INSTRUMENTAL MATRIX: Regenerative Systems in Hamilton, Ontario

by

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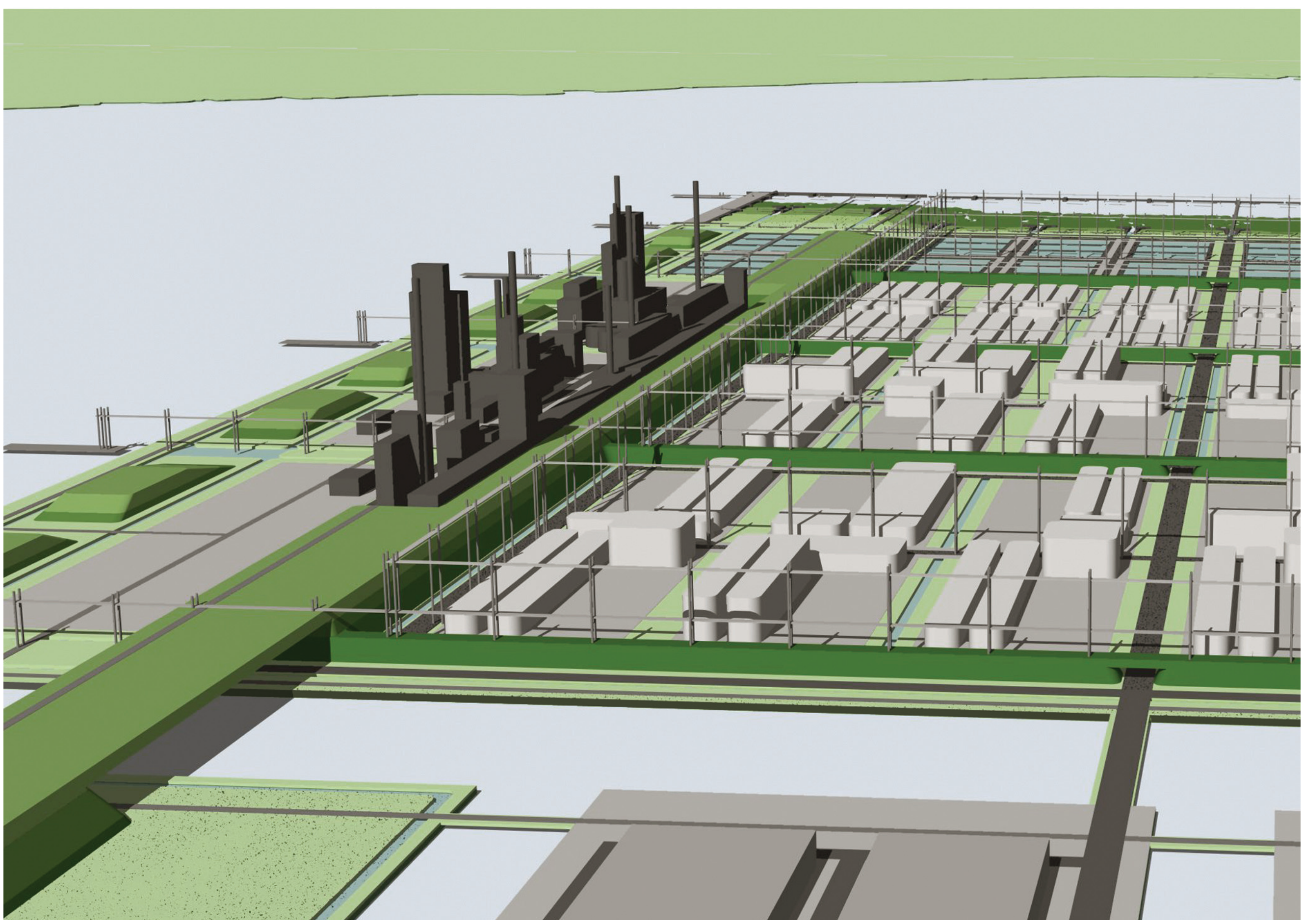
0.2. ABSTRACT

Positioned at the metaphysical divide between civilization and wilderness, this thesis investigates the potential for symbiotic relationships among cultural, ecological and industrial systems in an effort to suggest alternative modes for human sustainability. The City of Hamilton, where steel and iron industries continue to scar the landscape, serves as the location for a speculative design intervention. Amongst existing urban structures, a hybrid form of industrial production is proposed to acknowledge society's reliance on artificial devices. In turn, this hybrid form is integrated with natural ecological processes to demonstrate humanity's dependence on the natural world.



0.1. Instrumental Matrix: Overview

The first chapter positions the thesis within a discourse regarding the boundary between civilization and wilderness and their conventional dichotomy. The thesis is aligned to themes of ecological-artificial hybridization, which include the scientific application of biological metaphors, economic and manufacturing theories of industrial ecology, and architectural and design methodology.

Chapter two employs Complex Systems methodology to structure an analysis of Hamilton's 'intrinsic' and 'extrinsic' systems. The city is considered within ecological, historical, cultural, industrial and economic contexts, at local and regional scales.

Chapter three proposes an urban plan for Hamilton that seeks to regenerate and integrate ecological, cultural and industrial systems. Within the framework of this plan, industrial ecosystems can coexist with public function and ecological infrastructure in close proximity. Though designed for long term application, the plan is intended to provide context for a more detailed and immediate intervention within the scope of the thesis.

Chapter four proposes the implementation of a speculative urban design, as a central component of the urban plan. Sited on the Stelco pier, one of the largest and oldest steel producers in Canada, the design would reclaim a pivotal historical and physical location along the Hamilton waterfront. Regeneration of the heavily contaminated industrial site will be initiated with a phased program of remediation and managed ecological succession.

The new science of industrial ecology will inform this new development. This approach is based on a shift from 'open loop' systems, in which material and energy flows dissipate through processes of waste creation, towards 'closed loop' systems in which energy and material are recycled. A new Instrumental Matrix is proposed where decentralized cultural, ecological and industrial systems are interwoven to create diverse and sustainable habitats for wildlife, people and industry.

0.3. ACKNOWLEDGEMENTS

This thesis would certainly not have been possible without the academic input and advice from many individuals.

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0.4. TABLE OF CONTENTS

0.5. LIST OF ILLUSTRATIONS

CHAPTER 2.0. ANALYSIS: DYNAMICS OF HAMILTON HARBOUR

CHAPTER 3.0. URBAN FRAMEWORK: ECOLOGICAL, CULTURAL + INDUSTRIAL SYSTEMS

CHAPTER 4.0. IMPLEMENTATION: INSTRUMENTAL MATRIX

APPENDIX A1. ANALYSIS OF LAKE ONTARIO DRAINAGE BASIN

APPENDIX A2. ANALYSIS OF HAMILTON HARBOUR DRAINAGE BASIN

APPENDIX A3. ANALYSIS OF HAMILTON MUNICIPALITY

APPENDIX A4. HAMILTON HARBOUR MANAGEMENT UNITS

APPENDIX A5. STEEL PRODUCTION

APPENDIX A6. STEEL: INDUSTRIAL ECOLOGY

previous page:
1.1. Imagination: Liquid Politic

1.2. Hamilton Aerial:
demonstrates distinctive escarpment and harbour features, settlement patterns and industrial scarring

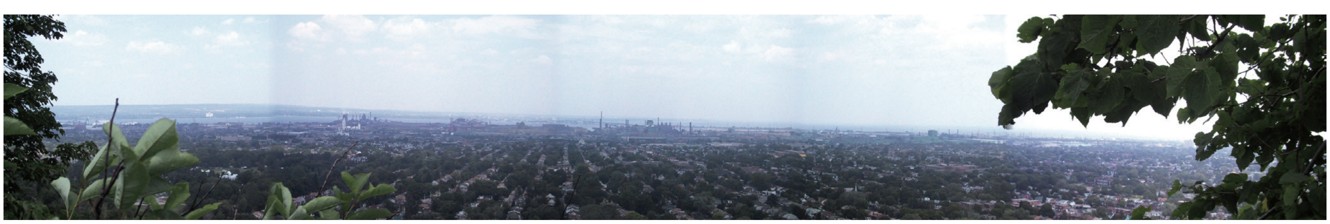
1.1. HAMILTON BACKGROUND

The city of Hamilton, Ontario has been examined as a quintessential industrialized environment; immeasurably scarred by an economic engine instrumental in the foundation and growth of its urban form. The protective enclosures of the harbour, and the escarpment, that once sheltered abundant ecological resources, historically defined Hamilton as an auspicious site for human settlement. Decades of misuse of these resources by steel and iron industrial firms have, however, seriously damaged the environment. In addition, chronic mismanagement of industrial and public resources has resulted in a suffering economy and a stifled culture.

Remnants of Hamilton's pre-settlement ecology are found in the Niagara Escarpment and related stream valleys which connect the city to larger ecological structures within the Lake Ontario Basin. The regeneration in Cootes Paradise, west of the bay, represents the wetland condition the once thrived within the entire harbour. An immense yet sublime industrial presence now dominates the shoreline and harbour.

This thesis asserts that industry can remain as an integral component of Hamilton's urban fabric. At the metaphysical boundary between the original wetland condition and the present industrial landscape a new model for habitation and development is investigated. This hybrid proposes a synthesis of ecological, cultural and industrial processes.

1.3. Hamilton Panaramic Overview:
taken from Niagara Escarpment, harbour and industry depicted in background



1.2. THE BOUNDARY

1.4. Hamilton Industry:
steel making facilities dominate Hamilton Harbour
1.5. Hamilton Boundary:
brick works at the Niagara Escarpment demonstrate a rape of the land and ecology
1.6. Hamilton Ecology:
Cootes Paradise now shows great recovery, yet has removed traces of human participation

NATURE-CULTURE DICHOTOMY

Historically, human interaction with nature has taken one of two distinct, and diametrically opposed positions. The first, closely associated with the Industrial Revolution, manifests itself as an abuse of natural resources. The second, a counteraction, is a preservationist approach that sequesters the land from human contact. Hamilton provides examples of both attitudes. Industrial pragmatism and economics have erased any notion of healthy ecology in the harbour, and suggest bleak prospects for the region. Cootes Paradise, as an ecological preserve, shows great promise to restore ecological systems, yet depends on strict boundaries and limited human access.

Based on these relationships, society tends to divide the landscape into two: the kingdom of wilderness and the kingdom of the market.[1] In the contemporary age of industrial progress, power structures assert the paradox that capitalism developed in order to improve the general quality of life. They do this, however, at the cost of destroying the mechanisms that preserve life. The logic of efficiency and the exclusive valuation of profit inherent to current industrial models have led to a devaluation of the environment. Consequently, the expense of destroying the earth, through processes of extraction, manufacturing and the production of waste, is largely absent from the marketplace.[2]

The concept of 'wilderness' has been effective in the preservation of some finite areas within the biosphere. Its usefulness is very limited however, as demonstrated by its failure to prevent damage wreaked on the much of the global landscape.[3] The romantic idea of 'wilderness' tends to force a polarized choice between man and nature, and is consequently incapable of discriminating between human interventions within nature.[4] Hubris, as a result of over reliance on technology, a lack of contact with natural processes, an oversimplification of temporal and spatial interactions within nature, as well as a reactionary longing for pristine, pre-industrial environments have all contributed to an ideal vision of nature separate from humans.

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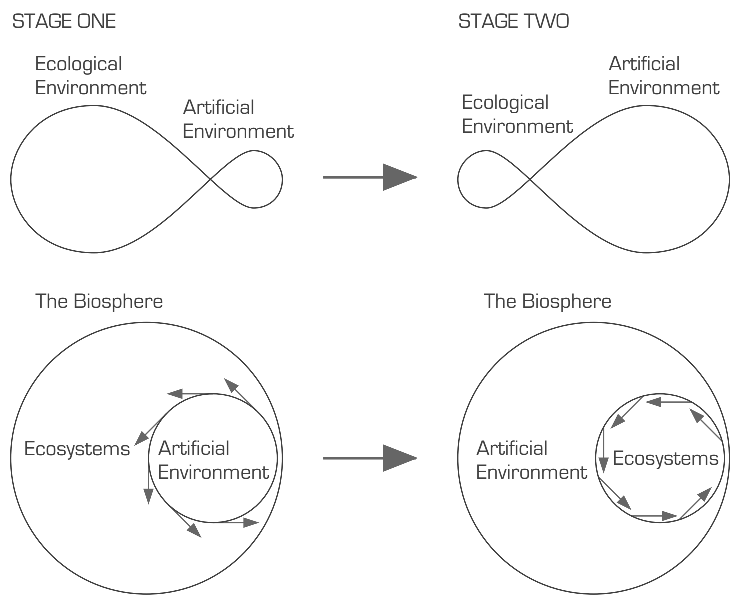
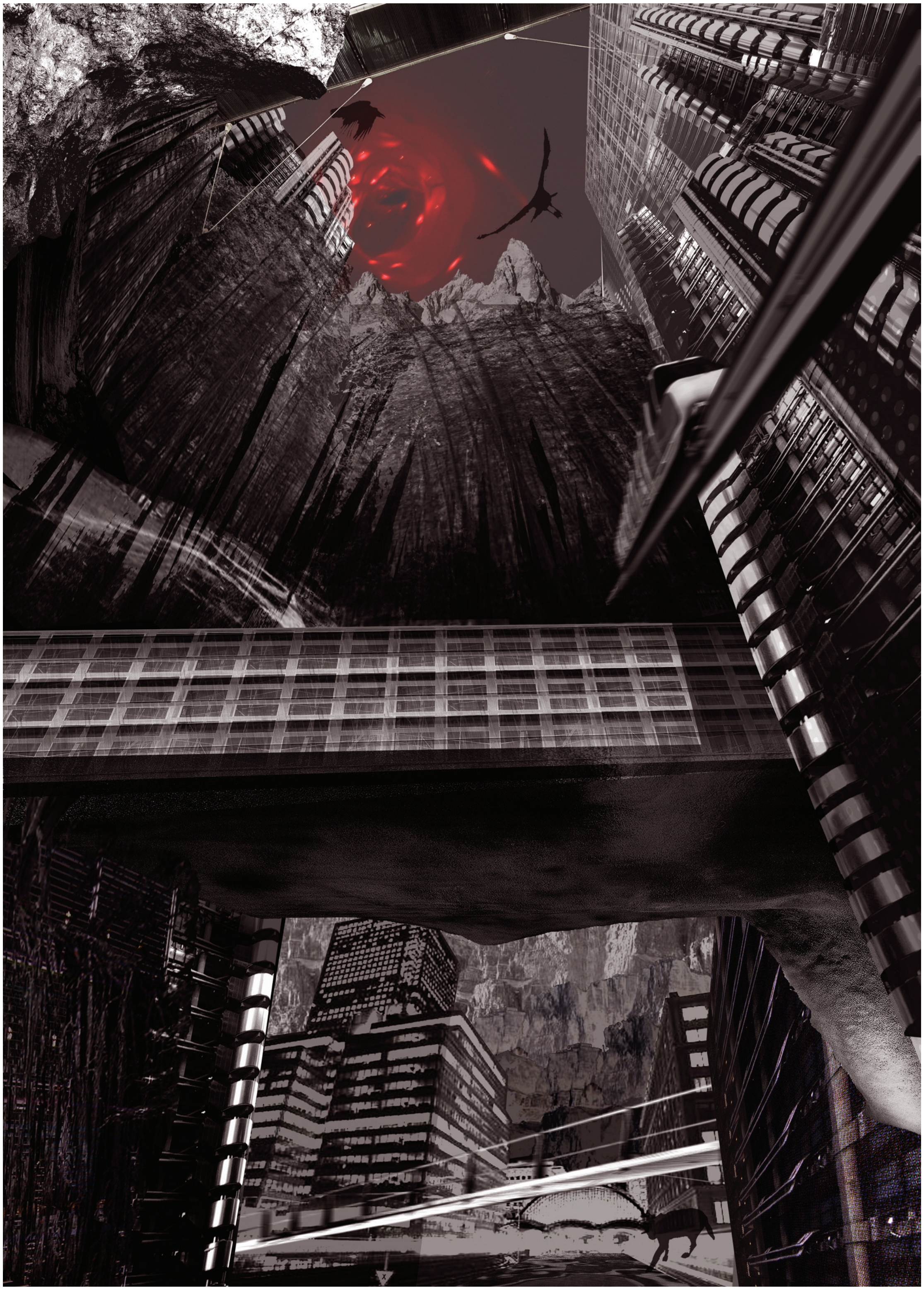


1.7. Biosphere Saturation

> **"... wilderness is also a profoundly alienating idea, for it drives a large wedge between man and nature. Set against the foil of nature's timeless cycles, human history appears linear and unpredictable..."** [5]

The wilderness ethic and free-enterprise economics can in fact be seen as reflections of each other. Natural laws and market laws both tend to supply a set of self regulating principles that autonomously govern. Both presuppose human intervention to be intrusive, or even destructive.[6] Neither of these two doctrines acknowledges that both nature and economics are inherently unstable.

As the biosphere nears its saturation point, civilizations continue to apply industrial pressures and shift the balance from ecological to artificial environments. Most of earth's environments exist today in an altered and degraded state. Neither of these extreme perspectives suggests strategies or mechanisms for appropriate ecological regeneration in the context of these development trends. The notion of a nature-culture dichotomy is increasingly irrelevant.



Given the choice between the limitless and sometimes terrifying possibilities that ecological diversity offer, versus the security afforded by both the wilderness ethic and western commercialism, individuals will almost certainly opt for security. Prejudice and self-interest mislead us into mistaking our particular interpretation for the correct explanation.[7] Ecologist Simon Levin explains:

> **"... to improve societies and to preserve the fragile biota that allows human societies to thrive, we must understand the strength of the selfish impulse, and the importance of the individual's actions in governing his or her behaviour."** [8]

To survey and negotiate the vast metaphysical boundaries between universal truth and limitless possibility we might refer to the nature of the mythological Trickster figure, whose seemingly amoral actions may provide the world with 'flexibility to endure'. At times the Trickster has taught cultures to fish with hook, net and weir. In other cases we find him limiting the spoils of the hunt as he de-baits hooks and un-sets traps. Lewis Hyde argues that the trickster myth asserts a paradox: "the origins, liveliness and durability of cultures requires that there be space for figures whose function is to uncover and disrupt the very things that cultures are based on." [9] The Trickster's unabashed interaction within both nature and culture may help civilizations to understand and accept their own roles within nature.

> **"Nature will condone an almost infinite number of possible futures...to exclude from these human desire would be unnatural."** [10]

opposite page:
1.8. Urban Masks:
depicts the conflict between nature and culture while demonstrating the power and potential of symbiosis

1.9. **Nickel Tailings No. 34**, by Edward Burtynsky:
Sudbury, Ontario 1996
1.10. **Kennecott Copper Mine No. 22**, by Edward Burtynsky:
Bingham Valley, Utah 1983

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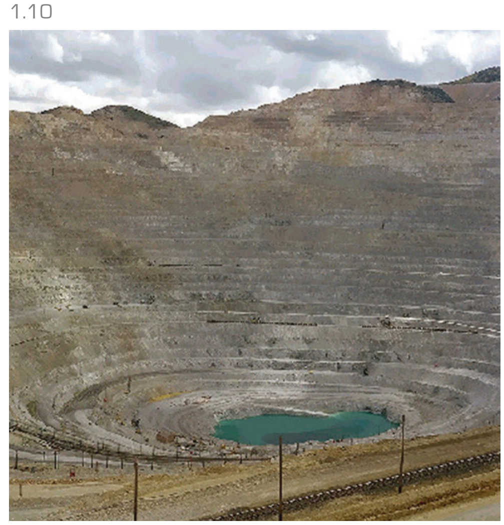


opposite page:
1.11. **Spiral Jetty**, by Robert Smithson: earthwork, 1970
1.12. Central Park Tree Moving Machine: "Manipulation of Nature ... larger trees could be transplanted and the lag between planting and finished apearance reduced..."
1.13. Central Park plan: "synthetic Arcadian Carpet grafted onto the Grid"

COMPLEXITY + COLLABORATION

Balance between the divergent states of universal truth and limitless possibility is critical to enduring stability, as evidenced in the etymology of the terms 'ecology' and 'economy'. Both share the common Greek root 'oikos', meaning 'house'. Ecology from 'logos', or 'discourse' means the **study** of the home; economy from 'namein', or 'to manage', means the **management** of the home.[11] Despite this inherent link the management of the global environment is not informed by the study of it. In fact many ecologists assert that the very idea of management of the biosphere is flawed, as our limited understanding of its complex mechanisms requires that we first concern ourselves with the management of our relationship to it.[12] Some ecologists assert that if business continues to grow it will destroy the world around it; conversely some economists believe that if business does not continue to grow it will destroy itself.[13]

Although both ecological and economic states employ systems of checks and balances between polarities of uniformity and diversity, neither can guarantee the perpetual maintenance of its existing conditions. The biosphere does not inherently value the particular set of conditions that it now maintains. Rather, it is a complex adaptive system which, through interaction between biota and their physical environment happens to have established a set of homeostatic mechanisms that allow for life.[14] Although the free-market economy that capitalism brings does intrinsically value profit, it similarly provides no guarantees for stability within given parameters. The key critical 'advantage' that a market holds over an ecosystem however, is the opportunity to engage in engineering and design, which in principle has no limitations on genuinely novel solutions.[15]

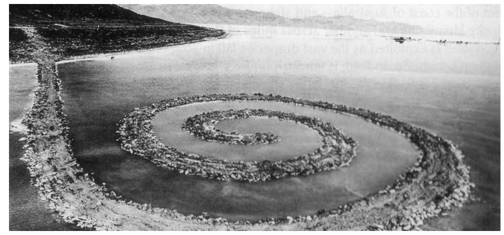
> **"We are one of only a handful of creatures with the capacity to deliberately alter our environment. To simply renounce that power [is] in some sense to renounce our humanity."**[16]

The artist Robert Smithson manipulated landscapes to create earthworks that challenged the conception of nature and culture as opposites. Throughout his projects land is utilized as both site and medium, as a dialogue between natural and artificial is initiated. He was interested in collaborating with ecological processes of growth and decay, while acknowledging the presence of technology and human engineering. Smithson's **Spiral Jetty** was constructed in Utah's Great Salt Lake, near a recovering oilfield site, and as such is positioned in the context of both sublime industry and natural beauty. Its artificiality was demonstrated through the use of technology to build the project, and its spiral form to suggest qualities of monumentality. Fluctuating water levels, multiplying salt crystals, and other natural processes occurring on the site express aspects of temporality and entropy. Smithson believed that the perceptual divide between ecology and industry could be mediated.[17]

> **"Smithson argued that human intervention on earth is as much a part of the natural process as an earthquake."** [18]

The design and construction of New York's Central Park in 1858, exists as an early example of a sensibility similar to Smithson's. In his writing Smithson recognized its landscape architect, Frederick Law Olmsted, as 'America's first earthwork artist'.[19] Although to many visitors Central Park appears as a natural preserve, the site was almost completely barren before the project began. The park is interlaced with infrastructural programs to facilitate water supply, vehicular circulation and public use. Olmsted's work with intrinsic aspects of site geology, and his acknowledgement of the park as a synthetic construction closely aligns his work to the principles and aspirations of Smithson's work. Olmstead saw the park as a "dialectic between the sylvan and the industrial." [20]

> **"As we manipulate the materials we extract from our environment, through our industrious efforts, we engage in the most fundamental relationship with nature, that of its reconstruction. Every material thing we create, everything we produce, reflects our relationship to the physical and biological world."** [21]



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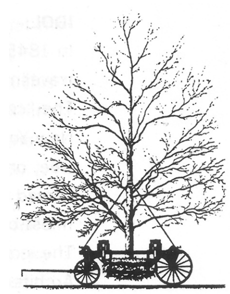

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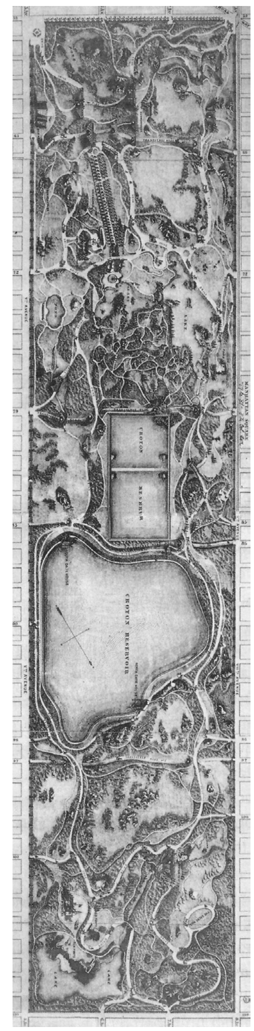

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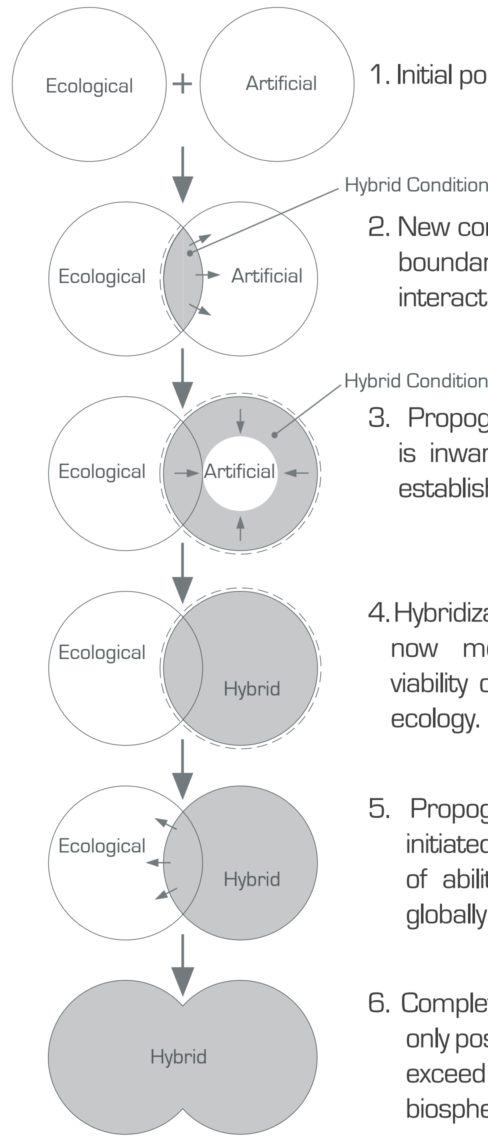
1.3. HYBRIDIZATION

1.14. Hybridization Methodology:
Hybridization at the boundary between nature and culture demonstrates a general strategy within the thesis for development and regeneration



1. Initial polarized condition.

2. New condition established at the boundary capable of sustainable interaction with both polarities.

3. Propogation of new condition is inward; artificial perimeter is established to preserve ecology.

4. Hybridization complete; perimeter now monitored to determine viability of hybrid condition within ecology.

5. Propogation of hybrid to be initiated only on determination of ability to indefinitely sustain globally life friendly conditions.

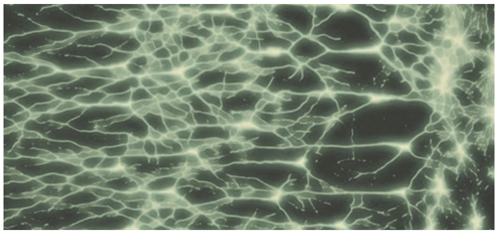
6. Complete propogation of hybrid only possible if it were to meet or exceed the current demands of biosphere.

HYBRID ETHIC

Through methods of hybridization the artificial distinction between nature and culture can be blurred and mitigated, if we recognize that “the difference between what life [as nature] needs to do and what we [as culture] need to do is another one of those boundaries that doesn’t exist.” [22] A new ethic of ‘hybridity’ may be informed by the thinking of Michael Pollan and his discussions regarding the principles of a garden. He suggests that the metaphor of a garden, and its long history of experiences in nature, may provide valuable instruction for contemporary cultural interactions with nature.[23] More specifically, the garden as a productive instrument, engaging in ecological processes, may serve to structure new sustainable industries.

> **“... the idea of a garden – as a place, both real and metaphorical, where nature and culture can be wedded in a way that can benefit both – may be as useful today as the idea of wilderness has been in the past.”** [24]

Pollan collects experiences from gardens and other gardeners to help formulate the following set of instructive principles: a garden ethic would emphasize a site specific approach, accept both cultural and natural contingency, and be frankly anthropocentric in its very conception. Pollan advocates recognition of the garden’s dependence on ecological processes, and of its need to work in balance with nature. The garden holds an essentially ‘unromantic’ view of nature, as a force without values, capable of destruction and indifferent to the survival of humans. Consequently it does not assume that human impact will be negative. Pollan suggest it is possible to balance human desires with nature’s needs. The garden is clearly dependant on nature, as it borrows materials and possibly goals from to create a ‘man-made analogue of natural processes. The need for observation, self-criticism, co-operation and restraint within a garden underscores the need for civilization to contribute to solutions for contemporary interactions with nature.[25]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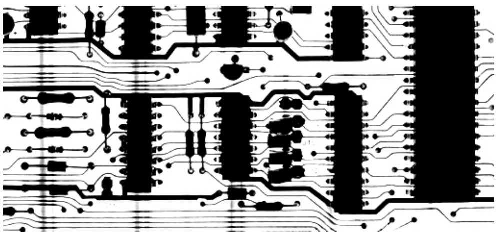
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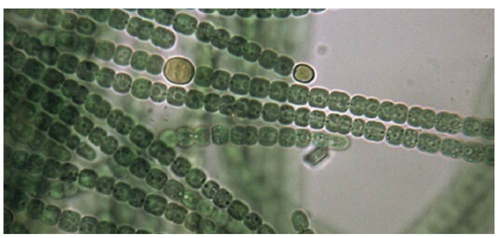
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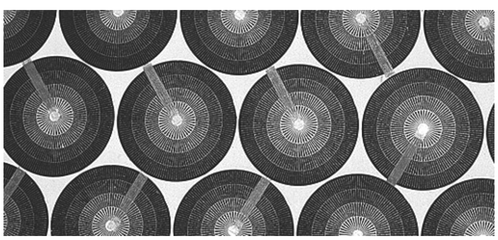

1.18

1.15. Nerve Cells:
fluorescence light micrograph of nerve cells (neurones) from the human brain
1.16. Circuit Board:
silhouette of a printed circuit board with integrated electronic components
1.17. Anabaena:
light micrograph of individual filaments, cyanobacteria that perform oxygenic photosynthesis
1.18. Photovoltaic Cells
circular solar cells made from single-crystal silicon, more efficient than their rectangular relatives

BIOLOGICAL METAPHORS

Accepting our right to manipulate the environment, and the need for productive cultures and ecologies, should not preclude our understanding of how to best engage the environment. To that end it is helpful to look to biological metaphors and the relatively new study of Biomimicry. Coined and illustrated by Janine Benyus in her book by the same name, the branch of research seeks 'innovation inspired by nature'. Among many existing and potential examples are solar cells copied from leaves, fibres woven to mimic spiders, high-tech ceramics inspired by mother-of-pearl, computers that signal like cells and a closed loop economy that takes cues from the likes of forests and coral reefs.[26] This science suggests a revolution in the way materials are manufactured and looks to strategies used in nature. These include life-friendly manufacturing processes, the creation of ordered hierarchies of structures, self-assembly, and templating of crystals with proteins.[27]

Study of ecology has lent to the development of the following set of Biomimicry strategies and principles: [28]

- Nature runs on sunlight.
- Nature uses only the energy it needs.
- Nature fits form to function.
- Nature recycles everything.
- Nature rewards cooperation.
- Nature banks on diversity.
- Nature demands local expertise.
- Nature curbs excesses from within.
- Nature taps the power of limits.

Robert Ayres, physicist and environmental economist, has extended the biological metaphor to describe an industrial metabolism. This is defined as the "set of physico-chemical transformations that convert raw materials (biomass, fuels, minerals, metals) into manufactured products and structures (i.e. 'goods'), and wastes." [29] The critical difference between existing industrial metabolism and biological metabolism is that natural cycles are essentially 'closed', while industrial cycles are 'open' and fail to recycle their nutrients. As an open cycle, the existing industrial system must either stabilize or eventually collapse into thermodynamic equilibrium where all flows cease. The first law of thermodynamics asserts the conservation of mass and energy and gives rise to the material balance principle. Application of this could inform the operation of a factory in a city, and thus work to stabilize industrial and urban demands within the requirements of the biosphere.

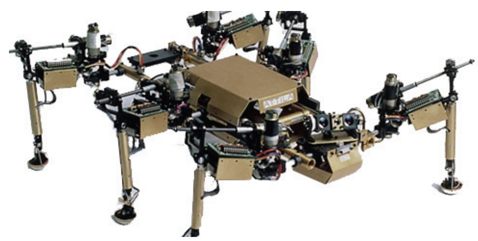
To help restructure our economic systems it is instructive to look to metaphors of ecological development. During early stages of ecological succession, pioneer species tend to dominate the landscape with characteristics of plant hardiness, rapid dissemination and appetite for energy. Through processes such as the stabilization of soil and extractions of trace elements from subsoil, intermediate stages create a foundation for later more complex systems that are highly efficient and resource conserving. These climax systems, though not impervious to change, do approximate a state of equilibrium among an association of organisms that is more resilient to disturbances within the environment.[30]

While it is evident that all stages of ecological succession are critical to the formation of complex systems, an inefficient use of energy, a lack of diversity, and a general lack of usefulness inherent to pioneer systems illustrate them as immature and undesirable. Ultimately their output is high while their use of resources is remarkably inefficient. Free-market capitalism has produced an industrial and economic system that has stalled at just such an immature state, rendering it inherently unstable and unsustainable.[31]

> **"... the present American culture is still the bare field full of colonizing weeds, struggling toward something more sophisticated, interwoven and permanent. Until now we've consistently chosen the resource hungry path of least resistance."**[32]

1.19. Jungle Nymph Stick Insect:
New Guinea walking stick
1.20. 'Attila' the Robot Insect:
under development at the Massachusetts Institute of Technology (MIT)

1.19



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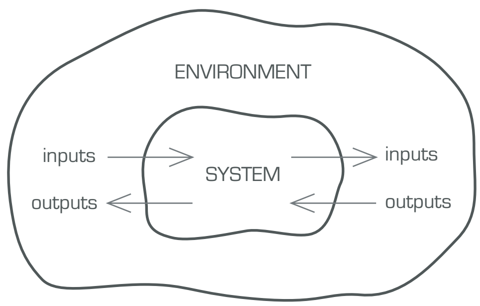


1.21. Cycling of Materials within an Ecosystem

INDUSTRIAL ECOLOGY

Industrial and economic systems are defined as the manufacture of goods and services, or rather the creation of value, from scarce resources. Unfortunately, accounting within these systems limits the consideration of scarce resources to capital and labour. Natural resources, such as land, water air and biodiversity are left largely unaccounted for. Similarly, raw materials used directly in manufacturing processes are only accounted for through the cost of their extraction, while factors of non-renewability are not acknowledged. Despite the creation of value relative to consumer based markets, the flow of nearly all material and energy extracted from the earth ultimately undergoes a devaluation or transformation to less useful forms. This waste creation further results in significant environmental degradation in the form of pollution from industrial processes and dissipative consumption of toxic substances form societal waste streams. "It follows from this simple relationship between inputs and outputs, a consequence of the law of conservation of mass, that economic growth tends to be accompanied by equivalent growth in waste generation and pollution." [33]

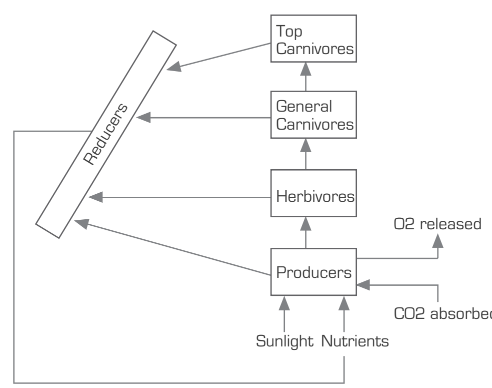
In his book **The Ecology of Commerce**, author Paul Hawken identifies an inherent lack of economic logic in the damaging and wasteful practices of many industries. However, as business is at the root of environmental problems, and the only contemporary institution powerful enough to initiate the necessary change, it must be part of the solution.[34] To structure this solution Hawken introduces the concept of a restorative economy that suggests if feedback loops are tightened and global resources are accounted for, the creation of profit and the regeneration of the environment can be part of the same process. This demands a redesign of commercial systems to benefit owners, employees, customers and the biosphere, but does not require a complete transformation of society. The viability of such human efforts must be "determined by the ability to integrate with or replicate cyclical systems, in its means of distribution and production." [35]

Robert Ayres has written broadly on the subjects of industrial metabolism, technological change and eco-restructuring. His book **Industrial Ecology: Towards Closing the Materials Cycle** outlines two basic perspectives that work within the same general discourse as Hawken. The first, informed by resource and environmental economics, is in direct response to the failure of industrial and economic systems to consider the productivity of all resources including by-products, waste streams, and environmental resources. To increase the productivity of material resources Ayres outlines four broad strategies that are technically and economically feasible: [36]

- Dematerialization – more efficient use of a given material for a given function
- Substitution – of scarce or hazardous materials with others
- Recycling – includes strategies of repair, re-use and remanufacturing to eliminate the extraction of raw materials
- Waste Mining – utilization of waste streams as alternative sources for other materials solves two-fold problem

The second perspective, structured by disciplines of engineering and technology, describes the science of industrial ecology. This relatively new field of study calls attention to biological analogies, and in so doing provides one of the most comprehensive and potentially feasible models to restructure industrial methods. Solutions for sustainable industry are identified in three fundamental principles that govern nature. Firstly, within an ecosystem most essential nutrients are recycled biologically, so that wastes of one species become the food of another. Application of this to industry could potentially eliminate waste and the need for raw materials, as well as generate profit from a former expense. Secondly, the only input to the operation of the biosphere is energy from the sun. This of course is linked to the critical search for renewable energy sources. Lastly, nature depends on diversity and mature ecosystems that are highly varied, specialized, and specific to time and place. This has vast ramifications throughout economies of mass production and monopolies.[37]

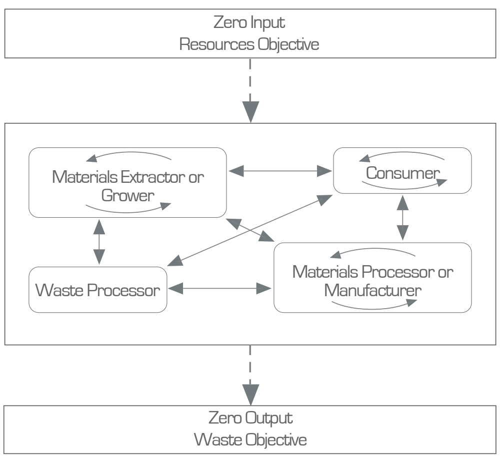
Although strategies of industrial ecology are technically feasible, they rely on assumptions that are regarded by some economists and biologists to be optimistic. Industrial ecology implies uses of biotechnology and market mechanisms that are capable of



1.22. Model of a System + Related Environments
demonstrates exchange relationships

1.23. Industrial Ecosystem Model
illustrates a change from linear dissipative material and energy flows to cyclical flows
1.24. Industrial Ecosystem Case Study
demonstrates basic exchange relationships in Kalunborg, Denmark

1.23



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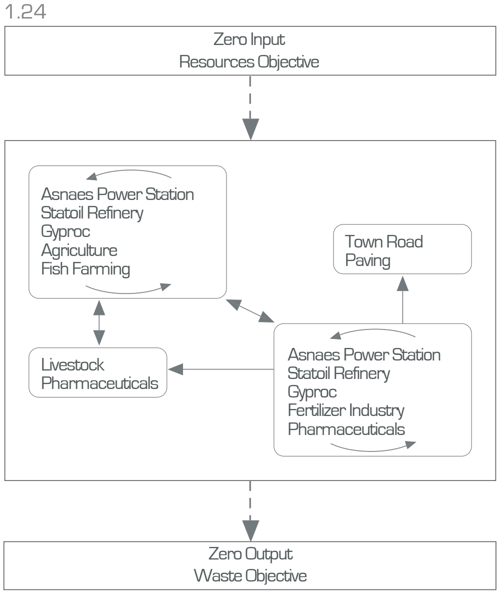


regenerating ecological systems to former states while global economies continue to grow.[38] Innovative policies such as green taxes and pollution permits will be critical to the realization of industrial ecology principles.[39] Paul Hawken stresses that:

> **"... industrial ecology provides for the first time a large-scale, integrated management tool that designs industrial infrastructures 'as if they were a series of interlocking, artificial ecosystems interfacing with the natural global ecosystem'... linking the 'metabolism' of one company with that of others."** [40]

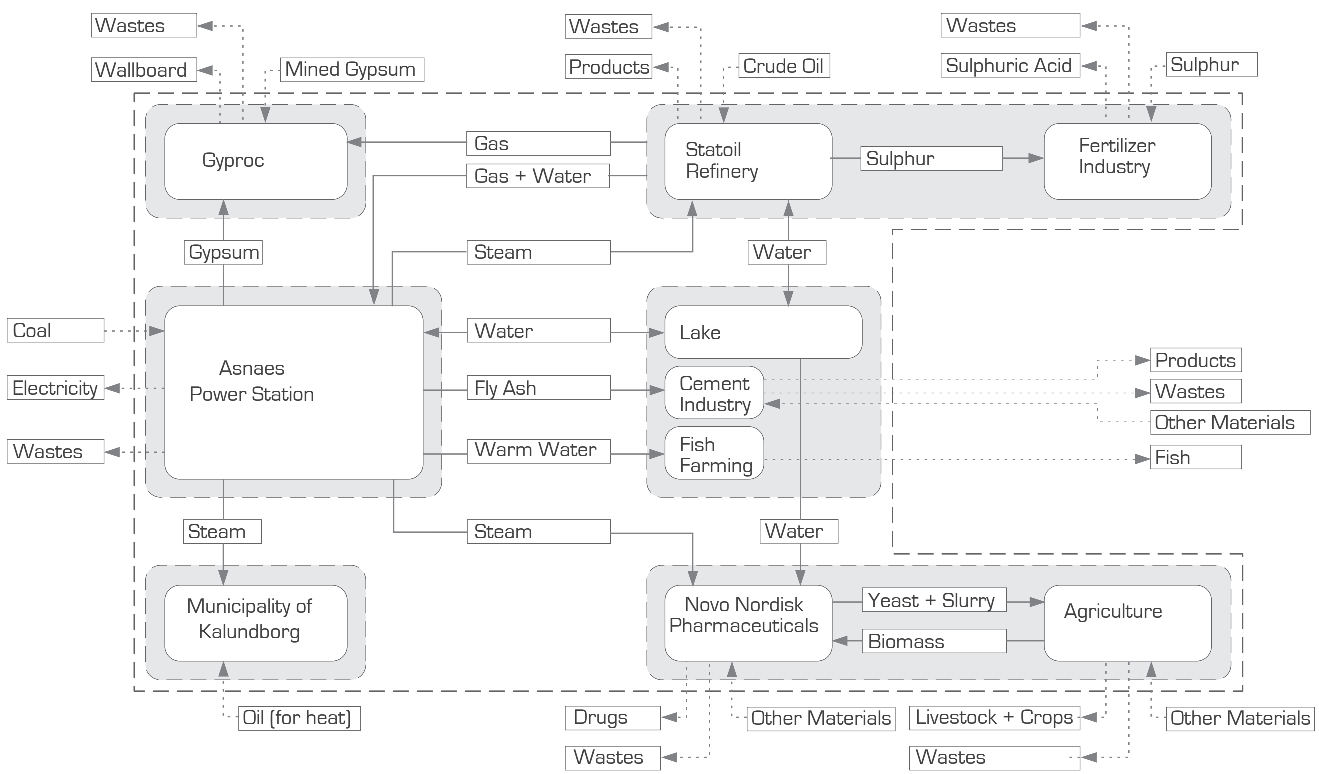
INDUSTRIAL ECOSYSTEM

The application of principles of industrial ecosystems and environmental economics can lead to the initiation of industrial ecosystems, or 'eco-industrial parks', in which a group of firms form a complex web of interactions that utilize waste products of each component firm as raw material for others.[41] This system would consist of specialized processors, consumers, and decomposers. One or more primary materials processors could form the centre in a collection of fabricators, suppliers, waste processors and secondary materials processors. "The main requirement is that there be a major 'export product' form the system as a whole, and that most of the wastes and by-products be utilized locally." [42]

Examples of this approach have been observed and studied. A widely-cited industrial ecosystem is in Kalundborg, Denmark, where a coal-fired power plant, an oil refinery, a pharmaceutical company, a sheetrock plant, concrete producers, sulphuric acid producers, the municipal heating authority, a fish farm, some greenhouses, local farms, and other enterprises work cooperatively together.[43] The process was initiated in the 1980s to recycle waste heat. This spawned many mutually profitable exchanges of water, gases and materials.

As a case study, the Kalundborg ecosystem demonstrates critical aspects that speak to the challenge of locating and maintaining waste relationships. In particular an increase in the number, diversity and efficiency of 'decomposers' will aid in the complete cycling of materials. Clearly a geographical proximity of a system's producers, consumers and decomposers within an 'eco-industrial park', facilitates exchange and allows for the sharing of infrastructure. Other key issues that must be addressed in such a system are sources of sustainable energy, and the application of 'limiting factors' to manage outputs and population sizes facilitated by either market or policy controls.

1.25. Kalundborg Material + Energy Flow Paths:
savings per year:
3,500 oil burning systems shut down
90% of sulphur in $CASO_4$
80,000 tons of gypsum
30,000 tons of coal
700,000 tons of sludge



1.4. ARCHITECTONICS + URBANISM

METABOLISM

Principles and strategies explored throughout the discourse of hybridization suggest implications for the fields of architecture, urban and infrastructure planning. The design of buildings and the organization of public and private space in connection with new industrial systems will need to generate highly adaptable structures and infrastructures. These in turn will need to accommodate multifunctional programmes that support complex distribution and connection systems issues.

In the 1960s the architectural movement of Metabolism aspired to similar objectives and offers a useful precedent for the architecture of industrial ecology and hybridization. Kisho

1.26. A plan for Tokyo by Kenzo Tange, 1960

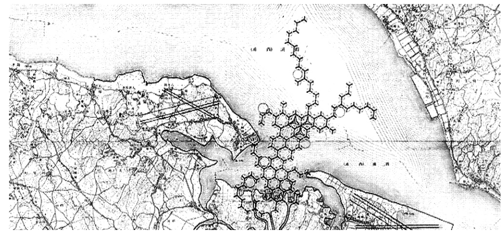
Kurokawa, a member in a group of Japanese architects who founded the movement, wrote of the biological metaphors that structured and communicated a new language of design and construction. The Metabolists compared buildings and cities to organisms and acknowledged cycles of natural and urban change in processes of growth, decay and renewal.[44]

> **"Their ideal is to design a city so flexible in its connections that its parts could grow, transform and die while the whole animal went on living."** [45]

Metabolist theory not only acknowledged natural and historical processes, but also pursued what they termed a 'metabolic development' of society. By reasserting human society as a part of a continuous natural entity that makes up the biosphere, technology was positioned as a direct and logical extension of humanity.[46] This position was contrasted with 'western' conceptions of a nature-culture dichotomy, and echoed Taoist philosophies of cosmic change and eternal growth.[47]

Embodied within examples of 'plug-in' buildings, capsules, megastructures and infrastructural projects, the Metabolists sought an architecture that achieved balance between artificial technologies and natural processes. Among other objectives they envisioned a separation of elements within a building or city to allow for multiple rates of change and obsolescence.[48] Among significant Metabolist principles the following ideas closely align with concepts of industrial ecology:

- emphasis on life and life forms
- emphasis on the existence and autonomy of parts, subsystems and subcultures
- buildings and cities as living organisms in both time and space
- architecture of temporariness in a dynamic balance
- information technology, life sciences and biotechnology produce architectural expression



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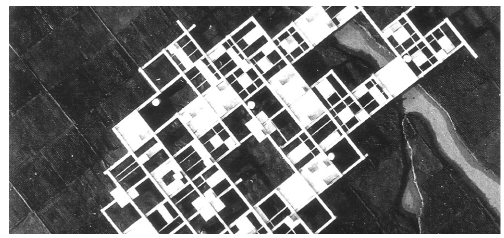

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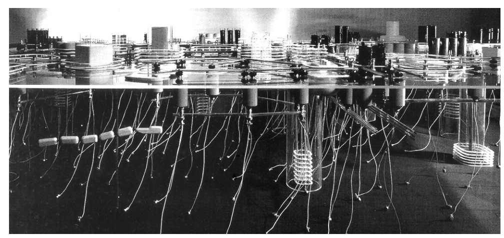

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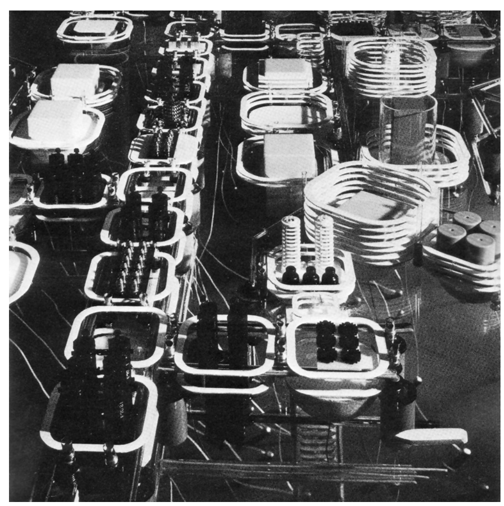

1.30

1.27. Floating City by Kisho Kurokawa, 1961
1.28. Agricultural City by Kisho Kurokawa, 1960
1.29. Floating Factory, 'Metabonate' by Kisho Kurokawa, 1969
1.30. Floating Factory

URBAN ECOLOGY

A growing body of contemporary architectural thought corresponds to the discourse of hybridization explored here. The Toronto landscape architect Michael Hough identifies the need to acknowledge and assert natural processes within urban and industrial environments. His book **Cities and Natural Process** argues to reshape urban landscapes based on two fundamental premises. First, that a sustainable environmental perspective must be an essential component of the economic, engineering, political and design processes that shape cities. Second, that environmental problems observed throughout the biosphere are rooted in cities and industrialized centres and therefore solutions must also be initiated there.[49]

1.31

1.32

1.31 + 1.32. Duisburg - Nord Landscape Park in Emscher, Germany
existing industrial facilities and infrastructures within decommissioned Thyssen steel works remain to integrate with new ecological regenerative systems in a public park. Factories accomodate new recreational and cultural programs; steel structures and railways accommodate new public prommenades and raised walkways; gardens, parks and water channels form an extensive remediation strategy.

