The Red + Green:

Creating a Regenerative Narrative through the Industrial Wastelands of Sudbury, Ontario

by

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The Red


Green

Abstract

Sudbury, Ontario, is recognized for its miraculous late twentieth-century Regreening efforts to remediate the smelter-polluted 'moonscape.' Yet, given the continued extractive activity and unmanaged mine waste, some areas remain subject to extensive environmental degradation. Therefore, a critical reflection on these industrial practices is necessary to continue this incomplete regenerative narrative, fully restoring all parts of the land. Thus, this thesis is informed by research into innovative ground surface treatment and biotechnologies to treat mine waste, and in regenerative architectural design principles. It demonstrates the potential of lifting the veil on hidden industrial wastelands, rehabilitating Copper Cliff's Central Tailings Area into a thriving regenerative park, and envisioning an interpretive centre into a mine waste facility that is harmoniously integrated into the changing landscape. This contributes to landscape remediation and integrates place-based storytelling to educate and empower future generations to participate in land stewardship and create ongoing sustainable environmental and social impacts.

Fig. 1 *The Red and Green Title Page [Previous Page]*

Fig. 2 *The Unique Industrial Landscape of Copper Cliff*

Keywords: Environmental remediation; Mining industry; Regenerative design; Storytelling; Industrial wastelands; Third landscape; Placemaking; Biotechnologies; Sudbury, Ontario

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Fig. 3 *Copper Cliff's Industrial Landscape and the Superstack*

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Preface

I owe a lot of my curiosity in my research journey to the unique industrial history and landscape of my hometown, Sudbury. Growing up in a city touched by evident traces of the industry, I was always curious about this legacy and wondered, “what happens to mine sites once there’s no ore left to mine?” To which my father replied that the mine shaft might be capped with concrete before the space is cleared and left behind in search of a new location to extract from. I was surpised to learn about this footprint we continue to leave behind on the natural environment. I was always amazed by this incredible story of restoring the Sudbury landscape; when I planted my first pine sapling as a child **[Fig 4]**, I first felt the importance of making an individual contribution to the regreening process that would add to an immense impact created by the community. Thinking about these wastelands left behind in industrial spaces, I knew our work wasn’t done.

Through my understanding of the Sudbury landscape, I always found it fascinating to exchange unique experiences with friends, family, and peers. This includes the strangely poetic experience of watching slag pours, tobogganing down the steep landscape, memories of playing in a once moonscape terrain, or collecting pieces of slag from schoolyards. Sharing stories and memories uniquely related to a place reinforces the importance of working to protect and restore it. If the community of Sudbury could put immense collaborative efforts into restoring a once-barren landscape, the built environment should also be active in this process. My journey attending the MSoA in downtown Sudbury ignited my passion for approaching the built environment with sustainable, biophilic, and regenerative strategies. I am incredibly grateful for my peers and professors who have inspired me and shaped my education towards this path, and that I could one day work to make a small contribution to my community.

Fig. 4 *Sapling Planted by Author as Part of Sudbury’s Regreening Initiative*

Introduction

Fig. 5 *Fossils of Trees on Sudbury's Landscape*




















Sudbury, Ontario, is a remarkable precedent of ecological remediation[1]. Nearly a century of intense mining activity and extraction has left a palimpsest of extreme anthropogenic damage to the land. As a counter-narrative to this destructive legacy, an extensive restoration effort to re-green Sudbury's 'moonscape' was undertaken in the late 1970s by researchers at Laurentian University **[Fig 6]**.[2] Applying lessons from over 40 years of local restoration ecology research has generated a success story in treating an immense polluted land mass recognized as the 'Sudbury Footprint;' restoring over 4000 hectares of the landscape with over 10 million trees planted.[3] However, continued dependence on mining activity implies ongoing practices that will continue to have major detrimental impacts on the environment for generations to come. Hence, this narrative of ecological remediation is incomplete–requiring urgent multidisciplinary attention and a critical shift in current industrial practices. For this reason, it is essential that the

Fig. 6 *The Red and Green Photo Montage in Sudbury*

1 "Regreening Awards," Greater Sudbury, accessed February 28, 2023, https://www.greatersudbury.ca/live/environment-and-sustainability1/regreening-program/regreening-awards/.
2 Morrissa Boerchers, Patricia Fitzpatrick, Christopher Storie, and Glen Hostetler, "Reinvention through regreening: Examining environmental change in Sudbury, Ontario," *The Extractive Industries and Society* 3, no. 3 (2016): 793.
3 John M. Gunn, "Global Lessons on Sudbury's Story," UN Biodiversity Convention (COP15), December 2022, https://www.unep.org/news-and-stories/story/cop15-ends-landmark-biodiversity-agreement#:~:text=The%20United%20Nations%20Biodiversity%20Conference,weeks%20for%20the%20important%20summit, Presentation.

narrative of ecological remediation in Sudbury expands and renews itself to better mitigate the negative environmental impacts of current industrial practices, but also to lift the veil on these practices and impacts happening on private property, educating and empowering people in order to move towards real community-based stewardship of the land for and by all Sudburians.

Following the accidental discovery of nickel-copper ore in the late 19th century, Sudbury was quickly put on the map with global leaders in nickel production and kickstarted the legacy of the local mining industry, which will be analyzed further in Chapter 1.[4] Although this brought a sense of prosperity to the region, these extractive practices left behind both a destructive environmental footprint, as well as several social impacts that arose within the community; compromising the safety of the lives of workers, and raising urgent health concerns throughout the city from the intense sulphur emissions from smelting operations.[5] This prompted the community of Sudbury to take action to improve the state of their surroundings, where several environmental initiatives took place in support of the regreening process.[6] Thanks to these initiatives to take back pride and ownership of the local landscape, Sudbury benefited from a preliminary regenerative story set by the community, shifting this narrative of an industrial-centred history. However, the ongoing mining activity within the region has continued to leave behind vast industrial wastelands as scars from a past legacy–most of which are hidden from the public eye, especially now that the regreening efforts have remediated most of the 'moonscape.' Most are invisible, if not for the massive Copper Cliff Vale Mining Complex, and the 381 metre-high Superstack chimney–which remains to this day a beacon of Sudbury's mining identity **[Fig. 7]**. More specifically, Vale's Central Tailings Area (CTA), being one of the largest tailings areas in Canada, hosts mine

Fig. 7 *Top of Superstack to the Bottom of the Mines in Copper Cliff Section*

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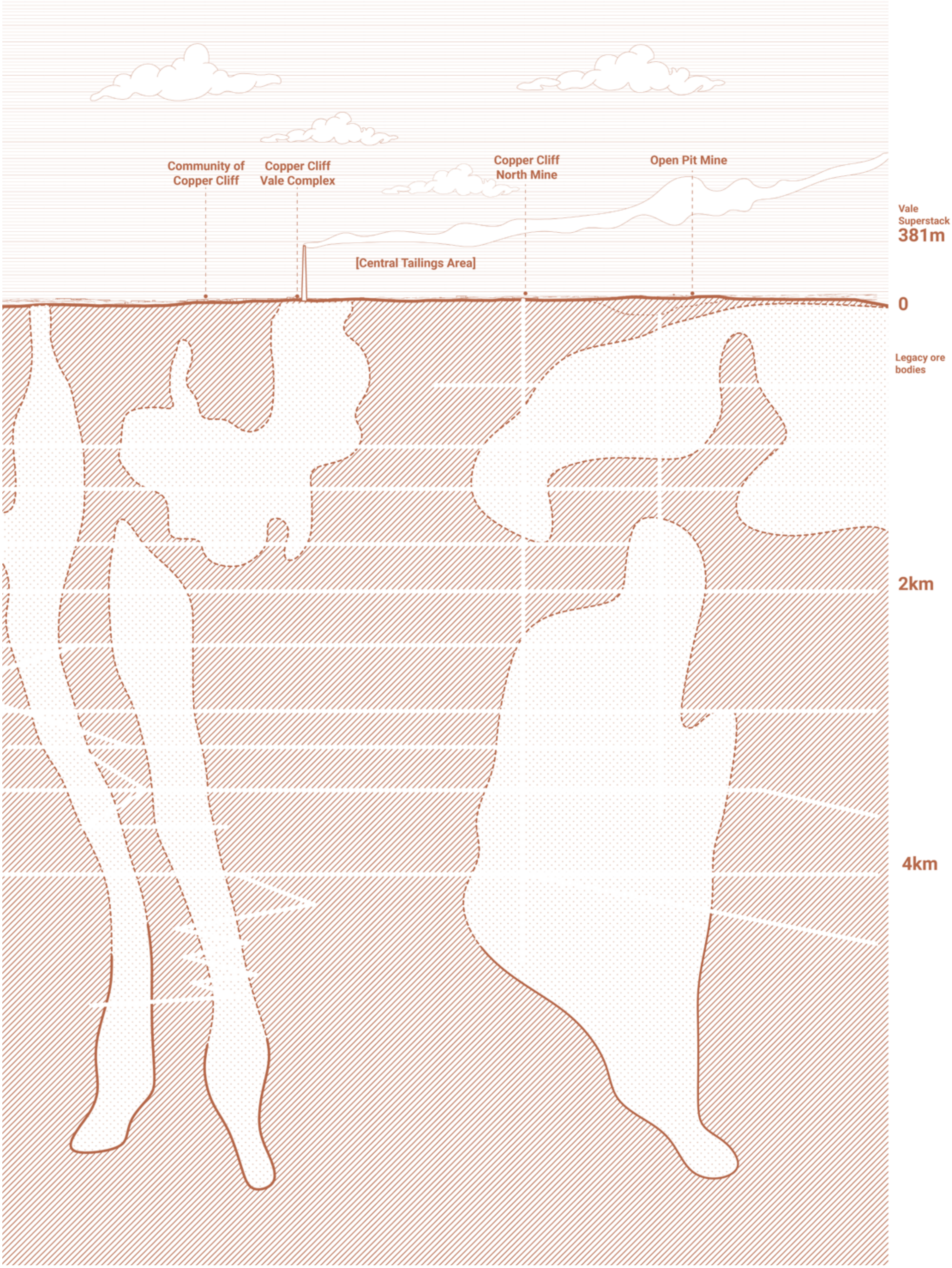
4 Desre M. Kramer, Emily Haynes, Nancy Lightfoot, and D. Linn Holness, "Dimensions of Community Change: How the Community of Sudbury Responded to Industrial Exposures and Cleaned up its Environment," *Journal of Community Engagement and Scholarship* 10, no. 2 (2018), 81.

5 David Leadbeater, *Mining Town Crisis : Globalization, Labour, and Resistance in Sudbury,* 109.

6 Desre M. Kramer, Emily Haynes, Nancy Lightfoot, and D. Linn Holness, "Dimensions of Community Change: How the Community of Sudbury Responded to Industrial Exposures and Cleaned up its Environment," 81-85.


Community of Copper Cliff
Copper Cliff Vale Complex
Copper Cliff North Mine
Open Pit Mine
Vale Superstack 381m
[Central Tailings Area]
0
Legacy ore bodies
2km
4km

waste deposits as by-products of milling and processing from extractive practices spanning nearly 8 kilometres in length **[Fig. 8]**. The tailings ponds are on private property, behind raised topography and a tree belt; as they are only revealed from an aerial view, there is otherwise little comprehension within the community of the sheer massiveness of the site and the eerily vibrant ponds that paint the landscape. Similarly, the mining itself happens fully underground through tunnels that can reach more than 4 kilometres in depth **[Fig.7]**. Although communities like Copper Cliff reside on top of the mines right next to the the tailings ponds, a clear boundary exists that ensures one cannot see the other. Nevertheless, this does not guarantee a safe cohabitation; polluted run-off flows through open-air streams that intersect the town before it is treated in wastewater infrastructure, posing continuous threats to the health of the environment and the community at large.

The mining industry and academic researchers are very much aware of the detrimental environmental impacts that are associated with the enormous untreated tailing ponds; oxidation leads to the acidification of the soils which pollutes the groundwater and greater watershed, in addition to risks of tailings dam collapses near the town.[7] As such, they are actively exploring ways to better manage mine waste and potentially remediate the extensive Central Tailings Area. To this effect, research initiatives are being carried out to explore ways to rehabilitate these industrial wastelands, which include various ground surface treatments as natural covers for these polluted sites, as discussed further in Chapter 2. Through biosolids and technosols, mixtures of crushed waste rock and recycled organic waste provide a growth substrate as a cover for tailings, which have effectively revegetated various mine sites around the community of Sudbury.[8] However, the remediation process is complex; one single solution is not viable to treat the long-term impacts of every mine site. In response to this, researchers at Laurentian University, MIRARCO, and industrial

7 Nadia Mykytczuk, "Module 5: Mine Waste Management: Legacy Challenges and Current Approaches," Environmental Remediation: Global Lessons from the Sudbury Story, Laurentian University Goodman School of Mines, Sudbury, 2018, Vimeo, https://vimeo.com/292357146.
8 Karen McKinley, "Biosolids Re-Green Mining Wasteland," *Northern Ontario Business* 38, no. 10 (2018): 11.

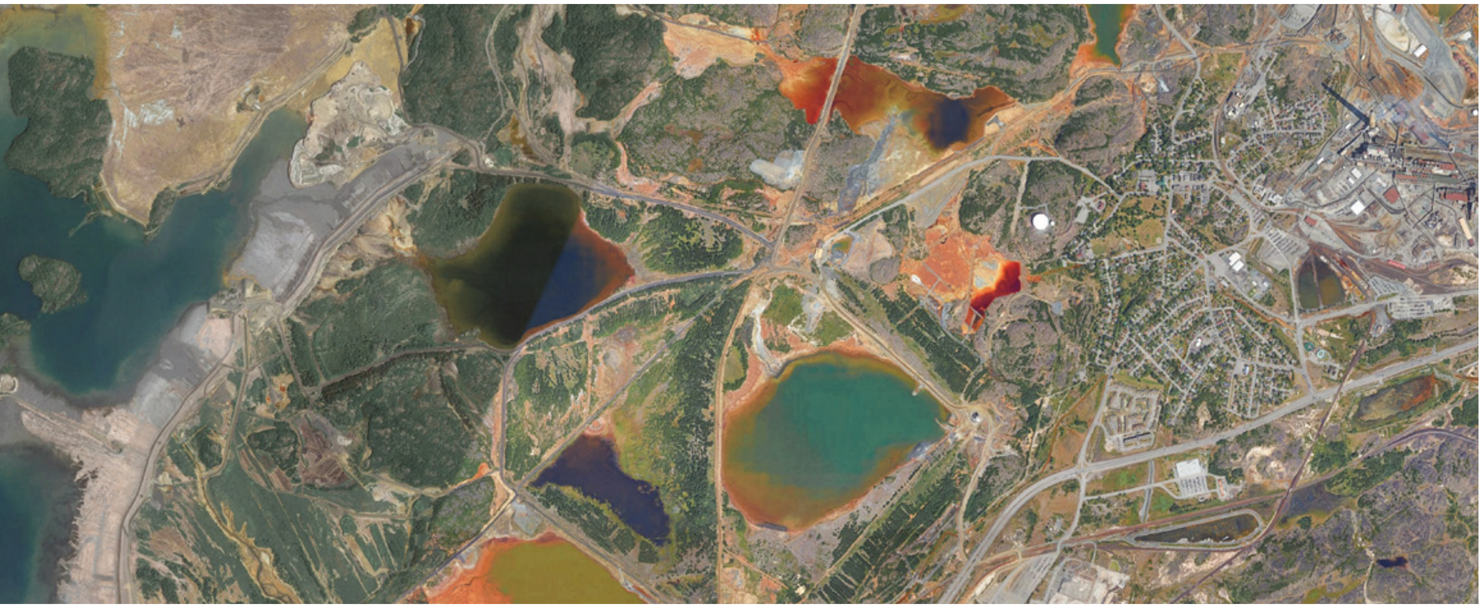


Fig. 8 *Strip of an Aerial Photograph of the Central Tailings Area*

partners are investigating promising solutions to treating active and legacy mine waste at the microscopic level. Through the implementation of biotechnologies, remaining reactive metals in tailings can be harvested by microorganisms through a natural process. These technologies not only pose a profitable solution, but also has tremendous potential to restore Sudbury's industrial wastelands.[9] As a result, a Centre for Mine Waste Research in Biotechnologies has been proposed within the community to mobilize these innovations towards large-scale restoration.[10] Currently, the proposed location for this facility is in Coniston, another historical mining town within the region, but this thesis will demonstrate (in Chapter 3) why Copper Cliff is better suited for this intervention. Placed in the heart of the massive Central Tailings Area, it could become the catalyst for major landscape remediation where it is urgently required, and in turn improve the overall well-being of the neighbouring community, as well as the Greater Sudbury area. That being said, as much as there is a dire need for a mine waste facility to remediate the landscape, this project also has the potential to

9 Nadia Mykytczuk, "Module 5: Mine Waste Management: Legacy Challenges and Current Approaches," Environmental Remediation: Global Lessons from the Sudbury Story, Laurentian University Goodman School of Mines, Sudbury, 2018, Vimeo, https://vimeo.com/292357146.
10 Nadia Mykytzuk, "The Centre for Mine Waste Biotechnology," MIRARCO, July 2021, https://miraro.org/wp-content/uploads/BioTech/Centre_FeasibilityBookletSmaller%20July%202022.pdf. PDF.

extend impacts beyond remediation, as its architecture could itself play a role in improving environmental conditions in and around its site, mobilized by regenerative design. Moreover, the project could play an active educational and storytelling role to facilitate social regeneration, by involving the community to rethink our role as stewards of the land and generate ongoing positive impacts.

To elaborate, regenerative design principles allow the built environment to become an active participant in contributing to improving the environmental conditions of a building's immediate area; for example, active wastewater management and purification allows water to be re-released into the environment cleaner than it was obtained in the first place. This emphasizes the idea of not only minimizing pollution or energy usage, but instead contributing more to the environment than what was consumed, or improving initial conditions; which is the essence of regenerative design.[11] This offers the opportunity to simultaneously remediate past and current environmental damage, and it is thus essential to further investigate this design theory (Chapter 4). Further, it is crucial to analyze the corresponding Living Building Challenge to learn about potential strategies that could be utilized to design a mine waste facility that remediates the landscape because of what's happening inside, but also because of the architecture that houses this innovative program.[12]

As previously explained, environmental regeneration may not suffice for the community members to become active participants in this new story of regeneration, to learn about what needs to be done, what is being done, and to demand the best practices and solutions to reclaim the land that was appropriated and destroyed by the mining industry. Indeed, there is also a need for social regeneration, which aims to empower the community to once again become the stewards of their landscape.[13] Social regeneration requires active participation

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11 Maibritt Pedersen Zari, *Regenerative Urban Design and Ecosystem Biomimicry,* London ;: Routledge, Taylor & Francis Group, 2018, 5.
12 "Living Building Challenge," International Living Future Institute, June 2019, https://living-future.org/lbc/, PDF.
13 Constantin Petcou, and Doina Petrescu, "Co-produced Urban Resilience: A Framework for Bottom-Up Regeneration," *Architectural design* 88, no. 5 (2018): 58–65.

to ensure the ongoing care of the holistic system, which can be manifested through educational and community-based programs that are geared towards repurposing the industrial infrastructure for public use, and educating future generations. In light of these ambitious objectives, this thesis asks the following question:

How do we remediate and repurpose Sudbury's industrial wastelands in order to educate the next generations about creating environmental and social regenerative impacts on the landscape and the community?

Recognizing the urgent need to treat unmanaged mine waste in the community of Sudbury, and to create lasting social impacts that benefit the entire community, this thesis aims to reimagine the program of the proposed mine waste research facility to be relocated into Sudbury's main industrial wastelands– the Central Tailings Area. This new building will become a catalyst to remediate the landscape, but more importantly, it will also play an active role to eliminate the boundaries separating the town of Copper Cliff from the hidden industrial wastelands. Lifting the veil over these landscapes to reveal the impacts of environmental degradation will further emphasize the needed remediation, but will also enforce a reflection to rethink the role of the community to pursue environmental stewardship of the land. Moreover, the new mine waste facility will be coupled with an interpretive centre; integrating public programs that educate the community about the remediation strategies at play, and reflecting on the destructive errors of a past mining legacy, to avoid repeating them and move toward a regenerative future. Through this healing landscape, access can be returned to the community gradually, where this polluted private property can be reimagined as a public park that will create a strong bond between the land and the community, the stewards. This idea is further grounded in design theory that emphasizes the significance of developing a strong understanding of a sense of place; to realign how people relate to the environment that sustains us and the unique characteristics that define a community in order to take pride in, protect, and enhance what already exists.[14] While orienting the design interventions within the community of Copper Cliff, it will more specifically target the most eligible agents for change; children, to curate a ripple effect of sustainable impacts over generations.[15] Utilizing current research initiatives in restoration ecology can become an educational tool for the community to better understand place, before proceeding with positive impacts and partaking in Sudbury's story of remediation.

This thesis is informed by restoration ecology research initiatives in order to reimagine the future of the industrial wastelands–the Central Tailing Area in Copper Cliff–by investigating multiple scales simultaneously, over a 100-year period (as discussed in Chapter 5). The large scale overlooks the transformation of the Central Tailings Area into a thriving public park, essentially by kickstarting the environmental remediation process. At the medium scale, several trail networks are developed within the park that curate an educational experience for the visitors, through this transforming environment. These are supported by built interventions as well as wayfinding elements that showcase the industrial past, immersing the users in Sudbury's complex layers of the natural environment through history, and stories. By weaving industrial relics into the trails, the idea is not to erase the scars of the industrial legacy but rather to embrace these elements as lessons of the past and initiate a new restorative narrative in the landscape. Finally, at the small scale, the mine waste research facility and the interpretive centre becomes a catalyst to actively treat Copper Cliff's third landscape, by introducing laboratories and support spaces that integrate innovations in biotechnologies and ground surface restoration.[16] The interpretive centre integrates community-oriented programs that weave a continuous narrative of Sudbury's complex history of the mining legacy to the restoration of the landscape, communicated through artistic media, workshops, and stories. Together, these architectural interventions will emphasize that the philosophy of

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14 "Living Building Challenge," International Living Future Institute.
15 Pamela Mang, and Bill Reed, "Designing from Place: a Regenerative Framework and Methodology," *Building research and information : the international journal of research, development and demonstration* 40, no. 1 (2012):28.
16 Nadia Mykytzuk, "The Centre for Mine Waste Biotechnology."

remediation goes beyond the landscape; Sudbury requires "an architecture that learned from our hard lessons on degradation and restoration and that took advantage of what the mining industry did not want and could destroy."[17] Ultimately reflecting the thesis title, '**The Red and Green**,' this is not only a reflection of the contrasting imagery of ongoing industrial operations with regreening initiatives in the Sudbury region–through slag pours and vibrant tailings to the transformation of a lush landscape–but it indicates that the complex realms of the Anthropocene and the natural environment must co-exist. Continuing the narrative of the community's tremendous environmental restoration efforts first requires a critical shift in industrial management practices, ultimately urging the reflection of our role as stewards of the land.

17 Jason F. McLennan, *The Philosophy of Sustainable Design : the Future of Architecture,* Kansas City, Mo: Ecotone, 2004, xxiii.

1
Sulphur + Saplings

Fig. 9 *Sulphur and Saplings*

The mining industry is embedded within Sudbury's identity and will remain active in the region for decades **[Fig. 10]**. This chapter analyzes the region's industrial history by examining the full scope of anthropogenic impacts, impeding within the environmental, social, and political realms. Subsection 1.1 analyses the exponential growth of the mining legacy resulting from the discovery of nickel-copper ore within the Sudbury Basin. With this industrial prosperity, an evident environmental footprint began to carve through the region, leaving behind devastating impacts on the landscape and severely affecting the health of the community. Subsection 1.2 discusses the formation of several community organizations in support of environmental initiatives, following the increasing awareness of severe ecological degradation. This curated collaboration between citizens to develop local restoration ecology research marked the beginning of the city's intensive regreening process.

Fig. 10 *Edward Burtinsky's Tailings #30 in Sudbury, 1996*

1.1 The [Post Meteorite] Impacts of the Mining Legacy

The geological and physical structure of the Sudbury landscape is the result of a meteorite impact nearly 2 billion years ago, leading to the formation of over 300 lakes, unique topography, and the deposit of nickel-copper ore **[Fig. 11]**. Situated on the territory of the Atikameksheng Anishnawbek, early human activity can be traced back 9000 years to the settlements of the Ojibwa people, where the region of Sudbury was one of the longest Algonquin-speaking nations.[18] Inhabitting the greater regions between Lake Huron and Lake Superior, the Ojibwa were fishers and gatherers, who grew vegetation around Ramsey Lake. A shift in activity occurred in the 17th century as the region was colonized by European settlers and became an active fur trade route.[19] Later, Sudbury became a junction to the Canadian Pacific Railway (CPR) between the Sault Branch Line and the CPR mainline in 1881, which initiated industrial activity.[20] Geographically, the region became a hub for construction activity through the expansion of the logging industry, resulting in deforestation that carved through the landscape. It wasn't until the accidental discovery of nickel-copper ore in 1883 near the McKim Township that the legacy of the local mining industry was kickstarted, placing Sudbury on the map for international leaders in nickel production.[21]

Beginning in the McKim Township, mining activity quickly expanded along the original CP rail, where the first mine officially opened in Copper Cliff in 1886.[22] Initial practices involved operating on the shallow ground surface through open pits **[Fig. 12]**. In 1888, the smelter and first **roast yards** were introduced to extract the precious minerals from the rock[23] **[Fig. 13]**. The intensity of pollutants from the extractive process created a very evident environmental footprint; during this time,

Fig. 11 *Map of the Sudbury Basin*

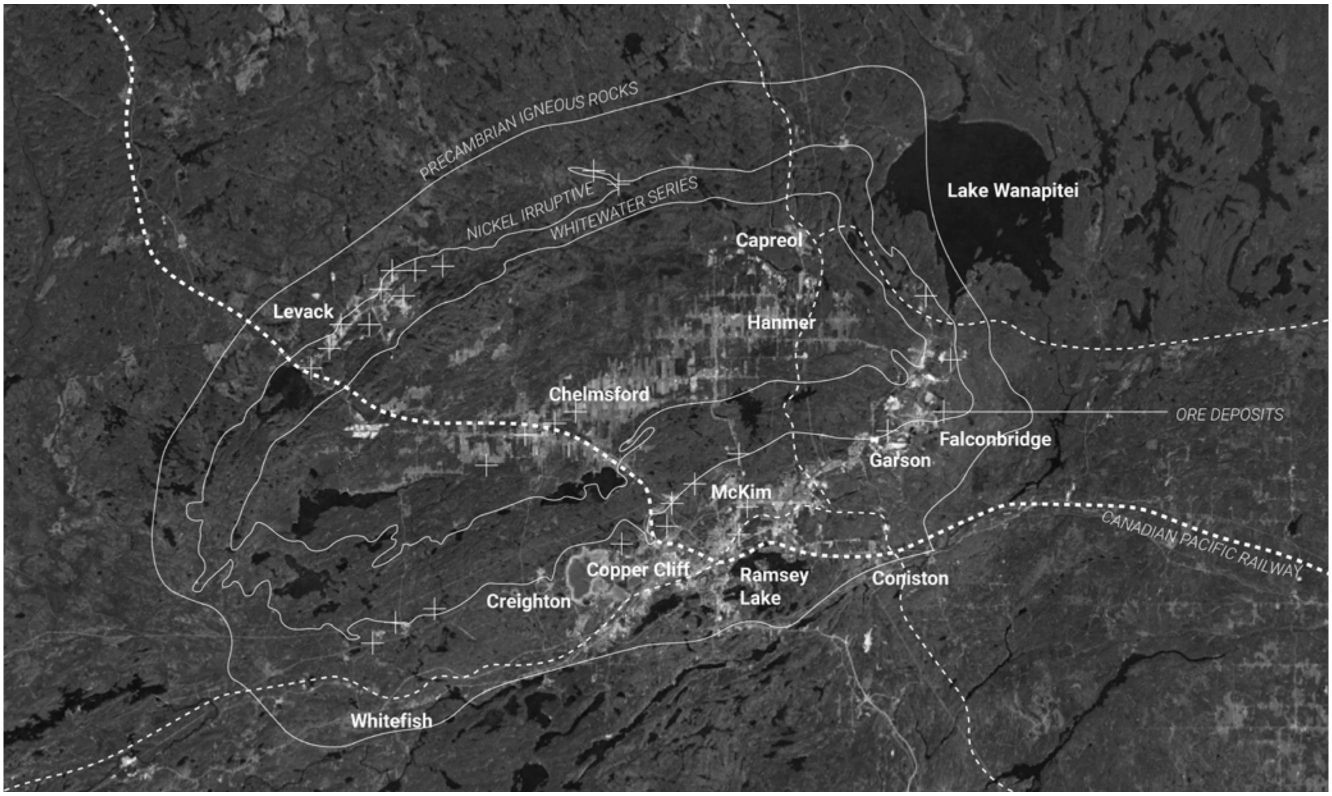
Fig. 12 *Open Pit at Creighton Mine, 1905*

Fig. 13 *Desolate Landscape following Roast Yard Activity*

Roast yards:

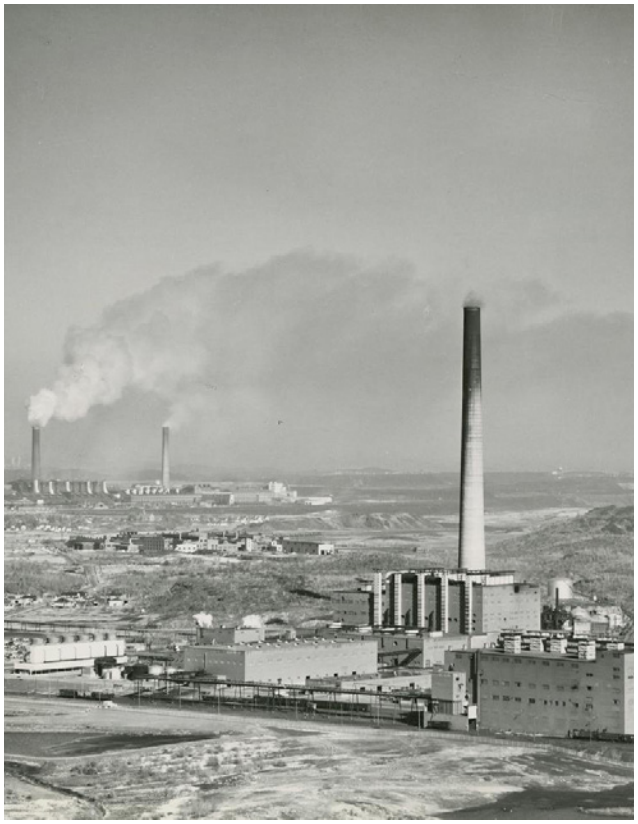
An open-air smelting process which involes heating piles of crushed ore on cordwood to extract precious minerals.

18 Adam Babin, Anissa Goupil, and Susan Manitowabi, "The Greater Sudbury Area – Atikamesksheng Anishnawbek," Historical and Contemporary Realities Movement Towards Reconciliation, accessed March 28, 2023, https://ecampusontario.pressbooks.pub/movementtowardsreconciliation/chapter/the-greater-sudbury-area-atikamesksheng-anishnawbek/.
19 Oiva Saarinen, "Sudbury," The Canadian Encyclopedia, accessed November 21, 2022, https://www.thecanadianencyclopedia.ca/en/article/sudbury-greater.
20 Oiva W. *Saarinen, From Meteorite Impact to Constellation City: A Historical Geography of Greater Sudbury,* Waterloo, Ontario, Canada: Wilfrid Laurier University Press, 2013, 62-63.
21 Ibid, 50.
22 Ibid, 51.
23 Keith Winterhalder, "Environmental Degradation and Rehabilitation of the Landscape Around Sudbury, a Major Mining and Smelting Area," Environmental reviews 4, no. 3 (1996): 187.



industrial activity released 10 million tonnes of sulphur dioxide at ground level, in combination with continuous deforestation to fuel the roast yards until 1929.[24] The opportunity to improve the inefficient refinement process attracted international companies to Sudbury, including Inco Limited, which became the region's largest mining company and, at the time, the world's leading

24 Bill Bradley, "A Primer on the Study, the Process and the Players Involved," Sudbury.com, accessed November 21, 2022, https://www.sudbury.com/local-news.



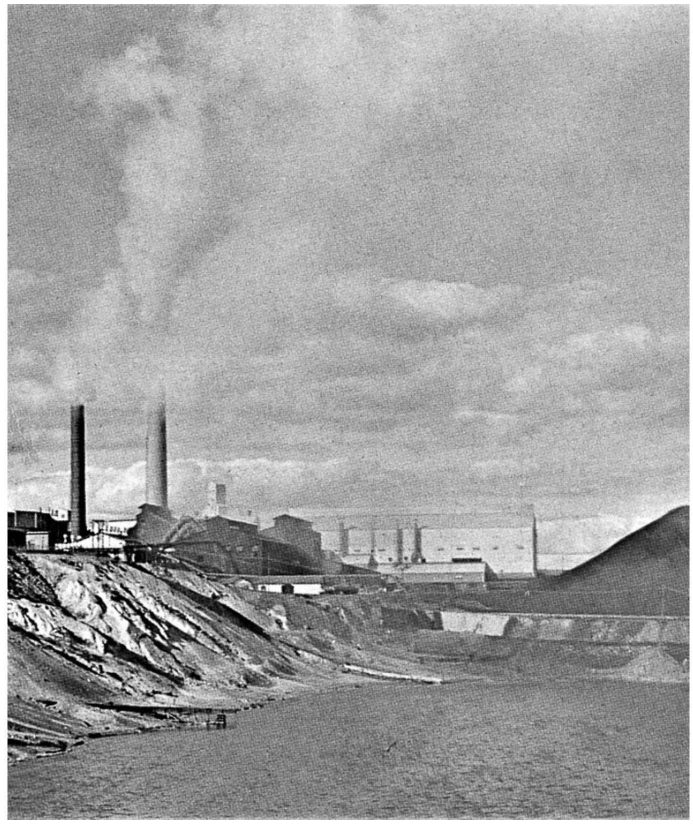


Fig. 14 *Inco Complex, 1966*

Fig. 15 *Faclonbridge Complex, 1960*

producer of nickel.[25] The mining towns experienced exponential growth through the mechanization of mining operations; by the 1950s and 1960s, the region grew into a city and became a single resource industry.[26] Industrial activity still has a strong presence in the community through two powerhouse companies, Inco (known as Vale today) **[Fig. 14]**, and Falconbridge Nickel Mines Inc. (known as Glencore's Sudbury Integrated Nickel Operations today) **[Fig. 15]**. The industry's success significantly shaped the city's development, resulting in dispersed communities throughout the greater region, forming what is infamously recognized as the 'constellation city' today.

The legacy of the mining industry is considerably associated with the Sudbury identity, bringing economic prosperity to the city, contributing to urban growth, and providing vast employment opportunities, but leaving behind severe environmental degradation. The traces of the mining industry left a palimpsest of scars in the landscape, which reveal themselves through abandoned mine sites and industrial

25 Desre M. Kramer, Emily Haynes, Nancy Lightfoot, and D. Linn Holness, "Dimensions of Community Change: How the Community of Sudbury Responded to Industrial Exposures and Cleaned up its Environment," *Journal of Community Engagement and Scholarship* 10, no. 2 (2018), 81.
26 Oiva W. Saarinen, *From Meteorite Impact to Constellation City: A Historical Geography of Greater Sudbury*, 81.

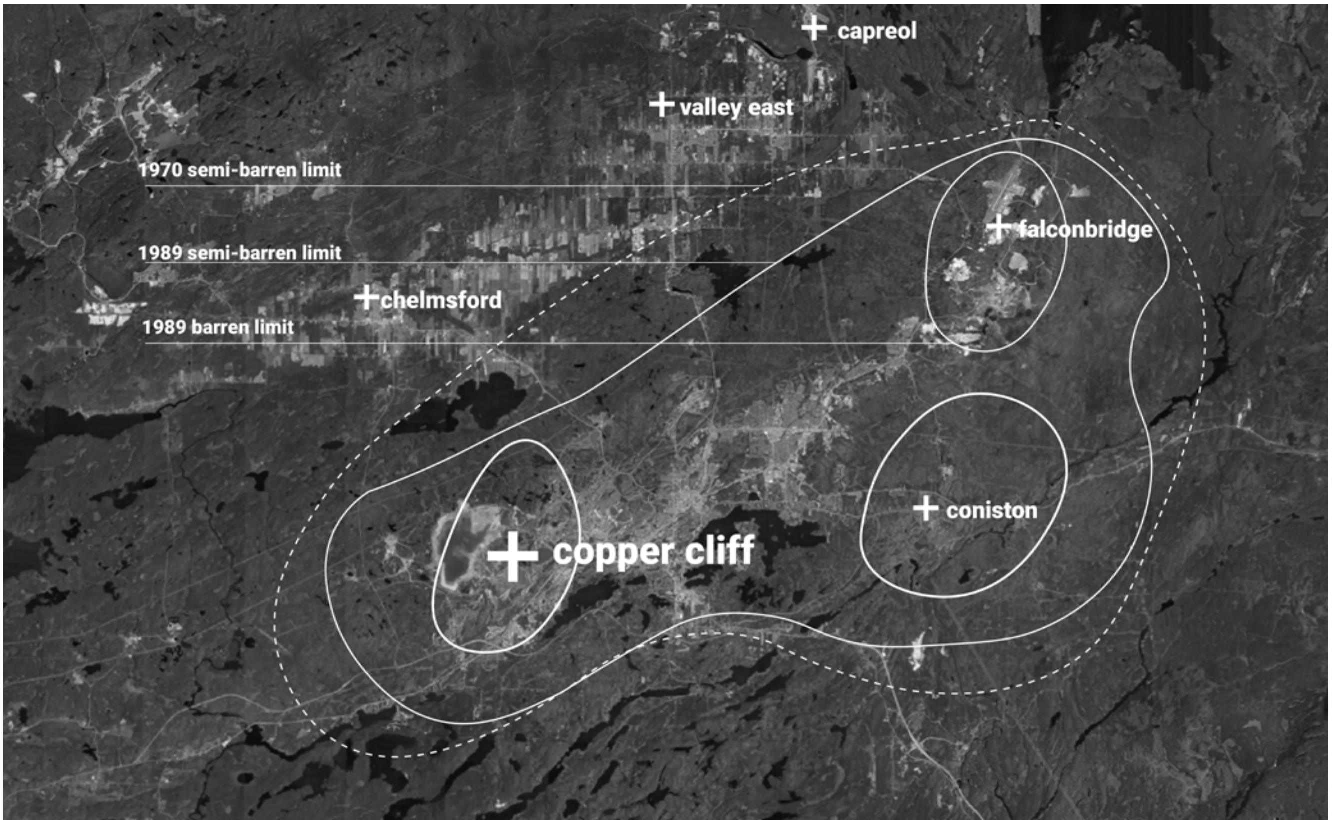


Fig. 16 *Map of Sudbury's Barren Rings*

equipment, a patchwork of mine waste and barren, sulphur-blackened rock. By the 1960s, Sudbury became the largest point source of industrial pollution on Earth. Through intense smelting activity in Copper Cliff, Coniston, and Falconbridge, the formation of '**barren rings**' were clear indicators of the extent of local environmental damage, creating horrific imagery of a barren landscape[27] **[Fig. 16]**. Sudbury became a unit of pollution, where researchers would ask;

'in terms of pollution, how many of your countries could make a Sudbury?'[28]

The mining legacy has not only imprinted scars within the physical landscape but has also affected the social and political environments of the community.

Barren rings:

The radii of polluted landscapes formed around the three main mine sites in the Sudbury region: Falconbridge, Copper Cliff, and Coniston.

27 Kramer, Desre M., Emily Haynes, Nancy Lightfoot, and D. Linn Holness, "Dimensions of Community Change: How the Community of Sudbury Responded to Industrial Exposures and Cleaned up its Environment," 81-82.

28 John M. Gunn, "Global Lessons on Sudbury's Story," UN Biodiversity Convention (COP15), December 2022, https://www.unep.org/news-and-stories/story/cop15-ends-landmark-biodiversity-agreement#:~:text=The%20United%20Nations%20Biodiversity%20Conference,weeks%20for%20the%20important%20summit. Presentation.

1.1.1 The Environmental Impacts

As mentioned, early industrial activity led to significant deforestation in the Sudbury region, which escalated soil erosion and stunted the process of ecological recession. Throughout the mining legacy, industrial activity eliminated approximately 1m of topsoil, being the most critical agent to ensure vegetation growth, which functions as the foundation of a thriving ecosystem[29] **[Fig. 17]**. Smelting activity generated the most intense pollutants during the legacy, carving barren areas into the landscape adjacent to active mine sites. The acidification of soils and watershed from metal particulate fallout generated acid rain, causing further damage to the environment and public property **[Fig. 18]**. The alteration of the territory formed the infamous 'Sudbury Moonscape' by the 1970s, where Apollo 16 astronauts conducted training on the terrain that similarly resembled the moon[30] **[Fig. 19]**. The imagery of the desolate, barren landscape is a relic of a collective memory shared by the community, where many people recall playing on the moonscape of the sulphur-blackened rocks as children.[31] The devastation of Sudbury's landscape became a phenomenon that was recognized globally and became cited as a counterexample by several environmental science and resource management textbooks.[32]

Fig. 17 *Barren Landscape in Coniston, 1960s*

Fig. 18 *Sudbury's Acidified Industrial Landscapes*

Fig. 19 *Apollo 16 Astronauts Training on the Sudbury Moonscape, 1971*

Through the rapidly increasing awareness of environmental pollution, government regulations enforced the reduction of local sulphur emissions, resulting in the construction of the iconic INCO Superstack in 1972. This 381m tall structure pierces the Sudbury skyline and is visible throughout the region–becoming the tallest 'chimney' in the world at the time[33] **[Fig. 20]**. While this innovation was successful in reducing emissions locally, it dispersed the pollutants further to a radius of 240km, affecting an estimated 100,000 hectares

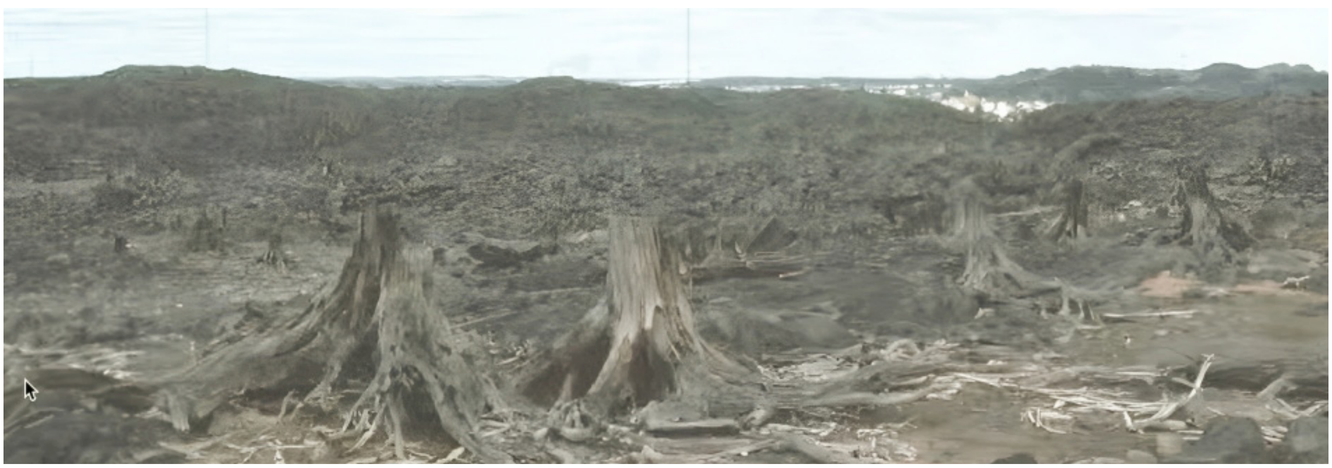
29 John M. Gunn, "Global Lessons on Sudbury's Story."

30 "Scientist Recalls Involvement with Sudbury Training for Apollo 16 Astronauts 50 Years Ago," CBCnews (CBC/Radio Canada, July 12, 2021), https://www.cbc.ca/news/canada/sudbury/apollo-asronauts-trained-sudbury-50-years-ago-1.6096556.

31 Morrissa Boerchers, Patricia Fitzpatrick, Christopher Storie, and Glen Hostetler, "Reinvention through regreening: Examining environmental change in Sudbury, Ontario," *The Extractive Industries and Society* 3, no. 3 (2016): 795.

32 Oiva W. Saarinen, *From Meteorite Impact to Constellation City: A Historical Geography of Greater Sudbury*, 103-106.

33 Jonathan Migneault, "The End of a Landmark: Reflections on Sudbury's Superstack," CBCnews (CBC/Radio Canada, March 14, 2023), https://www.cbc.ca/newsinteractives/features/superstack-reflections-sudbury.



of the natural landscape[34] **[Fig. 21]**. As a result, the emissions from intense smelting activity acidified over 7000 lakes, where some water bodies in the Killarney and Sudbury regions may never recover.[35] The environmental impacts reached as far as Mexico; this massive land mass affected by pollution became recognized as 'The Sudbury Footprint.'[36] The legacy's vast geographic extent of environmental damage became evident, being detrimental to the region's biodiversity, ecosystems, and ecological succession for decades.

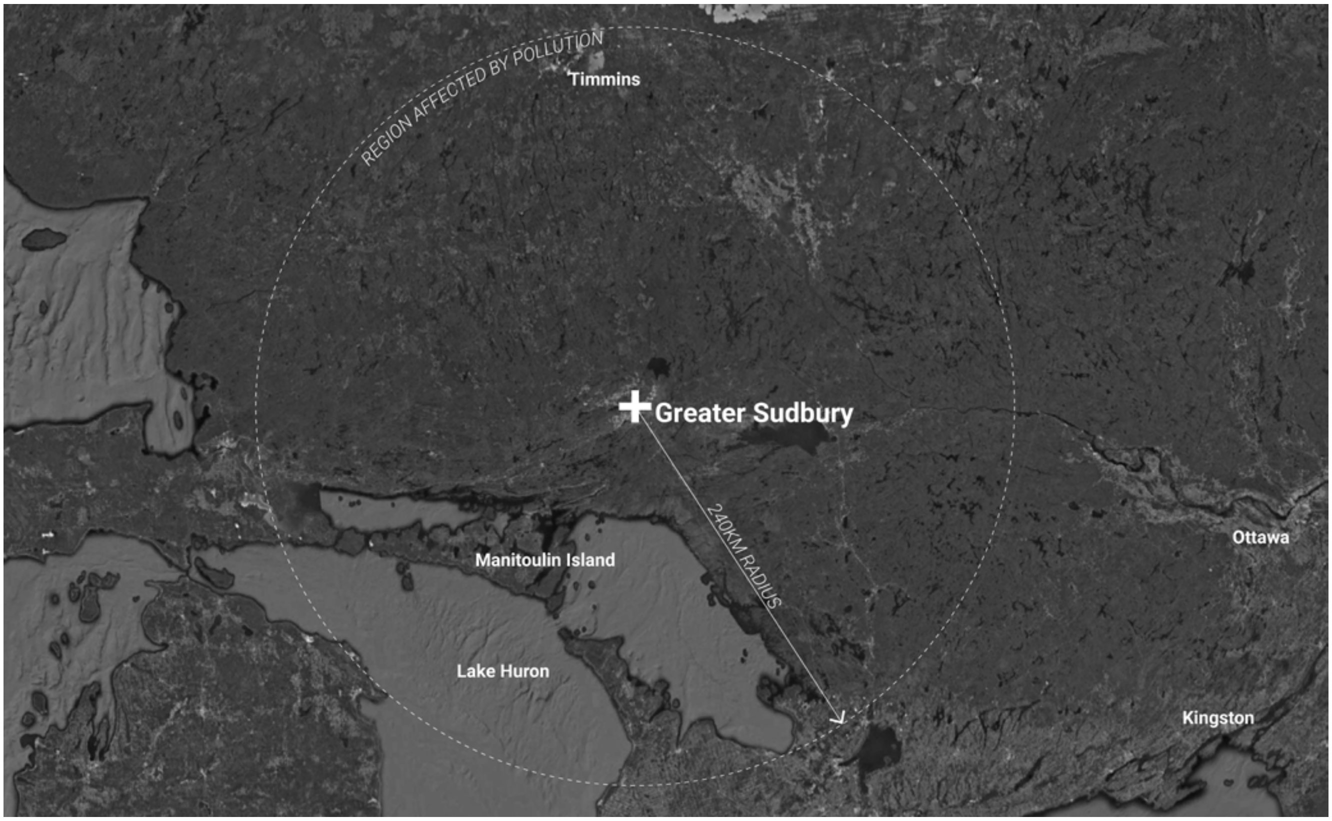
Fig. 20 *Aerial Photo of the Superstack and Copper Cliff Mining Complex*

Fig. 21 *The Radius of the 'Sudbury Footprint' Directly Affected by Pollution*

"It's a symbol that when you arrive from Timmins, you arrive from Toronto, you're arriving from Levack or Sault Ste. Marie, it's a symbol that you see many miles before and you say, 'That is where Sudbury is,' because you see the chimney before you see everything."[37]

Matteo Campagnaro
CBC Sudbury

34 Oiva W. Saarinen. *From Meteorite Impact to Constellation City: A Historical Geography of Greater Sudbury*, 81.
35 Leadbeater, David. *Mining Town Crisis : Globalization, Labour, and Resistance in Sudbury*. Black Point, N.S: Fernwood Pub., 2008, 107.
36 John M. Gunn, "Global Lessons on Sudbury's Story."
37 Jonathan Migneault, "The End of a Landmark: Reflections on Sudbury's Superstack.".



