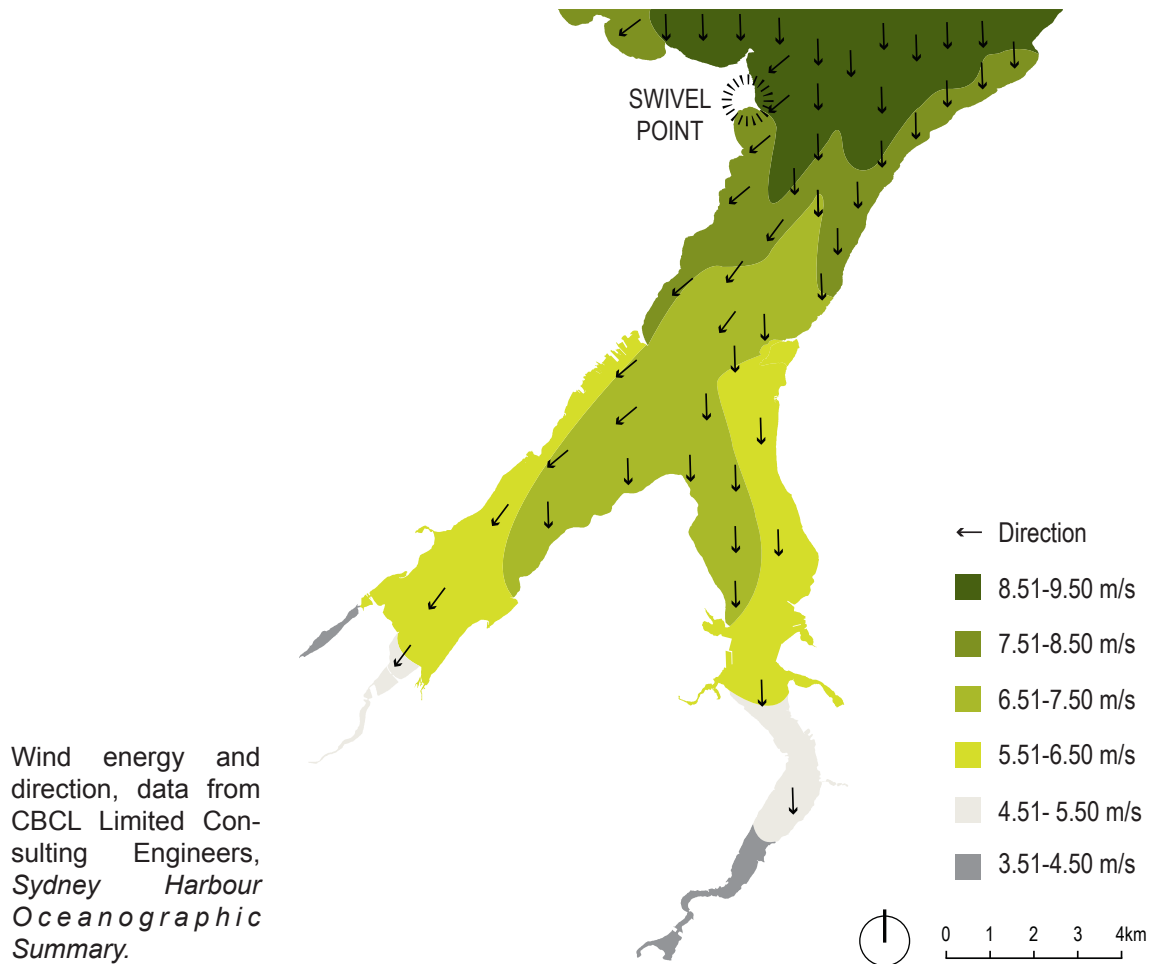
⁹ Ibid., 484.

The sedimentary composition of the geological formation of Sydney Mines is that of compressed, layered, minute, and previously loose particles, sediment deposits, and organic matter. This fosters high levels of coastal erosion. Coupled with twelve to fifteen metre cliffs, erosion levels can reach between thirty to sixty centimetres a year, depending on the climatic conditions. The sediment type allows for the penetration of surface water runoff and storm water, which seeps into the joints and seams of the cliff, widening the openings. Cracking and splitting in the joints and seams is increased in the winter months due to penetrating water freezing and causing frost shattering. With winter storms increasing due to climate change, problems triggered by water penetration is expected to rise.

Tidal action effects erosion to a lesser extent than climatic conditions. Tides may influence erosion by increasing the vertical aspirations of wave action on the cliff face¹⁰, increasing the rate at which waves erode the toe of the cliff.

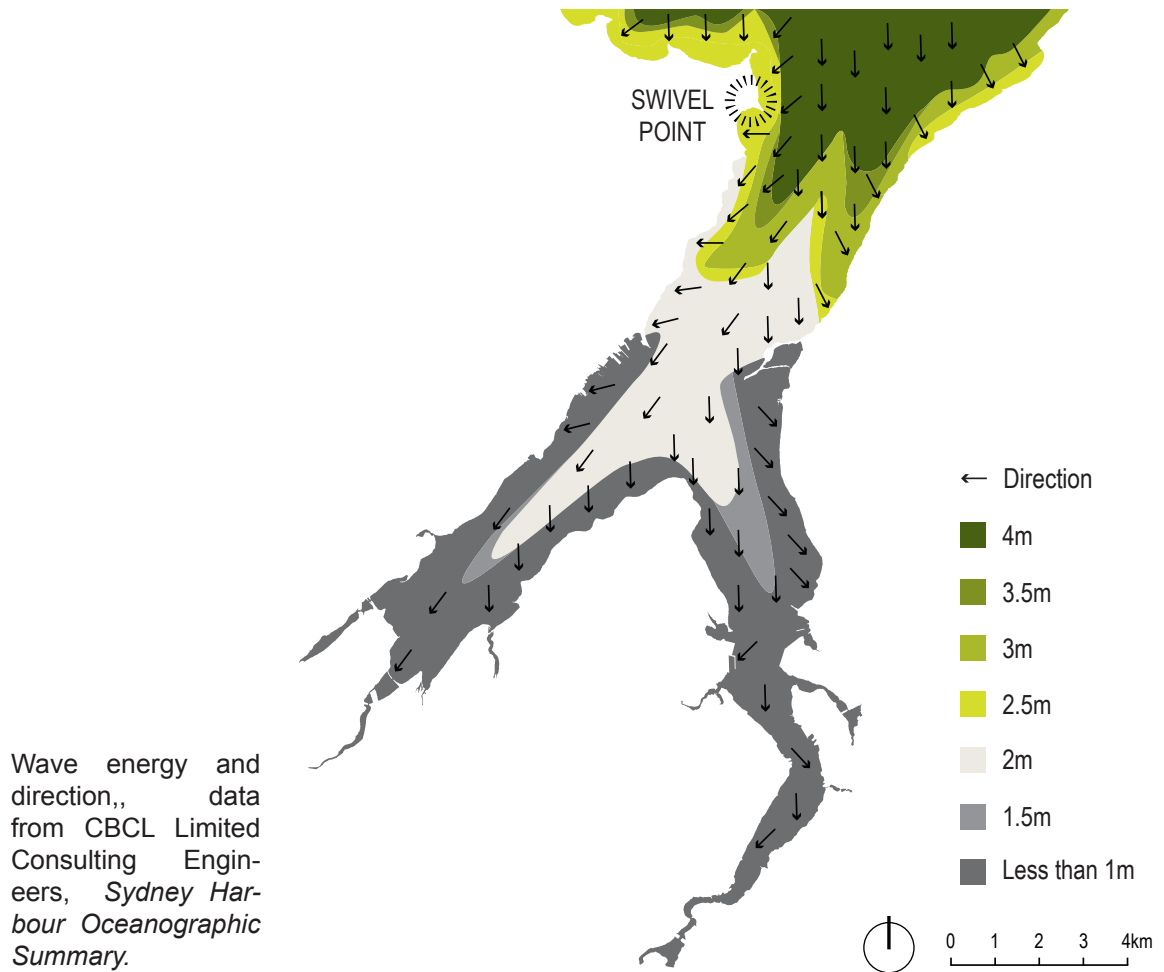
Weather and climate heavily dictate the rate of erosion through several means including wind, waves, storm surge, ice, rain, and climate change. Climate change is anticipated to accelerate erosion rates due to sea-level rise and the increased frequency of extreme storm events.

10 Robin Davidson-Arnott and Jeff Ollerhead, *Coastal Erosion and Climate Change*, Atlantic Climate Adaptation Solutions Association, (Charlottetown: Prince Edward Island Department of Environment, Labour and Justice, 2011), 8.



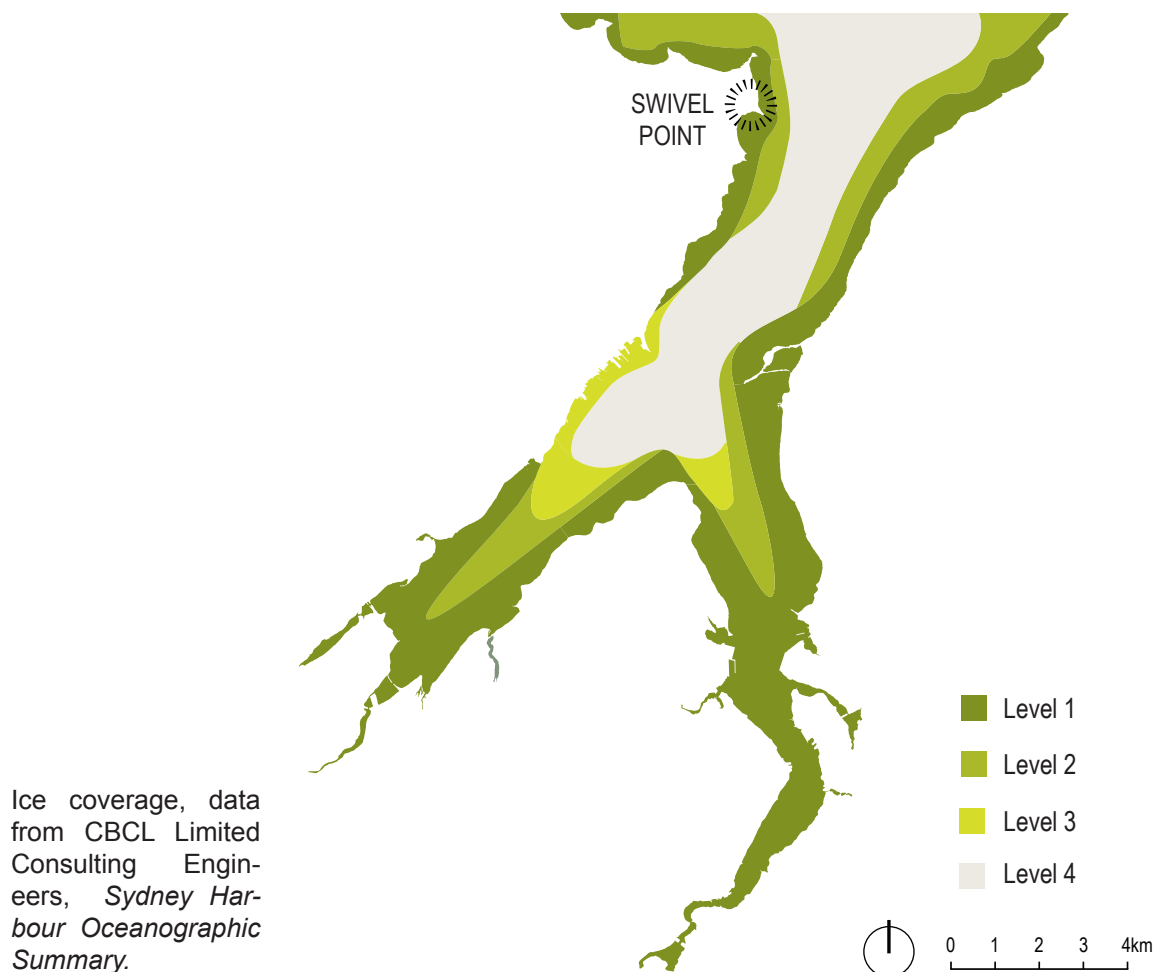
Atlantic Canada experiences mid-latitude tropical storm and hurricane weather.¹¹ These storms act as primary drivers to coastal erosion in the region. Heavy winds create higher levels of water and air penetration into the joints and seams of the cliff face, gradually breaking the cliff apart. The storms also affect erosion by increasing the strength of waves through the wave height and frequency.

¹¹ Ibid., 7.