1.31. illustrates raised walkways and water channels
1.32. illustrates a new courtyard among giant steel artefacts

Hough carries out a comprehensive analysis of cities as complex ecosystems. Natural and cultural environments are examined with respect to ecological systems operation, symbiosis between natural and cultural elements, and reciprocal inflections of urban processes or attitudes on natural systems. Among the observed limitations inherent to cities are a lack of environmental values, limited contribution of natural process and a reduction of complex communities.

This analysis reveals a contradiction of environmental values embodied in typical urban landscapes. A formalized boulevard, considered of high aesthetic and civic value, demonstrates little connection to natural process; alternatively an abandoned industrial site that demonstrates regenerating and functioning natural processes is regarded as derelict and in need of urban renewal. Hough describes a paradox: cities operate as the centre for large concentrations of nutrients, materials and energy, but urban soils remains sterile and non-productive.[50] Consequently, the management of urban resources remains anonymous, as the supply of material and processes of waste are invisible and removed from public responsibility.[51]

> **"We seek a design language whose inspiration derives from making the most of available opportunities; one that re-establishes the concept of multifunctional, productive and working landscapes that integrate ecology, people and economy."** [52]

A series of basic design principles is constructed from Hough's analysis that emphasizes process, economy of means, diversity and local response. Specific applications include urban forests, plantings based on ecological succession, grassland management, green wildlife corridors, biological wastewater treatment systems, and larger structures of urban spaces that create relationships between natural and cultural processes. Hough attempts to make visible the ecological, urban and industrial processes that sustain both our culture and life on earth; this aim is to produce more diverse environments, greater economic and biological productivity and increase social education.[53]

1.33. Formalized Urban Boulevard:
demonstrates little connection to ecological process
1.34. Abandoned Industrial Site:
demonstrates regenerating and functioning ecological process

1.33

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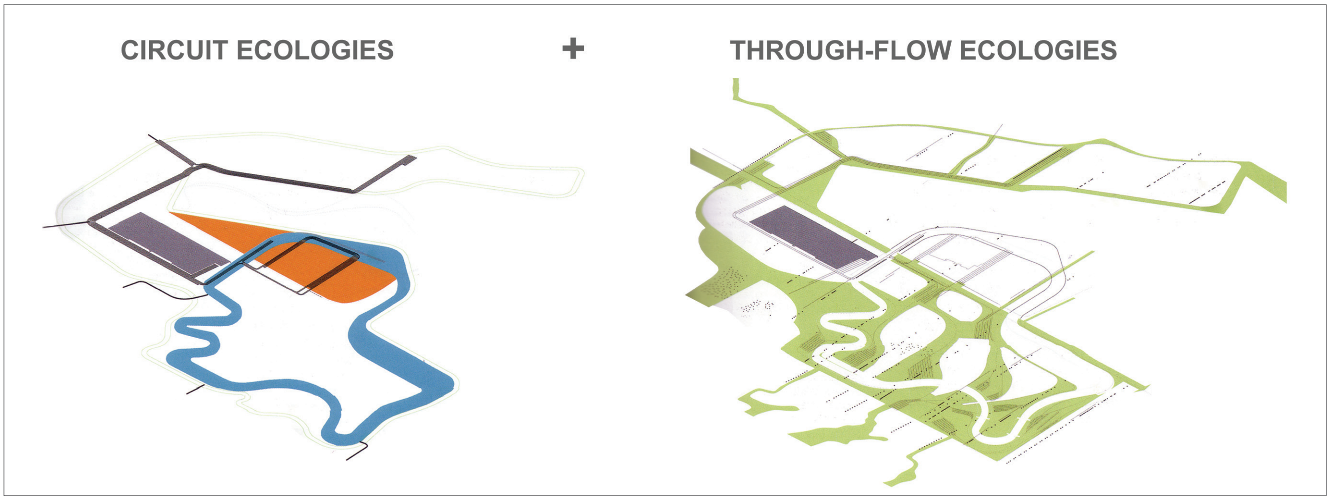

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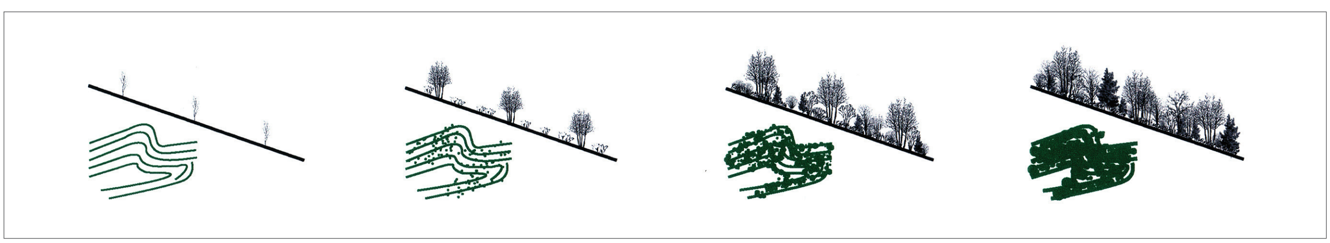

1.37

1.35. Downsview Park by Field Operations + Stan Allen: constructed systems are the organs and lifelines that direct and support the future demands of the site

1.36. Fresh Kills Park by Field Operations + Stan Allen: organizational elements structure the transformation of a 2,200 acre landfill in New York into public park

1.37. Fresh Kill Park Succession Development: demonstrates thicket planting on slopes into mature, multi-aged, stratified woodland

INFRASTRUCTURAL URBANISM

The architecture and writing of Stan Allen provides a constructive model for the specific integration of cultural, ecological and industrial interactions and structures. Proposals for systems that incorporate both artificial and natural elements reiterate an opposition to the nature-culture dichotomy in favour of hybrid models.[54] His methodology of infrastructural urbanism, illustrated in an essay by the same name, represents an 'instrumental' approach to architecture. This suggests a flexible development of programmatic elements while maintaining unified identity throughout a site.[55] Metaphors of ecologies help to structure not only biological systems, but also construction implementation, systems maintenance, user groups, and decision making structures, within a larger organizational framework.[56]

> **"Two claims can be made: first that architecture's instrumentality can be reconceived... as the site of architecture's contact with the complexity of the real...The second claim is for a practice engaged in time and process... to the production of directed fields in which program, event and activity can play themselves out."** [57]

The following seven propositions clearly illustrate the nature of this methodology: [58]

- Infrastructure works to construct the site itself, rather than to propose specific buildings.
- Infrastructures are flexible and anticipatory.
- Infrastructure work recognizes the collective nature of the city and allows for the participation of multiple authors.
- Infrastructures accommodate local contingency while maintaining overall continuity.
- Although themselves static, infrastructures organize and manage complex systems of flow, movement and exchange.
- Infrastructures systems work like artificial ecologies. They manage the flows of energy and resources on a site and they direct the density and distribution of a habitat.
- Infrastructures allow detailed design of typical elements or repetitive structures, facilitating an architectural approach to urbanism.

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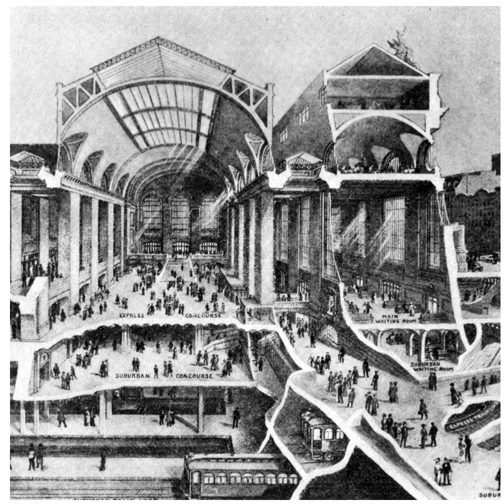
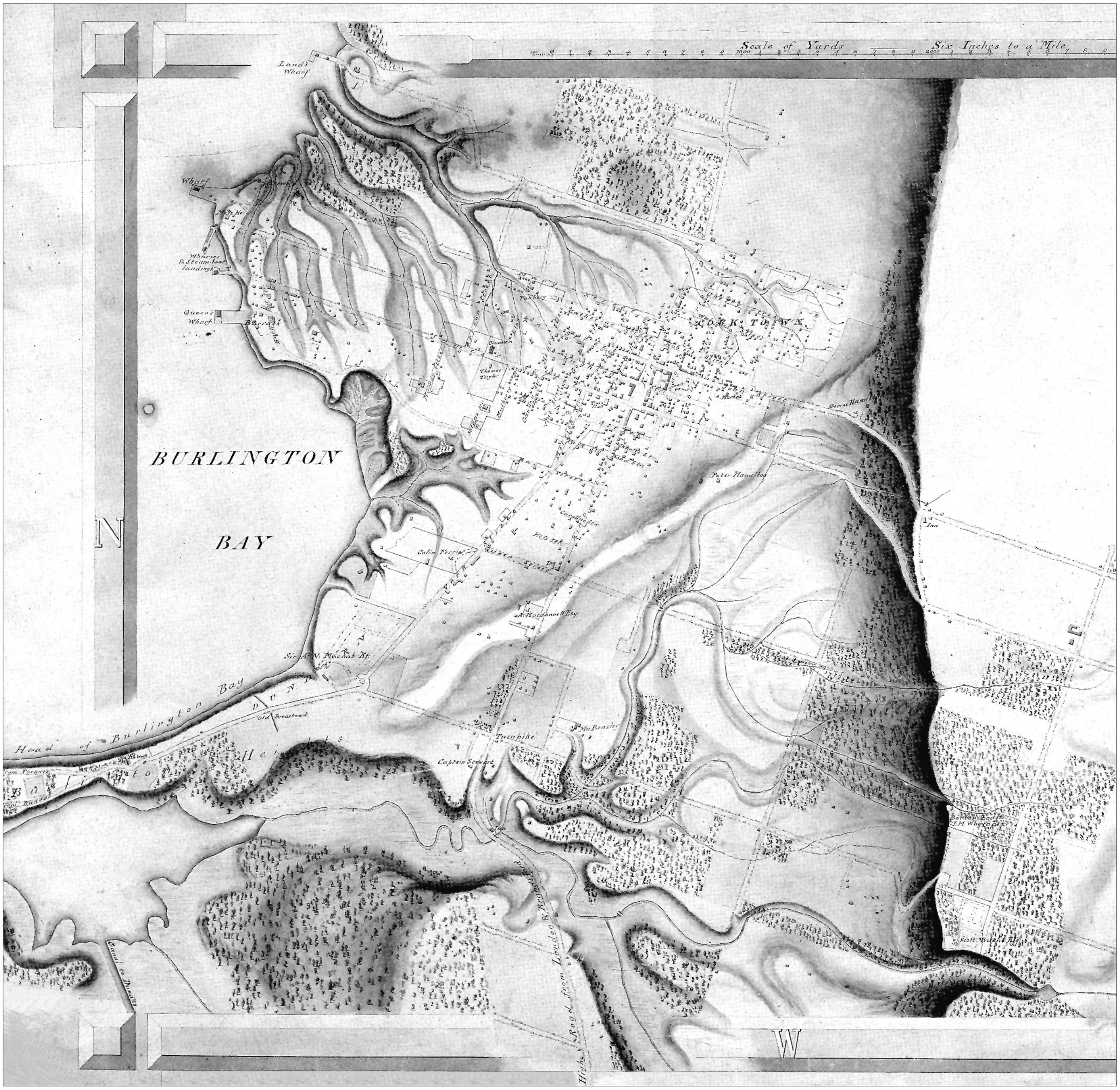


1.39

1.40

1.38. Windmill Farm, California:
potential for sustainable energy generation
1.39. Section of Grand Central Station, New York:
shows layered interwoven pedestrian, vehicular and train infrastructural systems
1.40. Highway Interchange:
demonstrates infrastructural catalogue of elements able to accomodate a variety of unique site conditions



previous page:
2.1. Hamilton Overview:
Hamilton Harbour in background (taken from Niagara Escarpment)

2.2. The Town of Hamilton (plan circa1842):
pre-rail settlement, signs of mercantile shippng

2.1. HISTORY + EXISTING CONDITIONS

The development of Hamilton has been inextricably linked to industry since its foundation. Situated between the base of the Niagara Escarpment and the south shore of the harbour, the city occupies a particularly auspicious site. Although the natural protection of the harbour that once supported prolific wetlands and a diverse range of plant and wildlife species, has attracted a range of human settlement including resource activities (fishing, ice harvesting) and recreation activities (boating, bathing and skating), industrial and shipping activities have initiated the largest population influx. The potential for a deep water port, local natural resources (limestone, clay etc.), proximity to raw materials and product markets, and a strategic location with respect to shipping and transportation infrastructure, all factored into the development of the largest concentration of steel and iron industries in Canada[1] as well as the largest port on the St. Lawrence Seaway.[2]

Separated from Lake Ontario by a thin sand bar, Hamilton Harbour was introduced to mercantile shipping in 1823 with a strategic canal cut.[3] This manmade connection increased the porosity of the harbour, initiated an exchange of water, and established a flow of goods, materials and people to and from the city. The protected inlets of the south and then wetland shore offered numerous natural or easily convertible piers. In addition to increased commercial activity, this act established Hamilton as a major debarking point for immigrants throughout the 1830s and 40s, particularly of Irish origin, and hence supplied a growing labour force.

In 1846 the incorporation of the city was accompanied by a widening of the canal to allow for larger vessels and increased traffic.[4] A complementary land link followed with the addition of a Great Western Railway terminal in 1853 (later CNR) to connect Toronto, London, Niagara and Hamilton.[5] While greatly improving connectivity and shipping potential, this construction did much more to increase the market potential for fledgling steel and iron companies, with its reciprocal demand for rail cars and tracks. Larger steel conglomerates such as Stelco and Dofasco incorporated in 1910 and 1912 respectively, and experienced much growth during both World Wars as well as through the boom of the automobile industry in the 1920s.[6]

2.3

2.4

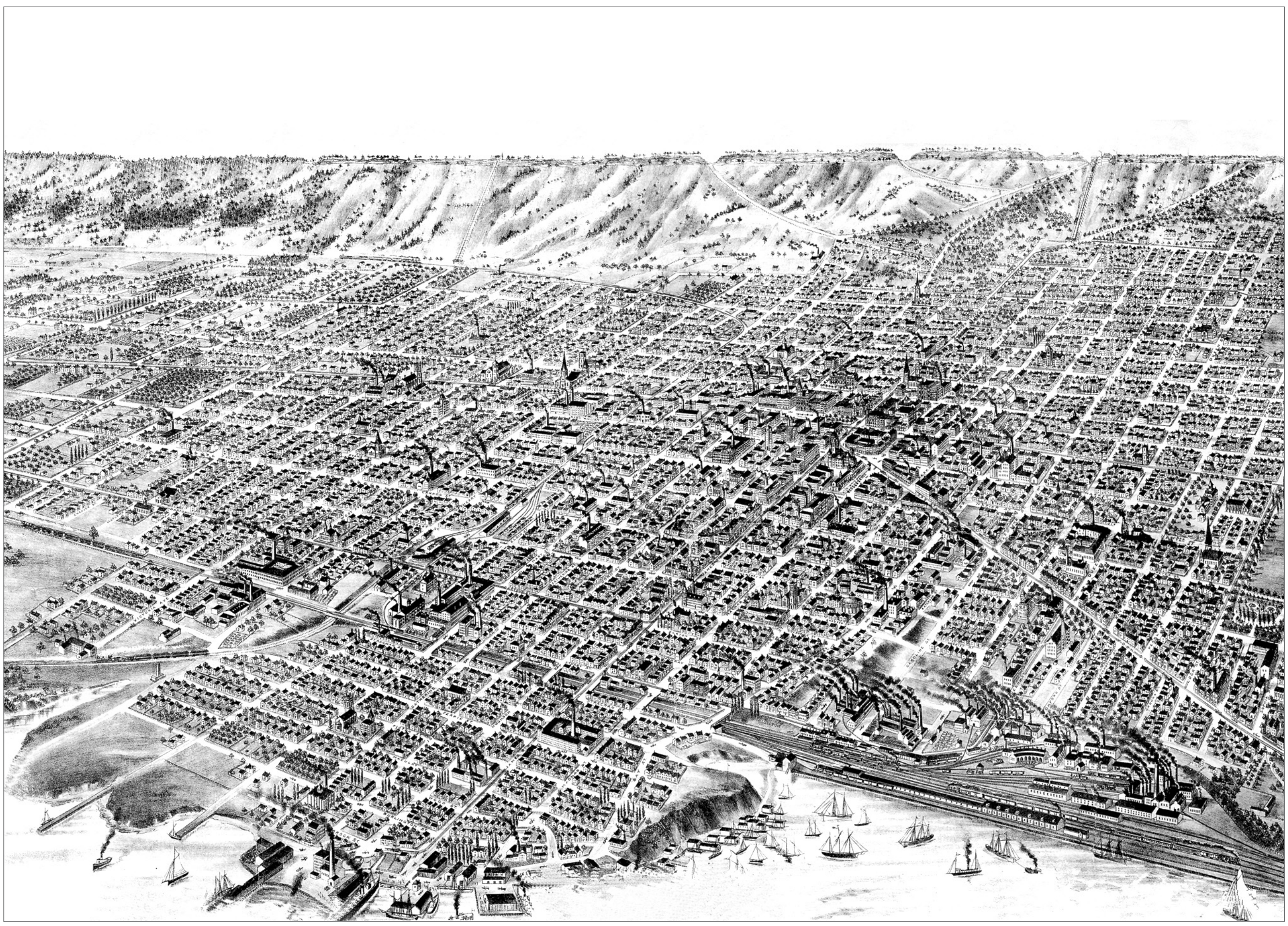
2.5

2.6

2.3. Great Western Railway yards and station, 1870
2.4. Steamer passing Burlington Channel, circa 1880
2.5. Union Drawn Steel, 1905
2.6. Lakeside of Hamilton Beach near Burlington Channel, 1910

Significant alteration of the harbour began in 1912, when land reclamation further encouraged industrial development. Shortly thereafter recreational use of the harbour began to decline, as in 1930 when a by-law was passed prohibiting swimming altogether.[7] The creation of the Welland Ship Canal in 1932, in conjunction with the completion of the St. Lawrence Seaway in 1959 precipitated expansion of existing Hamilton facilities in anticipation of international ship traffic, to create what is now known as the Burlington Shipping Canal.[8] Waterfront expansion continued till 1982, as dredging and infilling of water lots created industrial and port lands equivalent to 25% of the original harbour area.[9]

2.7. The City of Hamilton: bird's eye view (circa 1894): rail terminal is established, shipping activity is thriving; settlement is pushed back beyond the escarpment



In Hamilton's primacy, human habitation and industry coexisted along the shores of the harbour. In response to this resource the city developed outward from the waterfront edge to create an essentially continuous urban fabric up to and beyond the escarpment. As heavy industry expanded, so did its need for waterfront land and resources provided by the harbour. To support industrial growth Hamilton experienced a concurrent increase in population. Unfortunately, the poor living conditions and pollution that accompanied 19^{th} Century industries forced human habitation into retreat toward and beyond the Niagara Escarpment. Incongruously, the population became economically dependent, yet physically repelled from industry. Presently the waterfront is completely dominated by heavy industry, most prominently steel production, and due to historically toxic and dangerous processes the waterfront remains largely inaccessible to the public with a drastically altered ecology.

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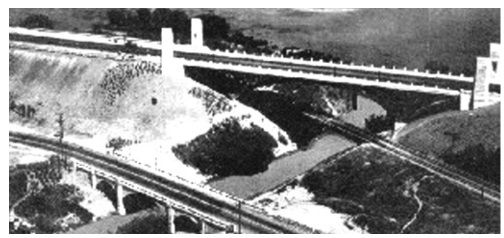

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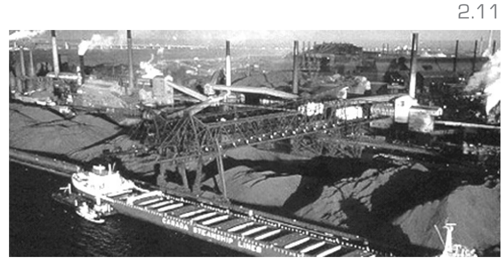


2.12

2.8. First deep sea steamer in Hamilton, 1900
2.9. Overview of Stelco Hamilton, 1930
2.10. High Level Bridge spanning Desjardins Canal, 1932
2.11. Skyway spanning Burlington Canal, 1958
2.12. Laker Ship supplying Stelco Hamilton, circa 1985

2.2. COMPLEX SYSTEMS ANALYSIS

ANALYSIS METHODOLOGY

A detailed analysis of systems within Hamilton's waterfront, and a contextual analysis of these systems within larger frames of reference, provides an outline of strategies for a synthesis of industrial, cultural and natural systems. This analysis helps establish principles and components critical to the initiation and maintenance of an industrial ecosystem in Hamilton. In this approach, several industrial firms in close proximity to each other use the waste products of each component firm as raw material for another. Within this new synthesis, space for human habitation and interaction is accounted for, as well as space for natural ecosystems to function.

The analysis of Hamilton is informed by an ecosystems approach comprised of analytical and anticipatory tools to support the maintenance of healthy ecologies and sustainable development. Inherent to this approach is the conception of humans as an integral component of ecological-economic systems. The creation of a sustainable society must therefore promote the maintenance of ecological integrity while providing for the needs of the human species. The methodology seeks an integration of bio-physical and human cultural perspectives to generate an expansive understanding of ecosystems, and positions itself in opposition to a nature-culture dichotomy. The approach lends itself to the formation of hybridized ecological forms, and to the 'coevolution' of cultural and natural landscapes toward self-organizing entities.

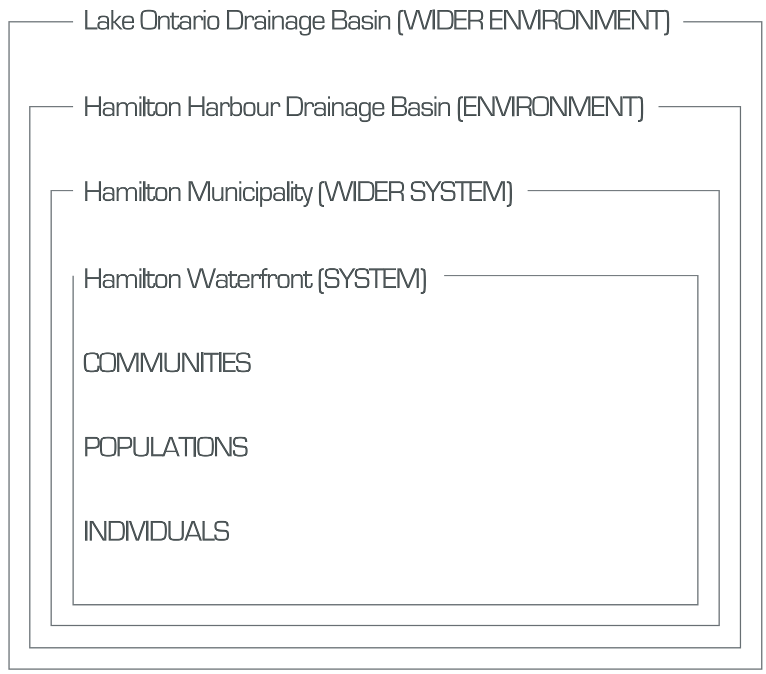
Based on principles of Complex Systems theory, this approach relies on an understanding of ecosystem dynamics as complex, self-organizing, indeterministic, and constantly evolving through processes of birth, growth, death and renewal.[10] Ecosystems are seen to exhibit catastrophic behaviour where sudden system changes are normal and even potentially healthy.[11] This implies that any given ecosystem can approach several stable, distinct states.

The ecosystems approach provides a comprehensive process that accounts for hierarchical structures and adaptive changes within complex systems. The framework allows for the study of both natural and artificial systems, and can be extended to encompass cultural, industrial and ecological systems within Hamilton. Its management structure is **anticipatory** and **adaptive**, to acknowledge that complex system predictions are ultimately judgements based on a subjective study of past history and a limited knowledge of existing variables.[12] The approach is based on both quantitative prediction, in terms of systems analysis, and qualitative understanding, with respect to the synthesis of cultural perspectives.

The complex systems analysis is structured within a 'conceptual model' that provides critical information regarding future system constraints and possibilities. This model describes linkages and interconnections among social, economic, political and ecological systems. [13] The study of such complex systems can only be understood in their entirety when placed in reference to their component parts and external context. A hierarchical perspective is adopted to place the system within a context of relevant scales.

The nested structure below provides a context for the Hamilton waterfront system with respect to both spatial scales (from global to local) and temporal scales (from prehistoric to present time). At each scale a methodical analysis is conducted within a framework of abiotic, biotic, cultural, industrial and energetic organizing principles. This analysis helps frame the scope of the thesis and increases the chance of accounting for potential and essential relationships.

2.13. Nested Hierarchical Framework:
Demonstrates the range of scales investigated in this analysis. These represent a context relevant to the study of the Hamilton waterfront within the scope of this thesis.



1. ABIOTIC:
- Air Flow – wind patterns, density of built and natural forms, pollution
- Water Flow – surficial flow, drainage, retention, harbour edge, pollution
- Geomorphology – historical evolution, topography, surficial layers, erosion

2. BIOTIC:
- Plant Life – diversity, health
- Wildlife – diversity, biomass, viable habitats, connectivity
- Population – density, demographics, diversity

3. CULTURAL:
- History – cultural development
- Land Use – residential, recreational, commercial, institutional, industrial
- Privatization – access to public, public use, neighbourhood connectivity
- Transportation – vehicular, rail, marine, pedestrian, connectivity

4. INDUSTRIAL:
- Land Use – function, productivity, toxicity, building density, boundaries and edge conditions
- Transportation – vehicular, rail, shipping, public connectivity
- Economics – manufacturing capacity, productivity, sales, efficiency
- Facilities – function, contents, toxicity, efficiency
- Industrial Ecology – diversity of industrial use, cycling of materials and energy

5. ENERGETICS:
- Nutrient Flows – overall energy balance, food web, trophic structure, nutrient cycles
- Energy Flows – public electricity use, industrial energy use, transportation energy use
- Waste Flows – municipal waste, raw material waste, pollution, by-products, recycling, reuse

Following the development of the conceptual model, the description of the system's existing conditions informs the development of scenarios for the Hamilton waterfront. In these narratives, cultural values are reconciled with the feasibility of ecological, cultural and industrial systems. Suggestions for the methodology of future governance, management and monitoring of Hamilton's systems are provided for implementation. Further application of the ecosystems approach would include the formation of an 'issues framework', intended to integrate diverse interests and priorities within public and private groups. Together with the conceptual model this framework fosters a methodology for management and decision making.

The objective is to develop strategic urban initiatives for the Hamilton Harbour waterfront that address historical pollution issues, existing industrial burdens on natural systems, issues of human re-inhabitation, and integration with natural systems without compromising the economics of a productive society.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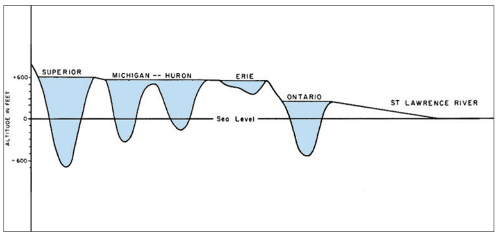

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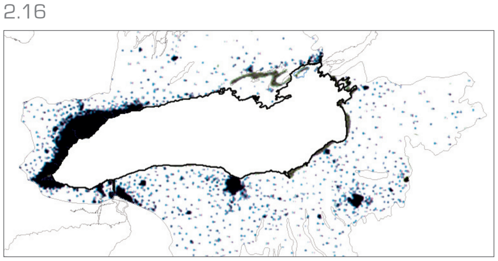

2.17

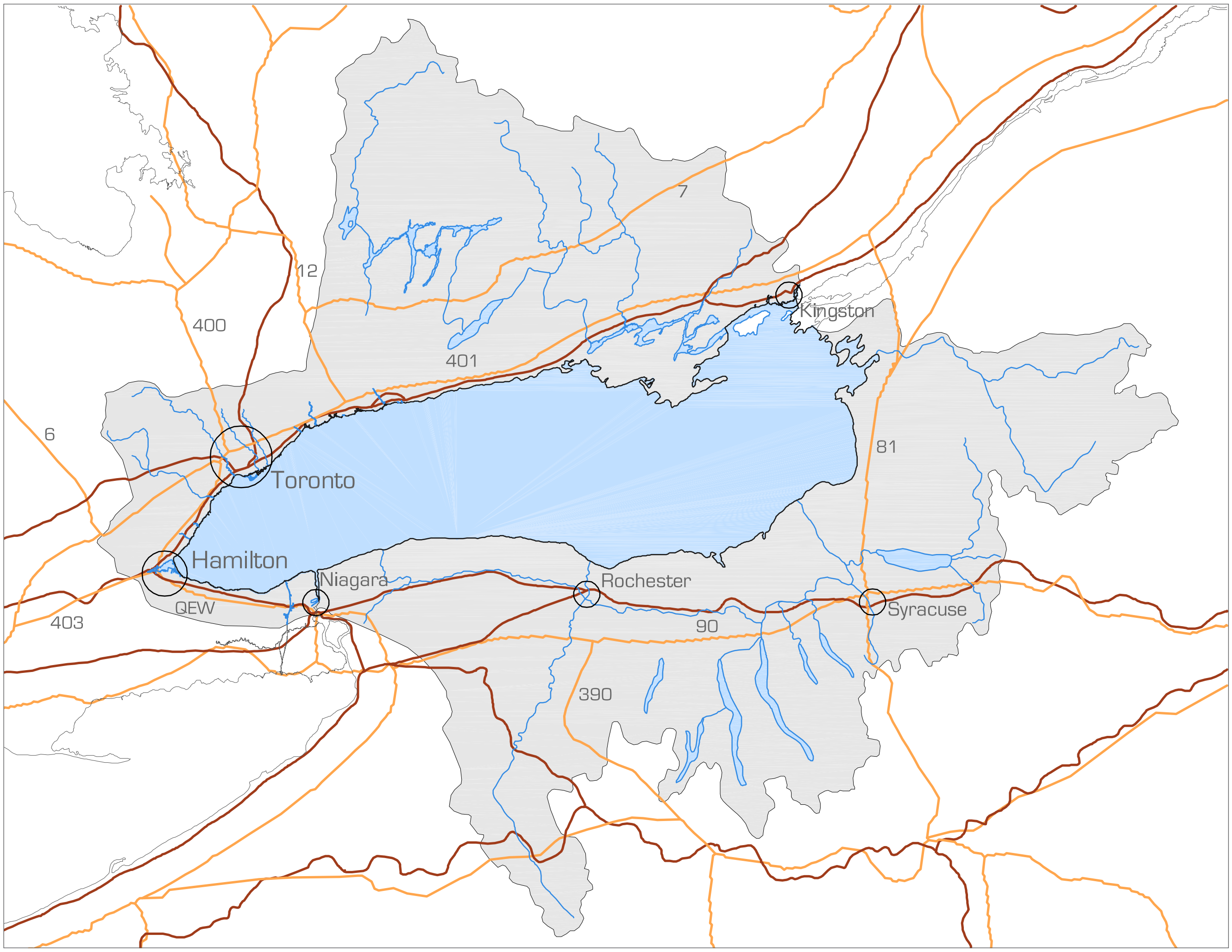
2.14. Lake Ontario Drainage Basin Location within the Great Lakes System
2.15. St. Lawrence Seaway System Longitudinal Section
2.16. Lake Ontario Drainage Basin
2.17. Lake Ontario Basin: Population Distribution

LAKE ONTARIO DRAINAGE BASIN (WIDER ENVIRONMENT)

Lake Ontario is the last in the chain of Great Lakes that partially define the Canadian - U.S. Border. Although it measures the smallest in surface area it is a great deal deeper than its upstream neighbour Lake Erie[14], and consequently provides greater climate moderation. The majority of development exists on the Canadian side of the basin with rural development along the perimeter and several major urban industrial centres, such as Hamilton and Toronto, along the western shore. The U.S. side is less urbanized and not intensively farmed.[15] As the last of the Great Lakes along the St. Lawrence Seaway, Lake Ontario carries an extensive flow of shipping traffic and is susceptible to pollution from all organic and inorganic flows initiated upstream.

With respect to the natural, cultural and industrial system dynamics of Hamilton Harbour, the Lake Ontario Basin represents the largest relevant scale of study. It is within the limits of this region that movements of wildlife, weather systems and market demands will significantly impact the Hamilton waterfront. Reciprocally, outputs of the Harbour's manufacturing sector could potentially register quantifiable negative and positive impacts at this scale, with respect to the flow of goods, materials, pollution and by-products. In fact approximately two thirds of the steel used in Canada is consumed within a 320 km range and approximately half of Canadian automotive steel needs are located within 100 km.[16]

Significant changes have occurred in the Lake Ontario ecosystem over the last century as a result of the effects of toxic pollution and rapid development of the Lake Ontario basin. Destruction of habitat, over-fishing and toxic contaminants, as well as the introduction of exotic species have all exacerbated the problems. Fortunately, progress has been made over the last twenty-five years and some of the species are returning, but the effects of industrialization will have impact far into the future of this region.



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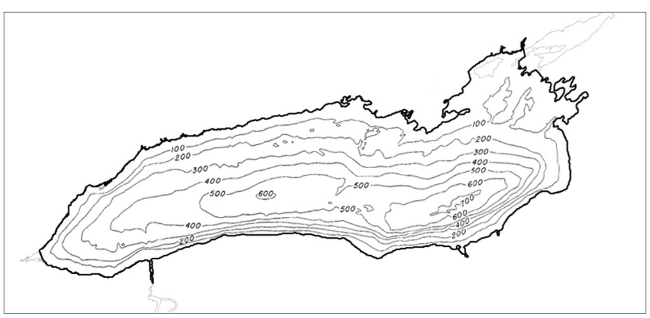
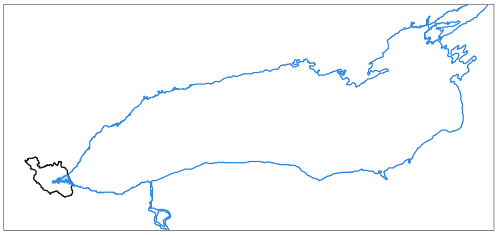


2.19

2.20

2.18. Lake Ontario Basin: Settlement + Transportation
Scale 1:3,000,000: showing population centres, transportation routes + links (orange: expressway - red: rail)
2.19. Lake Ontario: Bottom Topography
2.20. Lake Ontario: Surface Currents



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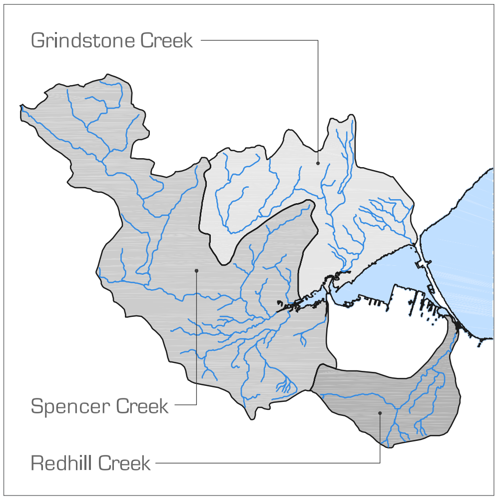

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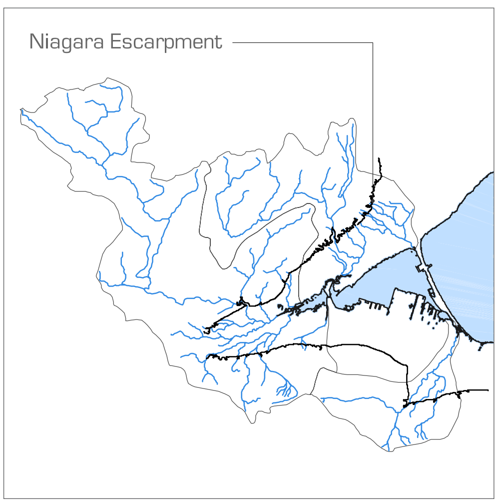

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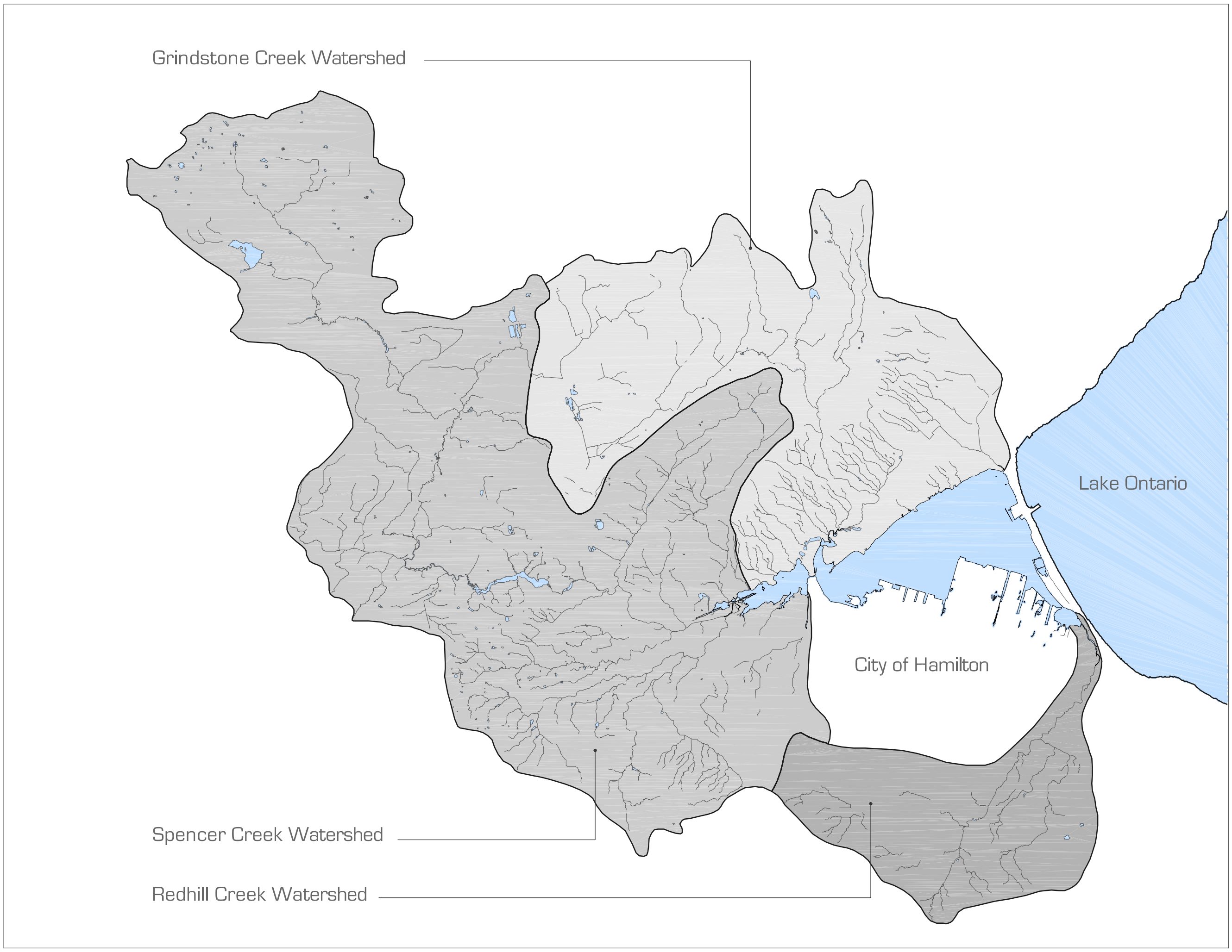
HAMILTON HARBOUR DRAINAGE BASIN (ENVIRONMENT)

Located at the southwest corner of Lake Ontario, the three primary watersheds that constitute Hamilton Harbour's catchment are the Spencer Creek and Redhill Creek Watersheds (under the Hamilton Conservation Authority) and the Grindstone Creek Watershed (under Conservation Halton).[17] Included within this boundary are the major municipalities of Hamilton and Burlington, as well as Dundas and portions of, Ancaster, Flamborough, Glanbrook and Stoney Creek.

The topography of the area is sharply distinguished by the Niagara Escarpment, which traces the south and west side of the harbour, and establishes a pattern of flow in the basin. The majority of the land has been developed, and serves as a conduit for multiple transportation routes, namely the Q.E.W. and 403 highway systems, several railway lines and many recreation trail systems.

Study of the harbour drainage basin is critical to understanding the habitation and migration patterns of wildlife, as well as to the regional hydrologic cycle, local ecology and microclimate. Crucial flow rates and patterns, at this larger scale, with respect to the movement of water, air, wildlife and people, help define key processes at the scale of Hamilton's waterfront systems.

2.21. Hamilton Harbour Drainage Basin Location: illustrated within Lake Ontario Basin
2.22. Hamilton Harbour Drainage Basin
2.23. Hamilton Harbour Basin: Niagara Escarpment



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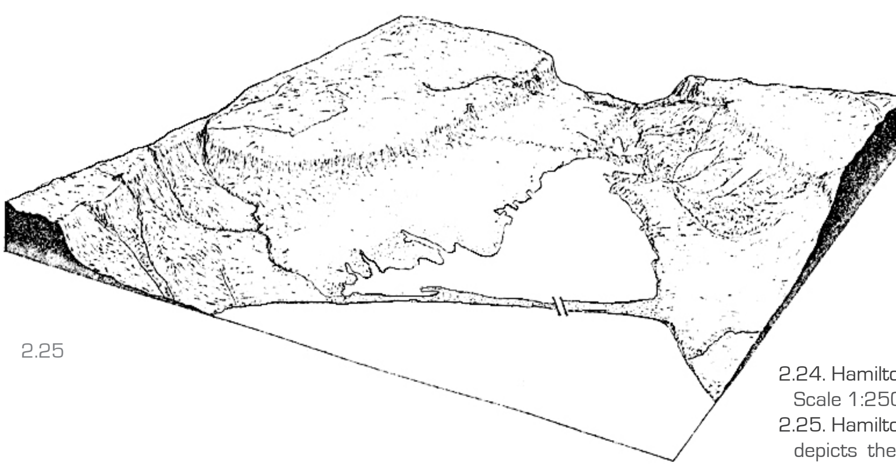
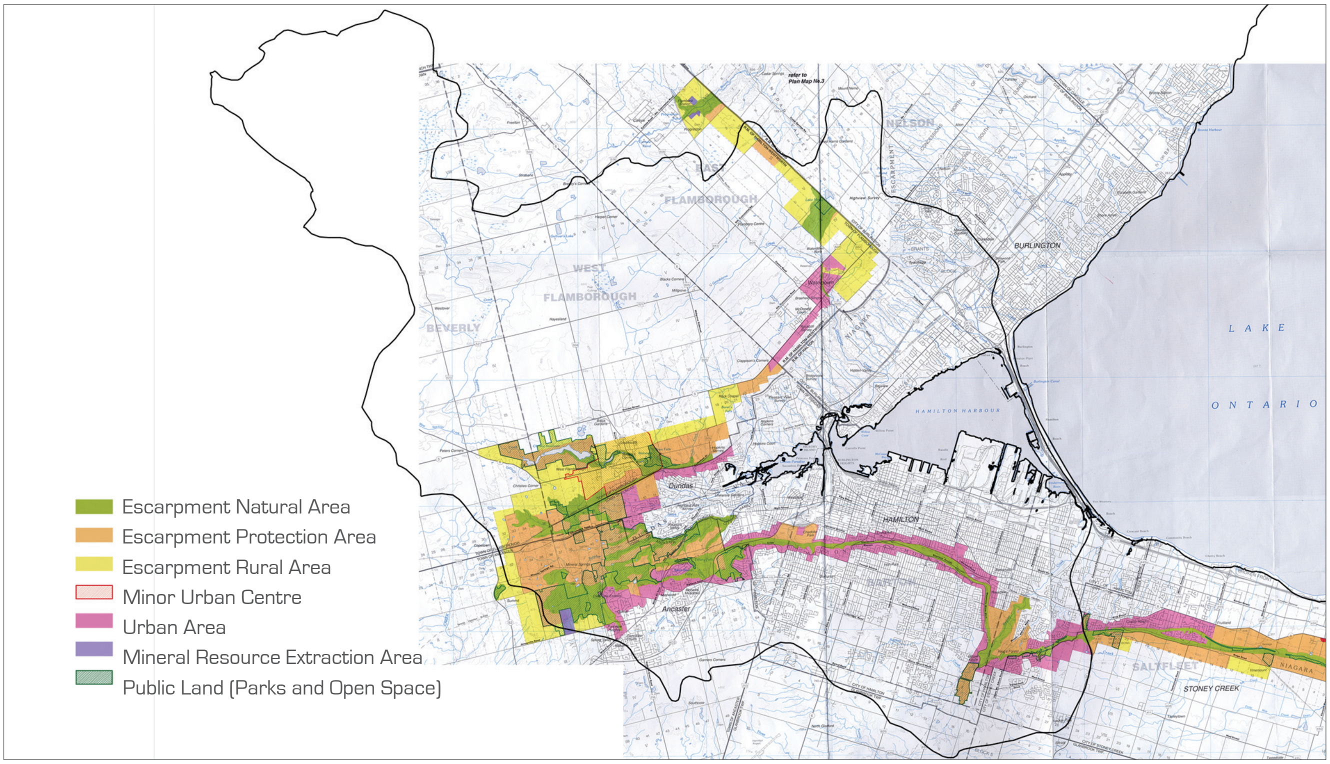


2.25

2.24. Hamilton Harbour Basin: Watersheds
Scale 1:250,000: locates all major streams and creaks
2.25. Hamilton Harbour Basin: Topography
depicts the pronounced concentric enclosures of the escarpment and the harbour



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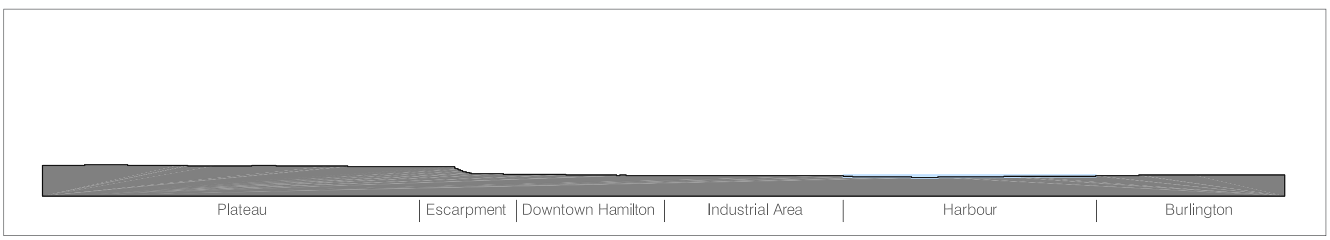

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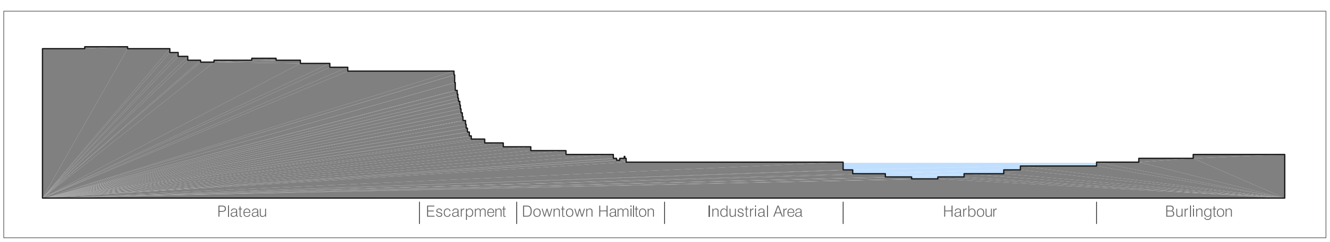

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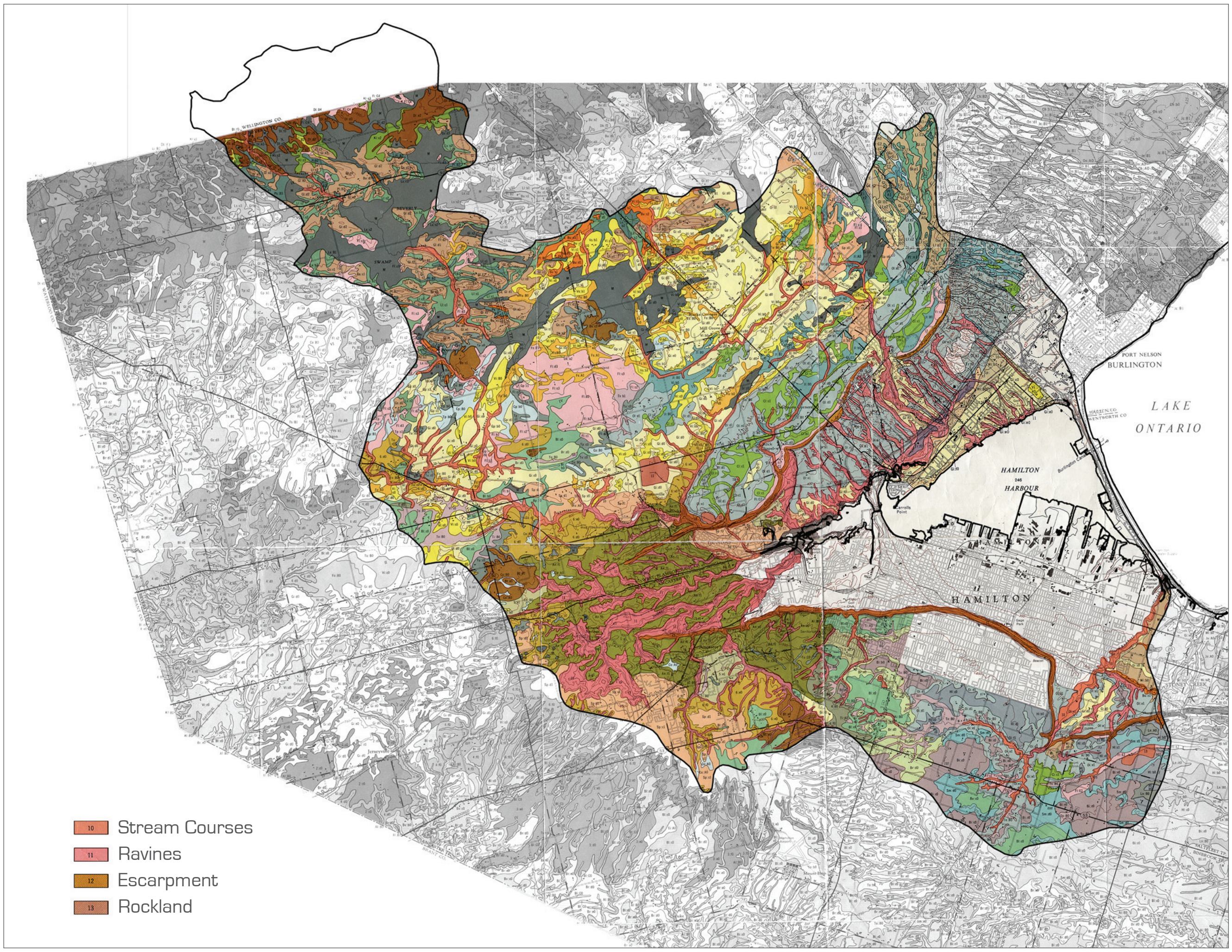
2.26. Hamilton Harbour Basin: Escarpment Land Use
Scale 1:300,000: demonstrates near continuous natural corrior despite urban and industrial pressures
2.27. Hamilton Harbour Basin: Section
Scale 1:100,000
2.28. Hamilton Harbour Basin: Section Amplification
Horizontal 1:100,000 - Vertical 1:10,000



SOIL TYPE	PARENT MATERIALS	SOIL MOISTURE	SOIL TYPE	PARENT MATERIALS	SOIL MOISTURE
silt loam	silt loam over clay	variable	sandy loam	water deposited medium + fine sand	well drained
silt loam	silty clay loam till	well drained	silty clay loam	clay till	imperfectly drained
silt loam	lacustrine silty clay loam + silty clay	imperfectly drained			very poorly drained
silt loam	silt loam over clay till	imperfectly drained	loam	clay loam till	well drained
silt loam	water deposited silt loam + fine sandy loam	well drained	silt loam	silt loam over clay till	moderately well drained
silt loam	lacustrine silty clay loam + silty clay	well drained	sandy loam	sand over outwash gravel	well drained
loam	less than 12" loam till over bedrock	well drained	silty clay loam	Lacustrine silty clay loam	poorly drained
loam	loam till	well drained	sandy loam	water deposited medium + fine sand	imperfectly drained

2.29. Hamilton Harbour Basin: Soil and Drainage
Scale 1:250,000: depicts good drainage through valleys and ravines

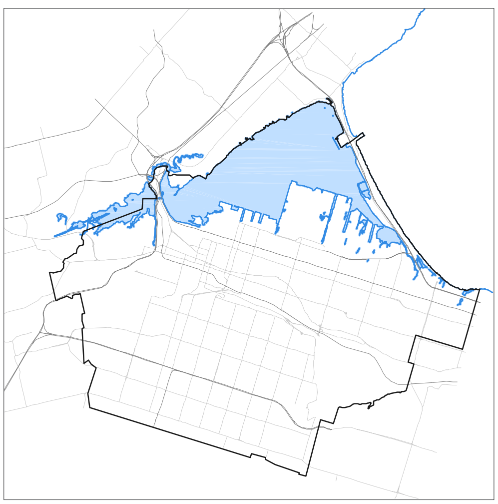
HAMILTON MUNICIPALITY (WIDER SYSTEM)

Situated between the base of the Niagara Escarpment and the south shore of the harbour, the City of Hamilton has attracted a wide range of human activity inclusive of recreation, habitation, industry, shipping and water supply uses. The land around the harbour is presently heavily urbanized up to and beyond the Niagara Escarpment.