"As a child I lived in Sudbury and I remember sliding down hills in the winter and not hitting a single tree, and making forts on rock edges and using old tree roots for 'phaser' guns." [38]

unknown
40th Anniversary of Regreening

"As kids, we used to build tree forts behind our house but it was hard to find trees that were big enough. I remember the deeper you went into the forest, the less forest there was."[39]

Hugh Sheppard
Conversation with author

38 "40th Anniversary of Regreening." Over To You Greater Sudbury. Accessed January 23, 2023. https://overtoyou.greatersudbury.ca/40th-anniversary-of-regreening.
39 Hugh Sheppard, conversation with author, January 2023.

In addition to the airborne sulphur emissions that acidified the greater landscape, ongoing mining operations continue to develop a physical footprint on the ground surface through mine waste production. This waste is a by-product of the milling, smelting, or refinement processes of extracting precious minerals from the ore.[40] **[Fig. 22]**. Slag is the most prominent form–finding its way into residential driveways, schoolyards, or other substitutes for paving–as it is highly visible throughout the city.[41] In contrast, **tailings**, a quicksand-like byproduct of the milling process, occupy a larger geographical footprint and are typically hidden from the public eye **[Fig. 23-24]**. To prevent the spread of toxic dust that kills vegetation and acidifies soils, landscape initiatives involve planting grasses or capping the tailings with water to slow the oxidation process, ultimately forming extensive tailing ponds that occupy a large region of Sudbury's landscape. The oxidation of metal particulates tints the water's edge to a copper tone, which paints the ponds in the landscape with eerily vibrant colours.

Through oxidation, mine waste becomes chemically reactive and can produce **acid mine drainage**, which acidifies soils and water bodies.[42] Historical industrial practices have left Sudbury with a legacy of contaminated waste, in which these short-term management solutions are insufficient in alleviating the greater environmental impacts. The volumetric extent of Copper Cliff's Central Tailings Area is recognized as one of the largest in Canada, where it is estimated that:

"For every tonne of metal that we are extracting and producing, we're depositing about 20 to 200 tonnes of solid waste into these **tailings**."[43]

There is a dire need to address the environmental footprint left behind by these industrial practices. Moreover, current storage areas for mine waste are also an ongoing

Acid mine drainage (AMD):

Polluted water run-off resulting from waste and processes affiliated with mining operations.

Tailings:

The waste product of the milling process - consists of waste rock in a beach sand or quick-sand-like consistency. Tailings are typically mixed with water to form a slurry which is then pumped to retention areas, known as tailing ponds.

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40 Nadia Mykytczuk, "Module 5: Mine Waste Management: Legacy Challenges and Current Approaches," Environmental Remediation: Global Lessons from the Sudbury Story, Laurentian University Goodman School of Mines, Sudbury, 2018, Vimeo, https://vimeo.com/292357146.
41 Ibid.
42 Ibid.
43 Ian Ross, "Biotech Could Liberate Billions from Sudbury's Mine Waste," Sudbury.com.Accessed October 6, 2022.

Fig. 22 *Edward Burtinsky's Nickel Tailings in Sudbury*

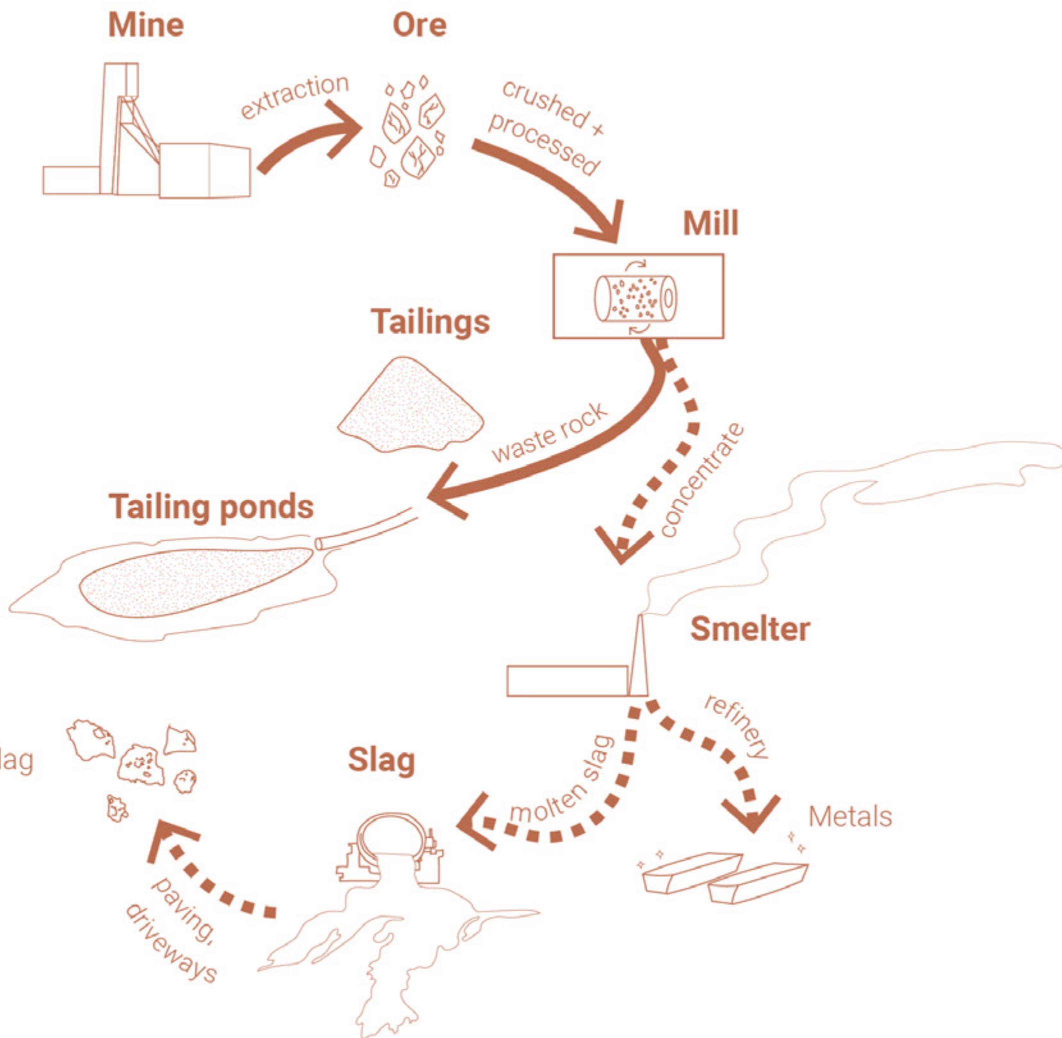
threat to the safety of nearby communities; Sudbury's tailing dams require an infrastructural upgrade and must undergo continuous maintenance, where

"[a report from Vale in 2019] listed eight dams in Copper Cliff that had an "extreme" hazard designation if they were to collapse."[44]

Unmanaged mine waste poses urgent threats to the environment, which only accelerates over generations the longer it is exposed to oxygen. Sudbury is integrated within the Great Lakes ecosystem, where polluted water from run-off through the tailings areas has become a consistent issue. More specifically, Copper Cliff's creek acts as an artery for this acidic water run-off to intersect the community before being treated in the local wastewater management facility.[45] However, not all of the particulates are removed through the treatment process before re-entering Junction Creek, effectively impacting the safety of the community, aquatic ecosystems, and the

44 Jonathan Migneault, "Avoiding Disaster: Vale Monitors and Upgrades Tailings Dams in Greater Sudbury | CBC News," CBCnews (CBC/Radio Canada, November 3, 2021), https://www.cbc.ca/news/canada/sudbury/vale-tailings-dams-greater-sudbury-1.6234260.

45 "Accent: Sudbury's Impact on Lake Huron (Hint — It's Major)," Accessed November 11, 2022, https://www.thesudburystar.com/news/local-news/accent-sudburys-impact-on-lake-huron-hint-its-major.



broader scope of the watershed that reaches Lake Huron.[46] This reinforces the idea that Sudbury's story of environmental restoration is incomplete; there's an urgency to address mine waste management solutions.

Our dependency on the mining industry indicates that the legacy will continue for decades to come–this requires a paradigm shift in terms of our current methods of extraction in order to proceed with a sustainable impact **[Fig. 25]**. A closer analysis of decades worth of restoration ecology research and research initiatives toward mine waste management solutions is crucial to taking the first step toward successfully continuing this narrative of rehabilitating the landscape.

Fig. 23 *Tailings and Mine Waste Diagram*

Fig. 24 *Edward Burtinsky's Nickel Tailings #34, in 1996*

46 "Accent: Sudbury's Impact on Lake Huron (Hint — It's Major)."

Some days, driving too fast on broken roads,
the tailings ponds sparkle turquoise, blink themselves
into being in peripheral vision- a bit seductive-
dive right into them on a hot day, just to see
how your bare feet look through that
crinkly tissue paper shade of blue.

But things in nature really shouldn't shimmer
in northern sunlight; untainted ponds of water
are more commonly painted in tones of deep navy
or ultramarine, depending on the weather and the
clouds that skirt across uncomfortably tall skies.

From here, beyond where the fence circles it
for safety, this tailings pond conjures beauty-
on days when sun slips across water.

Make no mistake: the ponds are dead inside,
and the remembered skeletons of tiny prehistoric fish
skitter across the bottom until they spin themselves
into the smallest grains of sand, swept aside and forgotten.[47]

Kim Fahner
Poem | "Tailing Ponds are Beautiful"
Emptying the Ocean

Fig. 25 *Geographical Footprint of the CTA [Next Page]*

47 Kim Fahner, Emptying the Ocean, The Goose 18, no. 2 (2020), 37.


1km
1km
[Central Tailings Area]
Meatbird Lake
Creighton
Lively


North Mine
Copper Cliff
South Mine
Kelly Lake

1.1.2 The Social Impacts

Fig. 26 *Inco Labour Strike, 1958*

Fig. 27 *Sudbury Smog from the Copper Cliff Smelter, 1968*

Aside from the traces of environmental impacts that inhabit the landscape, social impacts were also evident within the once corporate-industrial towns. The expansion of the local industry during the late 19th century led to the immigration of several cultural groups, where tangible segregation occurred in the early formations of the mining communities. Several informal settlements formed with inadequate housing conditions to host immigrant workers extremely close to industrial activity: including areas developed by Italians and Poles in Coniston, Finns in the South of the Region, and the community of Little Italy forming beneath the first smokestacks.[48] The growth of these communities led to the creation of several cultural spaces, such as clubhouses in Copper Cliff, expanding to the Donovan to contribute to the socio-cultural fabric of the city.[49]

Moreover, several labour strikes within the 1970s expressed urgent concerns for the safety of miners through the increased fatalities within Ontario.[50] Particularly, the extremely low wages and dangerous working conditions led to massive labour strikes against the Sudbury mining company Inco in 1958, and again in 1978-1979[51] **[Fig. 26]**. It is evident that outside of the industry's ecological footprint, there were implications that also impacted the social and political spheres of the community. Many stories have been documented and re-told regarding the experience of the sulphur dioxide-rich atmospheres downwind of Sudbury's mining operations **[Fig. 27]**. The health of the community has been a predominant concern over decades, where consistent complaints about lack of visibility, difficulty of breathing, and the smell made even the downtown area 'unbearable.'[52] The volume of the sulphur content in the air led to several hospitalizations and evacuations.

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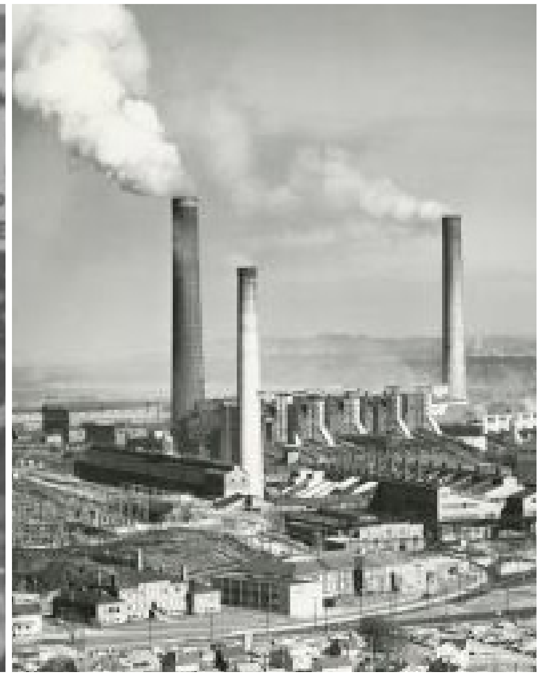
48 Oiva Saarinen, "Sudbury: A Historical Case Study of Multiple Urban-Economic Transformation," Collections Canada, Accessed March 5, 2023, https://www.collectionscanada.gc.ca/obj/thesescanada/vol2/OSUL/TC-OSUL-288.pdf, PDF.
49 Oiva W. Saarinen, *From Meteorite Impact to Constellation City*, 98-100.
50 Desre M. Kramer, Emily Haynes, Nancy Lightfoot, and D. Linn Holness, "Dimensions of Community Change: How the Community of Sudbury Responded to Industrial Exposures and Cleaned up its Environment," 84.

51 Heidi Ulrichsen, "Passing on Lessons from the 1978-79 Inco Strike," Sudbury.com, December 15, 2009, https://www.sudbury.com/local-news/passing-on-lessons-from-the-1978-79-inco-strike-226784.
52 David Leadbeater, *Mining Town Crisis : Globalization, Labour, and Resistance in Sudbury,* 109.



"Growing up in Coniston, I remember the barren hillsides around our small community, and the many days when prevailing winds carried sulphur into town, caused burning throats and eyes, and forcing the closure of windows during the day."[53]

Wayne Hugli
Sudbury Memories

"Old stories, flowers pressed in a prayer book:
How my dead relatives would hose off
The flower garden every morning at dawn,
The dew clinging stubbornly to stems and
Painting the backs of ladybugs. Even
The earwigs mistook them for simple beetles." [54]

Kim Fahner
Poem | Taking Down the Stack, Copper Cliff
Emptying the Ocean

53 Vicki Gilhula, "Memory Lane: Sudburians Recall How They Came Together to Heal the City's Broken Landscape," Sudbury.com, accessed January 23, 2023, https://www.sudbury.com/memory-lane/memory-lane-sudburians-recall-how-they-came-together-to-heal-the-citys-broken-landscape-4797352.
54 Kim Fahner, Emptying the Ocean, The Goose 18, no. 2 (2020), 36.

Although local emissions have since reduced following government regulations and industrial technological advancements, traces of mining activity still impact the environment within local communities today. In Copper Cliff, a polluted copper-tone stream intersects the neighbourhoods, carrying toxic run-off from industrial sites **[Fig. 28]**. This water flows close to the Copper Cliff Public School and draws a clear division within the schoolyard property, slicing the large public park central to the community. Former company towns throughout the city of Sudbury still retain environmental relics of the industry, both in ongoing and decommissioned sites; for example, following the closure of the Coniston smelter, several polluted ponds still surround the site and prevent ecosystem recovery. In most cases, mine sites are kept out of sight from the greater city–where there is little comprehension of their footprint. However, as discussed, the impacts of industrial landscapes extend far beyond their adjacent communities, by polluting the greater watershed and soils as ongoing hazards to residents.

Fig. 28 *Copper Cliff's Polluted Stream*

Throughout the region's history, the community took action towards addressing the detrimental threats to the local environment and to health concerns, which will be discussed further in the following subsection. The increasing concerns within Sudbury's social-political environments reflected an urgency for change, ultimately inviting a new narrative for ecological restoration. The notion of regenerating the natural environment is critical to improving the health of the community; therefore, these realms between the social and environmental contexts cannot exist independently from each other. Establishing this new direction forward to improve the physical environment would also determine a healthier future from a human perspective. Being a region defined by industrial powerhouse companies and extractive operations, there was then a shift created by the community to challenge this pre-determined industrial identity.

Fig. 29 *Community Volunteers Preparing to treat Sudbury's Landscape*

1.2 Community Change + Initiatives

In Sudbury's early industrial history, there was an evident power imbalance recognized within the community as mining companies employed a large percentage of the population.[55] Several events throughout the legacy prompted community action by forming activist groups, shifting the balance of power through intervention within the social, political, and environmental realms. As early as the 1910s, the Sudbury Horticulture Society formed to address the ongoing concerns about ecological damage to the farmland, as farmers were one of the dominant sectors of the local economy.[56] At the time, civic leaders had little authority over smelter emissions. Instead, they attempted to determine potential solutions for the coexistence between this intense industrial activity and agriculture. Over time, community members began to intervene to express concerns about the ongoing degradation of the natural environment, threatening the health of wildlife and citizens. This initiated an environmental justice movement in the region, creating momentum toward collaboration between citizen groups and stakeholders looking to transform the landscape through substantial reclamation efforts.

The formation of several community groups was a response to a sense of urgency for change, to reclaim the ownership and sense of pride over the state of the physical environment. The collaboration between government scientists, resource managers, university professors, municipal planners, and industry partners initiated the transformation of the smelter-damaged landscape through local restoration ecology research[57] **[Fig. 29]**. A theoretical model for community change instigated several principles to involve communities in environmental justice issues: to create awareness and a clear understanding of the community's history; to create social and organizational networks to share values, skills, and resources. To apply this model and research into practice, VETAC (Vegetation

55 John M. Gunn, *Restoration and Recovery of an Industrial Region: Progress in Restoring the Smelter-Damaged Landscape Near Sudbury, Canada*, 799.
56 Don Munton, and Owen Temby, "Smelter fumes, local interests, and political contestation in Sudbury, Ontario, during the 1910s." Urban History Review/Revue d'histoire urbaine 44, no. 1-2 (2015): 24-29.
57 Desre M. Kramer, Emily Haynes, Nancy Lightfoot, and D. Linn Holness, "Dimensions of Community Change: How the Community of Sudbury Responded to Industrial Exposures and Cleaned up its Environment," 81-85.

Fig. 30 *Volunteers from VETAC Treating the Landscape*

Enhancement Technical Advisory Committee, known today as the Regreening Advisory Panel) formed in 1973, working to neutralize soils and revegetate the landscape actively, being an essential component to the success of the regreening initiative[58] **[Fig. 30]**. Shortly after, the formation of the Technical Tree Planting Committee in 1974 began to test plots on the landscape, which effectively became a natural laboratory.[59] Once these tests were successful, this created a monumental shift as the city of Sudbury began its official Land Reclamation Plan in 1978, kickstarted a massive physical transformation across the region's landscape.

Sudbury's regreening initiative demonstrated the complete reconfiguration of a horrific, sulphur-blackened moonscape to a lush, thriving greenscape, restoring ecosystems and local biodiversity. It is recognized globally as a powerful success story, receiving recognition in 1992 from the United Nations through several awards.[60] Several other

58 Deb McIntosh, "Letter: City Councillor Thanks VETAC Members for Their Dedication," Sudbury.com, accessed September 25, 2022, https://www.sudbury.com/letters-to-the-editor/letter-city-councillor-thanks-vetac-members-for-their-dedication-913141.
59 Morrissa Boerchers, Patricia Fitzpatrick, Christopher Storie, and Glen Hostetler, "Reinvention through regreening: Examining environmental change in Sudbury, Ontario," 797.
60 "Regreening Awards," Greater Sudbury, accessed February 28, 2023, https://www.greatersudbury.ca/live/environment-and-sustainability1/regreening-program/regreening-awards/.

Junction Creek Stewardship Commitee

Restoration activities
Educational opportunities
Long-term stewardship

Biodiversity Action Plan
City of Sudbury Action Plan

Community feedback workshops
Greening the urban landscape

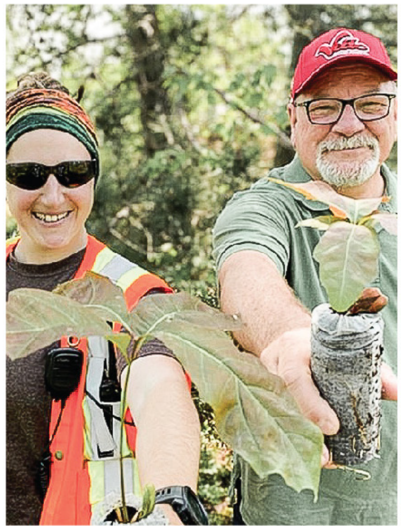
restoration initiatives extended to the local watershed to reduce acidification and contribute towards ecosystem regeneration **[Fig. 31]**, through the Junction Creek Stewardship Committee starting in 1999. The natural recipe created for this initiative was then brought to a global scale for environmental rehabilitation, which will be discussed further in the next chapter.

Following these initial rehabilitation efforts implemented in the landscape, several other civic programs continue to support regreening initiatives and educational workshops throughout the community. For example, the citizen activist group Community Committee on the Sudbury Soils Study (CCSSS) was formed in 2001, advocating for community access to appropriate tools and resources to facilitate active participation throughout the environmental risk assessment process. This happened in reaction to the fact that citizens criticized the original soils study for omitting information about threats to community health and the lack of education on the negative impacts of mining activity, shifting momentum towards further community intervention.[61] Further programs expanded to the Community Garden Advisory in 2008; the city's Biodiversity Action Plan starting in 2009;

61 Philippa Spoel, and Rebecca C. Den Hoed, "Places and people: rhetorical constructions of "community" in a Canadian environmental risk assessment," *Environmental Communication* 8, no. 3 (2014): 271-274.

Community Garden Network

Burst Project (seed bomb workshops)
Community garden workshops
Greater Sudbury Pollinator Project



Roots + Shoots
Jane Goodall Institute + Science North

Tree planting workshops + school visits

Fig. 31 *Sudbury's Environmental Programs [Pages 37-38]*

Roots and Shoots organized by Jane Goodall in 2012; and later expanding to the built environment through CEEP (Community Energy and Emissions Plan) in 2019.[62]

The formation of this unique narrative of remediation essentially re-established the community's role of stewardship of the landscape. Taking back ownership to preserve the state of the environment from what industrial powerhouses had previously destroyed created a sense of pride in the region with a new motivation to continue the ongoing restoration. It is clear that human intervention plays a significant role in the complete transformation or alteration of the physical landscape–the role of the community was at the core of the regreening initiative, and must be a considerable component in proceeding further with restoration efforts of the landscape **[Fig. 32]**.

"A tree fell; And now; Forty years on; Another stands in its place; Tall and vibrant and vigilant. It's there to remind each and every one of us; That there is still so much work to do; Now more than ever; And that not only must the work go on; But so must our gratitude and our praise."[63]

Lynda Lesny
"A TREE FELL"

62 "Environment and Sustainability," Greater Sudbury, accessed November 22, 2022, https://www.greatersudbury.ca/live/environment-and-sustainability1/.
63 Lynda Lesny, "A TREE FELL," Poem sent to author, 2022.

240
km radius
touched by pollution

7000
lakes
acidified

100+
years
of active mining operations

10,000,000
tonnes
of SO_2 released

1
metre
top soil lost

20 - 200
tonnes
of tailings generated per tonne of metal

40+
years
of restoration ecology research

10,000,000
trees
planted by the community

4000
hectares
reclaimed through liming and seeding

30+
years
to extract metals from tailings

50%
land mass
recovered from pollution

650,000
tonnes
of carbon sequestered from regreening

Fig. 32 *Statistics of Sudbury's Mining Legacy and Regreening Initiative*

2
Reconstructing the Landscape

Fig. 33 *Reconstructing the Landscape*

This chapter analyses over 40 years of restoration ecology research that contributed to rehabilitating Sudbury's industrially-damaged landscape starting in the 1970s. Subsection 2.1 discusses the concept of Sudbury's environment becoming a natural laboratory, where a 'recipe' was developed by local researchers and biologists to begin reintroducing vegetation and treating acidified soils. The application of this research was carried out by intensive volunteer efforts from the community. This regreening initiative has been recognized globally as a tremendous success story. However, because of the dependency on active mining practices continuing within the region, restoration initiatives must continue. In subsection 2.2, treatment solutions are analyzed for rehabilitating Sudbury's industrial sites, particularily within tailings areas. More specifically, biotechnologies and ground surface treatments are presented as promising solutions to treating unmanaged mine waste, mitigating the mining's environmental footprint within the community. In support of these initiatives, a research Centre for Mine Waste Biotechnologies has been proposed within Sudbury as a catalyst for this research application.

Fig. 34 *The Natural Recovery of Sudbury's Lichens Representing a Healing Landscape*

2.1 The Landscape Laboratory

As previously discussed, the region of Sudbury tells a tremendous success story of environmental remediation, which began with the urgency to treat industrially-altered landscapes. Experimentation with large-scale reclamation efforts was first initiated within the 1950s-1960s, when INCO agronomists worked to restore the company's tailings areas in search of a solution for a permanent vegetative cover.[64] These initiatives later extended to the region surrounding the Coniston smelter after its closure in 1971, beginning the first test site that endured severe pollution.[65] As a result of local mining companies taking the initiative toward reducing local sulphur emissions and rehabilitating industrial sites, the natural succession of the Sudbury landscape began to take place. Following the construction of the Superstack which reduced local emissions, the slow return of lichen species became sensitive natural indicators of improving air quality in their surroundings.[66] The natural recovery of lichens represented the progress of a healing landscape and therefore became symbolic of the start of the ecological restoration narrative **[Fig. 34]**. Populating the barren landscape like a natural carpet, lichens became substrates for lowbush blueberries to grow inside industrial wastelands and hillsides.[67] Blueberries were one of the first acid-tolerant plants that reclaimed human-altered landscapes within the region– they have great significance within the community as they are also symbolic of the successional process, and are celebrated through the annual Blueberry Festival. The abundance of lowbush blueberries began to support the growth of other successional tree species around the city; balsam poplar, aspen, and white birch being the most prominent species that were resilient to acidic soils.

Fig. 35 *Progression of Sudbury's Reclaimed Landscape, 1989*

Fig. 36 *Community Members Liming the Sudbury Landscape*

The regreening initiatives began to accelerate once researchers at Laurentian University and the Ontario Ministry of Natural Resources successfully developed a 'recipe' to treat

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64 Morrissa Boerchers, Patricia Fitzpatrick, Christopher Storie, and Glen Hostetler, "Reinvention through regreening: Examining environmental change in Sudbury, Ontario," *The Extractive Industries and Society* 3, no. 3 (2016): 797.
65 Ibid, 797.
66 Keith Winterhalder, "Environmental Degradation and Rehabilitation of the Landscape Around Sudbury, a Major Mining and Smelting Area," *Environmental reviews* 4, no. 3 (1996): 185–224.
67 Joseph D Shorthouse, "Barrens to Blueberries," Barrens to Blueberries | Natural History Magazine, accessed April 22, 2023, https://nhmag.com/features/253234/barrens-to-blueberries.

the acidic soils before introducing new plant species **[Fig. 35]**. Beginning this exploration with several test plots, the application of crushed limestone (through a process called **liming**) would first neutralize the pH levels of the topsoil before the integration of seeding introduced other plant species to kickstart natural ecological succession[68] **[Fig. 36]**. As the test plots became successful, the restoration of central highway corridors was then prioritized to improve the image of the city, before extending this initiative to other areas. This restoration model is known as the Sudbury Recipe, which has been studied globally and has significantly contributed to ecological restoration research and practice.

Liming:

A critical step in the process of rehabilitating Sudbury's industrially-damaged landscapes; involving speading crushed limestone on top of acidified soils and water bodies to neutralize the pH levels in preparation for revegetation and wildlife recovery.

Through the Land Reclamation Plan in 1978, several ongoing studies prompted resilient, diverse ecosystem creation by determining the ideal mixture of plant species in a given context **[Fig. 37-40]**. In the case of areas contaminated by active mine waste, grasses and other resilient vegetation are preferred to support the succession process. In other instances, generating optimal plant species mixtures would contribute to the biodiversity of ecosystems recovery and improve the pollinator

68 John M. Gunn, *Restoration and Recovery of an Industrial Region: Progress in Restoring the Smelter-Damaged Landscape Near Sudbury, Canada*, 341.

1984

1986

habitat qualities for natural succession.[69] Through the intensive volunteer efforts conducted by students, citizens, researchers and industrial partners, the community successfully restored 3070 hectares of barren land through grassing and planted over 1,692,00 trees by 1993, setting a global precedent.[70] Today, the regreening program has recovered well over 4000 hectares of barren land through liming and seeding.[71]

Fig. 37 *The Progression of Sudbury's Land Reclamation, 1984*

Fig. 38 *The Progression of Sudbury's Land Reclamation, 1986*

> "The regreening of Sudbury is a shining example of why I have hope — the resilience of nature and the indomitable spirit that tackles what seems impossible and will not give up."[72]

Jane Goodall
10 millionth tree event

69 Kierann Santala, Françoise Cardou, Denys Yemshanov, Fabio Campioni, Mackenzie Simpson, I. Tanya Handa, Peter Ryser, and Isabelle Aubin, "Finding the Perfect Mix: An Applied Model That Integrates Multiple Ecosystem Functions When Designing Restoration Programs," *Ecological engineering* 180 (2022): 1.

70 John M. Gunn, *Restoration and Recovery of an Industrial Region: Progress in Restoring the Smelter-Damaged Landscape Near Sudbury, Canada*, 116.

71 John M. Gunn, "Global Lessons on Sudbury's Story," UN Biodiversity Convention (COP15), December 2022, https://www.unep.org/news-and-stories/story/cop15-ends-landmark-biodiversity-agreement#:~:text=The%20United%20Nations%20Biodiversity%20Conference,weeks%20for%20the%20important%20summit. Presentation.

72 "Celebrating Greater Sudbury's Regreening Efforts with Dr. Jane Goodall," Greater Sudbury, accessed February 23, 2023, https://www.greatersudbury.ca/city-hall/news-and-public-notices/2022/celebrating-greater-sudburys-regreening-efforts-with-dr-jane-goodall/.

1990

1998

Fig. 39 *The Progression of Sudbury's Land Reclamation, 1990*

Fig. 40 *The Progression of Sudbury's Land Reclamation, 1998*

In July 2022, a ceremony led by Prime Minister Justin Trudeau with Dr. Jane Goodall planted the ten millionth tree as a momentous milestone to the community.[73] However, she emphasizes that the work toward environmental restoration is not done, and the story of restoration must continue. Following Sudbury's model of restoration, the city has restored only **50%** of all treatable areas within the region.[74] As stated by the community, without the regulations for industrial partners to reduce air pollution in the region, the regreening initiative wouldn't be successful.[75] Therefore, beyond restoring the physical landscape, a critical shift is required in designing the approach to current industrial practices and management. Similar to the significant regreening story established by the community of Sudbury, there's an opportunity to build on this educational narrative by revealing the complex, yet innovative and inspiring treatment solutions for tailings.

73 Angela Gemmill, "10 Millionth Tree Was Planted in Sudbury, Ont., and Icon Jane Goodall Was at the Milestone Event | CBC News," CBCnews (CBC/Radio Canada, July 8, 2022), https://www.cbc.ca/news/canada/sudbury/ten-millionth-tree-planted-sudbury-regreening-1.6513393.

74 John M. Gunn, "Global Lessons on Sudbury's Story."

75 Morrissa Boerchers, Patricia Fitzpatrick, Christopher Storie, and Glen Hostetler, "Reinvention through regreening: Examining environmental change in Sudbury, Ontario," 797.

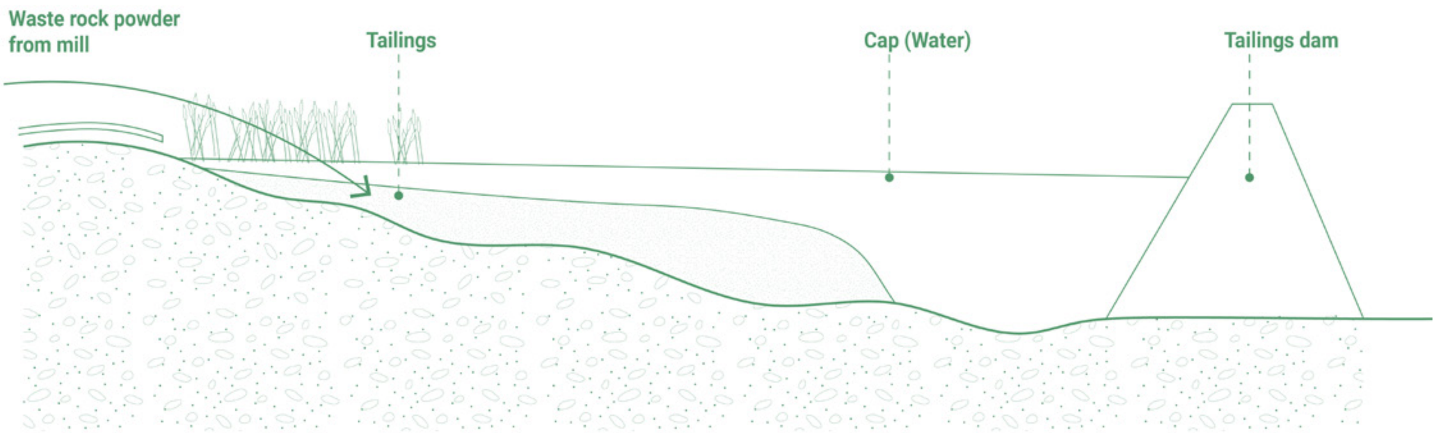
2.2 Tailings Treatment

Industrial partners within the city of Sudbury continue the initiative to restore industrial wastelands. For example, the inactive tunnels in Creighton Mine have contributed to the revegetation of mine sites through the operation of a year-round underground greenhouse.[76] Vale has also established an environmental program for revegetation and even declared the tailings around Copper Cliff to be a Wildlife Management Area,[77] indicating a monumental shift toward the approach of treating industrial sites moving forward. Following the regreening initiatives, Sudbury's physical landscape still faces a major industrial footprint, dealing with environmental concerns from generations of untreated mine waste. In the early stages of Sudbury's regreening efforts, the revegetation of tailings areas was critical to address dust control and improve the stabilization of soils; although using hay as a cover provided a temporary solution, the first attempts to grow crops were unsuccessful.[78]

Unlike the process of treating acidic soils, tailings have limited water-holding capacity, no nutrient value, and no organic matter, making this process extremely challenging. In 1956, a breakthrough occurred after a particular treatment recipe resulted in vegetation growth; using limestone, fertilizer, grasses, rye and mulching, making this the first successful attempt to revegetate tailings in the Western Hemisphere[79] **[Fig. 41]**. By 1967, this process transformed Falconbridge's most visible tailings site into Centennial Park. Now a thriving ecosystem, the landscape is suitable for local wildlife and supports a native vegetation cover. This discovery intersected with the community's regreening initiative, by extending these research initiatives from the visible landscape directly into industrial sites. More specifically, several research solutions within the city have been developed; including ground surface treatment solutions to provide effective growth mediums, and innovations in biotechnologies that treat reactive mine waste at the microscopic level which will be discussed further.

Fig. 41 *Composition of Sudbury's Surface Treatments on Tailings*

76 "Accent: Mining a Bright Future | Sudbury Star," accessed November 14, 2022, https://www.thesudburystar.com/2013/04/13/accent-mining-a-bright-future.
77 Oiva W. Saarinen, *From Meteorite Impact to Constellation City,* 267.
78 Ibid, 267.
79 Ibid, 267.



2.2.1 Biosolids + Technosols

Fig. 42 *Tailings Covers*

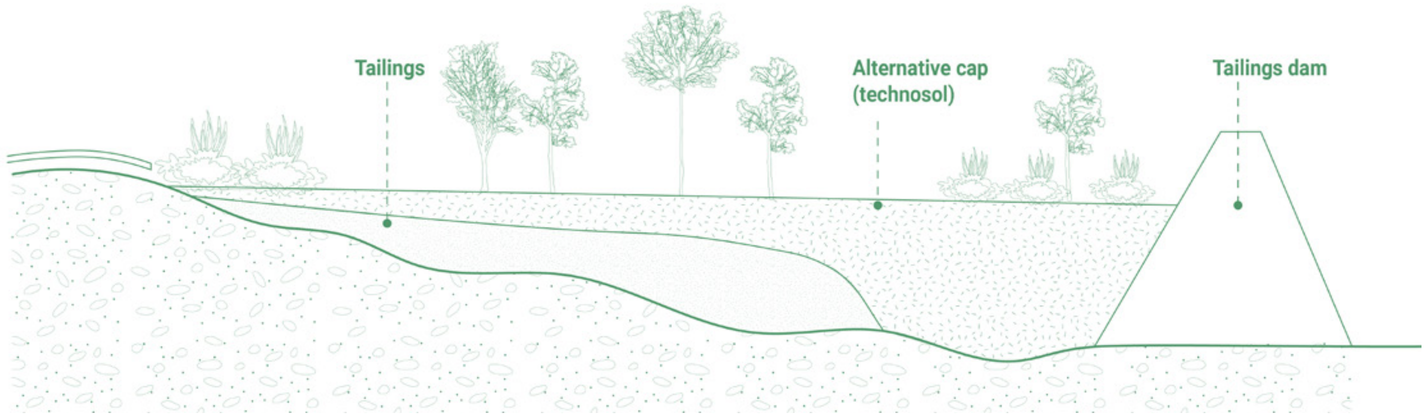
Surface mining is undoubtedly environmentally destructive, and although reclamation of industrial sites can alleviate these impacts, improper execution of this practice may lead to the expansion of Sudbury's industrial footprint.[80] Suitable options for soil covers are often acquired through the excavation of local soils or are imported, which causes further disturbance through industrial wastelands. The natural recovery of tailings is challenging due to the acidic content and sand-like texture. However, Vale has taken the initiative to explore other ground treatment solutions, utilizing **biosolids** as a strategy to kickstart vegetation growth and the restoration of ecosystems in the Central Tailings Area (CTA).[81] Biosolids typically consist of treated sewage sludge, a nutrient-rich organic material often used in farming operations for agricultural fertilizer. This growth substrate recycles local municipal waste, including yard waste, wood chips, etc. It can also repurpose waste produced by Copper Cliff's Wastewater Treatment plant to be recycled through the industrial landscape. Vale has continued to pursue these strategies in compliance with their tailings pond reclamation project by planting trees and vegetation to rehabilitate the CTA:

Biosolids:

An organic soil mixture used made from wastewater treatment sludge, and nutrient-rich organic waste, typically used to rehabilitate industrial landscapes.

80 Autumn D. Watkinson, Alan S. Lock, Peter J. Beckett, and Graeme Spiers, "Developing Manufactured Soils from Industrial By-products for Use as Growth Substrates in Mine Reclamation," *Restoration ecology* 25, no. 4 (2017): 587.

81 Karen McKinley, "Biosolids Re-Green Mining Wasteland," *Northern Ontario Business 38*, no. 10 (2018): 11.



"While the Copper Cliff tailings will be closed off to humans for the foreseeable future, [it] is encouraging to see how fast and safe the mix is proving to be in regenerating mine sites for the ecosystems."[82]

Karen McKinley
Northern Ontario Business Article

Biosolids are a viable treatment option for industrial lands and challenge the idea of what these wastelands will become over the next generations.

Alternatively, **technosols** provide another growth medium for industrially-polluted landscapes, acting as a natural cover to tailings and mine waste to prevent oxidation while improving biodiversity[83] **[Fig. 42]**. These mixtures are manufactured from woody residuals, paper sludge, and crushed mine rock.[84] Since 2009, several plant species including switchgrass, canola, corn, and sunflowers, have successfully reclaimed industrial sites as a productive and aesthetic treatment of the landscape[85] **[Fig. 41]**. Through this approach, several trees and plant species have repopulated Copper Cliff's landscape and Glencore's

Technosols:

A mixture of waste rock, wood residuals, and paper sludge that provides a natural ground cover for tailings to allow for vegetation growth.

82 Karen McKinley, "Biosolids Re-Green Mining Wasteland," 11.
83 Nadia Mykytczuk, "Module 5: Mine Waste Covers."
84 Autumn D. Watkinson, Alan S. Lock, Peter J. Beckett, and Graeme Spiers, "Developing Manufactured Soils from Industrial By-products for Use as Growth Substrates in Mine Reclamation," 587.
85 Nadia Mykytczuk, "Module 5: Mine Waste Covers."

Fig. 43 *Working with Technosols in the Landscape Photo Composition*

Fig. 44 *Revegetating Industrial Sites with Technosols*

properties– willows and poplars have successfully grown over tailings, with the opportunity to sustain themselves through a newly constructed ecosystem.

To researchers at Laurentian University and industrial partnerships, it is still a question whether these approaches will serve as long-term solutions to treating Sudbury's legacy of untreated mine waste **[Fig. 43-44]**. Utilizing technosols or biosolids is a promising method to kickstart ecological succession; however, one solution is not guaranteed to solve all the complexities within the industrial wastelands.[86] Each deposit of mine waste or tailing pond has different levels of metal particulate content and, therefore, requires different remediation approaches. A combination of strategies related to biotechnologies is required to rehabilitate industrial landscapes effectively–active management is required, supported by the design of long-term sustainable practices that minimize the footprint of mine waste altogether. To better understand the shortcoming of ground surface treatments as long-term solutions, it is crucial to further investigate biotechnologies to address the chemical reactions in mine waste.

86 Nadia Mykytczuk, "Module 5: Mine Waste Covers."

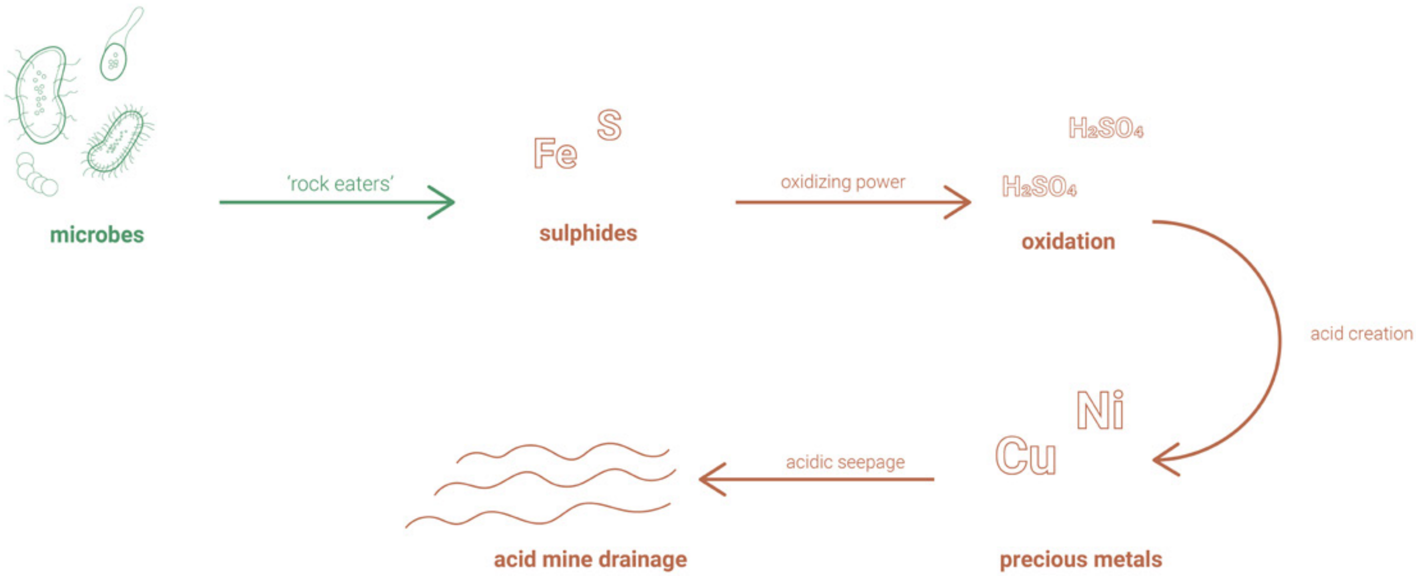


Fig. 45 *Bioleaching 01*

2.2.2 Bioleaching

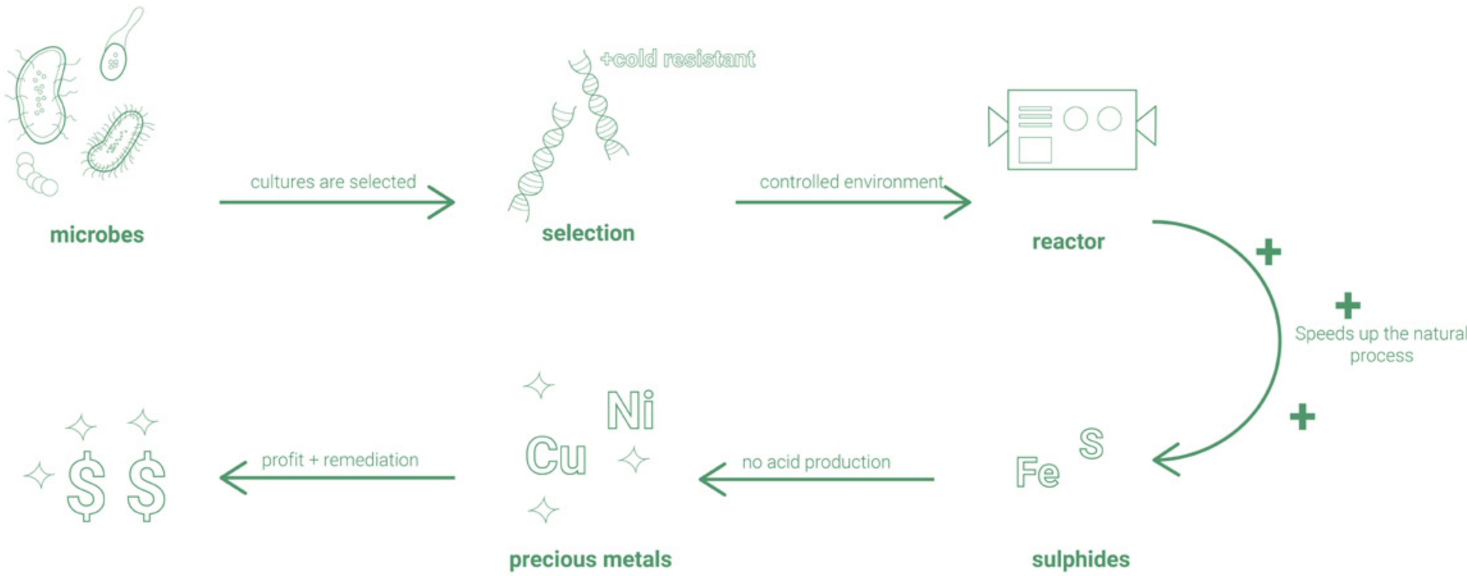
Although successful at the ground surface level, revegetation independently does not prevent underground waste contents from oxidizing and, therefore, does not eliminate risks for acidic seepage and groundwater contamination.[87] Current management strategies must be re-evaluated to tackle long-term sustainable practices, by cleaning past and active mine waste deposits. Researchers at Laurentian University, the Goodman School of Mines, and MIRARCO (Mining Innovation Rehabilitation and Applied Research Corporation), have analyzed **biotechnologies** as promising solutions to treating current and legacy mine waste. By examining mine waste at the microscopic level, these strategies aim to mitigate acid mine drainage (AMD) and potentially transform industrial wastelands into thriving landscapes.[88] The region of Sudbury is an optimal location to implement these strategies, as it would accelerate the remediation process and encourage a reflection on our extractive management practices.

Biotechnologies:

Utilizing natural processes, including microorganism cultures in order to achieve a particular service or action.

Legacy and active mine waste management is a continuous challenge, and leaving these deposits uncovered

87 Nadia Mykytczuk, "Module 5: Mine Waste Covers."
88 Nadia Mykytczuk, "Module 5: Microbes in Mine Waste," Environmental Remediation: Global Lessons from the Sudbury Story, Laurentian University Goodman School of Mines, Sudbury, 2018, Vimeo, https://vimeo.com/290966968.



and untreated is not an option. When mine waste is left unmanaged, microbes (**chemolithotrophs**) make a living off of the elements and, through oxidation, the waste becomes toxic and reactive[89] **[Fig. 45]**. Therefore, the bacteria interacting with the minerals accelerate AMD production, contributing to the industrial footprint. As discussed, AMD is extremely difficult to control as it seeps into groundwater and soils, but it is crucial to stop this process altogether. Researchers at MIRARCO have been investigating a process called **bioleaching** to work this natural phenomenon to their advantage.