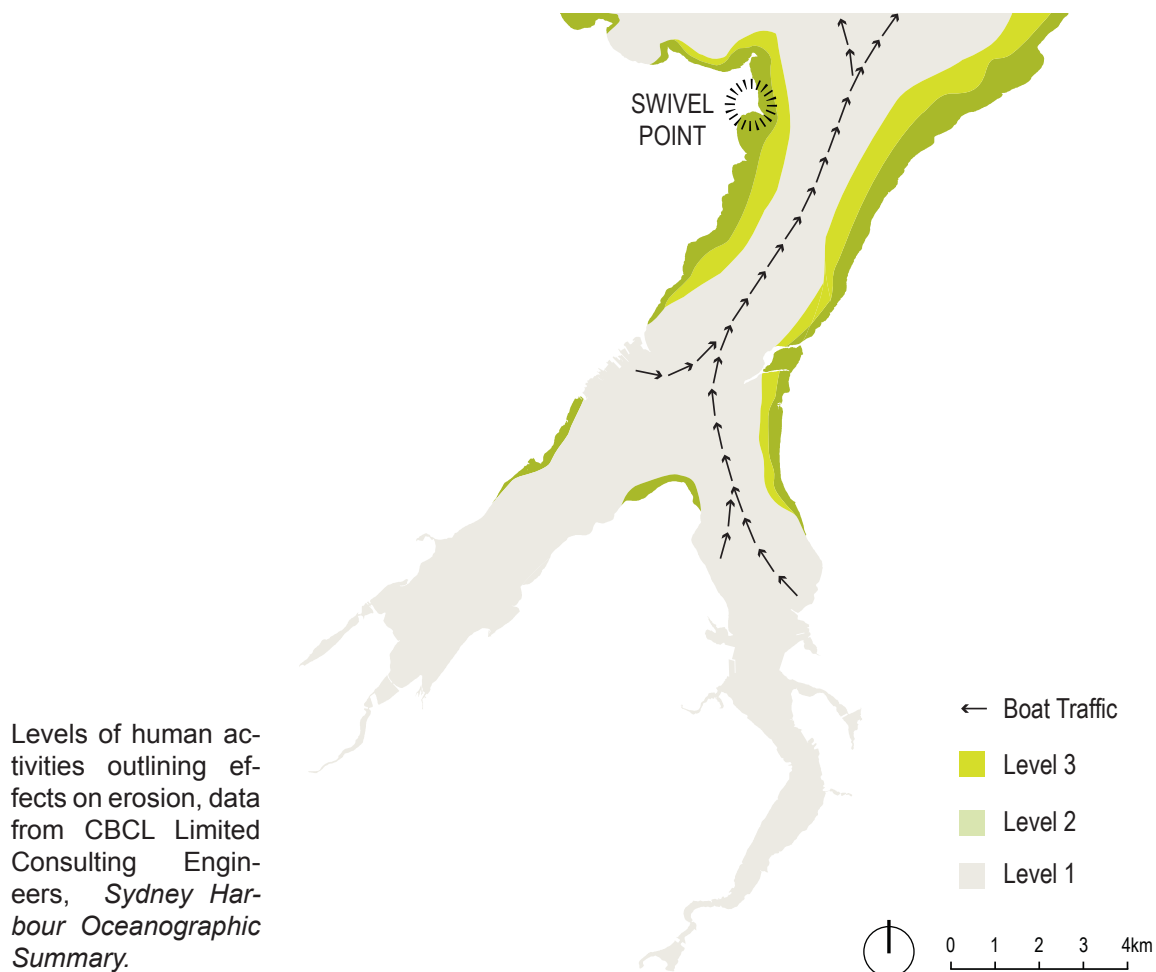
The biggest factor affecting coastal erosion is the strength of the waves breaking along the coastline. Increased and intensified wave activity on heavily exposed surfaces pummels the toe of the cliff, which undercuts the cliff, allowing larger pieces of rock to break off, and the process of erosion to advance more quickly.¹² Heavily exposed areas to the wave and storm activity of the ocean erodes at an immensely increased rate.

¹² Ibid., 7.



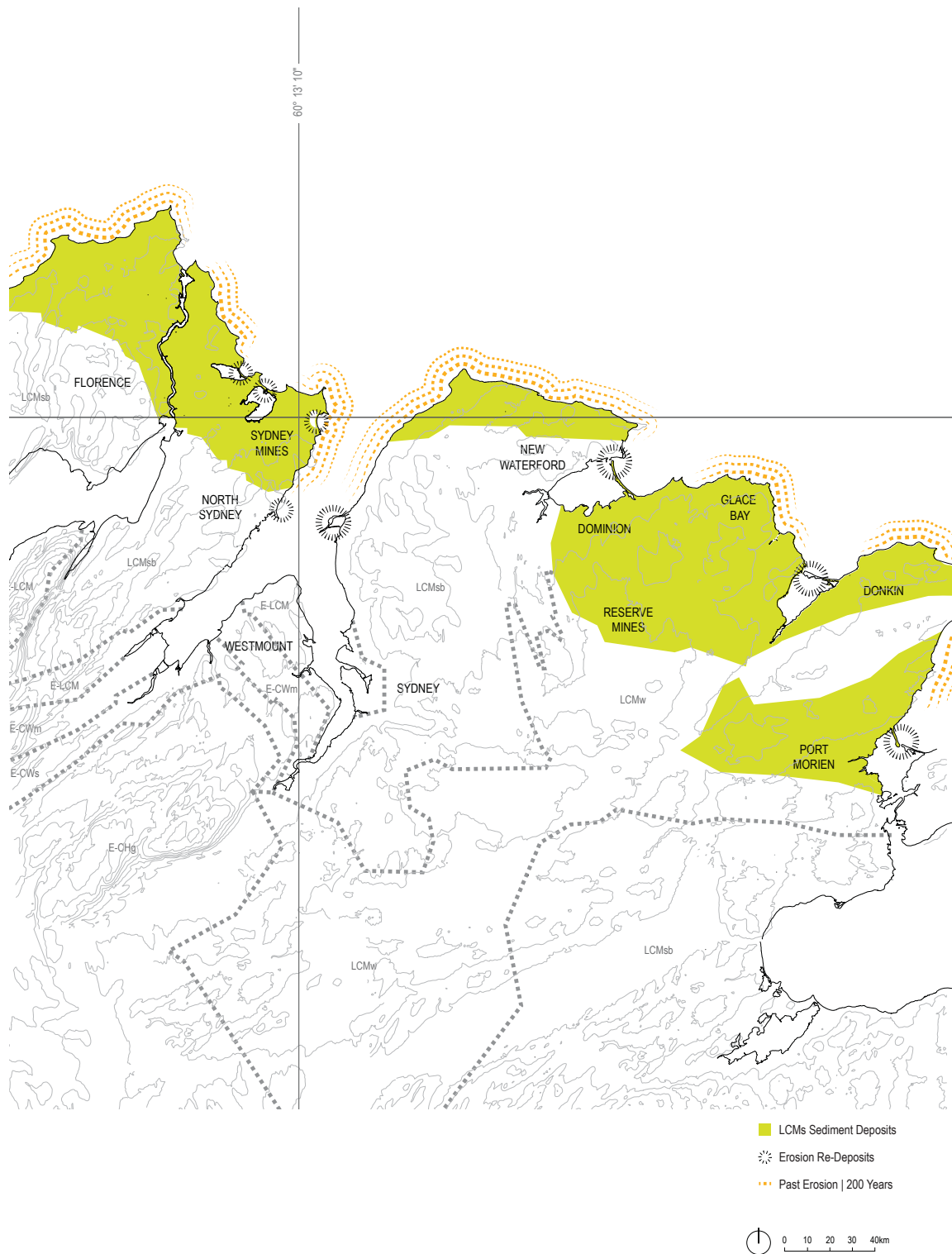
Coastal processes are also affected by the development of shore-fast and sea ice during the winter months. Though ice in the harbour has some negative effects, they are outweighed by its ability to protect the toe of the cliff from enhanced scour by waves. It slows wave activity and decreases the rate of erosion in the winter months.¹³ With climate change, levels of ice protection are decreasing, allowing for the winter weather to penetrate the sediments and erode the coast.

¹³ Ibid., 7.

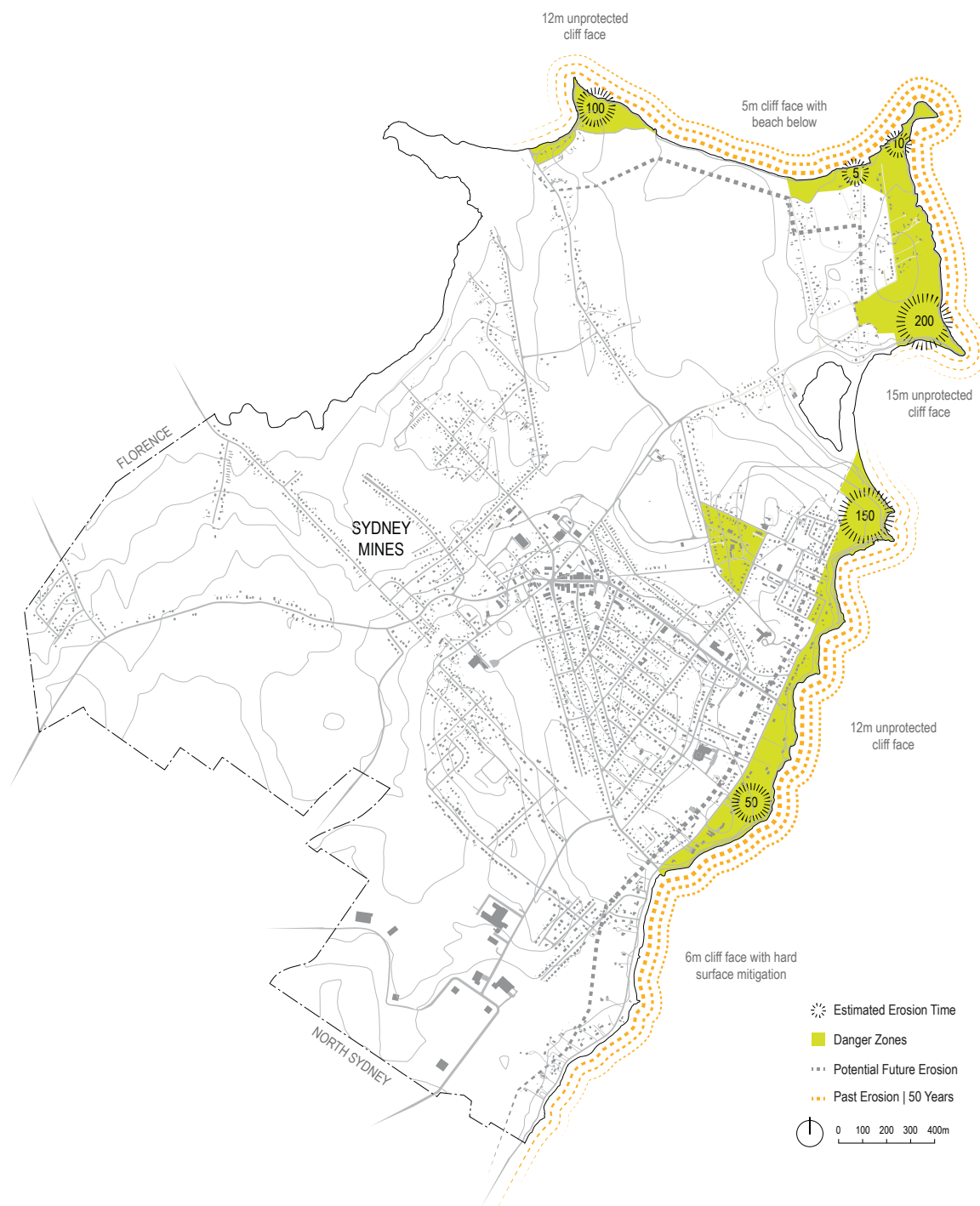


Human activities, as well as human habitation, affects rates of erosion. Activities such as the waves caused by the repetitious wake of the ferry to Newfoundland creates a two-fold wave exposure coming in and out of the harbour, which stimulates movement of coastline to typically unexposed areas. Activities and habitation including mining practices have left the landscape scarred and deformed. Shafts and pits have previously been filled with waste rock. Shoreline depletion is exponentially increased in areas where the coastline has eroded to the point where waste rock and other mine debris are exposed. Also, human habitation, including edge paths, loosen soil and sod allowing further water penetration, instigating accelerated erosion.

This thesis believes that coastal erosion is a natural process that is in equilibrium, and should be viewed as neither good nor bad. It is a process that has continually shaped the coast, but, in the event of a sudden failure, this lateral movement of the shoreline often poses problems for long-term human activity and habitation by jeopardizing buildings and infrastructure along the shore edge. The issues of erosion should be identified as the nature of human activity, the means of habitation, and the lack of adaptability where coastal erosion occurs, rather than the process itself.



Coastal erosion and geology across north-eastern Cape Breton, data from J.D. Keppie, *The Geological Map of the Province of Nova Scotia*.



Coastal erosion in Sydney Mines, data from J.D. Keppie, *The Geological Map of the Province of Nova Scotia*.

Existing Mitigation Strategies

The mitigation of shoreline retreat has been an on-going battle for as long as humans have inhabited the coast. In areas that are a hazardous zone defined by the cliff recession, mitigation techniques are often used to increase slope stability and to reduce, or eliminate, toe erosion. In Cape Breton, hard surface protection is most commonly used as an attempt to protect the cliff toe.

These two ways of approaching the management of cliff erosion through hard surface protection include engineered or non-engineered techniques. An engineer designed and constructed revetment made of such materials as armourstone, rip-rap, or other dense, yet porous materials, may provide protection for an area for upwards of seventy-five to one-hundred years, with proper maintenance.¹⁴ Protection that has not been designed or supervised by engineers often utilizes non-standard materials that are dumped haphazardly at the base of the cliff to provide toe protection. As a result, the majority of these approaches are unsuccessful, and fail within a short duration of time. This often produces adverse effects by undermining the integral security of the mitigation construction at the shore platform, increasing toe depletion and accelerating erosion.

Mitigation approaches can be a costly endeavour financially, but also environmentally. By protecting an individual area on the cliff, problems may be generated as vulnerability is increased in adjoining sections. Protective strategies lead to the deflection of wave energy and activity to other areas of the coast. In certain cases, landward migration is increased due to the presence of mitigation techniques.

14 Davidson-Arnott, and Ollerhead, *Coastal Erosion and Climate Change*, 26.

Coastal erosion is best viewed not as a problem, but as a natural, on-going practice to which we must adapt. Careful land-use planning and design, built on a foundation of understanding the natural processes that shape the coast, will lead to new building typologies that can adapt to live with erosion, rather than fight erosion. It is difficult to predict the exact rates at which a cliff will erode, but with the impacts of climate change becoming harsher, rates are certain to increase. Therefore, a strategy for adaptation is both possible and necessary.