The downtown core is sited below the southwest corner of the harbour, between the initial port activities and the wilderness area of Cootes Paradise. As economic activity began to take over the harbour, residential and cultural activities were pushed further south and established a division between industrial and residential neighbourhoods that presently exist at Barton Street. Despite this perceptible divide, public access and several residential pockets extend as far as Burlington Street where industry and shipping form a consistent barrier along approximately half of the shoreline.

Industries, specifically steel and iron, provide the main economic generator for the region as well as direct employment for approximately 16,000 of the roughly 500,000 population.[18] In turn the associated deep-water port provides direct and indirect employment for roughly 30% of the population.[19] Hamilton Harbour, the largest port (by tonnage) of the St. Lawrence Seaway, acts as a shipping hub for the largest centre of steel manufacturing in Canada.[20]

The harbour's assets that could potentially sustain cultural, industrial and ecological systems concurrently have been largely monopolized by industrial and economic uses. The non-renewable or fragile nature of these resources however, necessitates a careful management and prioritization of use. This process has begun with the Remedial Action Plan (RAP), alongside other similar actions, created to re-naturalize Cootes Paradise, and reclaim 27% of waterfront land for public access.



2.30

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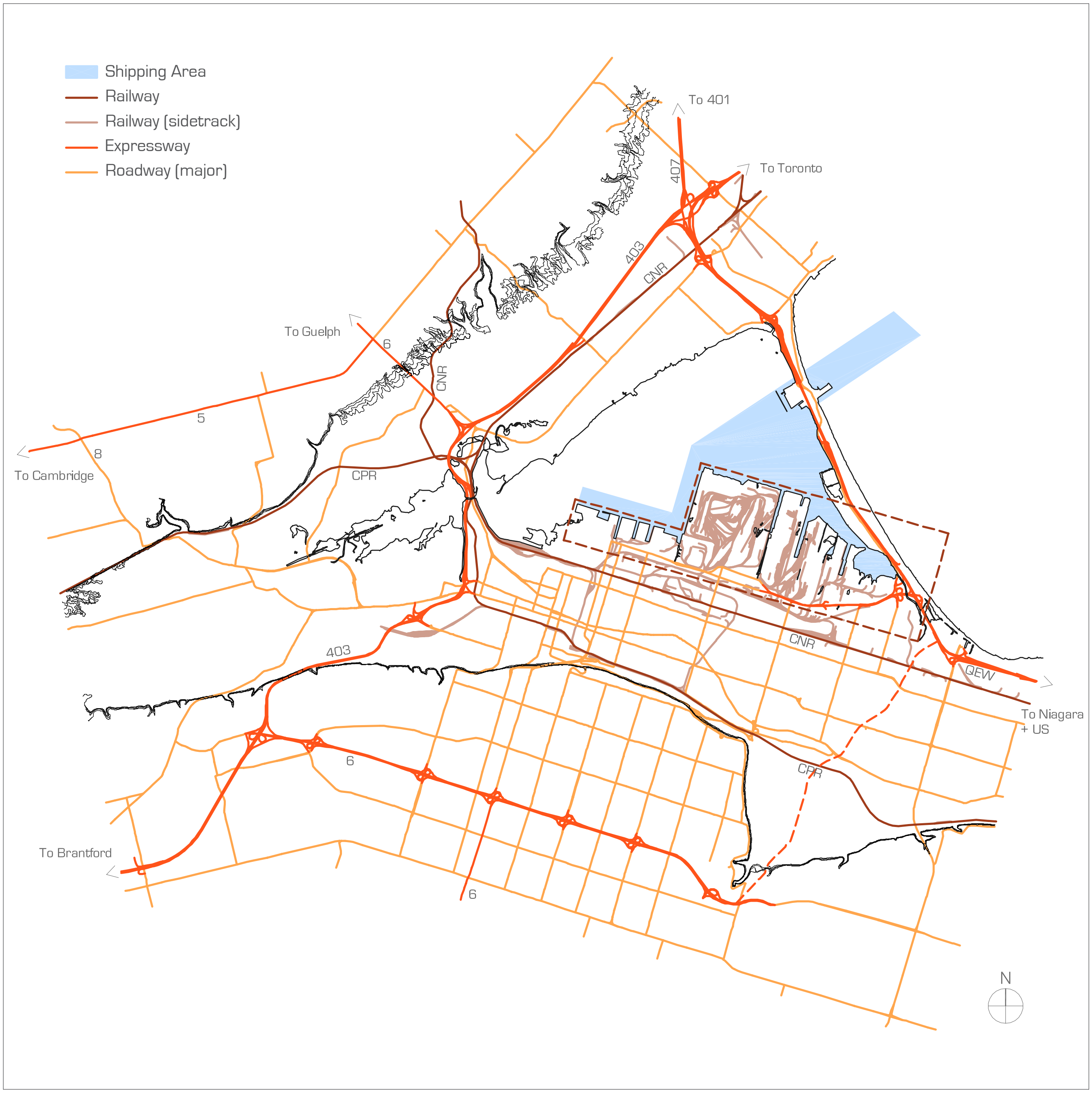
2.30. Hamilton Municipality
2.31. Hamilton City Overview
taken from Niagara Escarpment, shows industrial waterfront in background

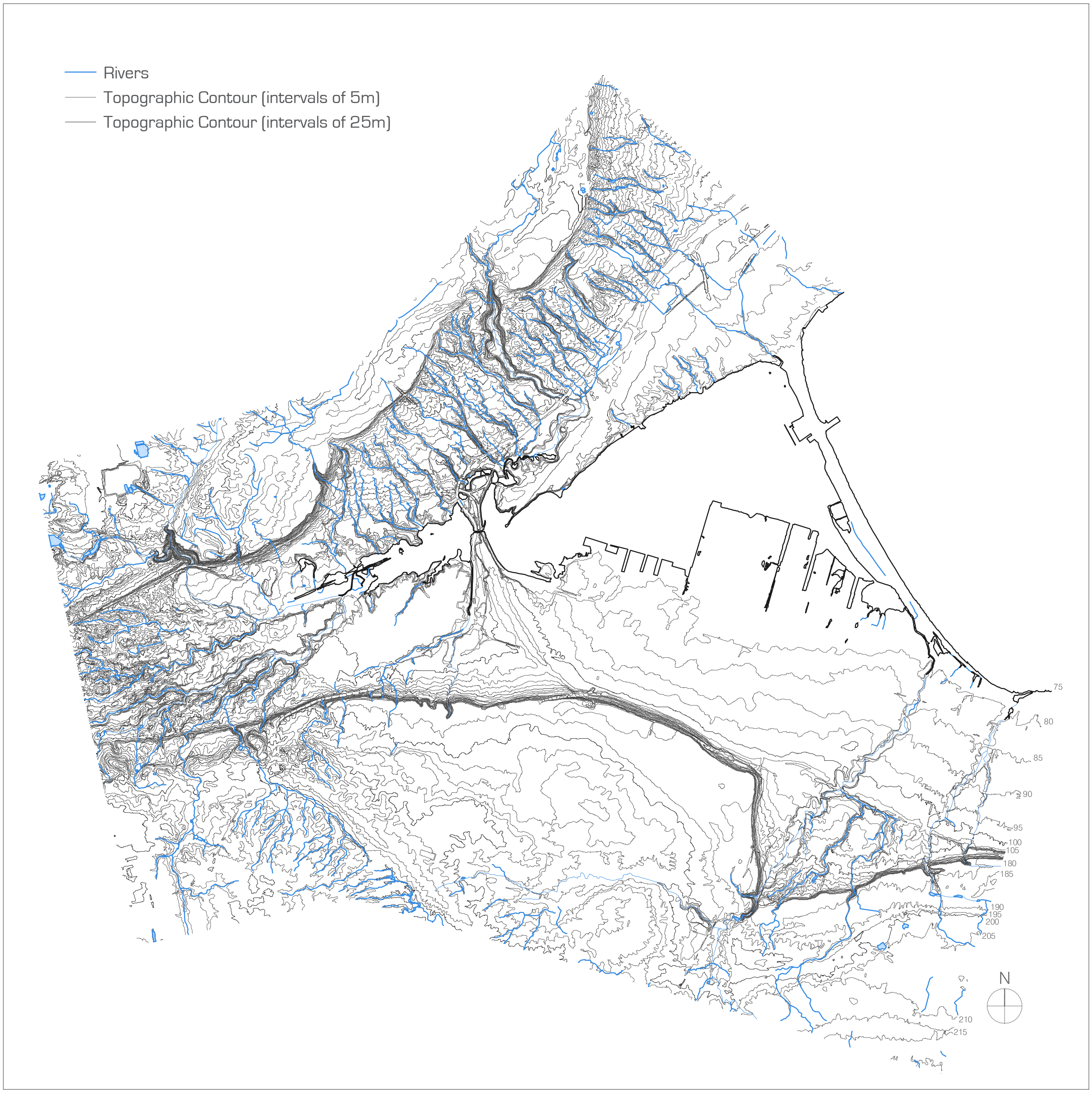
2.32. Hamilton Municipality: Land Use
Scale 1:140,000

2.33. Hamilton Municipality: Built Area
Scale 1:140,000

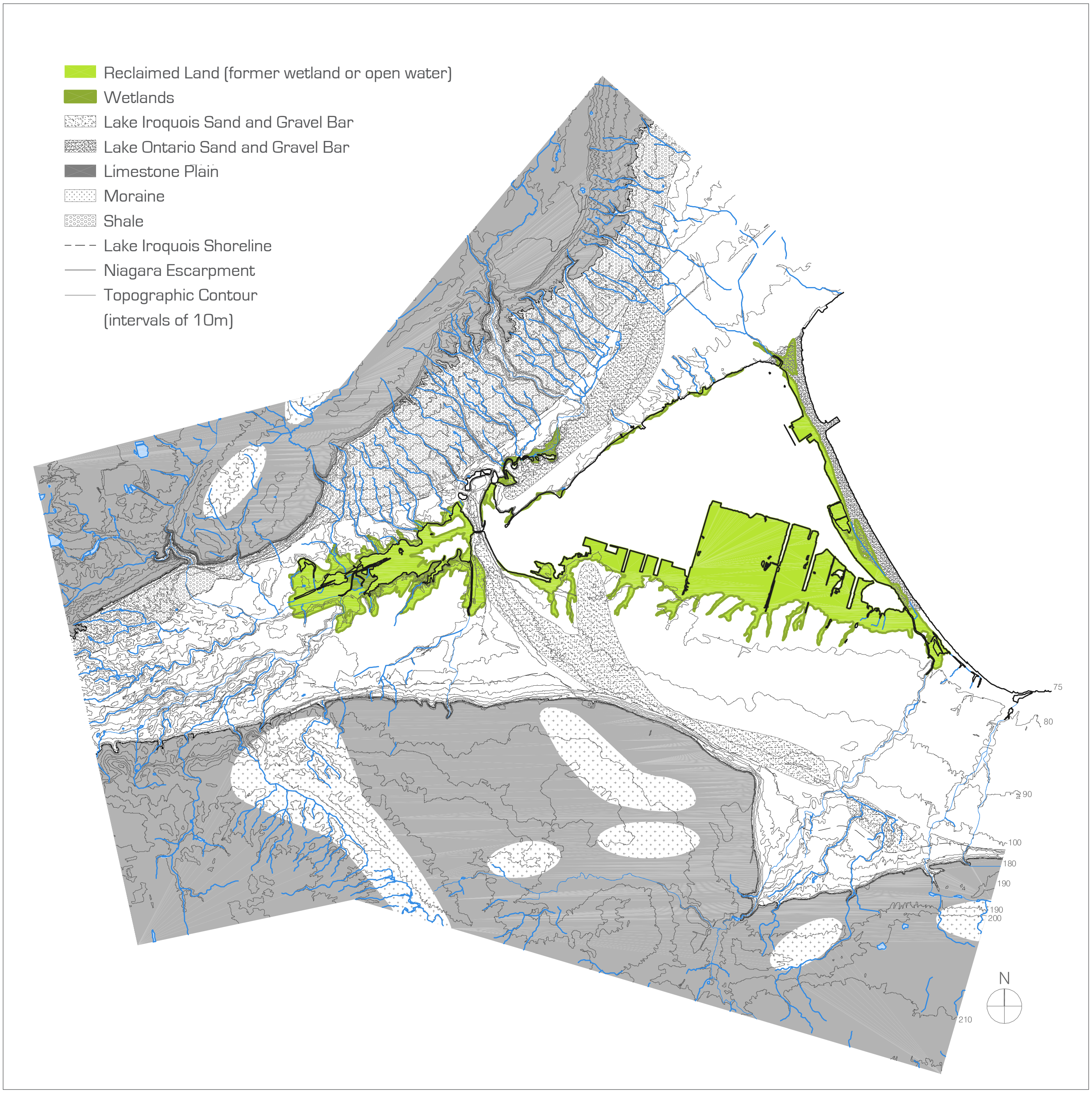


2.34. Hamilton Municipality: Transportation Systems
Scale 1:140,000

2.35. Hamilton Municipality: Green Areas
Scale 1:140,000

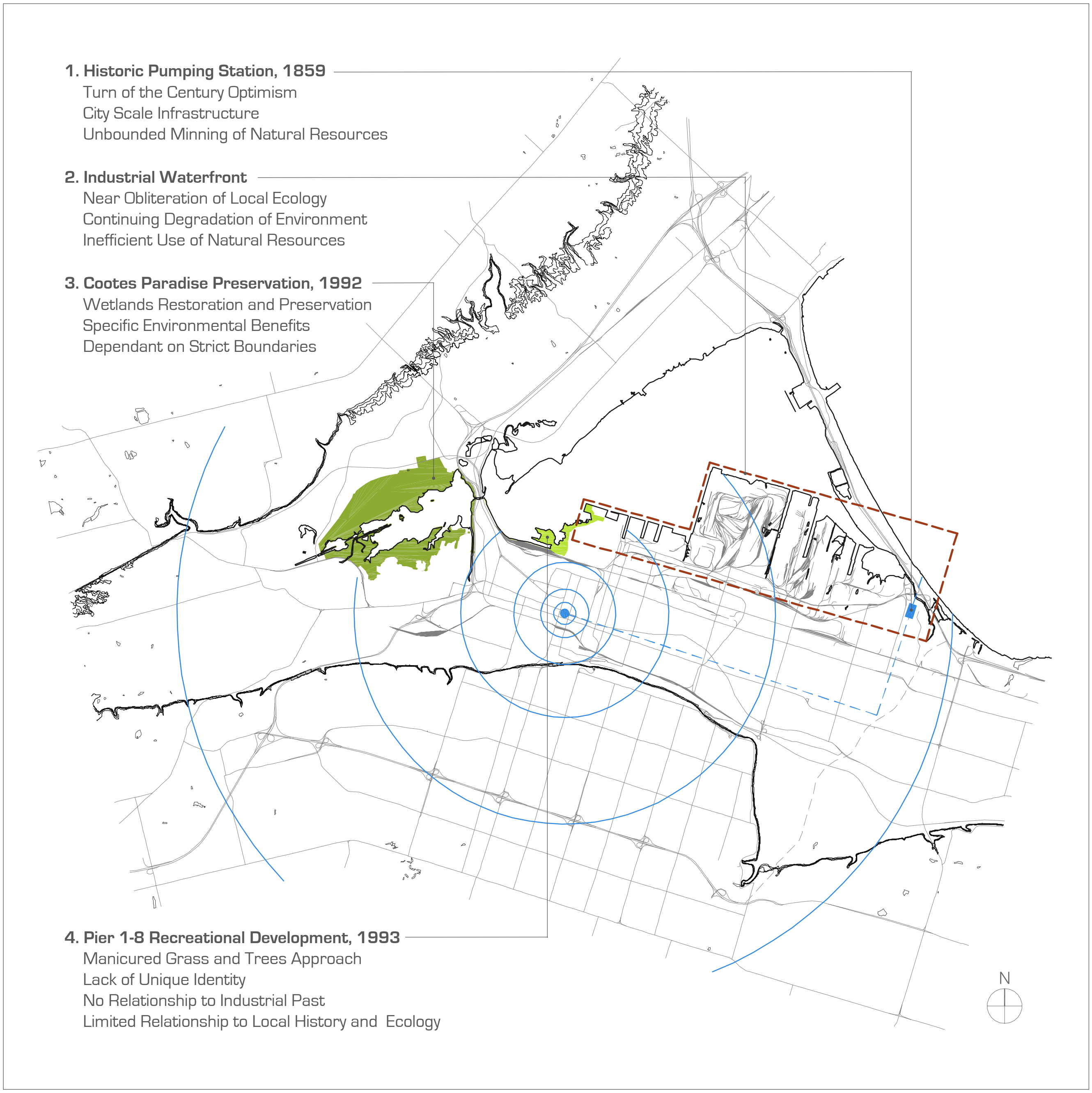


2.36. Hamilton Municipality: Topography
Scale 1:140,000



2.37. Hamilton Municipality: Physiography + Geology
Scale 1:140,000

Demonstrates the formation of the Cootes enclosure by the Lake Iroquois sand bar through glacial wave action, and the later formation of Hamilton Harbour by the Lake Ontario Sand Bar through wave action on Lake Ontario.



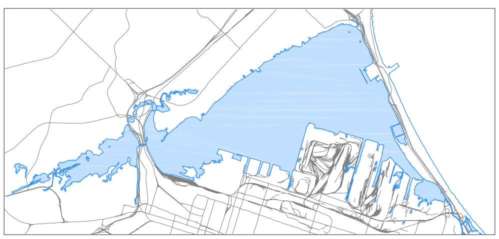
2.38. Hamilton Municipality: Natural Intervention Analysis
Scale 1:140,000

Demonstrates four distinct and limited approaches to ecological intervention. Suggests a need for new methodolgies and new relationships to natural systems.

HAMILTON WATERFRONT (SYSTEM)

Upon first settlement the Hamilton waterfront was recognized as a prolific wetland, a significant repository of what we now call 'biodiversity'. Extensive filling and dredging processes over the years have resulted in a 75% reduction in wetlands, and a 25% reduction in harbour area[21], in favour of industrial port lands. Although originally a shared resource, the waterfront has been almost completely dominated by industrial development, demonstrating its pivotal role in the regional growth and economic structure of Hamilton.

The most intensive development has occurred along the south and east shores of the harbour. The existing shoreline use is presently 49% industrial, shipping and transportation activities, 27% public open space and 24% residential, institutional and private open space.[22] The harbour, waterfront and many of the smaller piers fall under the jurisdiction of the Hamilton Port Authority and accommodate several small firms including shipping, storage, processing, and waste treatment facilities.



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The majority of Hamilton's industrial firms are directly or indirectly related to steel and iron manufacturing in the form of steel makers, steel processors, and service centres. Most notably Stelco Hamilton and Dofasco Hamilton, the two largest steel makers in Canada, dominate almost 2,000 acres of waterfront land. Of these two companies, Dofasco is by far the more progressive, as evidenced by their economic standing within Canada. Stelco on the other hand, has failed to adapt to new technologies, environmental standards, new management practices and global economies, and is in danger of declaring bankruptcy. South of Burlington Street and north of Barton Street, an industrial culture exists where many smaller firms are found among public streets and residential pockets. Primarily these firms serve as steel service centres, providing processing and storage facilities. Among them however, the steel maker Slater Steel, presently operates under bankruptcy protection.

2.39. Hamilton Waterfront
2.40. Stelco Hamilton Blast Furnace
2.41. Dofasco Hamilton Operations

While far from being a completely sustainable industry, steel and iron manufacturing systems have begun to address certain environmental issues. The development of the electric arc furnace, and subsequently mini mills, is increasing the potential for recycling. In theory this technology could eliminate the need for raw materials such as iron and coal, as well as the associated toxic coking processes. Air emissions have already been reduced and some waste streams are being redirected to other industries and manufacturing processes. Despite these industry wide advancements, much of Hamilton's steel industry continues to operate with old technology and continues to degrade natural resources. Steel practices in Hamilton face serious challenges, including the updating of facilities and equipment, remediation of toxic lands and the reassessment of land and harbour use.

An in depth Complex Systems analysis of the Hamilton Waterfront System follows, framed within abiotic, biotic, cultural, industrial and energetic organizing principles. For equivalent analyses of the previous larger scales of study refer to Appendices A1 through A3.


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2.42. Hamilton Habour Waterfront Trail
2.43. Cootes Paradise Preservation Area
2.44. Pier 14: Industry, Dry Dock, General and Dry Bulk Cargo Terminal
2.45. Pier 10: Industry Dry and Liquid Bulk Cargo Terminal
2.46. Pier 25: Marine Industry, Dry and Liquid Bulk Cargo Terminal

2.47. Hamilton Waterfront: ABCE Analysis
abiotic, biotic, cultural, energetics complex systems analysis of system

SYSTEM PERSPECTIVE INFLUENCES

ORGANIZING PRINCIPLE: NATURAL - ABIOTIC

AIR FLOWS

MICRO CLIMATE:
- Local Wind: off shore winds; patterns of flow around buildings and infrastructure

AIR POLLUTION:
- Point Sources: over 20 major smoke stacks on industrial lands
- Non-point Sources: automobiles, buildings

WATER FLOWS

INFLOWS:
- 27 billion gallons of waste discharged from industrial and municipal outfalls per year (40 % of harbour volume) some are treated and others diluted [23]

WATER POLLUTION:
- Point Sources: industrial and municipal outfalls
- Industrial Sources: 7 points including Stelco and Dofasco [24]
- Municipal Sources: 4 waste water treatment plants (combined sewer and storm water); Woodward Avenue discharges into Red Hill Creek, Dundas discharges into Cootes Paradise, Waterdown discharges into Grindstone Creek and Skyway (Burlington) discharges into the northeast end of harbour [25]
- Toxic Hotspots: contaminated sediments along harbour bottom; particularly high concentration at Randle Reef, Windemere Basin and Ottawa Street Slip [26]
- Non-point Sources: urban and industrial run off, combined sewer overflows

CONTAMINANTS:
- Red Hill and Spencer Creeks Pollutants: chemicals such as pesticides and fertilizer from suburban and agricultural uses, and bacterial contaminants [27]
- Treatment Plant Pollutants: phosphorous, ammonia (both spur growth of algae, increase murkiness of water and use up oxygen for fish)
- Other: elevated levels of phosphorous, ammonia, heavy metals and PAHs [28]

GEOMORPHOLOGY

MANIPULATION:
- Desjardins Canal: to link Dundas to harbour and Lake Ontario (1823-1830) [29]
- Burlington Ship Canal: to provide ship access between harbour and Lake Ontario in 1823 (1926 -1969 doubled in size to current dimensions: 88 m wide by 10 m deep) [30]
- Infilling: for port activities decreased harbour waters 25% (1926-1982) [31]
- Reduction in Wetlands: 75% (1900-1982) [32]

REGENERATION:
- Marsh Habitat: increased by 3.4 km^2 (1990 - 2001) [33]

SURFACE:
- Almost continuous development is characterized by impermeable surfaces; creates storm water run-off problems (critical on toxic industrial sites)
- Wetlands, such as Cootes Paradise, help to moderate storm water flow

ORGANIZING PRINCIPLE: NATURAL - BIOTIC

PLANT LIFE

ORIGINAL CONDITION:
- 1800: Highly productive, shallow, emergent marsh ecosystem; as late as 1949, wild celery and wild rice was abundant, as well as aquatic plants found today [34]
- Harbour Shore: a complex system of lagoons and sand beaches; Brant’s Pond existed as a large wetland [35]

DEGRADATION:

- Cootes Paradise wetland lost 85% of its emergent vegetation (bulrush, cattail) between 1934 and 1985; the abundance and species composition of submerged vegetation declined from 24 species in 1949 to 10 in 1970; factors include degraded water, stabilization of Ontario Lake water levels through the construction of the St. Lawrence Seaway and sediment resuspension. [36]
- Harbour Shore: 1900 to 1975, the complex ecosystem of plants and animals in the harbour was driven to near extinction by the loss of wetlands along the south and east shores, sewer overflows, sewage treatment plant discharge, effluent from industries, contaminated sediment and landfilling for urban development. [37]
- Waterfront Trail: The vegetation communities consist of early to late successional habitats typical of areas disturbed by heavy human use (railways).

REGENERATION:

- 1975 to Present: Concerns for pollution lead to the designation of Hamilton Harbour as one of 43 Areas of Concern in the Great Lakes; the Remedial Action Plan was prepared by 46 community stake-holders and approved in 1992. [38]
- Cootes: Actions taken over the past ten years have resulted in significant improvements in water quality. External sources of contaminants have now been controlled to a level where restoration of habitat features can be considered.

EXISTING CONDITION:

- The present vegetation community is characterized by a low diversity of hardy emergents, largely restricted to the shoreline and dominated by undesirable exotic species (fowl-manna grass and purple loosestrife). [39]
- Cootes: 1997 fishway and carp barrier was operational, changing submerged plant growth throughout the marsh. Along the shoreline and in some open water sections, mats of submerged plants cover the bottom. Several varieties of pondweed, waterweed, non-native Eurasian water milfoil and horned pondweed, (a rare species in Ontario), are found growing in the marsh. Wild celery, not present for over 50 years, can be found growing in open water at the east end of the marsh. An area in Hopkins Bay, formerly open water, is now vegetated with cattails (build-up of sediment around the cattails is a sign of marsh functioning). [40]
- Lasalle Park: The shoreline is naturalizing following three years of vigorous growth by the trees and shrubs planted as part of the restoration project. [41]
- Northeastern Shoreline: The aquatic plant community has changed from sparse to vegetated cover because of the reduction in wave action due to constructed islands; a natural trail runs along the shoreline and ends at a viewing platform. [42]

WILDLIFE

ORIGINAL CONDITION:

- 1800: The area was home to waterfowl, loons, nighthawks, gannets, eagles and plovers; countless warm-water fish (bass, pike, yellow perch, sunfish, muskellunge) and important cold water species (herring, trout and whitefish) occupied the bay; wild mammal included otter, beaver, mink and muskrat. [43]
- Cootes Paradise: 1800 to 1930 supported diverse fish and wildlife habitat providing spawning, nursery and adult habitats for a warm water fish community; otter, beaver, fisher, minks, muskrats and snakes were abundant. [44]

DEGRADATION:

- Harbour Shore: The environmental quality of the area deteriorated with a rise in air, water and noise pollution. Land-filling to create the Queen Elizabeth Way and Eastport Drive replaced the natural shoreline with an armourstone edge effectively destroying fish and wildlife habitat. [45]
- Warm-water species, tolerant of degraded conditions, now dominate the fish community. The low percent composition of piscivores and specialists and the high percent of generalist species are reflective of the eutrophic conditions in the nearshore zone. [46]

- Cootes: The degradation of the marsh ecosystem resulted in alteration in fish community structure once dominated by native piscivores to the present community, dominated by tolerant omnivorous species, several of which are exotics. Carp and alewife are the dominant species of this altered fish community. [47]

REGENERATION:

- The Hamilton Harbour Remedial Action Plan (RAP) assumes that habitat restoration in Hamilton Harbour will not occur naturally. A key component of the strategy is to reduce carp populations through transformation of the fish community to one dominated by native predators, such as pike and bass. This transformation could be accomplished through predator stocking and the creation of suitable habitat. [48]
- Cootes: Waterfowl numbers rose dramatically due to the increased distribution and abundance of aquatic plants and the birds stayed longer in the marsh before their migratory flight. [49]
- Waterfront to Pier 4: In 1993, about 2 km. of fish habitat was constructed at Bayfront Park. Over 50 different shoreline configurations were added to the harbour edge, three coastal wetlands were created, two beaches and the City of Hamilton constructed underwater reefs and spawning beds. Underwater habitat modules were placed offshore for fish, Monitoring show significant improvement in aquatic vegetation and a fourfold increase in fish at the site compared to other adjacent areas of the harbour. [50]
- La Salle Park: activities to reduce pollution from industry and municipal waste water treatment plants improved the water quality of the harbour. [51]
- Lasalle Park: Restoration of the beach area involved the removal of tonnes of rock fill that had been added over the years. In its place is a sandy pebble beach where frogs, turtles and salamanders travel between the water and the natural wetland located at the base of the forested bluff. [52]

EXISTING CONDITION:

- Lasalle Park: Fish habitat improvements have resulted in up to 18 different species using the near shore as compared to only 6 to 8 species prior to the restoration project. Turtles and migratory ducks can be seen in large numbers. Trumpeter swans using the area have been monitored since 1993. [53]
- Cootes: Wildlife diversity and density is currently only a small percentage of pre-1930s levels, but represents one of the few remaining shallow wetland areas in the highly urbanized region. [54]
- Cootes: breeding bird densities within the marsh are low, localized areas of remnant marsh, vegetated shoreline, and adjacent upland areas support small populations of waterfowl and water birds, including a number of regionally rare species; concentrations of turtles and frogs are found in the shallow emergent vegetation, and sixteen large mammal species have been recorded within the Cootes Paradise wildlife sanctuary. [55]

ORGANIZING PRINCIPLE: CULTURE

LAND USE:

- Industrial: 46% of 45 km long shoreline is industrial and shipping use, 3% for transportation [56]
- Culture: 10% for residential, 10% for institutional (cemeteries, public buildings), 4% for private open space (private marinas, golf courses) [57]
- Cultural and Natural: 27% for public open space (public marinas, parkland, wildlife habitat) [58]

RECREATION:

- Shoreline Access: increased from 7% to 27% (1990-2001); target is 35% [59]
- Boating is available on the harbour, or through facilities: La Salle Park Marina, Royal Hamilton Yacht Club, Leander Boat Club, MacDonald Marine, Harbour West Marina and Macassa Bay Yacht Club [60]

- Estimated that sailing, canoeing, kayaking and motor boating involve between 175,000 and 350,000 Hamilton residents per year [61]

TRANSPORTATION:
- Roads: general circulation problems are created from an over reliance on one-way traffic flow. Several north-south arterial roads (Bay, James and John Streets) connect the downtown to the Waterfront Trail and Pier 4 development. All other north-south arterial routes terminate at Barton St. demonstrating a lack of waterfront connectivity. East-west connection along the waterfront is provided by Burlington Street, however this is dominated by industrial traffic and accommodates little public programme.
- Trails: although trails are well reasonably well connected in the region harbour front access is highly limited; the construction of the Waterfront Trail has increased access in the southwest corner; the remainder of the south shore is almost completely restricted; northwest shore access remains intermittent; the northeast shore has limited access

HISTORICAL SIGNIFICANCE:
- The resource of the harbour was crucial to the initial settlement in terms of recreation, natural harvesting and water supply

ORGANIZING PRINCIPLE: INDUSTRY

EMPLOYMENT:
- Manufacturing: accounts for 56% (including steel + iron industries) [62]
- Steelmaking and Processing: approx. 16,000 people directly employed [63]

ECONOMY:
- Steelmakers: 3 in Hamilton are Stelco Inc, Dofasco Inc and Slater Steels' Hamilton Specialty Bar Division (within 50km are also Atlas Specialty Steels and Stelco's Lake Erie Steel Company) [64]
- Steel Processors: 4 in Hamilton (Laurel Steel, Cold Metal Products, Union Drawn Steel II and Canadian Drawn Steel) [65]
- Service Centres: process and store approx. 30% of Canadian produced steel for the mills and the mill's customers (shear, slit, flatten, level, temper, torch cut, pickle and oil, and store); serve as distribution centres [66]

LOCAL RESOURCES:
- Utilities and infrastructure: cost competitive water and sewer rates, available and affordable electricity and natural gas rates [67]
- Extensive telecommunications capabilities [68]
- Distances: 1 hr from Toronto; 1 hr from Buffalo, NY

PRODUCTION

STELCO, HAMILTON:
- Hamilton Area: 1,110 acres [69]
- Coke Facilities: 2 blast furnace (1 offline), 83 ovens [70]
- Steelmaking Facilities: 3 basic oxygen furnaces [71]
- Production: 2.7 million tonnes (2002) [72]
- Products: plate, hot rolled sheet, cold rolled sheet, galvanized sheet, painted sheet, wire rods, carbon and alloy merchant bars and reinforcing bars [73]
- Applications: automotive, appliances, drums and pails, siding, roofing, metal studs, office furniture, pipe and tubing, steel storage tanks, railroad cars, ship building, concrete construction [74]
- Employment: 5000 people (in Hamilton) [75]

DOFASCO, HAMILTON:
- Hamilton Area: 7,30 acres [76]
- Coke Facilities: 3 blast furnaces, 211 ovens [77]
- Steelmaking Facilities: 1 basic oxygen furnace, 1 electric arc furnace [78]
- Production: 4.8 million tonnes (2002) [79]
- Products: hot rolled sheet, cold rolled, sheet, vitreous enameling sheet, galvanized and Galvalume sheet, tinplate, tin free steel (chromium coated) and painted sheet. [80]

- Applications: includes automotive, appliances, food and beverage cans, drums and pails, siding, roofing, metal studs, office furniture, pipe and tubing. [81]
- Dofasco is the first integrated producer in North America to have an electric arc furnace feeding its hot mill. [82]
- Employment: 7400 people (in Hamilton) [83]

SLATER STEEL:

- Steelmaking Facilities: 1 electric arc furnace, 1 ladle furnace [84]
- Production: 500,000 tonnes [85]
- Products: wide range of bar products and special shapes including special bar-quality steels, steel rounds and flats, and forged steel grinding balls [86]
- Applications: includes automotive, forging, cold finish [87]

TRANSPORTATION

WATERWAY:

- Navigational Season: April to mid December [88]
- Main Channel Depth: 8.8 m; Channel Width: 88 m [89]
- Docking Capacity: 11,000 m of dockwall available (approx. 30+ ships) [90]
- Traffic: docks over 700 ships per year [91]

ROADWAY:

- Road: Barton and Burlington streets, smaller local roads and private roads facilitates the transfer of material and goods to highways

RAILWAY:

- Rail Link: facilitates transactions between Rail Companies and Hamilton industry (notably Stelco, Dofasco, Imperial Oil and Ontario Power Generation) [92]

AIRWAY:

- Hamilton International Airport: cargo hub 20 min south of Hamilton's waterfront [93]

MATERIALS:

- Some Raw Materials Delivered: coal + iron ore (steel production), salt + sand, grains + soybeans, liquid fertilizer and jet fuel [94]
- Sourced in Canada and US [95]

ORGANIZING PRINCIPLE: ENERGETICS

ENERGY FLOWS

INTEGRATED STEEL:

- Integrated Steel Inputs: iron ore, coal (coke), flux (eg. Limestone, dolomite), scrap metal, alloying metals (manganese, aluminum, nickel, etc), water (cooling), oxygen
- Integrated Steel Outputs: by-products such as slag, light oils, amonia, iron oxides, coal tar, carbon dioxide and hot water are created during the coke and iron making processes
- Integrated Steel Reuse: some by-products can be used as raw materials to make aggregates for road pavement + cements, fertilizer, plastics, electronics and roofing compounds

MINI-MILL:

- Electric Arc Furnace Inputs: recycled steel, electricity, water
- Electric Arc Furnace Outputs
- The electric arc furnace has the potential to eliminate the need for many raw materials including coal and iron, as well as eliminate pollution associate with coal, and coke.

MATERIAL FLOWS

WATERWAY (INFLOW):

- Cargo: over 12 million tonnes per year (approx. 80% is iron ore and coal for steel); Stelco and Dofasco are together responsible for 25% of all Cargo on the St. Lawrence Seaway [96]

ROADWAY (OUTFLOW):

- 95% of steel is shipped out by truck [97]

WASTE FLOWS

- Industrial and municipal waste streams have the greatest impact at this scale
- Toxic matter flows via water and wildlife

Pier 1-4	Public Park
Pier 5	Royal Hamilton Yacht Club, Hamilton + District Chamber of Commerce, Leander Boat Club
Pier 6-8	Harbour-West Marina, Hamilton-Halton Police Marine Unit, Marine Discovery Centre
Pier 8	General Cargo, Overseas Terminal
Pier 10	General Cargo, Overseas Terminal
Pier 11	Dry + Liquid Bulk Cargo, Industrial
Pier 12	General + Dry Bulk Cargo, Ro-Ro Terminal
Pier 14	General + Dry Bulk Cargo, Industrial, Drydock
Pier 15	Tug Service, Work Boats, Barges, Warehousing, Industrial
Pier 16-18	Stelco
Pier 20-22	Dofasco
Pier 23	General Liquid + Dry Bulk Cargo, Industrial
Pier 24	Warehousing, Bunkering Service, Industrial
Pier 25	Marine-Industrial Park, Dry + Liquid Bulk Cargo Terminal
Pier 26	Marine-Industrial Park, Dry + Liquid Bulk Cargo Terminal
Pier 27	Future Development
Pier 28	Fisherman's Pier, Canal Boat Launch
Pier 29	Canada's Center for Inland Waters
Pier 34	Lasalle Park, Burlington Sailing + Boating Club, Lasalle Park Marina

2.48. Hamilton Waterfront: Port Use
Scale 1:70,000

2.49. Hamilton Waterfront: Industrial Buildings
Scale 1:70,000

2.50. Hamilton Waterfront: Transportation Systems
Scale 1:70,000

2.51. Hamilton Waterfront: Public vs Private Access
Scale 1:70,000

2.52. Hamilton Waterfront: Green Areas
Scale 1:70,000

2.3. POTENTIAL MANAGEMENT STRATEGIES

2.53. Significant Hamilton RAP Participants:

INDUSTRY: Steel producers Dofasco and Stelco

FEDERAL GOVERNMENT: Environment Canada, Department of Fisheries and Oceans, Hamilton Harbour Remedial Action Plan Office

PROVINCIAL GOVERNMENT: Ministry of the Environment, Ministry of Transportation, Waterfront Regeneration Trust

LOCAL GOVERNMENT: City of Hamilton, City of Burlington, Regional Municipality of Halton

COMMUNITY AGENCIES: Hamilton Port Authority, Canadian Centre for Inland Waters, Hamilton Region Conservation Authority, Conservation Halton, Royal Botanical Gardens

COMMUNITY GROUPS: Bay Area Restoration Council, Friends of Red Hill Valley

EDUCATIONAL: McMaster University, Mohawk College

2.54. Hamilton Harbour RAP Key Indicators:

1. Water Quality and Bacterial Contamination
2. Toxic Substances and Sediment Remediation
3. Fish and Wildlife
4. Public Access and Aesthetics
5. Watershed Management (Urbanization and Land Management)
6. Education and Public Information
7. Research and Monitoring

2.55. Hamilton Harbour RAP Primary Principles:

1. Ecosystem approach.
2. Zero discharge of inputs of persistent toxic substances.
3. Sustainable communities.

Regeneration of systems along the Hamilton waterfront requires the participation and cooperation of diverse groups to accomplish the wide range of organizational, investment, implementation and monitoring tasks involved.

The Hamilton Harbour Remedial Action Plan (RAP) provides a useful framework for this thesis in terms of ecological goals and participating organizations. First published in 1992, it was created following the identification of the harbour as an 'Area of Concern' to address the severely degraded ecology. In accordance with the Great Lakes Water Quality Agreement, the harbour was designated unsafe for people and wildlife due to its extensive legacy of industrial and municipal pollution. The plan's stated purpose is "to bring about sustainable natural ecosystems in Hamilton Harbour and its entire watershed, and to improve the potential for more extensive recreational uses while maintaining the harbour and the watershed's essential economic function." The Bay Area Restoration Council promotes and monitors restoration efforts, while a coalition of public and private organizations execute specific projects.[98]

Although significant ecological progress has been made through RAP implementation, efforts towards the regeneration of industrial and cultural systems seem to be limited by the distinctly separate management of natural and artificial systems. Reclamation of some port lands and the provision of a waterfront recreation trail have increased public access. The city as a whole however remains disconnected from the harbour. Similarly, there has been no attempt to integrate industrial systems into the fabric of the city. Instead industries are either left to stagnate in place, or else pushed out of the harbour altogether. Mechanisms need to be established that encourage industrial systems to integrate sustainable practices.

MANAGEMENT UNITS

The diversity of existing natural, cultural and industrial systems along the Hamilton waterfront results in complex interactions. Efficient implementation and monitoring can be achieved by establishing distinct management units. The boundaries of these units are determined according to ecologic, economic,

and sociologic factors, as well as ownership boundaries. Within each unit a community consisting of wildlife, human and industrial populations, itself comprised of individuals, forms an integral part of the larger system. Analysis of each unit, although beyond the scope of the thesis, should be carried out according to the complex systems approach and adhere to the same organizational principles outlined in the larger scales.

Although this thesis will address the regeneration of the entire harbour, focus will be placed on management units along the industrial waterfront.

2.56. Hamilton Waterfront Management Units
Scale 1:70,000

1. Cootes Paradise + Recreation Zone
2. Piers 8 - 15
3. Stelco (Piers 16 - 18)
4. Dofasco (Piers 20 – 22)
5. Piers 23 - 28 + Windemere Basin
6. Barton Street Industry
7. Burlington Shore

2.4. ANTICIPATED HAMILTON SCENARIOS

The Hamilton waterfront remains dominated by industrial and port activities, a large part of which is devoted to the production of iron and steel, the storage of related raw and finished materials, and related shipping areas. Although manufacturing processes have improved greatly, industry and municipal waste streams continue to degrade local, regional and global environments. As a result of historically toxic and dangerous manufacturing processes the harbour ecology has been drastically altered and remains largely inaccessible to the public. This development will likely propel the Hamilton waterfront toward one of three possible outcomes or 'attractor' states.

1. EXPULSION OF INDUSTRIAL PRODUCTION:

In an effort to reclaim the harbour for public use and to guard against health risks the Hamilton public or government may push industry to the periphery or even out of the region. This action would almost certainly result in a loss of jobs, and potentially cripple the city's economic means. In addition a complete erasure of industry would signify a loss of regional identity and history. Most importantly however, the expulsion of Hamilton industry signifies a disconnect among society, the means of production that support it, and the waste, by-products and pollution that are created through these processes. The increasing trend to relocate manufacturing centres to the periphery of human settlement simply shifts existing problems out of sight and mind, resulting in a false sense of security, less monitoring, and decreased pressure for stringent environmental standards. Compelling society to place habitation and industry in close proximity forces both parties to realize and deal with potential environmental problems and issues.

2. INCREASED INDUSTRIAL MONOPOLIZATION:

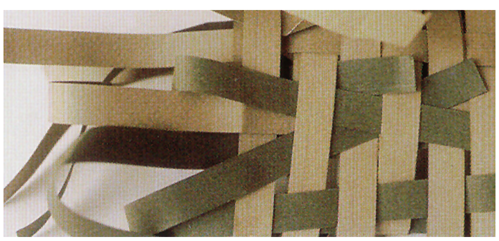
Alternatively, and less likely, industrial activities could increase within Hamilton Harbour. Despite boundaries restricting significant expansion of port lands, there are a few remaining water lots for development. Piers 26 and 27, on the eastern shore of the harbour, are partially filled and await new occupants. On existing port lands there is room for re-intensification and expansion of industrial use.

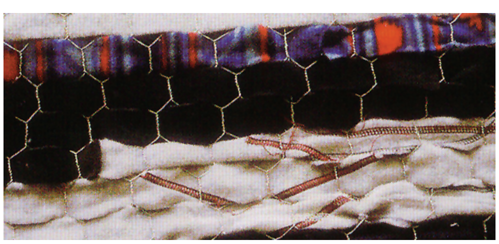
Although manufacturing processes have been much improved in recent years many new technologies have yet to be implemented in Hamilton. An expansion of current industrial activities would certainly lead to increased toxicity of port lands, further degradation of local ecology, and increased health risks to wildlife and human populations. Ultimately, this would repel commercial and recreational uses not directly connected to industry, decreasing the local population base. The local population would continue the current trend toward suburban sprawl, leading to the inverse of the above 'attractor' state. Hamilton would become detached from its livelihood and means of production.

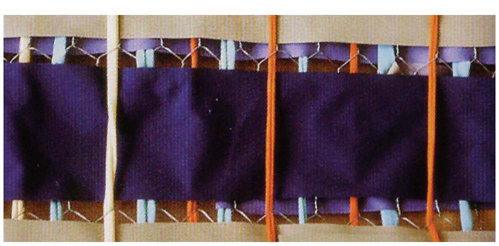
3. PERSISTENCE OF EXISTING RECLAMATION STRATEGIES:

In the past decade efforts have been made to recover parts of the waterfront for communal and recreational uses. Approximately 27% of the waterfront is once again open public land in the form of parks, marinas and some wildlife habitats.[99] Unfortunately this development strategy has been largely limited to a kind of pastoral fantasy, where all trace of industry is erased. This approach has little relationship to past ecology and no relationship to cultural history. The result is the antithesis of both industrial and natural ecosystems: the land is rendered almost completely devoid of productive means, and exists merely for the gratification of the public.

Industry and shipping activities remain active along half of the shoreline and continue to degrade the environment.[100] Although completely inaccessible this land exists in various states of productivity; much of it simply too toxic to inhabit. The sublime beauty and bleakness of the industrial waterfront tends to stimulate public interest, but simultaneously repels any desire to jointly inhabit the land.







previous page:
3.1. to 3.3. **Woven Inhabitation** by Toshiko Mori

3.4. Ecology: Cootes Paradise
3.5. Culture: Downtown Hamilton
3.6. Industry: Stelco Facilites

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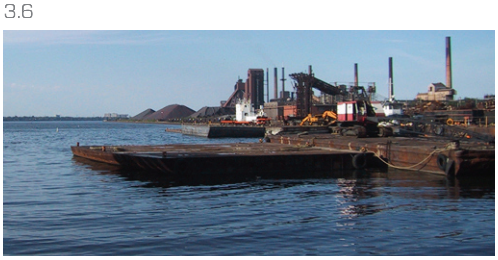


3.1. STRATEGIC URBAN INITIATIVES

Ecological, industrial and cultural systems in Hamilton remain disconnected and degraded. The Great Lakes Water Quality Agreement has identified the harbour as an 'Area of Concern', designating it unsafe for people and wildlife.[1] The subsequent Hamilton Harbour Remedial Action Plan (RAP) has begun to address many of the related pollution issues. These initiatives, are however, divorced from industrial production and the local ecology remains severely impaired. Hamilton is tending toward a state of stagnation, characterized by a dichotomy between sanitized park developments and toxic industrial relics.

Hamilton's industrial systems are defined by steel; historically a toxic process that has severely degraded local, regional and global environments, and created inhospitable conditions. Industry, if left on its present course, will continue to dictate the state of the harbour and abuse the environment. Existing strategies of relocation and the fragmentary reclamation of industrial lands similarly present Hamilton with limited future prospects. Despite industrial burdens however, Hamilton Harbour remains a strategic location for many manufacturing activities. Existing facilities associated with steel production, an experienced labour force, existing knowledge from professional and educational representatives, shipping infrastructure, transportation networks, as well as proximity to raw material sources, end product markets and end-use recovery markets all suggest a perpetuation of Hamilton as an industrial centre. In addition, advances in steel manufacturing processes demonstrate potential to significantly reduce environmental pressures.

The surrounding landscape, although overwhelmed by industrial pressures and pollution, still has potential for the renewal of ecological and cultural systems. The escarpment, valleys and shoreline offer unique environments for habitat and migration systems, and if interconnected and regenerated, possess the capacity to foster further ecological diversity. Similarly, a reprioritization of land use to include a greater diversity of recreational, residential and commercial functions in desirable locations could redefine Hamilton as a beneficial place to live and work.