Essentially, by placing microbes within a controlled environment, a process called genomic sequencing allows for the selection of 'magic cultures' to achieve optimal performance in certain conditions[90] **[Fig. 46]**. Growing bacterial species within a lab enables cultures to be cold-resistant, become copper resilient, or respond effectively to the chemical balance within a particular tailings pond. After placing a specific culture in a processor, it harvests precious metals from mine waste while minimizing AMD production altogether, leaving behind clean samples that can be sold for profit. As mining companies

Chemolithotrophs:

Referred to as "rock eaters," which are microorganisms that generate energy through the oxidation of inorganic molecules.

Bioleaching:

A process in which microbes harvest remaining reactive metals in mine waste.

Fig. 46 *Bioleaching 02*

89 Nadia Mykytczuk, "Module 5: Microbes in Mine Waste."
90 Julian Wiesner (MIRARCO), conversation with author, November 24, 2022.

advance towards green-centred initiatives, increasing demand for lower-grade metals within mine waste can be utilized for electric-powered vehicles.[91] This controlled environment accelerates the process from what might happen naturally within a year to just a few days.

"Bio-leaching accomplishes two things: it safely and cheaply breaks down the rock and extracts much-needed minerals while cleaning up the chemical nasties in the process — like the sulphide which produces acid mine drainage — and separates them out in solution as benign waste."[92]

Nadia Mykytczuk
Northern Ontario Business Article

With the potential to practice remediation through bioleaching over a large scale, this process must be executed carefully, through active management and monitoring of microbe cultures to ensure the most effective performance possible. Considering the volumetric massiveness of the tailings that inhabit the Sudbury landscape, even after processing the waste through biotechnologies, a significant percentage of tailings will be left over.[93] This contributes to potential risks of tailings dam collapses that are detrimental threats to nearby communities. As a response to this, local mining companies have considered strategies to recycle the waste for other industrial purposes: tailings can be pumped with wastewater to backfill unused mine tunnels, produce construction materials for roads, foundations for buildings, etc.[94] Moreover, through the implementation of technosols as a cover to tailings, the organic elements in the mix absorb the moisture within the waste and works to alleviate the pressure put on the retention dams.[95] Research initiatives in developing ground surface treatments for tailings have the potential to address the concerns for the remaining waste deposited within the landscape, but these

91 Ian Ross, "Biotech Could Liberate Billions from Sudbury's Mine Waste," Sudbury.com, Accessed December 6, 2022, https://www.sudbury.com/local-news/biotech-could-liberate-billions-from-sudburys-mine-waste-5429514.
92 Ian Ross, "The Drift: Sudbury Has the Solution for Canada's Mine Waste Problems," Northern Ontario Business, accessed March 11, 2023, https://www.northernontariobusiness.com/the-drift/the-drift-sudbury-has-the-solution-for-canadas-mine-waste-problems-5426129.
93 Julian Wiesner (MIRARCO), conversation with author, November 24, 2022.
94 Nadia Mykytczuk, "Module 5: Mine Waste Management: Legacy Challenges and Current Approaches," Environmental Remediation: Global Lessons from the Sudbury Story, Laurentian University Goodman School of Mines, Sudbury, 2018, Vimeo, https://vimeo.com/292357146.
95 Peter J. Beckett (Laurentian University Professor, Ecological Restoration Researcher), conversation with author, April 14, 2022.

Fig. 47 *Map of Active Industrial Sites Adjacent to Copper Cliff and Coniston [Next Page]*

solutions are continuing to be explored. While these research initiatives are still in developmental stages, they pave the way to speculate the future of industrial wastelands by reimagining these landscapes as safe, accessible spaces. It is estimated to take at least 30 years to harvest the metals out of the tailings,[96] therefore, utilizing biotechnologies and ground surface treatments sets a clear, collective vision toward regeneration.

In support of this innovative research, MIRARCO has proposed a Centre for Mine Waste Biotechnology to be constructed in the town of Coniston, where mining operations have previously been decommissioned. This project would provide a pilot-scale research facility to process mine waste samples, accelerating the commercialization of this technology.[97] There is an evident need for urgent waste management solutions in Sudbury, and biotechnologies have tremendous potential to restore Sudbury's growing footprint of a century's worth of mine waste production. Through an architectural lens, a mine waste research facility can extend positive impacts beyond remediating the physical landscape; becoming an educational tool to the community through the reflection of current industrial practices and treatment of the environment. This thesis reimagines the potential for the current proposal to intersect with social impacts; beginning with relocating the building site from Coniston to Copper Cliff **[Fig. 47]**. As a town with active mining operations, the research innovations in biotechnologies can be brought directly to the CTA, which is the largest tailings area in Greater Sudbury. Considering its close proximity to the residential community, there is an opportunity to lift the veil over this industrial landscape, which will be discussed in the next chapter. By embracing these research methods for ecological rehabilitation, the built environment can play an active role in the remediation process, extending positive impacts over generations.

96 "Toronto Company Looks to Extract Billions in Value from Sudbury Mine Waste," CBCnews (CBC/Radio Canada, June 8, 2022), https://www.cbc.ca/news/canada/sudbury/mine-waste-bacteria-extraction-1.6480504.

97 Nadia Mykytzuk, "The Centre for Mine Waste Biotechnology," MIRARCO, July 2021, https://miraco.org/wp-content/uploads/BioTech/Centre_FeasibilityBookletSmaller%20July%202022.pdf. PDF.


Murray Mine
Central Tailings Area
North Mine
Vale Complex
Copper Cliff
Creighton
South Mine
South


Garson
New Sudbury
Downtown
End
[Decommissioned Smelter]
Coniston

3
Copper Cliff + The Third Landscape

Fig. 48 *Discovering Copper Cliff's Third Landscape*

This chapter further contextualizes research in restoration ecology that contributed to reconstructing Sudbury's landscape within the corporate mining town of Copper Cliff. A site that once produced the greatest point source of industrial pollution on earth could hypothetically demonstrate a counternarrative of significant environmental remediation. Hosting prominent mining within the region today, the town acts as a distinct intersection between the active industry, and the natural environment, which completely surrounds the residential community. The result of continued extractive operations has formed the extensive geographical footprint of the Central Tailings Area: an untreated, polluted site posing ongoing threats to the environment and adjacent community through the presence of untreated mine waste. This site is further linked to the notion of the Third Landscape, as industrial wastelands existing between the human and the non-human systems, requiring urgent human intervention in order to be restored. Addressing the immense environmental impacts tracing back to active industrial sites is critical to proceed with Sudbury's narrative of restoration. Copper Cliff proves to be a suitable site for the proposed research Centre for Mine Waste Biotechnology; being in close proximity to the community and requiring active mine waste management, it has tremendous potential to be reimagined through a new, regenerative lens.

Fig. 49 *Looking Over the Industrial Wastelands in Copper Cliff*

Copper Cliff + The Third Landscape

As demonstrated earlier, the mining legacy remains predominant with the region of Greater Sudbury, where several communities still host an active industrial presence today. The region was put on the global map with leaders in nickel production, thanks to three main operating mine sites in Coniston, Falconbridge, and Copper Cliff.[98] Copper Cliff is still heavily associated with active extraction operations, where the community is a close neighbour to the Vale Inco Complex, the Copper Cliff South and North mines, and the Vale Superstack, which are significant landmarks of Sudbury's mining industry **[Fig. 52]**. Considering the site historically was one of the greatest contributors to pollution and environmental damage on earth, it also has tremendous potential to demonstrate significant restoration efforts that will contribute to both environmental and social generation–which will be unpacked further within this chapter.

Historically a self-sustaining corporate town, the town produced the greatest amount of copper the operating mines in the region and soared to the top of the nickel industry.[99] Located at a node of transportation in the region, the railway created a direct connection from Copper Cliff to the downtown for transporting materials **[Fig. 50]**. The town's urban fabric tells the story of the first settlements forming around early mine sites, while the arrival of immigrant labourers expanded the settlements to create five communities: Little Italy (also referred to as the Crow's Nest); Shantytown; English Town; Old Smelter; and Evan's mine[100]**[Fig. 51]**. Several socio-cultural spaces reveal the vibrancy of a historic mining town, including the Copper Cliff Club, and other social infrastructures that created inclusive spaces for immigrant groups such as the Italian Club. By the 1930s, the closure of the last roast yards initiated preliminary revegetation efforts, including Nickel Park central to the town, which was once utilized for ore processing practices **[Fig. 54]**.

Fig. 50 *"The No. 2 smelter: trestles with locomotive and ore cars," 1900*

Fig. 51 *Early Communities in Copper Cliff, 1900s*

Fig. 52 *Inco Complex in Copper Cliff, 1958*

Fig. 53 *Slag Train Pouring on INCO Slag Dump, 1953*

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98 Oiva W. Saarinen, *From Meteorite Impact to Constellation City: A Historical Geography of Greater Sudbury*, 97.

99 Margaret Bertulli, Cheryl Daminato, and Rae Swan, *A Bit of the Cliff : a Brief History of the Town of Copper Cliff, Ontario, 1901-1972, [Sudbury]*, Copper Cliff, Ont: Copper Cliff Museum, 1982, 5.

100 Oiva W. Saarinen, *From Meteorite Impact to Constellation City: A Historical Geography of Greater Sudbury*, 97-99.


Fig. 50


Fig. 51


Fig. 52

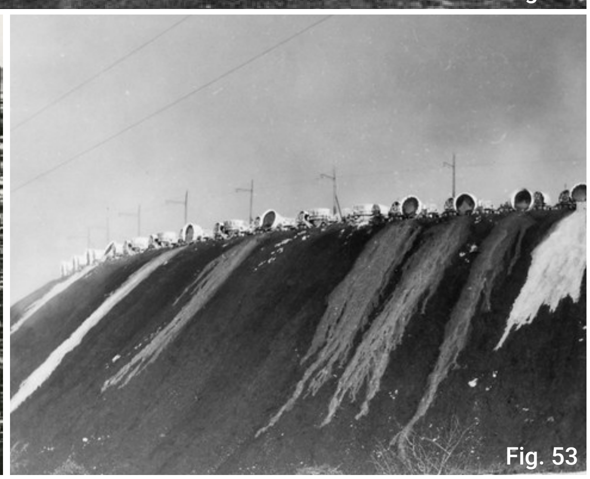


Fig. 53

"I can recall my father telling me about one time he was driving a buggy through the smoke from the Copper Cliff roast yard and lost the road. He left the buggy to find the road; he found the road but he lost the horse and buggy!"[101]

Leslie Wingrave
A Bit of the Cliff

"The copper sky burns our eyes, below us
We see a yellow haze of sulphur so thick
We taste it on our teeth."[102]

Thomas Leduc
Poem | Sulphur Sunrises
Slagflower

Fig. 54 *Map of Copper Cliff's Early Communities and Industry*

101 Margaret Bertulli, Cheryl. Daminato, and Rae. Swan, *A Bit of the Cliff : a Brief History of the Town of Copper Cliff, Ontario, 1901-197,* 7.

102 Thomas Leduc, Slagflower: Poems Unearthed from a Mining Town, Latitude46, 2019, 12.

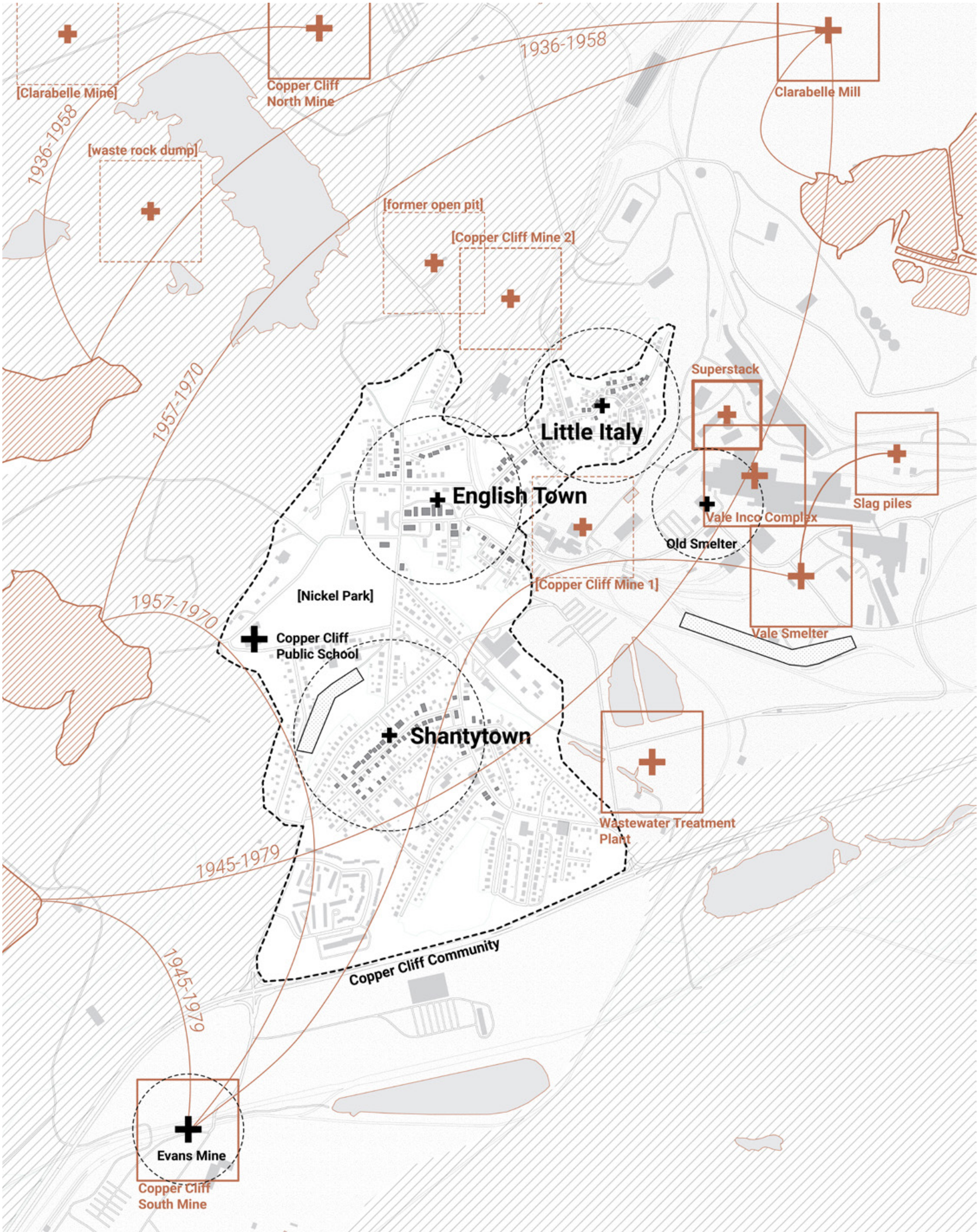

[Clarabelle Mine]
Copper Cliff North Mine
1936-1958
Clarabelle Mill
1936-1958
[waste rock dump]
[former open pit]
[Copper Cliff Mine 2]
1957-1970
Superstack
Little Italy
English Town
Slag piles
Vale Inco Complex
Old Smelter
[Copper Cliff Mine 1]
[Nickel Park]
1957-1970
Vale Smelter
Copper Cliff Public School
Shantytown
Wastewater Treatment Plant
1945-1979
Copper Cliff Community
1945-1979
Evans Mine
Copper Cliff South Mine


Fig. 55


Fig. 56


Fig. 57


Fig. 58

"When I was a kid, my parents
packed us into the station wagon
and hauled us out to watch
the slag dump.

[...]The mines have since scribbled over the slag
With peat and lichens, and trees line the ridge.
Bee hives have been installed to soften the image
Now honey crawls down the hill instead of slag."[103]

Thomas Leduc
Poem | Slag Dump
Slagflower

Today, industrial operations continue in close view to the community **[Fig. 55]**; for example, slag pours have become a familiar phenomenon within the city, where molten metals are poured over slag heaps through the refinement process of ore and tint the sky with a fiery red[104] **[Fig. 53, 56]**. In recent years, the town's population has shifted towards a younger demographic due to the affordable housing market that supports young families. More specifically, the cost of real estate in Copper Cliff is approximately 20% lower than the average cost in the city, which can explain why as much as 37% of households are with children.[105] The Copper Cliff Public School and the park are currently the core spaces of the built environment that support youth in the town **[Fig. 57-58]**. Children, being the most frequent greenspace users, are presumably the most familiar with the landscape as it becomes a natural playground to a certain extent.[106] The industrially-polluted landscape bleeds into the town's unique natural environment and is currently unsafe for

Fig. 55 *Community of Copper Cliff Below the Superstack*

Fig. 56 *Sudbury Slag Pour*

Fig. 57 *Copper Cliff Public School and Park*

Fig. 58 *The Polluted Stream Between Copper Cliff Public School and the Park*

103 Thomas Leduc, Slagflower: Poems Unearthed from a Mining Town, Latitude46, 2019, 30.
104 Carol Mulligan, "Accent: Lore of the Pour ," The Sudbury Star, October 21, 2016, https://www.thesudburystar.com/2016/10/21/accent-lore-of-the-pour.
105 "Demographic Data in the City of Greater Sudbury," sudbury.maps.arcgis.com. Accessed November 30, 2022. https://sudbury.maps.arcgis.com/apps/MapSeries/index.html?appid=2624ebe80fcc435d993f446d66920f51.
106 Matluba Khan, Simon Bell, and Jenny Wood, *Place, Pedagogy and Play : Participation, Design and Research with Children*, Edited by Matluba Khan, Simon Bell, and Jenny Wood, Abingdon, Oxon ;: Routledge, Taylor & Francis Group, 2021, 195.

Fig. 59 *Industry, Community, and Third Landscape in Copper Cliff*

community access, which must be addressed for the safety of its users. These safety concerns are due to the close proximity to industrial infrastructures and equipment, including a tailings dam adjacent to the public school, and the stream of polluted run-off that cuts through the town before treatment.

Copper Cliff acts as a geographical intersection between the industry, community, and damaged natural environment, as the three realms are in close proximity **[Fig. 59]**. Clear physical boundaries are defined between the community and industrial wastelands through gates, fences, and signage **[Fig. 60]**. From an aerial view, barren landscapes are exceptionally prominent as they essentially surround the town of Copper Cliff. This industrial wasteland is the Central Tailings Area (CTA), a private property used for Vale's industrial activity that hides behind a cloak of topography and a tree belt. This zone hosts several retention ponds and deposits of mine waste spanning nearly 8km. Although the operation of most tailing ponds ended between 1936-1960, the largest pond to the far West, Meatbird Lake, is expected to remain active until 2035.[107] The current mine plan estimates 932 million tonnes of tailings will be contained within this area by the end of its life. However, these tailings areas are

107 "Copper Cliff Central Tailings Area (CTA)," Vale Inco, https://bc-mlard.ca/files/presentations/2008-14-COCCHIARELLA-copper-cliff-central-tailings-area.pdf. PDF.

Fig. 60 *Photo Montage of Gates to the Third Landscape*

invisible to the public eye; there is little comprehension of the extent of their geographical footprint, let alone the immense impact on the environment.[108]

A century of mining activity has created a patchwork of industrial wastelands interwoven throughout the Sudbury Basin. As hosts of mine waste deposits or abandoned industry relics, the ecological recession is stunted. Gilles Clement presents this phenomenon as the '**Third Landscape**,' the result of a neglected space of a previously exploited site, existing between the human and the non-human dimensions.[109] With the absence of human decision, the landscape's character is left to the ecology of the territory. In the case of industrial sites, especially through ongoing mining activity, ecological succession will be stunted and face major difficulty in restoring biodiversity and the state of its previous ecosystem.

Considering third landscapes are often adjacent to industrial sites, they can take the form of tailings areas, abandoned areas of mine waste deposits, slag piles, or other exploited sites. These areas are not unfamiliar to the Sudbury

Third Landscape:

A neglected area - the result of the abandonment of a previously exploited site. It reveals traces of the Anthropocene, existing between the human and the non-human systems without current intervention.

108 Oiva W. Saarinen, *From Meteorite Impact to Constellation City,* 266.
109 Gilles Clément, "Manifesto of the Third Landscape," *Editions Sujet/Objet* (2004).

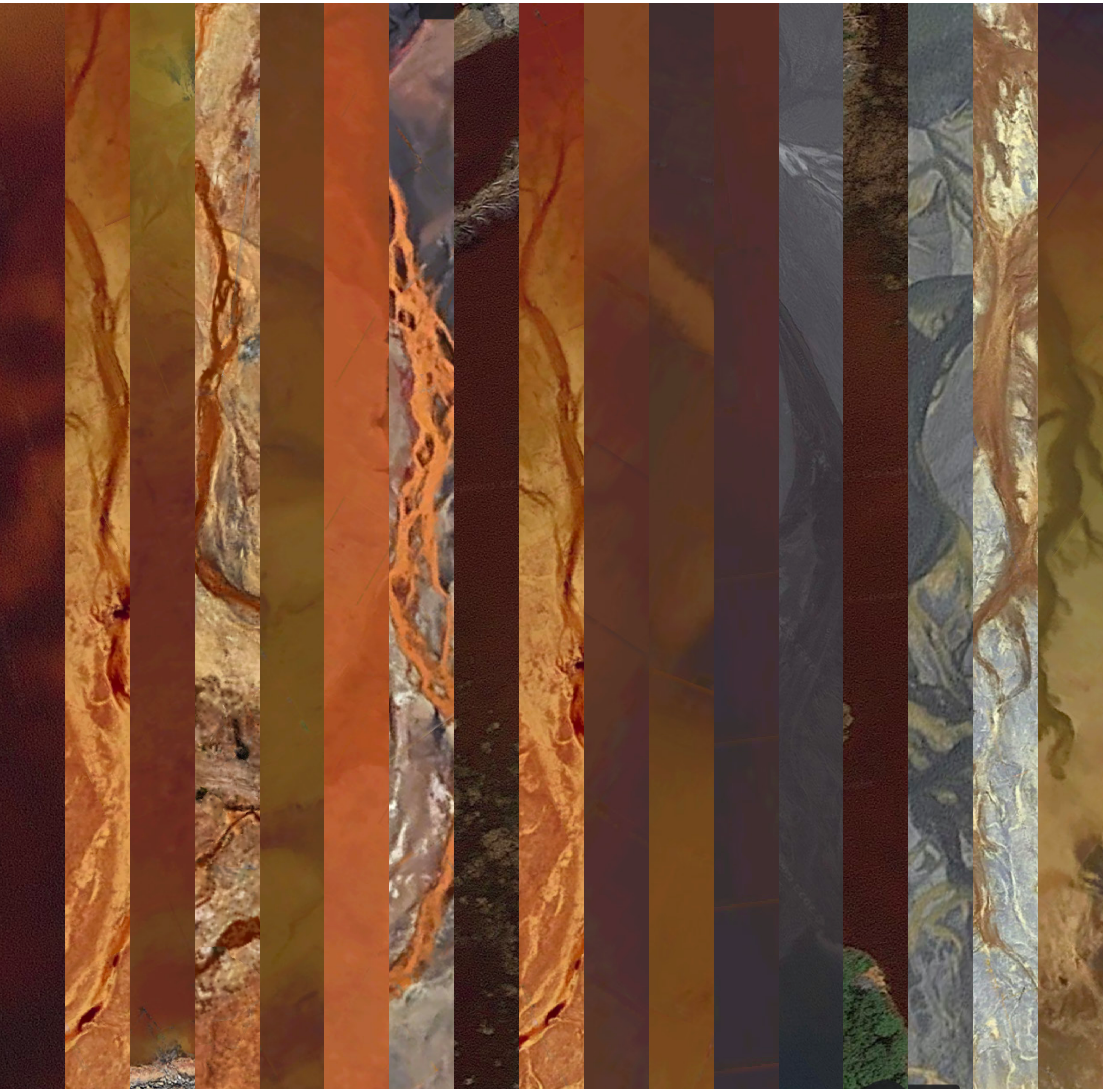
region and, in fact, provide opportunities for continued restoration efforts. As Clement states, third landscapes are synonymous with wastelands.[110] Preserving the landscape or improving the dynamics of the space ultimately involves a political dimension–human intervention is therefore required. As sites that are invisible to the community–like the Central Tailings Area to the Community of Copper Cliff–the environmental impact is easily disregarded **[Fig. 61]**. Although the environmental footprint is not obvious at first, it is detrimental to both the ecology and the community, where the impact accelerates over generations. If the third landscape were revealed to the community, a new sense of urgency to take action to restore these spaces would ensue, and it would bring to question a new purpose to these sites.

The wastelands within Copper Cliff occupy a massive geographical footprint, presenting detrimental environmental threats through unmanaged tailings areas and mine waste that acidify the soils and eventually seep into the watershed **[Fig. 62]**. As discussed in previous chapters, this is already evident within the community through the polluted stormwater

110 Gilles Clément, "Manifesto of the Third Landscape."

canal that intersects the town with a bright orange stream; this third landscape is located at the heart of a busy town filled with children, where their surrounding natural environments and playscapes are compromised, and dangerous. This further emphasizes that urgent remediation efforts are more than necessary, to improve the health of the environment and community at large. Therefore, the thesis reimagines the aforementioned proposal for a research Centre for Mine Waste Biotechnologies within Copper Cliff's CTA. As a vast site with active industrial operations, the project has the potential to provide active management solutions for mine waste. Sudbury has proved to be a successful natural laboratory for restoration ecology research, given the prominence of the ongoing mining legacy–grounding existing research into this neglected industrial site creates the opportunity to continue this unfinished narrative. Treatment of the third landscape is core to creating regenerative impacts that not only improve the local environment but inspire social change and stewardship to continue over generations.

Fig. 61 *Photo Montage of Copper Cliff's Third Landscape*



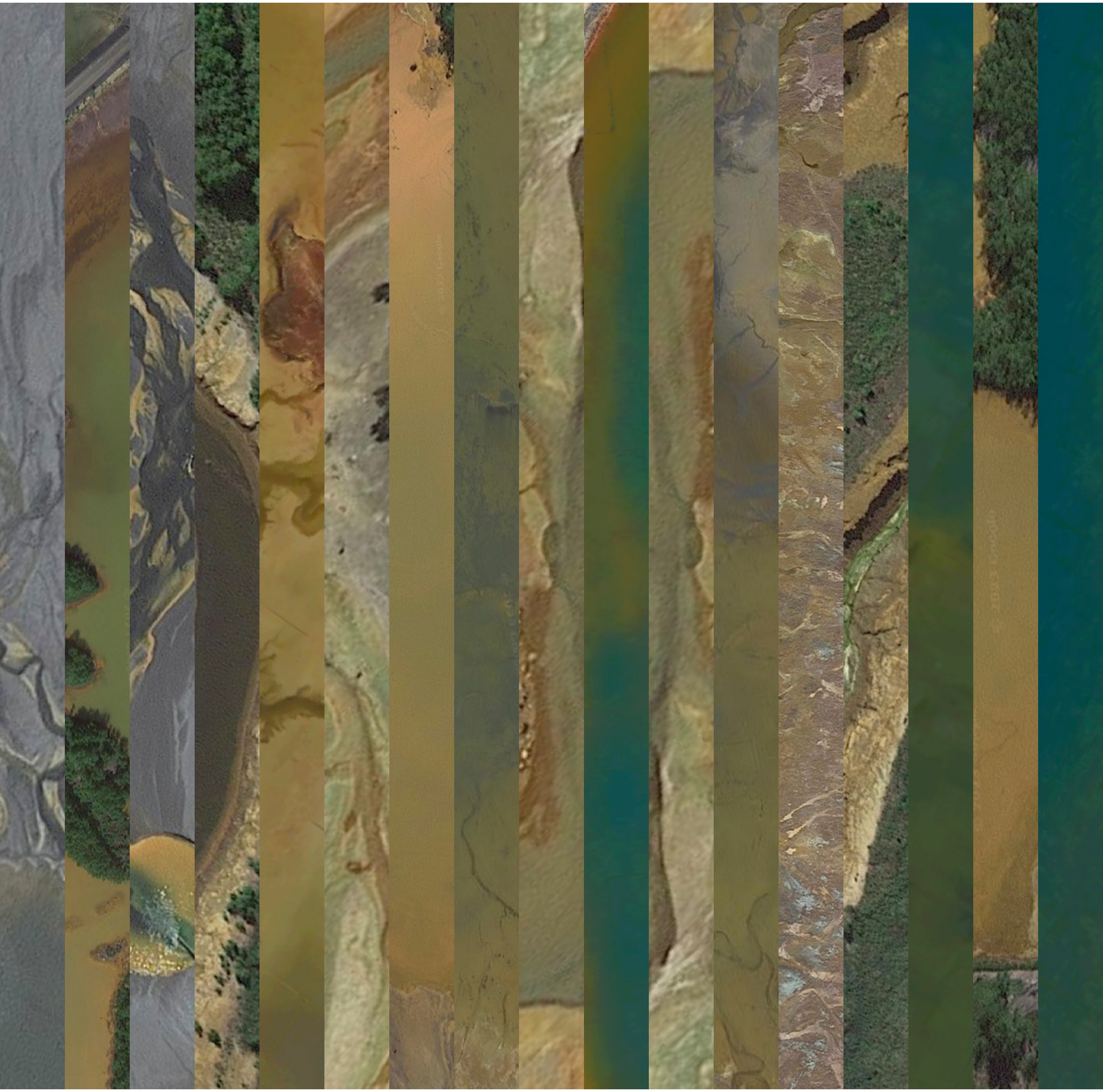
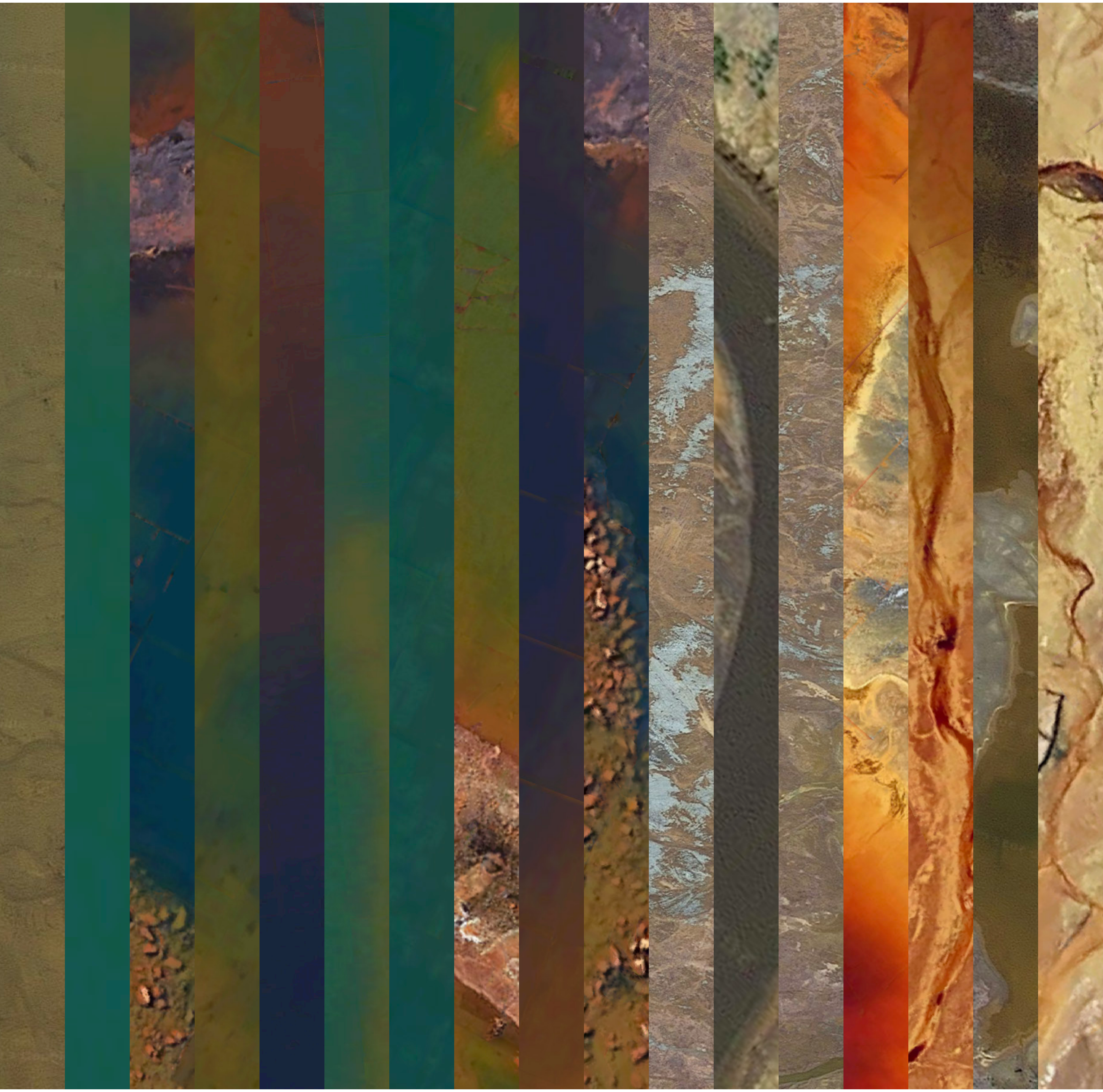


Fig. 62 *Collapsed Collage of Tailings in Copper Cliff [Part 1]*



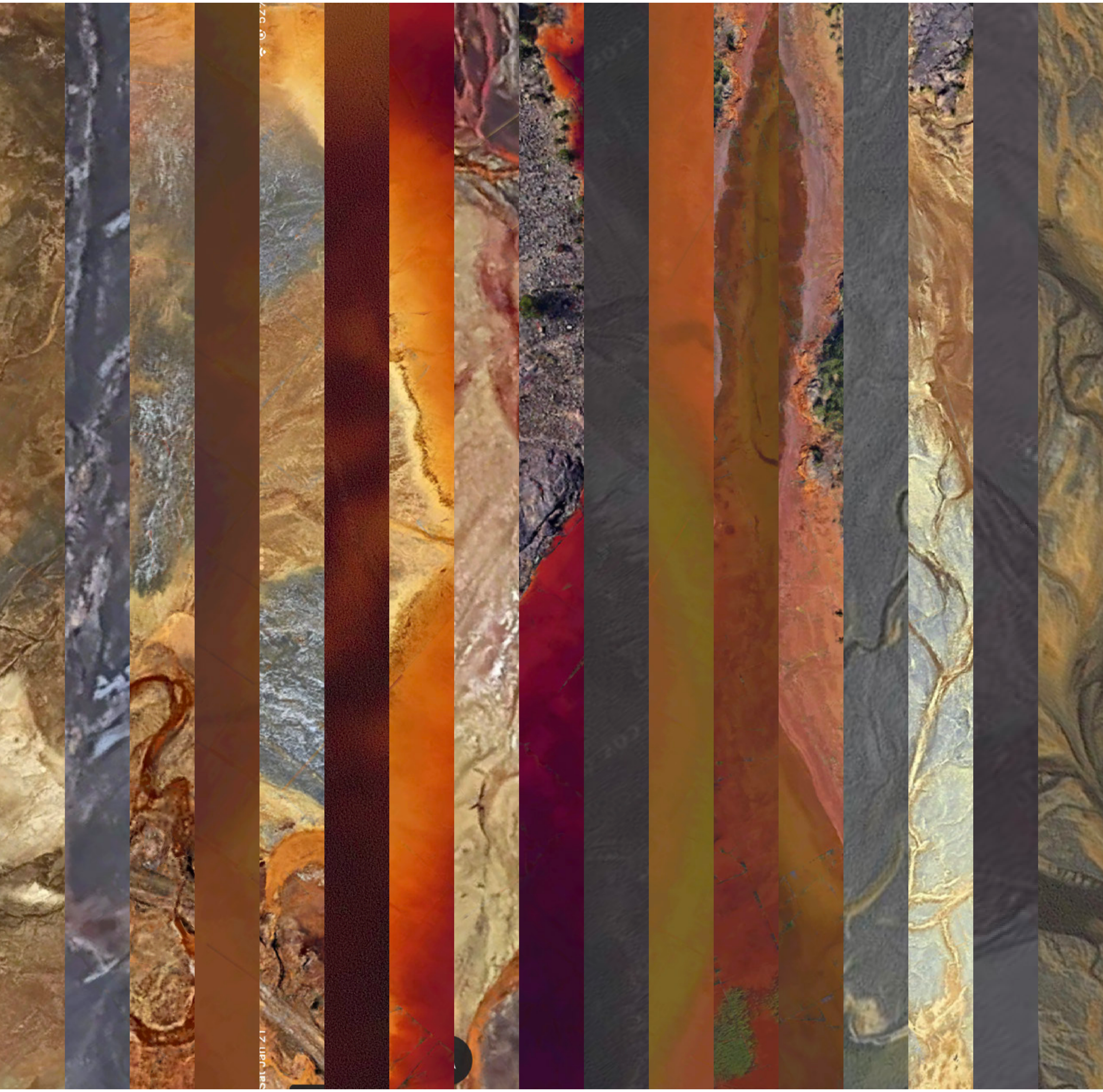


Fig. 62 *Collapsed Collage of Tailings in Copper Cliff [Part 2]*


+Ni

Fig. 63 *A Regenerative Narrative*

4
A Regenerative Narrative

Analyzing several concepts within design theory, this chapter reflects on the potential for architecture to play an active role in remediating the surrounding landscape. Subsection 4.1 discusses regenerative design principles and theory, with the aim of providing beneficial environmental impacts to offset the negative impacts of construction and operation. Subsubsection 4.1.2 analyzes specific strategies that facilitate environmental regeneration: such as Low-Impact Development; renewable energy generation; and air purification, to create positive impacts through the built environment. Subsection 4.2 discusses the understanding of place, where storytelling strategies help to teach the next generations about the complexities of Sudbury's history and natural environment, working to pursue change within industrial landscapes over generations. Together, these strategies will help remediate the environment of the Central Tailings Area (CTA) and Copper Cliff, while empowering the community by removing the barriers that separate the town from the third landscape. Access to this landscape is returned to the residents, where they are invited to learn more about the environmental impacts of the mining industry, as well as the restoration efforts. These strategies thus play an active role in this educational storytelling as the third landscape becomes part of the heart of the community.

Fig. 64 *Sudbury's Blueberries, the First Plants to Grow Inside the Polluted Landscape*

4.1 Regenerative Design

The built environment must contribute to positive ecological impacts while facilitating a responsible environmental footprint. Several design frameworks outline green-design initiatives through philosophy-based and performance-based certifications; sustainability or green design often emphasizes a metric for the performance of buildings that includes resource use, waste, comfort, etc. Performance criteria can range from quantitative to qualitative, aiming to maximize the quality of the built environment while minimizing the negative impact on the natural environment.[111] However, discourse on regenerative design emphasizes that mitigating pollution or conserving energy use is not enough. Beyond building performance, regenerative design requires a reconceptualization in terms of enabling the role of the built environment within a larger, complex system.[112] As discussed, reversing the impacts of Sudbury's industrial footprint requires a fundamental shift in the approach to our built environment. Regenerative design is a step toward co-existence between human and non-human systems, demonstrating green design initiatives and practicing social responsibility for the landscape.

4.1.1 Regenerative Environmental Theory

Regenerative theory becomes critical of sustainable practices that aim for a 'neutral' environmental impact, where there is little to no attempt to remediate past ecological damage.[113] By definition, regenerative design seeks to develop the built environment to restore the capacity of ecosystems to function at optimal health of both human and non-human life. Ideally, this would inform the creation of performative buildings and systems that provide more to the environment than they consume.[114] Therefore, a regenerative approach does not involve doing 'less bad' but instead creates a mutually beneficial relationship between the human and non-human systems **[Fig. 65]**. This approach is supported by the relationship to

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111 Jason F. McLennan, *The Philosophy of Sustainable Design : the Future of Architecture*. Kansas City, Mo: Ecotone, 2004, 4.
112 Raymond J. Cole, "Transitioning from green to regenerative design," Building Research & Information 40, no. 1 (2012): 45-47.
113 Maibritt Pedersen Zari, *Regenerative Urban Design and Ecosystem Biomimicry*, London ;: Routledge, Taylor & Francis Group, 2018, 4.
114 Ibid, 5.

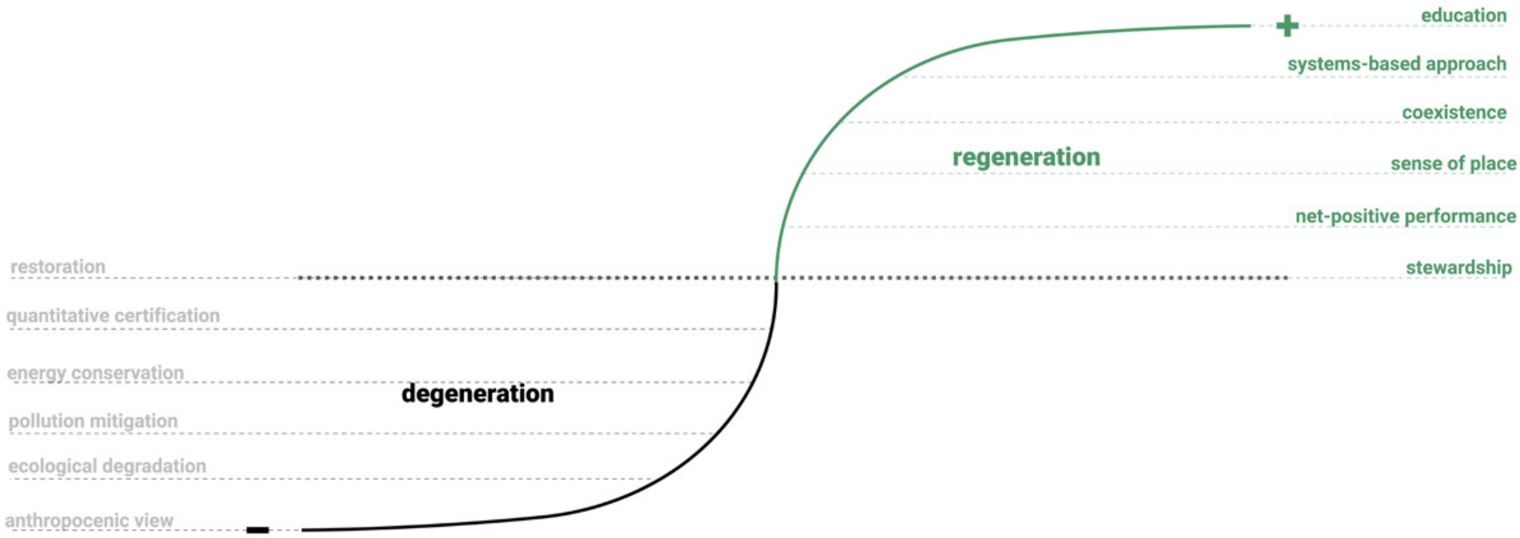

Fig. 65 *Regenerative Design*

ecosystem services, which are classified as provisioning services, regulating services, supporting services, and cultural services.[115] These systems intersect within the human and non-human realms, creating the urgency to address food, fresh water, the health of soils, or decomposition, which holistically impact the entirety of the ecosystem. Therefore, regenerative design not only addresses initiatives at the building scale but must also benefit the landscape beyond the built environment.

In practice, several frameworks demonstrate regenerative approaches to the built environment, such as REGEN, LENSES, and the Living Building Challenge (LBC). REGEN and LENSES provide philosophy-based tools to approach the design of the built environment outside of performance, including principles of stewardship, collaboration, and co-existence that promote aspects of health and well-being.[116] The Living Building Challenge combines philosophy-based principles with a performance-based metric model through seven categories or 'petals:' place; water; energy; health and happiness; materials; equity; and beauty.[117] At the scale of the building, several petals emphasize the monitoring systems integration for net-positive performance, including rainwater harvesting strategies, renewable energy production, net-positive carbon, and utilizing local and responsible materials. Outside of building performance, the petals outline aspects of social responsibility carried through by the users; net positive waste management, urban agriculture, habitat creation, environments to promote physical activity, etc. These initiatives presented by the Living Building Challenge will help create regenerative impacts on the environment and will be discussed further below through specific landscape and building strategies.

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115 Maibritt Pedersen Zari, *Regenerative Urban Design and Ecosystem Biomimicry*, 113.
116 Ibid, 47-50.
117 "Living Building Challenge," International Living Future Institute, June 2019, https://living-future.org/lbc/. PDF.

4.1.2 Regenerative Environmental Strategies for the Building + Landscape

Copper Cliff's Central Tailings area has great potential to incorporate various landscape strategies that work harmoniously with the built environment to continuously treat the polluted landscape. As an example, the presence of wastewater is prominent on the site: it transports tailings from the mill to different retention areas through pumps; becomes a cap to tailing ponds; and cools industrial machinery. By reinterpreting this previous industrial narrative, water can be treated as a poetic feature of the thesis project, where purification strategies can improve the health of the surrounding landscape. Vale's Living with Lakes Centre is a successful example of integrating the built environment harmoniously within Sudbury's natural landscape while actively benefitting the surroundings[118] **[Fig. 66-67]**. The project utilizes natural processing systems for water collection, diverting rainwater to a wetland on-site before reusing it within the building. The building's locally-sourced materials also contribute to the health of the landscape; the limestone cladding neutralizes rainfall to a more plant-friendly pH level.[119] This project is interwoven with Sudbury's complex history, hosting laboratories to continue monitoring the health of previously acidified lakes–recognizing the building must play a role in reversing the effects of the industrial footprint. Such strategies, including ones that take place both within the building and in the surrounding landscape, will be further analyzed to be implemented within Copper Cliff and the CTA in order to remediate the surrounding landscape, with a greater sensitivity to the context of Sudbury.

LID Landscape Strategies + Wastewater Treatment

In addition to biotechnologies and treatments that revegetate industrial wastelands, several landscape initiatives can provide continuous benefits to surrounding ecosystems through Low Impact Development[120] **[Fig. 69]**. Bioswales are one example of bio-retention devices that mitigate pollutants in stormwater run-off through phytoremediation–utilizing plants to treat acidic water run-off naturally. This method of soft engineering would prevent metal particulates from polluting

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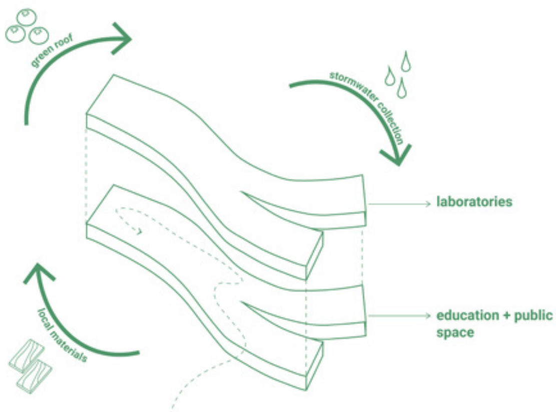
118 Jeff Laberge, "The Living with Lakes Centre," (Presentation, Sudbury, March 6, 2023).
119 Ibid.
120 Low Impact Development : a Design Manual for Urban Areas, Fayetteville, Ark: University of Arkansas Community Design Center, 2011, 26.



Copper Cliff's groundwater and, therefore, the entire watershed. Adjacent to the service roads that intersect the tailings area, implementing filter strips will control and filter water run-off into a sheet flow as another purification strategy towards receiving water bodies.[121] Both systems would work in cohesion to treat the site's tributaries.

Fig. 66 *Vale's Living with Lakes Centre + Regenerative Strategies*

Fig. 67 *Vale's Living with Lakes Centre Aerial Photograph*

As discussed, bioleaching can potentially remove reactive elements from tailings, so they no longer pose an environmental threat. Over time, the regions that once held retention ponds of mine waste can be reimagined as constructed wetlands, a large-scale landscape intervention. The construction of artificial marshes will eventually retain permanent standing water contributing to a full range of ecosystem services, pretreat polluted stormwater, and restoring biodiversity within a once barren wasteland.[122]

While soft engineering strategies improve the health of the landscape, integrating active systems at the building scale can also contribute to regeneration. For example, extending landscape strategies to the building through a vegetated roof collects rainwater at its source and regulates the volume through evapotranspiration – evaporating water at the soil.[123]

121 Low Impact Development : a Design Manual for Urban Areas, 162.
122 Ibid, 186-187.
123 Ibid, 170-171

Wastewater Management

solar aquatics system

rainwater harvesting

IMPACTS:

Wastewater is purified through bio-aumentation, using the natural process of wetlands before it is reused for greywater / irrigation.