Site Description

Swivel Point Site Overview

Swivel Point is a site rich with mining history. It was originally harvested for coal by extraction from the cliff face, but was also the home of Princess Colliery, one of the founding coal mines in Sydney Mines. Though the site is located two kilometres from downtown, this short distance is bridged by old roads established in the development of the town, and by an old train track path that has been converted into a recreational trail. Swivel Point is bordered by Sydney Harbour to the east, Lloyd Cove to the south, and by residential housing to the north and west. It also neighbours former Lloyd Cove Collieries No.2 and No.7, which lie directly outside of the Princess Colliery site.

Princess Colliery opened and began operations, in 1873, as a sunk mine shaft to the Lloyd Cove Seam of the Sydney Coal Field, which averaged 1.6 m in thickness. There were two shafts located on the site that ran perpendicular to the geological layers to reach the coal, a hoisting shaft at 4.5 m in diameter and a person shaft at 3.5 m in diameter that were close to 200 m deep.¹⁵

15 Frost, "History of the Sydney Coal Field," *Mining History Nova Scotia*.

Princess Colliery was the first mine to operate undersea coal extraction to a large degree in the Sydney Coal Field, operating five kilometres out under the ocean. Longwall advancing was the method of coal extraction at this time in the mines. In this process, the longwalls were mechanized to cut and load the coal, while friction-type steel props supported the ceiling. As the extraction advanced, the steel props followed, leaving the ceiling to cave in behind the operations.¹⁶ These submarine processes continued until the mine closed in 1975. Throughout the extent of the life of Princess Colliery, nearly thirty million long tonnes of coal were produced, extracted from an area of 2,630 hectares, over a one hundred year time.

Lengthy mining operations at Swivel Point have left the landscape marked and barren. The site is absent of vegetation other than long grass that has been slowly reclaiming its natural place in the environment. Train tracks and old road pathways are still visible, as are the scars and scrapes of coal mining infrastructure and equipment. The site ends abruptly as the edges fall away into Sydney Harbour. The east cliff face is greatly exposed to weather, wind, and waves making erosion occur at a higher rate here than on the south-facing cliff, which is partly sheltered by Lloyd Cove, and has a slightly less aggressive topography.

This being an unused site, exhibiting erosion, and with rich history, suggests an innovative approach to design is required. Though Swivel Point, in Sydney Mines, has been selected as the location of this re-development project, it is important to note that the strategies and considerations intend to be prototypical in their application. The ideas expressed may be applied to other erosion-afflicted coastal mining communities throughout Cape Breton.

16 Ibid.

Programme Development

Sydney Mines is eroding in terms of both the environment, and the community itself. It has suffered socially and economically after the closure of its mining and steel industries. With the lack of employment in the area, there is a steady population migration leaving Sydney Mines facing difficulties maintaining stability within the town. With a general decline in population due to poor economic conditions and lack of employment, it must be re-stated that it is paramount that Sydney Mines becomes an economic generator, as well as a place where people want to live.

Coastal Community Re-Development

Since the departure of industry in the area, the local economy's current strategy is to focus and profit from the heavy tourist traffic that travels through North Sydney's ferry terminal. The town's attempt at attracting the tourist market is the use of small-scale museums, displays, and a heritage centre. These are completely under-utilized spaces and missed opportunities to draw visitors into the town. Though this methodology stimulates the economy, it is a highly seasonal sector, making this approach unsustainable throughout the entire year, and only engages a small number of local residents. Instead of a season market trend, what is needed is economic growth to enhance the social and economic foundation of Sydney Mines so that it is an attractive place for people to live and invest year round.¹⁷ This includes employment, education, social, cultural opportunities within the community.

Healthy, attractive towns include social spaces within the community. Shared, multi-purpose public spaces create social networks, a sense of identity and culture, as well as a desire to contribute to the

¹⁷ Enterprise Cape Breton Corporation, *Enterprise Cape Breton Corporation Annual Report 2010-2011*, November 12, 2013, <http://www.ecbc-secb.gc.ca/index.php?cid=13&pid=159&lang=e>.

town to allow it to thrive. Shared social spaces foster interaction for pleasure and work, and encourage community involvement and relationships. Social public interaction harbours a sense of belonging, increases the quality of life for the individual, and stimulates economic gain through further investment in the town.

To foster a healthy social environment, importance should be placed on education. Education in a community provides individual development, contributing to overall societal benefit. Knowledge is power and can be used for the greater good of the community, but the lack of on-going education and professional development opportunities means that both workers and industry have become static. When education is based upon learning that is relevant to the local community, a sense and understanding of the surroundings is reached.

The existing physical, socio-economic, and educational structure, in Sydney Mines, is liable to fail against the current wave of global change. A viable solution for the future must rely on creative strategies of adaptation rather than standard mitigation techniques. Such a solution requires awareness of the interplay of programmatic components, looking to new horizons as yet unseen.

CHAPTER 2: DESIGN

A Vision for Princess Colliery

The proposed master plan for Swivel Point capitalizes on a variety of elements, buildings, and programmatic components in order to activate Sydney Mines. This thesis project uses the development of an institution, the Geological Centre of Cape Breton, to facilitate education, employment, and social opportunities. With response to environmental erosion and related community decline, the concepts of permanence, adaptation, and sacrifice can be applied to both architecture and programme in the stimulation of the economy.

The Geological Centre has three main components of growth and stimulation in the domains of education, economic development, and social spaces. It is the intention of this project to merge all three of these re-developmental concerns into a singular long-term vision for Sydney Mines and its neighbouring towns. By adapting programme for alternate use while maintaining a presence of invested community-based development and continuous involvement, residents, as well as visitors, will have an inherent connection with the history of the site, as well as an attachment to place.

Education is a means to encourage research and innovation.¹⁸ Higher learning will be introduced to Sydney Mines through the strategic development of the graduate and undergraduate Earth Sciences Department at Cape Breton University, located twenty minutes away in Sydney. It will act as a satellite campus, offering collaborations with other Atlantic universities to introduce and promote the Geological Centre of Cape Breton as a hub of earth sciences learning, research, teaching, and practice with the use of research labs and related academic facilities. The Geological Centre

18 Cape Breton County Economic Development Authority. "Cape Breton Economic Development Strategy 2006-2016." Cape Breton County, Sydney, 2006.

of Cape Breton will provide learning and education through facilities for scientific study, both in the field, and in the classroom, research, fellowships, teaching, and practice.

The existence of such an institutional entity and centre will have positive economic impacts due to related businesses and services required as a support network. Related businesses could include restaurants, bookstores, entertainment, and services. Full-time employment will be formed to accommodate these new businesses and services, which will provide care and maintenance of the infrastructure, as well as to the practitioners and visitors of the Centre. Catering to the concentrated, seasonal tourist market, and creating stable, long-term employment will achieve economic generation. Tourism will be created by developing the Discovery Centre on site that will re-home the Fossil Centre of Cape Breton, and the Mining Museum of Sydney Mines. Displays of fossils, geological formations and processes of the area, mining exhibitions, and research presentations will be scattered throughout the site, and will draw both the residents and tourists onto the site of the Geological Centre. A National Resource field office will be located on site, bringing a permanent educated group of professionals to the area.

Economically, growth will also be stimulated by the construction of the Geological Centre itself. All trade work has the potential to be finalized locally. Trade groups will be established to organize labour with an emphasis on the steel, welding, and concrete pre-fabrication work being completed on site. Developing the skills and training of local workers will have a long-term benefit to the unemployment rates in the area, thereby stimulating the surrounding communities in perpetuity. Training facilities and community outreach centres will be established to develop this local expertise, with the specialization in steel and concrete. Raw materials will be shipped to the North Sydney shipyard, and further distributed for

construction locally at workshops, manufacturing plants, assembly sites, and the building site.

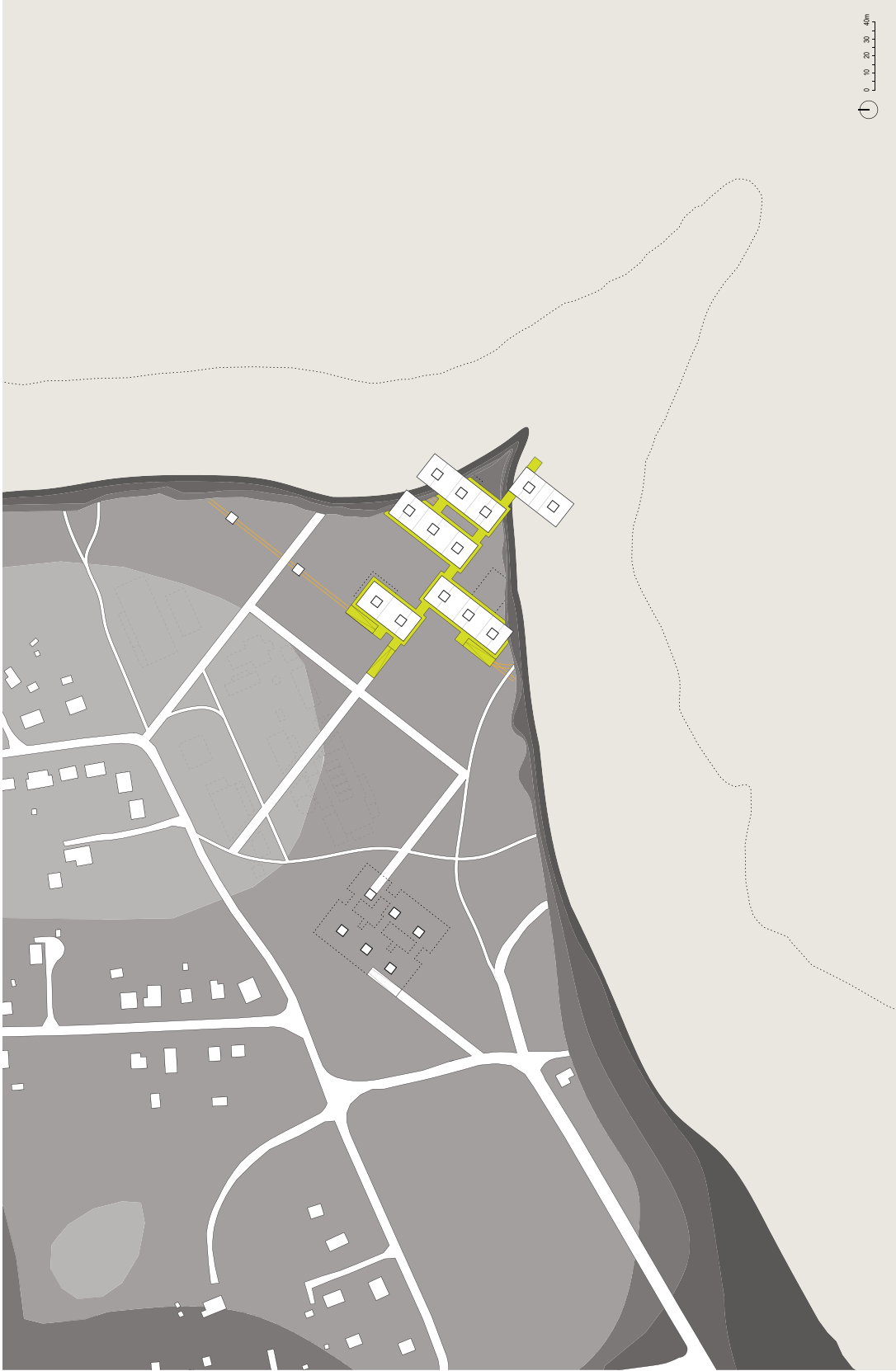
Furthermore, real estate and rental property management will experience an increase in business through the reclamation and conversion of abandoned homes for the purpose of rental properties for students, and permanent residences for professionals. Re-purposing abandoned homes will help negate the feeling of neglect and desertion in the surrounding neighbourhoods of Swivel Point, and assist in the renewal of attachment to Sydney Mines.

Culturally, social spaces can engage in the sense of attachment to place through community activities and growing resident relationships. Social spaces will be intermixed with the academic spaces, promoting more interaction and social networking. Multi-purpose spaces will be located in conjunction with academic areas to encourage community involvement, interest, and a desire to participate. Adaptable social spaces will provide the community with areas to gather for reasons related to exploring Cape Breton's culture, geology, mining, history, and further learning. Both interior and exterior areas will be utilized to express adaptation on the site.