A disconnect between industry and habitation that might once have been necessary can now be replaced by an integration of ecological, cultural and industrial systems to form a productive whole. A reprioritization of resources needs to take place that regenerates cultural and ecological systems while increasing the environmental and economic efficiency of manufacturing processes and infrastructure.

This integration will require action at a variety of temporal and spatial scales. Critical objectives will involve:

ECOLOGY:
- Creation of new wildlife habitats
- Establishment of continuous green infrastructure to increase connectivity of new and existing wildlife habitats
- Implementation of phased program of remediation and treatment wetlands throughout toxic port lands and harbour
- Connection of green infrastructure to treatment wetlands

CULTURE:
- Extension of public infrastructure to the waterfront edge
- Establishment of public use flow patterns through port lands
- Provision of continuous public access along harbour edge
- Amplification and enhancement of urban, cultural and recreation use north of Barton St. and up to the harbour edge

INDUSTRY:
- Mediation and redefinition of existing industrial boundaries
- Diversification of type and scale of industrial activities
- Increased efficiency of land and port use
- Creation of a matter and energy exchange network to eliminate waste and support industrial ecosystems
- Establishment of flow patterns for industrial land use, infrastructure and transportation
- Selective destruction of industrial facilities based on cultural + industrial significance, potential reuse and health concerns
- Reclamation of industrial land for public use

3.2. PROPOSED URBAN PLAN

This thesis proposes an urban framework for Hamilton in which human, industrial and natural process can coexist in close proximity. Once developed, the city could serve as a model for sustainable urban habitation in which material and energy cycles must be ‘closed’ and self-sustaining. The specific arrangements proposed in this study suggest that potentially detrimental activities such as waste production and heavy industrial manufacturing need not be pushed to the periphery of society. This model does, however, require restrictions in that all actions must contribute positively to local and regional ecosystems. Ultimately, this recasting of industry could suggest new possibilities for human sustainability in a symbiosis between city ‘wild’ and natural ‘wild’.

Strategies for the integration of these diverse ecological, cultural and industrial systems require a hybrid arrangement of natural and artificial elements throughout the city. Natural elements of the proposal derive inspiration from the prolific wetlands that historically pervaded the shoreline and occupied the plain now inhabited by the city. As a model for biodiversity and productivity regenerated wetlands could serve both ecological and industrial functions. Connected with larger regional systems, ecological structures will aid in the remediation and maintenance of all three systems.

In this proposal artificial elements of the proposal are structured according to principles of industrial ecology and concepts of industrial ecosystems. In this way artificial systems utilize biological metaphors and materials to increase material and energy efficiencies within both industrial and ecological terms of reference. The central component of a new industrial ecosystem will address Hamilton’s extensive history of steel-making, and the ecosystem’s primary producer could be cast as either a steel mini-mill or an energy producer. Success of artificial elements within the proposal will be dependant on their ability to integrate with, or replicate cyclical systems found in nature. The dynamics of such an industrial ecosystem must approach the complexity, and capacity for self-organization, inherent to natural ecosystems.

3.7. Historical Wetland Narrative
scale 1:140,000

demonstrates a significant destruction of wetland area and consequent loss of biomass and ecological diversity within the harbour

The execution of this proposed hybrid framework is further described through an urban plan, informed by both the complex systems analysis and the strategic urban initiatives. Though designed to be implemented over an extended time period, this plan can serve as context for more detailed and immediate interventions within the port lands. To regenerate and structure layered ecological, cultural and industrial systems the proposal utilizes existing infrastructures, including the escarpment, valleys, piers, highways, rail corridors and the basic urban street grid. In this way existing links to larger regional structures provide a basis for system regeneration, while local elements are redefined and repaired to interweave continuous systems within the city.

Ecological, cultural and industrial systems are extended to the waterfront, connected through the city, around the harbour and finally to the surrounding region. The integration of these systems is most apparent and vital within the select urban nodes. Projected from the urban grid toward the resource rich harbour, these nodes accommodate both movement systems and production centres for each of the ecological, cultural and industrial systems.

Across the water front, the established history of harbour manipulation is reinforced, in order to create amenity for all three systems. An array of incisions creates a series of large islands intended for intensive industrial use, as well as an inter-

3.8. Hybrid Collage:
illustrates synthesis of ecological, cultural and industrial systems

3.9. Hamilton Urban Plan Parti
Scale 1:70,000

digitated edge that increases ecological and cultural interaction with the harbour. This operation also increases the effective shoreline area, in which ecological processes and constructed wetlands may find shelter.

Although each aspect of the analysis aided in the formation of all aspects of the urban design, extension of its abiotic, biotic, cultural, industrial and energetic organizational principles have provided relatively clear links to the organization of ecological, cultural and industrial systems.

ORGANIZATION PRINCIPLE: NATURAL – ABIOTIC
Abiotic analyses have contributed to a variety of design elements. Observations with respect to water flows have informed the design of Drainage + Ecological Treatment. The waterfront's history of geomorphologic changes, on the other hand have informed the new synthetic management of the harbour's surfaces and form.

ORGANIZATION PRINCIPLE: NATURAL – BIOTIC
Biotic analyses, and observations regarding the conditions of plant life and wildlife, have contributed largely to the design of ecological elements, such as Ecological Infrastructural elements, as well as Drainage + Ecological Treatment elements in their capacity to augment infrastructural elements. Ecological Treatment elements also draw on information relevant to their ecological processes.

ORGANIZATION PRINCIPLE: CULTURE
Analysis of Hamilton's cultural aspects contributed to the design of several urban elements. Land use distribution had obvious implications in the organization of Industrial Zoning. Potentials and problems of public transportation systems and infrastructure, informed the regeneration of Cultural Infrastructure, just as the analysis of trail systems and harbour use informed the development of Recreational Infrastructure.

ORGANIZATION PRINCIPLE: INDUSTRY
Analyses of existing industrial systems and resources have also informed an improved organization of Industrial Zoning. Information pertaining to existing transportation links or inter-

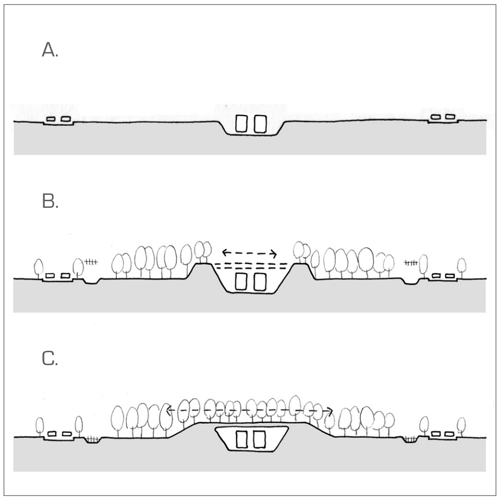
ruptions, as well as redundant infrastructure has assisted in the design of Industrial Infrastructure.

ORGANIZATION PRINCIPLE: ENERGETICS
Analyses of energetics within Hamilton informed the basic organization of priority remediation areas. In addition information with respect to product output and waste output help achieve overall strategies and goals relevant to industrial ecology.

A more detailed application of these strategies however, informs an organization of the urban plan into the following separate elements:

1. Ecological Infrastructure
2. Ecological Drainage + Treatment
3. Priority Remediation Areas
4. Industrial Zoning
5. Industrial Infrastructure
6. Cultural Infrastructure
7. Recreational Infrastructure

3.3. URBAN PLAN ELEMENTS



3.10. Green Infrastructure Implementation Strategies:
A. existing rail corridor
B. proposed green corridor
C. bridged connection

1. ECOLOGICAL INFRASTRUCTURE:

The mapping of existing natural systems and the design of new ecological infrastructure is closely linked with the now widely used principles of green infrastructure: "an interconnected network of protected land and water that supports native species, maintains natural ecological processes, sustains air and water resources and contributes to the health and quality of life."[2] In addition ecological infrastructure provides a multi-functional platform for the development of cultural activities, an extensive buffer system for industrial activities, and a framework for the design of many of the following urban elements. The following basic principles will help guide the design and implementation of ecological infrastructure:

- recognize ecosystem and watershed contexts
- protect and regenerate health and biodiversity
- provide a multifunctional platform for development
- create linkages between new and existing ecological areas
- improve image and reinforce sense of place
- involve and engage the community

As a basic strategy many of the existing rail corridors are utilized to support continuous ecological connections through the city, as well as establish regional connections to larger existing ecological areas in Dundas Valley, Red Hill Valley and the Niagara Escarpment. These linkages establish clear movement systems for plant and wildlife, among existing terrestrial, riparian and grassland habitats, and provide some space for new habitats. Greater capacity for new habitat creation occurs within the urban nodes, which connect to both the rail corridors and port lands at regular intervals. Managed successional planting throughout the ecological infrastructure system will ultimately foster a new repository of ecological diversity.

As a corollary, ecological infrastructure will foster the creation of cultural habitats. In particular, the urban nodes incorporate park areas, sports fields, exercise circuits, natural trails and other public programs. In addition, landscaping and planting will establish a buffer system for wildlife, people and industrial firms among critical ecological, cultural and industrial systems.

3.11. Urban Plan: Ecological Infrastructure
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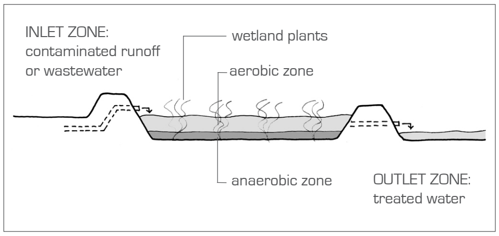

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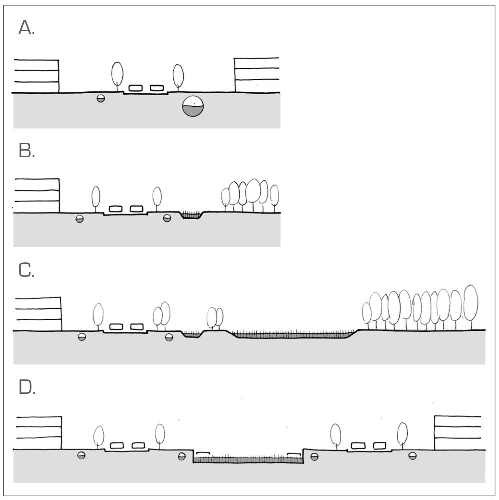

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3.12. Basic Wetland Treatment Process
3.13. Water Collection Implementation Strategies:
A. large enclosed culvert
B. open drainage channel (with enclosed collection)
C. natural treatment pond (with buffer)
D. urban treatment pond (with enclosed collection)

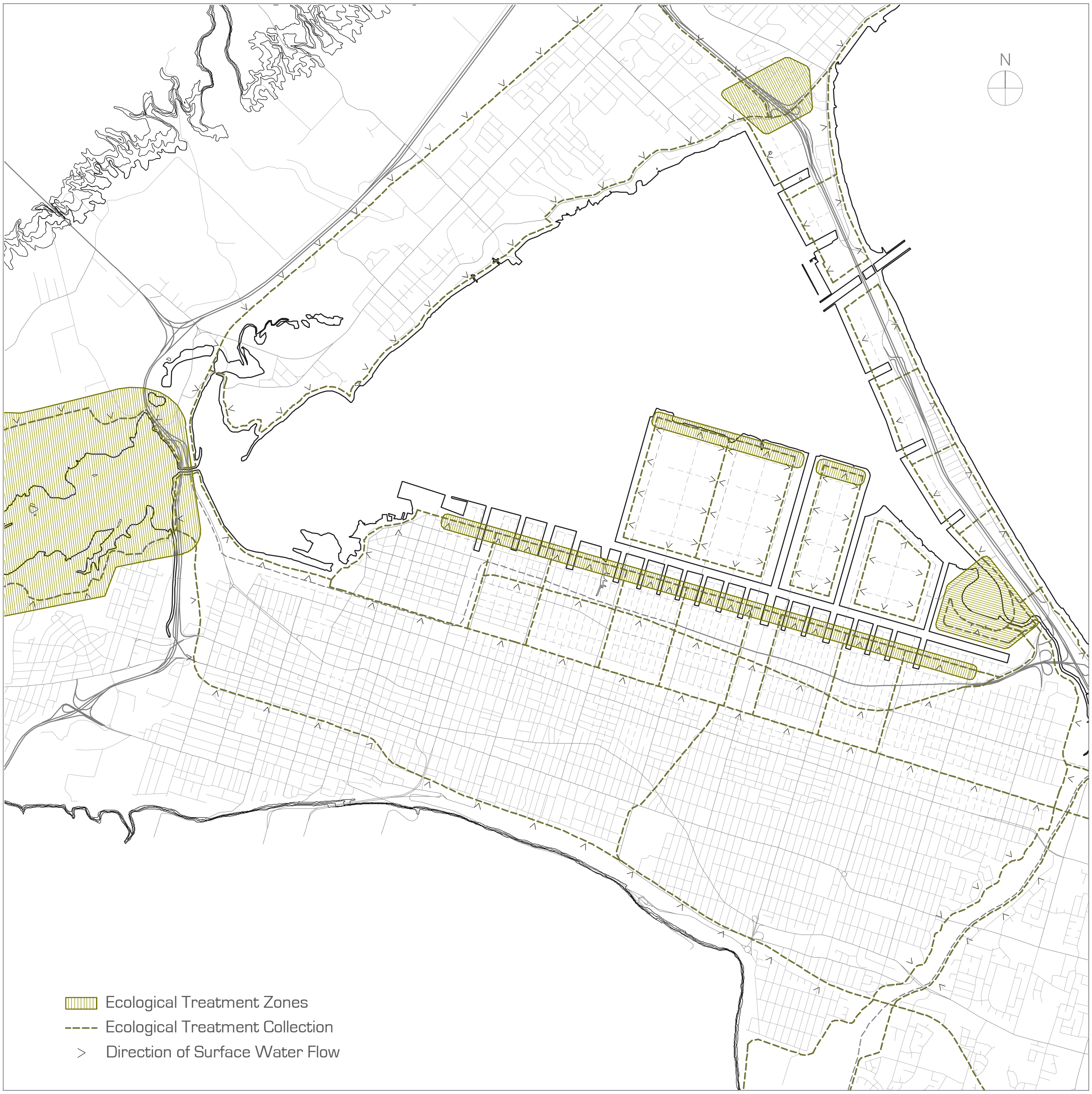
2. ECOLOGICAL DRAINAGE + TREATMENT:

Incorporated into the design of ecological infrastructure and existing drainage patterns within the Hamilton area, the implementation of an ecological drainage and treatment system interlaces the city. This engineered system, composed of collection and treatment devices, combines conventional treatment concepts of aeration, aerobic and anaerobic treatment with natural purifying processes present in wetlands. In this way the system addresses issues of urban or industrial runoff, wastewater treatment and potentially sewage treatment. Among the multitude of benefits to this system are:

- buffers and filters for harbour and ecological areas
- remediation and wetland regeneration at the waterfront
- efficient decentralized facilities at outfall locations
- lack of chemical and air pollution risks
- community assets and potential education centres
- economic derivatives of aquaculture, harvested vegetation, and plant nurseries

A series of multifunctional enclosed and open drainage channels are designed to buffer sensitive ecological resources in Cootes Paradise, Red Hill Valley, and Hamilton Harbour from pollution, as well as transport contaminants to larger treatment areas. In addition, the channels are devised to begin treatment en route with the application of biological processes during low flow periods.

Locations of treatment zones take advantage of existing wetlands in Cootes Paradise, Windemere Basin and the north corner of the harbour, as well as the potential for constructed wetland devices within the articulated south shore. Facilities may take the form of open retention systems or enclosed greenhouses, but principally “rely on bacteria, algae, plants and aquatic animals to metabolize the nutrients and contaminants in wastewater as it flows through a series of tanks, engineered streams, and constructed marshes.” [3] Existing plans for Combined Sewer Overflows (CSO) within Hamilton may also be incorporated into this new treatment system.



3.14. Urban Plan: Ecological Drainage + Treatment
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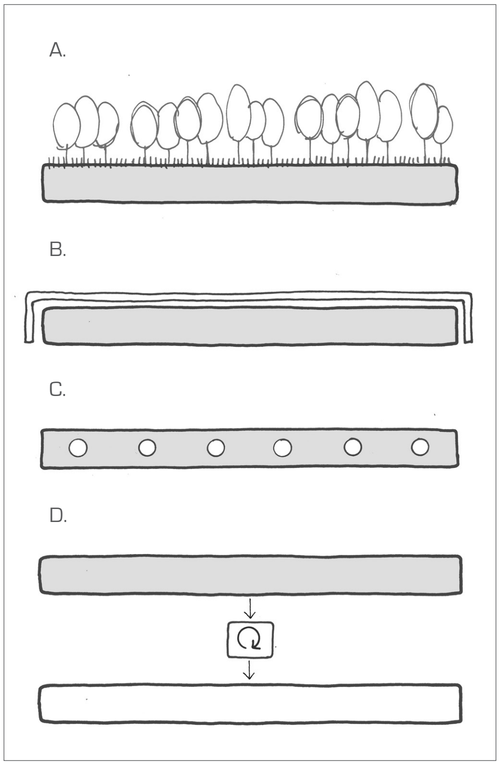


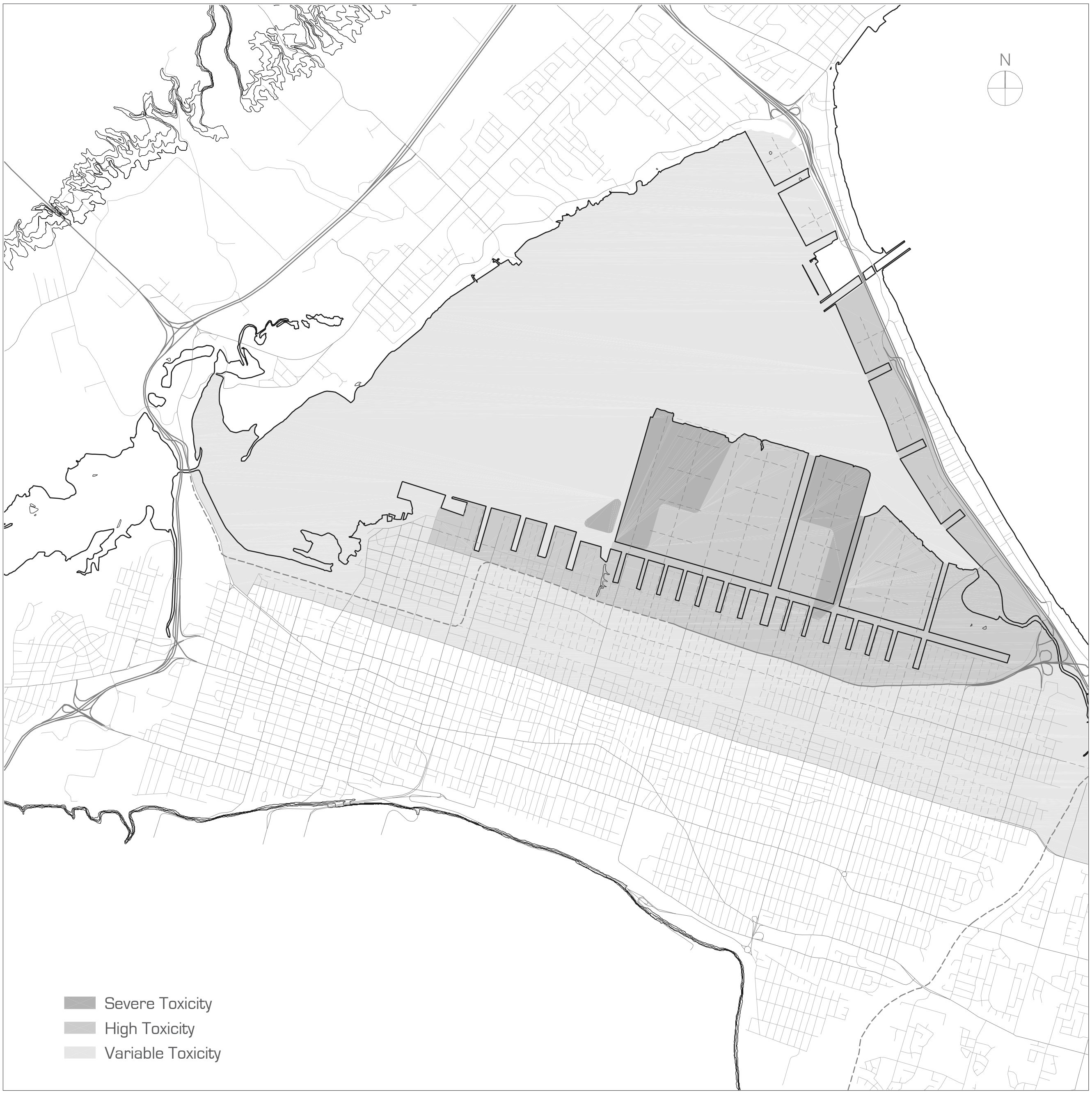
3.15. Basic Remediation Strategies:
A. Extensive In Situ: biological process
B. Containment: natural + artificial cap
C. Intensive In Situ: chemical + mechanical process
D. Intensive Ex Situ: relocation + local treatment

3. PRIORITY REMEDIATION AREAS:

Information on pollution and toxicity levels throughout Hamilton is sporadic and limited. Due to the privatization of much of Hamilton's port lands, most information regarding the contamination of soil, surface water and groundwater is either nonexistent or remains in private hands. An approximate evaluation of Hamilton's toxicity levels, based on historical and existing land use patterns, relies on the following assumptions:

- Areas occupied by industry have some degree of toxicity
- Port lands constructed of fill are likely composed of contaminated materials
- Shipping activity, run-off and seepage have created significant pollution problems throughout the harbour
- Existing and former steel production areas are highly contaminated with both organic and inorganic compounds in the associated land and water
- Coal and coke handling areas are severely toxic and require immediate attention. These include Stelco and Dofasco's coal docks, and the harbour area known as Randle Reef, where large coal deposits lie off the west shore of the Stelco Pier.

Although detailed study is required to determine appropriate remediation strategies for any given site, the application of certain basic strategies are relevant to the city as a whole. Extensive and in situ strategies will be given preference in the interest of promoting environmentally beneficial and low cost solutions, where time and resources permit. These include bioremediation and phytoremediation, which employ plants and microbes to remove contaminants from soil and water. Containment strategies will apply to sites that pose imminent danger to adjacent land. These take the form of either biological or artificial barriers, and may work in concert with natural attenuation. Intensive in situ strategies will be used when the land is scheduled for near future use that necessitates shorter timetables. These include mechanical and chemical processes. Lastly, intensive ex situ strategies will apply to severely contaminated sites that require immediate attention and will be coordinated with excavation activities of the urban plan.



3.16. Urban Plan: Priority Remediation Areas
Scale 1:70,000

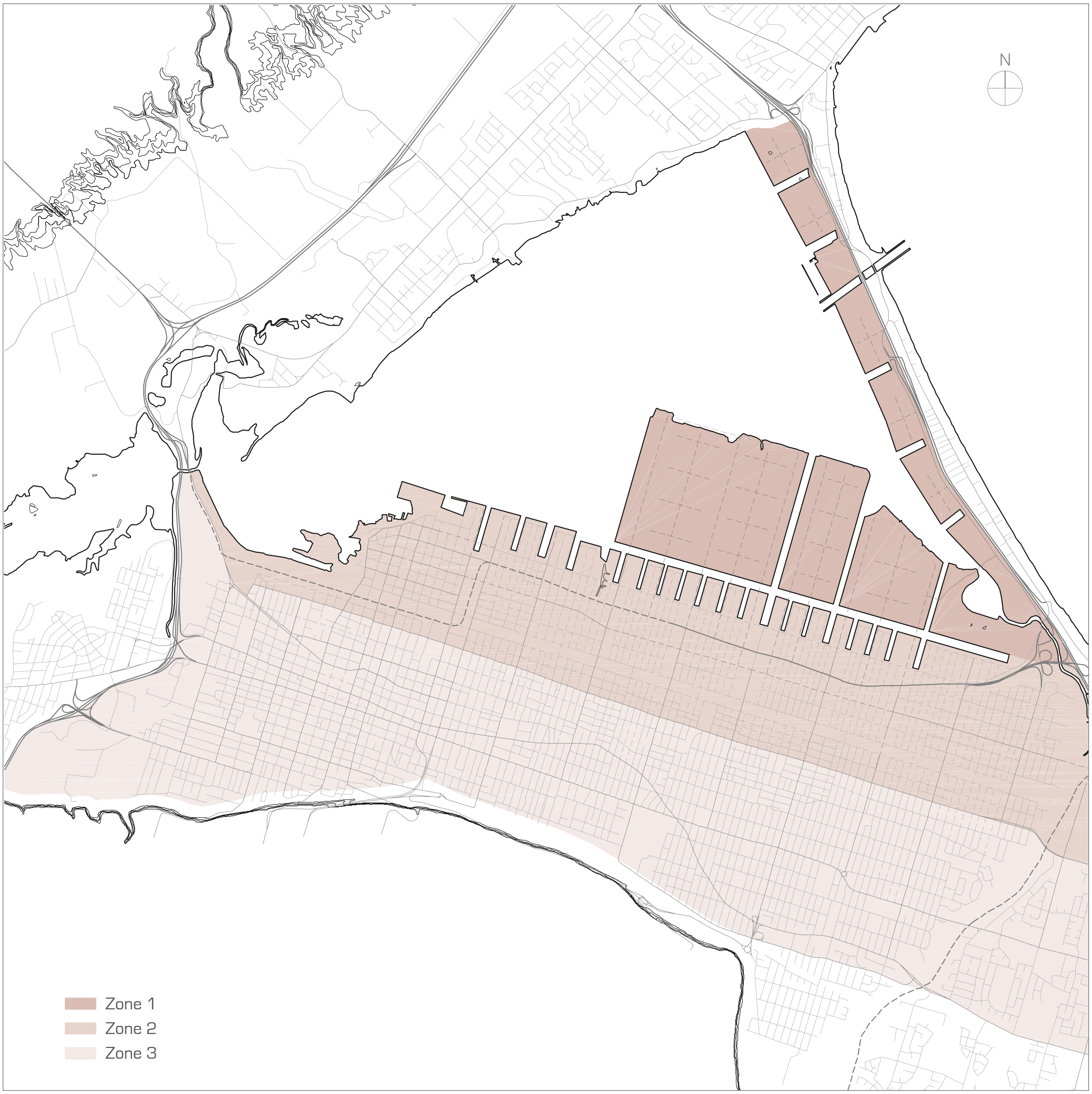
4. INDUSTRIAL ZONING:

Throughout Hamilton a diversification of land use will be promoted, that includes a balance of ecological, cultural and industrial functions. Specific organization is limited to the assignment of industrial programme relative to manufacturing processes and scale. This reorganization is based on existing land use patterns, as well as the location of existing and future industrial infrastructure. The following specifies both the objectives and restrictions of each new industrial zone.

Zone 1:
- Intensive land use accommodates large scale facilities
- required to treat all pollution on site and encouraged to foster industrial ecosystems and thus eliminate by-products and wastes
- buffered from and unobtrusive to urban fabric
- efficient exchange of large amounts of material and energy
- improved access to transportation, shipping, exchange infrastructure
- provides some infrastructure to deal with by-products and effluents

Zone 2:
- mixed use with smaller industrial firms (secondary and tertiary producers)
- relatively close proximity to transport hub, port and other infrastructure
- required to fit within existing urban block structure
- required to treat all pollution on site and account for all by-products and wastes

Zone3:
- mixed use with only small manufacturing sites (tertiary or independent producers)
- greater diversification of building use within block structure
- required to treat all pollution on site and account for all by-products and wastes



3.17. Urban Plan: Industrial Zoning
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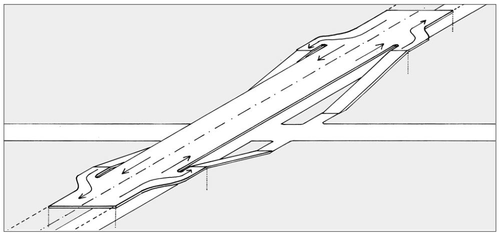

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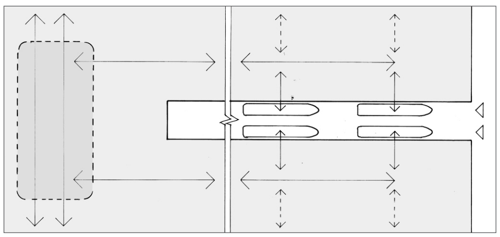

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5. INDUSTRIAL INFRASTRUCTURE:

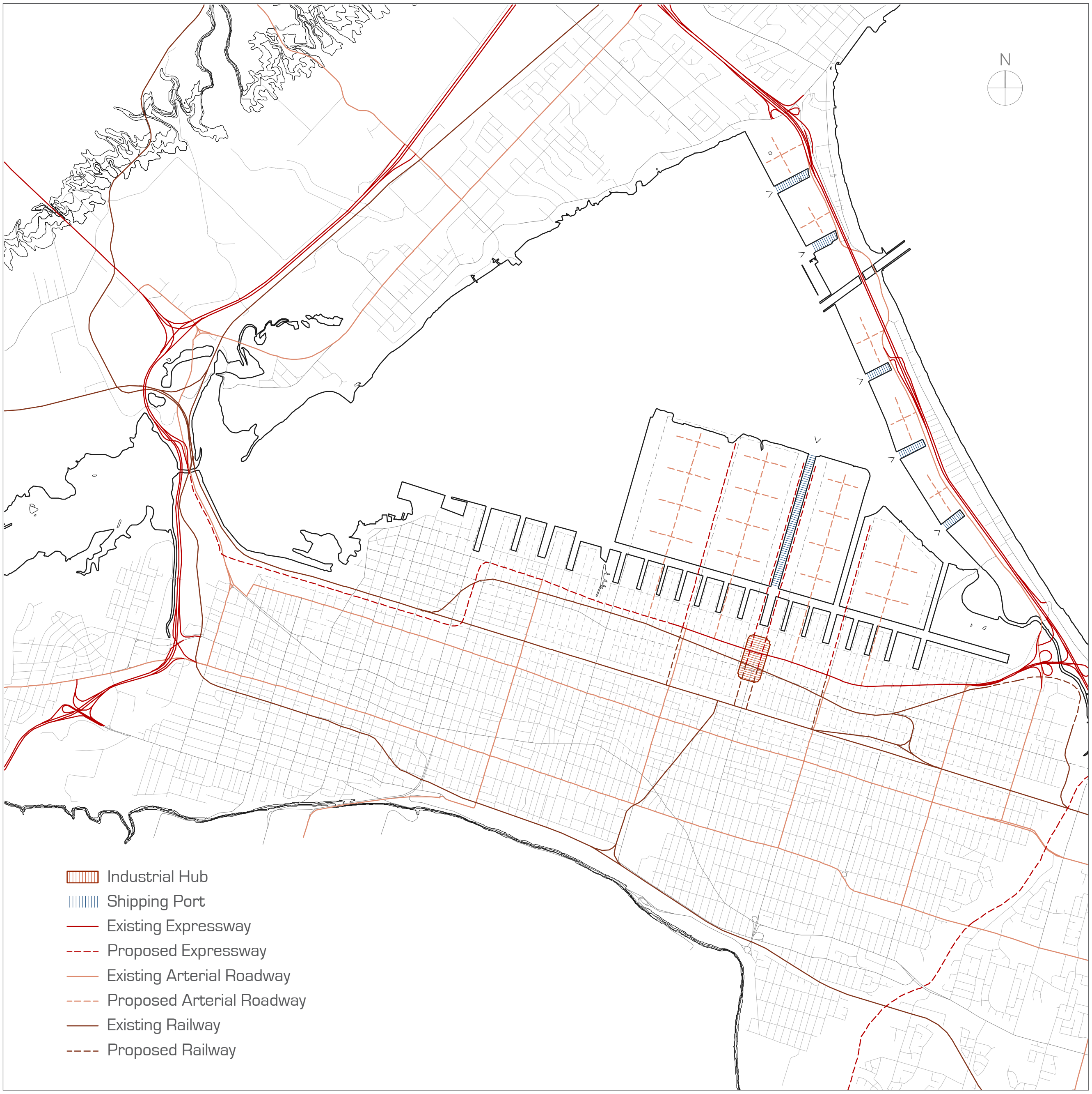
Regional vehicular links to and from the city are efficient; however improvements are required at the local level. A lack of industrial connections through the port lands leave industrial traffic encumbered by local traffic, which is in turn overwhelmed by the size and volume of industrial flow.

The existing raised sections of Burlington Street will be renovated to provide a new continuous raised link along the entire edge of the port lands. This will effectively link the QEW route along the Burlington Sandbar with highway 403 on the other side of the city. A diagrammatic sketch demonstrates how this may be implemented in terms of access to and from the raised route and the inclusion of a concurrent surface road.

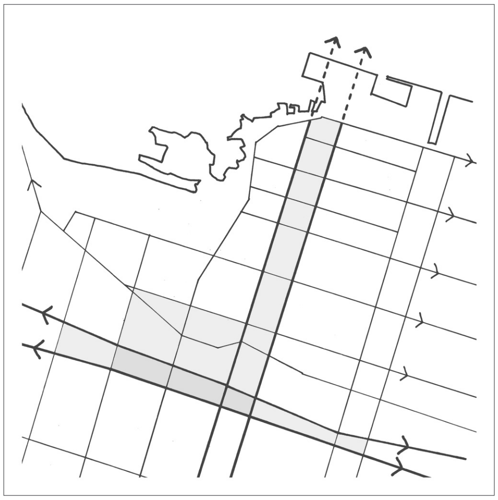
A shift to steel mini-mill operations over integrated operations will reduce the need for iron, coal and other bulk materials, and consequently the need for large international shipping facilities. Any remaining large scale shipping activities will therefore be relocated to one central port between the existing Stelco and Dofasco facilities. In addition smaller expansion ports will be located along the eastern edge of the harbour away from the city, while some small scale marine based activities will be left in existing ports. This will free up valuable waterfront for cultural and ecological programmes.

The large central port will be linked to a transportation hub that will facilitate the distribution of goods and materials among local industrial firms. This hub will also link the port and local industry to regional markets and suppliers through direct access to existing rail lines and new highway links.

3.18. Raised Highway Basic Implementation Strategy
3.19. Central Port Essential Exchange Relationships: capacity for eight full size international tankers, provision of movement to and from trasportation hub, and through industrial zone 1



3.20. Urban Plan: Industrial Infrastructure
Scale 1:70,000



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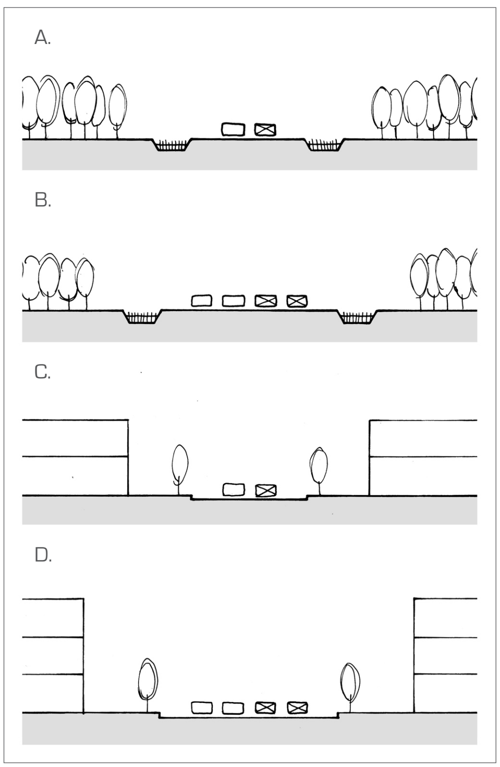

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3.21. Downtown Core Linked to Port Lands
3.22. Cultural Infrastructure Implementation Strategies:
A. minor road in ecological context
B. major road in ecological context
C. minor road in urban context
D. major road in urban context

6. CULTURAL INFRASTRUCTURE:

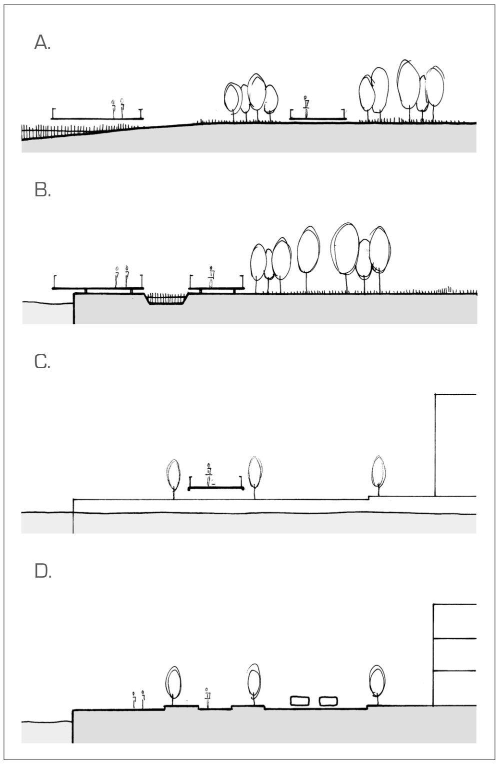
Vehicular movement through Hamilton is characterized by inefficient one-way streets, and almost complete disconnection from the waterfront. Basic strategies within the urban plan attempt to address these issues. The primary focus is to increase public access to and along the harbour front, and improve overall circulation with a move towards bi-directional traffic flow patterns.

Main Street will become two-way along its entire length, to take some pressure off King Street, and the downtown core, while maintaining flow across the city. The raised highway extension above Burlington and Barton Streets will also decrease general traffic pressures, and accommodate traffic travelling directly through the city. To improve north-south movement, Sherman Avenue and Wentworth Street will be converted to two-way arteries.

A reorganization of traffic patterns within the port lands will increase public access. New roads, constructed at the scale and orientation of existing urban fabric, provide a normative block structure within which commercial and cultural development can develop. In addition, existing major roads are extended into the urban nodes highlighted in the urban parti. A secondary system of roads is extended into the port lands to provide continuous north-south routes for local traffic. These connect to a series of new east-west routes, constructed from segments of existing roads. One major route travels between Burlington and Barton streets, and the northern most secondary route travels just back from the new pier incisions.

Commercial and cultural development will be promoted in strategic zones in order to foster continuous programme throughout the city and down to the waterfront. In particular this will attempt to link the downtown core to the waterfront along James and John Streets. In addition Sherman and Strathearne Avenues will support cultural development through the port lands, into two strategic urban nodes, and toward the waterfront.

3.23. Urban Plan: Cultural Infrastructure
Scale 1:70,000



3.24. Recreational Infrastructure Implemenation Strategies: Pedestrian + Cycle
A. boardwalk and trails along wetland edge
B. boardwalk and trails along park edge
C. bridged urban connection
D. sidewalk and trails along urban edge

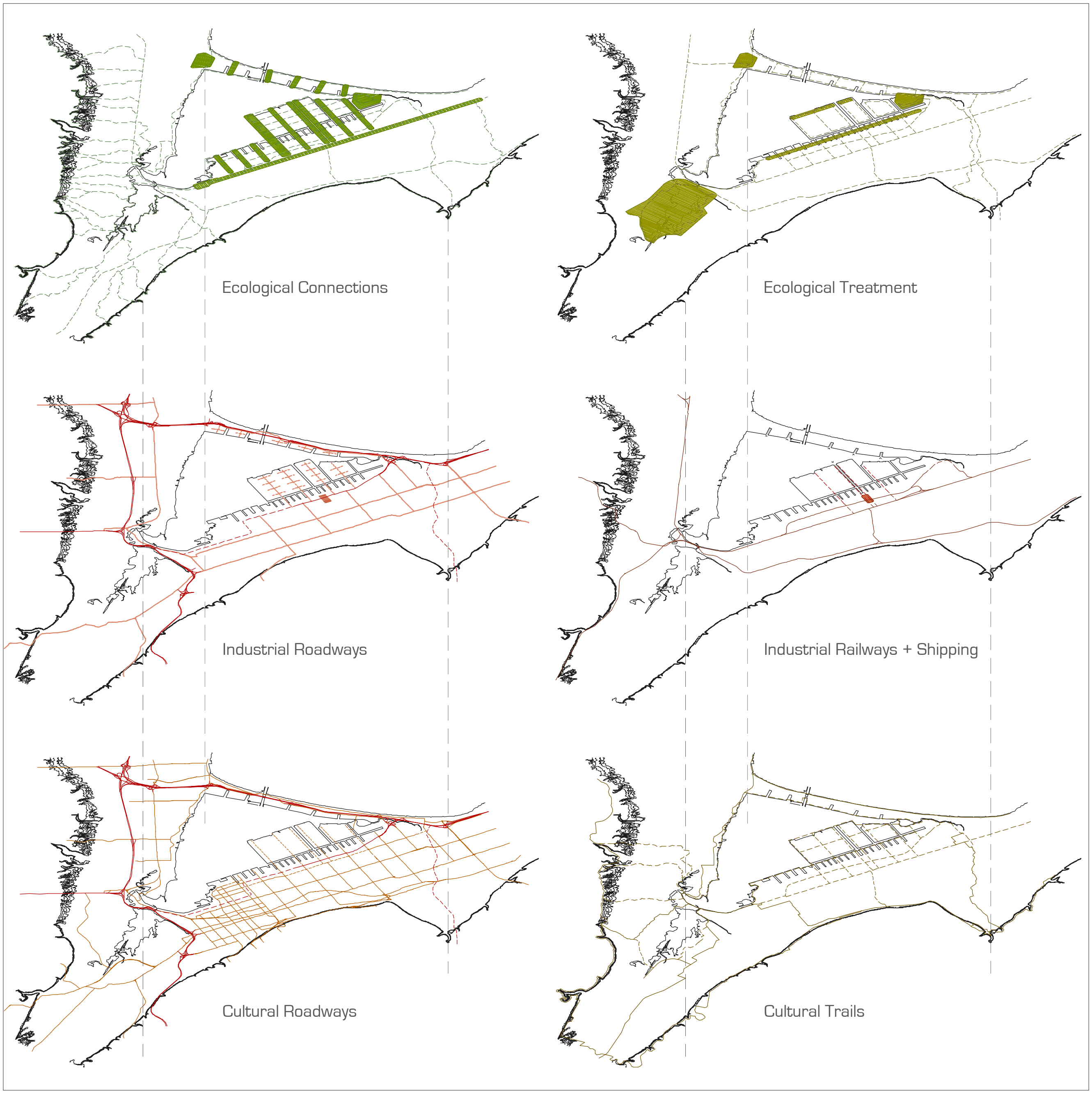
7. RECREATIONAL INFRASTRUCTURE:

The existing public trail system provides access throughout Cootes Paradise, the Niagara Escarpment and Red Hill Valley. In addition the recreational development from Cootes to Pier 4 receives active use. While these systems provide excellent access to resources around Hamilton's perimeter and a small corner of the harbour, resources within the city are underutilized. The design of recreational infrastructure intends to create new connections among existing systems and make better use of the harbour's resources.

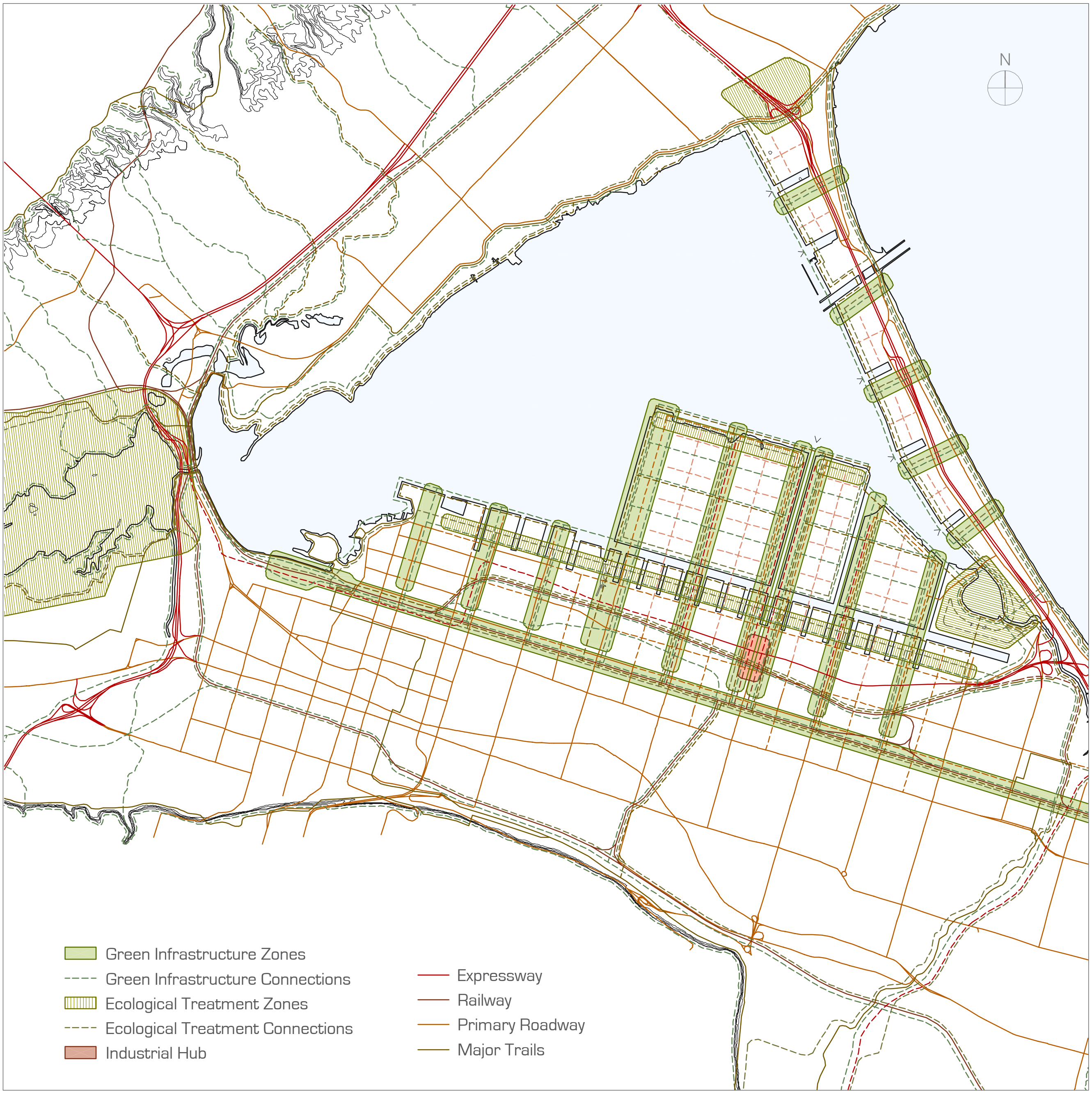
A new trail system will take advantage of new green corridors that link Cootes and Red Hill across the city, and provide connections south toward the escarpment. From these corridors, links to the urban nodes provide direct access to the south shore and new public areas. Around the perimeter of the harbour itself a range of urban sidewalks, woodland trails and wetland boardwalks provide continuous access to the waterfront.

Cultural interaction with the harbour is increased along the southern shore, where new incisions have created an interdigitated edge. Along this edge there is extensive space for cultural and commercial activities on waterfront lots. Since these new piers are intended primarily for public use they are not impeded by pedestrian connections provided along the waterfront edge. If necessary, these bridges could take the form of operable structures to accommodate small industrial and commercial functions.

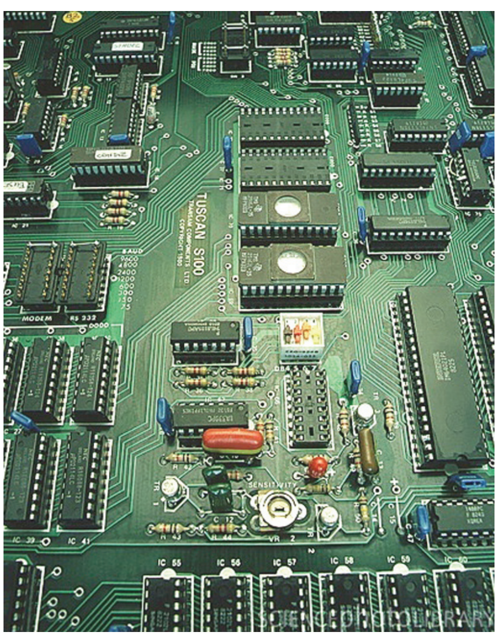
3.25. Urban Plan: Recreational Infrastructure
Scale 1:70,000



3.26. Axonometric of Urban Elements



3.27. Urban Plan: Composite
Scale 1:70,000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4.1. DESIGN STRATEGIES

The urban plan outlined in the previous chapter provides a useful context for further and more detailed design interventions. Its proposed structure creates a flexible framework within which a hybridization of natural and artificial systems can interact with and alongside existing urban fabric.

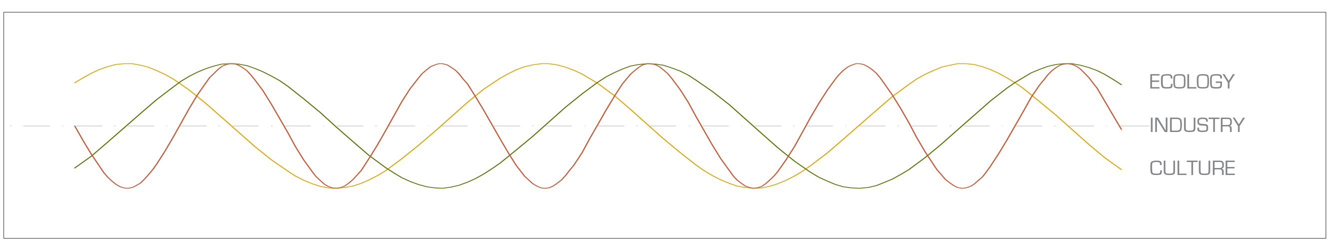
This thesis proposes the reclamation of the existing Stelco Pier as one such detailed urban speculation. The pier has played a critical role in both positive and negative aspects of Hamilton's growth and its current condition is representative of both the city's problems and potentials. Speculation and potential redevelopment of this property are critical to the formulation of new sustainable systems within the harbour. Specific application of regenerative systems within this pivotal location will attempt to repair much of the local ecological damage, as well as allow for new industrial and cultural relationships towards the harbour and natural systems.