Low-Impact Development

bioswales

constructed wetlands

vegetated roof

filter strips

IMPACTS:

Low-impact development landscape strategies offer a full range of ecosysten services to treat polluted stormwater and improve wildlife habitat.

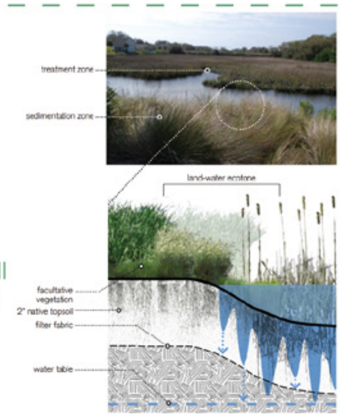


Fig. 68 *Wastewater Management*

Fig. 69 *Low-Impact Development*

Solar aquatic systems replicate the natural processes in wetlands to treat wastewater, allowing it to be stored and recycled for irrigation or greywater use inside the building[124] **[Fig. 68]**. These systems function inside a greenhouse through a series of clear tanks, utilizing sunlight, oxygen, bacteria, algae, and plants to maintain independent ecosystems that are self-organizing and resilient. These controlled conditions allow water purification to take place within a few days, and through mixing and aeration, this method reduces the sludge produced in the treatment process.[125] Like bioleaching, solar aquatic systems use natural processes and microorganisms to eradicate toxic particulates from water run-off. The sludge from this treatment can be recycled for biosolids, using solid waste to generate nutrient-rich soils for the revegetation of mine sites. Keeping these building systems transparent to the public is key to creating an educational opportunity for revealing the treatment process. Ideally, these strategies would work cohesively with other proposed biotechnologies to contribute to a remedial narrative of the industrial landscape.

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124 "Solar Aquatics Systems," Ecological Engineering Group, accessed March 8, 2023, https://ecological-engineering.com/solaraquatics/#:~:text=Solar%20Aquatics%20Systems%20replicate%20and,better%20than%20mechanical%2Fchemical%20systems.

125 "Solar Aquatics System," Solar Aquatics System TM, accessed March 8, 2023, http://www.ecotek.ca/ECO-TEK_Ecological_Technologies/Solar_Aquatics.html.

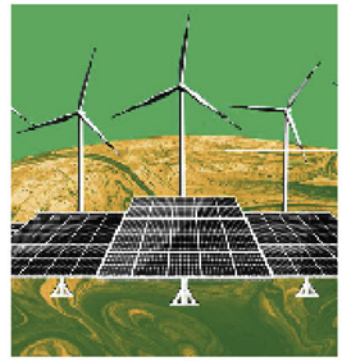
Renewable Energy Production

wind energy

photovoltaics

IMPACTS:

Utilizing wastelands to produce renewable energy contributes to the notion of providing more to the landscape/community than what is consumed.



Air Purification

Photocatalyst Treatment (transparent surface treatment coating)

vegetated wall

IMPACTS:

Eco-friendly surface treatments that provide air purification solutions within building interiors.

Fig. 70 *Renewable Energy Production*

Fig. 71 *Air Purification*

Renewable energy generation

In this critical shift towards more sustainable practices following the extractive process, generating renewable energy on-site is another strategy that reduces the environmental footprint and emissions **[Fig. 70]**. Derived from natural sources, this energy is replenished at a higher rate than consumed and therefore fits into the philosophy of regenerative impacts.[126] Solar energy, collected from photovoltaic panels, is the most abundant renewable source and can be harvested in cloudy weather. Similarly, wind turbines harvest kinetic energy from prevailing winds which can be utilized for heating, electricity, cooling, etc. The geographic scale of Sudbury's industrial wastelands hosts immense opportunities for renewable energy implementation; this energy generation can inspire a shift towards green industrial technology. Not only do these strategies provide positive impacts as explained, but they should be made visible to the public to contribute to the storytelling of remediation; especially to younger generations, and inspire them to contribute to a regenerative future.

126 "What Is Renewable Energy?," United Nations (United Nations), accessed March 11, 2023, https://www.un.org/en/climatechange/what-is-renewable-energy.

Air Purification + Surface Treatments

Both the interior and the exterior of the building can benefit the occupants and reduce the footprint on the landscape, through surface treatments. A Photocatalyst (titanium dioxide) coating is an environmentally friendly surface treatment that performs as an air purification system.[127] This transparent coating is activated through ultraviolet rays and destroys floating toxins in the air, creating a safe, clean interior environment for its occupants. Similarly, air purification can take place through vegetated walls in the building's interior **[Fig. 71]**. These systems can be classified as passive or active systems, as an extension of the building envelope that regulates building temperatures.[128] It is crucial to implement such strategies within an industrial environment, in which air quality has been a continuous concern through the presence of mining operations. Although there have been improvements in emissions reductions, this idea further emphasizes that architecture can play a key role in remediating the built environment and benefit the health of the community.

Materials

To an extent, regenerative strategies demonstrate a passage of time as a new narrative progresses toward a healing landscape and performative building. The materials of a building can demonstrate a sense of change through weathering, indicating transformation over a timeline **[Fig. 72]**. When metals oxidize, the exposure to air and water particles tint the colour of the surface that acts as an anti-corrosion barrier.[129] More specifically, corten steel and copper develop a reddish or green patina through this natural process. These materials will be utilized within this thesis as a poetic expression of the project, reflecting an industrial past and transforming *with* the surrounding landscape over time from a brown-red wasteland to a vibrant, green space **[Fig. 72]**. Through this visualization, the building facade itself generates its own educational narrative; telling a story for the community to partake in the regeneration process.

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127 "Photocatalytic Air Purifier - UV Air Purifier: PCO Technology," Green Millennium, December 10, 2016, http://www.greenmillennium.com/air-purification-solution/.

128 Low Impact Development : a Design Manual for Urban Areas, 168-169.

129 Eduardo Souza, "From Red to Green: The Contradictory Aesthetics of Oxidized Facades," ArchDaily (ArchDaily, May 22, 2020), https://www.archdaily.com/939460/from-red-to-green-the-contradictory-aesthetics-of-oxidized-facades.

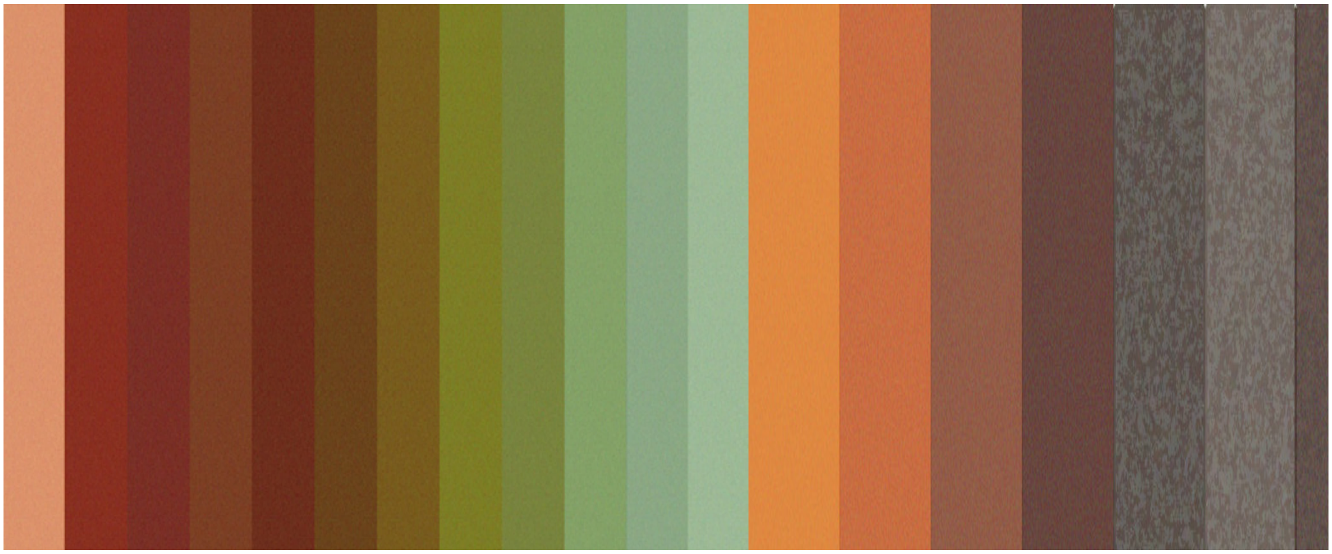

Fig. 72 *Weathering Copper and Corten-Steel*

Fig. 73 *Sudbury's Transforming Mine Sites*

4.2 Social Regeneration through Place-Based Storytelling

The manifestation of regenerative impacts ideally takes place over a temporal scale and, therefore, must begin with a strong understanding of place. The direct definition of 'place' is not always straightforward, as it is the result of a unique, multilayered network of living systems that form complex interactions.[130] Place can be recognized by a geographic region's natural and cultural ecologies with a co-creative relationship between humans and the spaces they inhabit. This is often associated with identity, tied to an intricate history, culture, or the unique nature of the physical landscape. Only with this relationship to place can humans experience their role and identity within the living world, giving significant value to their surroundings. Understanding place involves the learning process for humans to co-evolve with their environment, therefore becoming the first step to initiating regenerative impacts.[131]

> 'Regenerative development begins with the recognition that each place is a dynamic entity with its own unique history and future.'[132]

Pamela Mang + Bill Reed
Designing from Place

While 'place' is often associated with the spaces we live, work, and create, it is also deeply pedagogical.[133] Education plays a critical role in paving a path towards a regenerative future, as it establishes a community's sense of ownership. The practice of placemaking begins as children start to develop a deeper understanding and relationship with their surroundings. For children, the experience within the natural environment is similar to that of the built environment, providing a sense of refuge, comfort, security, and creativity. Simon Unwin presents the concept of 'narrative mapping' to describe children as mental cartographers, helping to synthesize the order of space, functions, and the activities associated with our surroundings.[134] Humans play a vital role in shaping the places we inhabit,

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130 Pamela Mang and Bill Reed, "Designing from Place: a Regenerative Framework and Methodology," *Building research and information : the international journal of research, development and demonstration* 40, no. 1 (2012): 28.
131 Ibid, 30.
132 Ibid, 31.
133 Iderlina Mateo-Babiano, and Kelum Palipane, *Placemaking Sandbox: Emergent Approaches, Techniques and Practices to Create More Thriving Places*, Singapore: Palgrave Macmillan UK, 2020, 2.
134 Simon Unwin, *Children as Place-Makers : the Innate Architect in All of Us*, New York: Routledge, 2019, 54-78.

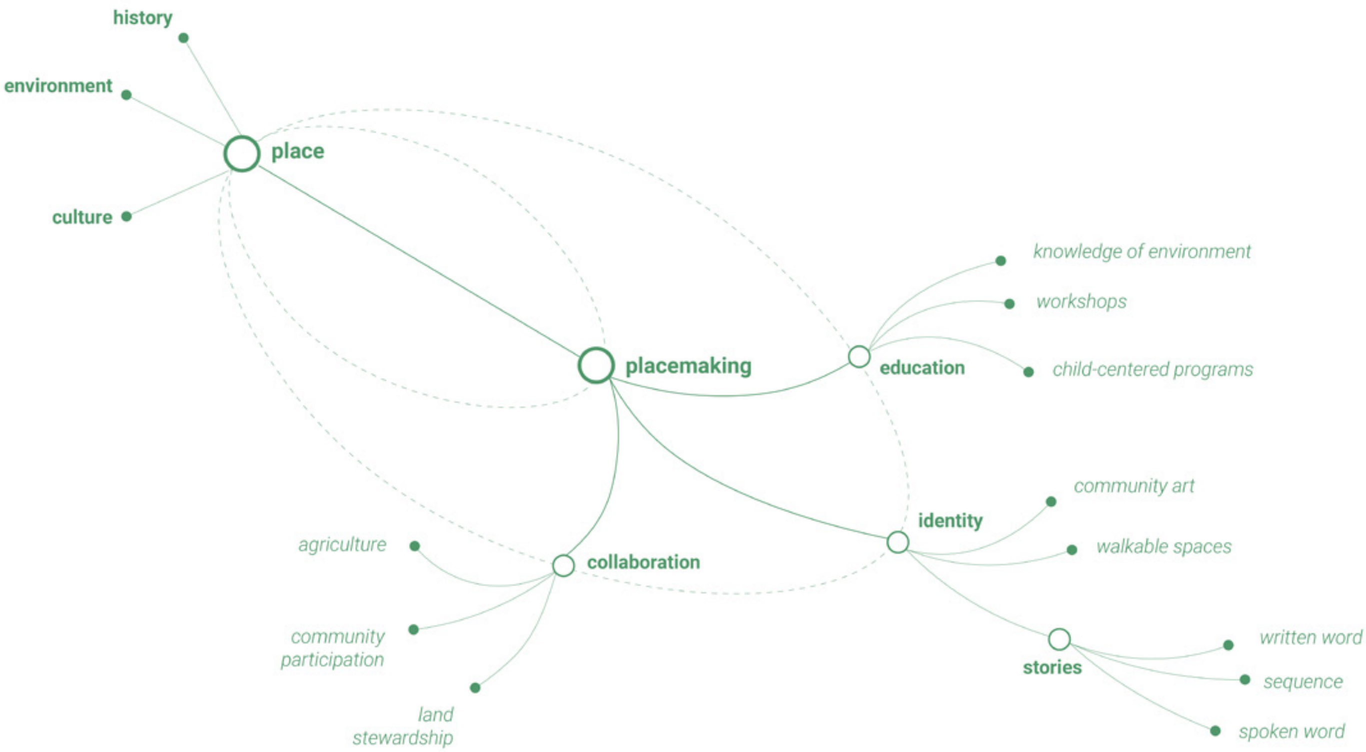

Fig. 74 *Placemaking Diagram*

beginning with youth as the most significant placemakers of the natural environment. Alternatively, stories become a medium for individuals to grasp the complex whole of a place, which especially resonates with younger generations. Considering the human memory is story-based, this medium can be used to maintain a culture's integrity through a lens of personalization that grounds historical context and knowledge.[135] Storytelling becomes a method of educating the community about the complex narrative between the mining legacy and intensive environmental restoration, which will be discussed in further subsubsections.

Placemaking can thus be synthesized into different categories; collaboration, education, and identity **[Fig. 74]**. Education becomes the first step toward identifying a place's historical, cultural, and environmental context. In the context of Sudbury, effectively communicating the historical narrative of 'place' enriches the understanding of the weight of the industrial impacts on the environment. The effort to educate younger generations prevents the repetition of the past exploitations of the environment to the point of severe degradation. Therefore, embracing the collective knowledge of the past can reshape the

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135 "Designing from Place: a Regenerative Framework and Methodology," 29.

future.[136] Social interaction and the idea of building community are central to placemaking, which can thus be achieved through collaboration.[137] Programs that facilitate participatory efforts can contribute to land stewardship and social regeneration through practices such as urban agriculture or the management of public green spaces. Efforts towards regenerative practice require collaboration within a community to create value, meaning and ultimately establish a collective identity.[138] Such architectural programs will be considered in the context of Copper Cliff and the third landscape, to further involve the community in the education and management of a healing environment.

4.2.1 Social Regeneration Design Strategies

As previously explained, aspects of regeneration transcend the green performance of a building and involve the social responsibility of the occupants. In addition to efficient building systems integration, implementing architectural programs to support educational environments promotes stewardship within the natural environment. For example, the architecture firm Atelier d'architecture autogérée (AAA) has developed a bottom-up approach for social regeneration practices through small-scale urban interventions that influence self-maintaining community projects.[139] AAA has deployed several projects within this research initiative, including Agrocity, an experimental micro-farm that integrates building systems such as rainwater collection, solar production, and greywater recycling **[Fig. 75-76]**. The project also supports food production and soil-making workshops to encourage resiliency and sustainability through community participation. Community-oriented programs contribute to creating co-existence in the environment while reflecting on the role of humans within a holistic ecosystem.

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136 Fred London, *Healthy Placemaking : Wellbeing through Urban Design*, London: RIBA Publishing, 2020, 40.
137 Ibid, 40-41.
138 "Designing from Place: a Regenerative Framework and Methodology," 30.
139 Constantin Petcou, and Doina Petrescu, "Co-produced Urban Resilience: A Framework for Bottom-Up Regeneration," *Architectural design* 88, no. 5 (2018): 58–65.


Fig. 75

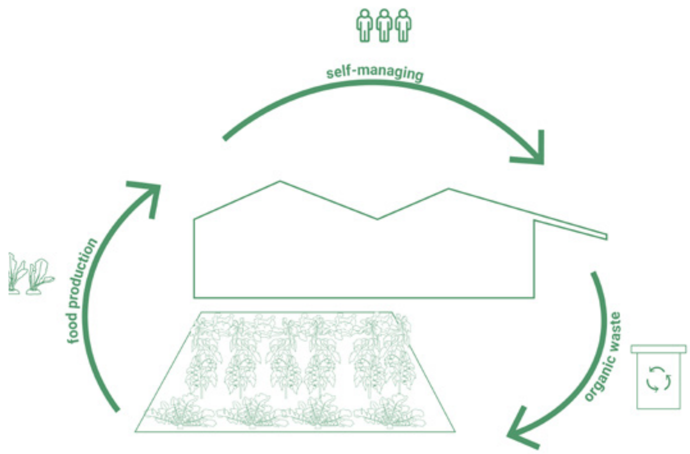


Fig. 76

Fig. 75 *Agrocity 01*

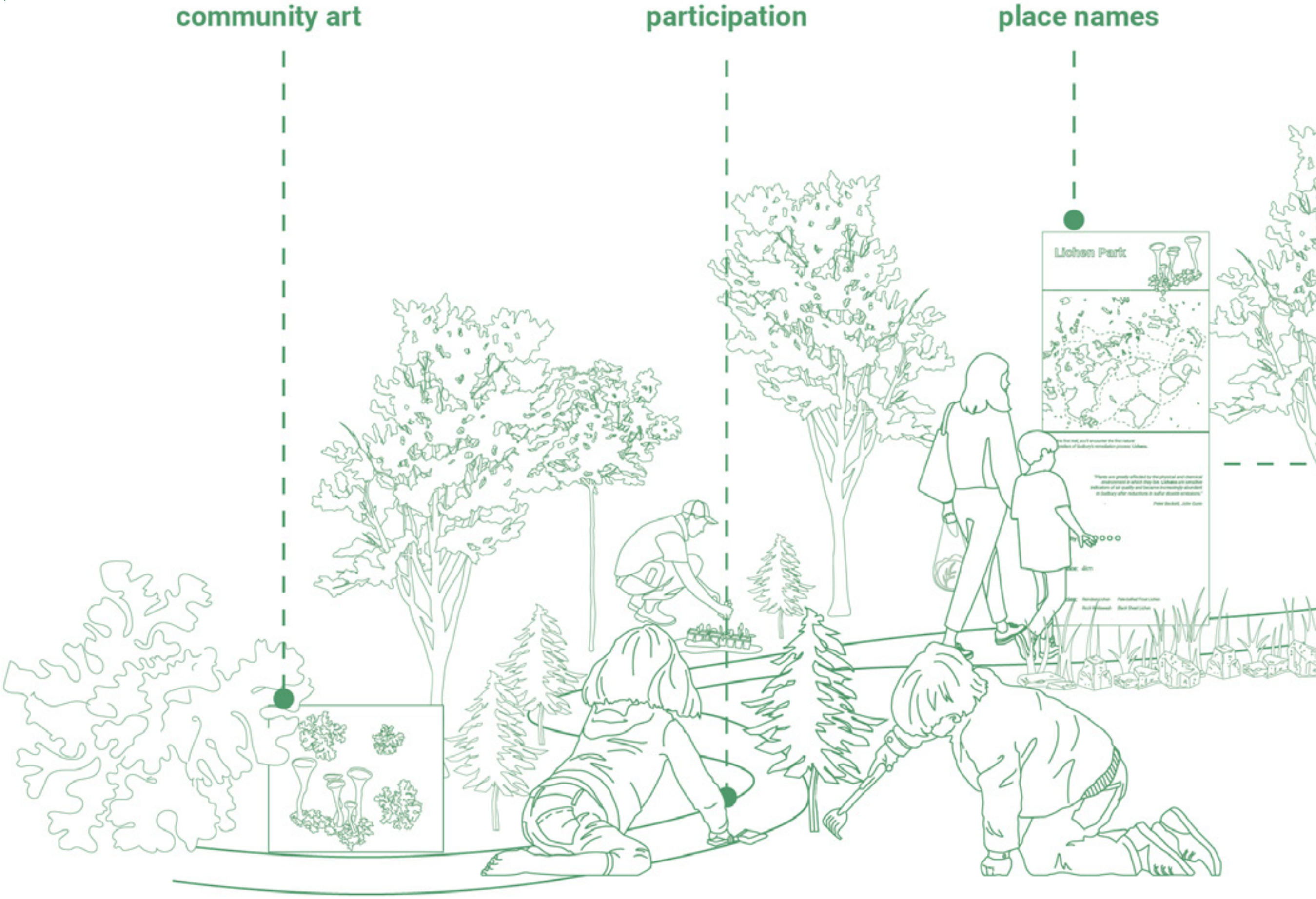
Fig. 76 *Agrocity 02*


Fig. 77


Fig. 78

Fig. 77 *MFO Park 01*

Fig. 78 *MFO Park 02*



Another strategy contributing to social regeneration involves repurposing industrial infrastructure for public use. For example, MFO Park in Zurich, Switzerland, features a repurposed factory building that was transformed into a vibrant public park[140] **[Fig 77-78]**. The metal shell of the industrial structure is preserved and interwoven with trellises to support vines, climbing plants, and ash trees that puncture the open space; essentially, vegetation replaces the original cladding. This project demonstrates a rewritten narrative from a once polluted, industrial brownfield site to a rehabilitated space donated to the community – hosting public events and activities with urban furniture, balconies, and sun decks. Repurposing industrial infrastructure avoids the complete erasure of remnants from an industrial past–it leaves behind a reflection of ecological lessons and creates programs that invite the community to participate in a regenerative narrative. Through this preservation of the memory, this becomes a method of storytelling that is especially educational in its specific context and can be further elaborated by unravelling components of Sudbury's mining legacy.

140 Rebecca Ildiko Leete, "Paul Clemence Captures Burckhardt & Partners' Zürich's MFO Park in Bloom," ArchDaily (ArchDaily, April 16, 2022), https://www.archdaily.com/980008/paul-clemence-captures-burckhardt-and-partners-zurichs-mfo-park-in-bloom.

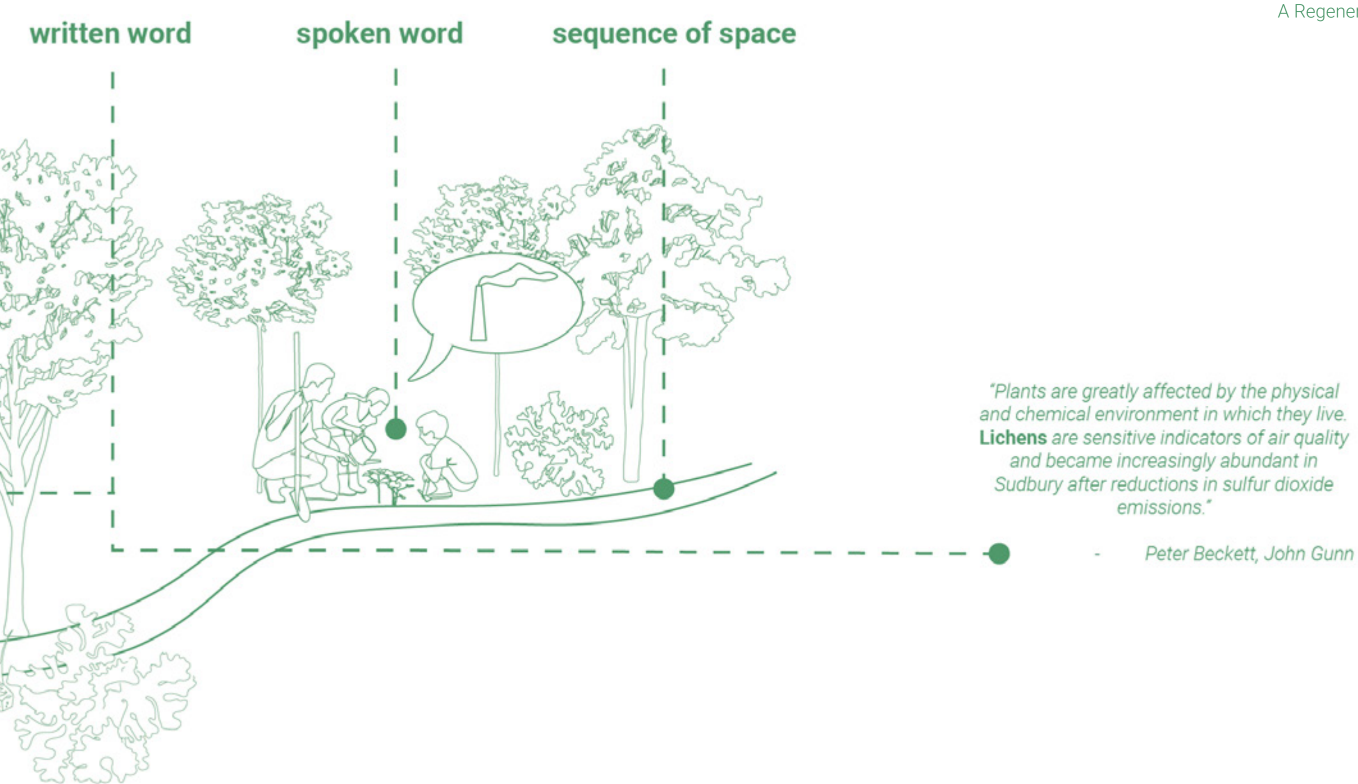


Fig. 79 *Storytelling Diagram*

4.2.2 Educational Storytelling in Sudbury

Sudbury's story of miraculous environmental restoration cannot be told through a single photograph but rather through a collection of snapshots that communicate a continuing, growing narrative. Through time, there is a reliance on research, data, or images for newer generations to grasp the complexity of the region's lessons of remediation after only experiencing the post-rehabilitation of the polluted moonscape. The personalization of Sudbury stories reinforces the impact of ecological lessons and makes the information more accessible to youth. Therefore, stories become a powerful agent for change; while establishing a collective memory, individuals can collectively reimagine the future.

Stories are recognized through text, poems, speech, or other art mediums. The process of interweaving stories through urban design essentially forms 'narrative landscapes' that create cycles of interaction between the users and the built environment through everyday activities.[141] Using artistic mediums can foster awareness about environmental issues to ensure care for people, place, and the natural landscape[142] **[Fig. 79]**. Sudbury demonstrates a unique integration of art

141 Mark C. Childs, "Storytelling and Urban Design," *Journal of Urbanism* 1, no. 2 (2008): 173.
142 Ibid, 198-201.

culture through its urban fabric; through paintings, murals, or sculptures, visual media expresses the narrative of the city's identity. Creative writing and poetry also capture stories and experiences that contribute to forming a collective identity: texts such as ***Sulphur: Laurentian University's Literary Journal***[143] and ***Slagflower: Poems Unearthed from a Mining Town***[144] are examples of documented stories and creative writing from the community, which are especially tied to the experiences of Sudbury's mining industry. Integrating art within a landscape becomes a strategy for curating a narrative landscape, communicating a narrative of the past to pave forward a regenerative path for the future.

Architecturally, the built environment communicates narratives through the urban fabric; using place names, monuments, installations, integrated text, or by formulating a strategic sequence of spaces.[145] More specifically, industrial spaces reveal the social legacies of a site by exposing the layers of landscape exploitation. Considering Sudbury's Superstack is scheduled for demolition, this would erase a monument to Vale's mining legacy, which is visible throughout the city.[146] Covering up or removing industrial scars is unnecessary, as it exposes the traces of the past and forces a reflection of our ecological footprint. There's potential to reinvent the social legacies of industrial landscapes through storytelling to ensure social responsibility while partaking in the rehabilitation of the industrial landscape and essentially the re-creation of the narrative.[147] Through the integration of all these strategies, these methods of preservation of relics and storytelling will be explored in detail in the hopes of socially and environmentally regenerating the industrial landscapes within Copper Cliff.

143 *SULPHUR: Laurentian University's Literary Journal*, Laurentian University's English Department, 2021.
144 Thomas Leduc, *Slagflower: Poems Unearthed from a Mining Town,* Latitude46, 2019.
145 Mark C. Childs, "Storytelling and Urban Design," 173-175.
146 Lindsay Kelly, "Slow Process of Demolition to Start on Vale's Superstack," Northern Ontario Business, accessed January 21, 2023, https://www.northernontariobusiness.com/regional-news/sudbury/slow-process-of-demolition-to-start-on-vales-superstack-2598483.
147 Joshua Zeunert, *Landscape Architecture and Environmental Sustainability : Creating Positive Change through Design*, London ;: Fairchild Books, 2017, 224.

"The result of years of continuous mining and expulsion of associated pollutants resulted in approximately 7,000 lakes within 17,000 square kilometers being acidified, 20,000 hectares of barren land being created in which no vegetation grows and significant erosion has occurred, and 80,000 hectares of semi-barren land."[148]

John Gunn
Restoring the Smelter Damaged Landscape near Sudbury, Canada

"I remember planting trees on a large cliffside near Garson Coniston Road. At the time, the Sudbury Model Aircraft Club picked their spot across the road where there weren't any trees in sight, to fly their model planes."[149]

Hugh Sheppard
Conversation with author

"My older brother, Doug, and I and all the other students carried five-gallon pails of lime and spread it on the plot. They told us that next year there would be grass there. The students thought 'not a chance.'But next year, sure enough, grass was growing on the rock."[150]

Craig Miron
Sudbury Memories

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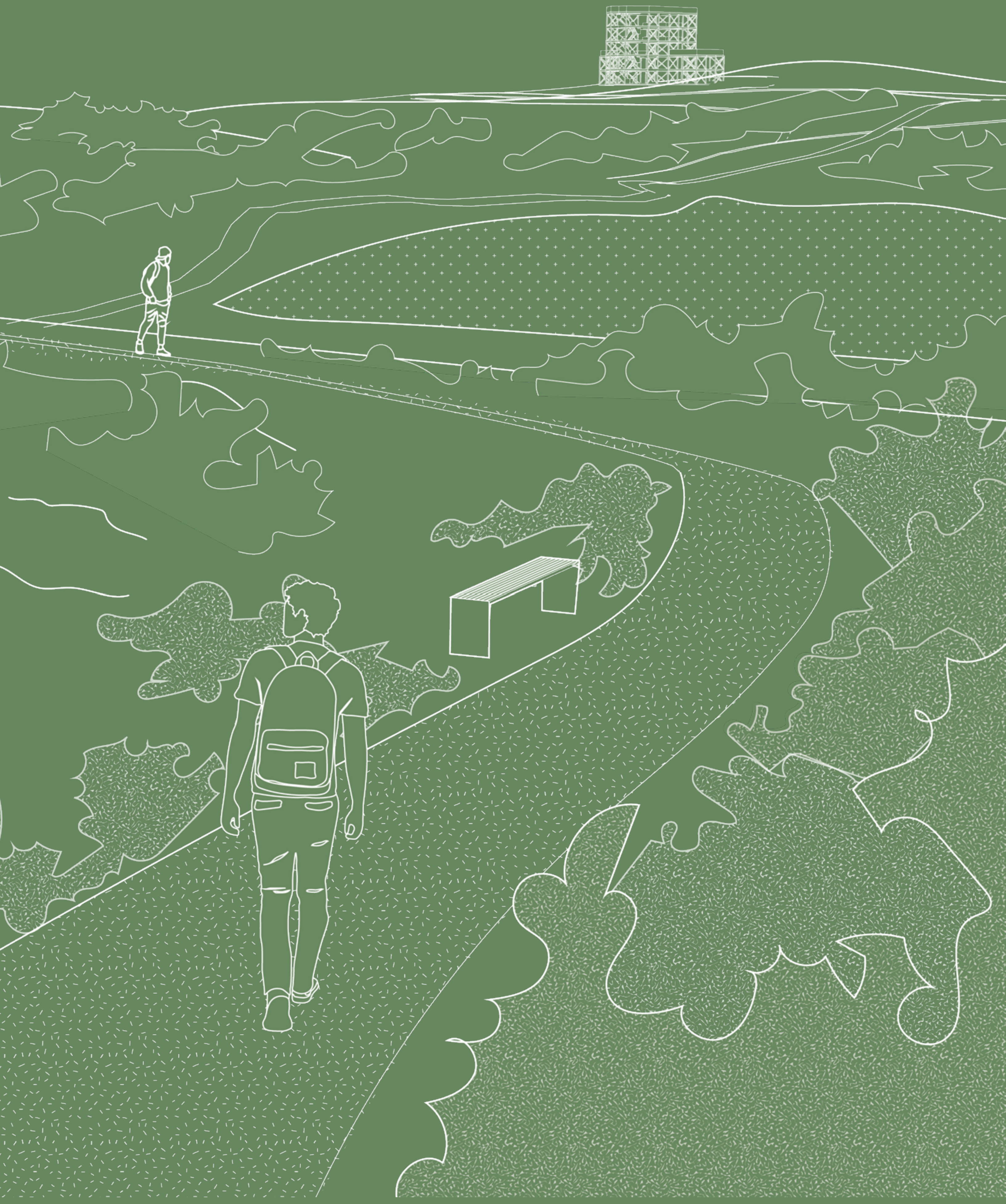
148 John M. Gunn, "Restoring the Smelter Damaged Landscape near Sudbury, Canada." Restoration & Management Notes 14, no. 2 (1996).

149 Hugh Sheppard, conversation with author, January 2023.

150 Vicki Gilhula, "Memory Lane: Sudburians Recall How They Came Together to Heal the City's Broken Landscape," Sudbury.com, accessed January 23, 2023, https://www.sudbury.com/memory-lane/memory-lane-sudburians-recall-how-they-came-together-to-heal-the-citys-broken-landscape-4797352.

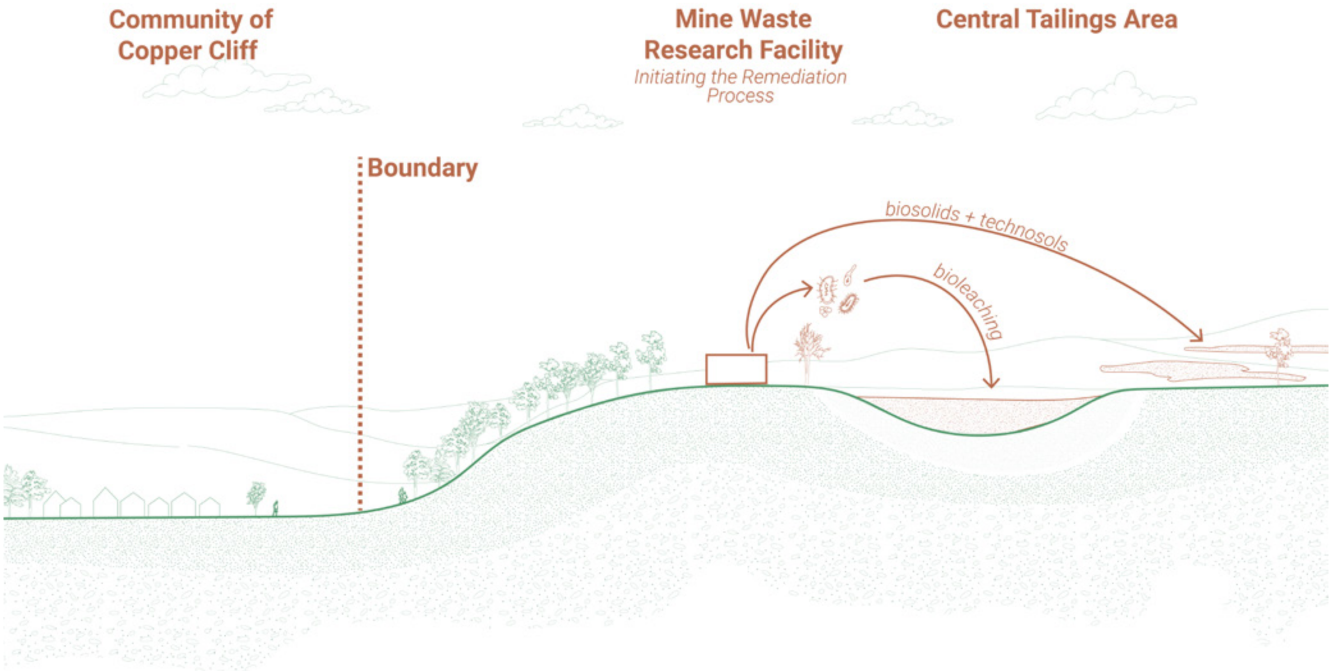


5
Designing a Red + Green Future

Fig. 80 *The Red + Green Park*

This chapter describes several design interventions that assist with the remediation and reconfiguration of Copper Cliff's industrial wastelands–the Central Tailings Area–into a thriving public park to be realized over the next decades. Subsection 5.1 discusses the vision of design principles and concepts that grounds the project, starting with lifting the veil over Copper Cliff's third landscape. Subsection 5.2 further analyzes the Central Tailings Area and the site of interest at a junction of industrial activity for the main architectural intervention, with supporting program that will be deployed across this large site. Subsection 5.3 discusses the thesis project in greater detail, at three design scales. The largest scale operates at a masterplan level for the transformation of Central Tailings Park over several phases, kickstarting remediation efforts to restore community access through growing trail networks. At the second scale, the first trail that initiates the timeline and supports a series of trail components and built interventions, Lichen Park Trail, is analyzed. The smallest project scale supports the primary architectural intervention–a mine waste research facility and interpretive centre–which facilitates the rehabilitation of the landscape while communicating an educational, remedial narrative through interpretive media. This facility is envisioned as a catalyst for the transforming park, situated at the heart of the trail networks.

Fig. 81 *Copper Cliff's Mosses*



5.1 The Vision

Fig. 82 *Unveiling the Third Landscape-Breaking Boundaries and Providing Community Access*

As discussed in chapter 4, the Sudbury Story becomes more impactful to younger generations through the retelling of personal narratives and by revisiting the imagery of a once desolate landscape. A thorough understanding of the past legacy will help create a paradigm shift by rethinking our current extraction methods, and ultimately, rethink our role in terms of maintaining stewardship of the land. The intention of this project is not to erase the remnants of the industrial legacy but rather to embrace physical relics as components of a new regenerative narrative to tell. The thesis project has several objectives: to pursue environmental remediation of the landscape by utilizing existing research in ecological restoration and in biotechnologies, as well as utilizing regenerative design at the building scale; to encourage social regeneration through community programs that connect the users toward a regenerative vision, as well as through educational and storytelling programs that empower younger generations to play an active role in placemaking and become stewards of the land.

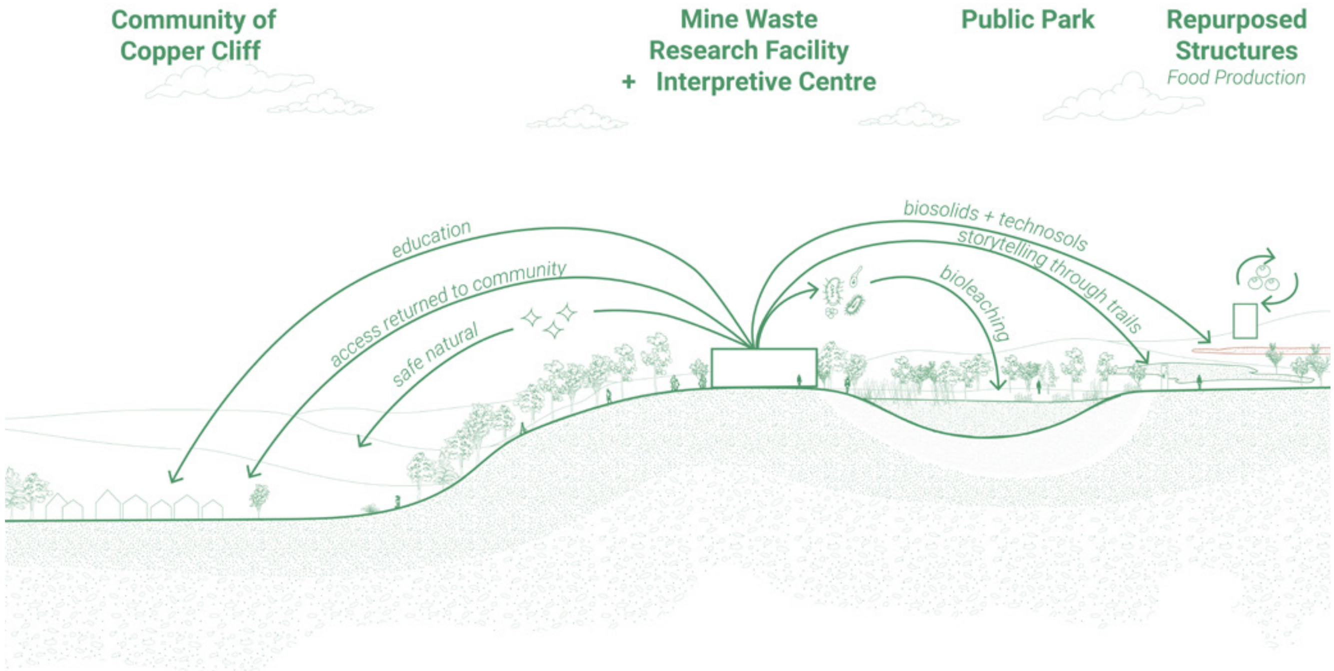
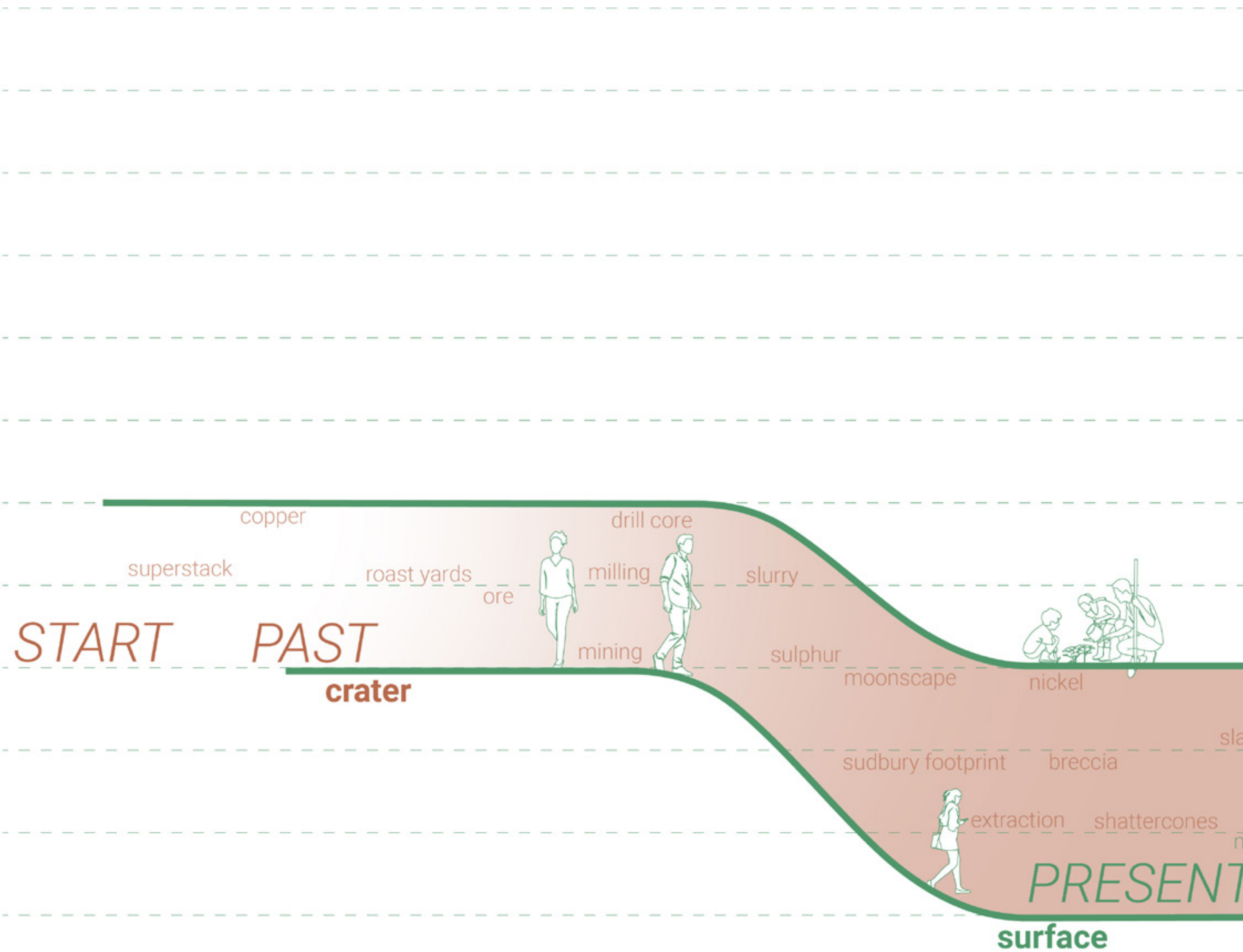


Fig. 83 *Unveiling the Third Landscape-Using the Built Environment as a Catalyst for Social and Ecological Regeneration*

Lifting the veil that now separates the Copper Cliff community from the hidden Central Tailings Area is essential in order to bring a sense of urgency to address restoration and stewardship initiatives. Building a mine waste research facility, hidden behind this veil, can help with large-scale remediation, however, the impacts for social regeneration may be limited **[Fig 82]**. The first step to creating more regenerative impacts is to allow the community to invest in this hidden third landscape, effectively revealing the industrial footprint and initiating a new ecological narrative. Gradually, the future of the tailings area can then be reimagined as a thriving public park that grew over a once-polluted landscape, supported by trail networks and a mine waste research facility and interpretive centre **[Fig 83]**. Allowing the users to go in the CTA will not only enable them to observe the transformation of the landscape, but create urgency for the remediation to be done correctly, and as quickly as possible. It will also allow the younger generations to learn about the past and the remediation efforts, as well as the impacts of our way of life, better enabling them to partake in this new story of regeneration.



The public park will consist of multiple trails that will each include a number of programmatic elements that contribute to educating the surrounding community and younger generations, but the key architectural element in the park remains the mine waste research facility and interpretive centre. Indeed, it directly contributes to the remediation of the landscape through biotechnologies, but also plays a key role in terms of storytelling through the educational interpretive program. This is envisioned as a museum-like experience that educates about the mining history and legacy, the resulting environmental impacts, as well as the ambitions for restoration efforts and a vision for the future of mining in the region. Facilitating a strategic sequence of spaces within the project inspires a new regenerative narrative both at the scale of the landscape and the built environment. At this micro-scale of the vision, the main architectural project takes inspiration from the sloping landscape that once hid the patchwork of the third landscape. The parti manifests itself through a curated sequence of spaces that allow the user to move through multiple levels, evocating the mining and regeneration experience **[Fig 84]**. The user is first exposed to the layers of the 'past'–the polluted landscape and extractive practices are revealed. Then, they go down to explore

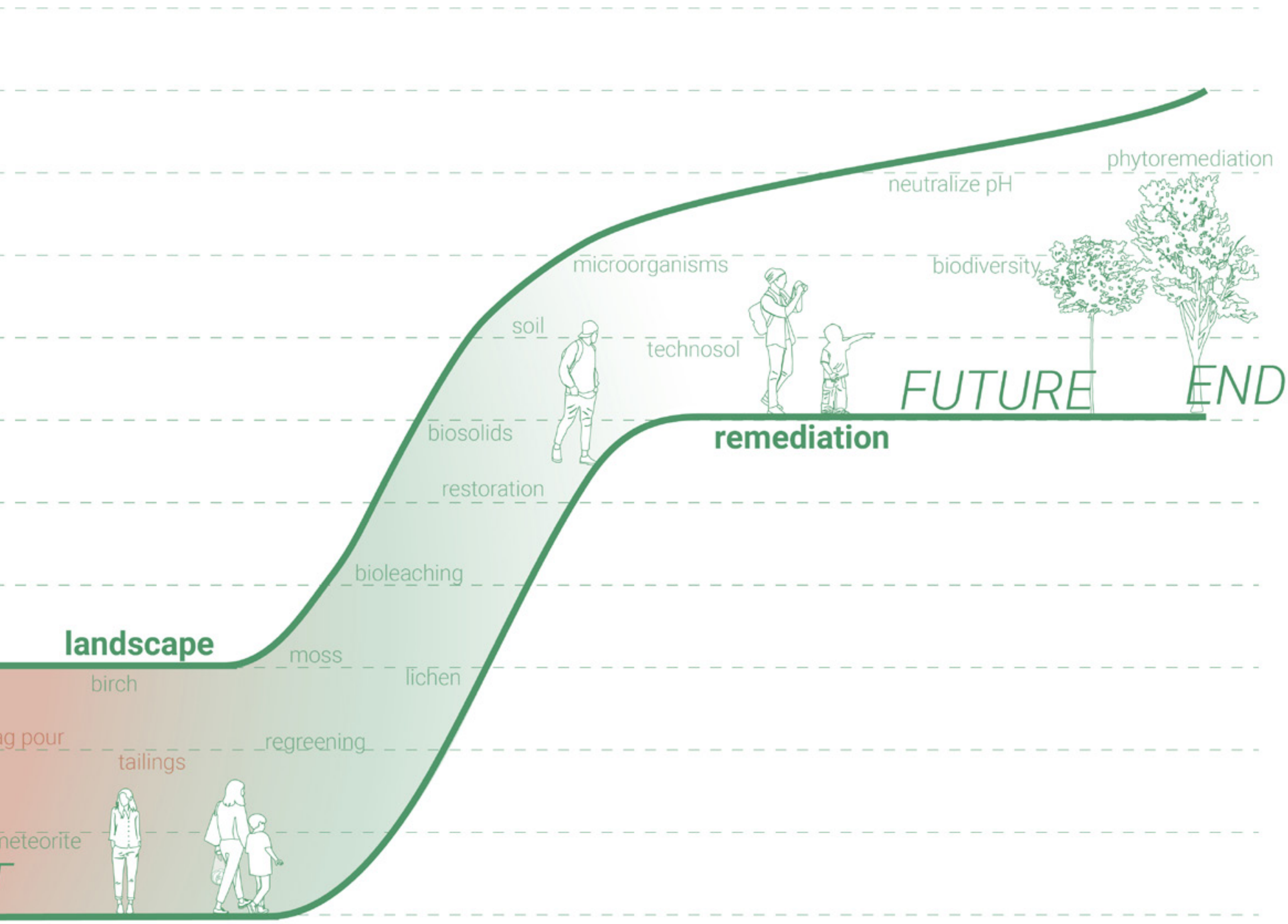


Fig. 84 *The Red and Green Parti*

the 'present' perception of the physical landscape, unravelling the geological structure, ecology, and wildlife that constitute the visible formation of the Sudbury landscape. By descending farther into the ground–farther away from the natural light and surface–it echoes the extractive process, moving passed this lens of darker, environmentally destructive days, and onward to something brighter.