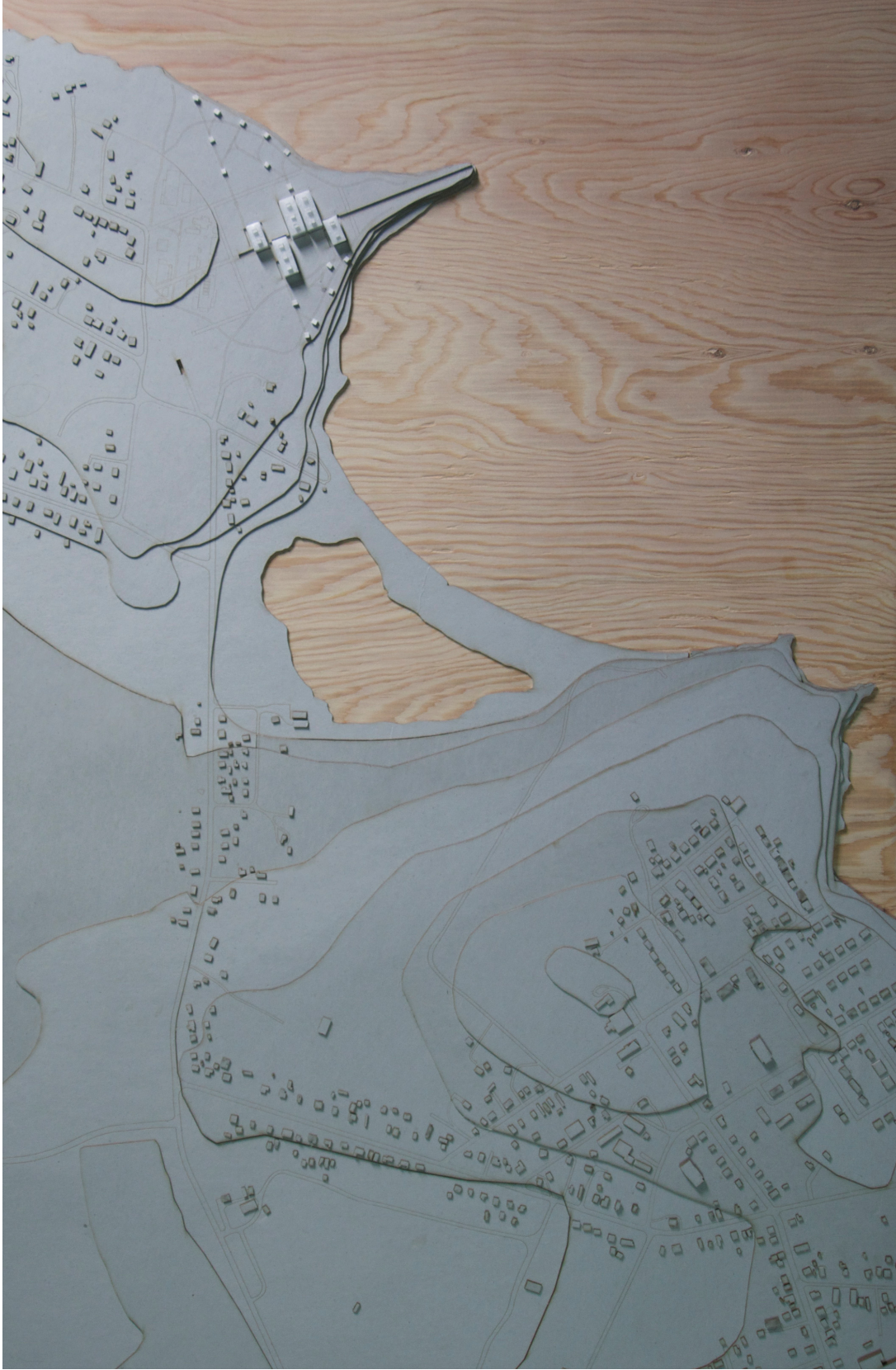
Due to the changing conditions of the coastline, as well as the community, the programme will be able to shift and adapt accordingly. The enablement of static and dynamic programmatic and spatial shifts that are capable of changing to the condition of erosion will stimulate growth and development in this coastal town. This allows for the programme to change according to the needs of the community over time, making the Geological Centre an evolving pillar within Sydney Mines and the surrounding area.



Site plan of Swivel Point showing present-day conditions.



Site plan of Swivel Point showing conditions as to be expected in 200 years.

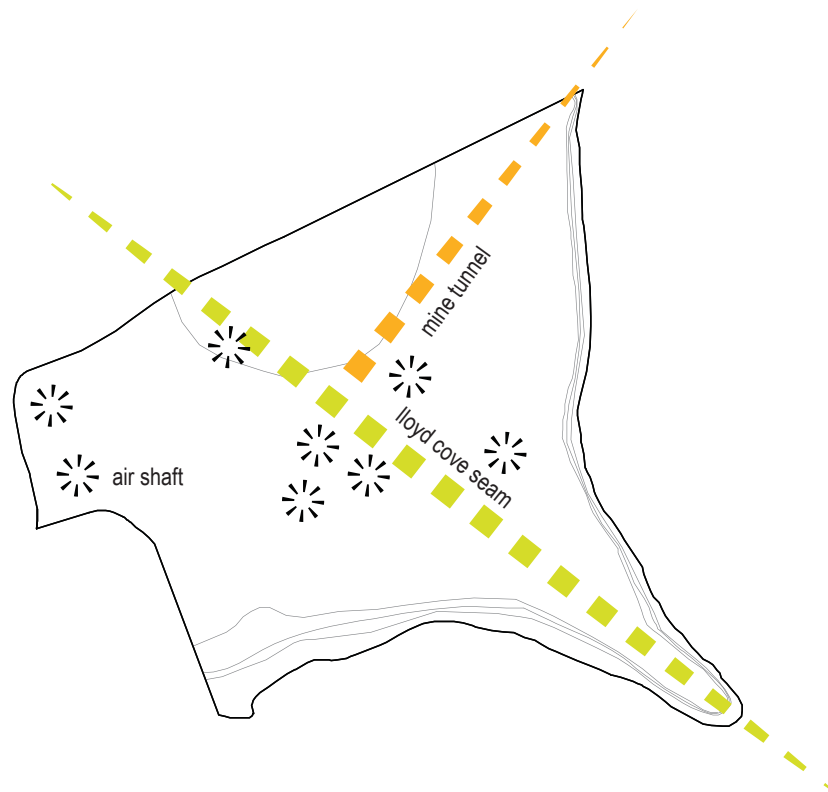


Site model of Sydney Mines showing connection of Swivel Point to the rest of the town and to coastal erosion.

Site Strategy

In Sydney Mines, the Geological Centre is situated at Princess Colliery, on Swivel Point. At Princess Colliery, two major axes are located. The Lloyd Cove coal seam cuts through the site extending out into Sydney Harbour and to the neighbouring residential area. The Princess Colliery mine tunnel is oriented perpendicularly and extends to sub-oceanic mining, which sustained mining operations at Princess Colliery until 1975. These axes are underground and, therefore, unseen. Both the Lloyd Cove coal seam, and the Princess Colliery mine tunnel, played an important role in the development of the site, giving it its rich industrial history.

Orientation of the Lloyd Cove coal seam and the Princess Colliery mine tunnel.

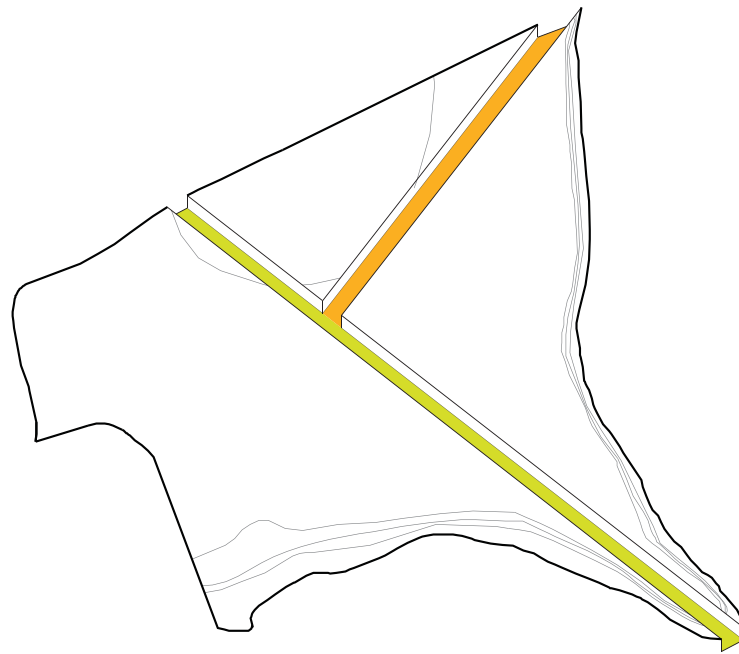


Incision

Following the lead of the major axes, a 2.5 m incision was cut into the landscape to trace the Lloyd Cove coal seam. The incision will be walled with rammed earth, made with the excavated materials of the incision. This will generate a visual connection with the wall

directly reflecting the geology of the site, allowing the users to be a part of the landscape and geology, while accessing and moving through the Geological Centre. To enter any of the buildings, a user must first enter the incision through a ramp and travel through the incision to any of the above-ground buildings to access the core. The incision culminates at the tip of Swivel Point where users look out into the harbour.

Incision cut into the site to trace the major axes.



Placement Strategy

Buildings were placed to follow the direction of the mining tunnel and run perpendicular to the Lloyd Cove coal seam. Placing the buildings of the Geological Centre perpendicularly also creates a dialogue with the eroding edge by indicating their presence by being directed towards the cliff without being immediately placed there. The Geological Centre was placed closer to the tip of Swivel Point to maintain a distance far enough away to ensure that effects of erosion will not be felt instantly, but experienced gradually and ephemerally.



Incision investigation cut into the site to trace the Lloyd Cove coal seam.

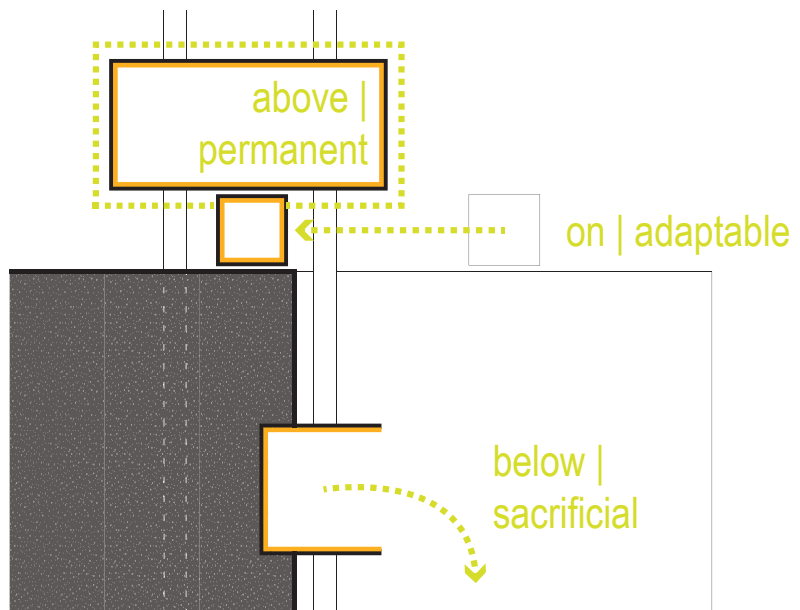


Incision investigation cut into the site to trace the Lloyd Cove coal seam.

Layering Typologies

To respond to environmental and community erosion, ideas of permanence, adaptation, and sacrifice have been used to establish an evolving and didactic architecture to act as a catalyst in the stimulation of the economy, and in the creation of stability in the town. Any intervention made on the site would neither increase nor decrease the rate of erosion of the shoreline. Mining activities were so extensive in the past that they have left the site scarred and highly susceptible to erosion. Since there is no perfect solution to the issues of coastal erosion, prototypical architecture was explored as a means to address this condition of erosion and three building typologies were developed: above-ground, which is permanent; on-ground, which is adaptable; and below-ground, which is sacrificial.

Typologies: above-ground and permanent, on-ground and adaptable, and below-ground and sacrificial.



Above-Ground

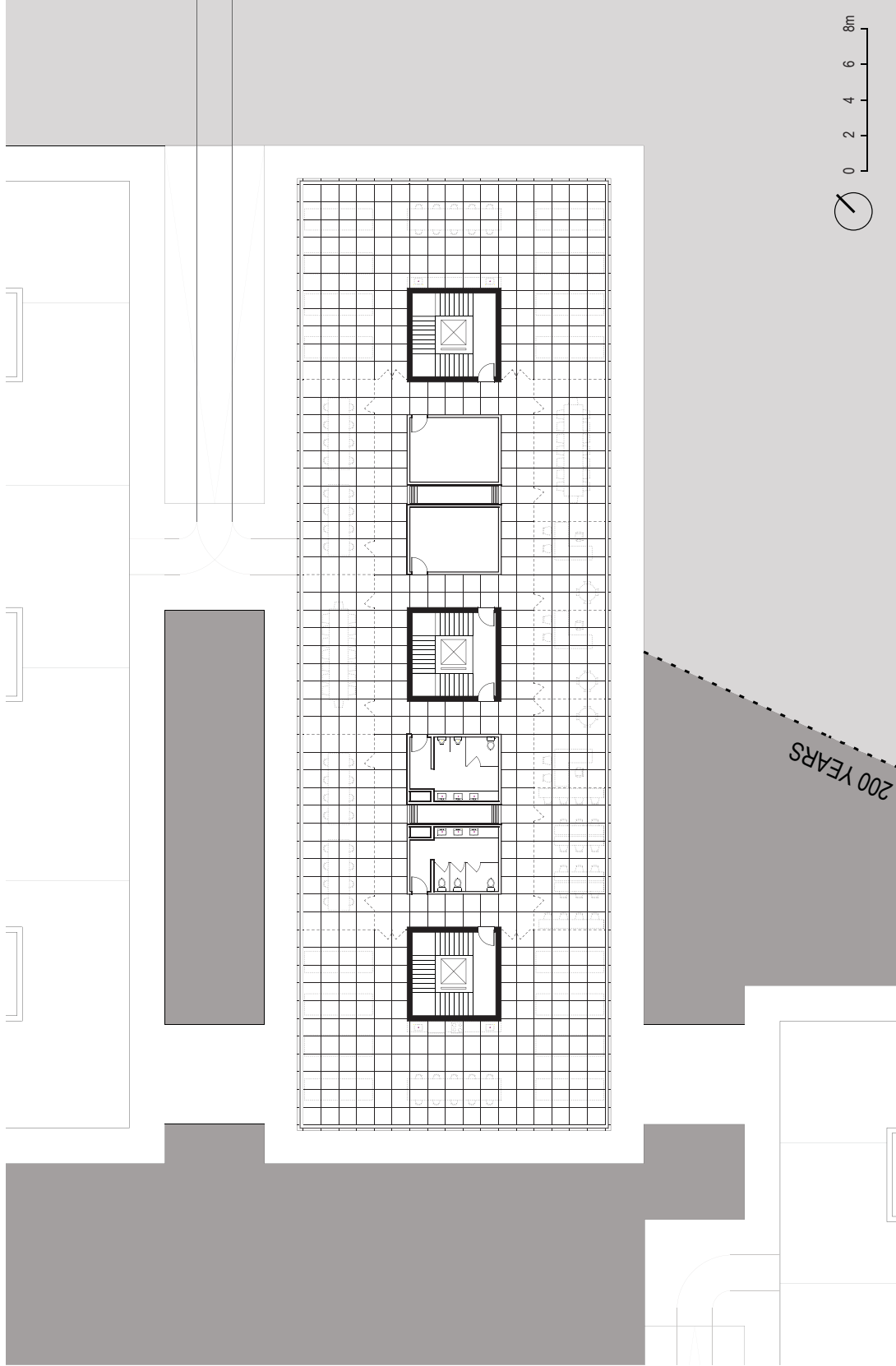
The above-ground and permanent typology is a grounded object in the landscape. As the cliff face erodes along the coastline, the building will remain static and in place. Being a permanent structure, the coast will fall away around the building, while the above-ground typology remains fixed, and a pillar within the landscape and community.