A new hybrid condition will be established, referred to as an **Instrumental Matrix**, within which decentralized cultural, ecological and industrial systems are interwoven to foster diverse and sustainable habitats for both wildlife and people. A symbiosis among these three systems may further suggest a new model for sustainable development and serve as a potential seed for the future growth of Hamilton. In keeping with the hybridization methodology outlined in chapter one, the development begins at the boundary of the harbour and propagates back through previous industrial and cultural constructions (phase 2 to 4 in fig.1.14). Suggestions for outward propagation of a new sustainable condition (shown dashed on the facing page), will be dependant on the satisfaction of extremely stringent conditions that meet or exceed the rigorous demands of both local and regional ecological systems (phase 5 of fig.1.14).

previous page:
4.1. Components on a Computer Processor Board

opposite page:
4.2. Instrumental Matrix: Plan Parti Diagram
illustrates primary design elements, complex interaction and strategies for potential expansion

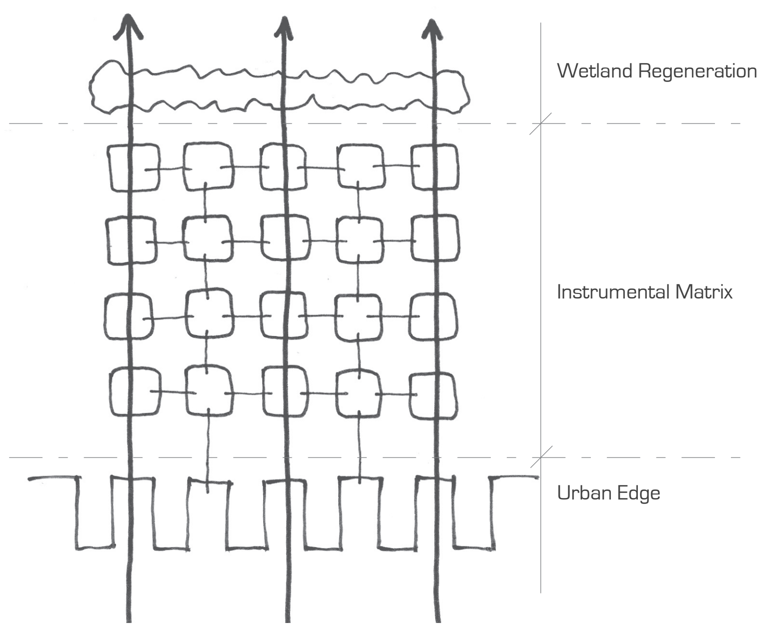
4.3. Instrumental Matrix: Sectional Parti
illustrates interwoven symbiosis of three systems



As an artificial and malleable construct suffering from heavy contamination, the former industrial pier is considered both suitable and capable of supporting new speculative and hybrid forms. Initiated with a phased program of intensive remediation and managed ecological succession the regenerated site will serve as the foundation for the proposal.

To facilitate the operation of the Instrumental Matrix, a series of new edge conditions clarify the relationships among various systems and programmes. A new urban edge is connected to a new island, which in turn offers a variety of multi-functional edge conditions, including public parks and a large shipping facility. On the far side of this island both public and private systems are connected to a regenerated wetland edge.

The existing Stelco pier is therefore severed from the city in order to establish the urban edge at the line of the adjacent piers. As discussed in the urban proposal, an array of incisions



4.4. Instrumental Matrix: Plan Parti Sketch
illustrates the creation of new edge conditions connected through a matrix in which ecology is pervasive, industry is interconnected and culture is emergent

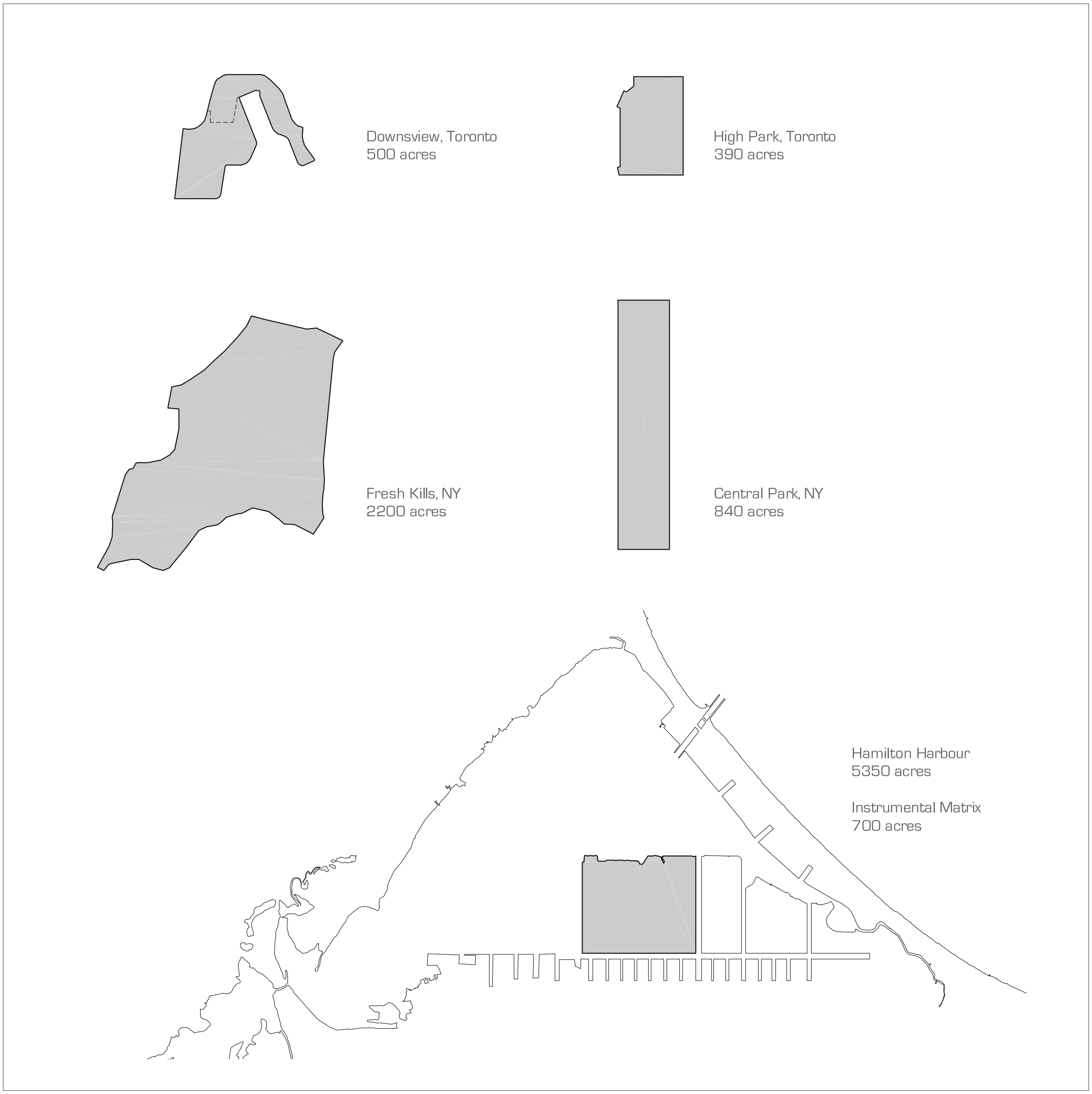
that define this new interdigitated surface will create public and private amenity, reconnect the city to the harbour, as well as reinforce the artificial nature of Hamilton's industrial shore.

Reaching north, the series of urban nodes, conjoined with wildlife corridors, will extend beyond the city toward the island. Together these nodes form a system of interconnected public spaces that consist primarily of three large urban parks. In particular, the western most node offers the largest diversity of public amenity with a cultural centre sited amongst former industrial structures.

Organization is accomplished through a system of ecological **connective tissue** and earth **berm structures** to form the framework of the proposal. The tissue serves to manage complex wildlife movements and flows, accommodate site drainage and water treatment, as well as provide ecological buffers between diverse programmatic uses.

Embedded within this framework is a permeable matrix of **instrumental cells**. Each cell is equipped to accommodate a variety of functions and is able to adjust its interaction with adjacent programme accordingly. Reciprocally, the vegetative planting forms a cell wall or membrane for each unit. Flexible and anticipatory infrastructures will allow for an extensive material and energy transfer network among these cells and thereby enable the creation of complex industrial ecosystems.

Finally, the wetland edge on the north side of the new island serves as a repository for ecological diversity that is critically connected through the site and beyond to regional ecological structures. In addition its treatment capacity services both private and public demands. This regenerated wetland exists as a reconstruction of past ecologies, and as such represents a new threshold or boundary between the City of Hamilton and its surrounding wilderness.



4.5. Diagramatic Size Comparison of Urban Parks

4.2. DESIGN SCENARIOS

STELCO, HAMILTON

Stelco Inc., founded in 1910, is a fixture in Hamilton Harbour and one of the largest employers in the area. The firm has extensive port and steel making facilities, and together with Dofasco constitutes the largest production of steel in Canada.[1]

As an integrated steel mill its manufacturing processes rely on coal, blast furnaces and basic oxygen furnaces that create significant pollution problems. Consequently, the 1,110 acres of port land occupied by Stelco has been made increasingly toxic throughout the mill's history. The entire facility and shoreline remains restricted to the public due to the safety and liability issues related to certain aspects of the process, as well as health concerns related to historic and existing pollution issues.

Stelco Inc, currently operating under bankruptcy protection, is desperately attempting to overcome significant fiscal and operational burdens. Mounting debt, strained union relations, poor management, limited environmental practices, as well as outdated technology and production methods have all amounted to a company that has failed to adapt to a changing global economy and manufacturing practices.

Although recent refinancing proposals and potential investment may breathe new life into the company, the operation of large integrated steel mills is obsolete. Ultimately Stelco, and other integrated steel companies, must undergo fundamental restructuring and modernization to survive as economically and environmentally viable operations. Stelco's significant infrastructure and strategic location however, remain as significant assets in Hamilton.

The following scenario represents one possible circumstance through which Stelco's Hamilton pier may be reclaimed and regenerated. Stelco, facing financial ruin, seeks a buyout. New management then shifts attention away from Hamilton, to the presently more productive Lake Erie facility. A precipitous wholesale auction of Stelco's Hamilton assets creates potential for partnerships between public agencies and private investors in a long-term redevelopment project.

From the perspective of government, such a public-private redevelopment could demonstrate a proactive stance on sustainable issues. Further, an endorsement of industrial ecology principles inherent to this project may unite the disparate interests of environmental and business groups. As one of the few potentially viable alternatives to present industrial systems, industrial ecology offers a reprioritization of environmental and production demands within the current economic language of profit. The demonstration of an industrial ecosystem could become a working model for development of future industrial projects and the restructuring of existing ones, and consequently generate future investment in the area. Other potential governmental benefits include a redeveloped waterfront, parkland and other public amenity that could generate public activity, new civic identity and increased investment throughout a suffering urban core.

Private investment in the project could provide critical support toward existing rehabilitation efforts of ecological systems in this area. Tax breaks and other fiscal incentives could be afforded in exchange for support with necessary remediation initiatives and the construction of public amenity. Industrial participants can also benefit from a strategically organized site, efficient infrastructures and facilities, potentially lucrative exchange relationships and numerous other economic benefits, such as those found in the industrial ecosystem of Kalundborg, Denmark. In addition participation would likely foster improved public relations, through local, regional and global scales.

STEEL PRODUCTION

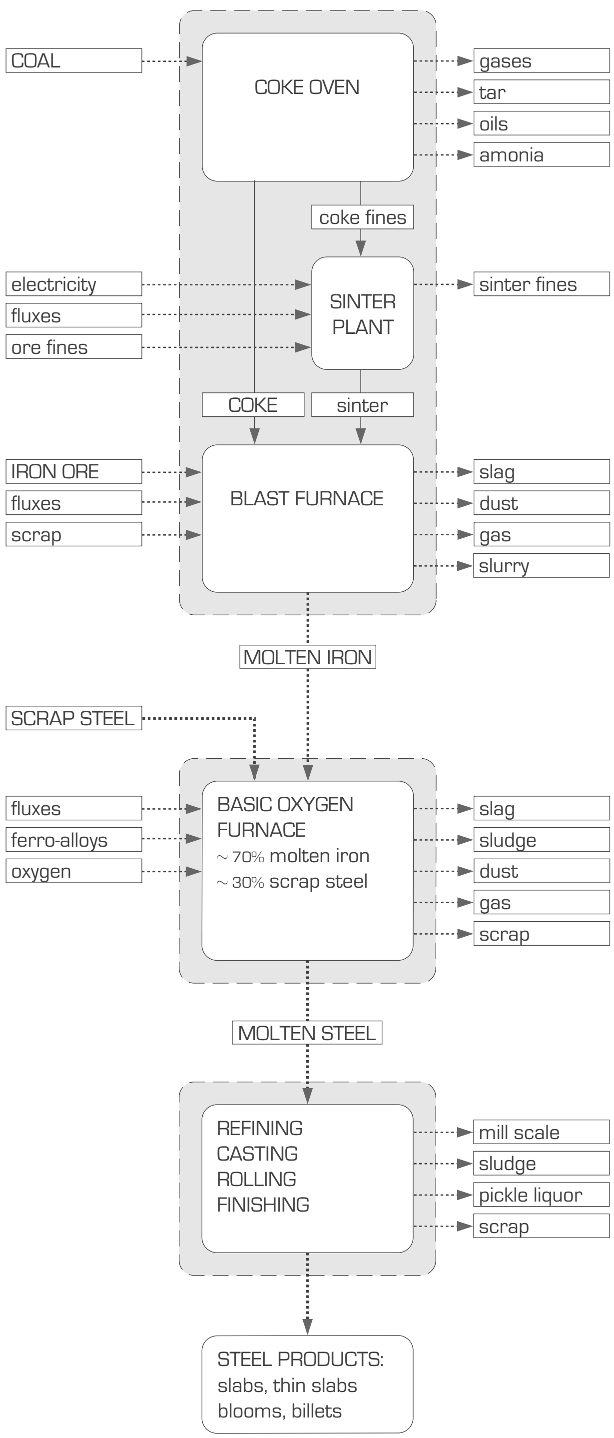
The steel industry is undeniably a highly material and energy intensive industry with an enormous legacy of pollution to account for. Given technological innovation, past, present and future industrial ecology relationships, as well as highly recyclable and durable products however, steel production has the potential to position itself as a sustainable industry.

Early examples of material and energy exchange relationships within the steel industry, date back to the late 19th century and the use of gas by-products for community lighting and heating needs. [2] An evolving body of industrial ecology examples have been intensified by increasing global competition and a need to streamline production. Steel producers have been forced to identify and characterize waste sources and sinks, and thereby realized environmental and economic benefits inherent to loop closing (waste reduction) activities.[3]

Air and water emissions remain a considerable problem, however public pressure, regulatory constraints and industrial initiatives have all contributed to substantial pollution reduction within the steel sector. Since 1970 North American smoke-stack pollution has been reduced by 95%, while 63 million tonnes of steel recycled in 2002 represented approximately 60% of new production in the same year.[4] More recently the North American steel industry demonstrated a reduction of energy use by 9% and a reduction in greenhouse gas emissions per unit of metal by almost 20% through the 1990s.[5] This progress continues although further advances are increasingly difficult.

Technological discoveries in the areas of steel making, casting and refining are reducing the destructive impact of steel production. Among these, advances in the operation of the electric arc furnace (EAF) are revolutionizing the industry, with the inclusion of virtually 100% scrap steel as feedstock for new steel. The EAF is quickly rendering the basic oxygen furnace (BOF) technology, which has formed the core of large integrated steel operations, obsolete. Although this older technology also uses scrap steel to make up about 28% of its feedstock it still requires

INTEGRATED STEEL PRODUCTION:

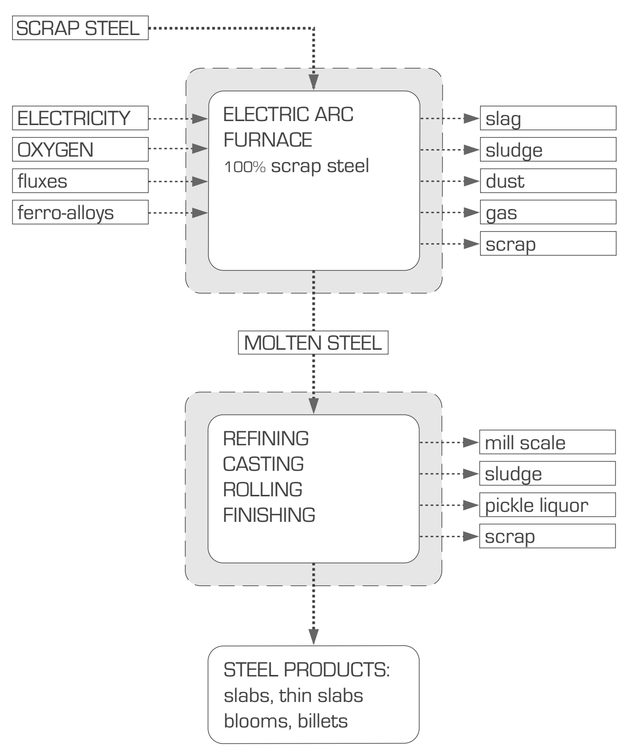


STEEL PRODUCTION BY - PRODUCTS:

Some by-products are either disposed of or escape to create environmental damage. Some by-products (such as gas for energy or slag + scrap for iron content) are being recycled to fill internal material and energy requirements. Other by-products are recovered for existing and potential reuse in other industries for such products as:

- cements
- sands
- road bed aggregates
- insulations
- plastics
- cosmetics
- sun block
- roofing compounds
- agricultural fertilizers
- electronics
- batteries
- ceramic magnets

MINI MILL STEEL PRODUCTION:



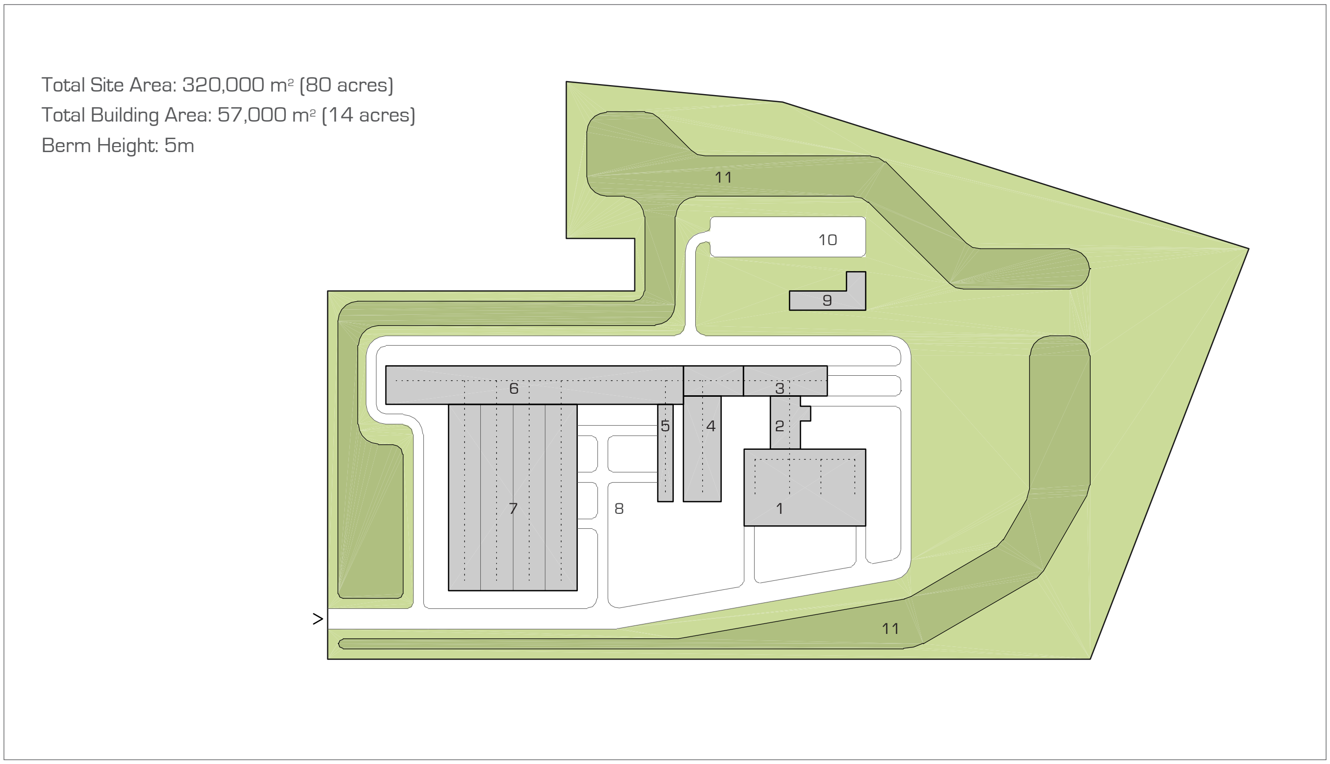
approximately 72% molten iron to produce steel. Molten iron in turn, is produced from blast furnaces, which require iron ore from mines, limestone from quarries, and coal to produce coke from batteries of ovens.

The EAF forms the central component of what is known as a 'mini mill' production model. Although the EAF uses large amounts of electricity to heat scrap, the elimination of toxic coking processes and the near exclusive focus on recycled steel provides mini mills with critical environmental and economic advantages of lower energy and raw material consumption. (For every tonne of steel recycled, there are 1.25 tonnes of iron ore, 0.5 tonnes of coal and about 20 kg of limestone saved.[6]) This suggests great potential for loop closing activities, with respect to iron ore and possibly other materials.

In addition, mini mills are much smaller scale and less capitally intensive due to the elimination of blast furnaces and coke ovens. Despite their size however, these operations are considered highly efficient and high yield. Production capacities are now approaching 1 to 2.5 million tonnes per year with a single furnace.[7] (Compare this to the 2.7 million tonnes produced in Stelco's Hamilton facility in 2002.[8]) Productivity rates of 4000 tonnes per employee are also very attractive in comparison to an integrated production rate of approximately 700 tonnes per employee in 1996.[9] Consequently, steel mini mills have grown from 10% of the North American steel market in 1970[10], to account for approximately one third of global steel production, and over half of North American steel production in 2003.[11]

An illustration of the One Steel plant in Sydney, Australia serves as a case study for typical mini mill operations. This relatively small facility operates a 60 tonne electric arc furnace continuously to produce 500,000 tonnes per year, within 14 acres of buildings on 80 acres of land.[12] Due to its location within a residential suburb, the facility has enclosed all noise generating machinery and constructed a five meter earth berm around the entire operation. In addition, an air monitoring station, a water processing plant and controlled site drainage ensures that emissions are well below required standards.[13] This entire facility efficiently operates relatively undetected by the local

4.6. Major Material + Energy Flows of Steel Production: comparison of older integrated steel production versus mini mill steel production demonstrates the elimination of the iron making processes, as well as associated raw material use and waste creation. Mini mills also allow for 100% recycled material and suggest potentials for a closed production cycle.



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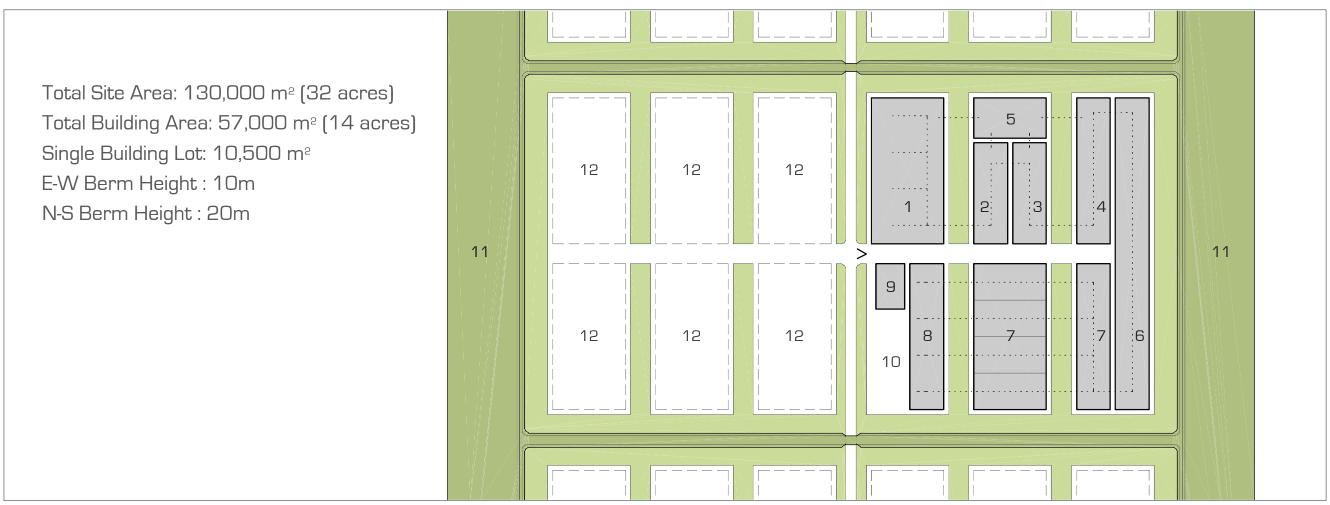


4.8

4.7. Case Study: One Steel Mini Mill: Sydney, Australia
4.8. Proposed Mini Mill Layout

1. Scrap Storage 2. Melt Shop 3. Cast Shop 4. Billet Storage 5. Dust + Fume Collection Plant 6. Rolling Mill 7. Product Finishing 8. Product Storage + Loading 9. Administration 10. Parking 11. Earth Berms 12. Adjacent Expansion Lot

community and clearly demonstrates the potential for unobtrusive industrial production within a populated urban setting.

For the purpose of this thesis, it will be supposed that Hamilton's steel production is reinvented in the model of steel mini mills. Specifically this production method will serve as the primary processor for the design implementation of an industrial ecosystem within the existing Stelco Pier.

The organization of the site into a series of instrumental cells is designed to coordinate several mini mills, and multiple secondary industrial firms, directly or indirectly related to the primary site production. It is assumed that a mini mill operation would be the largest occupant within the ecosystem and therefore the size of one cell is in large part determined in relation to the scale of the One Steel mini mill case study. In particular a cluster of six cells is arranged to accommodate the operations of one equivalently scaled mill. If an industrial firm requires more or less space, expansion to adjacent cells, or a reciprocal contraction to fill fewer cells, is possible.

The layout of the proposal suggests the operation of four such mini mills along the east side of the former pier. The remainder of the project could accommodate multiple supporting operations, to be determined as the industrial ecosystem develops. For the support of steel making, it could be assumed that oxygen suppliers, recycling and sorting facilities would participate. To alleviate problems due to upstream pollution from electricity production, an installation of electrical cogeneration facilities is suggested for the occupation of several cell clusters.

4.3. DESIGN PHASING

The scale, scope and complexity intrinsic to reclamation projects of monumental industrial sites (such as the Stelco Pier) and the construction of large infrastructural urban systems (such as the Instrumental Matrix) necessitates a long-term and phased implementation. Due to the toxic state of the Stelco site, an extensive programme of containment, remediation and filtration must be initiated before further development can occur. Through processes of removal, treatment, and monitoring the stability and health of the site can be determined, while levels of public and private inhabitation are adjusted on an ongoing basis.

The timeline of this project will most likely be structured over a 20 to 30 year period, to encompass multiple overlapping phases of remediation, seeding, infrastructure, programme and ultimately adaptation. Initial containment and intensive remediation would span the first five to ten years, while other more passive strategies will continue through site occupation, for up to thirty years. Amongst this temporal development systems and infrastructures will be implemented, through which complexity can grow and adapt.

REMEDIATION

Prior to any action it is clear that a comprehensive assessment must be undertaken to determine the precise toxicity of the site, and the approach best suited to its remediation. Specific technologies and methodologies must be selected with respect to the exact conditions of soil composition, toxicity, contamination depth, groundwater flow, future site use, construction scheduling, economic constraints and most importantly ecological integrity, public welfare and health.

Although this research is beyond the scope of the thesis, general conclusions can be drawn from the study of adjacent lands and other steel mills. Testing of harbour sediment reveals high levels of organic contaminants (PAHs, PCBs) and inorganic contaminants (toxic metals and mercury)[14] all of which have been found in the remediation of former steel mills. Remediation options are therefore suggested that generally address these known contaminants and project time frames. This framework incorporates issues of containment, short-term ex situ treatment as well as short or long-term in situ treatment, consistent with the methodology, implementation and operation of the project as a whole.

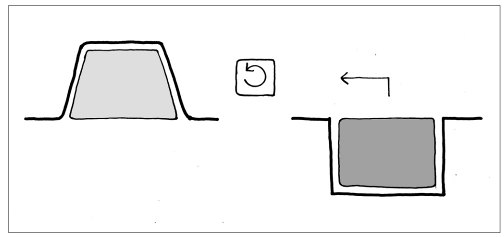
Priority remediation initiatives include the isolation of existing toxins within the site, and a simultaneous removal of excessively toxic soil for onsite treatment. These actions will be coordinated with further manipulation of the pier edge conditions, and future site constructions, such as the reciprocal creation of earth berm structures.

The removal of contaminated sediment from areas such as Randal Reef (a highly toxic coal spill off the western edge of the pier) and the Ottawa Street Slip (a severely degraded inlet at the east edge of the pier) are critical regenerative actions. This excavation will be orchestrated with the construction of the shipping port (inline with the Ottawa Slip) to a depth of about nine meters, and the excavation of the interdigitated edge (in line with the adjacent piers 8 through 15) to a depth of about six meters.

Following the reshaping of the pier, groundwater isolation is achieved through the use of containment walls, to eliminate continued contamination of adjacent lands, harbour waters and other downstream locations. A combination of impervious barriers that arrest or divert water flows, and treatment barriers that passively filter or actively degrade contaminants out of water flows, will be installed to accommodate specific site variables.

The most heavily contaminated soils within the pier will require removal for ex situ treatment within the perimeter of the site. Although public information regarding the contamination of Stelco land is limited at best, it is safe to assume that areas throughout the coal dock (in the northwest corner) will require substantial excavation. The resultant voids there will inform the subsequent construction of water treatment pools.

Other areas throughout the site will require similar immediate in situ and ex situ treatment processes. In particular those areas



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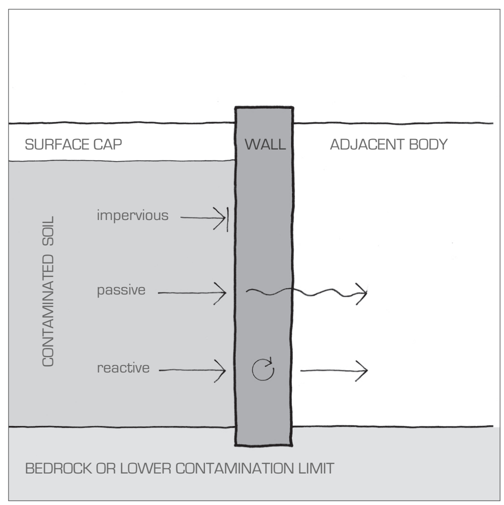


4.10

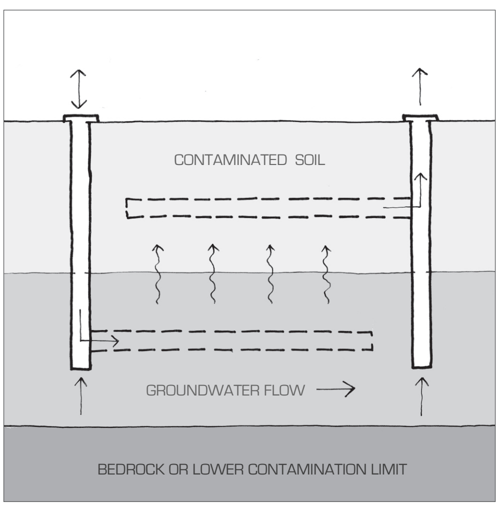
4.9. Diagramatic Earth Berm Construction: material is excavated, treated and redistributed
4.10. Containment Wall Strategies

involved in the obsolete production of iron making, in amongst the coke ovens and blast furnaces, are clearly representative of heavy contamination. Given the long and intensive range of industrial activities on the pier, and the dubious composition of the fill material, extensive testing must be done to determine which areas present imminent health risks. Among the initial treatment technologies employed are:

- Separation – a series of ex situ processes whereby contaminants are detached from the soil through the use of gravity, magnetic forces or other filtering devices (short-term).[15]
- Soil Washing – an ex situ water based process to scrub and remove contaminants from soils by dissolving, suspending or concentrating them in a smaller volume (short-term).[16]
- Soil Flushing – an in situ water based process to extract contaminants through injection or infiltration (short to mid-term).[17]

Alongside these intensive, short-term strategies a series of mid to long-term treatments that involve biological processes will be employed wherever toxicity levels and time frame allow. In order to provide support for a range of technologies vertical and directional wells will be installed as required. These will allow for the extraction and monitoring of groundwater, as well as the injection of fresh air and water. These technologies would include:

- Groundwater Pumping – an in situ process that extracts contaminated groundwater for ex situ treatment, such as in a constructed wetland (depending on treatment process short to long-term).[18]
- Bioventing – an in situ process than injects oxygen through soil at low flow rates to stimulate biodegradation of contaminants (mid to long-term).[19]
- Enhanced Bioremediation – an in situ process to stimulate the activity of naturally occurring microbes. Water based solutions are circulated through soil to enhance the biological degradation of organic contaminants or the immobilization of inorganic contaminants. (mid to long-term).[20]



4.11

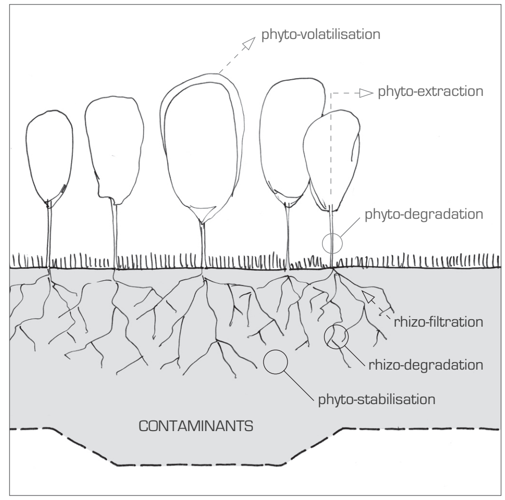
4.11. Vertical + Directional Wells:
allow for monitoring, pumping and treatment of contaminated groundwater

Testing will likely reveal large areas of the Stelco Pier, in which contamination does not pose major health concerns. In cases where this coincides with the construction of public space, long-term ecological strategies such as phytoremediation will be utilized to inform an instructive and interactive approach to remediation. In particular this could include large sections within the western most urban node, and potentially locations throughout the industrial areas prior to occupation.

Phytoremediation represents a series of processes that use plants to stabilize, transfer, remove or degrade contaminants in soil and groundwater through mechanisms of phyto-stabilization, rhizosphere degradation, rhizo-filtration, phyto-degradation, phyto-extraction and phyto-volatilisation.[21] Specifically phyto-extraction (or accumulation) demonstrates good potential for the removal and recovery of heavy metals through planting and harvesting of such plants as Indian mustard and sunflowers. Phyto-degradation (in the plant tissue) and rhizosphere degradation (in the roots) demonstrate potential to metabolize organic compounds such as oils and creosote with plants such as rye and other grasses. In addition plants such as poplar, cottonwood and willow, can provide hydraulic control with respect to the aquifer level and erosion control.[22]

Throughout the remediation phase former industrial structures will be selectively demolished and recycled onsite. Some buildings that do not interfere with construction or remediation activities may remain for transitional use as either production centres or storage sheds. Buildings that intersect with public spaces, and can be reused for either exterior or interior functions will be restored to remain as artefacts. Specifically factory buildings involved in the production of iron and located in the western most urban node will form the nucleus of a new information and cultural centre.

Due to health and liability issues, public use of the pier will remain limited through this phase. Potential for observation may exist via a surface road along the urban edge and a temporary path along the west edge of the pier.

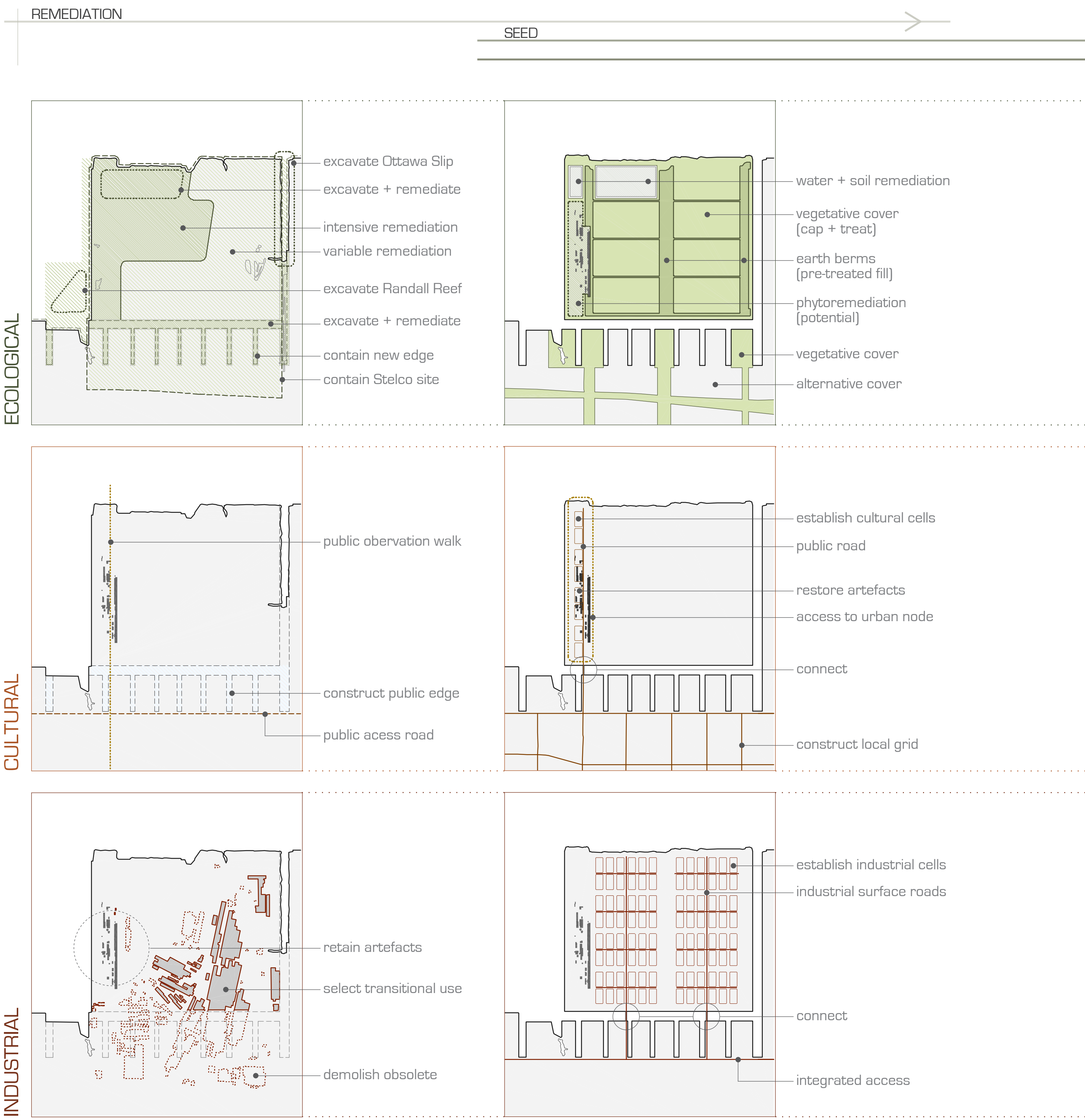


4.12

4.13

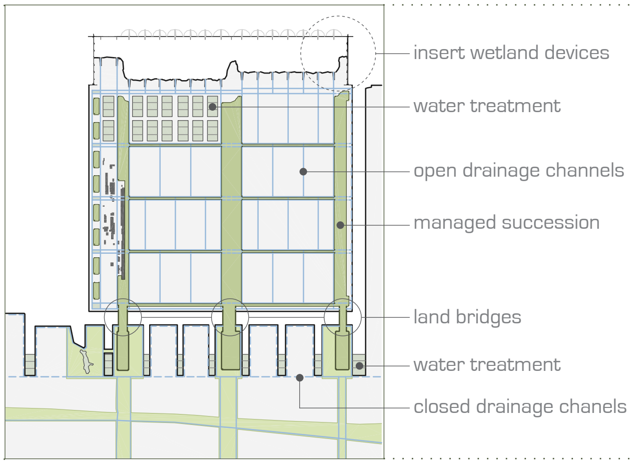
4.12. Basic Phytoremediation Processes:
uses ecological processes to stabilize, transfer, remove or degrade contaminants
4.13. Potential Phytoremediation Site

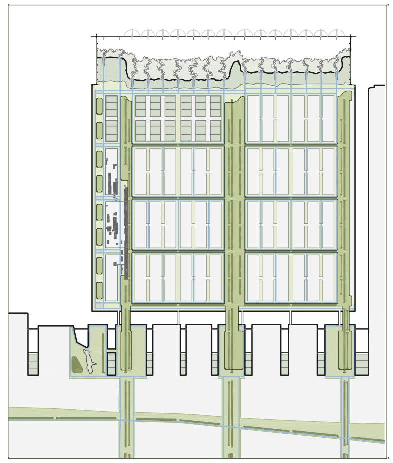
following page:
4.14. Instrumental Matrix Phasing Sequence:
illustrates the structured implementation of remediation, seeding, infrastructural, programming and adaptation phases through a 20-30 year time period.


REMEDIATION
SEED
ECOLOGICAL
excavate Ottawa Slip
excavate + remediate
intensive remediation
variable remediation
excavate Randall Reef
excavate + remediate
contain new edge
contain Stelco site
water + soil remediation
vegetative cover
(cap + treat)
earth berms
(pre-treated fill)
phytoremediation
(potential)
vegetative cover
alternative cover
CULTURAL
public obervation walk
construct public edge
public acess road
establish cultural cells
public road
restore artefacts
access to urban node
connect
construct local grid
INDUSTRIAL
retain artefacts
select transitional use
demolish obsolete
establish industrial cells
industrial surface roads
connect
integrated access

INFRASTRUCTURE

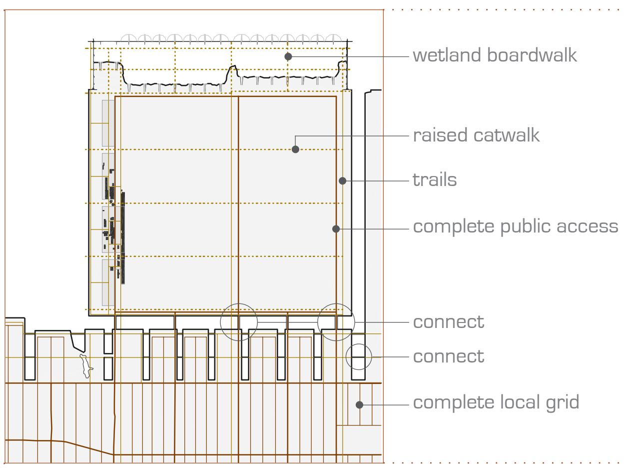
PROGRAMME + ADAPTATION

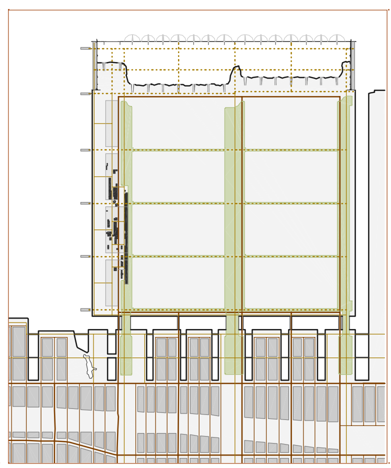




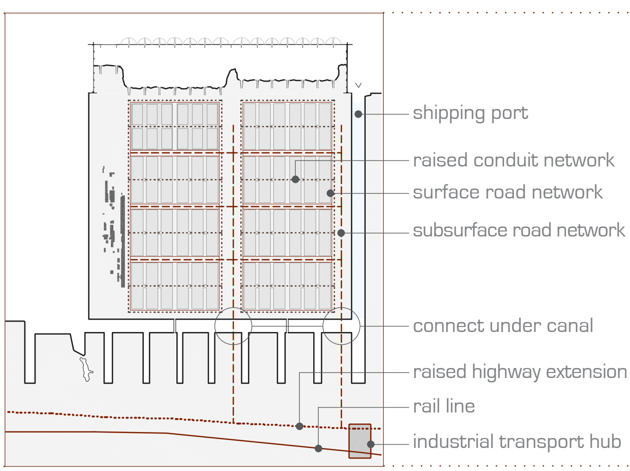
- continued adaptive management
- complex ecosystem development:

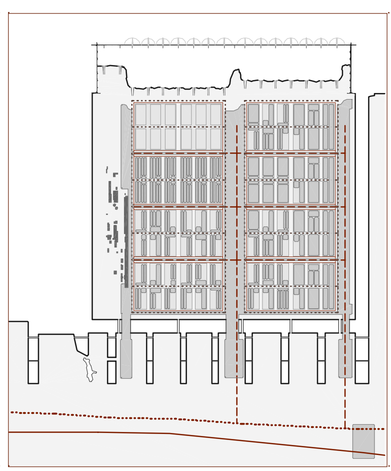
  aquatic
  wetland
  grassland
  savanah
  woodland





- complete public parks, sports fields, markets, etc.
- cultural complex amongst artefacts
- demonstration sites
- mixed used development in piers

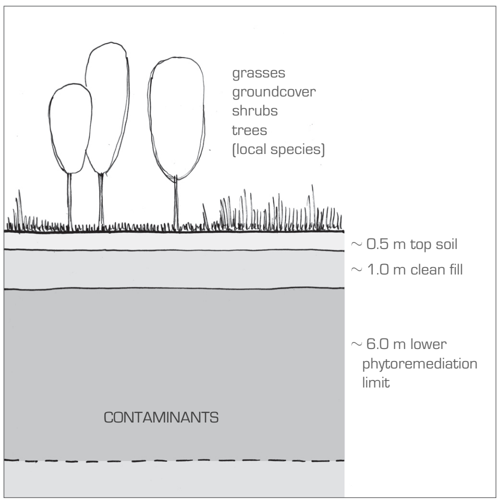




- primary processors (steel mini mills)
- secondary processors (recyling centres, material suppliers, etc.)
- electrical cogneration
- aquaculture + agriculture
- research centres

4.15. Vegetative Cover:
impermeable, long-term self-sustaining barrier that can incorporate multiple remediation strategies
4.16. Ecological Waste Water Treatment:
uses ecological processes to filter and degrade contaminants from water

4.15



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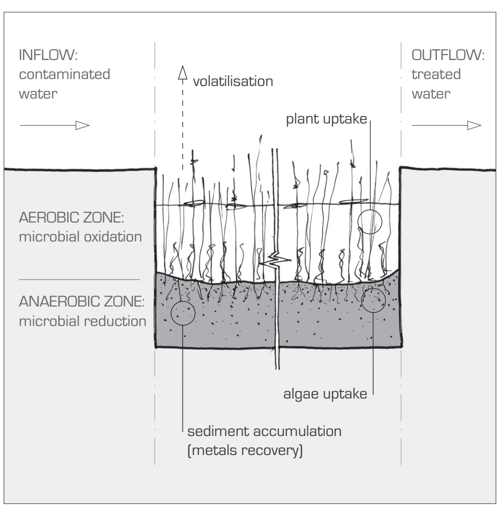


SEED

Following the remediation of excavated soil, the material will be used as clean fill for the substrate of large earth berm structures. Within these structures biological treatments, that include the controlled addition of moisture, heat, nutrients, oxygen and pH, may be employed to enhance the degradation of any remaining contaminants.[23] In addition, this pre-treated material will provide a base (approximately one metre thick) for a long-term vegetative cap applied as a default condition over the entire site. This self-sustaining cover of planted material will create an impermeable barrier that minimizes erosion and isolates any remaining toxins below, to prevent groundwater contamination.[24] Composed of grasses, groundcovers, shrubs and trees (both evergreen and deciduous) with an emphasis on native species, this relatively low cost technology will require minimal maintenance and act as a foundation for processes of managed ecological succession.[25]

Multiple remediation technologies may be incorporated throughout the vegetative cap. Underneath, processes of natural attenuation, whereby dilution, volatilization, biodegradation and adsorption reduce contaminant levels within strictly monitored conditions.[26] Systems of vertical and directional wells are incorporated into the fabric to allow for the monitoring of soil and groundwater and the implementation of various in situ technologies. Within the planted cover phytoremediation processes can be employed to address contamination to a depth of approximately six metres[27] while maintaining the integrity of the barrier. Although this condition will be maintained whenever possible throughout programming of the site, alternative barriers, such as concrete, may need to be explored for future occupations.

An ecological water treatment facility, established in the place of the former coal dock, will serve as a constructed wetland and utilize natural geochemical and biological processes inherent to organic soil, microbial fauna, algae, plants, and micro organisms to filter and degrade contaminants from water.[28] This will service early remediation technologies such as groundwater pumping and soil flushing, and ultimately provide for long-term site operations.

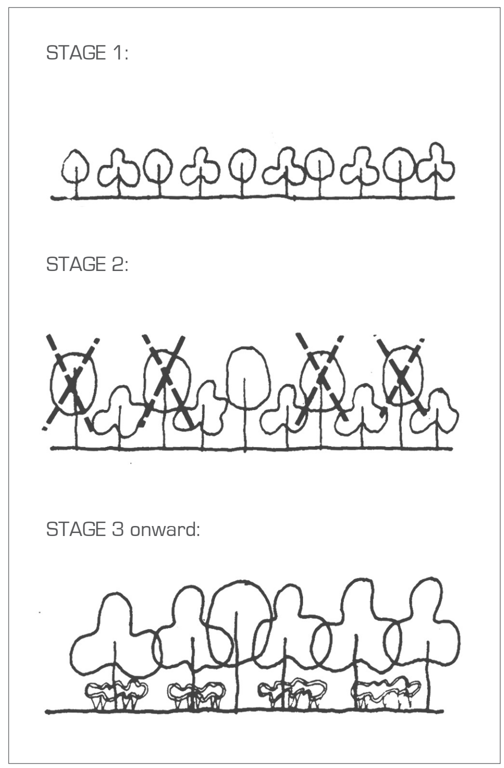
Throughout the early planting phase cultural activity within the site will increase as health risks diminish. The construction of public trails throughout the western node and early occupation of industrial artefacts will serve as the first programmatic elements. Strategies of vegetative caps and phytoremediation will be continued in the planted areas of the urban edge, while new roads and built up areas will be constructed to link to the city fabric.

Final demolition of transitional industrial structures will mark a break with former production methods. Surface roads will be constructed throughout the island to allow for potential early use of instrumental cells within the site.