The user is then directed toward the 'future' through remediation practices to restore both the landscape and the community's relationship to the natural environment. Here, the pathway leads back up toward the ground surface and the light–revealing the beauty of the surrounding natural environment, which was completely removed from view upon descending into the ground. Now, being re-introduced to the landscape, there is a greater appreciation for its delicacy and complexities–changing our viewpoint on the way we manage and care for our surroundings. The transition between these themes will create a seamless connection across a rather complex timeline, teaching the story of Sudbury in its entirety through interpretive media and art.

5.2 Program + Site

As discussed in Chapter 3, the town of Copper Cliff and the adjacent Central Tailings Area has an excellent potential to host a regenerative narrative–a site that once contributed to the greatest source of industrial pollution produced on Earth has a significant opportunity to demonstrate significant change and restoration.

Through the gradual rehabilitation of Central Tailings Park, trail networks will expand through the landscape through the progression of restoration and connect the community to these spaces. Several built interventions will inhabit the trails through furniture, wayfinding components, sheltered spaces, and repurposed industrial infrastructure to provide unique destination points. These pathways act as an introduction to the educational narrative before approaching the proposed architectural building. Through this transformation, it is important to stress that the remediation process is not linear–given the massiveness of the region, and the complex process involved with restoring tailings, this process requires active, careful management. Moreover, with the consideration of Vale's plans to keep expanding in Sudbury,[151] and with the idea that it could take several decades to remediate the tailings in the CTA as discussed in Chapter 2, we must be conscious that the mining legacy is ongoing. Therefore, the project is intended to develop over four phases in a 100-year timeline (from 2025-2125) **[Fig 85]**.

Initiating the timeline, Phase 1 lifts the veil over the CTA through the opening of Lichen Park Trail; providing access points to the community, and ultimately marking the beginning of the regenerative narrative. Here, the main architectural building is deployed–the mine waste research facility–which kickstarts the remediation process to begin the transformation of the landscape, supported by several landscape initiatives and programs that contribute to social generation for the community. The thesis project focuses on this scale, implementing several trail components and built interventions

151 James Snell, "Vale to Spend $150m to Extend Life of Thompson Mining Operation," The Sudbury Star, August 3, 2021, https://www.thesudburystar.com/news/local-news/vale-to-spent-150m-to-extend-life-of-thompson-mining-operation.

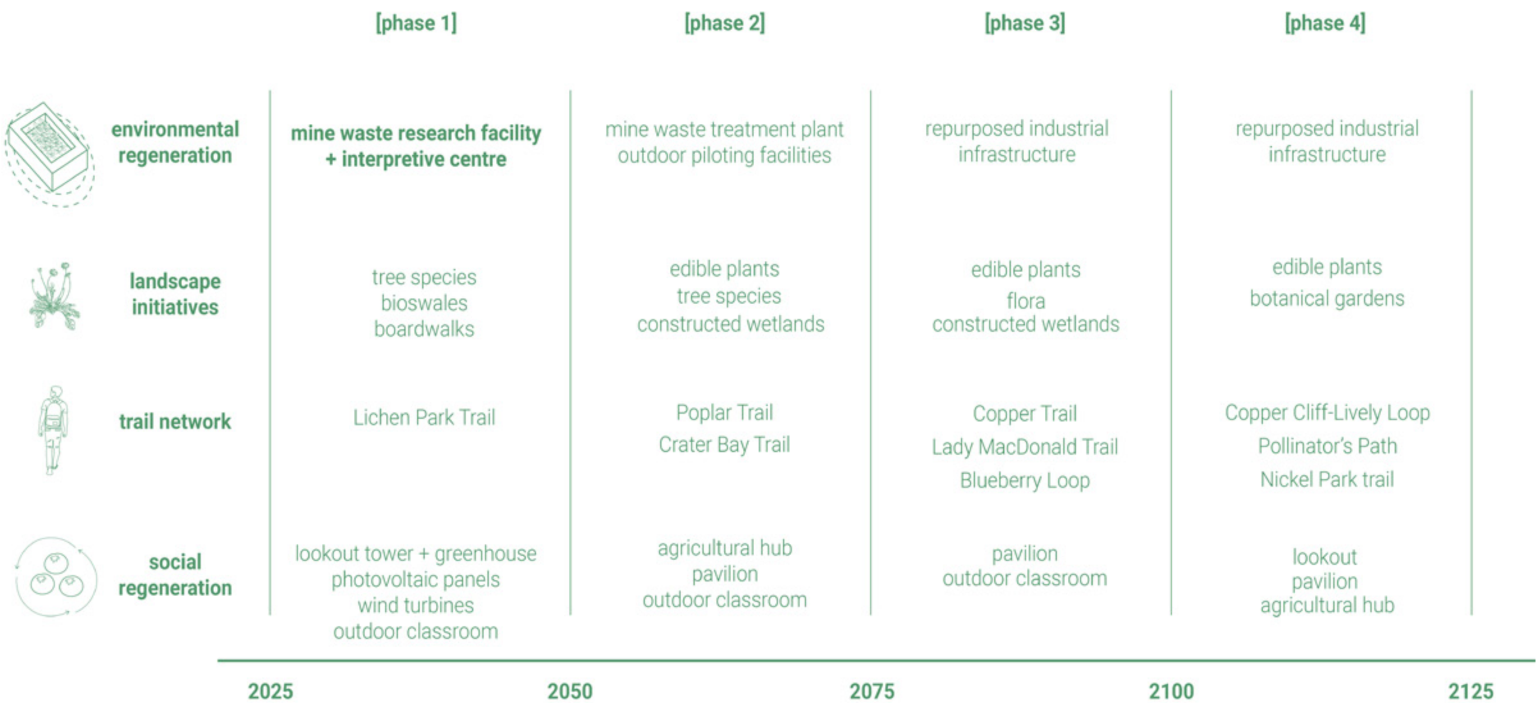


Fig. 85 *Central Tailings Park Phases*

to support the educational narrative of the park, which will be analyzed more thoroughly in the following subsections. Later, in Phase 2, the trail networks will branch further West to introduce ***Crater Bay*** and ***Poplar Trail***. An industrial mine waste treatment plant is deployed in support of the advancement in research at the main facility, which is a critical component to accelerate the treatment of the industrial sites over a large scale. These networks are also supported by more interventions that will continue to populate the trails, along with landscape initiatives that further improve biodiversity and ecosystem recovery. Phase 3 continues to introduce more trail networks to connect several legacy tailings ponds around the area, that would area, which would ideally be restored, introducing ***Lady MacDonald Trail***, ***Blueberry Loop***, and ***Copper Trail.*** Large-scale landscape strategies take shape to bring vibrancy to the greater area through sunflower fields, edible plants, and further revegetation initiatives. Finally, Phase 4 marks an era towards the end of the mining legacy–or towards greener mining operations–effectively remediating the largest tailings pond anticipated to have the longest active life-span, and opening the final trail, the Copper Cliff-Lively Loop. Ultimately, the vision for this park urges a reflection of our current practices in the mining industry, and by shifting our current way of thinking to repurpose industrial wastelands, it can create positive social and environmental impacts over generations.

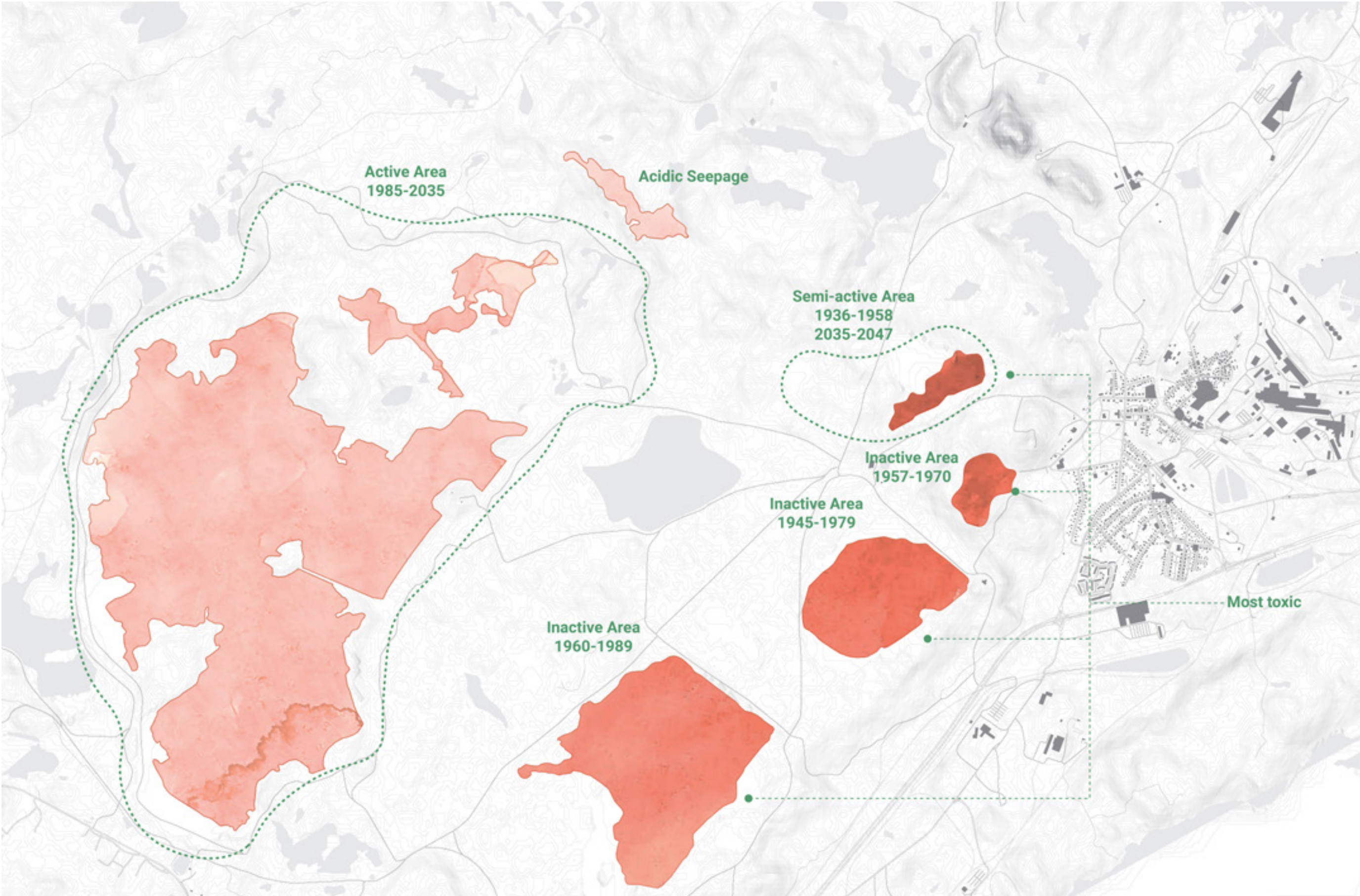
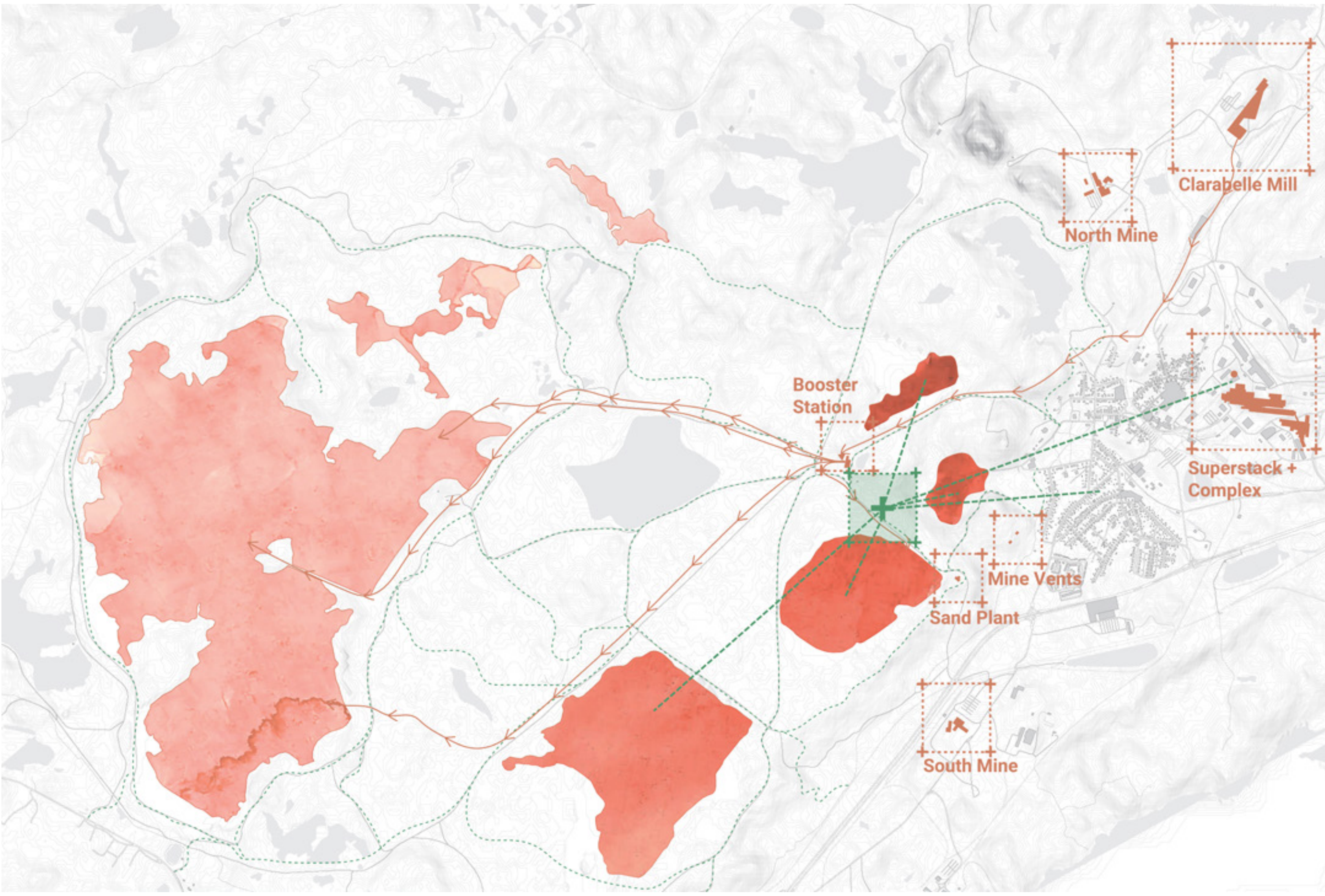


Fig. 86 *Central Tailings Area Legacy Ponds and Toxicity*

Within the Central Tailings Area, several industrial buildings populate the site that assist with mining operations and the distribution of mine waste. While advancing towards a regenerative future and a more sustainable approach to mine waste management, these infrastructures have great potential to be folded into the project timeline; preserved as relics that are connected by the trails, they become educational components for the users to experience and learn from, reflecting on a past legacy. One example includes the industrial sand plant, a tall structure visible from the highway that is used to backfill mine tunnels after they are decommissioned. Through the implementation of biotechnologies, remediated tailings could be used instead and eliminate the need for sand; the structure could then be repurposed as a public lookout tower. Moreover, several platforms are visible on site with vents that lead to legacy mine tunnels, which also become educational components that interact with the trails. A booster station pumps wastewater from Clarabelle Mill, at a junction which processes ore from all mines across the city before the waste is placed into the landscape.[152] Essentially, at the heart of the Central Tailings Area, a diversion point is created that distributes mine waste

152 "Central Tailings Area Orientation," Vale Inco, http://extportal.vale.com/ld/sud/modules/Linked%20Resource%20Documents/Canadian%20Operations%20Tailings%20Management%20Policy%202018.pdf, PDF.



from the region into the landscape. This site between this industrial infrastructure becomes a place of interest for the main architectural intervention, with the potential of shifting the previous narrative of the mining legacy told through these relics, by learning from the destructive impacts of the past and moving towards a regenerative future.

Analyzing the site of interest for the architectural project more closely, it resides in an area already touched by some revegetation efforts, on a soft slope that overlooks a vibrant red legacy pond, and the town of Copper Cliff. Throughout the entirety of the CTA, the legacy ponds which have the greatest toxicity levels— generated with dated technology—also happen to be located closest to the community **[Fig 86]**. This further emphasizes that this must be targeted first within the project timeline through the implementation of the research facility, in order to improve the health of the community and the surrounding environment. At the location of the proposed building site, indicated in green, key visual connections can be made to the community, the Vale mining complex, the Superstack, the industrial infrastructures, and several surrounding tailing ponds from this elevation **[Fig 87]**. This demonstrates a suitable project site for the proposed mine waste research facility, addressing Sudbury's urgency to improve mine waste management and providing a space to observe the transformation of the improving environment over time **[Fig 88]**.

Fig. 87 *Central Tailings Area Industrial Infrastructure + Site*

The facility integrates existing research in restoration ecology, as a catalyst to treat the wastelands of the Central Tailings Area. Researchers will be provided designated workspaces, laboratories and piloting spaces to practice their work actively, testing on mine waste samples from the surrounding landscape. The program in the research facility reflects the critical spaces proposed by MIRARCO within their feasibility study; providing the appropriate equipment and spatial relationships to practice innovative solutions with biotechnologies **[Fig 89]**.[153] Through consultations with research specialists in the field of mine waste management, this research will investigate the opportunity for the built environment to pilot innovative remediation strategies for mine sites. In addition to the building program that actively heals the surrounding environment, regenerative design principles mobilize these initiatives further, allowing the building itself to become an added layer to contribute to the environment.

To integrate community involvement in this process of restoration, this industrial program will be combined with an interpretive centre **[Fig 89]**. Hosting a socially inclusive program allows for interactive and educational environments open to the community and organized school group visits. The interpretive centre acts as a creative and poetic medium to translate complex scientific concepts from the research facility in a comprehensive manner. Although these two programs are very different, moments of interaction between the two will seamlessly merge educational pathways for users to engage with this regenerative vision. The building parti is especially representative of the strategic spatial interactions between the interpretive centre and the mine waste research facility, providing interactive and educational spaces in the construction of a cohesive narrative.

Fig. 88 *Project Site in the CTA Looking Over the Legacy Tailing Pond Toward the Building Location*

Fig. 89 *Architectural Program Breakdown*

153 Nadia Mykytzuk, "The Centre for Mine Waste Biotechnology," Mirarco, July 2021, https://miraco.org/wp-content/uploads/BioTech/Centre_FeasibilityBookletSmaller%20July%202022.pdf. PDF.

Mine Waste Research Facility

Current Proposal: MIRARCO + Laurentian University Goodman School of Mines

Demonstration Labs

material processing
piloting space

Support Labs

biomining lab (bioleaching)
bioremediation lab (soil/water/plants)
chemical analysis
microbiology

Support Spaces

administration
meeting room
storage (equipment + tanks)

+

Interpretive Centre

Interpretive Spaces

industrial exhibit
extraction exhibit
remediation exhibit

Education

workshop
multipurpose room
courtyard
green roof terrace

Support Spaces

administration
cafe
storage

5.3 My New Story of Regeneration

I've always been fascinated by Sudbury's landscape. My relatives have shared many memories with me about what it was like to play within the moonscape; in search of branches to play with to only finding fossils of dried trees; to be able to stand on the top of the black sulphur-tinted rock and see all of the town of Coniston from Garson; tobogganing in the steep landscape in winter without fear of hitting a single tree. When I stare at the mountainous black rock with a thin layer of vegetation, I can begin to imagine this past–I try to picture the rock without vegetation, and then I can imagine a group of people planting these trees one by one. What is also fascinating to me are the mine sites, which are the reason for this strange landscape; taking up so much space in the environment, but a space I've never seen. I've heard stories about people sneaking in at night, exploring these invisible sites, and visiting the rainbow-coloured tailing ponds, almost seeming like it was a local legend. But today I get to investigate Sudbury's largest tailings site in Copper Cliff, the Central Tailings Area **[Fig 90]**. *It still feels as if I'm sneaking in, seeing something I'm not supposed to see–but now, with this thesis project, we can start to imagine the site transforming into something thriving, something entirely new.*

5.3.1 Large Scale: Central Tailings Park

The overarching vision looks toward transforming the Central Tailings Area into a remediated park; now called Central Tailings Park. But remediation as a process isn't linear, and the city's mining industry will still continue for many years–some even tell me there are still over 100 years left, which is reflected in the lifespan of the Masterplan. For now, I get to explore the current phase of the project, Phase 1 **[Fig 91]**. *Marking the beginning of the timeline with Lichen Park Trail, access is now provided to the community to explore this entirely new landscape. The building is located here–the mine waste research facility–which is the key component to the transformation and remediation of this previously polluted industrial site.*

Later into the timeline, in Phase 2, the advancement in restoration ecology research will help with remediation at a large scale, which will be mobilized by an industrial mine waste treatment plant **[Fig 92]**. *While the landscape heals, we will eventually be able to explore the sculpture park and pavilions*

located around more remediating tailings ponds, around Crater Bay and Poplar Trail. Through Phase 3, the landscape re-introduces itself, from a once industrial wasteland to thriving gardens, blueberry patches and flower fields **[Fig 93]**; it will then become a colourful space with restored ecosystems and introduces Lady MacDonald Trail, Blueberry Loop, and Copper Trail. The names of the trails are reminiscent of themes familiar to Sudbury residents, like the presence of blueberries being abundant in acidic soils, or remembering the previously polluted Lady MacDonald Lake. Finally, Phase 4 completes the park the trail around the largest tailings pond–Metabird Lake–creating the Copper Cliff-Lively Loop **[Fig 94]**. The users will be able to ascend the landscape over several lookout points, towards what was once a turquoise sea of mine waste, now a large thriving landscape. This trail will speak to the advancements toward green industrial practices and waste management; looking back to the past legacy in a metaphorical and literal sense, the users will be able to look forward to a bright future toward regeneration.

Reflecting on this greater timeline, I want to partake in this new story myself, and I proceed to the first trail of the park, to get a first glimpse into this future.

Fig. 90 *Ascending the Landscape to Central Tailings Park, Looking Over the Tailings Pond and Dam*

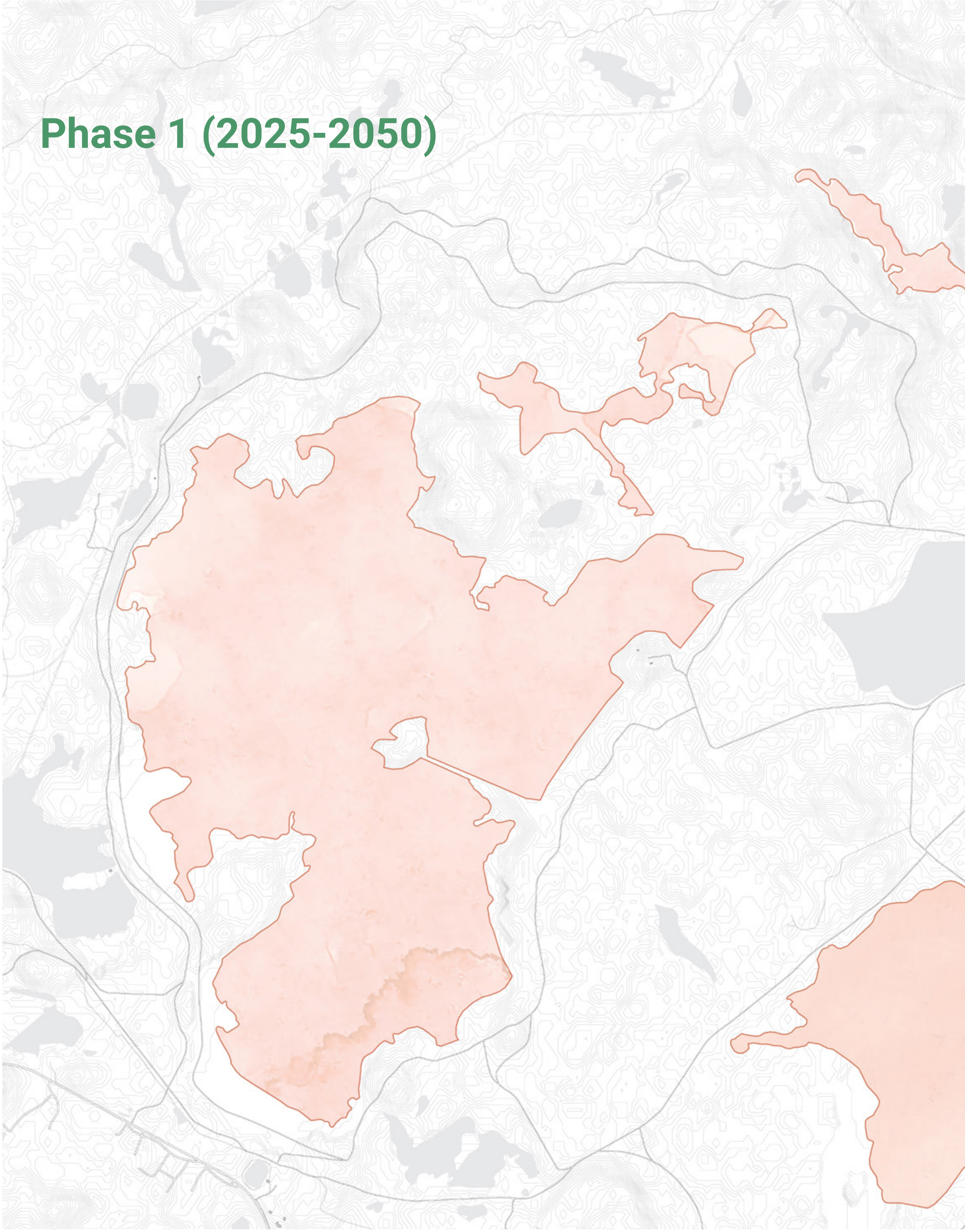
Fig. 91 *Central Tailings Park Site Map–Phase 1 (2025-2050) [Next Page]*

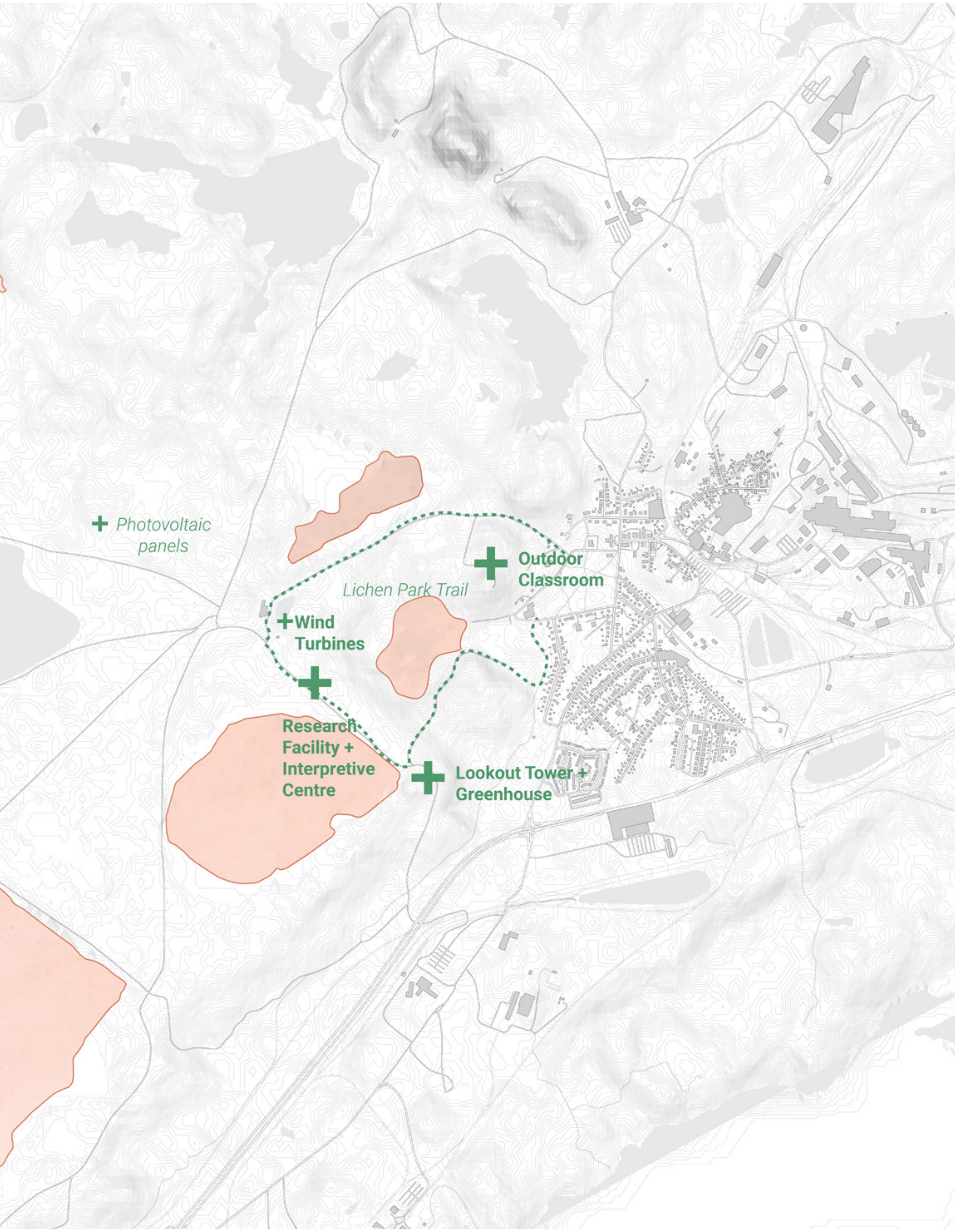
Fig. 92 *Central Tailings Park Site Map–Phase 2 (2050-2075) [Next Page]*

Fig. 93 *Central Tailings Park Site Map–Phase 3 (2075-2100) [Next Page]*

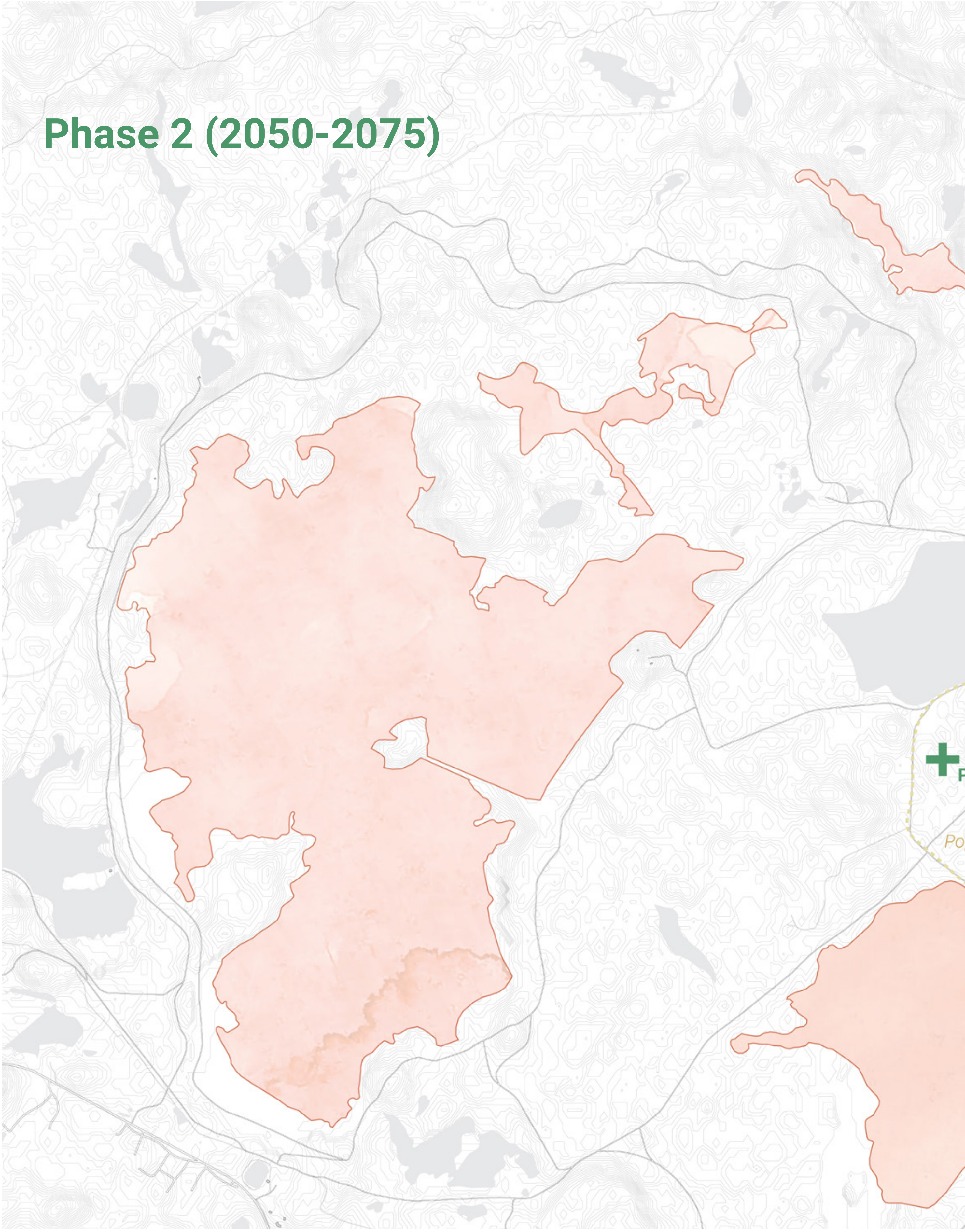
Fig. 94 *Central Tailings Park Site Map–Phase 4 (2100-2125) [Next Page]*

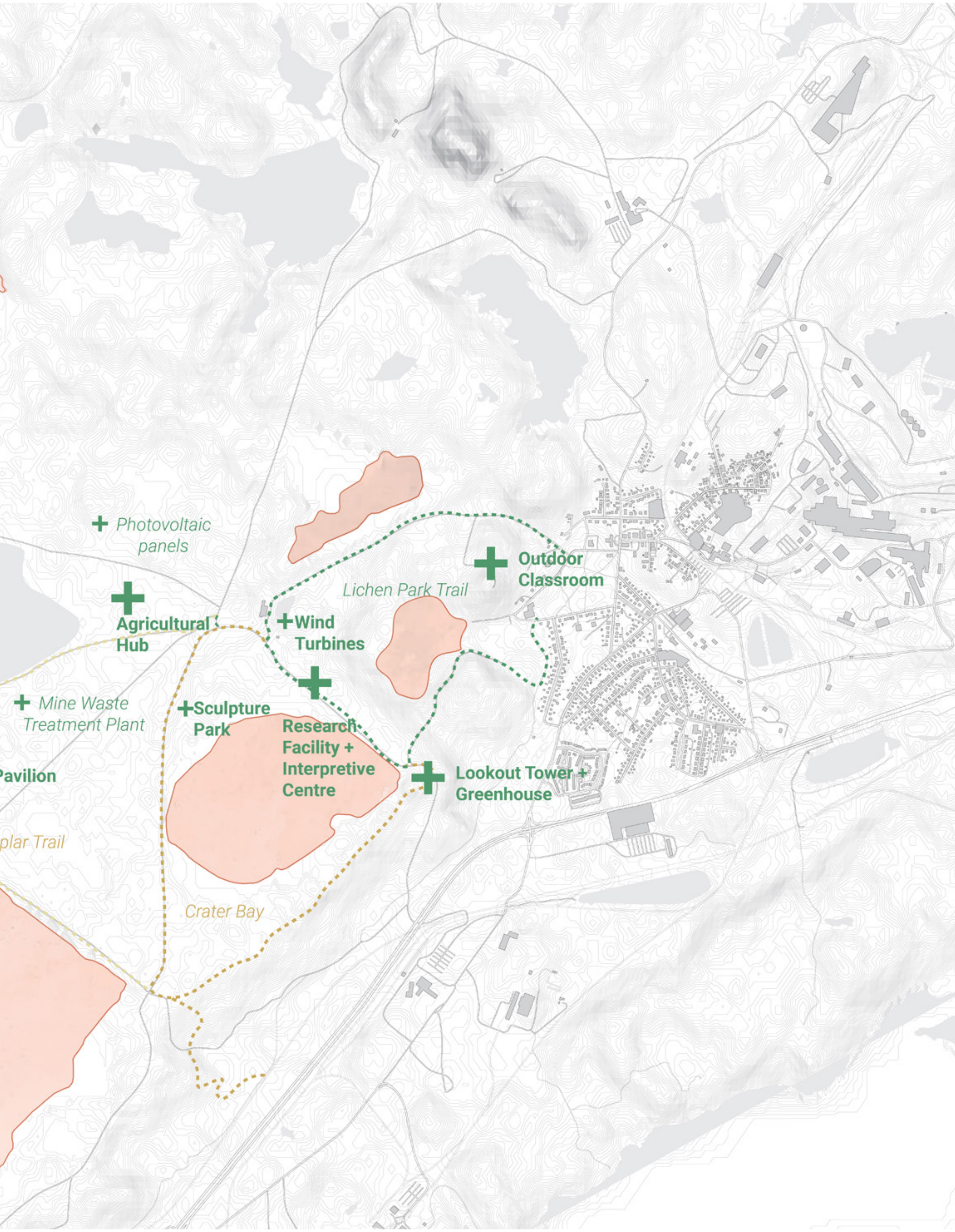
Phase 1 (2025-2050)




+ Photovoltaic panels
Outdoor Classroom
Lichen Park Trail
+Wind Turbines
Research Facility + Interpretive Centre
Lookout Tower + Greenhouse

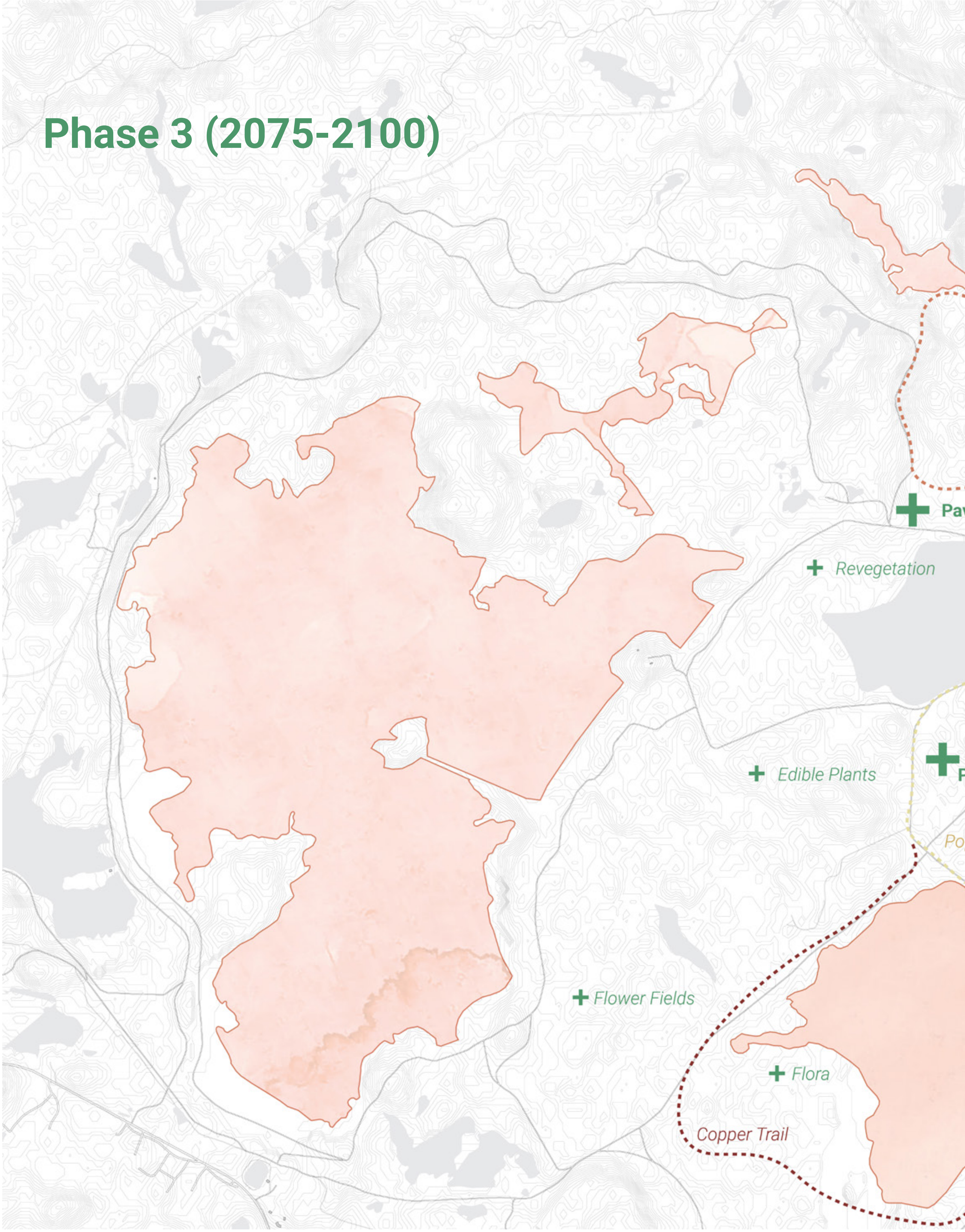
Phase 2 (2050-2075)

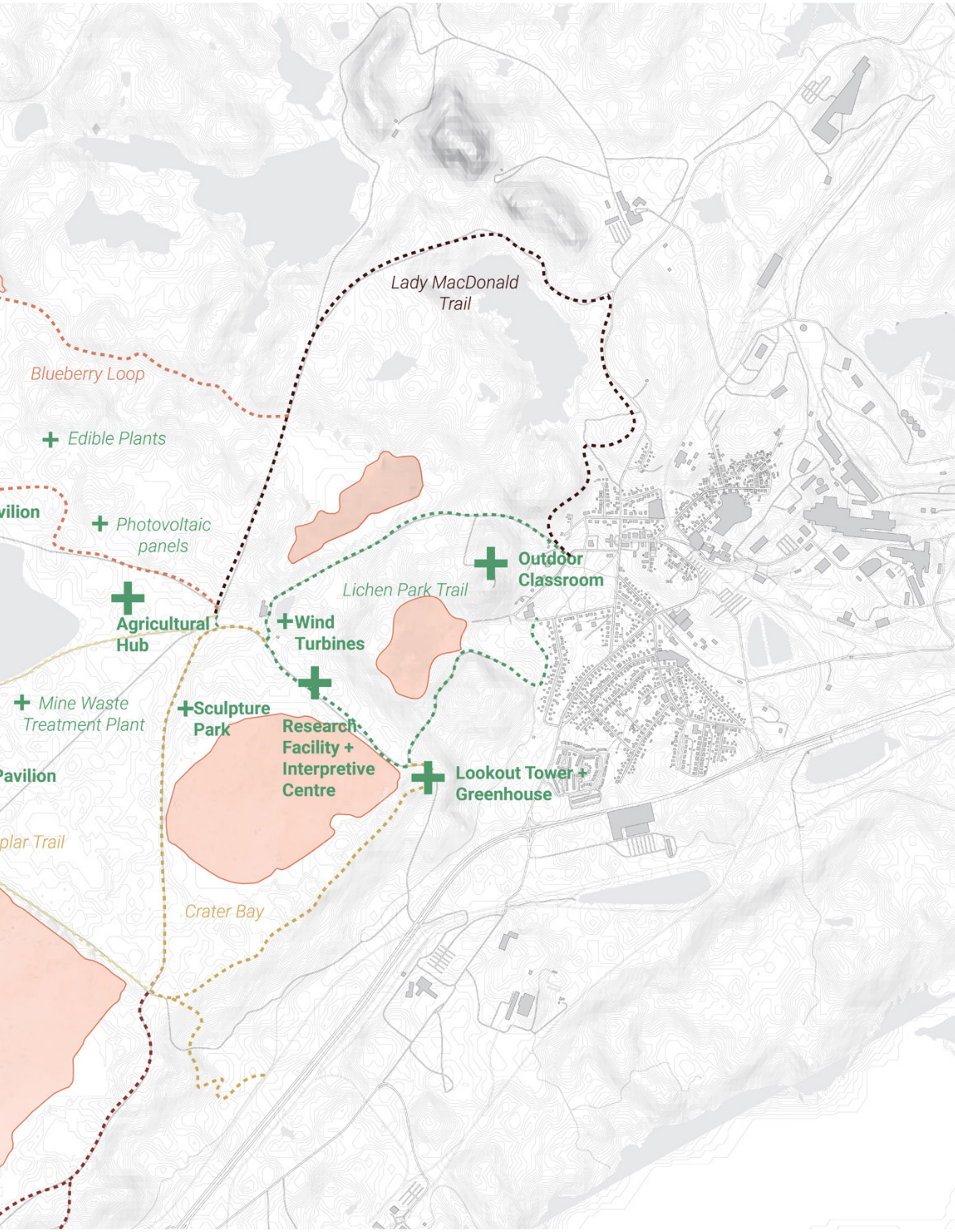




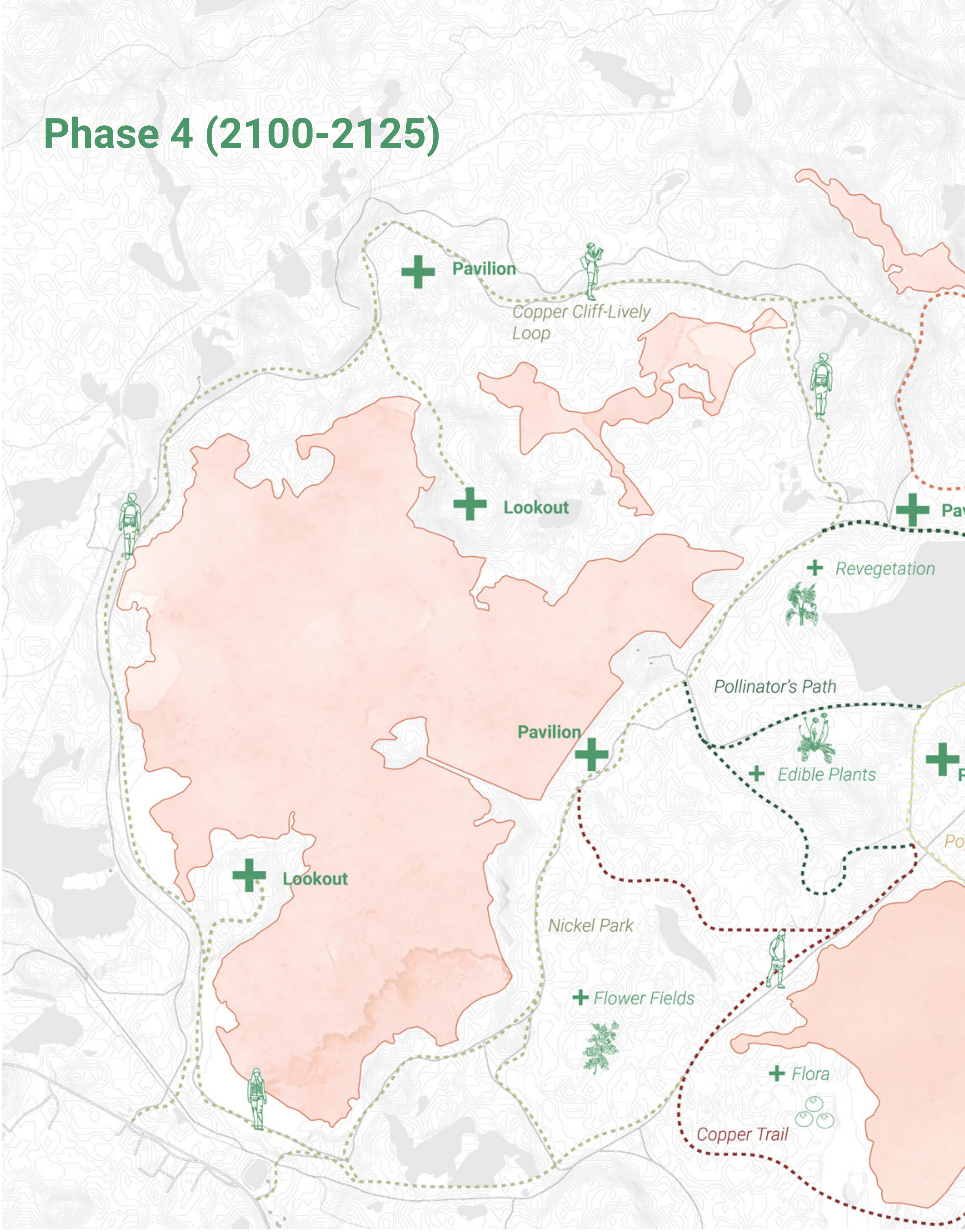
Photovoltaic panels
Agricultural Hub
Mine Waste Treatment Plant
Pavilion
plar Trail
Sculpture Park
Research Facility + Interpretive Centre
Wind Turbines
Lichen Park Trail
Outdoor Classroom
Lookout Tower + Greenhouse
Crater Bay