Since the building is static along the shoreline, the main structure is concrete and steel to withstand the effects of wear and weathering as the cliff erodes. As the cliff erodes, the above-typology can be used to track the rate of erosion, allowing for the building itself to teach users about the surrounding geology. The above-typology was designed so that, in the future, when the cliff substantially erodes, it can support itself and its means of circulation, connecting it to the other above-ground buildings and back to stable land. This allows the above-ground typology to act as the primary structure from which both the other typologies stem.

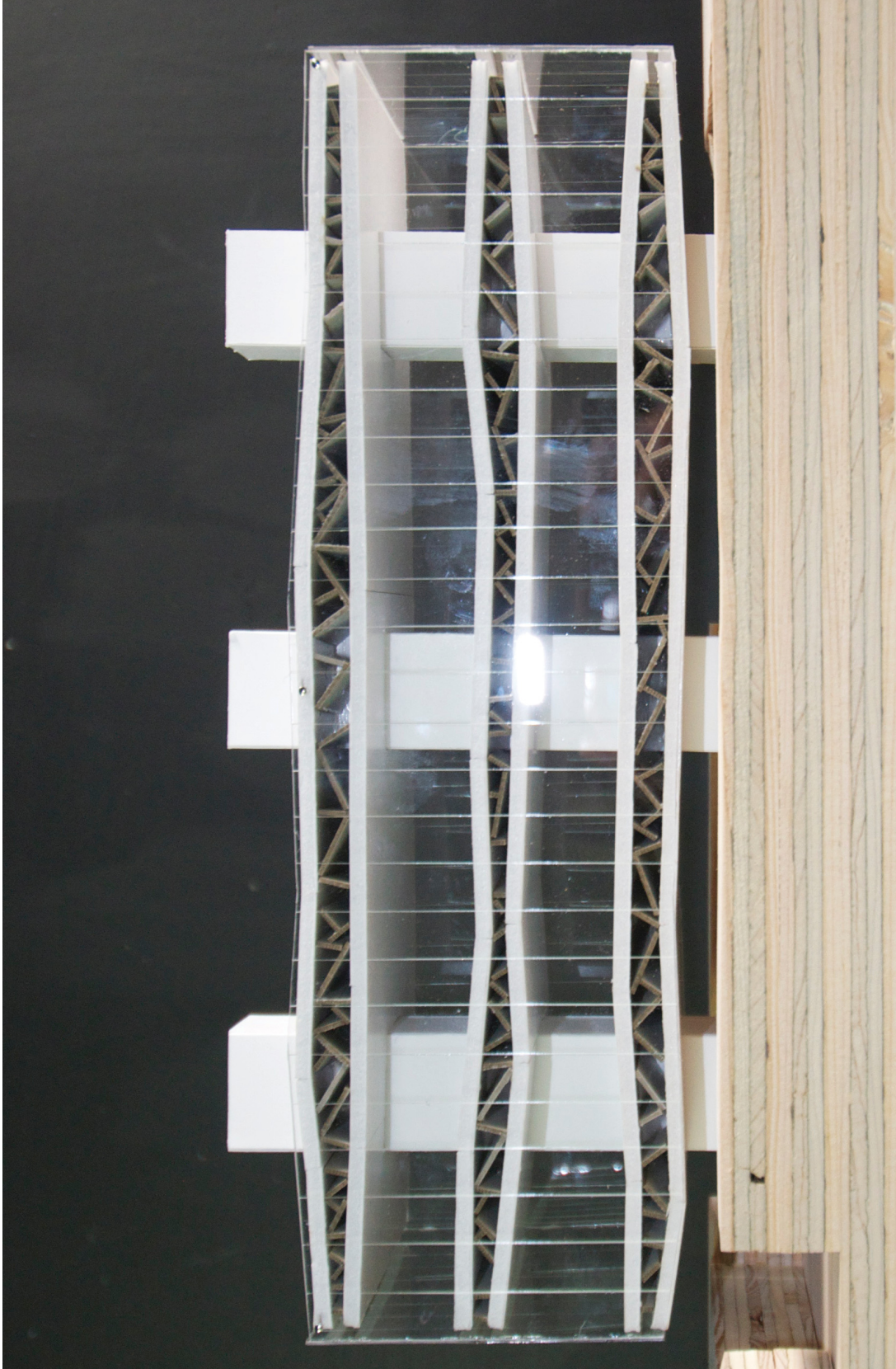
The above-ground typology is programmed to act as the main container for the Geological Centre of Cape Breton. It will host classrooms, workshops and laboratories, and offices, as well as provide community spaces. The programme will shift according to community need since the building is designed to last centuries.



Above-ground and permanent typology showing track system and incision.



Above-ground and permanent typology showing a typical floor plan.



Model of the above-ground and permanent typology.



Entering the Geological Centre of Cape Breton through the incision.



The above-ground and permanent typology after 200 years.

On-Ground

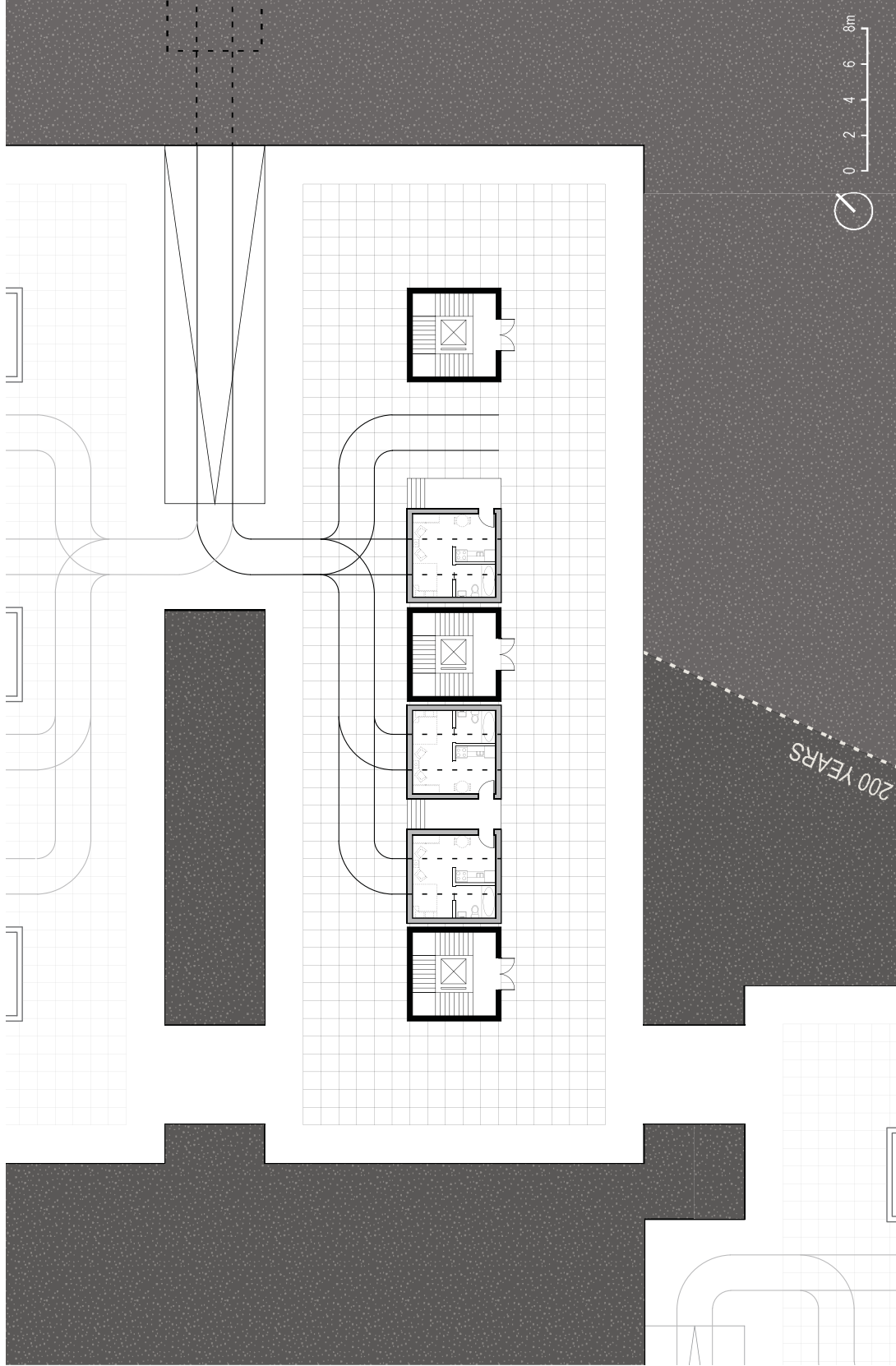
The on-ground and adaptable typology is a dynamic object, which moves across the landscape. Its movement is possible through the use of a track system, generated from the train track culture of the mines. Tracks were of such importance as they were used in the process of harvesting the coal from the depths of the mines, as well as transporting the coal to the shipyard in North Sydney. The tracks allow the on-ground typology to retreat from the moving edge condition. To power the movement of these buildings, a trolley motor is stored in the floor to utilize battery power. The trolley motor allows for the movement of a heavy object with minimal effort.

The buildings are made of pre-cast, hollow-core concrete panels to decrease weight for ease of movement, while maintaining a visual connection to above-ground typology. Through the use of concrete panels that resemble the core shafts in the above-ground typology, it can be imagined that a single core was sliced into equal segments and scattered across the site.

This typology, which is programmed as accommodation suites, eventually docks onto the above-ground and permanent structure when the coast erodes to the point where there is no more space for them to inhabit. The tracks allow for the dispersed, adaptable buildings to gather and descend down a small ramp to an area in the above-ground typology designed to host them in the future. The on-ground and adaptable typology changes to the circumstances of erosion. They are capable of moving away from the cliff to different degrees depending on the rates of erosion at their specific location.



On-ground and adaptable typology showing track system and incision.



On-ground and adaptable typology showing how to dock to the above-ground typology on the track system.



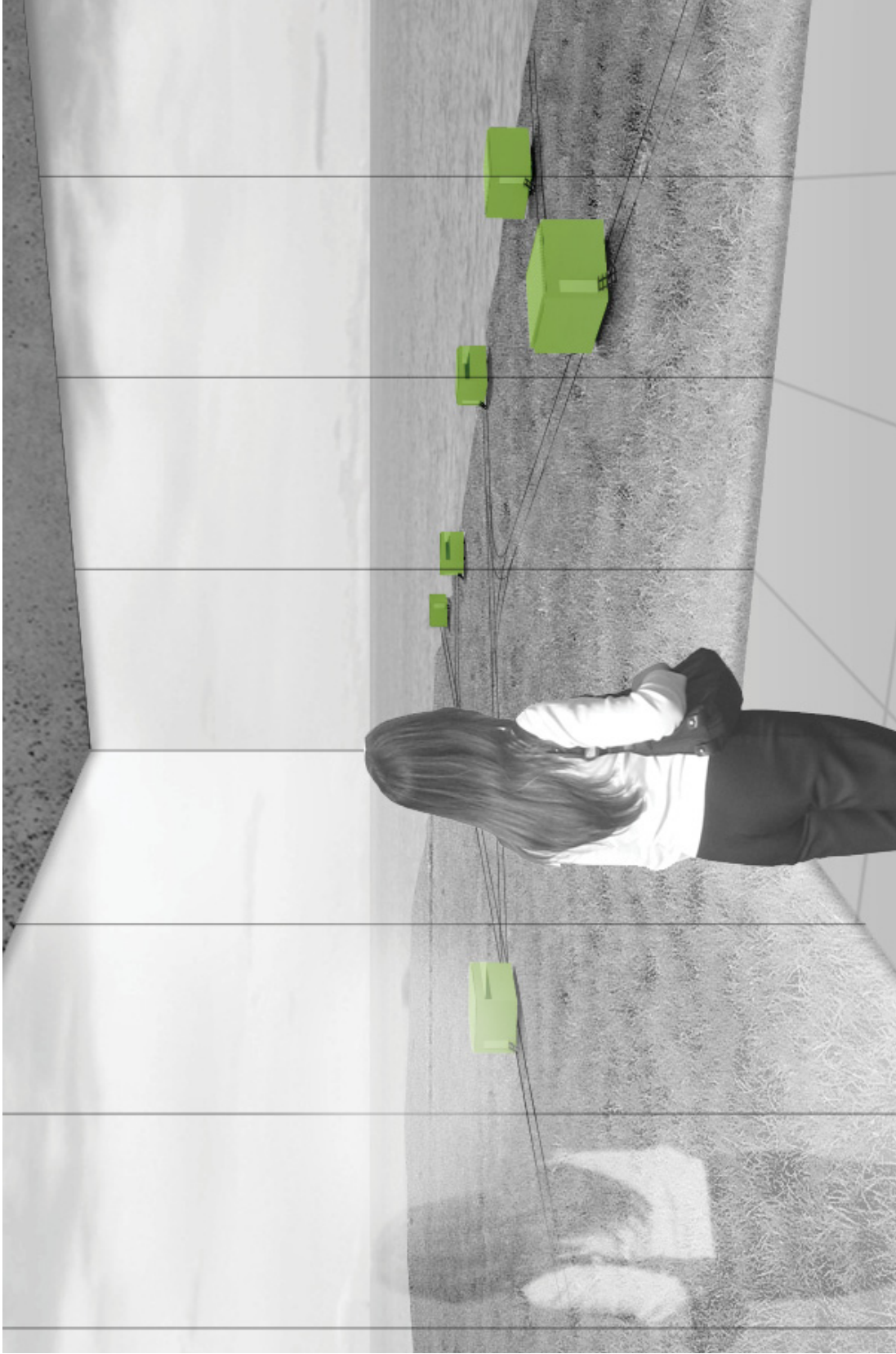
Model of the on-ground and adaptable typology showing relationship to the cliff edge.