INFRASTRUCTURE

Following the initial seeding of the site, more complex ecological structures can be implemented and fostered. In this phase the planted tissue throughout the island will be connected to the urban edge via land bridges, to form continuous ecological infrastructure. The addition of both pioneer and climax species will initiate a process of managed ecological succession.[29] Preliminary plantings will function to improve drainage, fix nitrogen, stimulate soil micro-organisms and create conditions favourable for the establishment of complex ecosystems and diverse wildlife habitat.

A system of surface and subsurface drainage channels will be established throughout the island and the urban edge to service surface runoff and pre treated effluent. Constructed as small riparian corridors these channels will both process water and transport it toward the water treatment facility. At the north edge of the island, a series of devices inserted into the landscape will establish a regenerated wetland. This sheltered area will receive clean waters and sediment from the water treatment facility or directly from the drainage channels. As this wetland develops it will form both a repository for greater ecological diversity, and also allow for the processing of cultural and industrial wastewater.



4.17. Managed Succession Reforestation Strategy:
STAGE 1: Establishment - pioneer and climax species mixed (Typical Plant Species: Poplar, Alder, Maple, Basswood, Hemlock)
STAGE 2: Canopy closure and thinning
STAGE 3 onward: Mature climax woodland development (with understorey planting)

Cultural infrastructure will be completed through this phase as public connections are established among the large urban parks or nodes. Vehicular access is provided throughout these spaces and bridged back toward the city. Similarly, a system of public trails and overhead walkways are constructed to provide a finer grain of pedestrian access. Along the urban edge, the new system of piers, surface roads and public parks is connected to the city, while occupation of this new urban fabric is initiated.

The completion of a dedicated tunnel system throughout the island will provide full scale vehicular access to industrial sites. Built concurrently with the earth berm structures, this system will connect to the industrial surface roads at grade and back to the city through underwater tunnels. Construction of the international shipping facility, an industrial transportation hub and larger urban projects, such as the raised highway extension along Burlington Avenue, will initiate connections between the site and larger regional systems. Reciprocally, the completion of raised conduit systems on the island, will allow for internal connections and the initiation of industrial exchange relationships.

PROGRAMME

In the final phase planting programs will continue within a framework of anticipatory and adaptive management to foster the creation of complex ecosystems. The health and integrity of ecological systems will be closely monitored in the context of adjacent industrial and cultural activities.

Completion of public parks, sports fields, public markets and other amenities will allow for full scale public occupation of the site and the initiation of waterfront and outdoor activities. The cultural complex, in and amongst the industrial artefacts, will form the nexus of this activity. Ongoing remediation and site operations will inform the establishment of certain demonstration sites, such as phytoremediation and water treatment gardens.

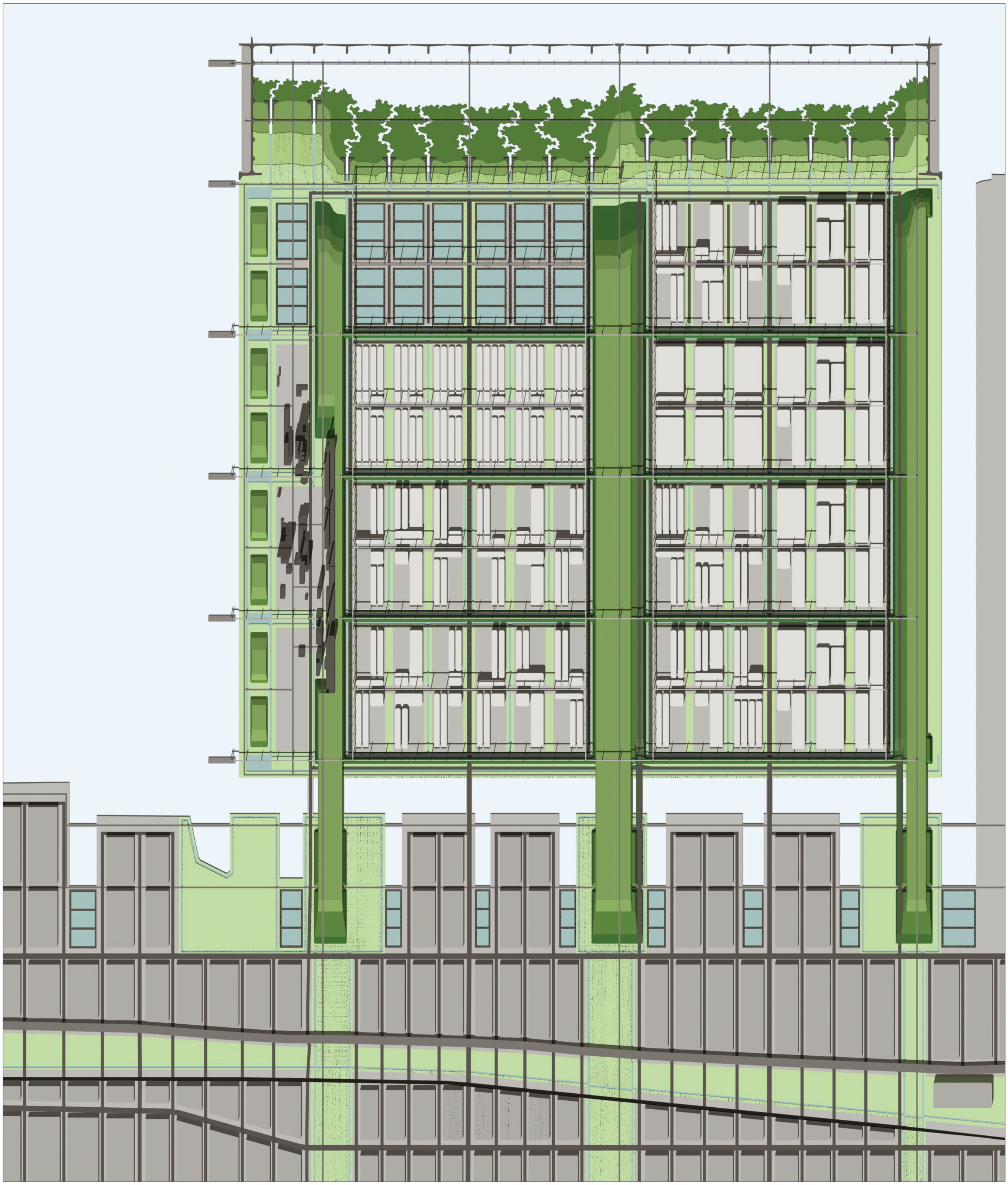
Upon completion of industrial infrastructural systems the proposal will support full scale industrial operations. The installation of primary processors, selected as steel mini mills in this scenario, will initiate the creation of industrial ecosystems. The addition of electrical cogeneration and secondary industrial firms, such as material suppliers and recycling centres, will likely follow shortly thereafter. Later, industrial firms and processes will be added and removed as a more complex industrial ecosystem develops. Among these, ecologically based industries, such as aquaculture and agriculture will be favoured to increase potential for cultural integration.

Research centres to investigate further potential for such processes as phytoremediation, bioremediation and ecological wastewater treatment will be established early in this phase to facilitate operations and growth. Industrial ecology research in particular, will be pivotal during the programming phase to increase potential for complex exchange relationships.

ADAPTATION

The programme phase marks the completed implementation of the Instrumental Matrix. The key to the project's success however, will be ongoing adaptation in the face of local and regional changes with respect to ecological, cultural and industrial systems. To that end, dense and varied ecological structures, along with careful management, are intended to support a delicate balance inherent to natural cycles. Similarly, a wide range of urban spaces, public parks and waterfront amenity are intended to support a stable inhabitation of the surrounding urban fabric with a diverse assembly of recreational, residential, commercial and cultural programmes. The provision of malleable cells within a network of flexible exchange and support systems is intended to allow for a diversity of industrial production, sufficient for economic stability. Reciprocally, a reorganization of industrial programme within these cells, or additions to the highly repeatable infrastructures will accommodate for significant shifts within both local and global markets. Ultimately, the proposal is intended to provide a framework that fosters the development of complex systems. Individual systems will allow for local contingency, while as a collective they maintain site continuity and allow for large system shifts.

4.4. DESIGN ELEMENTS



The design of the Instrumental Matrix is conceived as an interconnected urban strategy composed of various structural and organizational elements. Operational, functional and spatial attributes of each element are first represented individually, followed by an examination of the proposal as a whole.

1. Surfaces
connective tissue
instrumental cells

2. Structures
berms
insertions
artefacts

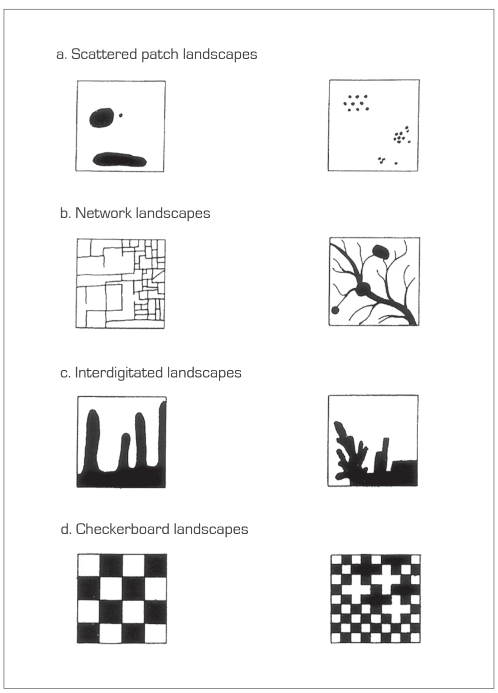
3. Site Flows
water
wildlife
public

4. Service Networks
integrated
dedicated

5. Programme
ecological
cultural
industrial

opposite page:
4.18. Instrumental Maxtrix: Rendered Plan

4.19



4.20

4.19. Typical Leaf Structure
4.20. Patch Ecology Typologies

1A. SURFACES: Connective Tissue

An integral organizational element for the proposal is the formation of a connective tissue. Primary spines or stems of the tissue are accommodated within the urban nodes, and relate to the context of the urban plan. As in the structure of a leaf, vein analogous pathways branch out from three major stems in a hierarchical network that facilitates continuity of cultural and ecological programme. Continuous planting of this element provides a default condition within which a variety of habitats and public function can coexist. This planting also functions as a vegetative barrier between surface water runoff and any remaining contaminated soil underneath.

The expansive and interconnected nature of the connective tissue allows for a large amount of functionality and diversity within its anatomy. For organizational strategies of this territory, landscape ecology provides useful concepts. Patches, defined as a "non-linear surface area differing in appearance from its surroundings"[30], refer to either regenerated ecological habitat or public space. Corridors are the reciprocal links between these areas and represent pathways for movement, services and function. These principles are structured to meet the requirements and objectives of biological aims, such as the ecological infrastructure of the urban plan. They apply equally well however, to urban planning objectives and cultural requirements.

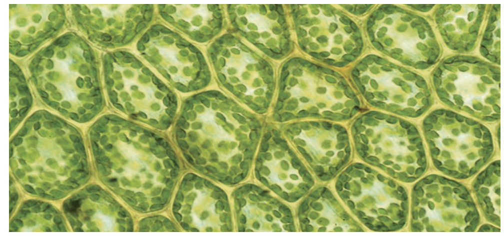
Through seeding and infrastructural phases, wildlife habitat and public function are loosely established with the intention of permitting complex adaptation to take place. Ultimately local needs will determine future development as human participation is limited to observation and minimal management.

1B. SURFACES: Instrumental Cells

The connective tissue is integrally related to its inverse which dictates the division of the site into a base unit or cell. The vegetative planting serves to filter adjacent functions from the populations traveling within it, and as such forms a cell wall or membrane for each unit. Extension of the leaf metaphor equates these areas of the site to a leaf blade: the large flat area that functions to focus sunlight on photosynthetic cells.[31]

The cellular division of the site informs its instrumental nature, as it describes a field of unspecified instrumental cells. Akin to stem cells, these can later be activated to host a variety of functions, inclusive of, but not limited to: soil remediation, industrial production, water treatment, agriculture and aquaculture. These cells are organized in groups of twelve and smaller subgroups, or clusters, of six in order to ease the formation of multicellular organisms. In this way the functions of individual cells can merge to inform more complex processes, such as the operation of a large industrial firm. Further more complex organization, in the form of cell colonies, can develop from the collaboration of groups of individual cells, or groups of multicellular organisms, to describe an industrial ecosystem.

The cells are intended to provide a default condition akin to a fallow field, situated within an extensive service network. Unoccupied they can provide habitat for wildlife and undergo both passive and active remediation. Once occupied they can either host manufacturing processes or processes relevant to the operation of the site as a whole. Location and function are determined in order to best achieve industrial exchange relationships and to foster industrial ecosystems.



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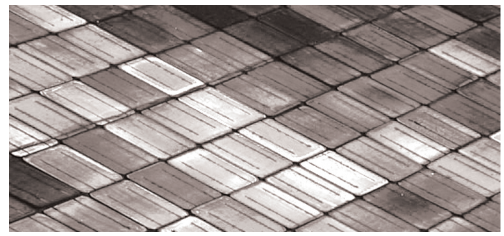

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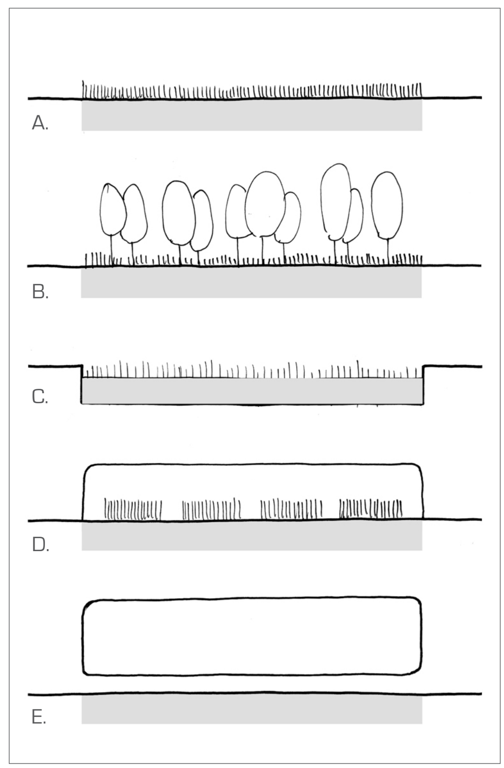
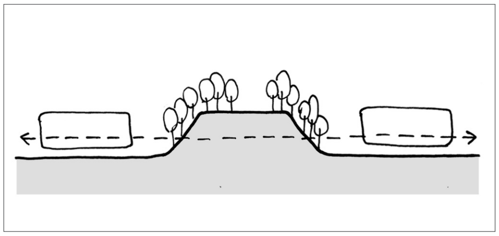


4.23

4.21. Biological Cell Structure
4.22. Synthetic Solar Cell Array
4.23. Instrumental Cells: Possible Variations
A. Vegetative Cap
B. Biological Treatment
C. Water Industry
D. Agricultural Industry
E. Enclosed Industry

2A. STRUCTURES: Berms

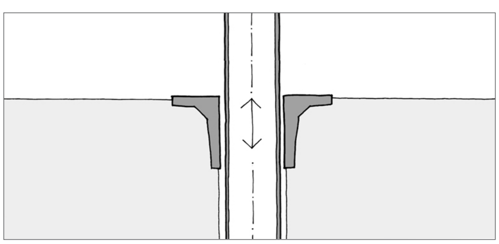


4.24

The creation of incisions at the boundary between the site and the city further shapes the site through a reciprocal creation of large earthworks, or berms. Contaminated material, excavated to provide for a shipping port and cultural piers, is treated on site as per the remediation plan. The treated soil is ultimately redistributed along the paths of the connective tissue to construct a series of multifunctional berm structures. The tissue is connected back toward the urban edge via large land bridges.

The berms help organize a division of programme throughout the site, critical to the operation of the instrumental landscape. Vertical separation allows intensive industrial activity to function in relative close proximity to extensive cultural and ecological activities. Specifically this allows for unrestrained movement of material and energy at the original ground plane, with the use of tunnels and conduit through the mass of the berms. Simultaneously, a system of bridges, plateaus and trails amongst the berms support the movement of people and wildlife through the remainder of the site. They also serve to buffer noise from industrial facilities, and provide wind shelter for the entire site.

2B. STRUCTURES: Insertions



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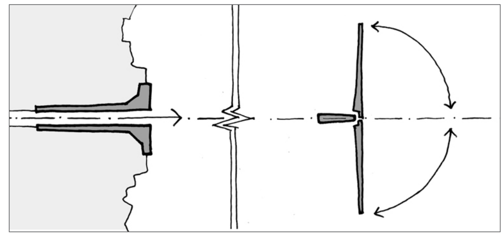
Throughout the proposal various artificial insertions, constructed primarily of steel, dot the landscape. These enable specific operations towards the provision of site functionality and amenity.

An array of post insertions support a network of raised public and private catwalk structures, as well as a raised conduit structure. Designed as a basic truss system composed of HSS steel tubing and tensioned cable elements, the assembly is meant to be cost effective, modular and highly adaptable. The structural system allows for relatively thin and large spans, minimizing intrusion throughout the site, while supporting the insertion of pumps to treat and monitor the groundwater and soil throughout the site.

4.24. Berm Structure:
function is seperated, while connectivity is maintained
4.25. Post Insertions
provide structural support and capacity for instrumental devices

Wetland gate insertions are systematically constructed throughout the regenerated wetland to maintain and control the flow of water and sediment. This gate system is composed of two major elements. The first element maintains open inlets from the new landscape into the wetland, while the second establishes the boundary of the sheltered area, and allows for variable flow between the wetland and the harbour.



4.26

2C. STRUCTURES: Artefacts

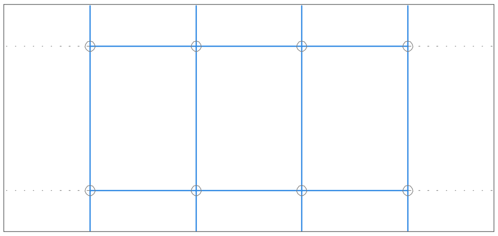
Although many of the existing Stelco facilities are obsolete, several structures will remain as artefacts in public areas where they do not interrupt new functionality of the site.

These structures will persist as spatial markers in the landscape that represent both positive and negative aspects of heavy steel production. Rehabilitated blast furnaces, coke ovens and steel making facilities will stand as a record of historical steel making processes. Both the exterior and interior of these buildings will function in new ways for both recreational and cultural purposes. In several locations raised public catwalks pierce the walls of these structures, and suggest opportunities for public occupation of their volumes.

4.27

4.28

4.26. Wetland Gate Insertions
maintain and control the flow of water and sediment
4.27 + 4.28. Industrial Artefacts
Duisburg-Nord Landscape Park in Emscher, Germany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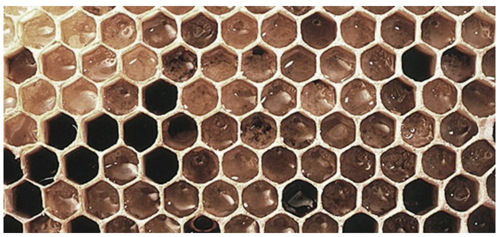
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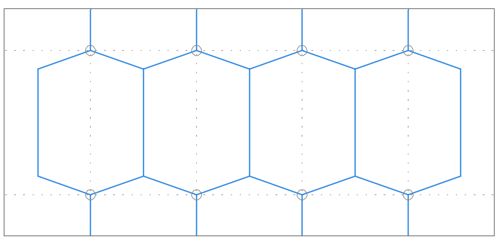

4.31


4.32

4.29. Direct Flow Path Drainage Diagram
4.30. Honeycomb Structure
4.31. Increased Flow Path Drainage Diagram
4.32. Drainage Channel as Riparian Corridor

3A. SITE FLOWS: Water

The site drainage strategy reasserts the direction of pre-settlement water flow that originates above the Niagara Escarpment, disperses through the Iroquois Plain below and discharges at the harbour shoreline. Storm water from the city is redirected to large wastewater treatment facilities through conduit or planted channels, as outlined in the urban plan. In the specific site implementation smaller scale wetland treatment tanks are inserted into the urban edge to foster decentralized treatment.

Drainage of the proposed island is achieved through channels carved into the impermeable vegetative cap. Strategic gradients are constructed to direct water through a honeycomb pattern that establishes long flow paths. The creation of riparian vegetation along these paths increases the filtering and treatment capacity of the site and allows for wildlife habitat. This water flow can be directed through a series of large treatment reservoirs, inserted into the former coal dock, to store and improve water quality.

Depending on contamination levels, the site drainage water can flow through a variable number of treatment tanks until specific quality standards are met. Any waste water remaining from industrial production may also be added to this flow, under strict contaminant guidelines. Alternatively, areas of the site can drain directly into the regenerated wetlands to rely on its treatment capacity, and thereby re-establish the drainage patterns which created the once prolific wetlands throughout Hamilton Harbour.

3B. SITE FLOWS: Wildlife

Corridors of vegetation improve the connectivity and circulation within the site and link it to larger ecological systems. These in combination with ecological patches allow for wildlife flows to migrate and drift through the site as complex ecosystems self organize with a minimum of human interaction. Although multi-functional, the central and eastern most berms are established primarily for the support of native plant life and wildlife flows.

These help to ensure connections through the proposal, into areas of diverse wetland habitat, and on toward the aquatic habitats and the resource of the harbour.

3C. SITE FLOWS: Public

Although the site is conceived as a distinct and unique urban condition, its success is dependant on its connection to the city. The primary objective for public access is to improve circulation from the city, through the island, to the regenerated wetland. North-south axes, asserted in the urban plan, are extended past the urban edge to bridge into each node, providing vehicular access to all public areas of the site. Pedestrian and cycling trails provide a finer grain of access consisting of smaller bridges among the urban edge, as well as access to parks, fields, wooded and wetland areas throughout the site.

Raised maintenance catwalks, some of which are open to the public, are placed level with the top edge of the largest berms at a height of approximately 15 metres. These serve to connect the major public spaces of the urban nodes across and above intensive industrial processes. Crossings run in line with secondary or transverse berm structures, are sheltered by plantings below, and do not interfere with industrial operations.

The walkways allow the public a protected view of the instrumental cells. Public access is located along the top of the berms and from public stairs located in the western, most public node. The system is modular and can be readily extended to a cell activated with public function. The catwalk system connects to similar raised paths that run just above the regenerated wetland, and suggest a public participation in ecological processes.

4.33

4.34

4.35

4.33. Local Vegetation and Wildlife Corridors
meadow above Albion Falls, Hamilton
4.34. Wildlife Inhabitation
4.35. Public Catwalks
elevated walkways through Park de la Villette

4A. SERVICE NETWORKS: Integrated

As with public connections to the city, connectivity of industrial flows, internal and external to the proposal, are critical to successfully foster desired industrial exchange relationships. Of two fields of instrumental cells, split by the central berm, each is serviced by a hierarchical system of integrated surface roads.

On each field three north-south axes provide vehicular access along the length of the site, and link to unidirectional roads that circle each cell cluster. This system is intended to establish connections among cells within the island, as well as to the city through a series of bridges. The central axis on each field also connects to laneways that split cell clusters, and provide an internal spine and administrative access.

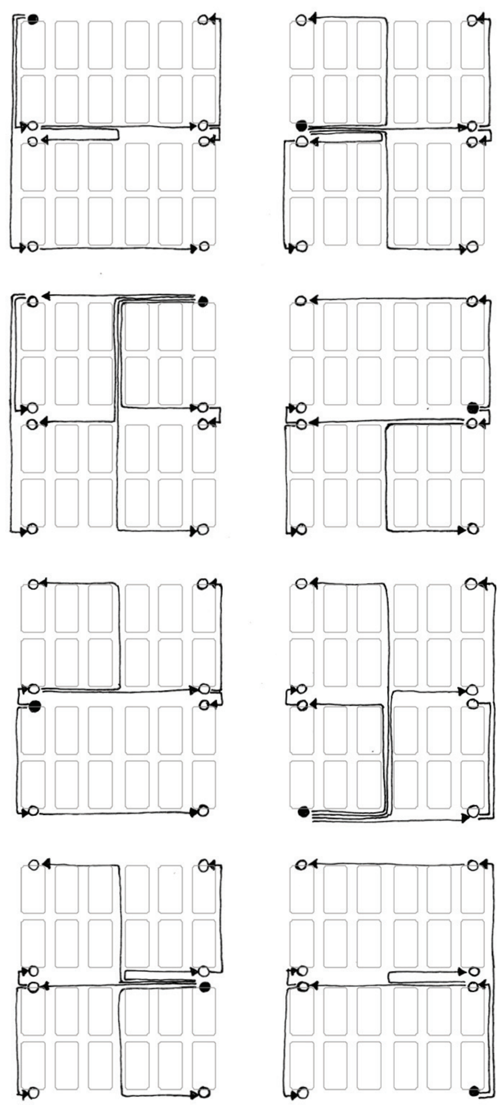
The network of raised conduit facilitates the generation of exchange relationships among the instrumental cells. The steel truss structure, integrated with public walkways, provides flexible and accessible spaces for the transport of matter and energy in such forms as gas, steam, water, heat, electricity and information.

Connection to this system can be accomplished horizontally at a height of approximately 30 metres, or vertically through the steel post insertions that provide underground connections points for every cell. Access to a service catwalk that runs above the conduit is found at key locations. Adjacent to this catwalk, an array of solar cells generate power necessary for operations or maintenance related to the conduit, as well as all public site lighting.

4B. SERVICE NETWORKS: Dedicated

Industrial operations demand efficient transportation in and out of the city. To facilitate both regional and local transfer of large materials and products, dedicated routes connect to the integrated road system at regular intervals and effectively link all cell clusters to Hamilton and regions beyond. These roads direct heavy traffic flow through tunnels within the berms, enabling vehicles to travel unimpeded at existing grade level through much of the site. To connect to the city the dedicated routes tunnel under water, toward the city, and link with local roads.

The central shipping port, established to the east of the island, acts as an infrastructural spine. This international facility is connected to the island and the city via the dedicated road system and is augmented by a rail line. A direct connection to a transportation hub within the city links the port to regional highways and railway lines.



4.36. Vehicular Movement Score of Service Network
Eight locations, within an assembly of four cell cluster, are taken as representative of embarking points for industrial material and energy exchange. Paths are traced from each of these to all of the others in accordance with design of proposed traffic patterns.


4.37


4.38


4.39


4.40

4.37. Aquatic Ecology
4.38. Wetland Ecology
4.39. Grassland Ecology
4.40. Savanah Ecology

opposite page:
4.41. Landscaped Trail Among Industrial Artefacts
Duisburg-Nord Landscape Park in Emscher, Germany
4.42. Water Treatment + Aquaculture Tanks
4.43 + 4.44. Industrial Structures
factory buildings by Nicholas Grimshaw & Partners

5A. PROGRAMME: Ecological

The use of ecological programme in the proposal is multi functional. Its design is structured to promote ecological diversity, act as an environmental filter for people and wildlife and provide instrumental infrastructure for industrial and remediation processes. Toward the goal of diversity a variety of wildlife habitats are seeded to foster unique ecosystem development, such as wetlands, riparian stream beds, grasslands, savannahs, meadows and woodlands.

Berms and land bridges function to establish and buffer habitat from other aspects of the site. They stitch ecological patches together, while acting as the substrate for many ecological corridors. Cultural counterparts to these habitats, intended to provide public amenity, can also serve as patches and corridors for wildlife function. Parks, landscaped paths, trails, roadway swales, and landscaped streets can be included among these programmatic elements.

Finally, the instrumental capacities of ecological materials are utilized to aid in the regeneration of the site through phytoremediation plots and vegetative caps. Similarly, drainage channels and treatment wetlands use ecological functionality to facilitate the ongoing operation of the site as a whole.

5B. PROGRAMME: Cultural

Public use is meant to pervade the urban nodes of the proposal. The densification of specified cultural programme however, decreases toward the regenerated wetland. In addition the majority of specified programme resides within the most public western node. A network of public trails and access roads weave all public elements and spaces together to promote spontaneous use of the site and future adaptations.

Exterior programming consists largely of park space. Included are designations for exercise circuits, sports fields and water parks. A public market space and facilities, public docks, as well as picnic areas, pavilions and park furnishings provide further outdoor public amenity.

A cultural complex is established amongst the existing industrial artefacts. Specific programmes are adopted around the exterior of certain artefacts, including rock climbing walls and outdoor performance spaces. To fill the need for interior programme some artefacts are redefined as exhibition and gallery spaces, while performance spaces, restaurants and sports facilities fill others. Remaining structures serve as spatial markers and monuments of past industries.

Specific instrumental areas within the cultural urban node act as education and information sites, to help the public glean insight into industrial activities and site processes. In particular demonstration gardens are established for the operation of phytoremediation and water treatment facilities.

4.41

5C. PROGRAMME: Industrial

The proposal is ultimately designed to operate within a range of scenarios. Regardless of occupants certain industrial programmes are established to attend solely with the functionality of the site. Soil and water treatment, and reciprocal research centres, are exclusively concerned with remediation and maintenance of the site. A large shipping facility and the suggestion of electrical cogeneration facilities are similarly concerned with overall site operation.

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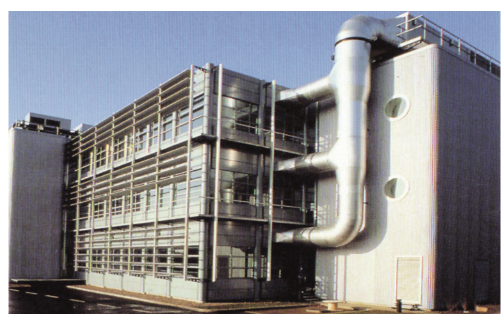


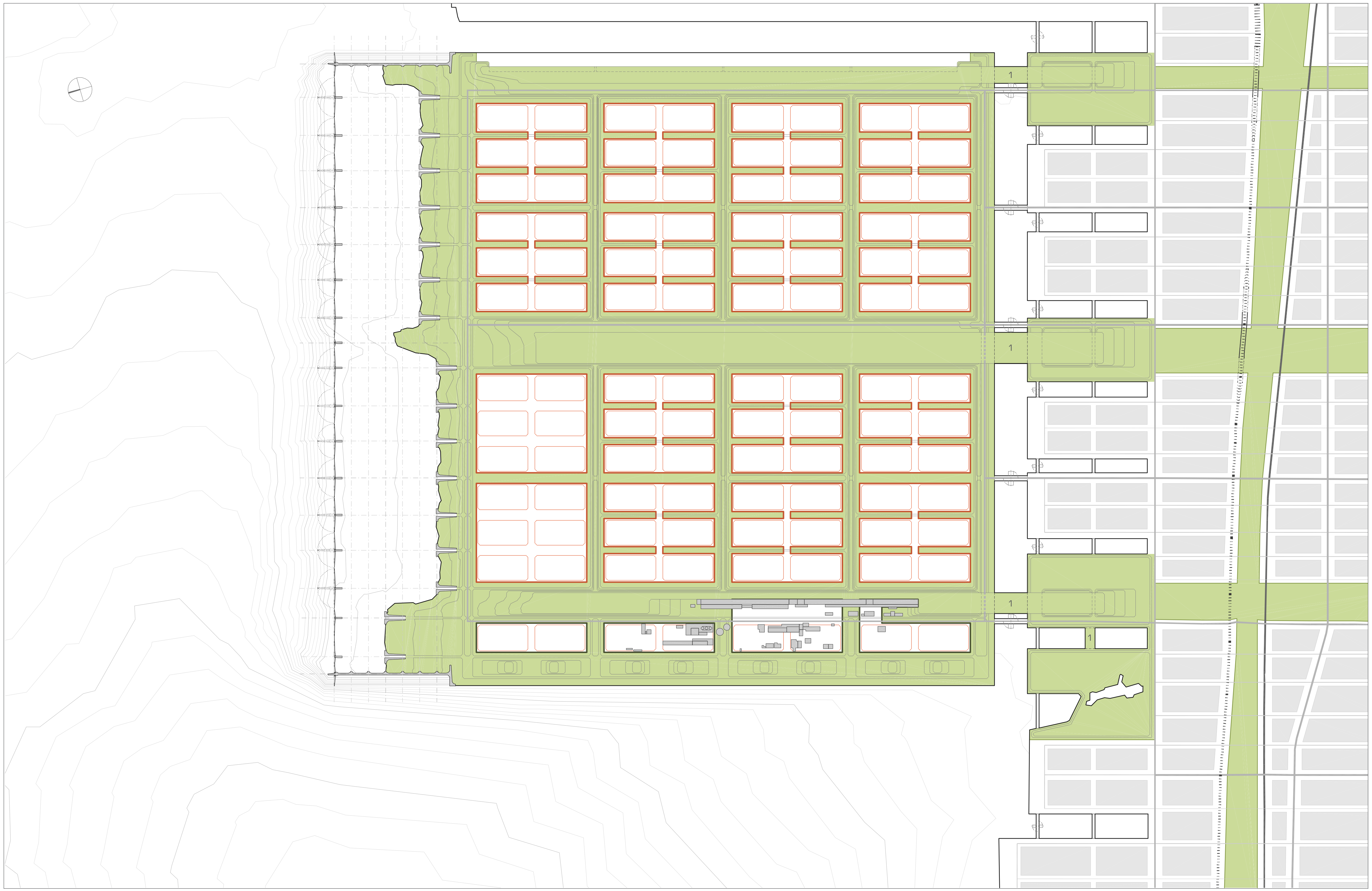
4.43

In order to foster an industrial ecosystem it is clear that primary and secondary producers will be required. It has been established that initial conditions suggest the selection of steel mini mills as primary producers. In this scenario firms such as recycling facilities, and other material suppliers could operate as secondary producers. Other cell clusters, closer to cultural programme, could be occupied by agricultural and aquacultural industries. In order to stimulate and foster these exchange relationships an industrial ecology research centre and a matter and energy exchange facilitation center are established within the industrial transportation hub. It is important to emphasize however, that a multitude of possibilities exist for both this and alternative scenarios.

4.44

4.5. DESIGN IMPLEMENTATION

4.45. Instrumental Matrix
Site Axonometric: directed south-west



4.46. Instrumental Matrix Plan (Scale 1:12,500)

1. SURFACES: Tissue + Cells

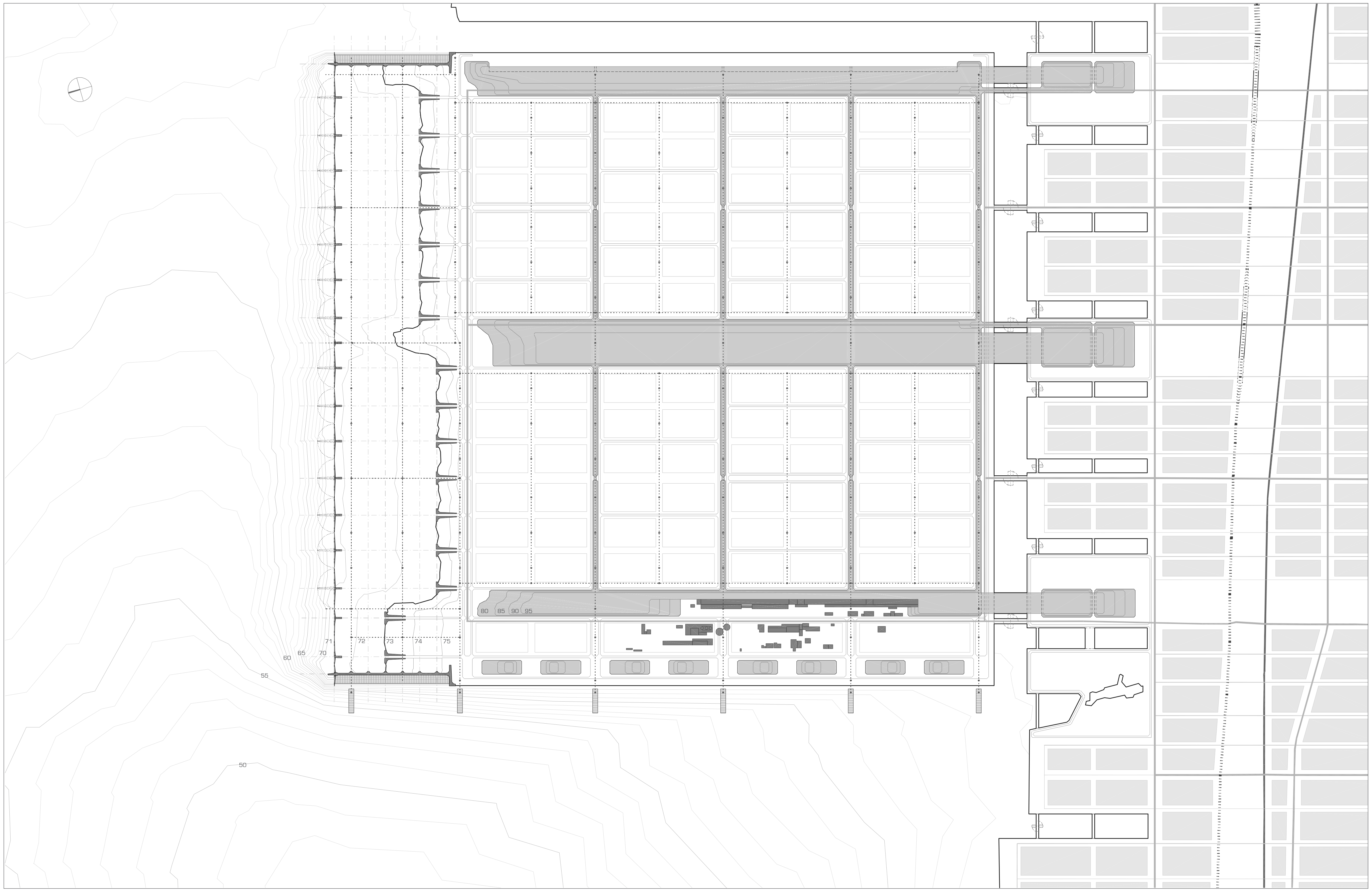
Connective Tissue

Instrumental Cells

Cultural Cell Clusters

Industrial Cell Clusters

1. Land Bridge



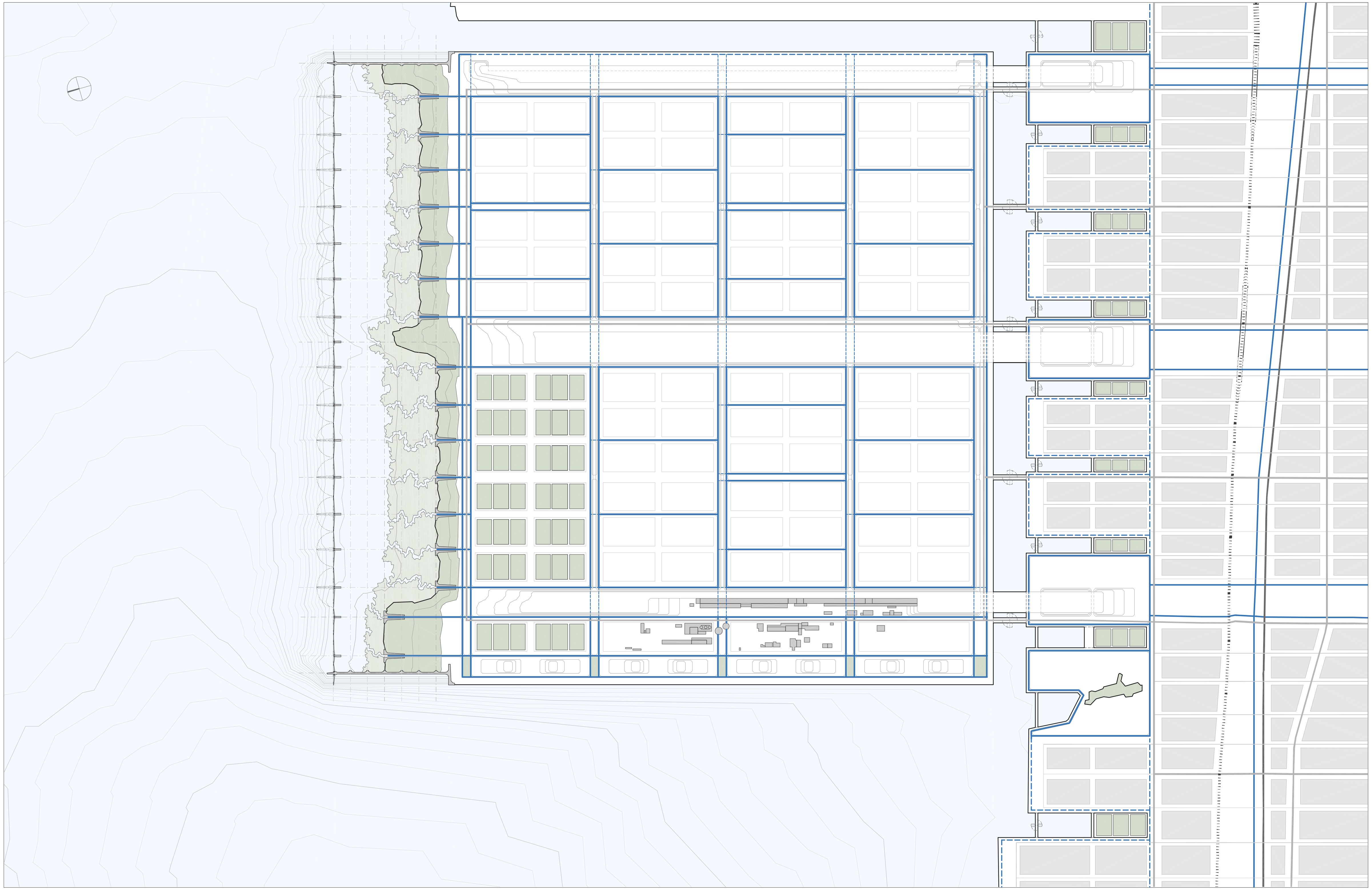
4.47. Instrumental Matrix Plan (Scale 1:12,500)

2. STRUCTURES: Artefacts, Berms + Insertions

Artefacts

Berms
Contour (above water line - 5m interval)
Water Line (73m)
Contour (below water line - 5m interval)
Contour (below water line - 1m interval)

Wetland Containment Structure
Wetland Gate
Wetland Flow Management
Raised Infrastructure

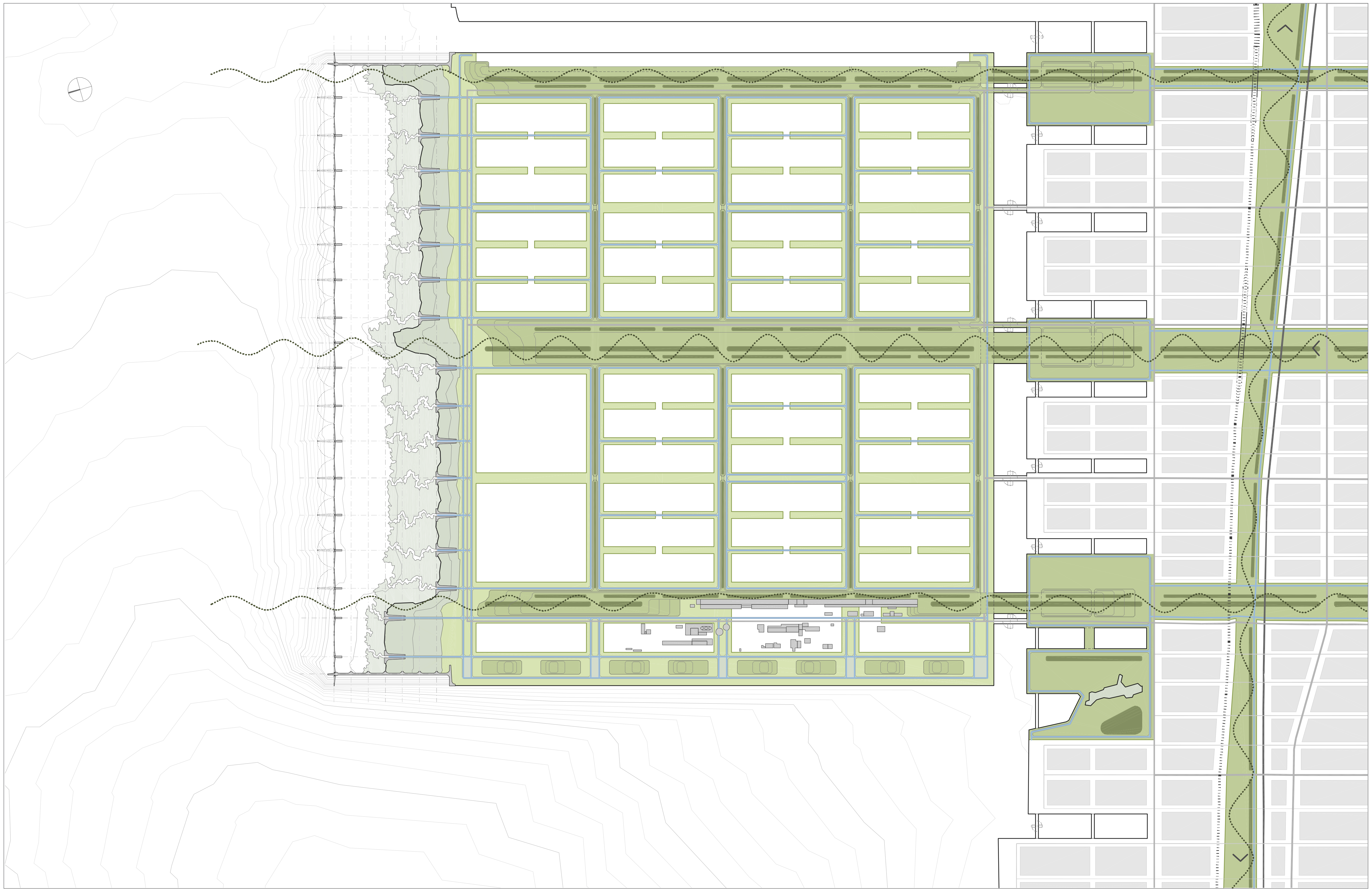


4.48. Instrumental Matrix Plan (Scale 1:12,500)

3A. SITE FLOWS: Water

Regenerated + Constructed Wetland
Emergent Wetland Ecology

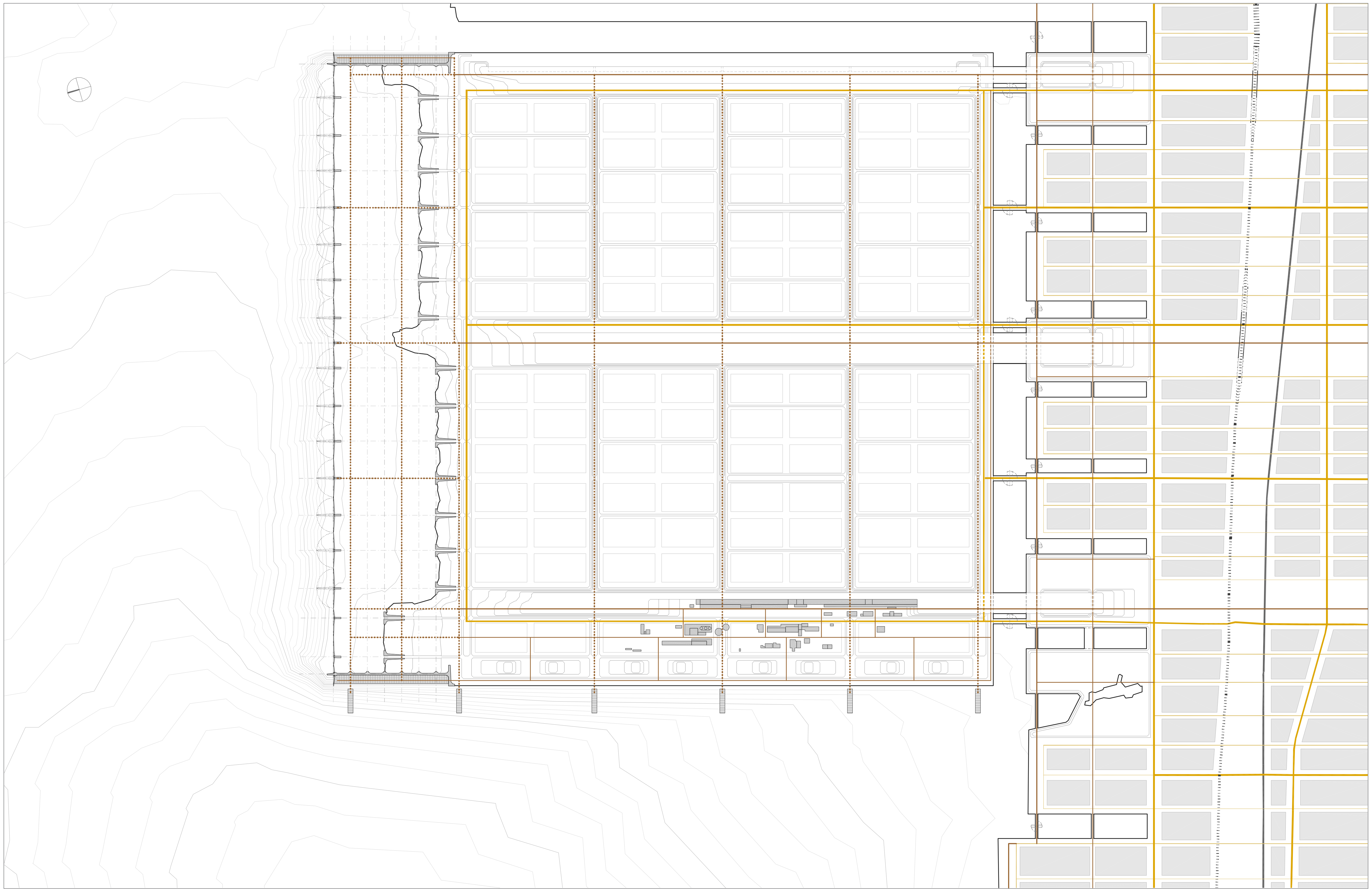
Drainage Channels
Channels (under or below)



4.49. Instrumental Matrix Plan (Scale 1:12,500)

3B. SITE FLOWS: Wildlife

- Aquatic Habitats
- Wetland Habitats
- Water Course Habitats
- Grassland Habitats
- Savanah + Meadow Habitats
- Woodland Habitats
- Wildlife Gradient Flows
- General Flow Direction