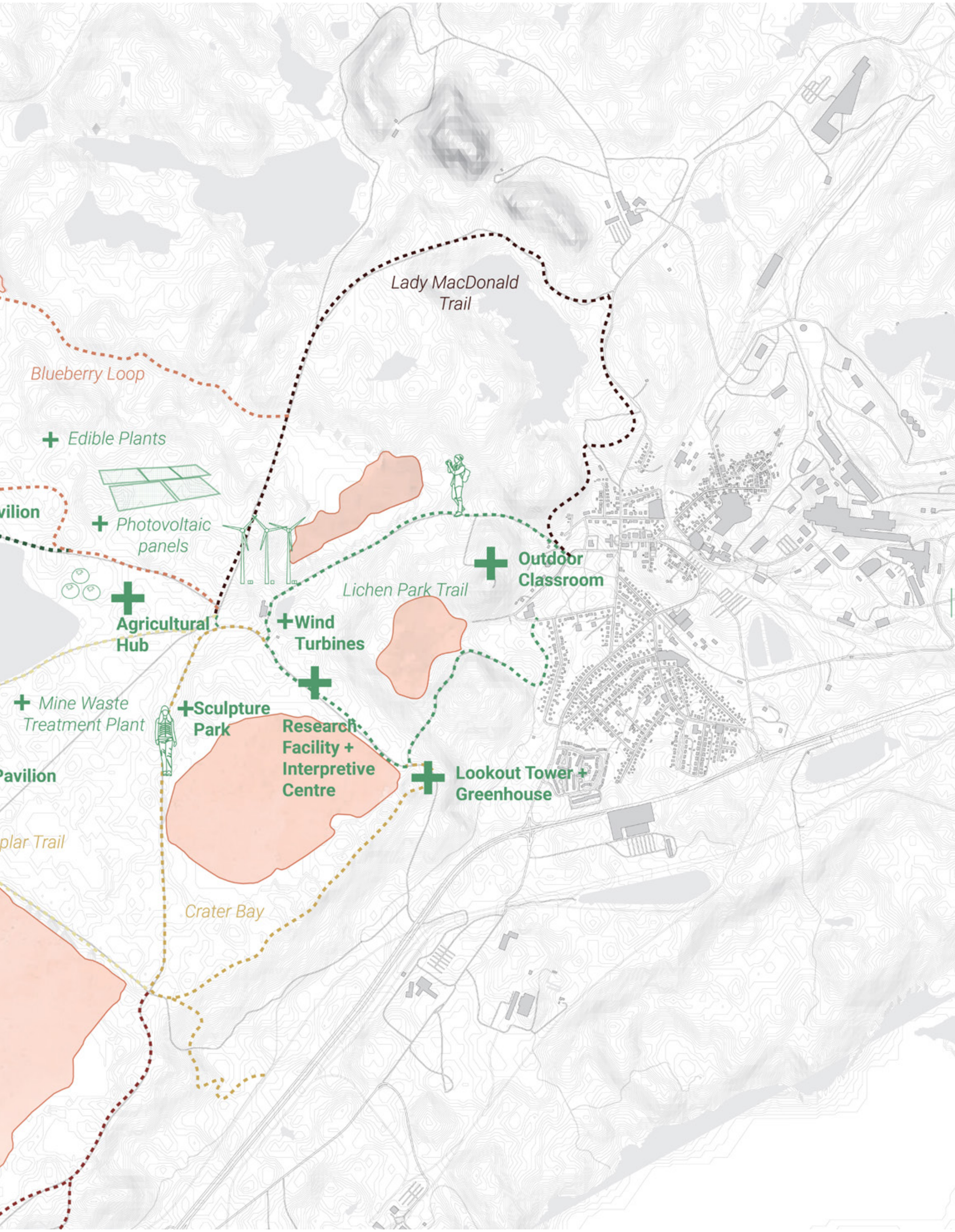
Phase 3 (2075-2100)




Lady MacDonald Trail
Blueberry Loop
Edible Plants
vilion
Photovoltaic panels
Outdoor Classroom
Lichen Park Trail
Agricultural Hub
Wind Turbines
Mine Waste Treatment Plant
Sculpture Park
Research Facility + Interpretive Centre
Pavilion
Lookout Tower + Greenhouse
plar Trail
Crater Bay

Phase 4 (2100-2125)




Lady MacDonald
Trail
Blueberry Loop
Edible Plants
vilion
Photovoltaic
panels
Outdoor
Classroom
Lichen Park Trail
Agricultural
Hub
Wind
Turbines
Mine Waste
Treatment Plant
Sculpture
Park
Research
Facility +
Interpretive
Centre
Lookout Tower +
Greenhouse
Pavilion
plar Trail
Crater Bay

5.3.2 Medium Scale: Lichen Park Trail

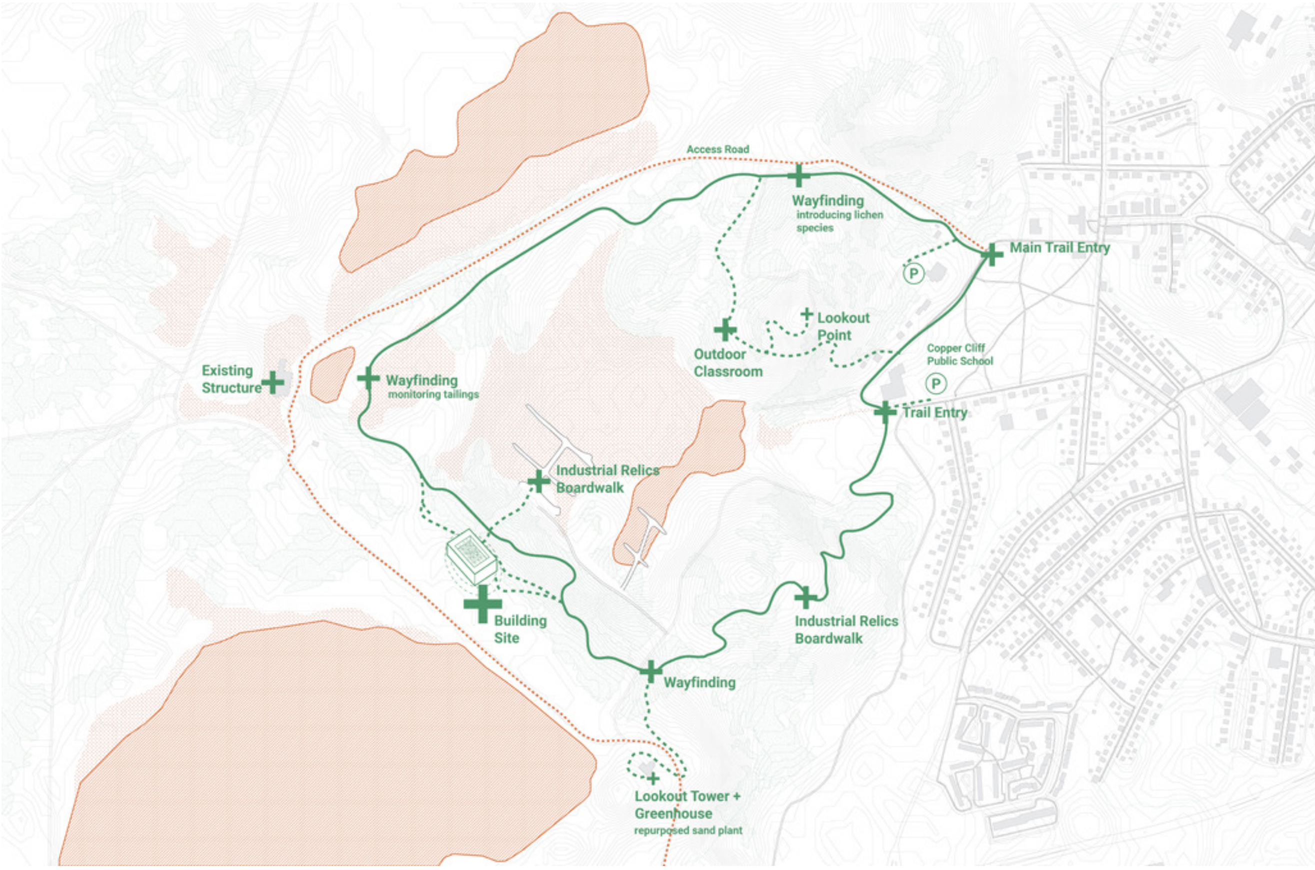
As I enter the site, I'm introduced to Lichen Park Trail, showcasing the beginning of the remediation efforts within the larger timeline. Entering the access point South of the Copper Cliff Public School, it becomes more evident that this space is in such close proximity to the community itself **[Fig 95]**. *I ascend over this topography that was previously gated with close surveillance, and an entirely new landscape reveals itself to me: tailing ponds are visible in the far distance with a copper-toned perimeter; dried tree trunks populate the ground like fossils; small ponds host pools of an ecosystem in succession; lichens peek through the cracks for rock; drill cores and slag sprinkle the site, similar to the ones I used to find in my own schoolyard. The trail forms a loop which connects a second entry point on the other side of the school, providing access from the students' schoolyard. From the town, only the towering tailings dam is visible upstream from the school; but at this elevated topography, a vibrant red legacy pond is revealed–like a heart. The pathways weave between the topography of the landscape, where some areas have already been touched by remediation efforts.*

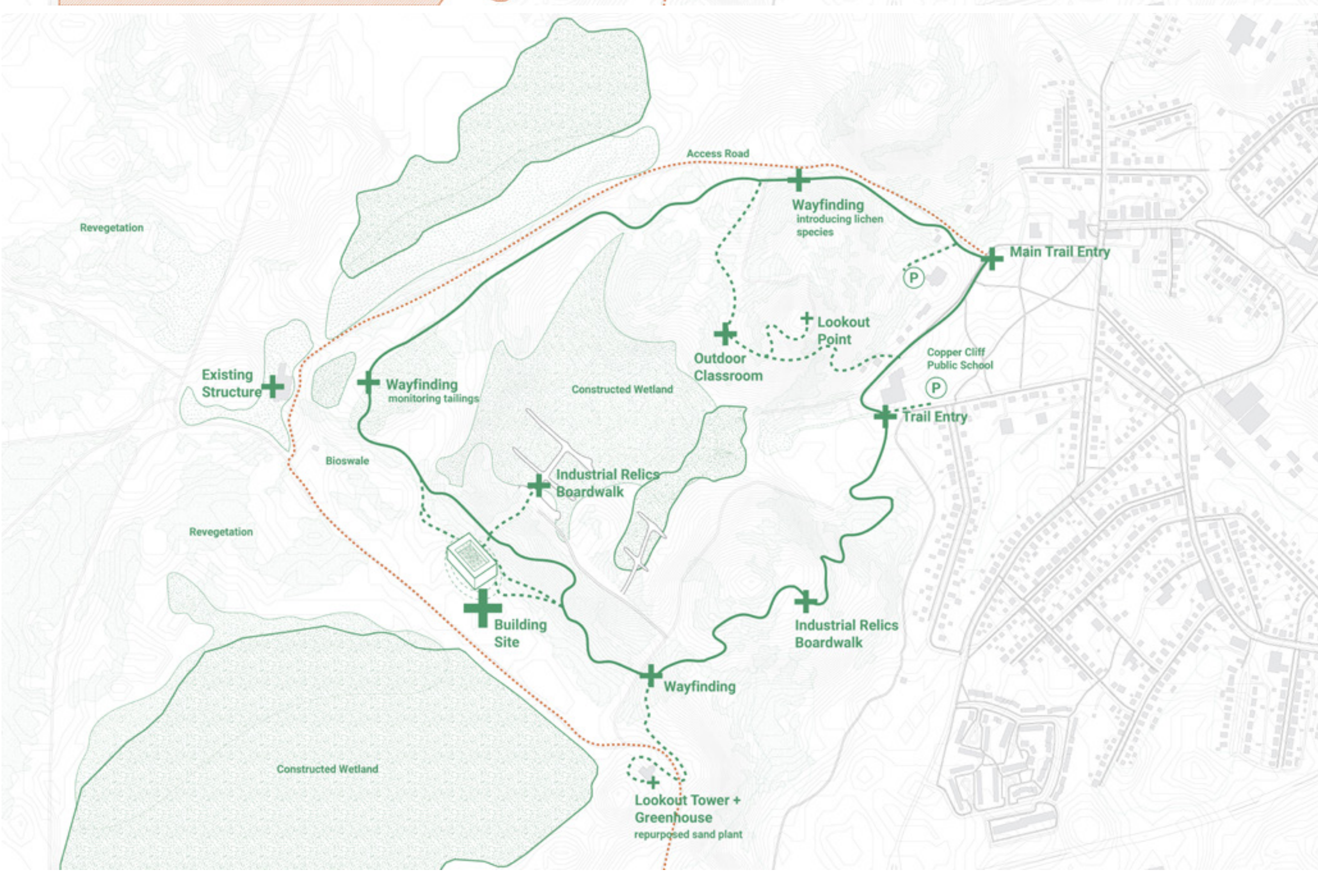
I can imagine how different the site will look in just a few years closer to Phase 2, after further remediation efforts take place and landscape strategies are implemented **[Fig 96]**. *Then, the severely polluted areas will become even more accessible to the community; for now, I still have to be cautious and keep a distance from the tailings pond at the center of the trail. Wayfinding panels along the path explained that the research facility is capable of cleaning this tailings pond, where the benign waste leftover can be repurposed for other uses including construction material, as backfill in mine tunnels, or even used in mixtures for growing mediums like technosols. In this case, I can imagine the pond one day becoming a constructed wetland when vegetation takes over; showing that there's a new life to this red-coloured pond, one day becoming a thriving ecosystem.*

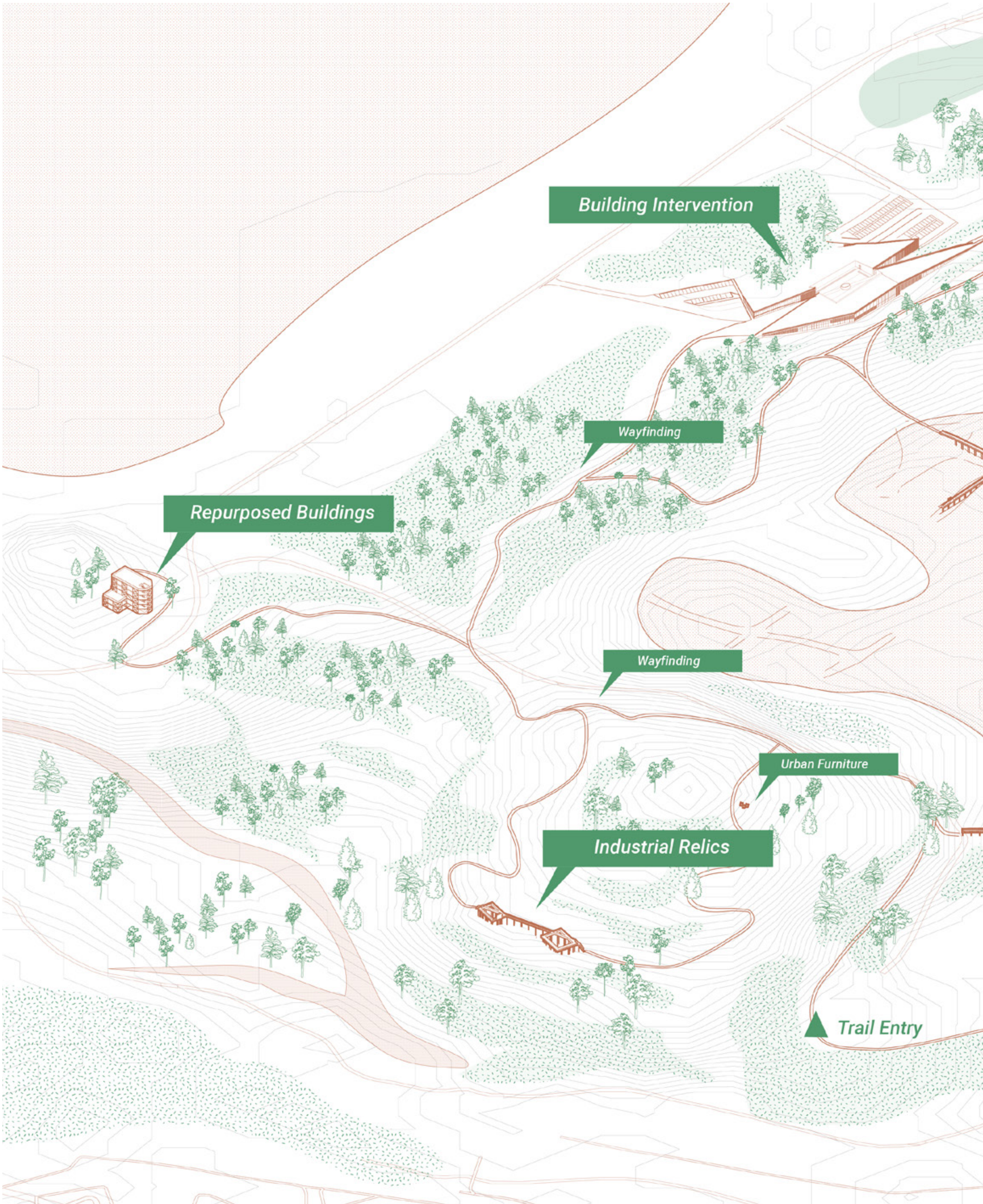
Fig. 95 *Lichen Park Trail Map, 2025*

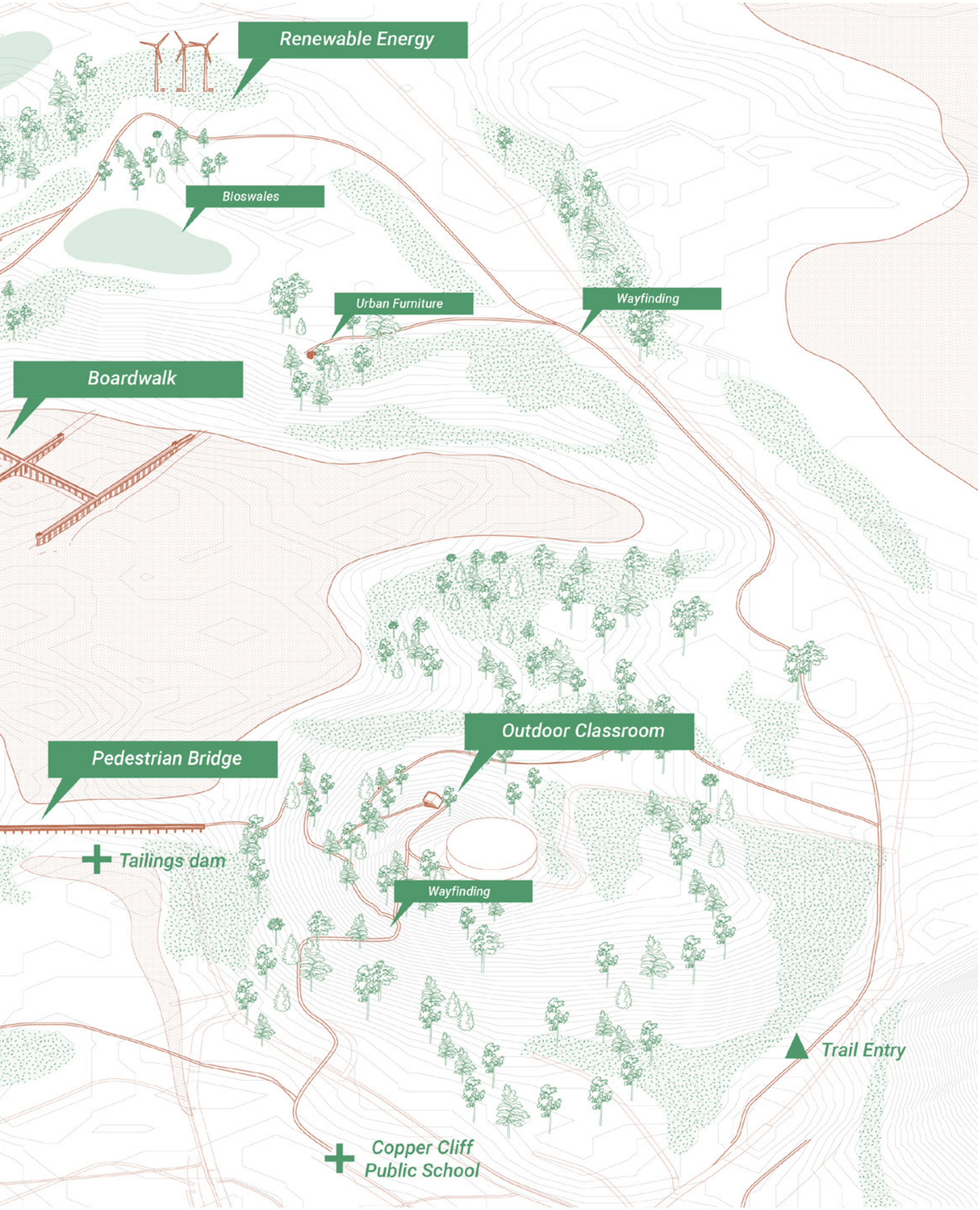
Fig. 96 *Lichen Park Trail Map, 2050*

Fig. 97 *Lichen Park Trail Isometric Map with Trail Components [Next Page]*

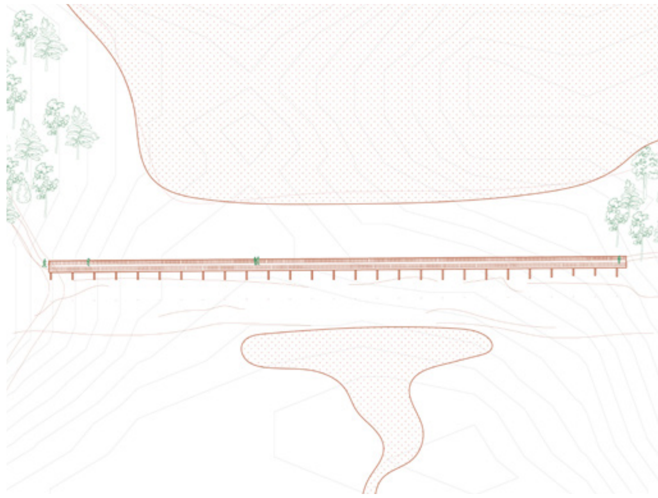

Access Road
Wayfinding
introducing lichen species
Main Trail Entry
Lookout Point
Outdoor Classroom
Copper Cliff Public School
Existing Structure
Wayfinding
monitoring tailings
Trail Entry
Industrial Relics Boardwalk
Building Site
Industrial Relics Boardwalk
Wayfinding
Lookout Tower + Greenhouse
repurposed sand plant


Access Road
Revegetation
Wayfinding
introducing lichen species
Main Trail Entry
Lookout Point
Outdoor Classroom
Copper Cliff Public School
Existing Structure
Wayfinding
monitoring tailings
Constructed Wetland
Trail Entry
Bioswale
Industrial Relics Boardwalk
Revegetation
Building Site
Industrial Relics Boardwalk
Wayfinding
Constructed Wetland
Lookout Tower + Greenhouse
repurposed sand plant


Building Intervention
Wayfinding
Repurposed Buildings
Wayfinding
Urban Furniture
Industrial Relics
Trail Entry


Renewable Energy
Bioswales
Urban Furniture
Wayfinding
Boardwalk
Outdoor Classroom
Pedestrian Bridge
Tailings dam
Wayfinding
Trail Entry
Copper Cliff
Public School

Repurposed Structure | *Lookout Tower + Greenhouse*



Bridge | *Boardwalk over a Tailings Dam*

Now that I've arrived at a high elevation, different built components are in view that contribute to the experience within the trail **[Fig 97-101]**. *Large-scale built interventions populate the trail, including boardwalks that add educational components around existing relics from the mining activity. Smaller structures are also visible through signage and furniture, adding to the comfort of the space and assisting with wayfinding while incorporating information about the history of the site. Finally, the paths intersect with the building on the opposite side of the pond, which puts the transformation of the landscape into action. Someone travelling on foot like myself would have to venture through a large portion of the hiking trail before approaching the building, adding to the overall experience of this approach.*

As I get closer, I see the outdoor classroom, where students access the space behind their schoolyard **[Fig 102]**. *The vegetated roof folds into the slope of the rock and becomes an extension of their play space. The structure looks over the greater landscape, acting as an educational space for the children of the community and a safe playground within the landscape. At a smaller scale, I can see the urban furniture and signage throughout the paths* **[Fig 103-104]**. *They assist with the navigation between weaving paths, located at critical viewpoints to orient the user toward specific moments within the transforming landscape. As I get closer to the path, I begin to see these moments more clearly.*

Fig. 98 *Lookout Tower + Greenhouse Trail Isometric*

Fig. 99 *Bridge Over Tailings Dam Trail Isometric*

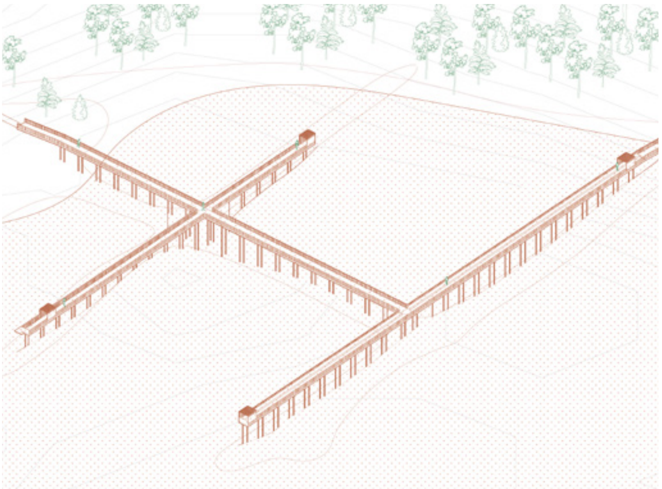
Fig. 100 *Elevated Boardwalk Over Tailings Trail Isometric*

Fig. 101 *Elevated Boardwalk Over Vents Trail Isometric*

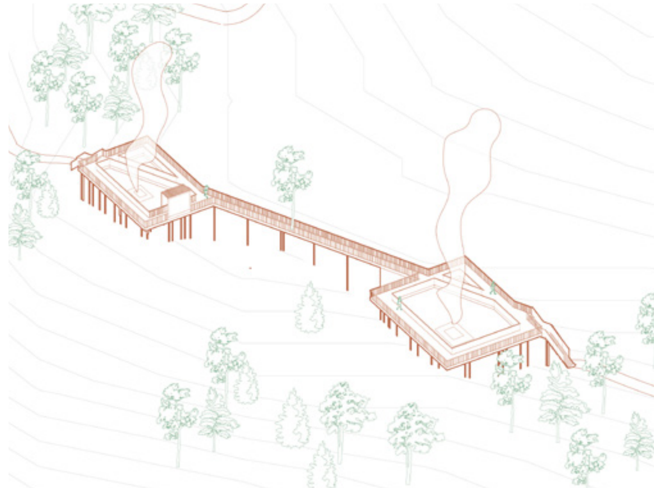
Fig. 102 *Outdoor Classroom Trail Isometric*

Fig. 103 *Urban FurnitureTrail Isometric*

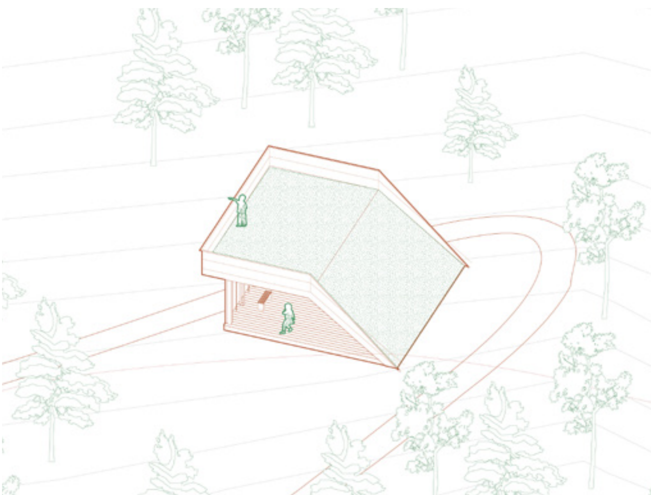
Fig. 104 *Wayfinding + Signage Trail Isometric*



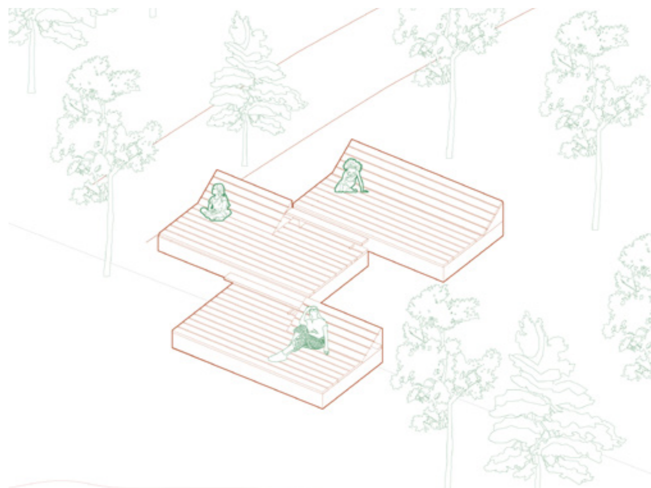
Elevated Boardwalk | *Tracing Industrial Vehicular Paths*



Elevated Boardwalk | *Tracing Mine Tunnel Vents*



Outdoor Classroom



Urban Furniture

Wayfinding Signage + Benches

As I approach the entry signage of the trails, I now understand the context behind the name–Lichen Park Trail–as lichens are known within Sudbury as a natural indicator of an improving landscape through air quality **[Fig 105]**. *After local emissions were reduced, lichens began to reappear at the beginning of the ecological succession process; therefore, they are the namesake of the first trail to start this process of the healing landscape. On the signage, I get a glimpse of the entire trail map that is planned for the future, accompanied by information about the current trail, and identification of endangered lichen species to watch out for along the journey.*

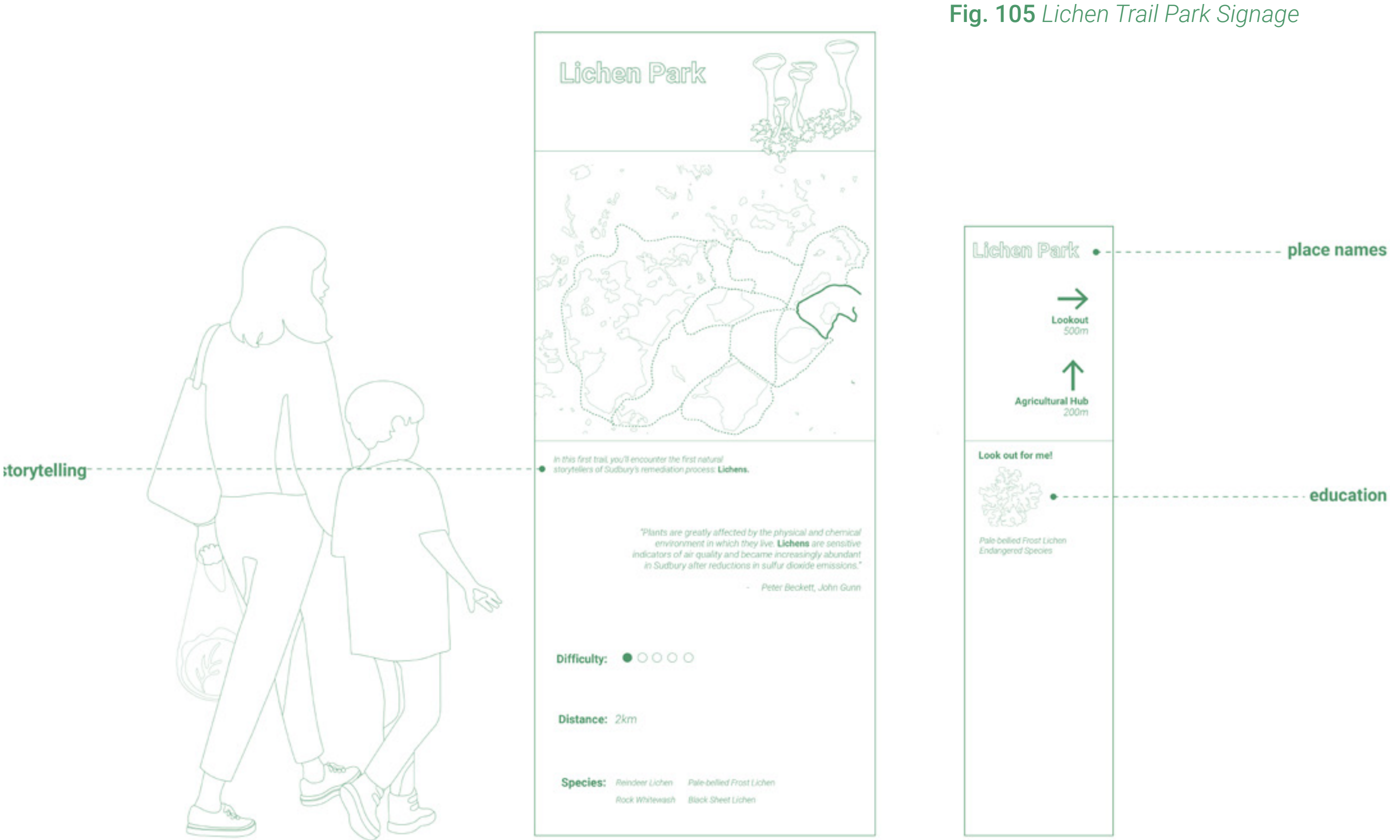


Fig. 105 *Lichen Trail Park Signage*

Fig. 106 *Lichen Trail Perspective with Wayfinding and Urban Furniture*

I notice the urban furniture being used by local residents **[Fig 106]**. *As tiered bleachers on the rock, they allow users to lounge and take a break from their hike; it reminds me of stories my family has told me about sunbathing on the black rocks in Copper Cliff, by absorbing heat from the sunlight. This furniture simulates a specific experience of the Sudbury landscape, which I get to participate in through the sharing of stories.*

The signage also incorporates poetry written by local residents, often describing the unique mining identity of the Sudbury region. Some pieces are more intense, as they depict a very dark past, with toxic sulphur-rich air and a polluted environment. Others are more hopeful, as they share memories of playing in the unique landscape or contributing to the regreening of the surroundings. It's interesting to consider the different ways the layers of the landscape can be revealed to us, by unravelling layers of history through personal stories, experiences, or through interaction **[Fig 135-141]**.

Walking through the trails further, the paths lead me to the first elevated boardwalk, forming rectangular perimeters around steam rising from the rocky outcrops **[Fig 107]**. *As I ascend up this structure, a singular axis intersects the two rectangles through a continuous path; upon closer examination, I learn that the steam is coming from concrete platforms, from old vents that allow air circulation through old mine tunnels. The boardwalk also projects several frames with frosted glass, with imagery of a scene behind; I can see children looking toward this imagery of the Vale Superstack, trying to line up this perspective with the real towering chimney behind. This frames an iconic monument to Sudbury's mining industry, seen from most points in the city at the skyline–now that the Superstack is scheduled for demolition, it preserves a memory of this past, frozen in time.*

Fig. 107 *Elevated Boardwalk Over Industrial Mine Tunnel Vents and Frame of the Superstack*

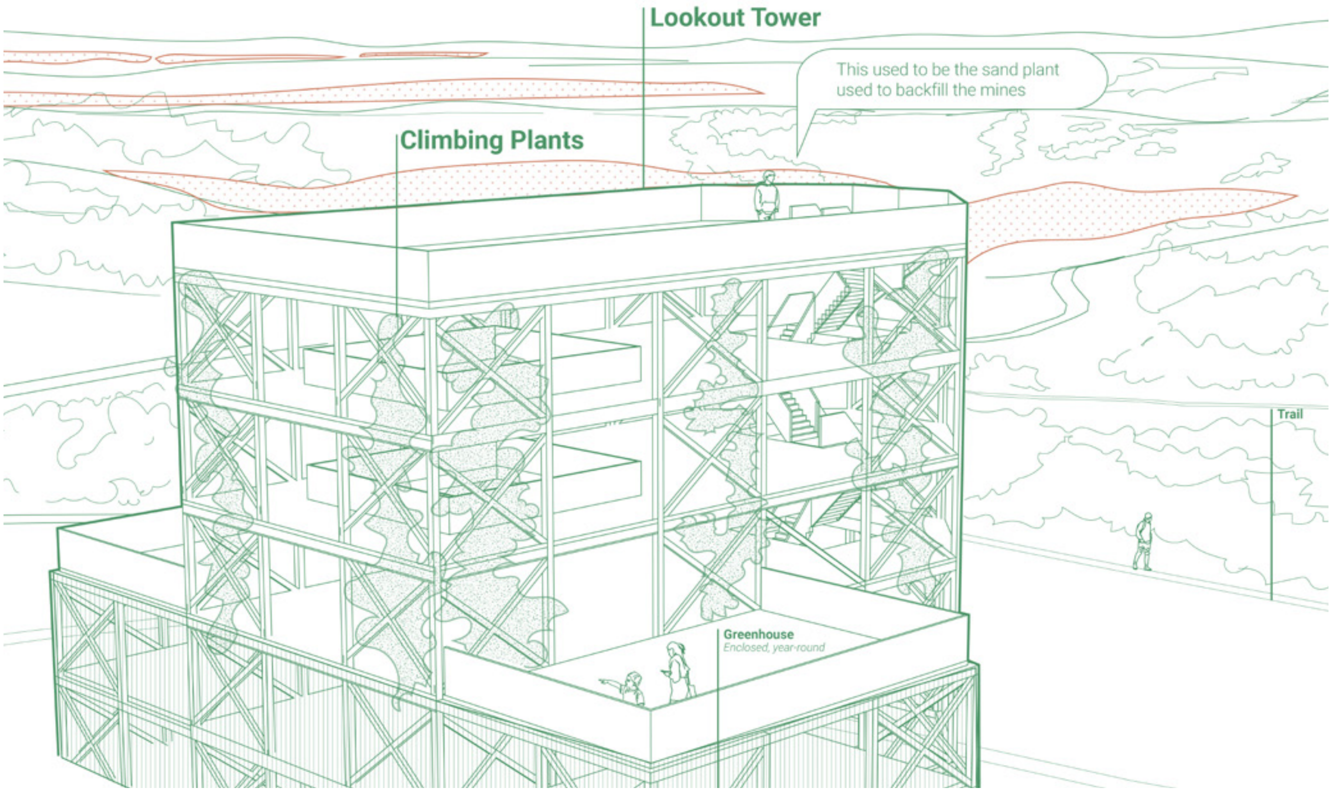
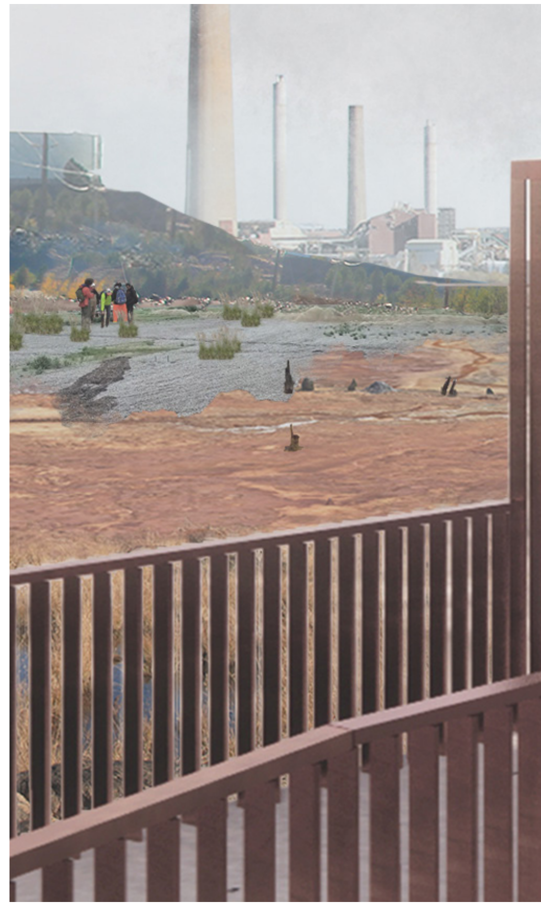
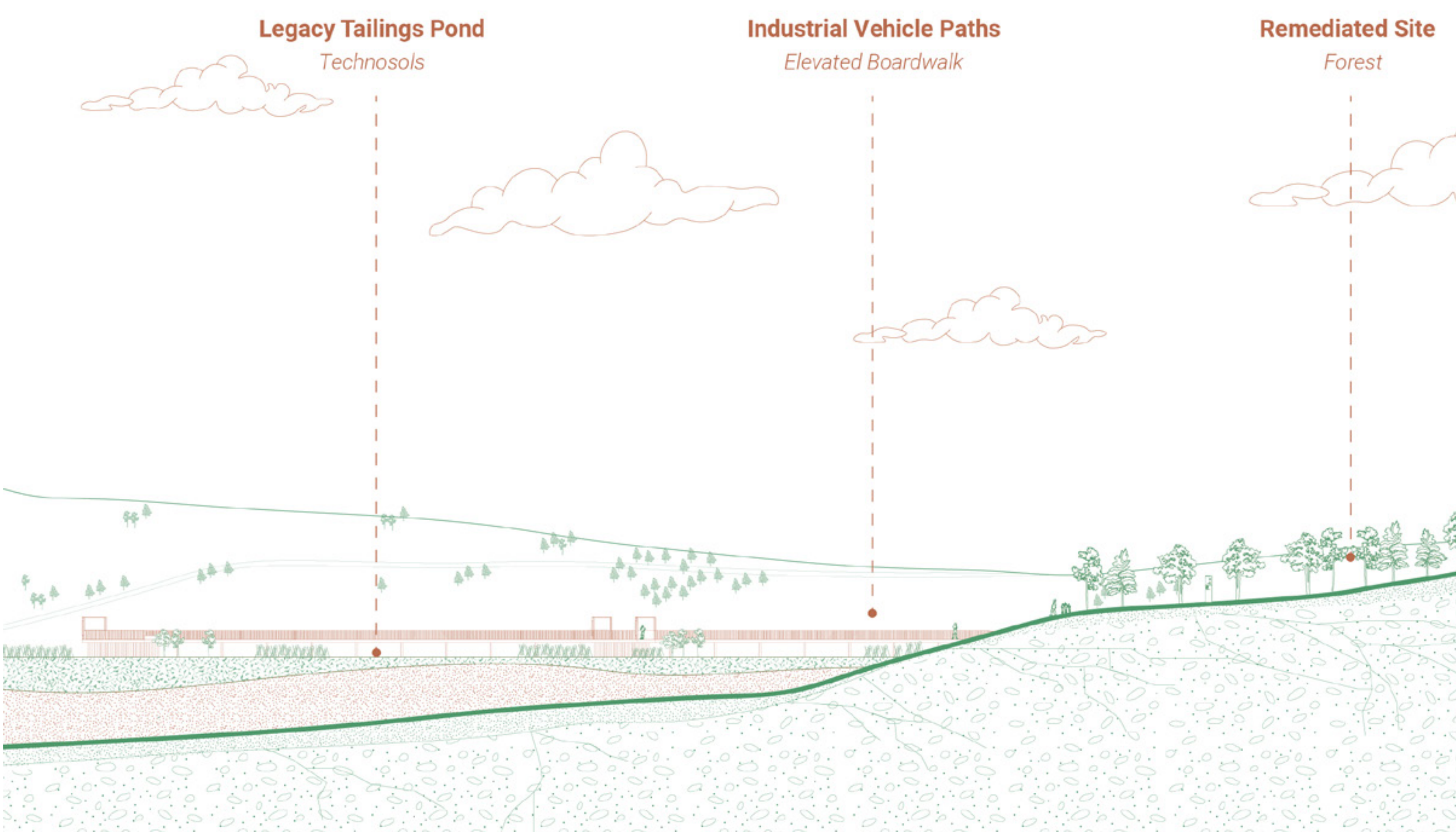


Fig. 108 *Lookout Tower and Greenhouse Repurposed from an Industrial Sand Plant*

I then approach the repurposed industrial structure, which towers over the topography and is visible from the highway to Copper Cliff **[Fig 108]**. *Now that the metal cladding is removed, the structure is revealed beneath, and replaced with climbing vegetation attached from planters and cables. I learn that this used to be the site's industrial sand plant, which was once used to backfill mines; now that the tailings are being remediated, they are used for backfill instead, eliminating the need to excavate sand from the landscape. I climb the stairs, which replace the old sand chute at the front of the structure. The tower has several levels with viewing platforms, each floor showcasing community artwork. At the top, I can now get a good view over the landscape, with 3 tailings ponds in clear site–they seem even larger in person. Climbing back down to ground level, I noticed the lower volume of the structure has become an enclosed greenhouse, which is now managed by the community as a source of food production, and vegetation that can be transplanted into the landscape.*

The building is now in close view, but I choose to continue walking to explore the largest of the boardwalks; leading me right into the middle of the tailings wasteland. Formed by the traces of the old vehicular paths once used to deposit tailings into the pond **[Fig 109]***, it now provides long, elevated pathways to explore the site, and a continuous bench perpendicular to create a view outward to the landscape. Frames wrap around the paths with imagery on frosted glass, giving the visitors a glimpse of what the landscape is envisioned to become in a few years; from a wasteland to a wetland. Then, the trails begin to weave through the building, which is great for hikers to get access to the interpretive centre from the community, but I see that they have also wisely used the existing service road to provide access to those arriving by car. For now, this ended my exploration of the walking trails, as the next part of my journey led me right to the Mine Waste Research Facility and Interpretive Centre***[Fig 110]**.