The on-ground and adaptable typology docking into the above-ground and permanent typology.



The on-ground and adaptable typology moving away from the eroding cliff.



Looking out towards the on-ground and adaptable typology from the above-ground and permanent typology.

Below-Ground

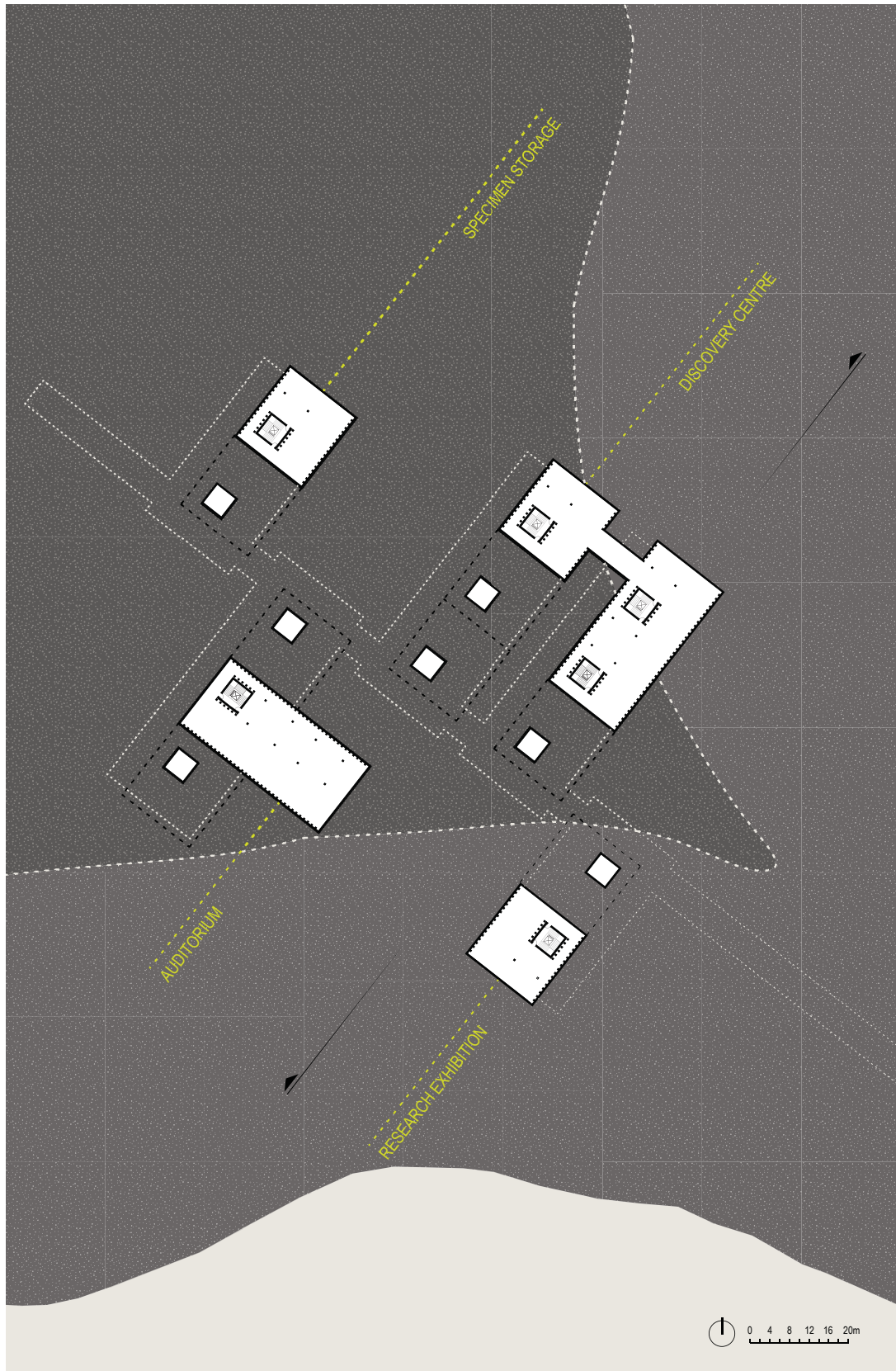
The below-ground and sacrificial typology is unseen in the immediate landscape. As the cliff erodes, in this instance, the building slowly crumbles and erodes with it, designed to be sacrificed to the climatic conditions.

With its sacrificial qualities, the below-ground typology exists as a contemporary ruin. Ruins exist in the area and remind residents and visitors of Sydney Mines' contribution to the war effort through the batteries located at Cranberry Point and Chapel Point. These ruins are a guide to what once was, and what will come, as well as determining future actions.¹⁹ At Sydney Mines, 'what once was' involves a booming mining town, 'what will come' is further erosion of the environment and community, and 'future actions', include these three building typologies of permanence, adaptability, and sacrifice. Monuments on-site, which reflect any history relating to coal extraction or steel production, do not exist. Not only would a ruin imply the past, but also the decay of the structure would ephemerally indicate the effects of erosion.

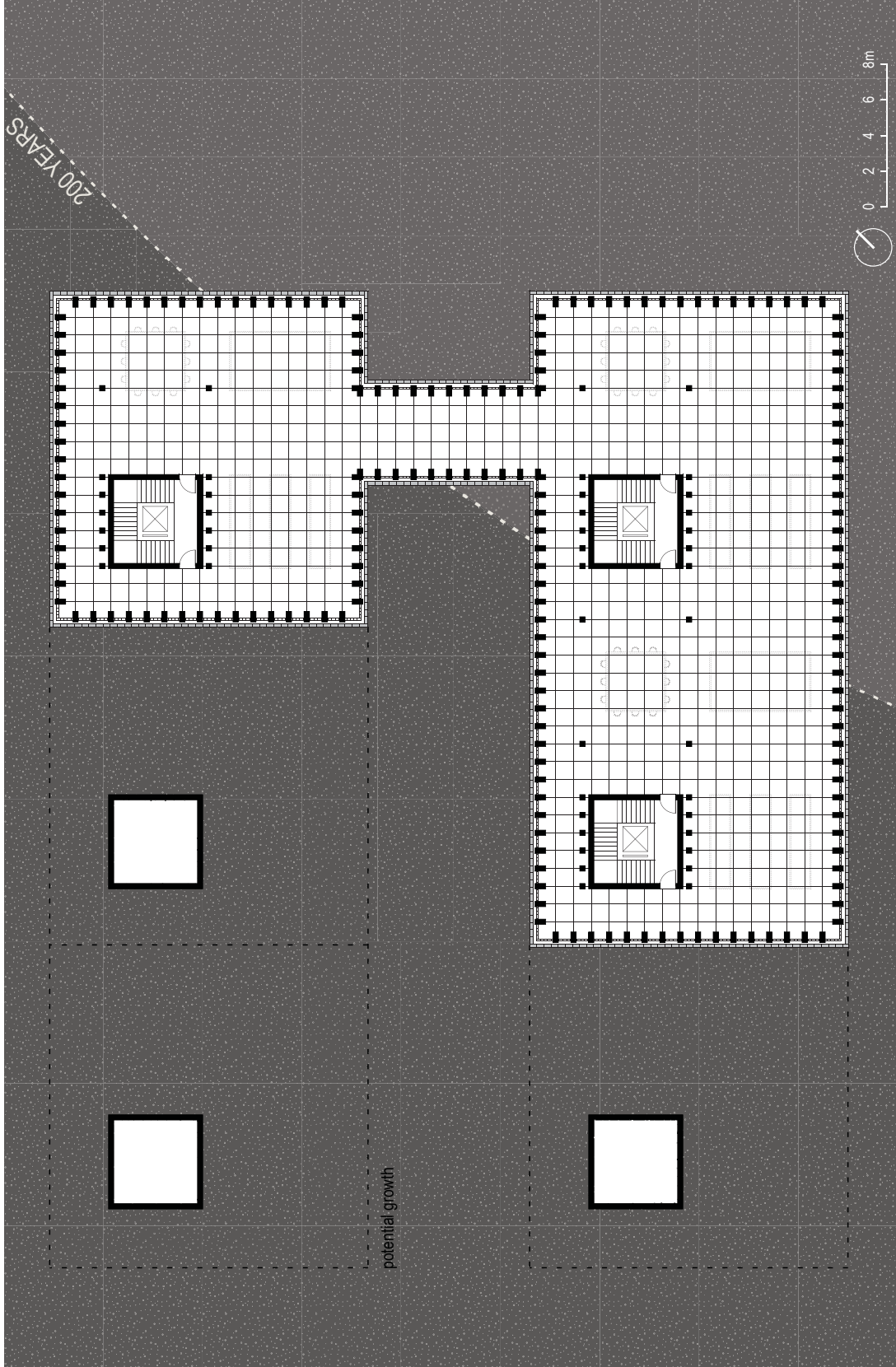
The below-ground typology is made of concrete to mirror the undulating patterns of the abstracted seam structure in the above-typology, but is constructed in a series of columns and beams to form a ribbing to allow for wear and weathering to occur. Where geology is stable enough to support its own weight, no extra support or infill materials are used to give the users a feeling of truly being in a mine cavern. The infill walls of the below-ground typology are made of brick. This creates visual differences in the rate of erosion for the structure and the fill materials.

¹⁹ John Brinckerhoff Jackson, *The Necessity for Ruins* (Amherst: The University of Massachusetts Press, 1980), 93.

The below-ground typology is programmed to contain the discovery centre with fossil, mining, and geological displays, research exhibitions, an auditorium, and specimen storage. When the building begins eroding into the ocean with the cliff, instead of condemning and abandoning it, programme is shifted within the Geological Centre, or within newly carved out below-ground spaces. There are infinite possibilities for larger or new spaces being added to the Geological Centre through tunnels and caverns connecting the below-ground typology. The spaces can easily change and adapt to the transforming needs of the Geological Centre and the community. When the below-ground typology begins eroding into the ocean, the ruins become lookouts and outdoor display areas so they may still be in use while being sacrificed.



Below-ground and sacrificial typology showing relationships to other typologies.



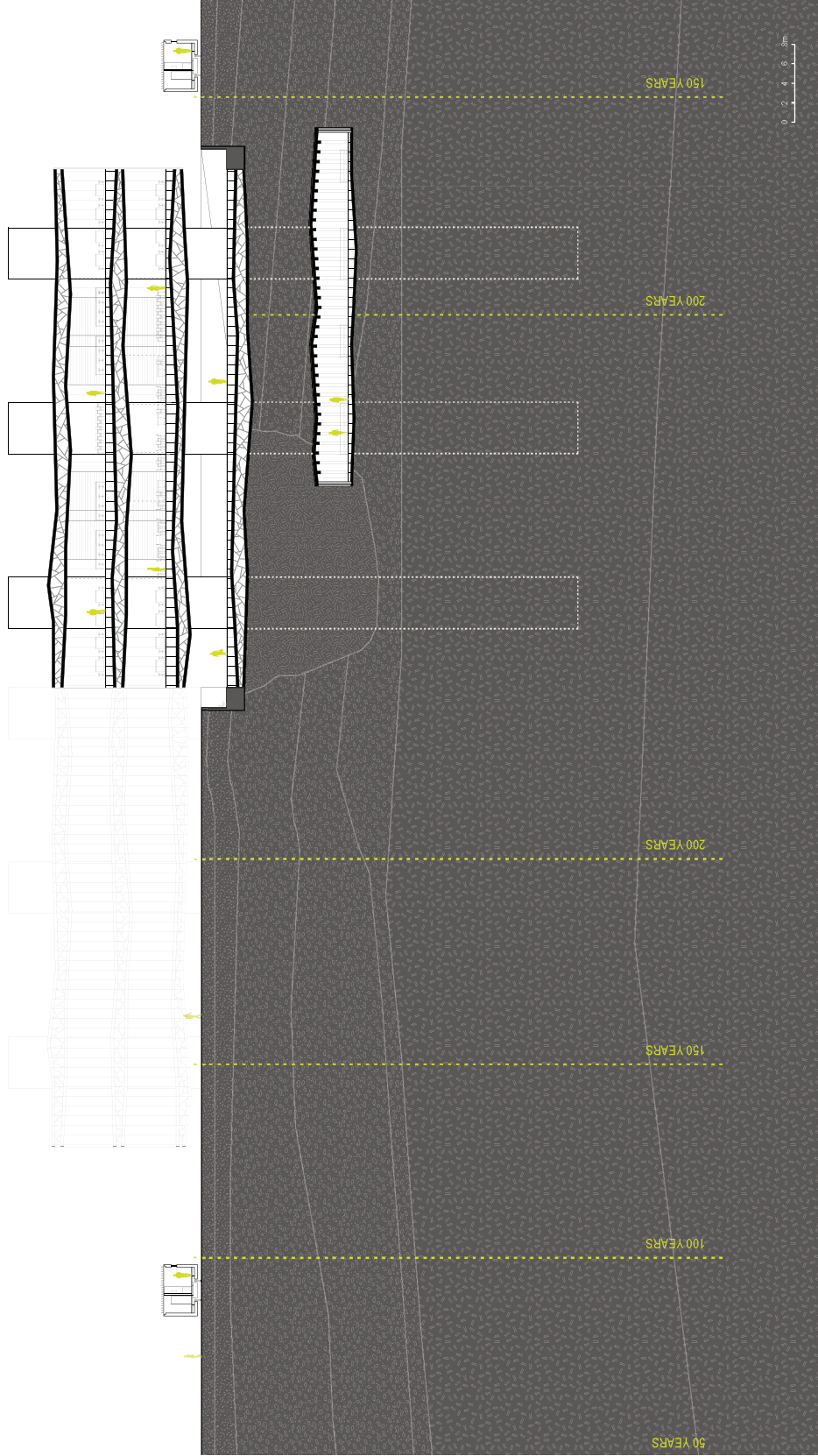
Below-ground and sacrificial typology showing the potential of growth through further carving-out of new space.