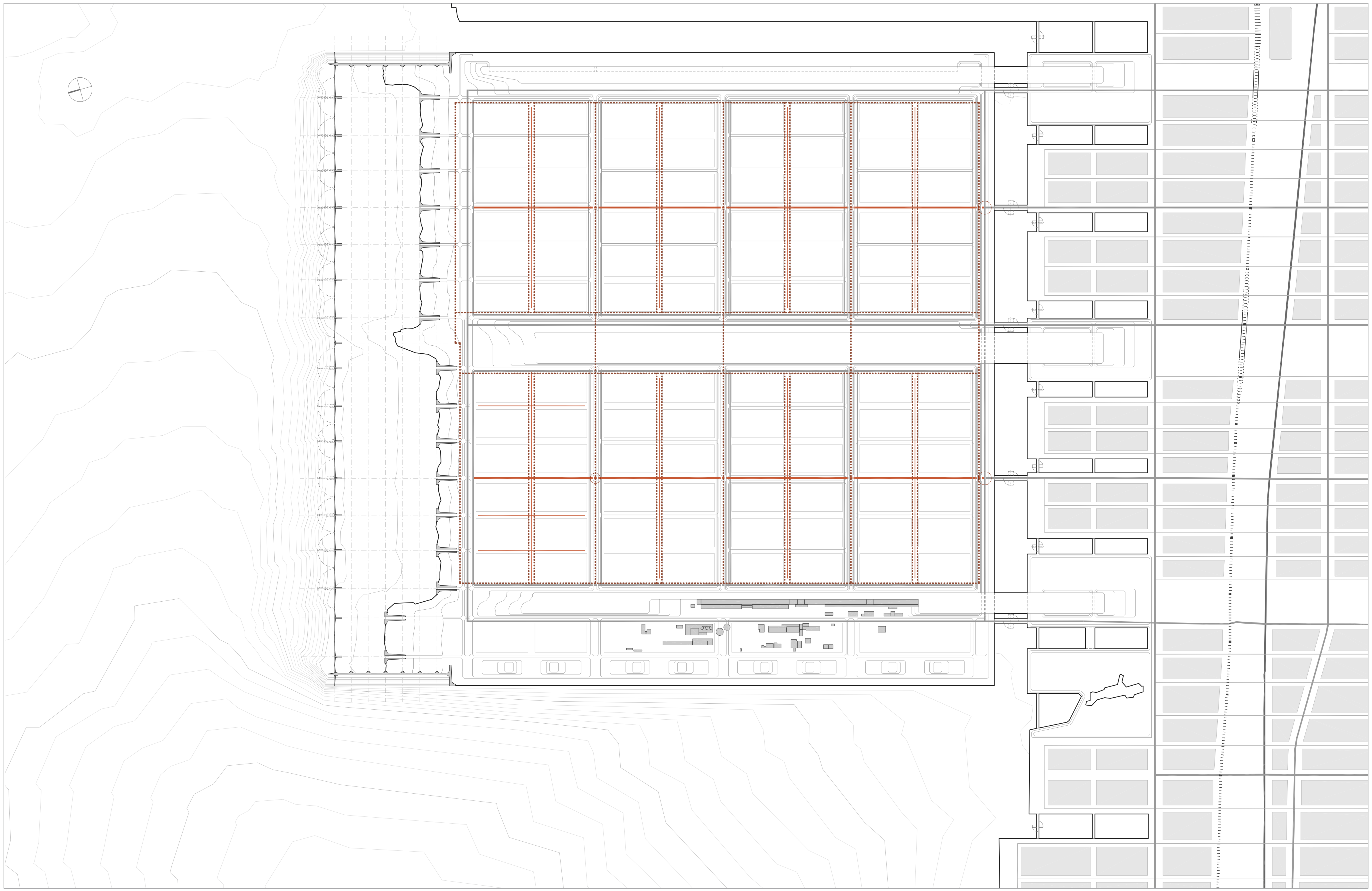


4.50. Instrumental Matrix Plan (Scale 1:12,500)

3C. SITE FLOWS: Public

- Raised Walkways
- Public Trails
- Public Trails (below)
- Primary Public Road
- Primary Public Road (below)
- Secondary Public Road
- Raised Highway + Surface Road

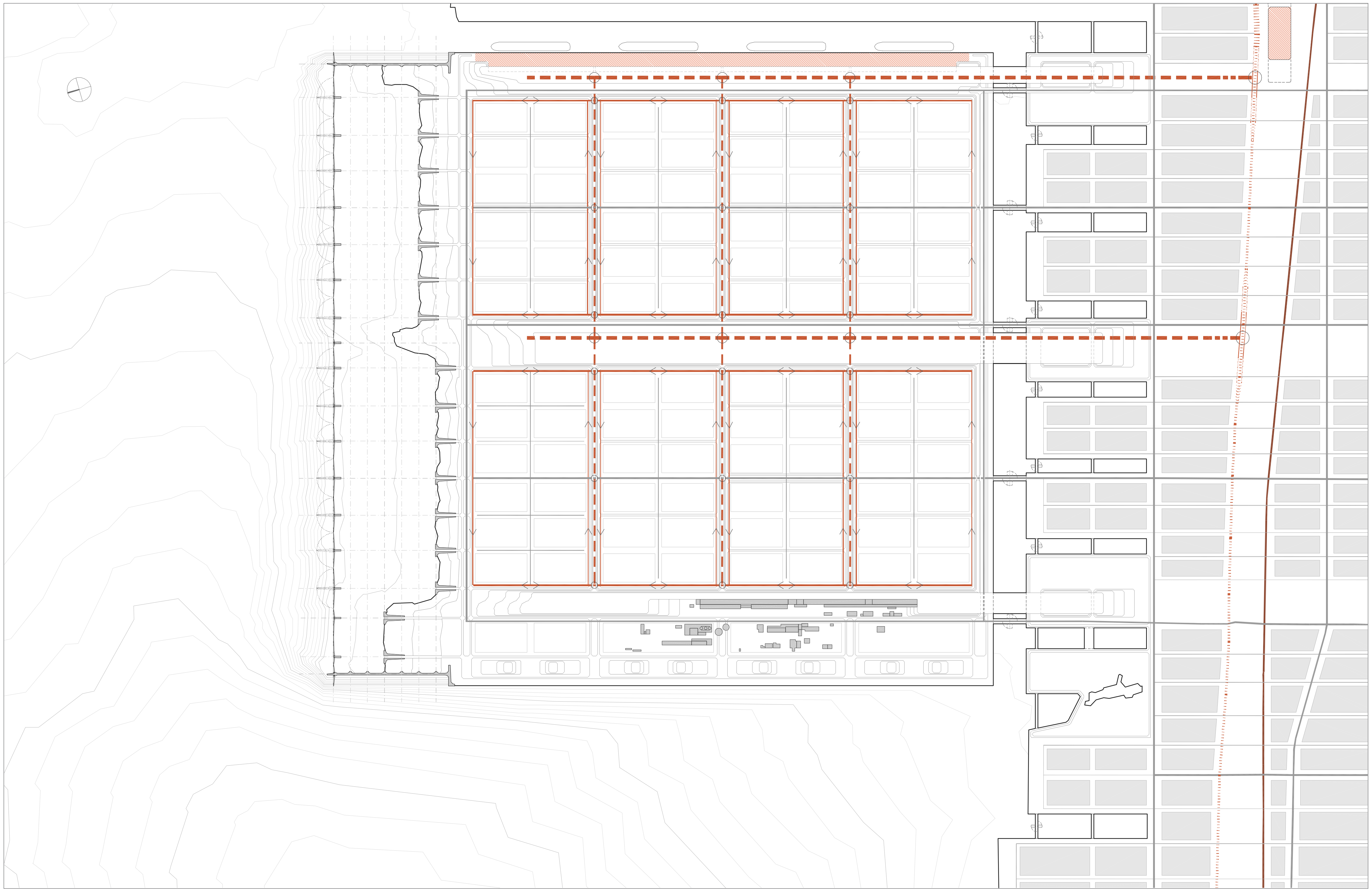
- Vehicular Bridge (operable)
- Pedestrian Bridge (operable)



4.51. Instrumental Matrix Plan (Scale 1:12,500)

4A. SERVICE NETWORKS: Integrated

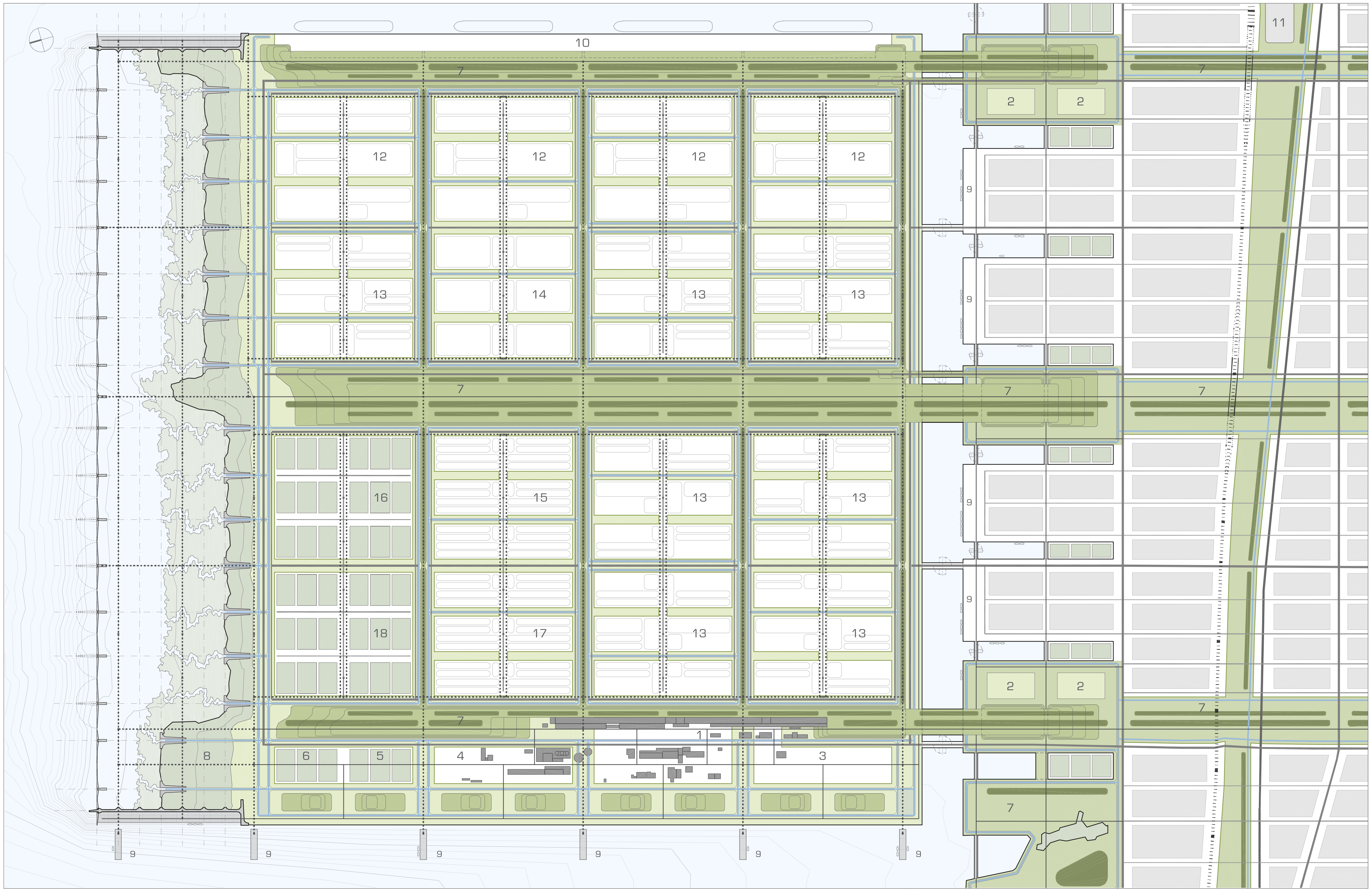
- Primary Integrated Road
- Primary Integrated Road (below)
- Secondary Integrated Road
- Public - Private Link+ Checkpoint
- Raised Integrated Conduit System
- Raised Highway + Service Road



4.52. Instrumental Matrix Plan (Scale 1:12,500)

4B. SERVICE NETWORKS: Dedicated

- Primary Bi-directional Road
- Bi-directional Road (under)
- Secondary Uni-directional Road
- Uni-directional Vehicular Flow
- Bi-directional Vehicular Flow
- Link to Dedicated Tunnel System
- Primary Dedicated Roads (within berms + port incisions)
- Secondary Dedicated Roads (within berms)
- International Shipping Port + Related Facilities
- Raised Highway + Service Road
- Highway Ramp
- Pimary Rail Line



4.53. Instrumental Matrix Plan (Scale 1:10,000)

5. PROGRAMME: Composite

ECOLOGICAL PROGRAMME

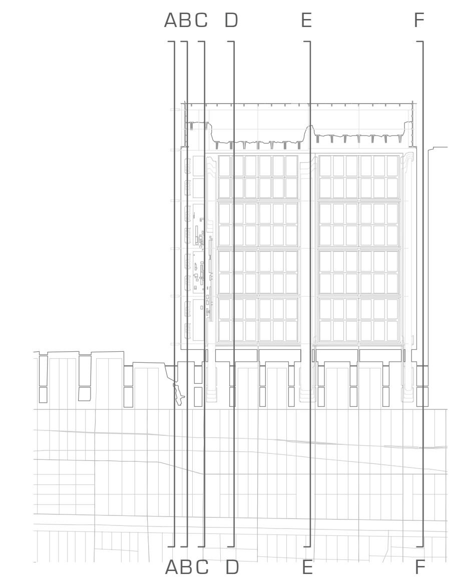
- Aquatic: Deep Water Ecologies
- Aquatic: Shallow Water Ecologies
- Wetland: Regenerated + Constructed
- Wetland: Riparian Streams + Swales
- Terrestrial: Grassland Ecologies
- Terrestrial: Savannah + Meadow Ecologies
- Terrestrial: Woodland Ecologies
- Berms +Land Bridges

CULTURAL PROGRAMME

1. Cultural Complex (among industrial artefacts) includes: indoor + outdoor performance space, exhibition + gallery space, planted boulevards, restaurants, cafes, restrooms, sports facility, rock climbing facility, picnic areas, pavillions + park furnishings
2. Sports Fields
3. Public Market Space
4. Phytoremediation Demonstration Gardens
5. Water Treatment Demonstration Gardens
6. Water Park
7. Public Park
8. Wetland Trail System
9. Public Dock

INDUSTRIAL PROGRAMME

10. International Shipping Facility
11. Industrial Hub + Research Facility includes: transportation hub, industrial ecology research centre, material + energy exchange facilitation centre
12. Primary Materials Producers: illustrates potential steel mini-mill layout within four seperate cell clusters
13. Additional Industrial Firms: illustrates various speculative factory layouts that could include fabricators, suppliers, waste processors, and secondary materials producers within a single cell or entire cell cluster
14. Electrical Cogeneration Facilities
15. Soil Treatment + Research Facilities
16. Water Treatment + Research Facilities
17. Agricultural Industries includes: farming + nursery operations
18. Water Based Industries includes: fish + plant aquaculture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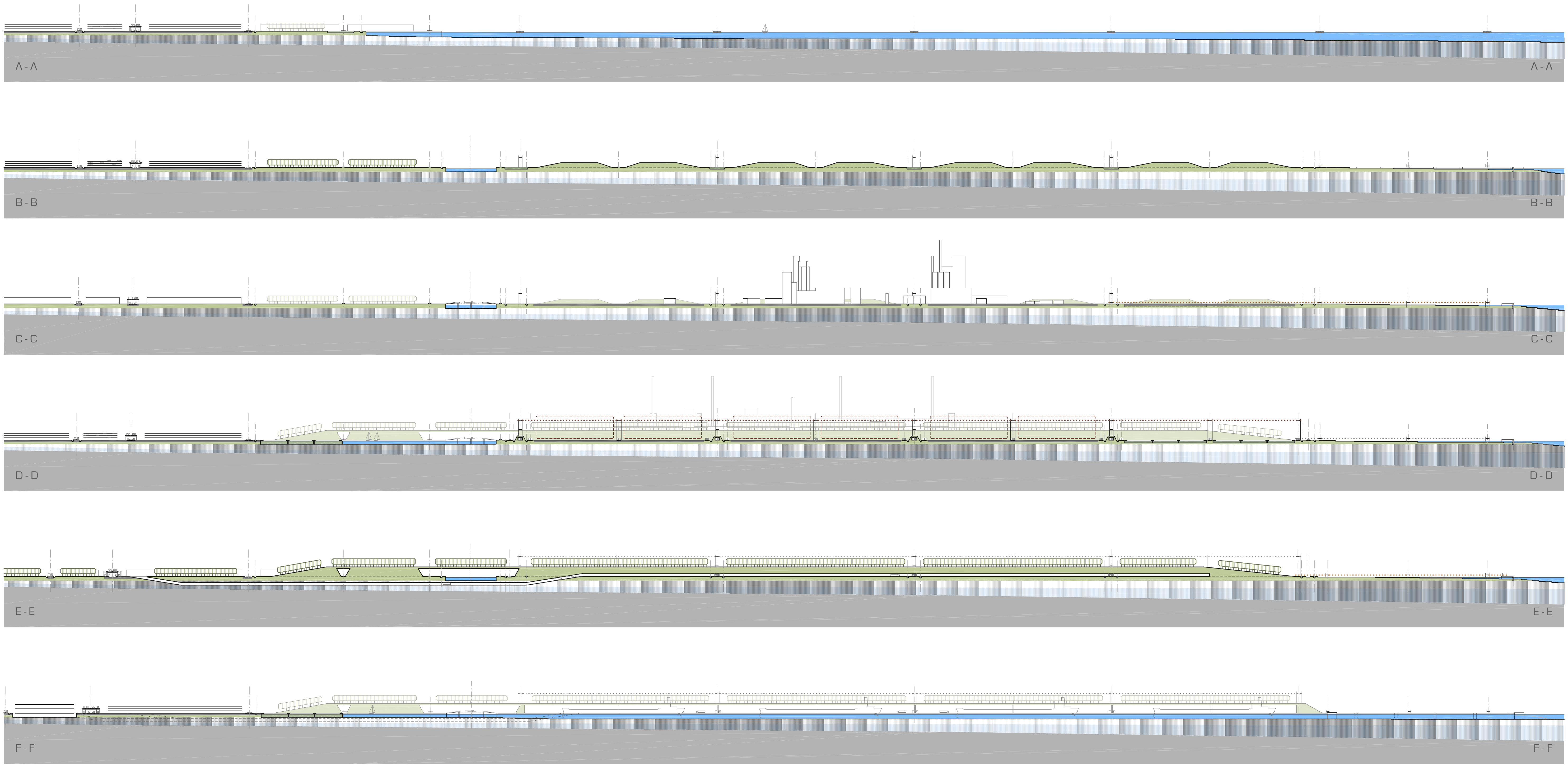
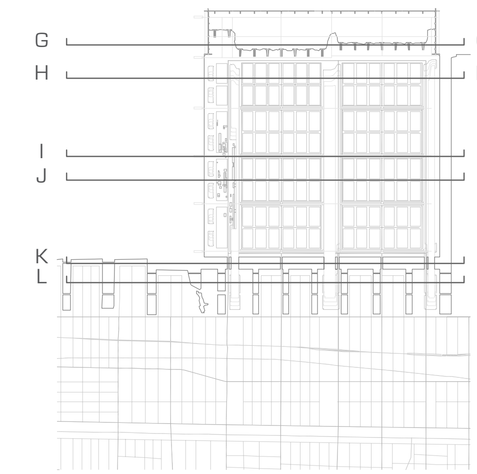
ABC D E F

4.54. Instrumental Matrix (Scale 1:7,500)

North - South Site Sections

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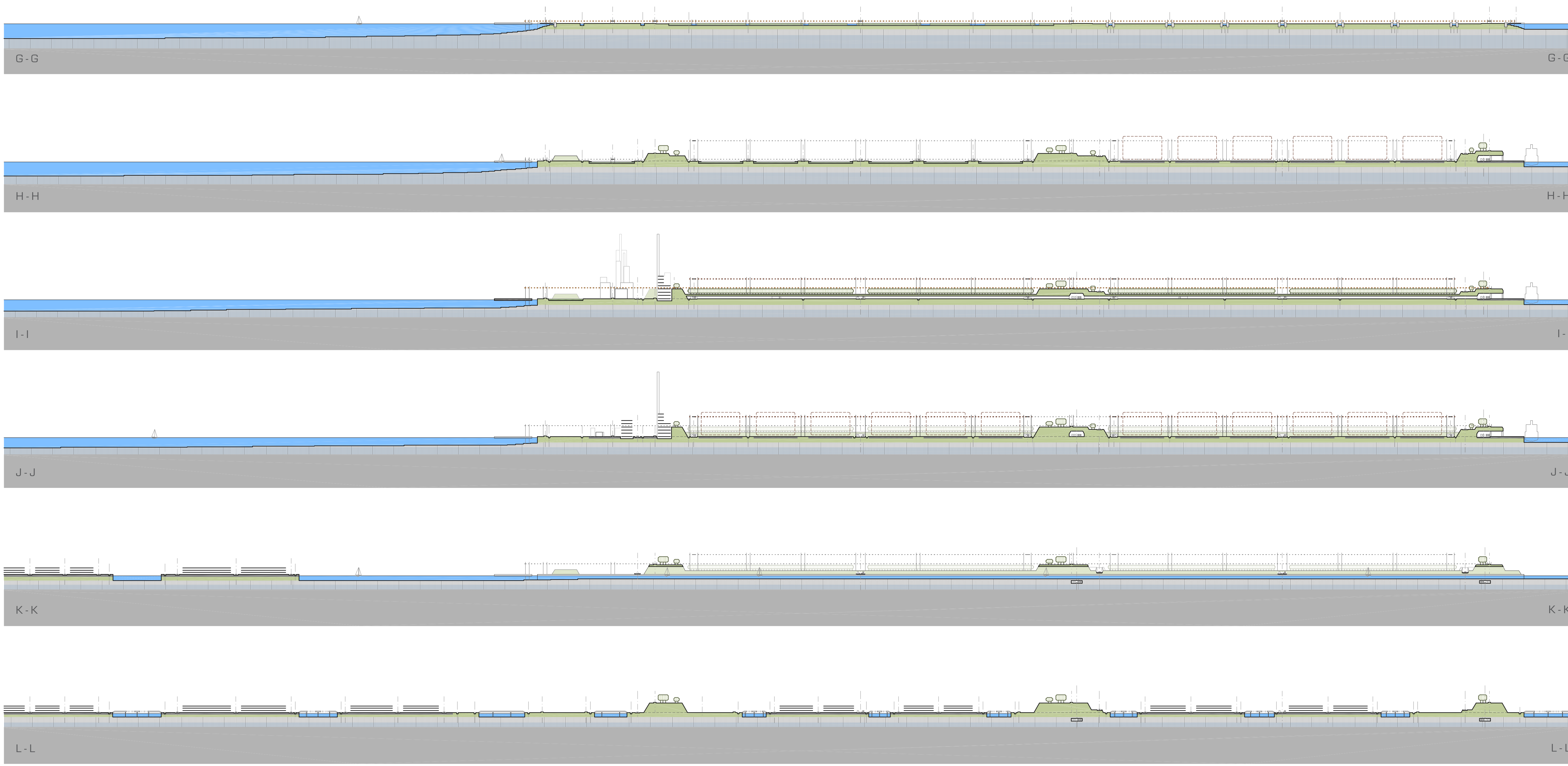
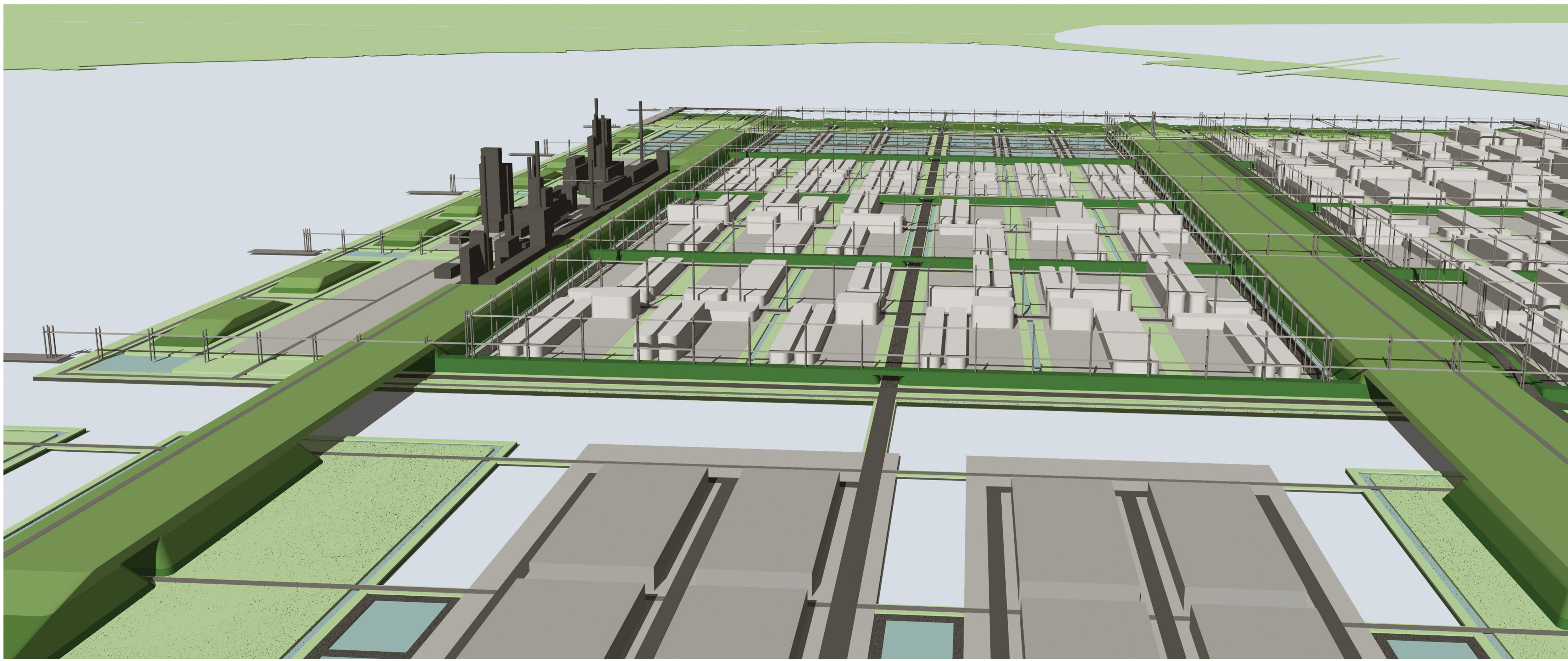
4.55. Implementation (Scale 1:7,500)

East - West Site Sections

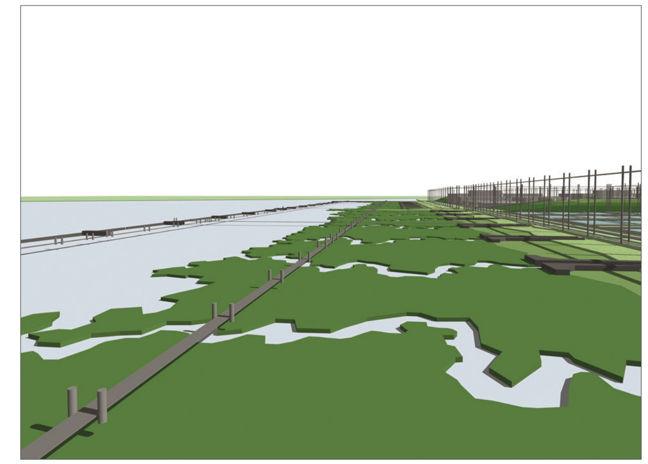


4.56. Instrumental Matrix

Site Perspective: directed north



4.6. DESIGN INHABITATION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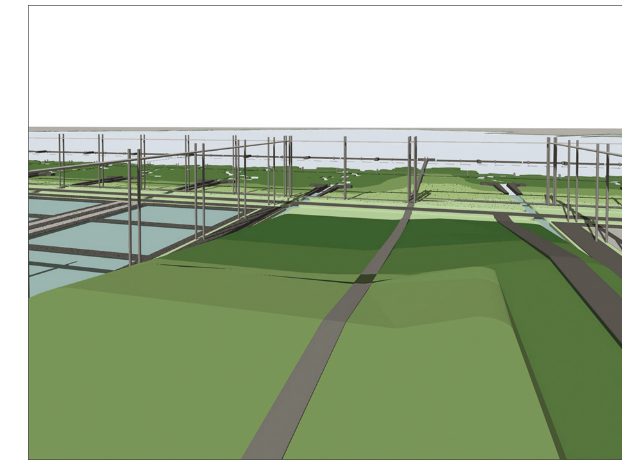
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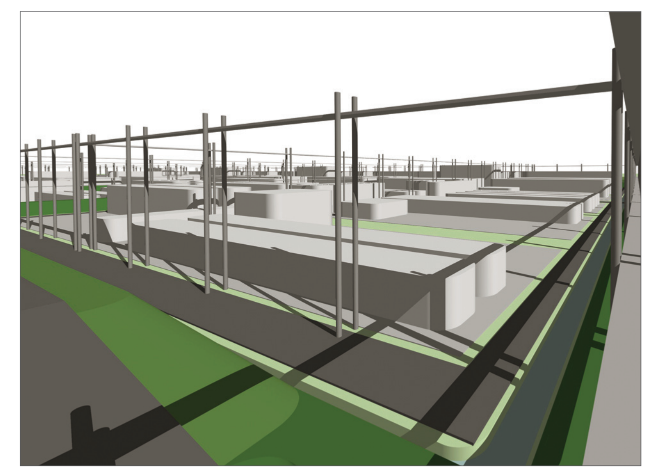
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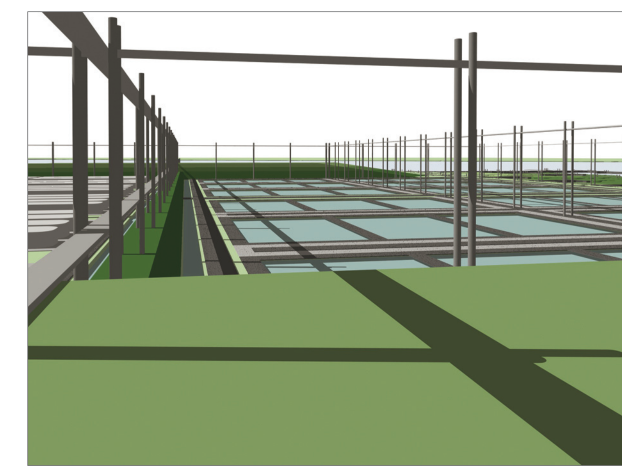
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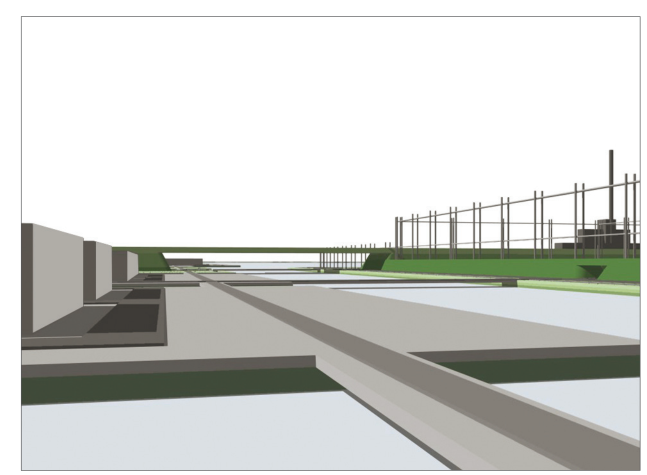
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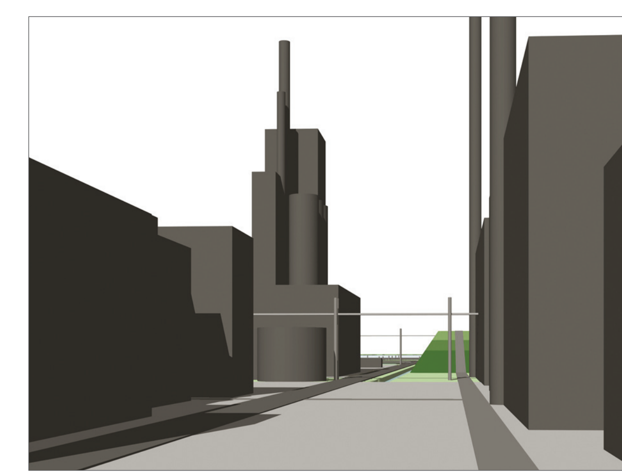
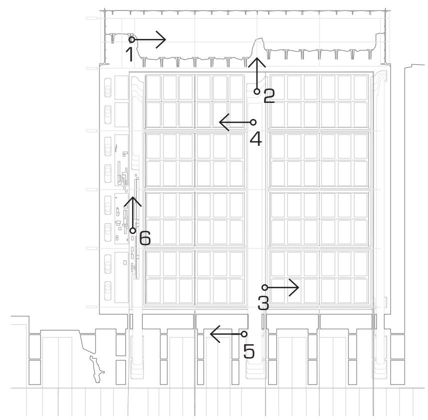

4.62

The design of the Instrumental Matrix attempts to activate many of the potential relationships among ecological, cultural and industrial systems uncovered throughout the research, analysis and urban investigations of this thesis. Within this context, the integration of these diverse and potentially divergent systems is critically dependant on the articulation of various threshold conditions among them.

The provision of a new articulated urban edge addresses the threshold between Hamilton and the harbour. Here the waterfront perimeter is re-established as a public and accessible space, while maintaining the city's port identity. Recognition of the existing edge as an artificial form allows for enhanced manipulation toward the creation of public amenity, as well as industrial and recreational port activities. Deep incisions have created a series of piers that afford large public gathering spaces adjacent to the harbour, in the form of open parks and paved urban terraces. In addition, this edge provides the city with an array of highly desirable waterfront lots ready for the construction of mixed use programming.

The construction of the urban edge clearly sets off the Instrumental Matrix as a separate and unique, albeit integrated, element of the harbour. This allows for relatively unrestricted industrial operations within a strategic and prominent position. The inclusion of multiple public functions on the island, within relatively close proximity requires the use of extensive buffer systems that structure public thresholds among various industrial conditions. Dense ecological planting, earth berm structures and raised catwalks enable public access to be interwoven with industrial process. Similarly, multiple connections to the city allow public movement between the island and the city.

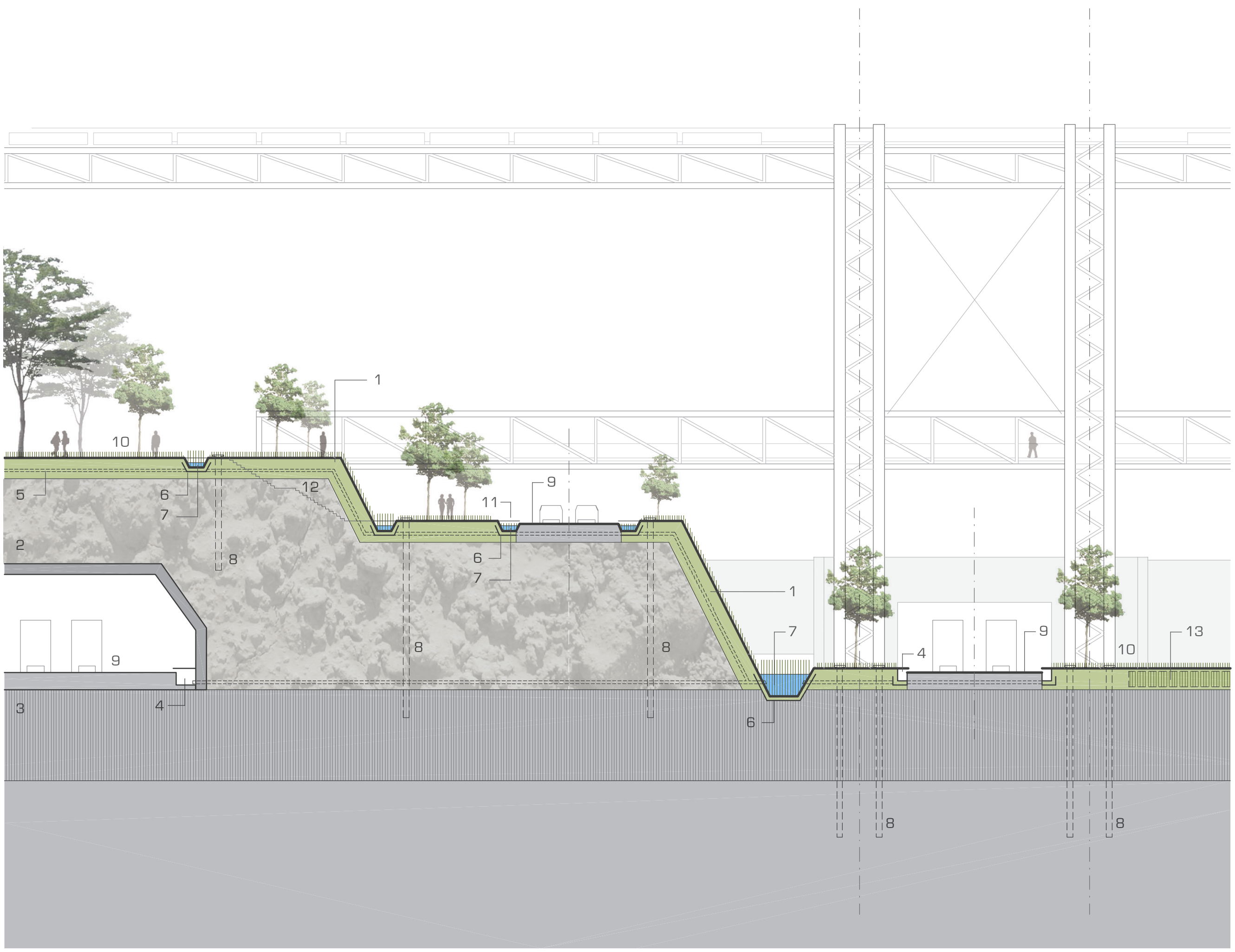
Ecological areas have been reconnected to the city through the proposed urban plan. Significant ecosystems in amongst Cootes' wetlands, Red Hill Valley, the Niagara Escarpment and Hamilton Harbour are regenerated and reasserted as critical elements of the city in the context of this urban plan. The artificial regeneration of Hamilton's original wetland condition presents the city with an inhabitable hybrid form that attempts to mediate between city and wilderness.



opposite page:
4.57. Instrumental Matrix View 1:
boardwalk - across regenerated wetland
4.58. Instrumental Matrix View 2:
central berm - toward wetland
4.59. Instrumental Matrix View 3:
central berm - across cell cluster
4.60. Instrumental Matrix View 4:
central berm - toward water treatment
4.61. Instrumental Matrix View 5:
urban edge - towards instrumental matrix
4.62. Instrumental Matrix View 6:
among artefacts + cultural complex

4.63. Berm + Connective Tissue Detail Section
Scale 1:500

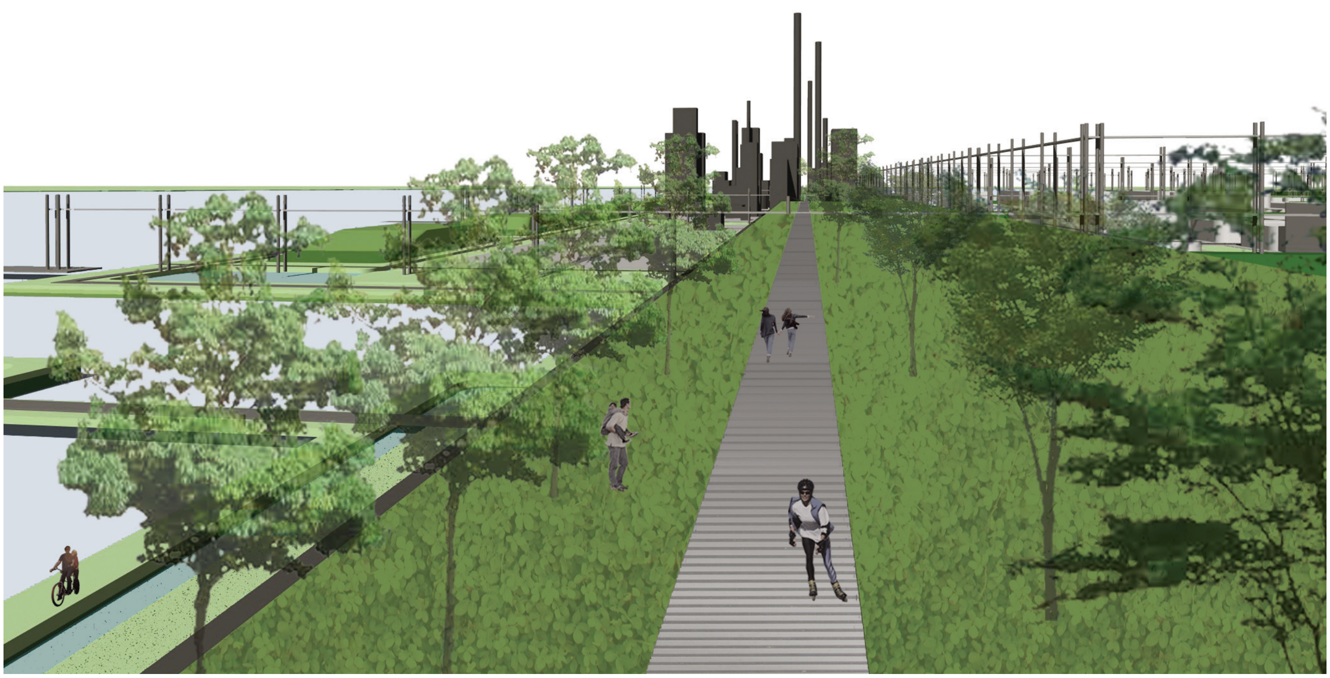
1. vegtative barrier
2. pre-treated on-site fill
3. existing soil
4. drainage channel
5. drainage piping
6. impermeable membrane
7. drainage + treatment channel
8. monitoring, pumping + treatment wells
9. impermeable surface
10. planted surface
11. slated public walk
12. public stair
13. instrumental cell



The continuity of plantings, earth berms and land bridges throughout the proposal provides for a large interconnected park system that gives access to recreation and cultural programmes. The berms act as visual markers in the landscape that lead the public toward a trail system connected through the city, along the waterfront, and across to the island via the large land bridges. Despite the size of these bridges, graduated slopes and multiple connecting stairs allow for accessible climbs, while dense plantings and the breadth of the structure creates almost imperceptible crossings.

As a visitor crosses to the island they find themselves traversing along articulated steel and concrete paths constructed throughout the site and further connected to the raised catwalks and wetland boardwalks. This circulatory system places the public amidst dense crops of wild grasses, shrubs and trees that

4.64. Earth Berm, Land Bridge + Connective Tissue Perspective View



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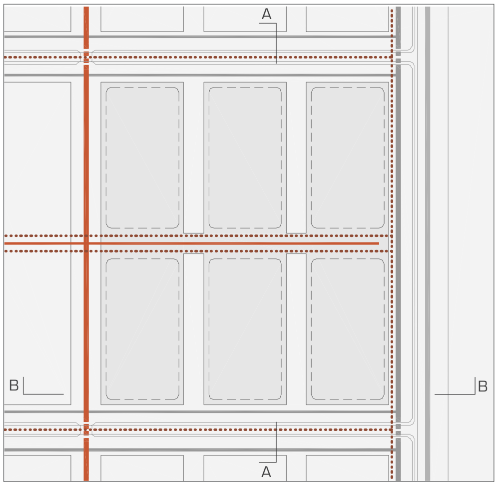

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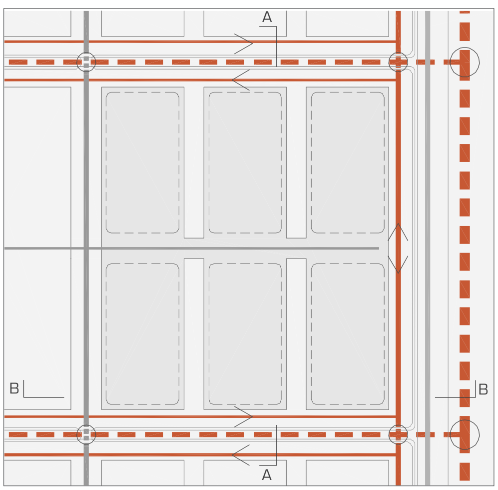

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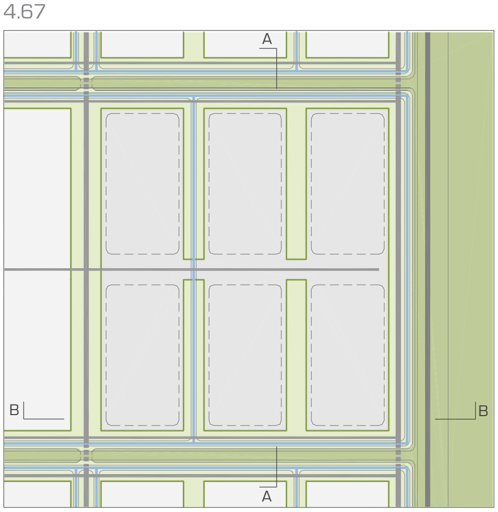
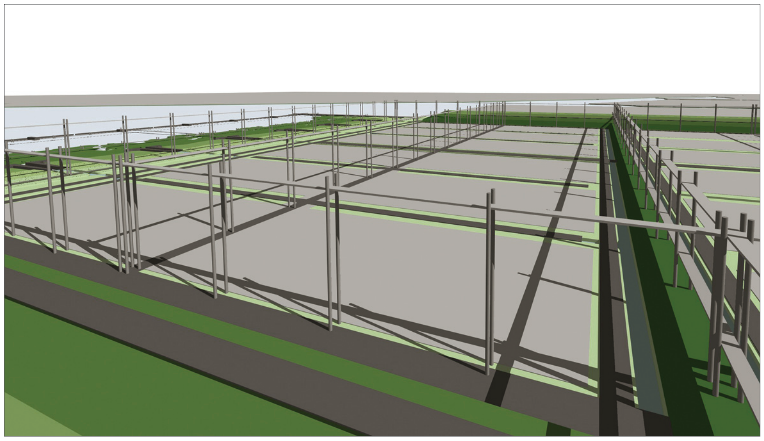


covers much of the berms structures and suggest potential for a public interaction with wildlife. Interspersed through this regenerated forest and savannah landscape are small clearings for resting or gathering, and a finer grain of rough trails loosely organized within the connective tissue.

Looking back from the bridges, the public is presented with excellent viewpoints toward the city and escarpment, while progression across provides glimpses toward the harbour and the unique structures of the Instrumental Matrix. The sublime beauty of the obsolete industrial artefacts will be visible from nearly all points of the site, while the objects themselves serve as spatial markers to orient people throughout the proposed island. Their iconic presence, severe forms and crude materiality will remain as instructive historical monuments and provide vivid contrast to new materials, forms and structures representative of regenerated industrial process.

Once across the bridges, views into the instrumental cell clusters are telling of the central role industrial production plays throughout the proposal. Ecological buffers and vertical separation allow the public to observe without concerns of liability, safety and privacy. From a raised vantage point and through a screen of trees visitors can get an overall sense of the new factory building complexes. While planted materials surround and buffer the cells, the synthetic and functional forms of industrial structures, articulated with respect to production efficiency, will provide stark contrast to their ecological context, and exert a clear instrumental presence within the landscape.

Private, sensitive and heavy machine operations will take place within dense, enclosed structures, composed of insulated and resistant steel and concrete walls, punctuated with articulated ventilation and service systems. Less sensitive processes may take place in lighter, more articulated structures composed of composite synthetic panels, such as recycled plastic, as well as clear transparent sections composed of glass, plastics and solar screens. Tensile elements and raised structures would further increase the degree of transparency through the industrial sites. Others operations, such as those associated with shipping and receiving may take place in the open or under



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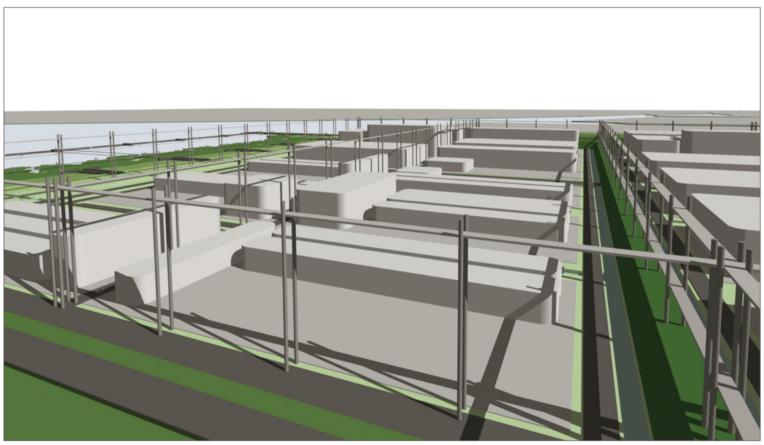
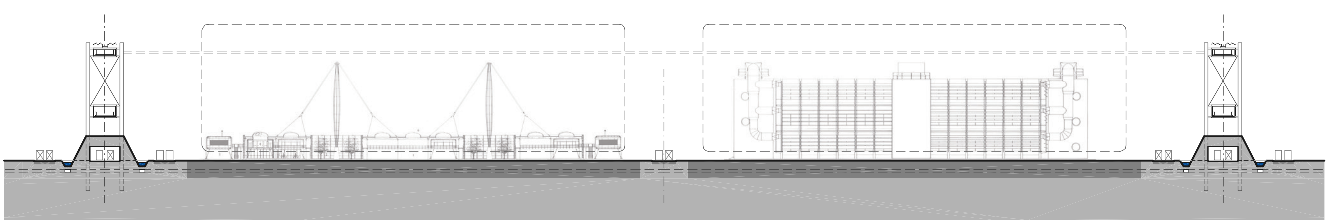


4.69

opposite page:
4.65 TO 4.67. Typical Cell Cluster Plans (1:7,500)
4.65. Integrated Service Network Plan
4.66. Dedicated Service Network Plan
4.67. Surfaces, Berms + Water Flow Plan

4.68. Unoccupied Cell Cluster Perspective View
4.69. Potential Occupied Cell Cluster Perspective View

4.70 TO 4.71. Typical Cell Cluster Sections (1:2,500)
factory prototypes by Nicholas Grimshaw & Partners
4.70. North - South Section A-A
4.71. East - West Section B-B



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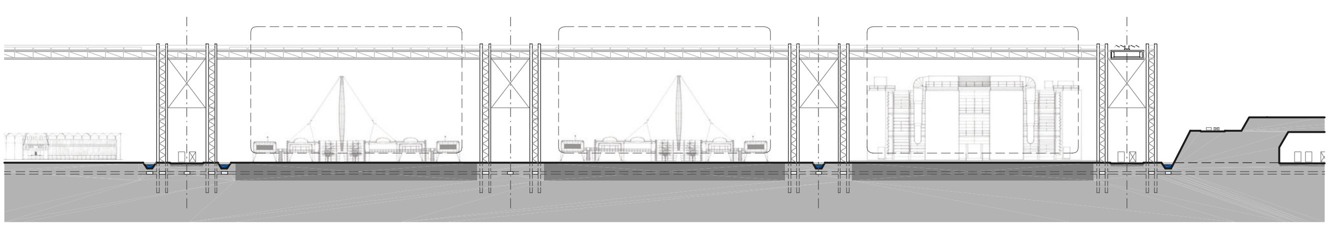
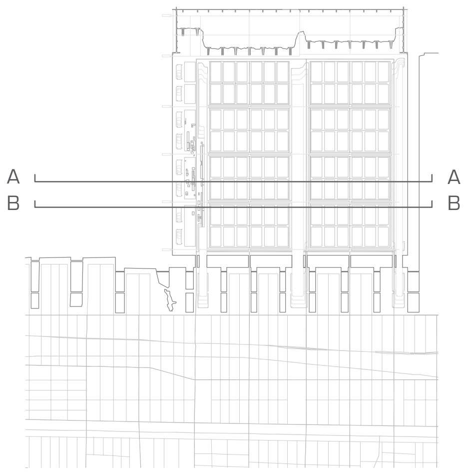


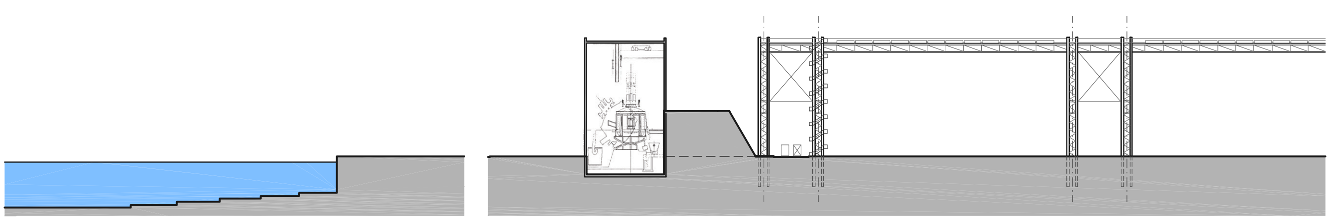
4.71

facing pages:
4.72 + 4.73. Typical Catwalk Infrastructure Elevations (Scale 1:2,500)
4.72. Catwalk Infrastructure Elevation A - A
4.73. Catwalk Infrastructure Elevation B - B



raised canopies, and as such be plainly visible for public observation. Underlying surfaces would be composed of vegetative material or permeable gravel surfaces, as well as impermeable paving where necessary. Above, the building roofs will incorporate planted systems and solar technology, wherever possible.