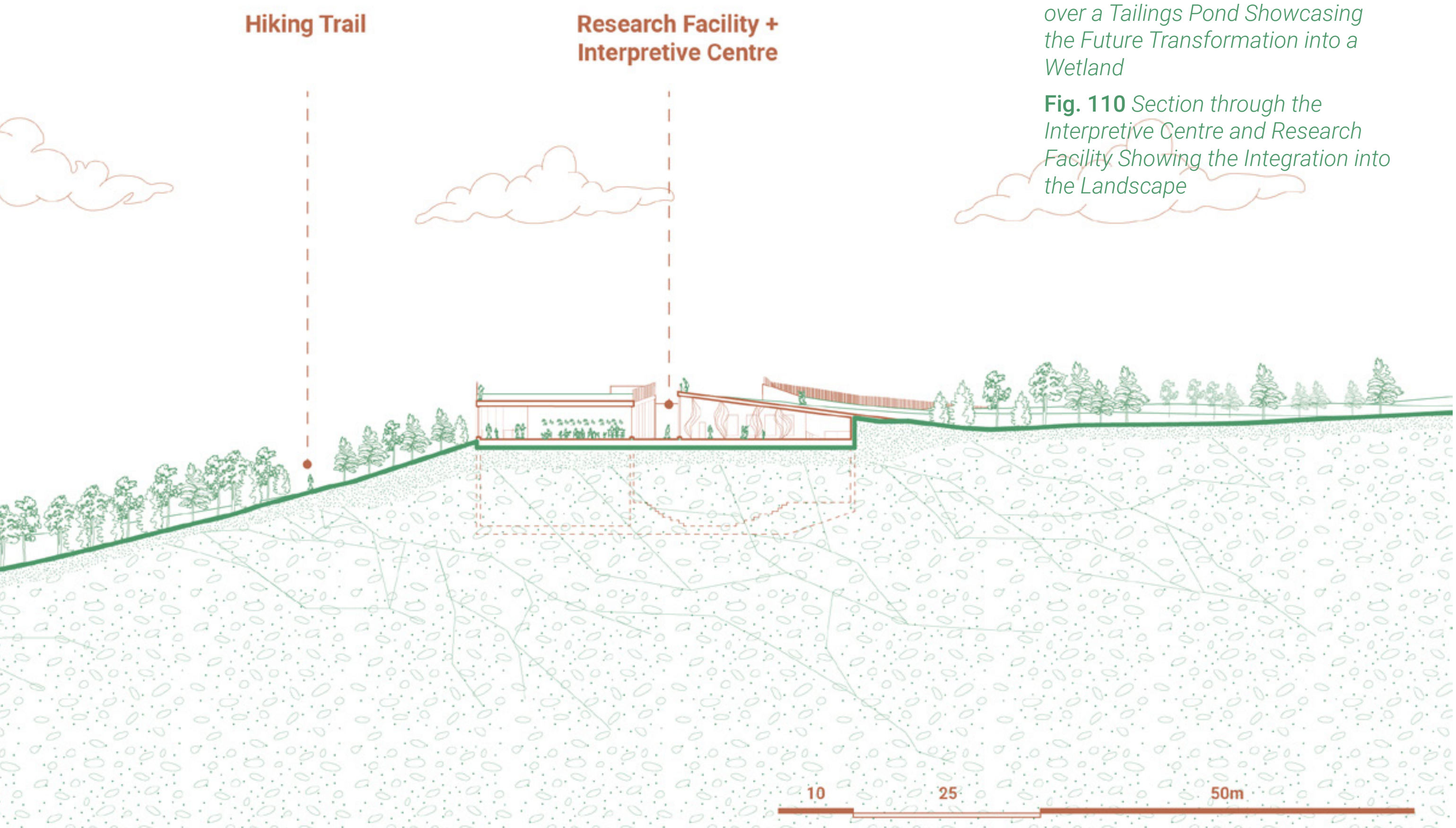
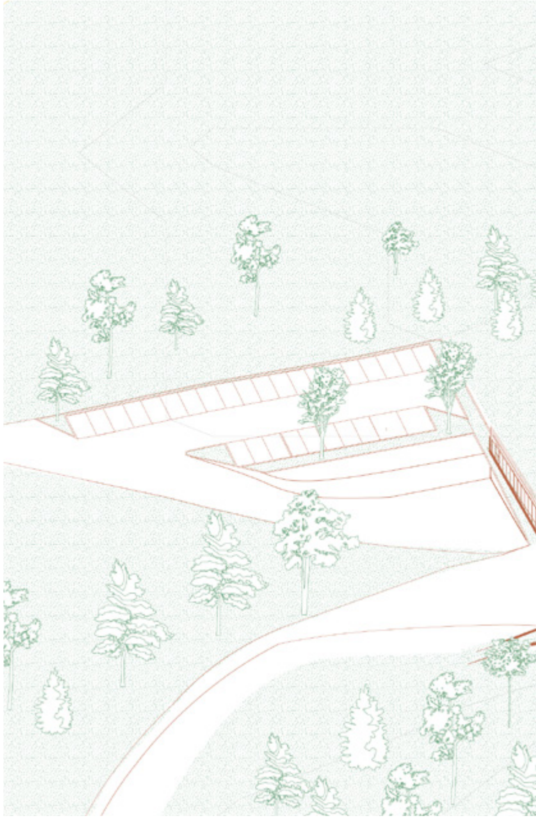


Fig. 109 *Elevated Boardwalk over a Tailings Pond Showcasing the Future Transformation into a Wetland*

Fig. 110 *Section through the Interpretive Centre and Research Facility Showing the Integration into the Landscape*



5.3.3 Small Scale: Interpretive Centre + Mine Waste Research Facility

Approaching the building, I begin to notice how the forms of the sloping roof fold into the landscape–like a fracture in the crater–and mould to the trail. The two masses emerging from the ground provide a continuous path in between, tilting upward to reveal the building facades **[Fig 111-112]**. *The path between the building opens to a large courtyard, seeming like a moment of extraction taking place through a rigid, rectangular shape. This contrasts the angular forms of the walls, resembling the abstract patterns of a shattercone in Sudbury's ancient rock caused by the meteorite impact. The void between the building volumes reminds me of the feeling of walking in between rock cuts, entering into a different landscape.*

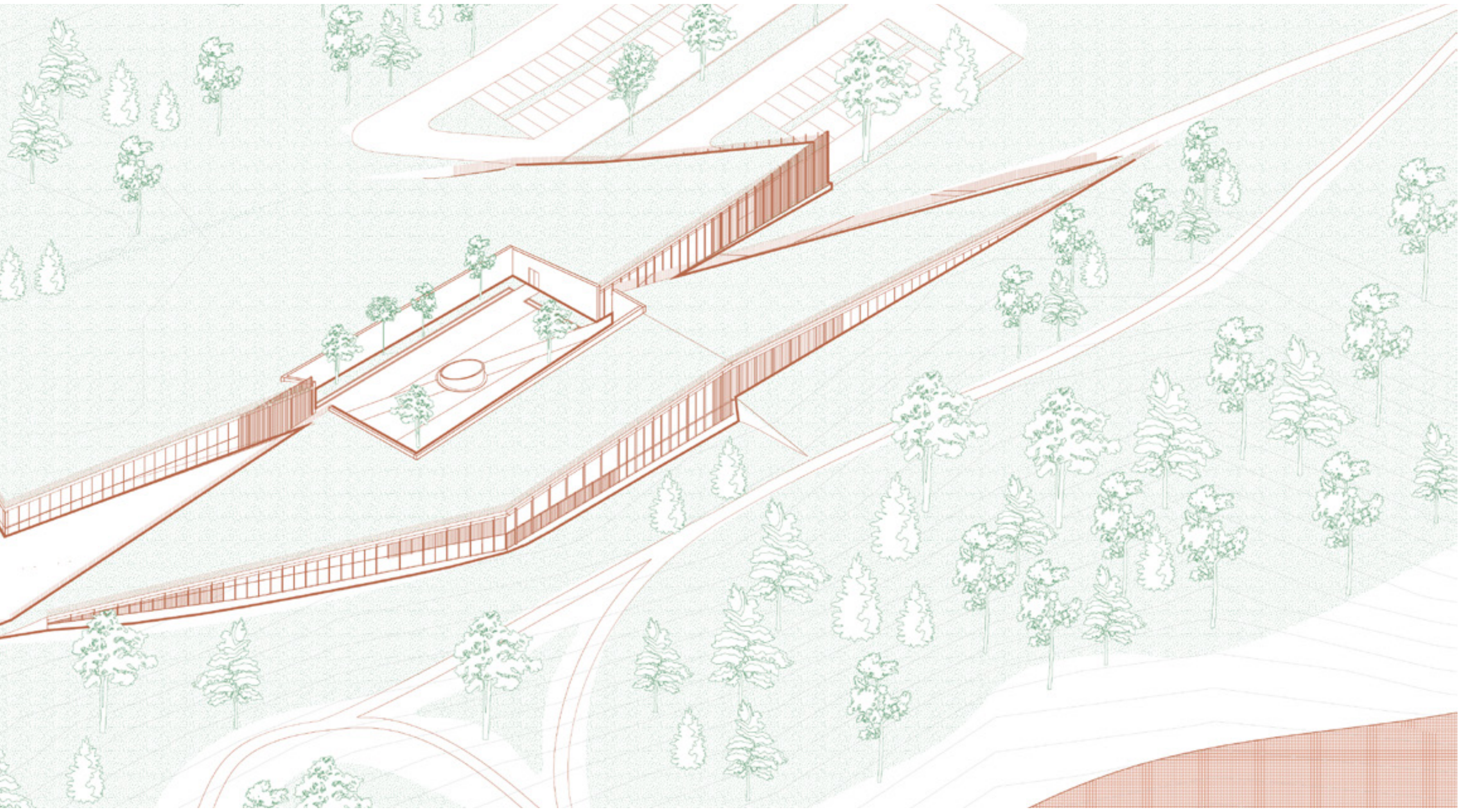
My eyes are still drawn to the towering presence of the Superstack not so far in the distance; now that I see the entire landscape, I can see layers of progression through this transformation **[Fig 113]**. *Close to the building, it becomes evident that remediation has taken place with vegetation slowly reclaiming the site. However, the vibrancy of the tailing pond hint at the change still to come–we're still in this mining legacy, which is still heavily associated with the identity of Sudbury.*

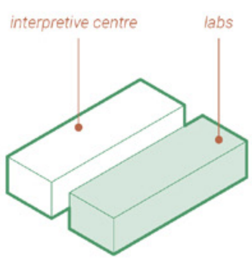
The building's exterior echoes the surrounding landscape, showcasing materials that weather over time. The reddish copper fins and corten steel elements remind me of rusty industrial infrastructures, but it is interesting to note that the copper is slowly turning green, changing colour and patina through oxidation, which is reminiscent of the landscape which is also changing from red to green as it is being remediated.

Fig. 111 *Interpretive Centre + Mine Waste Research Facility Isometric*

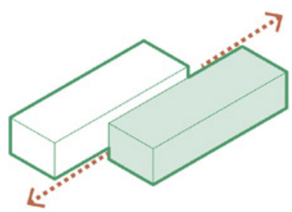
Fig. 112 *Massing and Program*

Fig. 113 *Perspective of the Approach to the Building, Overlooking the Tailings Pond and Mining Complex [Next Page]*

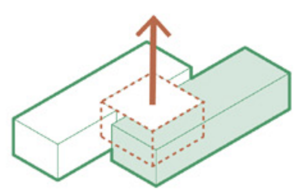




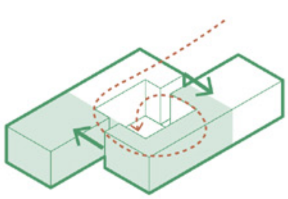
program



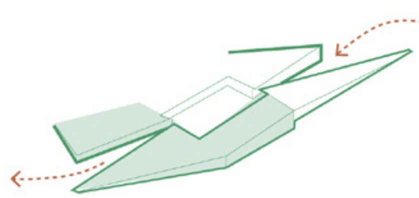
continuous paths



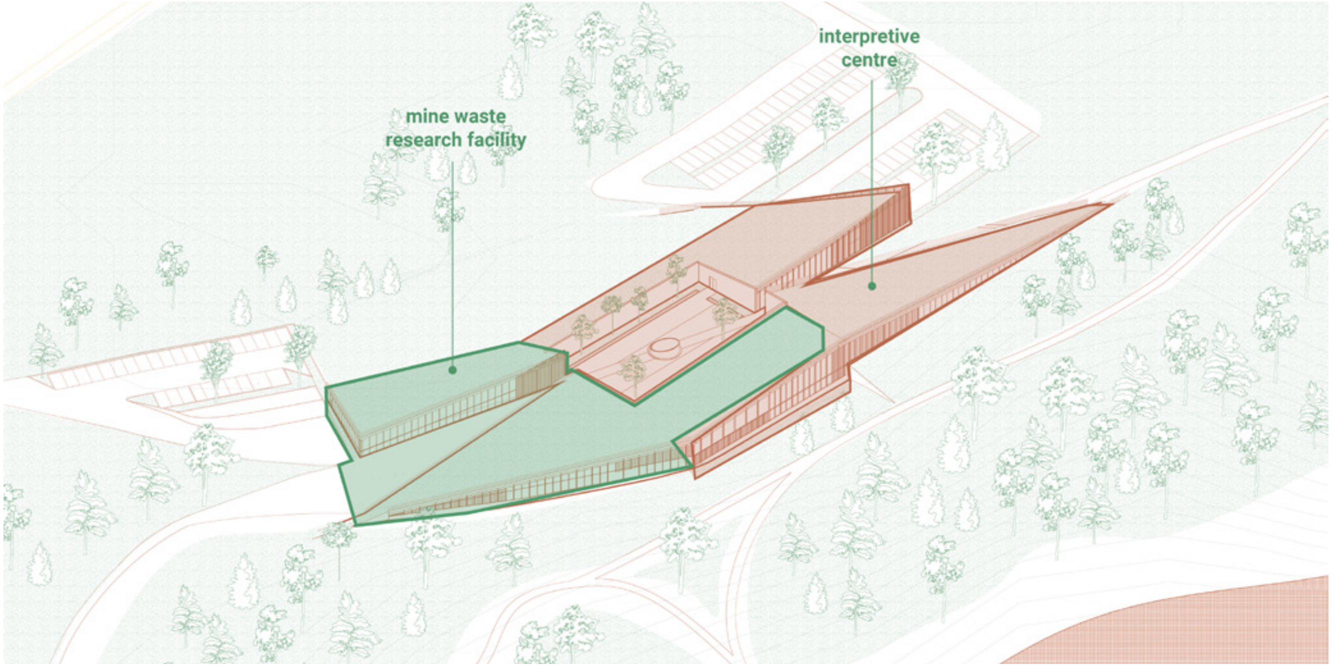
extraction

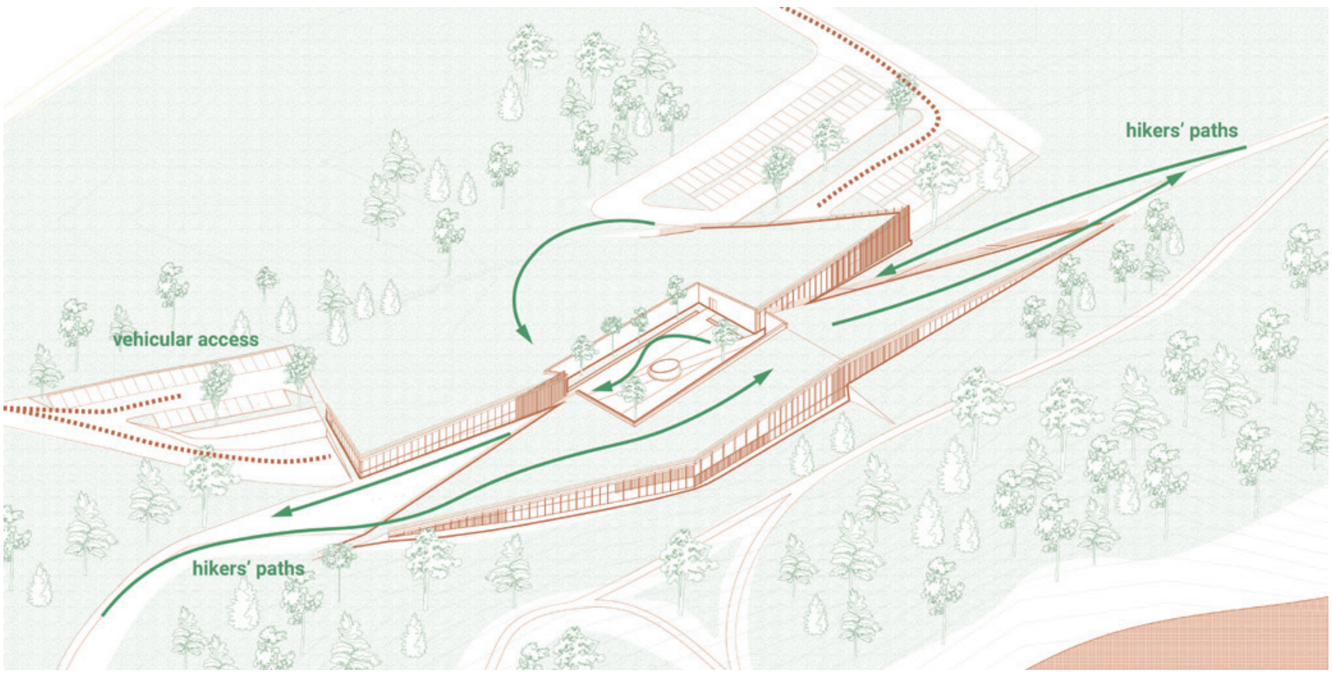


central circulation



formed to the landscape

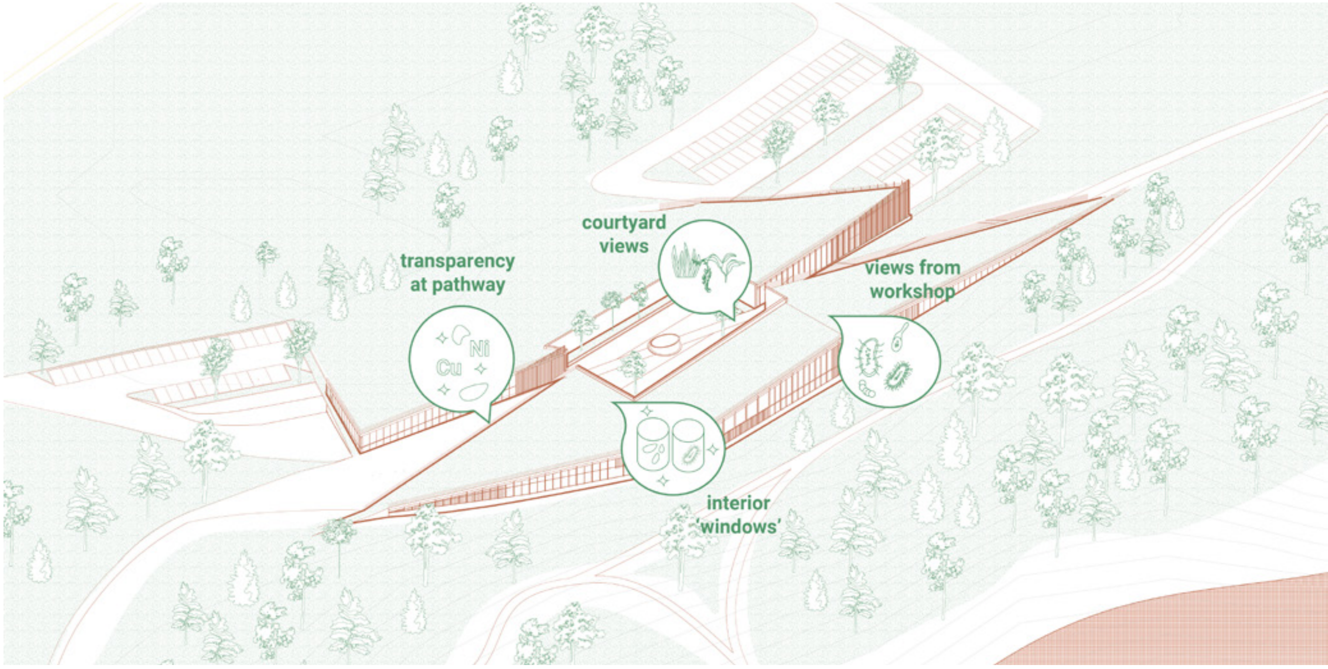


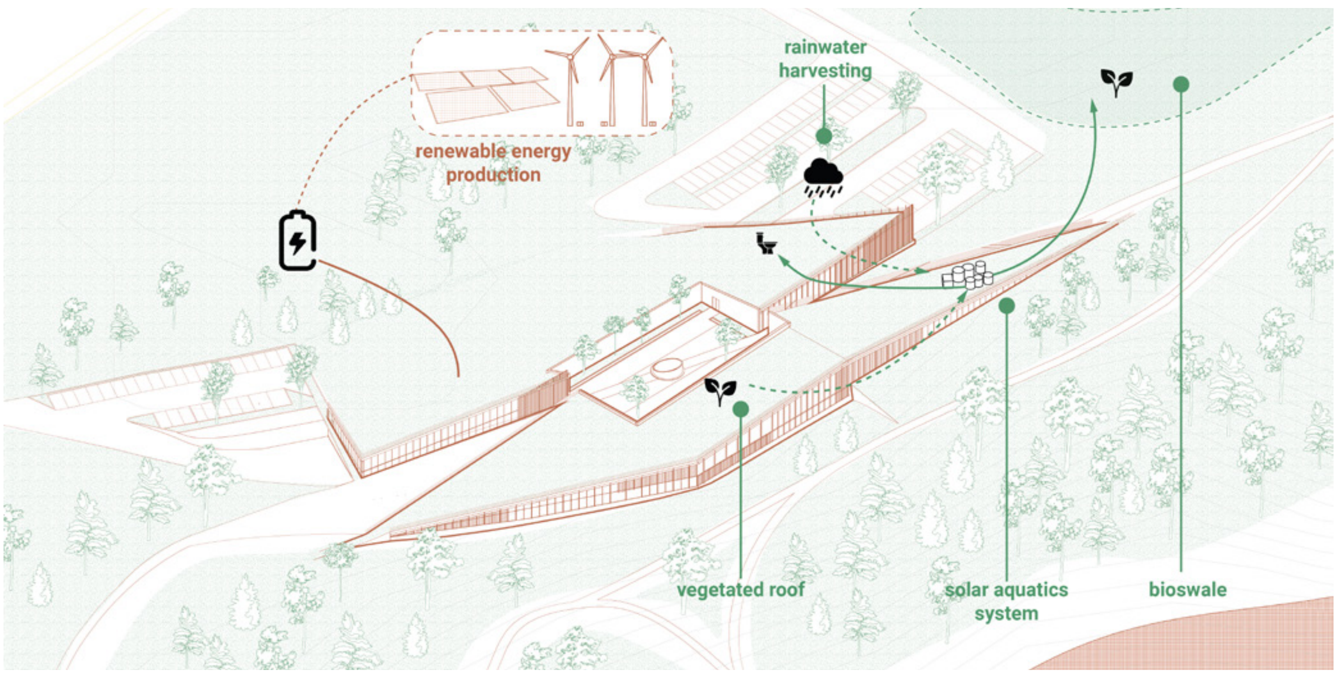


Observing the building more closely, I notice the movement of the users through the pedestrian trails; climbing on top of the vegetated roofs, they get a better view of the park **[Fig 114-115]**. *Others took the route through the courtyard, enjoying their lunch in this unique space, which feels like a unique mineral landscape that stands out when compared to the rest of the park. Those driving to the site used the old service road, which was used only for industrial purposes as part of Vale's previously private property. It became apparent that there were multiple pathways to access the building, generating multiple experiences.*

Fig. 114 *Program Isometric Diagram*

Fig. 115 *Circulation Isometric Diagram*





The main public access point is through the interpretive centre, but as a visitor, I was still curious to know more about the remediation process through the research facility **[Fig 116]**. *Fortunately, as I approach the building closer, are systems were revealed from the transparent facade* **[Fig 117]**: *I noticed the wind turbines on the path that contributed to the building's renewable energy generation; the vegetated roof helped with rainwater harvesting and filtering run-off; and the front wing of the building revealed the Solar Aquatics System. Similar to a greenhouse, this system uses plants and bacteria for natural water purification, to be recycled on-site and inside the building. Wastewater is a prominent feature of the Central Tailings Area, as it is used to cover dried tailings and transport them through pipes–but now, it's given a new, more poetic purpose.*

Fig. 116 *Educational 'Windows' into the Research Facility Isometric Diagram*
Fig. 117 *Regenerative Strategies Isometric Diagram*

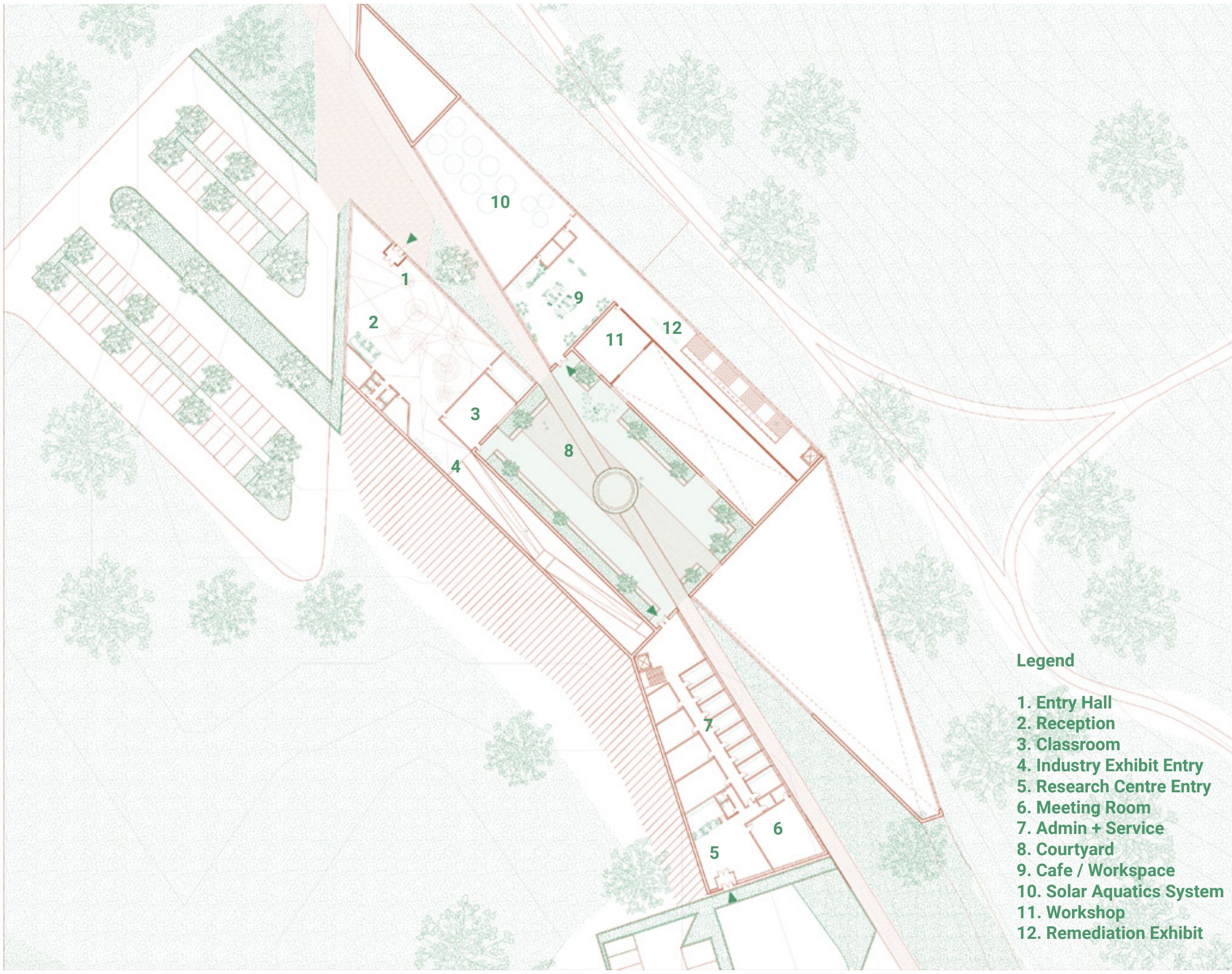
The 'wings' of the building funnel the visitors towards the courtyard, drawing them into this educational narrative from the trails **[Fig 118]**. *Watching the activity in the courtyard, it's apparent that this space is the 'heart' between the two programs. Here, entry is provided to both programs, which intersects the walking path* **[Fig 119]**. *Access is provided to the administration spaces of the research facility, making it easy to cross paths with the researchers, as they access the cafe. The concrete walls of the courtyard emphasize the idea of extraction from the earth, including a circular skylight sitting in the middle of the courtyard. The presence of water and vegetation wraps the perimeter while preserving the axis of walkways through bridges. At ground level, you can see into the double-height spaces of the laboratories. The industrial programming– the laboratories and research spaces–are located a level lower, having full views down to the landscape* **[Fig 120]**. *A loading bay receives on-site mine waste samples from a vehicular ramp, which becomes visible from the pedestrian path passing through the building. An open research space provides a collaborative work environment for researchers and students while accommodating conferences held for bioremediation and biomining research. At the lowest level, the last exhibition spaces wrap beneath the laboratories, before circulation is provided back to the ground surface* **[Fig 121]**. *Different experiences are curated between these different levels of the landscape, creating unique educational moments.*

Fig. 118 *Project Site Plan*

Fig. 119 *Ground Floor Plan*

Fig. 120 *B1 Floor Plan*

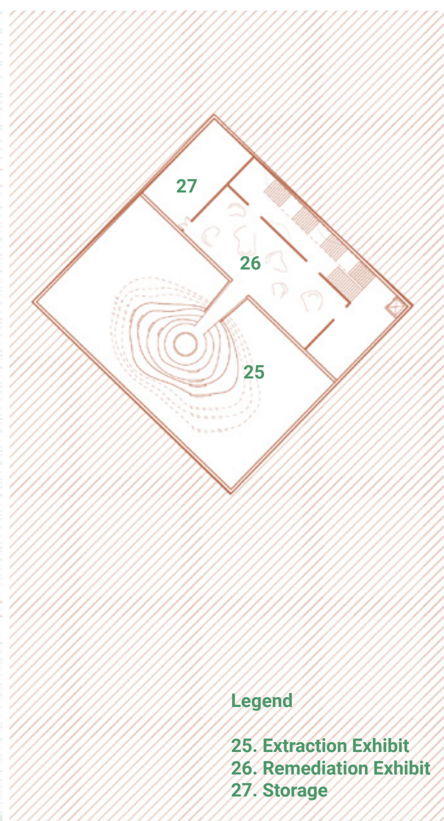
Fig. 121 *B2 Floor Plan*


Legend

1. Entry Hall
2. Reception
3. Classroom
4. Industry Exhibit Entry
5. Research Centre Entry
6. Meeting Room
7. Admin + Service
8. Courtyard
9. Cafe / Workspace
10. Solar Aquatics System
11. Workshop
12. Remediation Exhibit


Legend

13. Industry Exhibit
14. Extraction Exhibit Staircase
15. Bioremediation / Biomining Labs
16. Staircase
17. Open Research Space
18. Chemical Analysis Lab
19. Microbiology Lab
20. Piloting Space
21. Loading Bay
22. Material Processing
23. Mechanical
24. Bioleaching Tank Storage


Legend

25. Extraction Exhibit
26. Remediation Exhibit
27. Storage

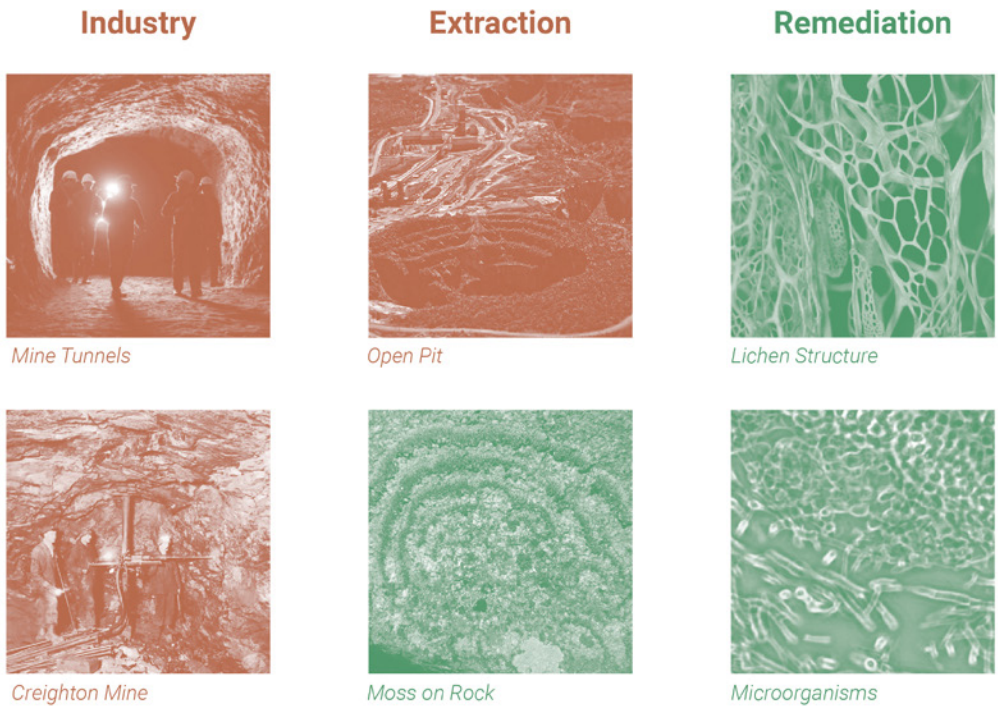
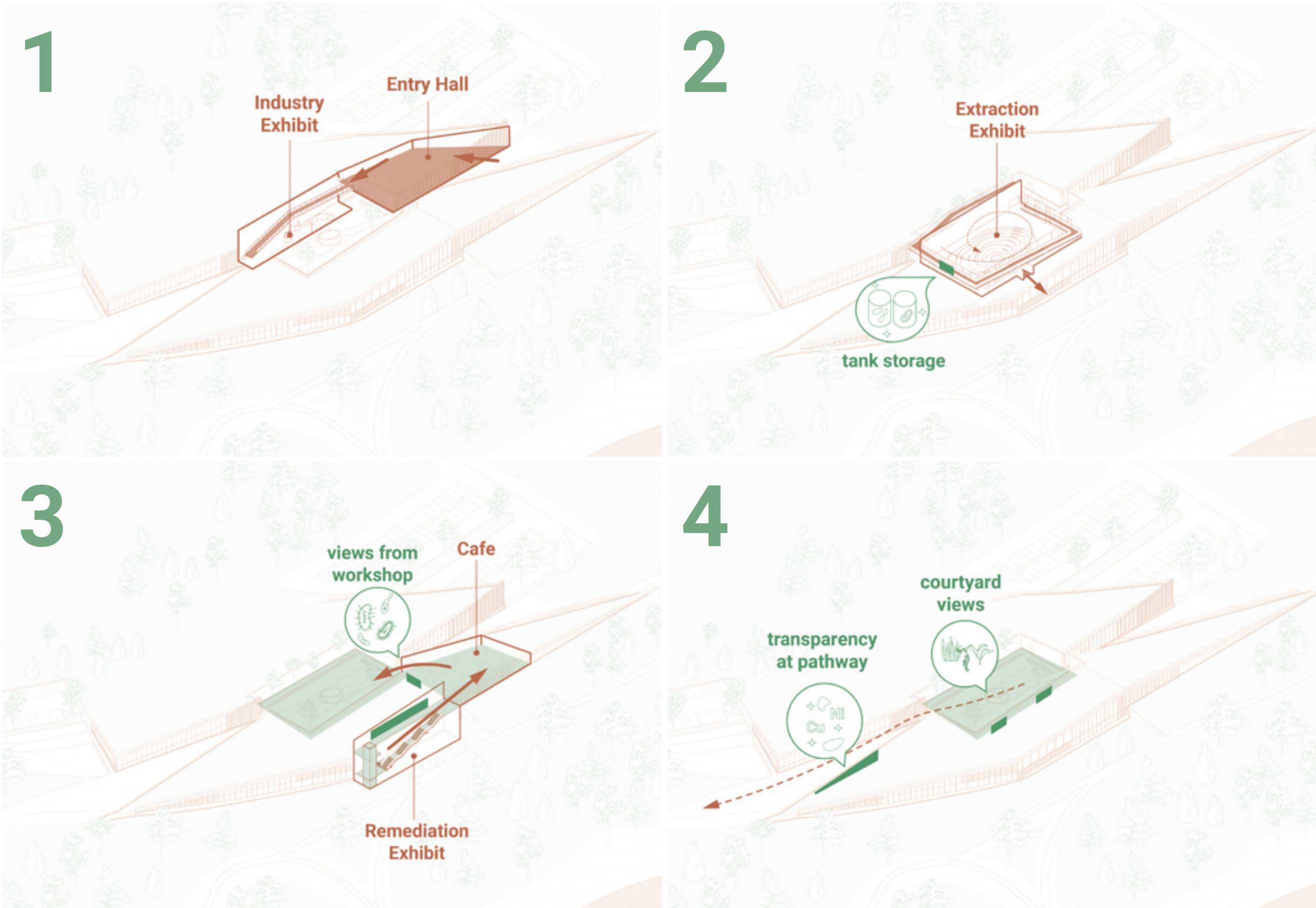


Fig. 122 *Interpretive Centre Exhibits*

To explore this myself, I enter the building through the interpretive centre, which was not so far off the hiking path. Through the entry hall, the users are first introduced to the three exhibits that are inspired by abstract experiences of the Sudbury landscape **[Fig 122]***: the first of which is the Industry Exhibit, creating a reflection of the start of the 'prosperous' mining legacy; the second guides the visitor through the Extraction Exhibit, reflecting on the layers of the landscape impacted post-extraction; the last ends the journey through the Remediation Exhibit, providing a new perspective toward a regenerative future, experiencing the complexities of local ecology with a glimpse into restoration initiatives.*

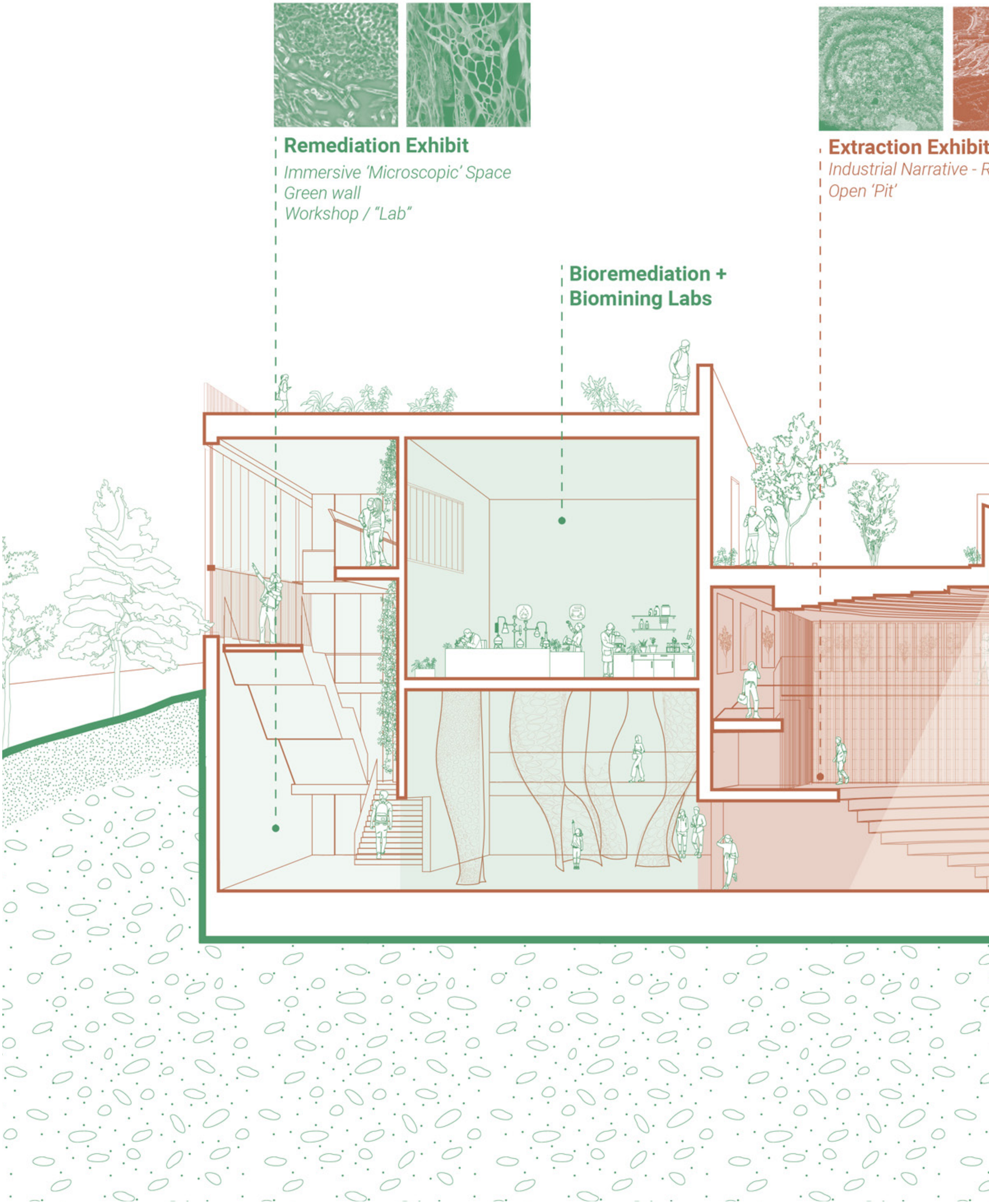
Unravelling this story of Sudbury in its entirety is extremely complex. I learned that the users can interpret different experiences of the centre through several layers; the first through an educational lens. In this sense, the journey between spaces reveals physical and metaphorical 'windows' into the laboratories of the research facility, as educational portals into the complex remediation process. This is revealed to the user after passing through the entry hall to a ramp descending into the first exhibit **[Fig 123]***. Near the core of the centre, the first window into the facility is revealed, through the Material Processing lab. Here, the bioleaching tank storage is framed, showcasing the microorganisms hard at work to eliminate toxic elements of*

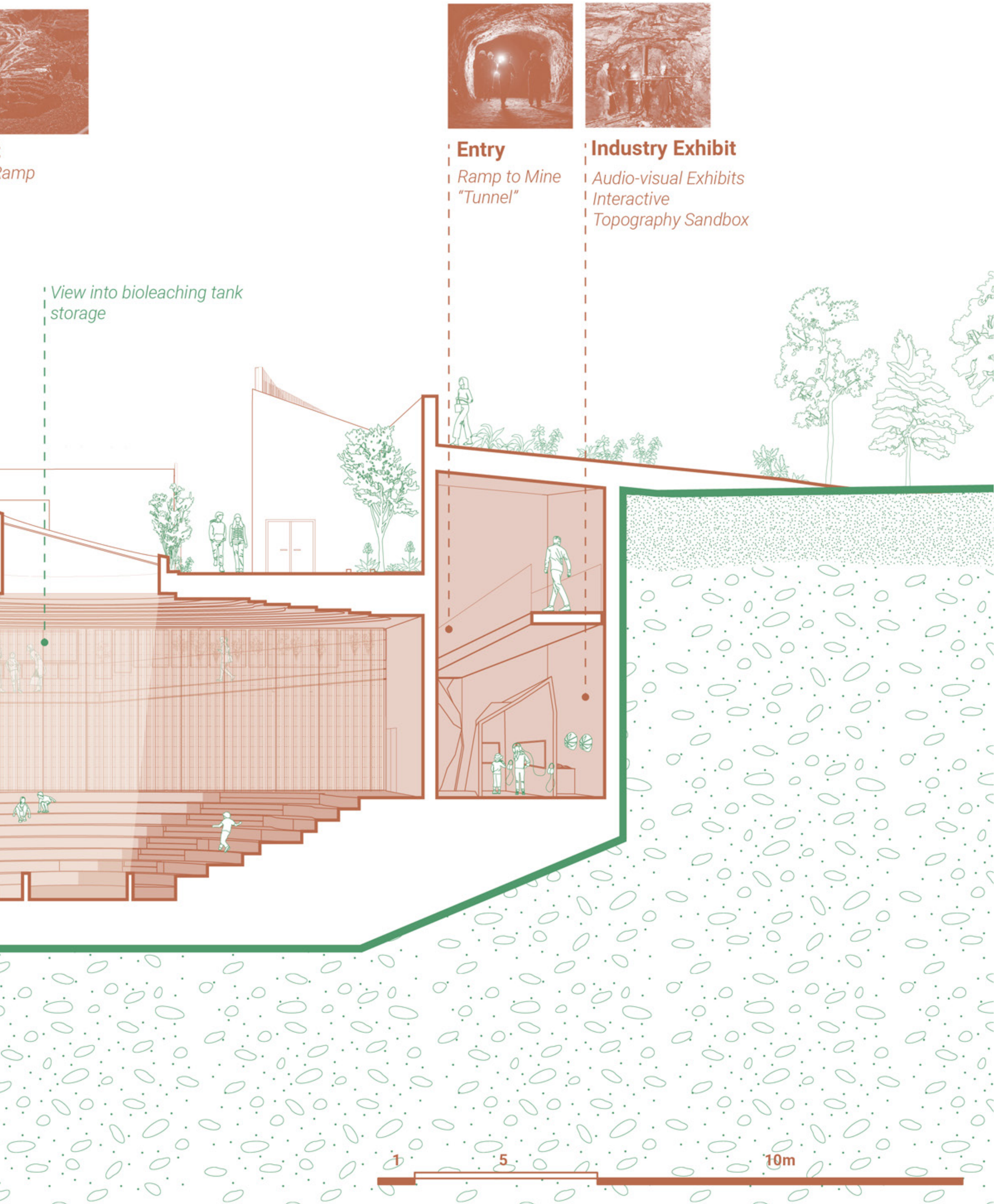


mine waste samples. Several other windows are provided from the main circulation space, as well as the workshop; both spaces look towards the Bioremediation and Biomining labs. Groups of visitors or students can participate in their hands-on workshops for potting plants and other activities, simulating similar activities taking place in the laboratories. Finally, once the users exit into the courtyard, they have the choice to continue their hike through the building where there are several chances to look into the various lab spaces from the outside; the building facade acts as its own educational portal. This is only one of the several narratives the building tells–teaching users about science, microbiology, and technical building systems that help the landscape around it. This journey through the exhibitions has allowed me to analyze the experiences of the spaces more closely, where I reflected on a more poetic story that makes me feel part of this narrative **[Fig 124]**.