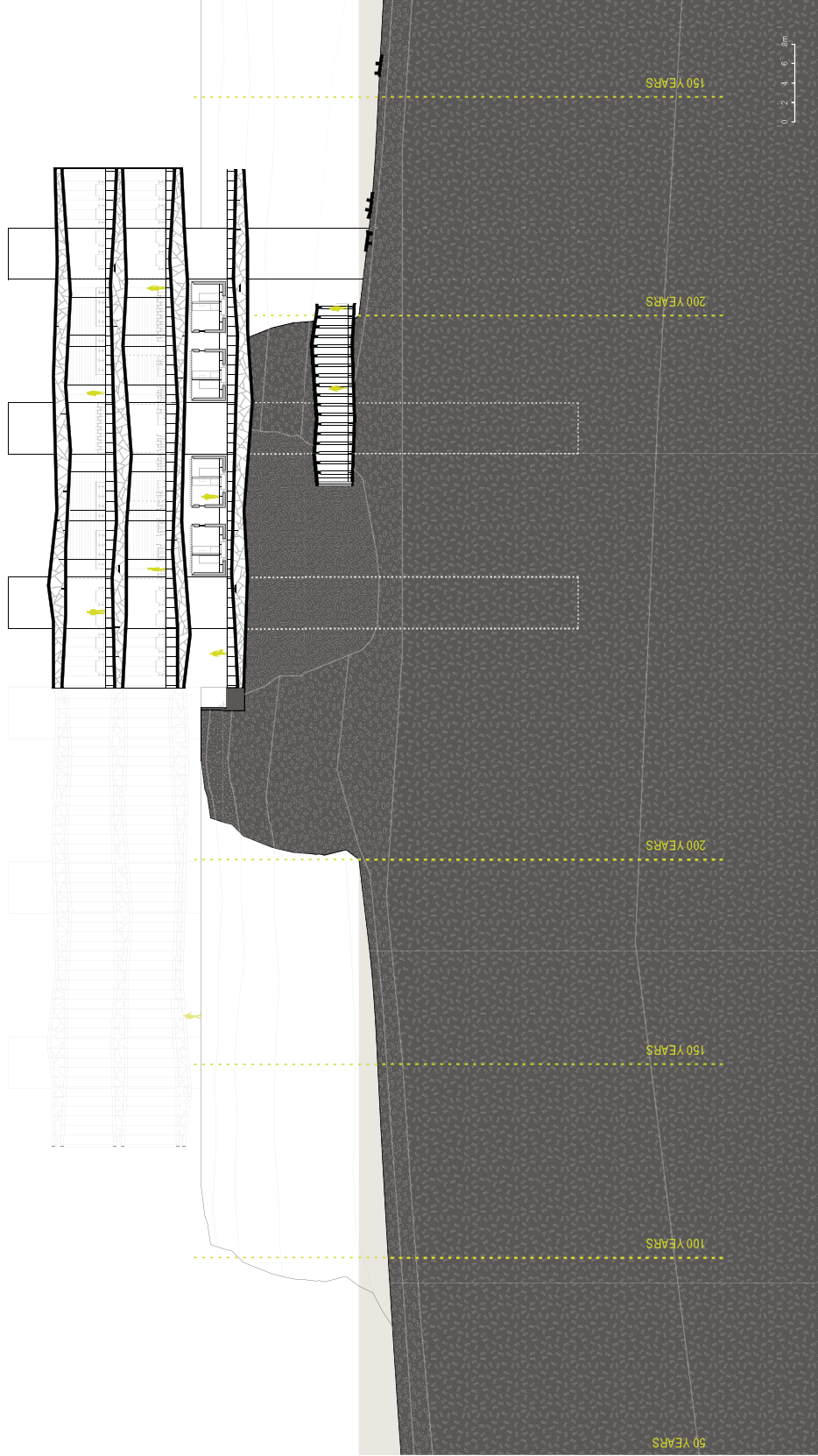
Model of the below-ground and sacrificial typology showing the space carved into the geology.



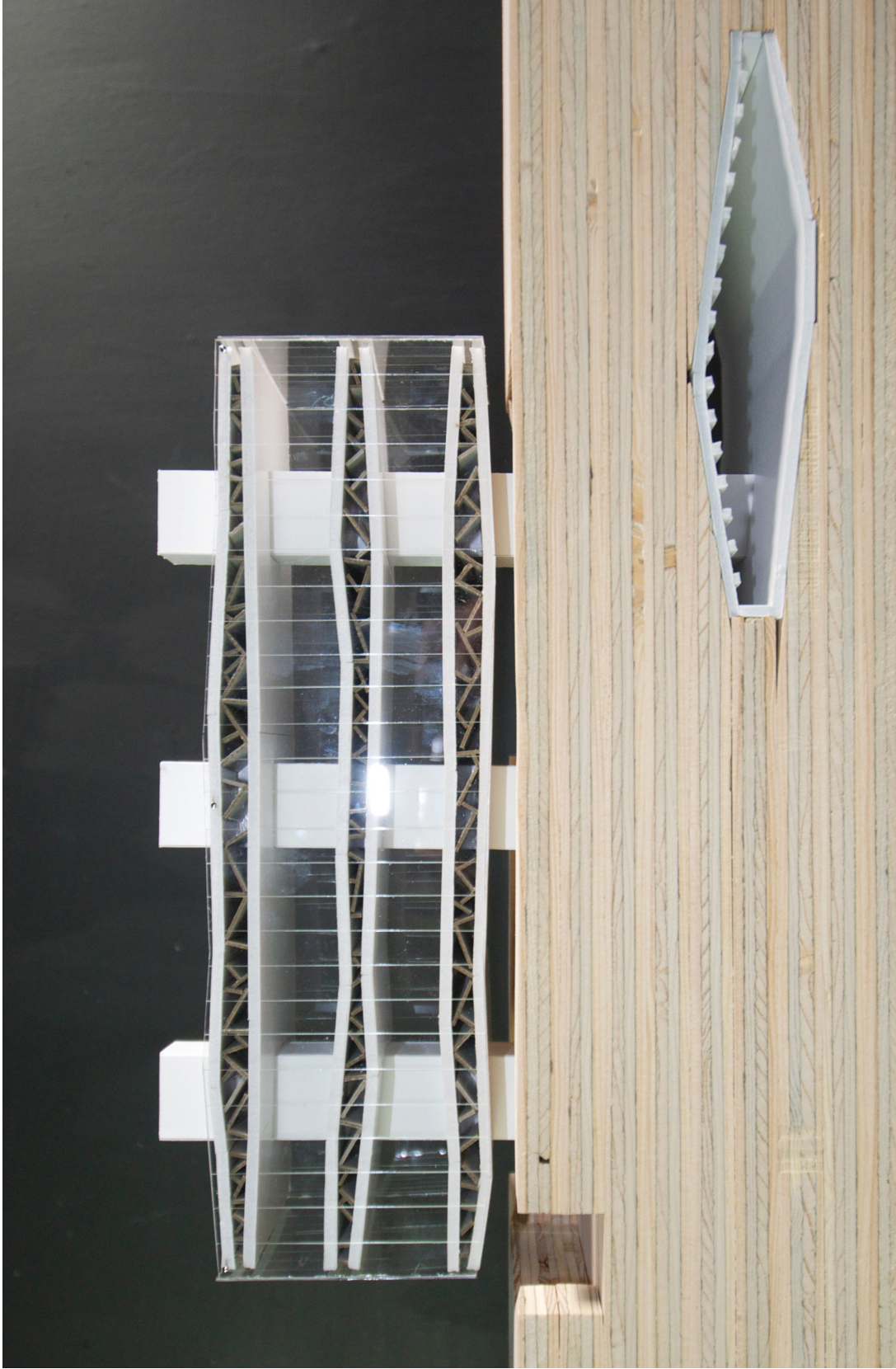
Below-Ground and Sacrificial Typology showing the exhibition space.



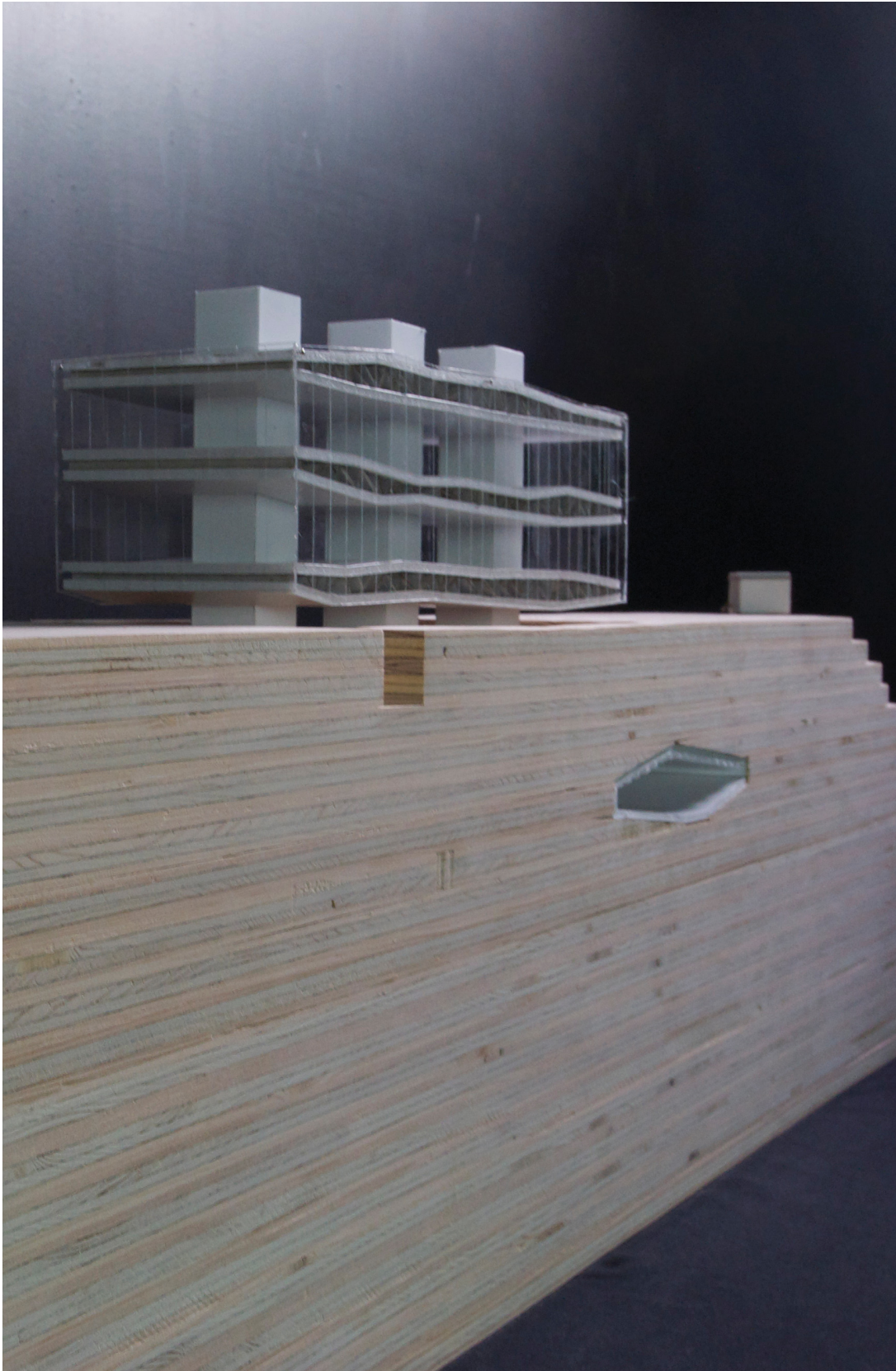
Section showing present-day conditions.



Section showing future conditions.



Model showing both the above and permanent, and the below and sacrificial building typologies.