Fig. 123 *The Educational Narrative through Building Isometrics*

Fig. 124 *Building Section through Exhibits [Next Page]*


Remediation Exhibit
Immersive 'Microscopic' Space
Green wall
Workshop / "Lab"
Extraction Exhibit
Industrial Narrative - R
Open 'Pit'
Bioremediation +
Biomining Labs


Entry
Ramp to Mine
"Tunnel"
Industry Exhibit
Audio-visual Exhibits
Interactive
Topography Sandbox
View into bioleaching tank storage
1
5
10m

When I entered the Industry Exhibit, I was introduced to the darker, more congested atmosphere that resembles entry into the Sudbury crater **[Fig 125]**. *I noticed the visitors watching the projected film on the concrete wall, showcasing clips through the history of activity in the mines, and the industrial partners hard at work. The motion down the ramp felt like an industrial catwalk, that hovered over a steep mine shaft with activity below; I got a glimpse into the interactive components of the exhibit at the lower level. Several geological-like rooms hosted audio-visual media, which encouraged users to enter into the rock cuts before being immersed in the artwork. Farther into the space, I saw a family playing with an interactive sandbox, using vibrant lights to generate unique topographical patterns; it made the manipulation of the physical landscape seem so effortless. The experience communicated the similarities with that of a mine tunnel or the entry into a different world; inside the geological basin.*

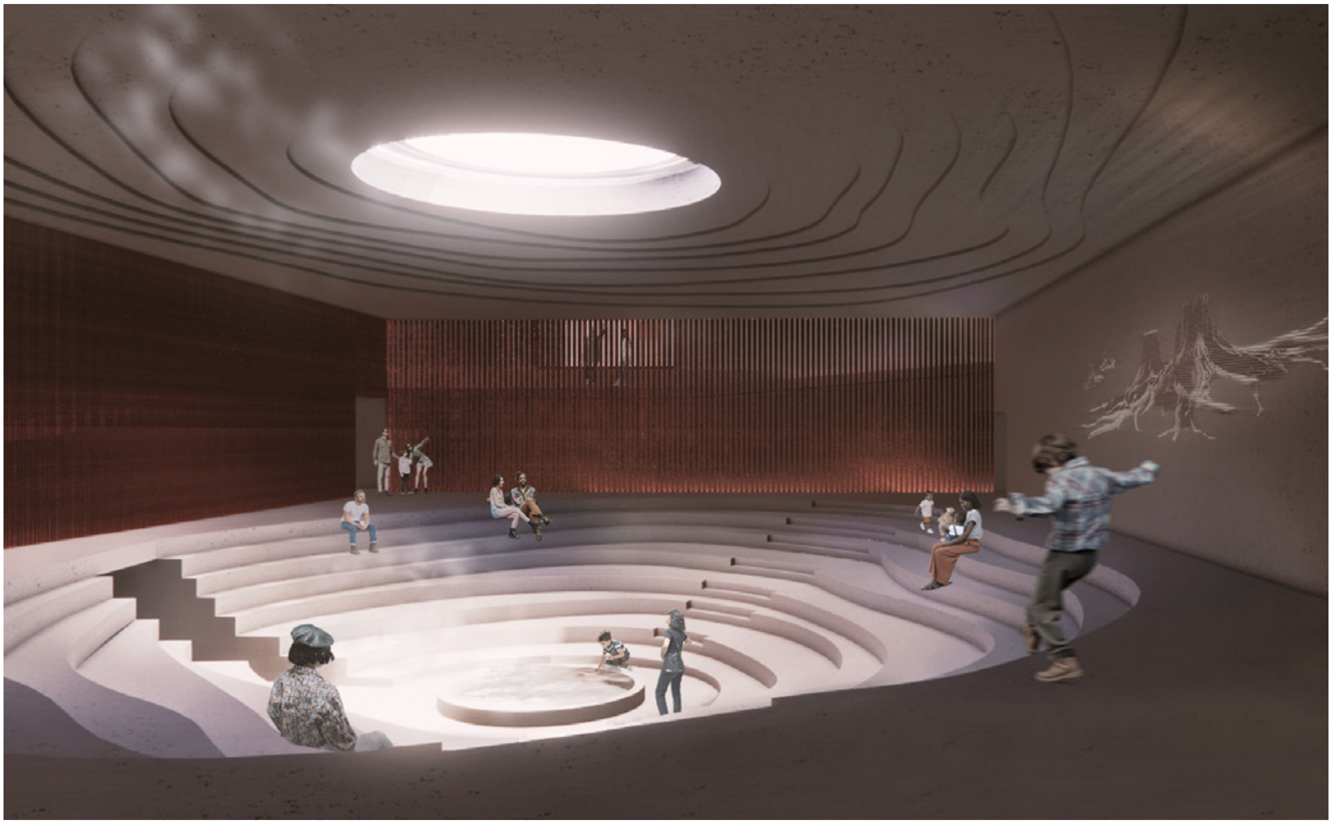
Fig. 125 *Perspective of the entry to the Industry Exhibit*

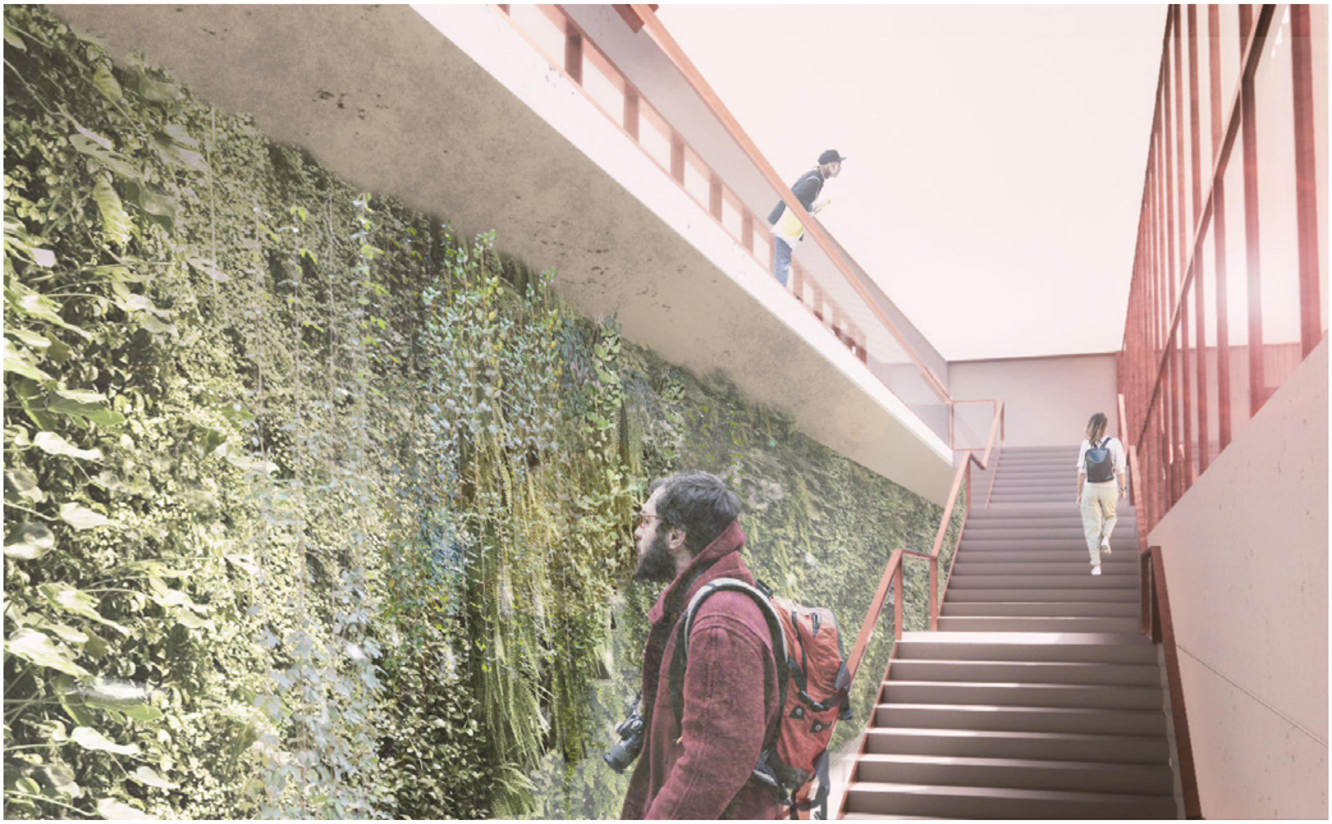
When I continued down the ramp, I noticed corten steel perforations wrapping another space behind, similar to the outside of the building, which hid the space behind **[Fig 126]**. *A sequence of large imagery revealed the layers of Sudbury's landscape through time, touched by industrial activity. I recognized several images that are very familiar to us residents; including the blackened landscape from the roast yards or the sparse dried tree stumps on the barren rock. I noticed a couple peering through the first window into the laboratory, reading about the bioleaching process on the glass and observing a researcher behind monitoring the storage tanks. Farther down the ramp, the imagery on the walls became more hopeful; they showed me the slow succession of the regreening process and the landscape that took back the vegetation that was there previously.*

Fig. 126 *Perspective of the Circulation Space Between the Industry and the Extraction Exhibit, with a Portal to the Research Facility*

The ramp wrapped the perimeter of the room, where it felt like a long, gradual descent to the bottom. Once I passed through the lower level of the Industry exhibit, the corten perforations ended. This is where the core was finally revealed through a sudden burst of light; here lies the Extraction Exhibit **[Fig 127]**. *A circular amphitheatre created the feeling of an open pit mine, drilling even farther into the ground. I observed several visitors getting comfortable in this space, sitting on the bleachers 'carved' from the floor, like the relics of what humans leave behind on the ground surface after the ore deposits are depleted. I was re-introduced to the courtyard skylight that provided an axis back to the outside world. The sunlight pierced through the space to a reflection pool at the bottom, where the reflections of light on the water created unique patterns on the ceiling. This space resembled an intersection between something Anthropogenic, yet, the presence of sunlight and water also made it feel natural. After I further examined the organic shapes on the floor, I was reminded of radial patterns that lichens create when they spore on barren rock. I then stepped to the bottom of the room and passed through to the next exhibit through the opening in the crater bleachers.*

Fig. 127 *Perspective of the Core of the Extraction Exhibit*





Finally, passing through the Remediation Exhibit, I entered the bright vertical circulation space, where the continuous staircase provided quick access back to the ground surface **[Fig 128]**. *Along the way, a lush green wall welcomed me back to the vegetated world. A mezzanine at ground level looked over the tailings pond outward to the landscape, with another window inward, oriented to the laboratories. After passing through this sequence of spaces, I looked back out to the park and reflected on the state of Copper Cliff's current landscape.*

After learning about the program of the research centre, I realize that remediation is by no means a linear process, and happens gradually. With these research initiatives in restoration ecology, I can reimagine the future of the entire Central Tailings Area towards a thriving state, one day completely safe to access for the community. It's difficult to comprehend the full extent of our extraction and alteration of this landscape, but, addressing the current practices of the local industry, I feel more hopeful about a future of remediation. As the landscape heals, I can imagine the corten steel and copper fins of the building transforming with it; over decades, oxidizing to the charcoal colours of the rock, and a green patina fades into the vegetation. In a few decades, the building might even disappear into the thriving landscape; telling us the story of ecological remediation holistically, through the passage of time **[Fig 129-130]**.

Fig. 128 *Perspective of the Circulation Space of the Remediation Exhibit*

Fig. 129 *The Building Exterior Transforming through Time–The Red [Pages 151-152]*

Fig. 130 *The Building Exterior Transforming through Time–The Green [Pages 153-154]*

Conclusion

Fig. 131 *Lessons from Lichens toward a Healing Industrial Landscape*


+Ni
+Cu
+$

This research journey began with the notion that Sudbury, Ontario, benefited in the past decades from a powerful narrative of ecological remediation, which has been recognized internationally thanks to the ongoing regreening efforts that made this place green and beautiful once again. That being said, we remain dependent on the extractive industry and for this reason, some regions in Sudbury remain subject to massive environmental degradation to this day, and for some time into the future. Therefore, a critical reflection on these practices is necessary to continue this incomplete narrative, fully healing all parts of the land from generations of environmental destruction **[Fig 132]**.

Consequently, this thesis focused on Sudbury's vast industrial wastelands, more specifically on the Central Tailings Area that surrounds the community of Copper Cliff, as this zone hosts an extensive volumetric mass of mine waste in tailing ponds a few hundred meters from houses and schools. The red polluted water being managed by the mining industry even flows through the town through open-air streams, emphasizing the urgency to address this situation and remediate the tailing ponds if we are to provide a healthy environment for the Copper Cliff residents. By doing so, the hope is that the remediation efforts will mitigate environmental detrimental impacts that extend well beyond Copper Cliff and the greater Sudbury area. Moreover, there is also hope that the regenerative story can

Fig. 132 *The Anthropocene and Natural Ecologies Conceptualization* empower and inspire the people of Sudbury, of Ontario, and those living in environmentally degraded environments anywhere else, so we can all become better stewards of our land.

This thesis thus sought to challenge current ideologies in industrial practices, ultimately changing the dynamics between mining companies managing private properties and the community members inhabiting the land, in order to reconfigure the community's role as stewards of the landscape. To achieve this goal, the thesis project proposes to lift the veil on industrial wastelands, revealing the damaged landscape to the community, so they become witnesses of its remediation and advocate for the regeneration efforts to match the gravity of the situation. Indeed, the thesis demonstrated the importance of the role of community members in the regreening efforts, restoring Sudbury's smelter-polluted landscape, and it is thus essential that the community plays an active role in this new regenerative story if it is to be successful. It is also essential that the project contributes to educating the younger generations about the impacts of the mining industry and the extensive efforts necessary for remediation so that we do not repeat the errors of the past. This will ensure that the project generates ongoing positive social and environmental impacts for generations to come. With this in mind, the thesis thus asked the following question:

How do we remediate and repurpose Sudbury's industrial wastelands in order to educate the next generations about creating environmental and social regenerative impacts on the landscape and the community?

The thesis thus began (Chapter 1) by investigating the history of Sudbury's mining legacy, looking into the industrial, environmental, political and social realms that are associated with this story of extraction. First, unravelling the impacts of the mining legacy revealed that through this economic prosperity, the extent of the 'Sudbury Footprint' devastated the environment and raised health concerns within the community. Prompting change within community groups, several research initiatives in restoration ecology resulted in collaborative and leadership efforts to rehabilitate the industrially-damaged landscape.

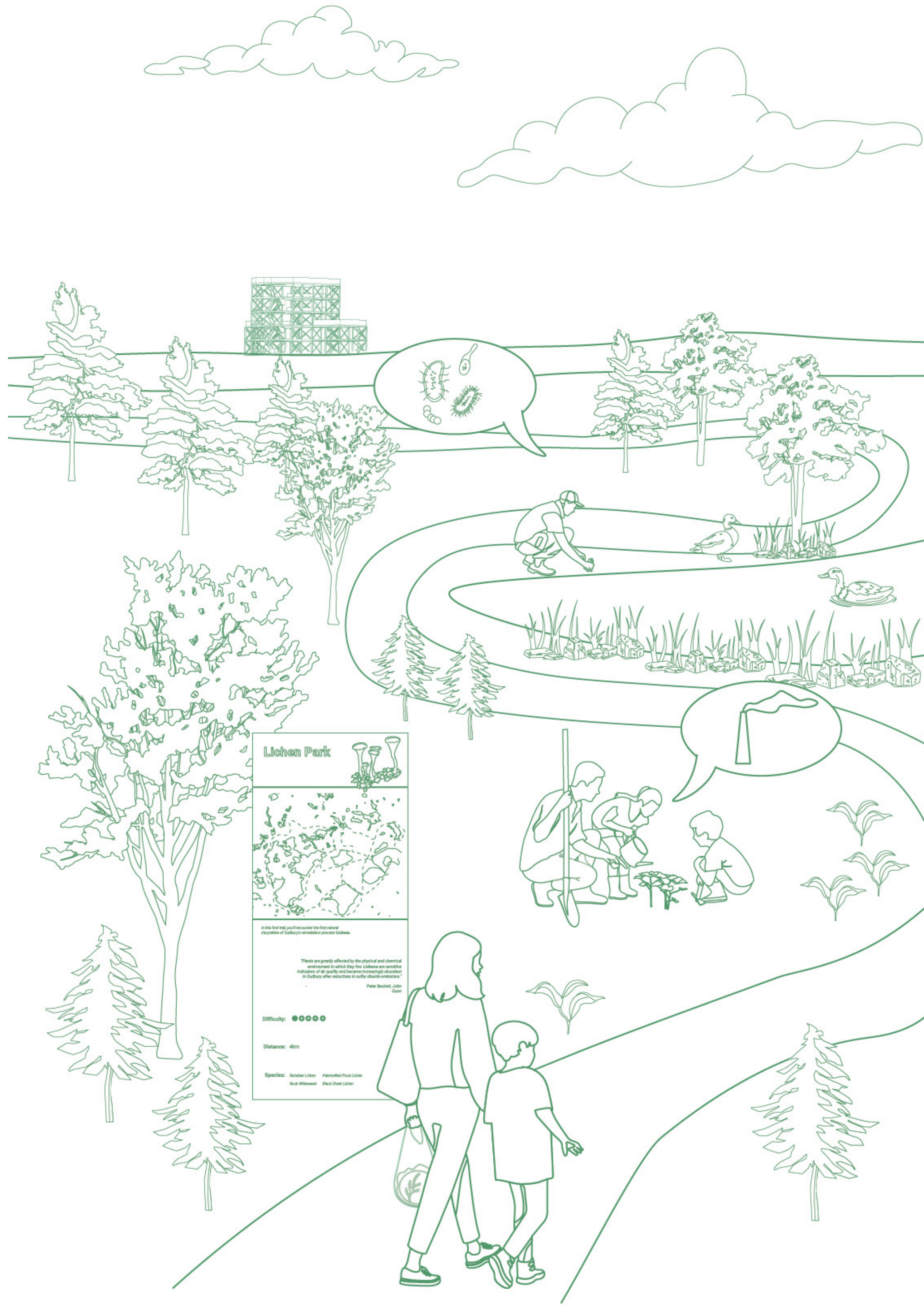
The thesis then turned to (Chapter 2) recent innovative research and initiatives that can better help with biodiversity and ecosystem recovery in the context of mine sites. These include the use of surface treatments through biosolids and technosols, which can provide effective growth substrates to revegetate tailings areas, restoring vibrancy and ecosystem recovery through industrial sites. The thesis also looked at recent advancements in the realm of biotechnologies, through strategies such as bioleaching, which offer tremendous potential for long-term restoration. Targeting the reactive elements at the microscopic level, this strategy alleviates long-term environmental impacts of mine waste by preventing acid mine drainage altogether, serving as an innovative solution to contribute to large-scale remediation efforts. Implementing these new biotechnology solutions in Sudbury would require a new centre for mine waste, which is already recognized through a proposal conducted by the local company MIRARCO. The thesis project thus proposes to build this facility in Copper Cliff where it is most needed (Chapter 3), as this building would become the catalyst for the rehabilitation of the landscape in the Central Tailings Area.

The thesis then analyzed (Chapter 4) the principles of regenerative design to investigate how the facility for mine waste research, through appropriate architectural solutions, could itself become an active participant in healing the surrounding environment, as well as the community. If done effectively, the building can contribute more to the environment than it consumes, having positive regenerative impacts. This can be done through the implementation of water purification and management systems, the integration of clean renewables, renewables, air purification and surface treatments, and so much more. Additionally, by allowing the building to play an active educational role by inviting community members to visit it to learn about the narrative of ecological remediation, using place-based storytelling strategies, it can also contribute to social regeneration. To achieve this, the thesis proposes to couple the mine waste research facility with an interpretive centre that will empower the community and teach them about the efforts needed to remediate the landscape, as well as preserve the environment in which they live. Here, they can learn about their industrial and mining history, reflect on the lessons of the past, and become inspired by the remediation solutions for the future. The building will welcome multiple community activities and cater to the most powerful agents of change, children.

In Chapter 5, a complete project was presented, learning from various theories, research initiatives, and the past industrial legacy, which has the potential to contribute to the remediation of the landscape and empower community members to become stewards of the land, sustaining positive environmental and social transformation for generations to come. Operating at multiple scales, the design proposal looks to transform the Central Tailings Area into a thriving park, over a 100-year timeline. This park would include an extensive network of hiking trails that will bring the visitors to the heart of this currently hidden landscape, curating a journey through a number of abandoned industrial relics, to the edge of the tailing ponds that are slowly transforming into wetlands, and so much more. Through several built interventions in the trails, including wayfinding components and urban furniture, the elements unravel the narrative of Sudbury's unique landscape, educating visitors about the errors of the past as well as the solutions of the future. The mine waste facility and interpretive centre will also contribute to the remediation efforts thanks to regenerative design strategies, on top of also becoming an education tool for the community to ultimately partake in the narrative of restoration.

Reflecting on the city's current proposal for the Centre for Mine Waste Biotechnologies, an important consideration to address is how this initiative could extend outside of the Sudbury context. It is crucial to recognize that many other communities around the world that have an active presence of mining activity face similar detrimental impacts through the presence of tailing ponds, requiring their own regenerative stories. This pilot facility paves the way for active management to take place within industrial sites, where biotechnologies could be applied at a large scale, to carefully proceed with appropriate treatments for mine waste. Other mining communities around the world could learn from this thesis proposal and adapt the strategies to fit their own needs; as a sensitive response to the specificity of their history, environmental context, and so on. Through place-based design and storytelling, they can also empower themselves to promote active stewardship of the land and initiate massive tailing ponds remediation efforts. Therefore, the project as a whole can almost be reimagined as a kit of parts, where trail components communicate unique aspects of the place through education, and stories, and by preserving the memory of industrial relics. Mobilized by the Mine Waste Research Facility to put long-term remediation efforts into action, the careful addition of public programming strengthens the empowerment of the community to participate in a regenerative narrative, creating impacts through the next generations.

Remediation is by no means a linear process. There are several challenges to the treatment of legacy and active mine waste production that requires urgent attention. In particular, through the advancements in biotechnologies–given the volumetric massiveness of mine waste content in the landscape–a substantial amount of tailings will remain following the treatment process. This research can expand on potential solutions to relocating, covering, or recycling this content from the landscape, in order to ensure successful long-term rehabilitation. Further, the structural integrity of tailings dams is a consistent safety concern amongst industrial sites and surrounding communities. Although biosolids as a surface treatment can alleviate the pressure put on dams through the absorption of excess moisture, further investigation into reconfiguring retention ponds altogether is necessary. Through the success of current treatment options implemented in the region, it gives us hope to reverse our anthropogenic impacts and restore the landscapes touched by the industry. Just as the research journey started with the determination to continue the narrative of ecological remediation, this merits an ongoing conversation between industrial partners, mining companies, architects, ecologists, researchers, biologists, and community members, to inspire us toward a regenerative future of industrial landscapes. That way, we can better manage the red and green **[Fig 133]**.


Lichen Park
In this first trail, you'll encounter the first natural storytellers of Sudbury's remediation process: Lichens.
"Plants are greatly affected by the physical and chemical environment in which they live. Lichens are sensitive indicators of air quality and became increasingly abundant in Sudbury after reductions in sulfur dioxide emissions."
Peter Beckett, John Gunn
Difficulty:
Distance: 4km
Species: Reindeer Lichen Pale-bellied Frost Lichen
Rock Whitewash Black Sheet Lichen

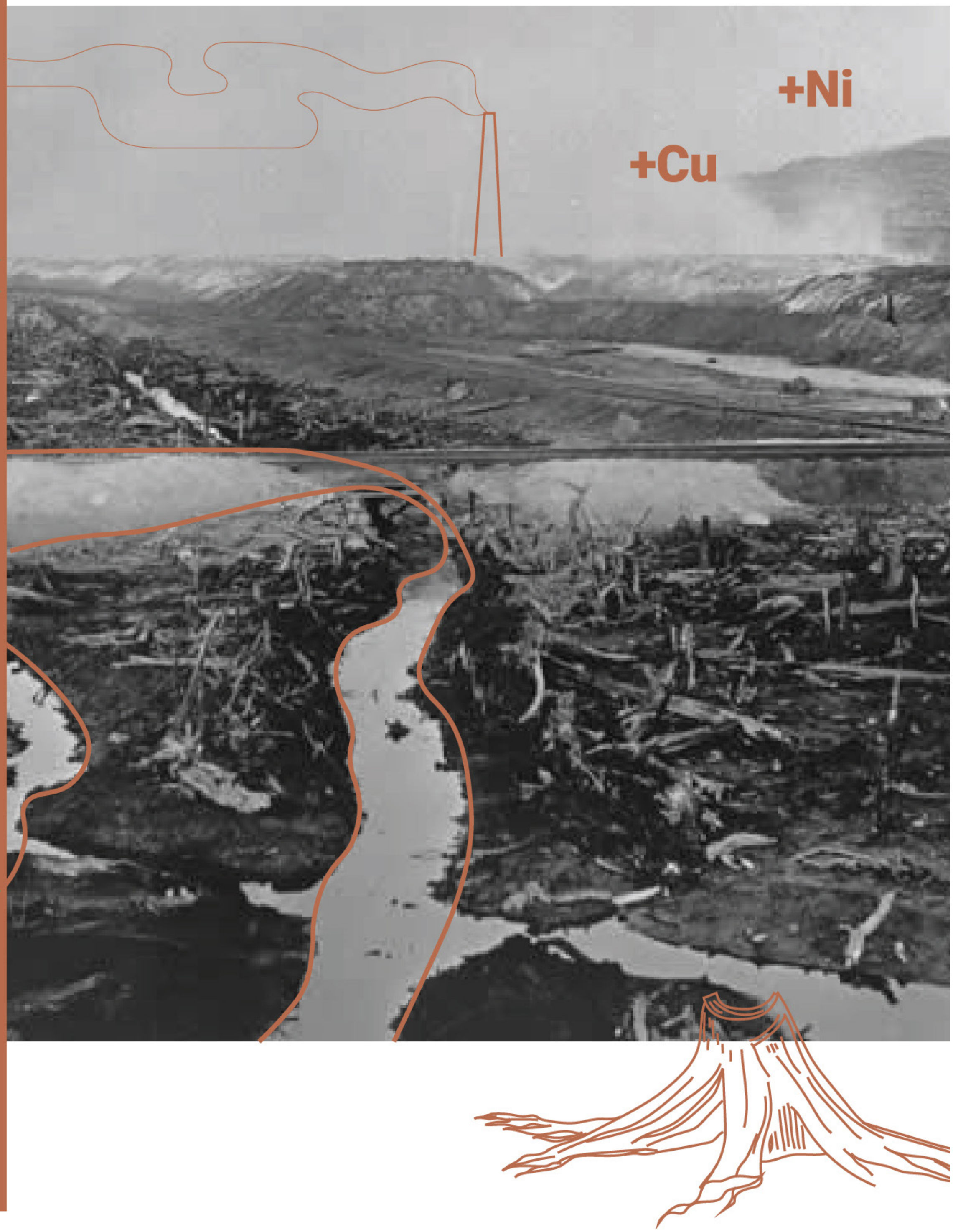


Fig. 133 *The Red and Green Speculative Illustration*

Bibliography

Sudbury

Babin, Adam, Anissa Goupil, and Susan Manitowabi. "The Greater Sudbury Area – Atikamesksheng Anishnawbek." Historical and Contemporary Realities Movement Towards Reconciliation. Accessed March 28, 2023. https://ecampusontario.pressbooks.pub/movementtowardsreconciliation/chapter/the-greater-sudbury-area-atikamesksheng-anishnawbek/.

Beckett, Peter J. (Laurentian University Professor, Ecological Restoration Researcher). Conversation with author, April 14, 2022.

Beckett, Peter J. "Lichens: sensitive indicators of improving air quality." In *Restoration and recovery of an industrial region*, pp. 81-91. Springer, New York, NY, 1995.

Bertulli, Margaret., Cheryl. Daminato, and Rae. Swan. *A Bit of the Cliff : a Brief History of the Town of Copper Cliff, Ontario, 1901-1972. [Sudbury].* Copper Cliff, Ont: Copper Cliff Museum, 1982.

Boerchers, Morrissa, Patricia Fitzpatrick, Christopher Storie, and Glen Hostetler. "Reinvention through regreening: Examining environmental change in Sudbury, Ontario." The Extractive Industries and Society 3, no. 3 (2016): 793-801.

Dépelteau, François. "DEFINITIONAL STRUGGLES, ENVIRONMENTAL RISK ASSESSMENTS AND THE LEVEL OF TRUST: THE SUDBURY SOILS STUDY, 2001-2008." HEALTH AND ENVIRONMENT: SOCIAL SCIENCE PERSPECTIVES (2010): 79.

Gunn, John M., Nels Conroy, William E. Lautenbach, David AB Pearson, Marty J. Puro, Joseph D. Shorthouse, and Mark E. Wiseman. "From restoration to sustainable ecosystems." In Restoration and recovery of an industrial region, pp. 335-344. Springer, New York, NY, 1995.

Gunn, John M. *Restoration and Recovery of an Industrial Region: Progress in Restoring the Smelter-Damaged Landscape Near Sudbury, Canada*. New York, NY: Springer New York, 1995.

Gunn, John M. "Restoring the Smelter Damaged Landscape near Sudbury, Canada." Restoration & Management Notes 14, no. 2 (1996): 129-136.

Gunn, John M., "Global Lessons on Sudbury's Story." UN Biodiversity Convention (COP15), December 2022. https://www.unep.org/news-and-stories/story/cop15-ends-landmark-biodiversity-agreement#:~:text=The%20United%20Nations%20Biodiversity%20Conference,weeks%20for%20the%20important%20summit. Presentation.

Gunn, J., W. Keller, J. Negusanti, R. Potvin, P. Beckett, and K. Winterhalder. "Ecosystem recovery after emission reductions: Sudbury, Canada." Water, Air, and Soil Pollution 85, no. 3 (1995): 1783-1788.

Kramer, Desre M., Emily Haynes, Nancy Lightfoot, and D. Linn Holness. "Dimensions of Community Change: How the Community of Sudbury Responded to Industrial Exposures and Cleaned up its Environment." Journal of Community Engagement and Scholarship 10, no. 2 (2018): 81-94.

Lautenbach, William E. “Land Reclamation Program 1978 - 1984 - Greater Sudbury.” Greater Sudbury. Accessed September 11, 2022. https://www.greatersudbury.ca/live/environment-and-sustainability1/regreening-progr am/pdf-documents/land-reclamation-program-1978-1984/. PDF.

Leadbeater, David. *Mining Town Crisis : Globalization, Labour, and Resistance in Sudbury.* Black Point, N.S: Fernwood Pub., 2008.

Migneault, Jonathan. “Avoiding Disaster: Vale Monitors and Upgrades Tailings Dams in Greater Sudbury | CBC News.” CBCnews. CBC/Radio Canada, November 3, 2021. https://www.cbc.ca/news/canada/sudbury/vale-tailings-dams-greater-sudbury-1.6234260.

Migneault, Jonathan. “The End of a Landmark: Reflections on Sudbury’s Superstack.” CBCnews. CBC/Radio Canada, March 14, 2023. https://www.cbc.ca/newsinteractives/features/superstack-reflections-sudbury.

Munton, Don, and Owen Temby. “Smelter fumes, local interests, and political contestation in Sudbury, Ontario, during the 1910s.” Urban History Review/Revue d’histoire urbaine 44, no. 1-2 (2015): 24-36.

Ross, Ian. “Biotech Could Liberate Billions from Sudbury’s Mine Waste.” Sudbury.com. Accessed October 6, 2022. https://www.sudbury.com/local-news/biotech-could-liberate-billions-from-sudburys-mine-waste-5429514.

Ross, Ian. “The Drift: Sudbury Has the Solution for Canada’s Mine Waste Problems.” Northern Ontario Business. Accessed March 11, 2023. https://www.northernontariobusiness.com/the-drift/the-drift-sudbury-has-the-solution-for-canadas-mine-waste-problems-5426129.

Saarinen, Oiva W. *From Meteorite Impact to Constellation City: A Historical Geography of Greater Sudbury.* Waterloo, Ontario, Canada: Wilfrid Laurier University Press, 2013.

Saarinen, Oiva. “Sudbury: A Historical Case Study of Multiple Urban-Economic Transformation.” Collections Canada. Accessed March 5, 2023. https://www.collectionscanada.gc.ca/obj/thesescanada/vol2/OSUL/TC-OSUL-288.pdf, PDF.

Saarinen, Oiva. “Sudbury.” The Canadian Encyclopedia. Accessed November 21, 2022. https://www.thecanadianencyclopedia.ca/en/article/sudbury-greater.

Santala, Kierann, Françoise Cardou, Denys Yemshanov, Fabio Campioni, Mackenzie Simpson, I. Tanya Handa, Peter Ryser, and Isabelle Aubin. “Finding the Perfect Mix: An Applied Model That Integrates Multiple Ecosystem Functions When Designing Restoration Programs.” Ecological engineering 180 (2022): 106646–.

“Scientist Recalls Involvement with Sudbury Training for Apollo 16 Astronauts 50 Years Ago .” CBCnews. CBC/Radio Canada, July 12, 2021.https://www.cbc.ca/news/canada/sudbury/apollo-asronauts-trained-sudbury-50-years-ago-1.6096556.

Snell, James. “Vale to Spend $150m to Extend Life of Thompson Mining Operation.” The Sudbury Star, August 3, 2021. https://www.thesudburystar.com/news/local-news/vale-to-spent-150m-to-extend-life-of-thompson-mining-operation.

Shorthouse, Joseph D. "Barrens to Blueberries." Barrens to Blueberries | Natural History Magazine. Accessed April 22, 2023. https://nhmag.com/features/253234/barrens-to-blueberries.

Spoel, Philippa, and Rebecca C. Den Hoed. "Places and people: rhetorical constructions of "community" in a Canadian environmental risk assessment." Environmental Communication 8, no. 3 (2014): 267-285.

Watkinson, Autumn D., Alan S. Lock, Peter J. Beckett, and Graeme Spiers. "Developing manufactured soils from industrial by-products for use as growth substrates in mine reclamation." *Restoration Ecology* 25, no. 4 (2017): 587-594.

Winterhalder, Keith. "Environmental Degradation and Rehabilitation of the Landscape Around Sudbury, a Major Mining and Smelting Area." Environmental reviews 4, no. 3 (1996): 185–224.

Regenerative Theory

Cole, Raymond J., Peter Busby, Robin Guenther, Leah Briney, Aiste Blaviesciunaite, and Tatiana Alencar. "A regenerative design framework: setting new aspirations and initiating new discussions." Building Research & Information 40, no. 1 (2012): 95-111.

Cole, Raymond J. "Transitioning from green to regenerative design." Building Research & Information 40, no. 1 (2012): 39-53.

"Living Building Challenge." International Living Future Institute, June 2019. https://living-future.org/lbc/. PDF.

Mang, Pamela, and Bill Reed. "Designing from Place: a Regenerative Framework and Methodology." *Building research and information : the international journal of research, development and demonstration* 40, no. 1 (2012): 23–38.

McLennan, Jason F. *The Philosophy of Sustainable Design : the Future of Architecture*. Kansas City, Mo: Ecotone, 2004.

McLennan, Jason F. *Transformational Thought*. 1st ed. Portland, OR: Ecotone Pub., n.d.

Pedersen Zari, Maibritt. *Regenerative Urban Design and Ecosystem Biomimicry*. London ;: Routledge, Taylor & Francis Group, 2018.

Petcou, Constantin, and Doina Petrescu. "Co-produced Urban Resilience: A Framework for Bottom-Up Regeneration." Architectural design 88, no. 5 (2018): 58–65.

Zeunert, Joshua. *Landscape Architecture and Environmental Sustainability : Creating Positive Change through Design.* London ;: Fairchild Books, 2017.

Other

"40th Anniversary of Regreening." Over To You Greater Sudbury. Accessed January 23, 2023. https://overtoyou.greatersudbury.ca/40th-anniversary-of-regreening.

"Accent: Mining a Bright Future | Sudbury Star," accessed November 14, 2022, https://www.thesudburystar.com/2013/04/13/accent-mining-a-bright-future.

Bradley, Bill. "A Primer on the Study, the Process and the Players Involved." Sudbury.com. Accessed November 21, 2022. https://www.sudbury.com/local-news.

"Celebrating Greater Sudbury's Regreening Efforts with Dr. Jane Goodall." Greater Sudbury. Accessed February 23, 2023. https://www.greatersudbury.ca/city-hall/news-and-public-notices/2022/celebrating-greater-sudburys-regreening-efforts-with-dr-jane-goodall/.

Childs, Mark C. "Storytelling and Urban Design." *Journal of Urbanism* 1, no. 2 (2008): 173-186.

Clément, Gilles. "Manifesto of the Third Landscape." *Editions Sujet/Objet* (2004).

"Central Tailings Area Orientation." Vale Inco. http://extportal.vale.com/ld/sud/modules/Linked%20Resource%20Documents/Canadian%20Operations%20Tailings%20Management%20Policy%202018.pdf. PDF.

"Copper Cliff at War." Community Stories. Accessed December 4, 2022. https://www.communitystories.ca/v1/pm_v2.php?id=record_detail&fl=0&lg=English&ex=00000865&hs=0&rd=264132.

"Copper Cliff Central Tailings Area (CTA)." Vale Inco. https://bc-mlard.ca/files/presentations/2008-14-COCCHIARELLA-copper-cliff-central-tailings-area.pdf. PDF.

"Copper Cliff, Greater Sudbury: A Driving Tour of Greater Sudbury's Mining Industry." Ontario. Accessed November 5, 2022. https://files.ontario.ca/ndmnrf-geotours-copper-cliff-en-2021-12-13.pdf.

"Demographic Data in the City of Greater Sudbury." sudbury.maps.arcgis.com. Accessed November 30, 2022. https://sudbury.maps.arcgis.com/apps/MapSeries/index.html?appid=2624ebe80fcc435d993f446d66920f51.

"Environment and Sustainability." Greater Sudbury. Accessed November 22, 2022. https://www.greatersudbury.ca/live/environment-and-sustainability1/.

Fahner, Kim. *Emptying the Ocean.* The Goose 18, no. 2 (2020).

Gemmill, Angela. "10 Millionth Tree Was Planted in Sudbury, Ont., and Icon Jane Goodall Was at the Milestone Event | CBC News." CBCnews. CBC/Radio Canada, July 8, 2022. https://www.cbc.ca/news/canada/sudbury/ten-millionth-tree-planted-sudbury-regreening-1.6513393.

Gilhula, Vicki. "Memory Lane: Sudburians Recall How They Came Together to Heal the City's Broken Landscape." Sudbury.com. Accessed January 23, 2023. https://www.sudbury.com/memory-lane/memory-lane-sudburians-recall-how-they-came-together-to-heal-the-citys-broken-landscape-4797352.

Kelly, Lindsay. "Slow Process of Demolition to Start on Vale's Superstack." Northern Ontario Business. Accessed January 21, 2023. https://www.northernontariobusiness.com/regional-news/sudbury/slow-process-of-demolition-to-start-on-vales-superstack-2598483.

Laberge, Jeff. "The Living with Lakes Centre." (Presentation, Sudbury, March 6, 2023).

Leduc, Thomas. *Slagflower: Poems Unearthed from a Mining Town.* Latitude46, 2019.

Leete, Rebecca Ildiko. "Paul Clemence Captures Burckhardt & Partners' Zürich's MFO Park in Bloom." ArchDaily. ArchDaily, April 16, 2022. https://www.archdaily.com/980008/paul-clemence-captures-burckhardt-and-partners-zurichs-mfo-park-in-bloom.

London, Fred. *Healthy Placemaking: Wellbeing through Urban Design.* London: RIBA Publishing, 2020.

Low Impact Development : a Design Manual for Urban Areas. Fayetteville, Ark: University of Arkansas Community Design Center, 2011.

Lesny, Lynda. "A TREE FELL." Poem sent to author, 2022.

Mateo-Babiano, Iderlina, and Kelum Palipane. *Placemaking Sandbox: Emergent Approaches, Techniques and Practices to Create More Thriving Places.* Singapore: Palgrave Macmillan UK, 2020.

"Mohawk NXT Production Line." International Living Future Institute, October 3, 2022. https://living-future.org/case-studies/mohawk-nxt-production-line/.

Mulligan, Carol. "Accent: Lore of the Pour ." The Sudbury Star, October 21, 2016. https://www.thesudburystar.com/2016/10/21/accent-lore-of-the-pour.

Mykytzuk, Nadia. "The Centre for Mine Waste Biotechnology." Mirarco, July 2021. https://mirarco.org/wp-content/uploads/BioTech/Centre_FeasibilityBookletSmaller%20July%202022.pdf. PDF.

Mykytczuk, Nadia. "Module 5: Mine Waste Management: Legacy Challenges and Current Approaches," Environmental Remediation: Global Lessons from the Sudbury Story, Laurentian University Goodman School of Mines, Sudbury, 2018, Vimeo, https://vimeo.com/292357146.

Mykytczuk, Nadia. "Module 5: Microbes in Mine Waste," Environmental Remediation: Global Lessons from the Sudbury Story, Laurentian University Goodman School of Mines, Sudbury, 2018, Vimeo, https://vimeo.com/290966968.

Mykytczuk, Nadia. "Module 5: Mine Waste Covers," Environmental Remediation: Global Lessons from the Sudbury Story, Laurentian University Goodman School of Mines, Sudbury, 2018, Vimeo, https://vimeo.com/292359669.

"Photocatalytic Air Purifier - UV Air Purifier: PCO Technology." Green Millennium, December 10, 2016. http://www.greenmillennium.com/air-purification-solution/.

"Regreening Awards." Greater Sudbury. Accessed February 28, 2023. https://www.greatersudbury.ca/live/environment-and-sustainability1/regreening-program/regreening-awards/.

Sheppard, Hugh. Conversation with author. January 2023.

"Solar Aquatics System," Solar Aquatics System TM, accessed March 8, 2023, http://www.ecotek.ca/ECO-TEK_Ecological_Technologies/Solar_Aquatics.html.

"Solar Aquatics Systems." Ecological Engineering Group. Accessed March 8, 2023. https://ecological-engineering.com/solaraquatics/#:~:text=Solar%20Aquatics%20Systems%20replicate%20and,better%20than%20mechanical%2Fchemical%20systems.

Souza, Eduardo. "From Red to Green: The Contradictory Aesthetics of Oxidized Facades." ArchDaily. ArchDaily, May 22, 2020. https://www.archdaily.com/939460/from-red-to-green-the-contradictory-aesthetics-of-oxidized-facades.

SULPHUR: Laurentian University's Literary Journal. Laurentian University's English Department, 2021.

"Toronto Company Looks to Extract Billions in Value from Sudbury Mine Waste." CBCnews. CBC/Radio Canada, June 8, 2022. https://www.cbc.ca/news/canada/sudbury/mine-waste-bacteria-extraction-1.6480504.

Ulrichsen, Heidi. "Passing on Lessons from the 1978-79 Inco Strike." Sudbury.com, December 15, 2009. https://www.sudbury.com/local-news/passing-on-lessons-from-the-1978-79-inco-strike-226784.

Unwin, Simon. *Children as Place-Makers : the Innate Architect in All of Us*. New York: Routledge, 2019.

Watkinson, Autumn D., Alan S. Lock, Peter J. Beckett, and Graeme Spiers. "Developing Manufactured Soils from Industrial By-products for Use as Growth Substrates in Mine Reclamation." ***Restoration Ecology*** 25, no. 4 (2017): 587–594.

Wiesner, Julian (Mirarco). Conversation with author. November 24, 2022.

"What Is Renewable Energy?" United Nations (United Nations), accessed March 11, 2023, https://www.un.org/en/climatechange/what-is-renewable-energy.

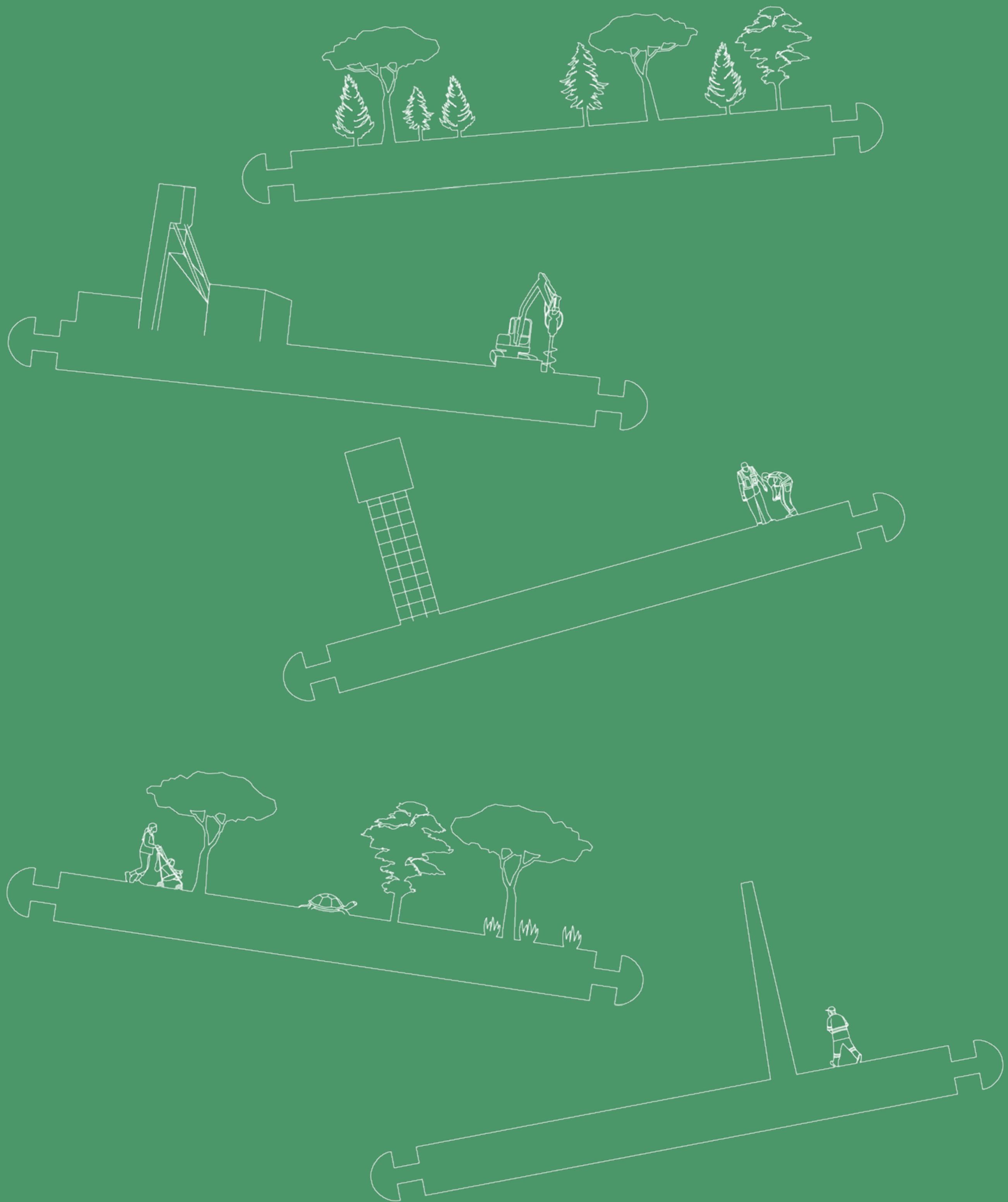


Fig. 134 *Model of the Shifting Sudbury Landscape*

Appendix: Artifact of the Shifting Landscape

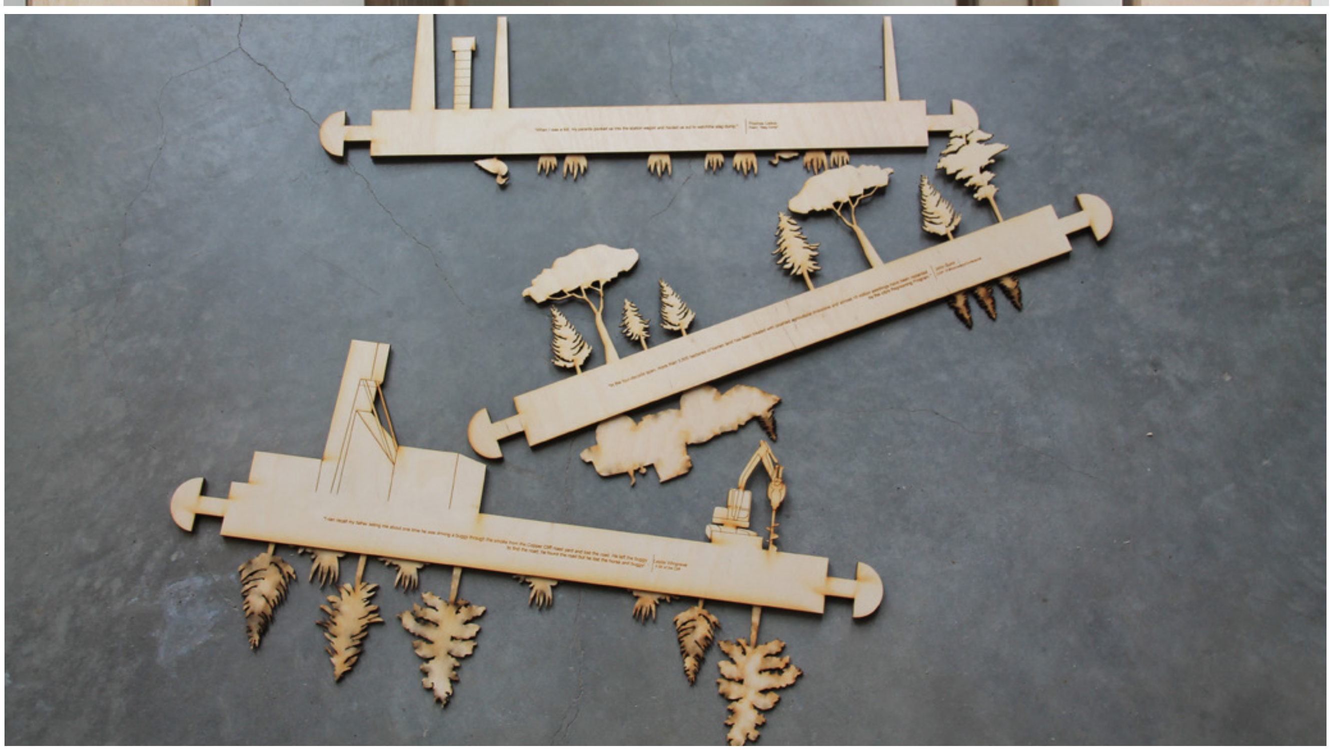


Fig. 135 *The Artifact-The Shifting Landscape*

Fig. 136 *Individual Storyboard Layers*

Fig. 137 *Photo Montage of the Shifting Landscape*

Fig. 138 *Flipping Layers of the Storyboard Photo Montage*

Fig. 139 *The Artifact - Red + Green Configuration*

Fig. 140 *The Artifact - Ecological Configuration*

Fig. 141 *The Artifact - Anthropogenic Configuration*


FROOD-STOBIE