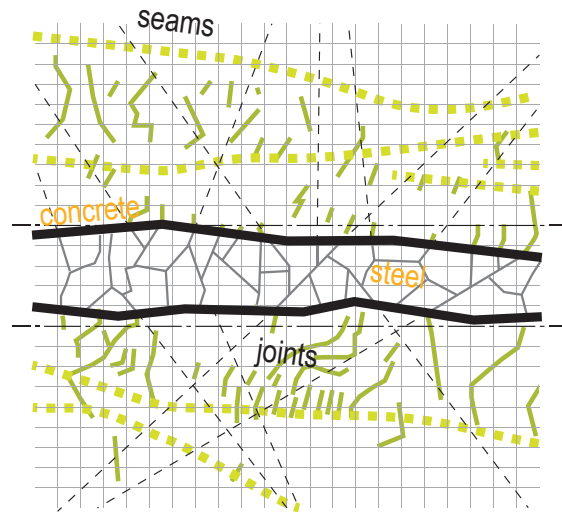


Model of the three building typologies showing their relationship to one another.

Structure

Geological Structure: Joints and Seams

While investigating geological layering as a means of a structural strategy, the cliff face of Swivel Point was mapped with regards to the horizontal seams and vertical joints. Within geological layers, the seam is a layer of sediments and minerals, and the joints are the cracking and splitting showing where structural weaknesses are located in the rocks. Where joints occur between seams is an indication of where load is transferred.



Floor structure based upon the joints and seams of sediments and minerals.

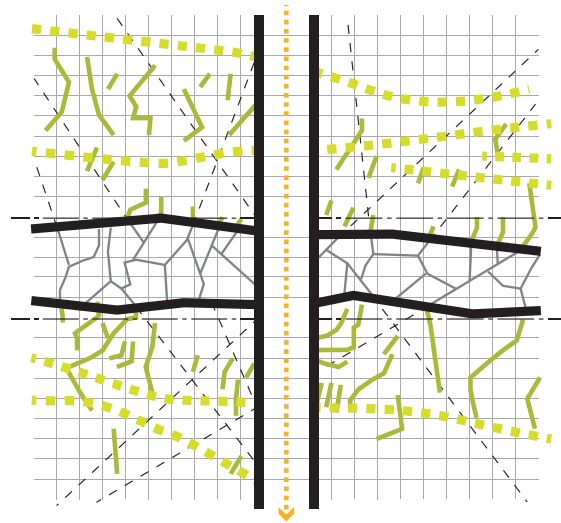
By translating this idea into structure, the joints and seams can be abstracted. Isolating one series of joints and seams to create a floor structure generates a structural floor system, which directly relates to the geological processes that occur on the site. The structure is made out of steel plates portraying the joints in the cliff face. These steel plates are welded to a grid, which is further encased in concrete creating the conceptual seam.



Model of the abstracted joints in seams of a cliff face.

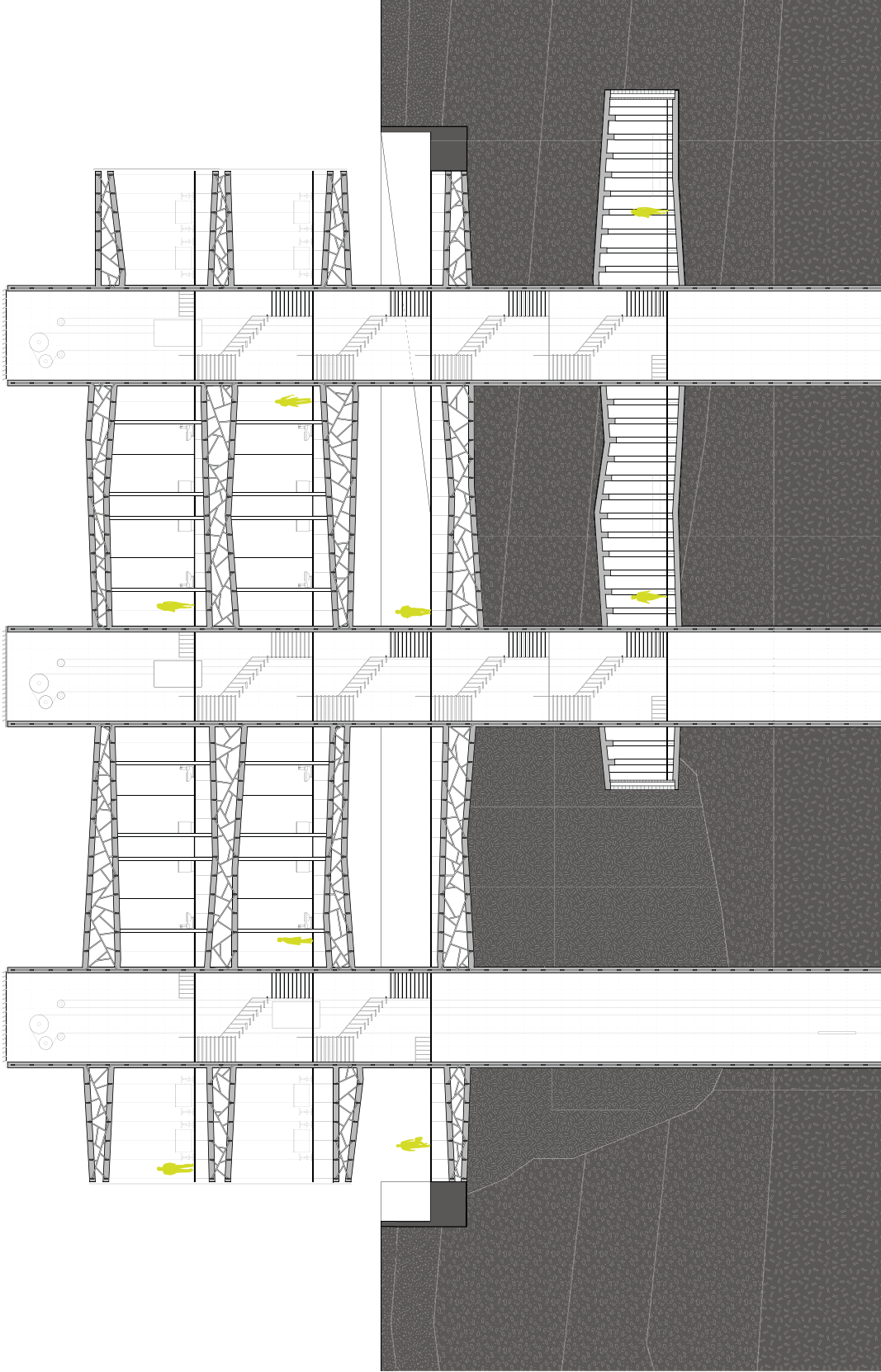
Cores: Penetrating Layers

The floor structure is connected and welded to a steel and concrete core creating a complete structural system. The cores act as the connecting and grounding element of the project, and were derived from the function and experience of a mine shaft. A mine shaft punctures the geological layers, and penetrates great depths into the earth. The cores, to establish themselves and remain stable once the coast erodes, also significantly burrow into the ground. The vertical element of the core penetrates both the abstracted and artificial layers of the above-typology, while also cutting into the physical geological layers below.



Cores based upon the mine shaft penetrating geological layers.

The mine shaft has a singular source of natural light from above, which is more diffused the deeper the user travels. This can be seen in the cores with artificial lighting becoming the dominant lighting source the further from the surface the user moves.



Structural section showing both the above and permanent, and the below and sacrificial building typologies.

Pathways and Landscaping

Existing pathways occur at the Princess Colliery properties, which are organic in form, and follow previously used mining roads and trails on the site. Further pathways were introduced following the site strategy, and aligned with the axis mine tunnel and coal seam. Landscaping has been established to outline where historic mining infrastructure once stood, through the use of a limited amount of bricks and vegetation. Organic and newly established pathways weave through the landscaping of the historic buildings, giving users of the Geological Centre an experience of being part of the mining history upon Princess Colliery. Pathways also lead visitors along the cliff trail to experience the inhabitability of the edge.

Adaptation and Evolution

Interior Partitions

The open floor plan of both the above- and below-ground typologies allow for flexible interior spaces. Interior walls are adaptable partitions, which move through the space on tracks that are built into the raised floors to temporarily divide areas to delineate function. This allows for a shifting programme according to community needs throughout time.

Exterior Skin

The above-ground typology has an exterior skin of glazing. These glazing panels have the ability to slide to the edges to completely open up part of the façade to the exterior. This allows for interior spaces to spill out to the exterior for a variety of community or institutional events. Throughout the life of the building, as the glazing panels become worn or damaged, they can be easily replaced.



The above and permanent typology shifting programme to become an indoor-outdoor theatre space.

CHAPTER 3: CONCLUSION

Throughout Cape Breton, coastal communities have been notoriously predisposed to erosion. This erosion describes two areas threatening these communities, in both the environment and the socio-economic contexts. With the loss of the coal industry, and the growing of climate change, erosion is accelerating. This leaves towns in risk of shrinking, and becoming neglected places that are poorly populated, as made evident by the increasing coastal erosion and out-migration rates.

Although Sydney Mines has yet tentatively managed to weather the economic storm of the mine closures in the past, its lack of employment opportunities and disappearing population make further survival nearly impossible. Coupled with homes, businesses, and community infrastructure built close to the cliff, coastal erosion is appropriating their homes and livelihoods. Without an innovative design and programmatic approach in the future, Sydney Mines will face an extensive loss of habitable coastline, as well as a significant socio-economic decline. What then, will become of Sydney Mines? Is it possible for architecture to facilitate a permanent solution for the rejuvenation of Sydney Mines and other disappearing coastal communities?

This thesis exploration aims to answer that question by responding to the various conditions of the prevailing erosion, suggesting an evolving architecture and programme as a feasible alternative for the future of Sydney Mines. By creating a Geological Centre of Cape Breton as an institution within the community, economic growth and a new-found attachment to place will be stimulated, generating re-imagined possibilities for this disappearing coastal community. Through ideas of permanence, adaptation, and sacrifice applied to both facets of erosion, the Geological Centre of Cape Breton will

withstand, but also change, and accede to the fluctuating coastal conditions, and will instruct and guide future generations about designing in a dynamic coastal environment.

APPENDIX: A BRIEF HISTORY OF MINING IN SYDNEY MINES

1672 Coal deposits were identified in Cape Breton's coal.

1720 Coal mining began to fuel the fortress at Louisbourg on the south-east coast of Cape Breton Island.

1766 Coal harvesting began in Sydney Mines.

1784 Mining began in Sydney Mines, a wharf was constructed for coal shipment in North Sydney, and the Mines (Sydney Mines) was founded. At this time, roads were trails, housing was primitive, and profits were slight.

1820 Forty-two men were employed in mining.

1827 General Mining Association of Great Britain took over mining operations.

1854 Jacob Pit and Queen Pit were opened.

1863 Sydney Mines Colliery opened (closed 1962).

Operations at Queen Pit in 1864, from the Nova Scotia Archives.



1867 A shaft was sunk for Winning Pit.

1873 Princess Colliery was opened (closed 1975).

1883 Barachois Colliery opened (a small colliery, which closed 1886).

1889 The town was incorporated into Sydney Mines.

Operations at No.4 Colliery in 1894, from the Nova Scotia Archives.



1896 Greener Colliery was opened (closed 1963).

1900 The Nova Scotia Steel and Coal Co. took over holdings of the General Mining Association's operations in Sydney Mines.

1902 The Nova Scotia Steel and Coal Corporation opened a steel plant.

1907 Sydney No.2 (Lloyd Cove) Colliery was opened (closed 1916).

1908 Sydney No.1 at Princess Colliery was opened (closed 1975). Sydney No.3 (Florence Colliery) was opened (closed 1961). Sydney No.4 (Scotia Colliery) was opened (closed 1921). Sydney No.5 (Queen Colliery) was opened (closed 1916).

1920 The steel industry went into a recession. Tom Pit Colliery was opened (closed 1942). Jack Pit Colliery opened (a small colliery, which operated only one year).

1921 The Sydney Mines Plant steel operations shut down. Scotia No.7 (Alexander Colliery) was opened (closed 1925).

1922 Barrington Colliery was opened (a small colliery, which closed 1925).

1924 Jubilee Mine was closed.

1925 A large strike crippled the Coal Industry. Hartigan Colliery was opened (a small colliery, which operated 1925 and 1929).

1928 Prospect Colliery was opened (closed 1931).

1932 MacDonald Colliery was opened (closed 1934).

1938 Twenty-two lives were lost on the runaway trip car at Princess Colliery. Thompson Colliery was opened (a small colliery, which closed 1940). Black Diamond Colliery was opened (a small colliery, which closed 1940).

1940 Tomson Colliery was opened (closed 1962). Sullivan Colliery was opened (closed 1946).

Operations at Florence Colliery in 1940, from the Nova Scotia Archives.



1941 7,000 coal miners walked off the job for a five-month long wage-bargaining strike. Coal production was reduced to two-thirds the normal output.

1944 Lloyd Cove No.7 Colliery was opened (closed 1956).

1946 Pension Plan for miners went into effect

1947 13,000 coal miners across Nova Scotia went on strike for three months for a pay raise.

1950 A Coal Washing Plant was built.

Coal Washing Plant in 1953, from the Nova Scotia Archives.



1960 The last pit pony to work was at Princess Colliery

1975 The last coal mine in Sydney Mines, Princess Colliery, closed down operations.

1976 The last load of coal was removed from Princess Colliery.

1977 The closure of Princess Colliery was completed.

1983 The coal Washing Plant was closed.

1995 Sydney Mines was amalgamated with neighbouring towns by the Cape Breton Regional Municipality.²⁰

²⁰ Centennial Project, *The History of Sydney Mines* (Sydney Mines: Princess Printing, 1990), 26-30.

Christina M. Lamey, "Davis Day through the Years: A Cape Breton Coal Mining Tradition." *Nova Scotia Historical Review* 16 (1996): 22-33.

Sydney S. Slaven, *The Sydney Mines Steel Plant 1902-1921*, Last modified February 1, 2006, http://sydneysteelmuseum.com/history/sydney_mines.htm.

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