Major organisational and infrastructural elements are visible from the perspective of the berms, and allow for a public understanding of basic industrial operations to, from and among various firms. Integrated surface roads below provide clear visual links among cells and factories, for industrial private and employee use. The dedicated road system is largely out of sight under the berms, but hints of its large scale operations are found at the connection points to the open surface roads. The raised conduit system, far out of reach above, presents an instructive physical manifestation of industrial exchange. Its tensioned steel structure, interwoven through the entire island, clearly traces flow paths of material and energy transfers



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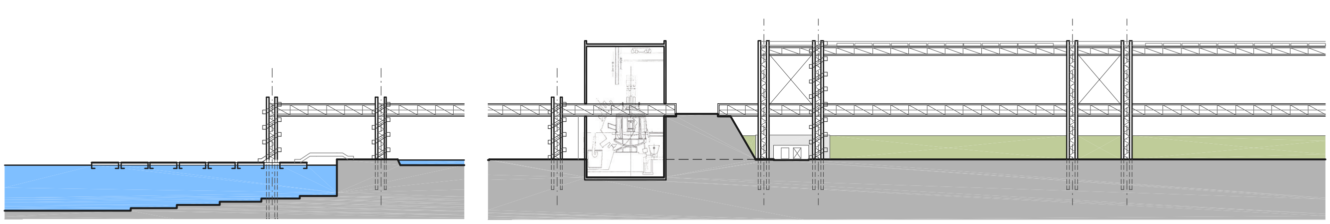

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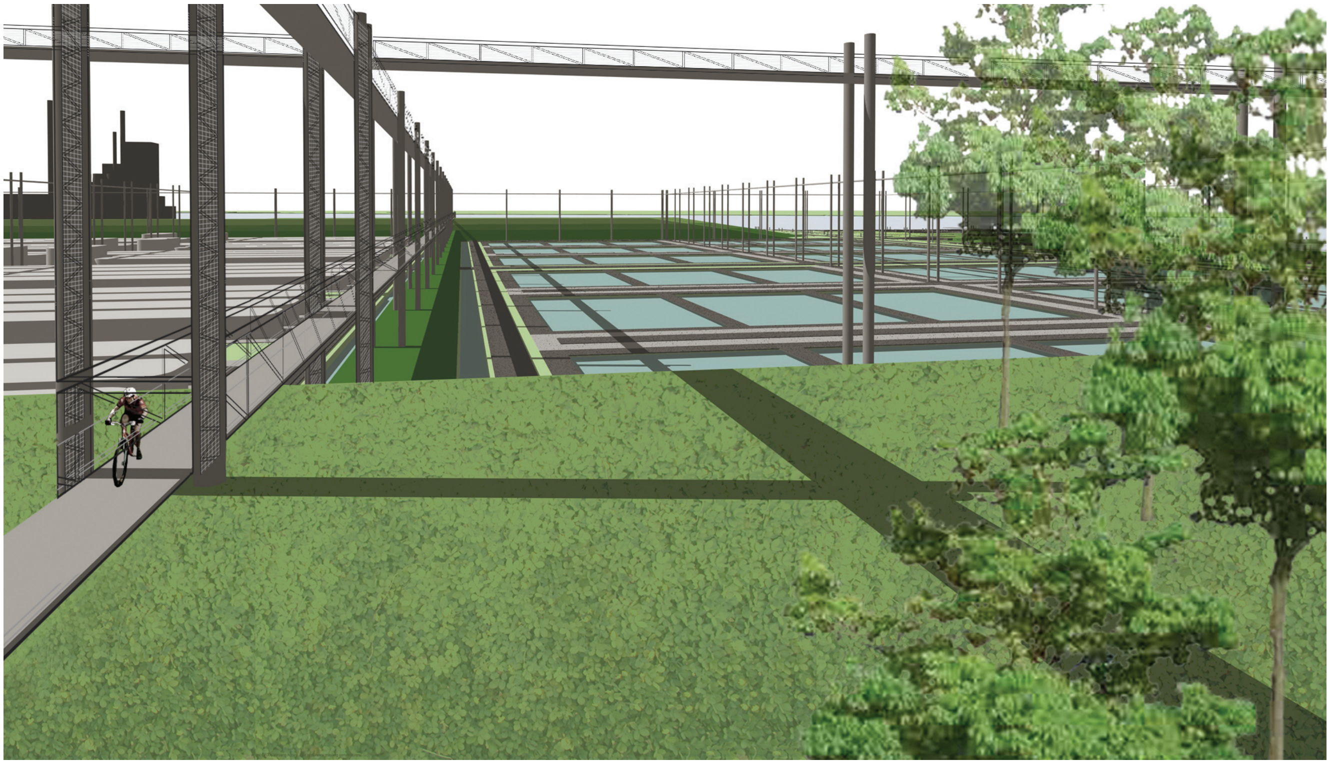
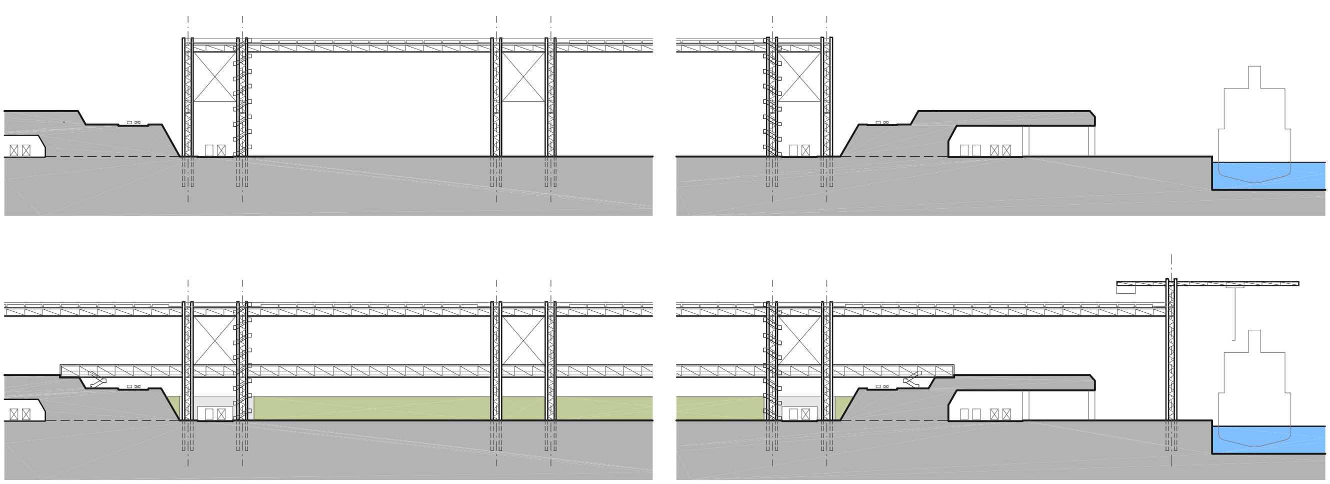
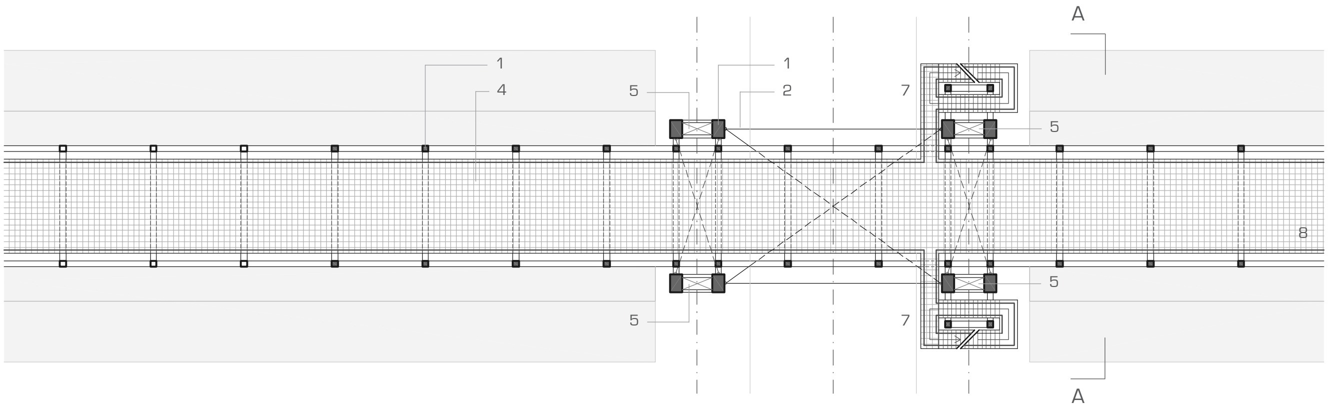


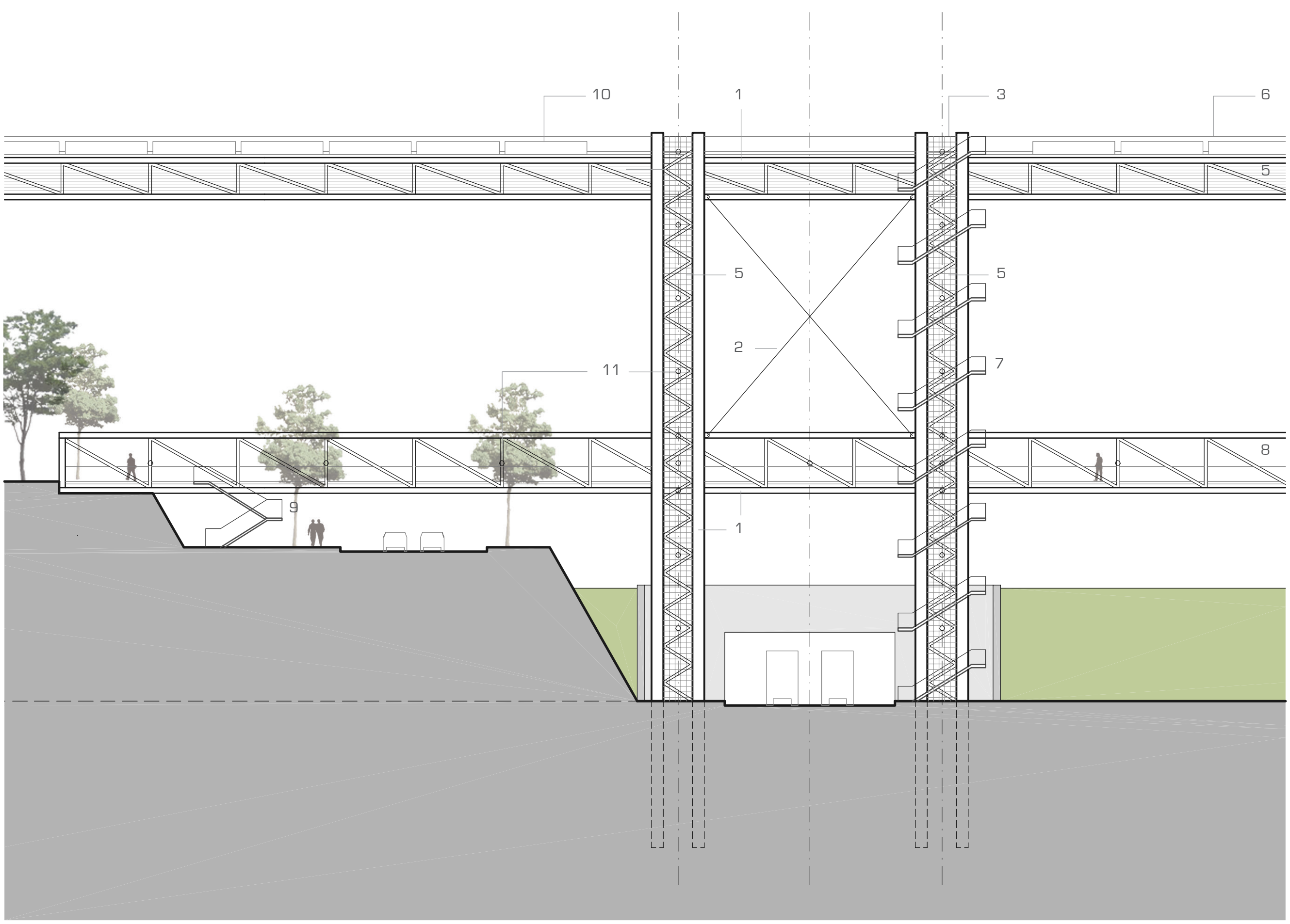
4.74. Catwalk Infrastructure Perspective View



4.75. Typical Catwalk Infrastructure Plan
Scale 1:500

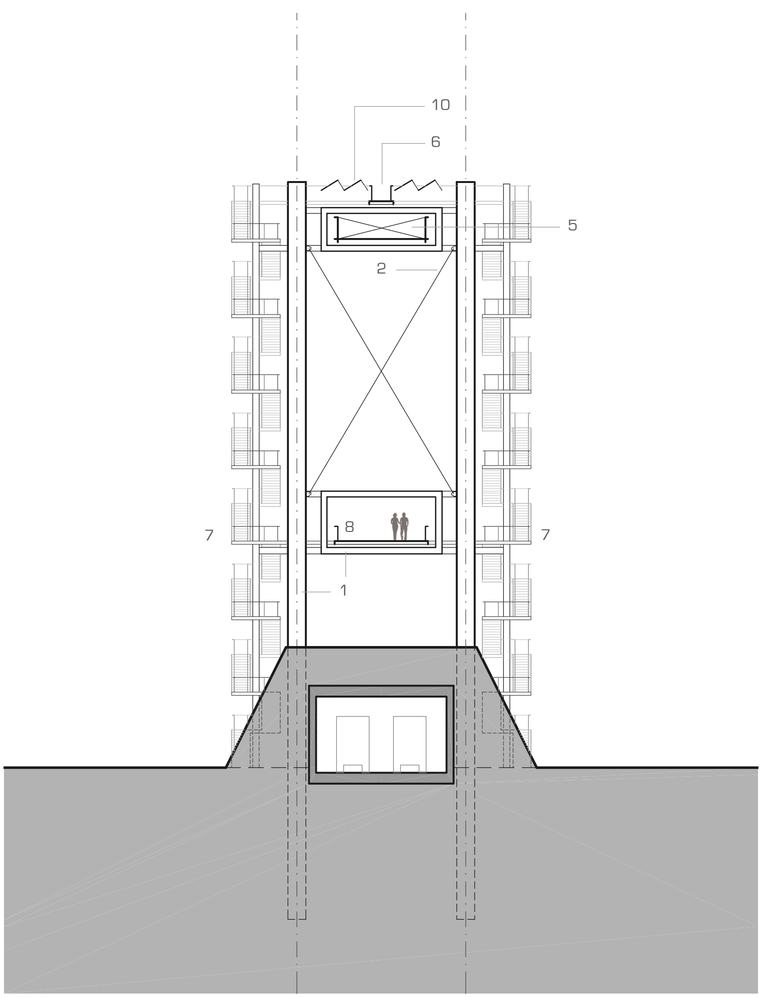


4.76. Typical Catwalk Infrastructure Elevation
Scale 1:500



among firms. Repetitive structural elements provide occupants with a sense of scale, while the lit structure orients visitors well into dusk and evening activities.

The raised catwalk section of the conduit structure greatly enables the public inhabitation of the proposal, as one of the primary circulation systems for pedestrians and cyclists through the site. Inserted at the top height of the earth berms, the catwalks allow for free movement among the three large urban parks.



1. HSS steel structure
2. steel tensioned cables
3. steel wire mesh
4. steel deckng
5. material + energy exchange conduit
6. service raised catwalk
7. service stair
8. public raised catwalk
9. public stair
10. solar panels
11. solar powered lighting

4.77. Typical Catwalk Infrastructure Section A - A
Scale 1:500

4.78. Cultural Complex Perspective View
illustrates the initiation of public ocupation amonst industrial artefacts

Progression through the site could lead a visitor through an exploration of the more serene eastern and central berms that focus on ecological process and recreational uses. Traversing through the vegetation of the eastern berm the public is presented with views down toward the shipping port and primary processors, which include steel mini mills. Progression westward along the steel catwalks carries visitors over industrial process, service roads and public access roads into the most densely planted central berm, programmed with running and cycling trails, in addition to picnic areas and open fields. Further travel westward allows observation of smaller scale industrial processing, water treatment facilities and potential community based agricultural projects that suggest possibilities for cultural-industrial integration. Alternatively, continued exploration throughout the catwalk system provides a general overview of nearly all industrial systems.

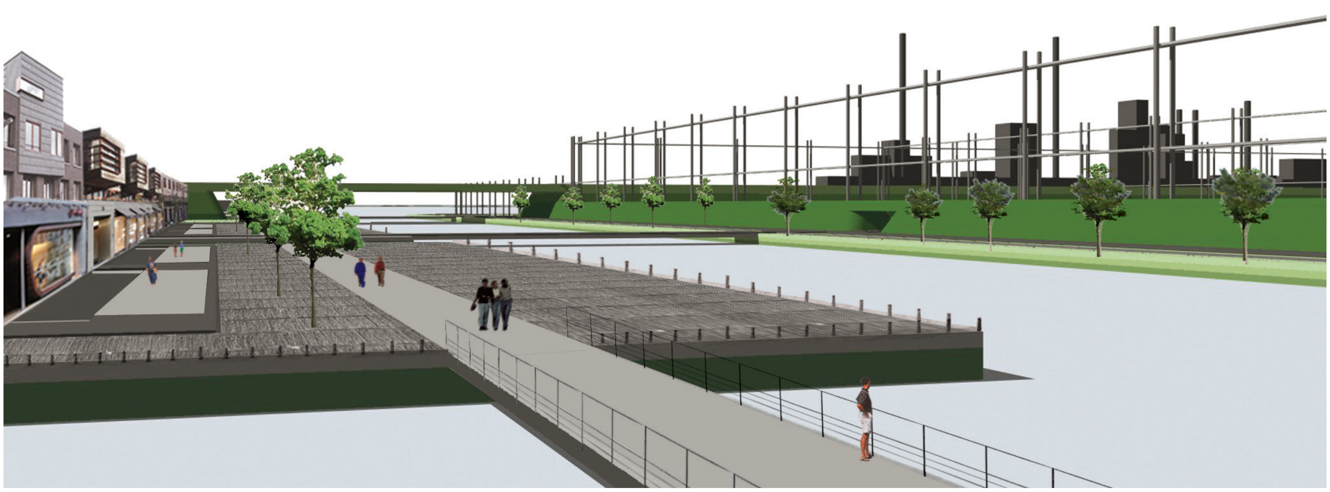
Exploration of the western berm presents the public with views to more heavily programmed areas of the site. As pedestrians walk along the catwalks, they pass through the berm and transition into the spaces between the industrial artefacts. In some cases they pass directly through the interior of these structures. Public stair towers or elevators bring the public to key locations within this urban node. At the water edge open space and a series of public docks connect to the harbour.

At the southern tip of the western node, facing the urban edge, open space and canopy elements allow for temporary public markets and other transient functions. The central cultural complex will provide more stable programmes that include galleries, studios and restaurant functions within the artefacts. A decrease in activity is experienced as visitors travel northward through a progression of phytoremediation and water treatment demonstration gardens, and finally reach the fine grain, minimally programmed, regenerated wetlands. Here in the open space of the wetland, one can walk along the paths and boardwalk structures that hover above the surface of the water. These provide a public interaction with emergent ecology, and a connection to the harbour without hindering ecological process.

4.79. Urban Edge Perspective View illustrates the begining of public activity on the large urban terraces and among new residential and commercial programming

As one progresses outward from the urban edge, toward the regenerated wetland, a gradual decrease in the programmatic density of public inhabitation is observed. Similarly, the emphasis of various processes and systems noticeably shifts as visitors move through the site and across threshold conditions. Within the urban edge, cultural activity is clearly dominant amongst open public space, as well as residential, commercial and civic structures, while industrial and ecological systems are relegated to connection and movement functions. Throughout the island, industrial operations take priority, while ecological processes buffer wildlife habitat and cultural programmes. At the furthest north edge of the project the regenerated wetland places ecological programme at the foreground of a hybrid form, which the public can observe.

Despite varying degrees of emphasis and significance, an integration of systems is evident throughout the site. Ultimately the Instrumental Matrix provides a conceptual form to make manifest what are already complex interactions among ecological, cultural and industrial systems.



4.80. Regenerated Wetland Perspective View
illustrates threshold between artificial + natural; city and wilderness

4.7. THESIS CONCLUSIONS

The implementation of the Instrumental Matrix is proposed as a working model for the integration and regeneration of ecological, cultural and industrial systems. The execution of further research and analysis of these systems, as well as a rigorous programme of adaptive management to inform an ongoing process of adaptation and growth, will be critical to ongoing success of the model. While this proposal represents a framework of potentially viable propositions, it is not a definitive solution to Hamilton's problems. The research and analysis illustrated in the thesis is not meant to be exhaustive, but rather a representative overview that suggests a conceptual methodology.

The Stelco site is presented as critical to the regeneration of Hamilton and emblematic of pervasive industrial problems. The city remains economically linked to this company and any future reclamation scenario must take into account existing fiscal obligations. There remains some potential to continue operations of some or all of Stelco's facilities in the short term. This thesis suggests however, that the toxicity of its lands, facilities and production methods are such that an ecological regeneration will be impaired by the perpetuation of these structures and methods. The fundamental shift from integrated steel production to an industrial ecosystem of more sustainable processes deemed existing facilities obsolete and informed the demolition plan for this proposal.

While this study focuses on steel production, its principles could also be used for a range of industries. Similarly, while the electric arc furnace and mini mill operations present a possible future for sustainable steel production, other technologies that improve on integrated steel production also offer alternative paths for the industry. The potential for reductions in material and energy consumption and suggestions for loop closing activities present the mini mill as an especially compelling choice. The application of small scale, high yield facilities enable industrial production to coexist among healthy, regenerated lands and neighbourhoods, within the urban centre. An assembly of small mini mill operations suggests a decentralized approach to production that creates potential for diverse and stable industrial ecosystems.

Despite the potential of this technology, pollution issues, including both local and upstream effects, remain to be addressed. In particular, the source of most electricity production remains as a potential limit for sustainable mini mill steel production. This is a global problem far beyond the scope of this thesis. The integration of an electrical cogeneration facility however, has been demonstrated as an effective step, and is therefore incorporated into the thesis proposal.

Issues of site ownership and occupation are operational challenges related to the development of the local industrial ecosystem which must be addressed and resolved, regardless of the resident process. Further research could explore two broad strategies. The first would transfer ownership to an occupant based on an approximation of existing and future needs. Expansion or contraction of any given industrial firm would occur on a free market basis, potentially under the supervision of a governing body. While this may create a system that is slow to adapt, long term ownership could foster a culture of stewardship. Alternatively, a system of leases and shorter-term occupation could be implemented to support a concept of adaptable and transformable sites. Larger permanent structures would be designed for reuse and kept to a minimum, while the majority of building components would be designed to be disassembled or simply transported to the next site. This system could support rapid reorganizations of the entire site in response to shifts in local or global markets.

The design is representative of a methodology intended for further application throughout a variety of sites. Although the design is site specific, the study of Hamilton as a cultural place has been treated schematically. Instead emphasis has been placed on the design of cultural infrastructure and a schematic organization of elements and systems. Coordinated with ecological and industrial systems this cultural infrastructure is intended to provide for public amenity. Ultimately, the thesis proposal can be considered as a method to reassert processes of industrial production within populated centres, while maintaining healthy cultural systems and regenerating ecological systems.

A 'field matrix' condition was selected to facilitate the creation of industrial ecosystems. The design presents a gridded cellular scheme intended to promote a transformable and adaptable system, the parts of which are interchangeable so long as the overarching grid is maintained. This structure demonstrates potential to foster diverse and numerous industrial processes that reside in close proximity, as observed in existing industrial ecosystem models. Alternatively, a 'centralized block' or 'openended' approach could present lower cost options that realize similar industrial ecology goals.

In addition the provision of uniform infrastructural support allows for adaptability of function and long tem site stability. Decentralized and redundant infrastructures that populate the proposal have potential for wide application. These interconnected systems are not critically interdependent and therefore successful operation of the entire site does not rely on the continuous operation of each element. Rather, they provide for multiple means of production, processing and exchange.

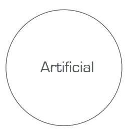
Realization of the proposal could result in a simplification of certain systems without compromising its primary industrial ecosystem function. Elements such as the drainage channels and the raised conduit could be concealed to potentially reduce cost and increase feasibility. Similarly the small celled matrix could be redefined to construct one cell cluster as a single cell, should the initial occupant require. Reciprocally this cell cluster could be subdivided later, as per the initial design. For the purpose of this thesis however, a visible and articulated form of all systems was favoured to emphasize the potential for diversity of occupants, function and exchange relationships.

The application of the Instrumental Matrix methodology provides physical form to the study field of industrial ecology and the concepts of industrial ecosystems. This methodology, while posing some potential challenges to societal perceptions, ultimately intends to reassert a responsibility and awareness of inputs and outputs required for the operation of society. In addition, it intends to push industry toward more stringent standards within the public eye, while potentially increasing the profitability of their operations.

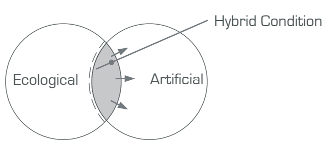
This method inevitably puts industry under increased pressure. Given the current economic reality of steel production in particular these changes may prove difficult. The design proposal however, assumes the context of a restorative economy, in which ecological resources are accounted for. In this economic model fiscal advantages such as green taxes may make such an operational shift possible.

4.81. Phased Regeneration of Hamilton:
illustrates proposed urban development relative to the hybridization methodology illustrated in fig. 1.14.

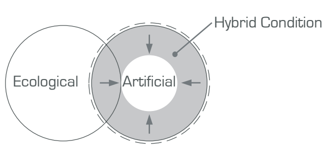
A. Oringinal Condition (pre 1840):
phase 1 - representative of initial ecological condition



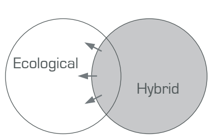
B. Existing Condition (2005):
phase 1 - representative of initial artificial condition



C. Instrumental Matrix:
phase 2 - representative of new hybrid condition



D. Proposed Urban Plan:
phase 3 + 4 - representative of inward propagation



E. Speculative Urban Growth:
phase 5 + 6 - representative of outward propagation. Viability is considered increasingly unlikely.

FUTURE IMPLICATIONS

The design proposal is intended to represent a method for future development both within Hamilton, and other sites. The accompanying urban plan proposal intentionally provides a context for growth demonstrated in the phased regeneration of Hamilton (fig.4.69). Using the hybridization methodology outlined in chapter one (fig.1.14) as a guide, it becomes clear that beyond the propagation of the methodology through the Hamilton port lands, future expansion into the harbour and Lake Ontario, must be undertaken only under great care.

The hybrid methodology proves instructive for implementation of future applications and makes important statements regarding the limitation of technology, artificial devices and cultural responsibility. The aim of the thesis and any subsequent methodological approaches is to work within the framework of existing societal structures and aspire towards the creation of increasing symbiotic relationships among ecological, cultural and industrial systems integral to modern civilization.

While this thesis proposal emphasized the visualization of spatial form and potential relationships further research must place increasing importance on economic and engineering realities. A detailed cost analysis and an in-depth narrative illustrating key participants, relationships and actions will be necessary steps to address design feasibility. Most critical will be consultation with industrial ecology principles and comparison to existing and theoretical models to determine the critical spatial relationships and infrastructures which will achieve a viable industrial ecosystem.

A1. ANALYSIS OF LAKE ONTARIO DRAINAGE BASIN

A1.1. ABCE Analysis: Wider Environment
abiotic, biotic, cultural, energetics complex systems analysis

SYSTEM PERSPECTIVE	INFLUENCES
ORGANIZING PRINCIPLE: NATURAL - ABIOTIC	
AIR FLOWS	
CLIMATE:	▪ Continental: hot, humid summers and cold, dry winters; Influence of Great Lakes to modify continental air [1]
	▪ Temperature: annual average 7°C (average summer high of 27°C to average winter low of -10°C) [2]
	▪ Prevailing Wind: west to southwest
	▪ Annual Precipitation Average: approx. 828 mm per annum [3]
AIR POLLUTION:	▪ Point sources: industry - industrial centres are concentrated along the western shore in Ontario between Toronto and Hamilton
	▪ Non-point sources: agricultural, automobiles, acid rain
WATER FLOWS	
CHARACTERISTICS:	▪ Lake Surface Area: 18,960 km^2 [(4)]
	▪ Land Drainage Area: 64,030 km^2 (including the Niagara River) [5]
	▪ Highest ratio of watershed to lake surface area within Great Lakes [6]
	▪ Mean Depth: 86 m, Maximum Depth: 224 m; Volume: 1640 km^3 [(7)]
	▪ Length: 311 km; Breadth: 85 km; Shoreline Length: 1146 km [(8)]
	▪ Maximum lake water level in June, minimum in February [9]
WATER TEMPERATURE:	▪ Temperature average: annual surface is 9.1°C [(10)]
	▪ Freezing Period: middle January to early April (avg. 15% coverage) [11]
CURRENTS + FLOW:	▪ Retention Time: 6 years [12]
	▪ Source: Lake Erie via Niagara River + the Welland Ship Canal [13]
	▪ Outlet: St. Lawrence River [14]
	▪ Currents: toward the east (wind + weather dependant) [15]
	▪ Wave Height: generally 0 - 1 m [(16)]
SURFICIAL INFLOW:	▪ 80% flows from upstream Great Lakes via Niagara River [17]
	▪ 14% flows from drainage basin; 6% enters from precipitation [18]
	▪ Ice retardation in winter and snow pack melting in spring have a significant impact lake levels [19]
SURFICIAL OUTFLOW:	▪ 93% flows out St. Lawrence River; 7% leaves by evaporation [20]
WATER POLLUTION:	▪ Receives impact of human activities in all upstream Great Lakes basins [21]
	▪ Point and non-point sources: (see air flow above)
GEOMORPHOLOGY	
GEOLOGY:	▪ Lake Ontario Elevation: 74m above mean sea level [22]
	▪ The southern rim of the lake basin is formed by the outcrop of the Niagaran Dolomite, which also forms the sill of the Niagara Falls. The greater part of the Ontario basin has been excavated by the Ordovician age and the northern half of the lake bed is underlain by Ordovician limestone. [23]

- The lake bottom has smooth troughs, containing a few small islands. They are directly related to the geology of the region and have important effects on the circulation of the lake waters. [24]

ORGANIZING PRINCIPLE: NATURAL - BIOTIC

PLANT LIFE

- Lost 80% of original forest cover, since 1800, due to clearing for agriculture, urban growth etc. [25]
- Non-native plant species: Purple Loose Strife, Garlic Mustard, Periwinkle - can potentially displace endemic species [26]

ECOZONES:
- Canadian: Boreal Shield (north above Oak Ridge Morraine), Mixedwood Plains (south) [27]

FOREST REGIONS:
- Canadian: Great Lakes - St. Lawrence (north above Oak Ridge Morraine) and Deciduous (south) [28]

WETLANDS:
- Over 70% of southern wetlands have been lost to due to drainage and filling for human use (reduction of biodiversity) [29]

WILDLIFE

NON-NATIVE+MIGRATORY:
- Non-native animal species: Zebra & Quagga mussels have caused the lake to have two new impairments: benthos and phytoplankton [30]
- Migratory animal species: Canada Geese - will deposit and transfer nutrients throughout the area and potentially spread disease [31]

THREATS:
- Drastic changes to the Lake Ontario ecosystem over the last century as a result of the effects of toxic pollution and rapid development of the Lake Ontario basin. [32]
- Development, urban expansion, golf courses, logging, extraction of sand and gravel, mining, and hydroelectric equipment [33]
- Destruction of habitat, over fishing, introduction of exotic (non-native) species, toxic contaminants (contaminated discharge), nutrient enrichment [34]

CONTAMINANTS:
- Critical pollutants (PCBs, DDT, mirex, dioxi/furans, mercury, dieldrin, Mercury, Pathogens, POPs/PCPs/Endocrine Disrupters) tend to be bioaccumulate [35]

IMPACTS:
- Climate change, Erosion, Health Advisories – fish and swimming, Nutrient pollution, Polluted runoff, Sediment contamination, Toxics [36]
- Degradation of water quality, loss of fish and wildlife populations and habitat, introduction of non-native species [37]
- Bottom sediments contaminated by toxic chemicals [38]

IMPROVEMENTS:
- Reduction of critical pollutants in fish and wildlife tissue [39]
- Waterbirds, Bald Eagle, Osprey, Lake Trout, River Otter and Mink recovered and returning to the basin [40]

NATURAL LANDSCAPE:
- All interactions provided by the structure or isolation of corridors and patches
- A description of the landscape will give a good indication of the potential flow of wildlife in and out the region. [41]

ORGANIZING PRINCIPLE: CULTURE

BASIN POPULATION:
- Canada Population: 5,446,611; US Population: 2,704,284 [42]
- Total Population: 8,150,895 (Projected increase: 2,000,000 by 2020) [43]
- Most densely populated and industrialized along Canadian western shore [44]

LANDUSE:
- Urban development is experiencing growth the form of low-density urban sprawl in Toronto and Hamilton – removing large areas of farmland and natural habitats [45]
- Rural developments are shifting to larger farms and fewer farmers and many country homes in rural subdivisions or scattered lots [46]

TRANSPORTATION:
- Major Highways: 400, 401, 403, 404, 6, 7, 8, 12, QEW

- Major Railways: CNR, CPR, Southern Ontario Railway, Go Train, Via Rail
- Major Trail Systems: Bruce Trail, Trans-Canada Trail, National Trail

ORGANIZING PRINCIPLE: INDUSTRY

PRODUCTION

- Industrial areas, manufacturing, agriculture, shipping

WATER USE:

- Power plants: Can 129.4 m^3/s, US 101.7 m^3/s [47]
- Industrial: Can 56.3 m^3/s, US 18 m^3/s [48]
- Domestic: Can 17.6 m^3/s, US 8.4 m^3/s [49]
- Irrigation: Can 1.1 m^3/s, US 0.6 m^3/s [50]
- Total: 336.6 m^3/s (Can 205.3 m^3/s, US 131.3 m^3/s) [51]

TRANSPORTATION

WATER: (St. Lawrence Seaway)

- Opened in 1959 - accessible to large ocean going vessels [52]
- Channel Depth: maintained at 8.2m minimum over the chart datum [53]
- Distance (Atlantic Ocean to Lake Superior): 3,700 km [54]
- 8.5 sailing days (includes some 245,750 km^2 of navigable waters) [55]
- Largest Port: Hamilton (by cargo and traffic) [56]

LAND:

- Major Highways: 400, 401, 403, 404, 6, 7, 8, 12, QEW
- Major Railway: CN Rail, CP Rail, Southern Ontario Railway, Railink

ORGANIZING PRINCIPLE: ENERGETICS

INDUSTRIAL FLOWS

STEEL:

- Mining and Extraction
- Process: 17 plants in Canada; Employment: approx. 34,000 people [57]
- Production: 17 million tonnes of steel (100 million tonnes in US) [58]
- Market: $11.2 billion (1998) - including $3 billion in exports, primarily to US [59]
- Consumption: approx. 66% of steel used in Canada is consumed within a 320 km radius (half of Canadian automotive industry's consumption lies within a 100km radius) [60]
- Consumption: approx. 33% of steel is shipped to US (closer than many US producers to many US markets) [61]

A2. ANALYSIS OF HAMILTON HARBOUR DRAINAGE BASIN

A2.1. ABCE Analysis: Environment
abiotic, biotic, cultural, energetics complex systems analysis

SYSTEM PERSPECTIVE	INFLUENCES
ORGANIZING PRINCIPLE: NATURAL - ABIOTIC	
AIR FLOWS	
CLIMATE:	▪ Continental: hot, humid summers; cold, dry winters; moderated by Lake Ontario [1]
	▪ Temperature: annual avg. 7°C (avg summer high 27°C; avg winter low -10°C) [2]
	▪ Prevailing Wind: west to southwest; Wind Speed Average: 12 km/hr [3]
	▪ Annual Precipitation Average: approx. 780 mm per annum [4]
	▪ First Frost Average: October 15; Late Frost Average: May 3 [5]
MICRO CLIMATE:	▪ Wind Patterns: the Niagara Escarpment shelters the lower part of Hamilton from warm southerly winds, making the downtown cooler than the south end on the escarpment
AIR POLLUTION:	▪ Point sources: industry
	▪ Non-point sources: agricultural, automobiles
WATER FLOWS	
WATERSHED:	▪ Catchment Surface Area: over 500 km^2 (6)
	▪ Harbour Surface Area: 21.6 km^2 (7)
SURFICIAL INFLOWS:	▪ The area is drained by dendritic streams and creeks (no large river systems are present); most consist of three distinct sections: headwaters above Niagara Escarpment, transition zone at the escarpment, flat lower reach [8]
	▪ Three major tributaries: Grindstone, Spencer and Red Hill [9]
	▪ Grindstone Creek Watershed: 88 km2 or about 18% (Includes: Falcon Creek, Indian Creek, Hager-Rambo Creek, West Aldershot Watershed, Edgewater-Stillwater Creek Watershed) [10]
	▪ Spencer Creek Watershed: 197 km2 or about 40% (includes: Fletcher, West Spencer, Logie's, Westover, Flamborough, Spring, Ancaster, Sulphur, Sydenham, Tiffany and Borer's) [11]
	▪ Red Hill Creek Watershed: 62 km2 or about 12% (includes: Buttermilk, Hannon and Davis) [12]
	▪ Other Surficial Flows: Mineral Springs Creek - 47 km2 (about 10%), Rock Chapel Creek - 21 km2 (about 4%), City of Hamilton - 78 km2 (about 16%) [13]
SURFICIAL OUTFLOWS:	▪ Primarily into Lake Ontario via Burlington Shipping Channel
	▪ Some water lost to industrial and municipal uses
GROUND FLOW:	▪ Quality: generally good; sulphur noted in 7% of wells [14]
	▪ Major Aquifers: Lockport-Amabel Formations and Guelph Formation dolomites (form the surface bedrock above the Niagara Escarpment) [15]
	▪ Municipal Wellhead Areas: Freelton, Carlisle, Lynden + Greensville [16]
	▪ Recharge Areas: predominantly above the escarpment; Galt Moraine serves as a major recharge and storage area for the north half of the region, and also acts as a headwater source for several stream systems (includes: Bronte, Spencer and Fairchild Creeks); the south half of the region receives recharge in eastern Ancaster (just south of the Dundas Valley rim) and extends along the top of the escarpment [17]

- Major Discharge Areas: predominantly below the escarpment; most common in the northern part of the region in springs arising from the southern flank of the Galt Moraine; along the edge of the escarpment discharge is focused in zones associated with re-entrant valleys (Bronte Creek Ravine, Grindstone Valley); in the Dundas Valley in springs, seepages and contributions to base flow [18]
- Intrinsic Susceptibility: agricultural land in Grindstone Watershed and areas throughout the Hamilton Municipality [19]
- Groundwater Contamination: bacterial and elevated nitrate levels [20]
- General flow is into Hamilton Harbour, although Red Hill Creek groundwater flows into Lake Ontario [21]

WATER POLLUTION:

- Point Sources: industrial and municipal sewer-storm outflows
- Non-point Sources: urban run-off, agricultural run-off, soil erosion & pesticide use, manure management practices, contaminated sediments, combined sewer overflows, leachate from toxic landfills, brownfields and industrial land, acid rain

GEOMORPHOLOGY

TOPOGRAPHY:

- Major Features: Niagara Escarpment, Dundas Valley and Lake Ontario Shoreline (including Hamilton Harbour embayment)
- Niagara Escarpment: divides the watershed area in half and gives rise to significant stream gradients and several waterfalls [22]
- Above the escarpment is largely flat with gradients of 1:2,000 [23]
- The escarpment falls from 190m to 100m above mean sea level (1:20) [24]
- Below the escarpment streams move across shallow gradients (approx. 1:100) of clay and sand, or through the Dundas Valley to Cootes Paradise, and terminate at the harbour (74m above sea level) [25]

GEOLOGY:

- Topography formed over five separate periods [26]
- Precambrian era to Miocene epoch: rock structure established [27]
- Pliocene epoch: streams eroded the rocks as dominant geomorphic agents [28]
- Pleistocene epoch (Ice Age): erosion and deposition by various proglacial lakes (Lake Iroquois and Lake Iroquois Sand Bar) [29]
- Post Pleistocene: streams returned as dominant agents [30]
- Recent History: erosion and deposition by Lake Ontario (Lake Ontario Sand Bar) [31]

SUFFACES:

- Soil Types: mainly clay, silt and sand sediments from the last glacial deposit [32]
- Soil Characteristics: recharge areas are associated with well drained soils; high productivity provides some of the best agricultural land in Canada [33]

ORGANIZING PRINCIPLE: NATURAL - BIOTIC

PLANT LIFE

FOREST REGIONS:

- The region is located in the transition zone between two major forest regions: Eastern Deciduous Forest (Carolinian Zone) and Great Lakes-St. Lawrence Forest; floral and fauna assemblage is diverse- includes many species at or near the northern or southern limits of their geographic range [34]

ECOLOGICAL SYSTEMS:

- Three systems represented: Aquatic, wetland and terrestrial [35]
- Aquatic: Lake Ontario Shoreline zone, Hamilton Harbour, Cootes Paradise, many small stream systems, four inland reservoirs created by dams, natural inland ponds, many small artificial in-line ponds and dugouts [36]

- Wetland: common in Flamborough (areas of relatively undisturbed lowland forest on poorly drained, shallow, rocky soils); forests include a mix of broadleaf swamps, mixed swamps and cedar swamps; other wetland environments represented in this region include riparian (floodplain) marshes and swamps, small slough forest remnants, shoreline marshes, kettle bogs [37]
- Terrestrial: dominated by agricultural and urban land use throughout region; Dundas Valley and Niagara Escarpment corridors are the largest remaining natural terrestrial habitats; smaller, more disturbed upland areas with woodlots, plantations and old field habitats are widespread [38]

PLANT COMMUNITIES:

- Great Lakes: deep water, shallow water, shoreline wetland, shoreline [39]
- Aquatic: deep water, shallow water [40]
- Wetland: marsh, wet meadow, bog, fen, swamp, riparian wetland [41]
- Terrestrial: upland woods, escarpment, floodplain, limestone/dolostone alvar, prairie and savannah, early successional and other non-forested communities, plantations, anthropogenic maintained sites [42]
- Several fern species occur mainly along the Niagara Escarpment, a number of Carolinian and southern species reach the northern limit of their range along one of the southern facing sections of the escarpment [43]
- Unique system of open grassland alvars grow on thin soils over level limestone or dolostone rock; found on the Flamborough Plain [44]
- Riparian communities found along the meanders stream valleys of Twenty Mile Creek and Welland River in Glanbrook; support significant species such as rattlesnake manna grass and beaked sedge [45]

WILDLIFE

SPECIES:

- Habitat: inland marshes and ponds (typically associated with reservoirs and man-made ponds) provide essential breeding habitat from several significant bird species [46]
- Fish: 94 total species on the regional checklist; 85 extant, eight extirpated, one extinct [47]
- Birds: 168 total species on the regional checklist; five extirpated, one extinct and 162 currently species breed; of these 162 three were extirpated and have re-established [48]
- Mammals: 50 total species are on the regional checklist; 41 extant resident, eight extirpated [49]

NATURAL LANDSCAPE:

- Corridors: provided by the Niagara Escarpment, Dundas Valley and Red Hill Valley
- Significant Patches: the largest are associated with the Niagara Escarpment, the Dundas Valley, and the large bedrock plain above the escarpment in the Grindstone Watershed (Flamborough) [50]
- Minor Patches: below the escarpment to the shore, and above the escarpment in the southern and western areas of the region, natural areas exist in isolated woodlots, small wetlands or incised stream valleys [51]

ORGANIZING PRINCIPLE: CULTURE

BASIN POPULATION:

- Approx. 650,000; 95% live in urban locations (60 % of which live in the older central city of Hamilton) [52]

LAND USE:

- 65% agricultural - mixed farms (livestock, hay, grains, corn), fruit and vegetable farms; 14% residential; 8% industrial, commercial, institutional + government; 8% public open + conservation, 5% vacant, private open space + railways [53]
- Recreation Areas: 21 conservation areas, the Royal Botanical Gardens and natural areas and trails associated with the Niagara Escarpment [54]

BUILT LANDSCAPE:
- Development: 12% of Grindstone Creek Watershed; 20% of Spencer Creek Watershed; 80% of Red Hill Creek Watershed; new development is focused on Hamilton Mountain and Flamborough [55]

TRANSPORTATION:
- Major highways (403, QEW, 5, 6, 8), commercial and passenger railway system (CNR, CPR, OSR, Go Train, Via Rail), international airport
- All transportation systems impact on local and regional ecosystems thereby impacting habitat and water quality
- Trails: Trans Canada Trail, Bruce Trail and Regional Trails systems

ORGANIZING PRINCIPLE: INDUSTRY

ECONOMY:
- Manufacturing accounts for 56% of employment (including the largest concentration of steel + iron industries in Canada) [56]

TRANSPORTATION:
- Shipping by highways, railways (Railink CNR, CPR, OSR,) and Lakes to all major centres (Toronto, London, US etc.)

ORGANIZING PRINCIPLE: ENERGETICS

NUTRIENT FLOWS:
- Food: most not grown locally, although regional agriculture use is significant [57]
- Nutrient Cycles: isolation of wildlife patches stretches the food web and decreases population hardiness and genetic diversity
- Water: industrial use requires low quality supply (problems with contamination); municipal use requires high quality supply (development is stretching current supply)

A3. ANALYSIS OF HAMILTON MUNICIPALITY

A3.1. ABCE Analysis: Wider System
abiotic, biotic, cultural, energetics complex systems analysis

SYSTEM PERSPECTIVE	INFLUENCES
ORGANIZING PRINCIPLE: NATURAL - ABIOTIC	
AIR FLOWS	
MICRO CLIMATE:	▪ Prevailing Wind: west to southwest
	▪ Local Wind: Lake Ontario easterlies increase local precipitation and storm counts [1]
AIR POLLUTION:	▪ Point sources: industry
	▪ Non-point sources: agricultural, automobiles
WATER FLOWS	
COOTES PARADISE:	▪ Surface Area: 12 km^2 [(2)]
	▪ Mean Depth: 0.5 m; Max. Depth: 2 m [(3)]
HAMILTON HARBOUR:	▪ Surface Area: 21.6 km^2 [(4)]
	▪ Mean Depth: 13 m; Max. Depth: 25 m; Water Volume: 7.9 million m^3 [(5)]
	▪ Shoreline Length: 45 km [(6)]
	▪ Temperature: slightly warmer than Lake Ontario at 9°C (proves advantageous for plant growth, but also increased algae growth) [7]
CURRENTS AND FLOW:	▪ Harbour Retention Time: 3 months [8]
	▪ Winter Flow: random water exchange in and out of Burlington Ship Canal [9]
	▪ Summer Flow: cooler lake water flows into harbour through the bottom of the canal; warmer harbour water flows out of the harbour on top (this lake inflow carries vital oxygen to the harbour, and is the one thing keeping the harbour's bottom layer from becoming completely anoxic) [10]
	▪ Harbour Stratification: warmer water, containing sufficient oxygen levels, sits on top; below 7m the cooler level is virtually anoxic from June to October (greatly impairs fish species recovery) [11]
WATER POLLUTION:	▪ Point Sources: industrial and municipal outfalls
	▪ Treated Sewage: suspended solids flow into the harbour from two major sources: Red Hill and Spencer Creeks and also from storm sewer outlets (Hamilton Harbour also receives treated sewage from all of Stoney Creek and Burlington) [12]
	▪ Untreated Sewage Sources: bypasses on Hamilton's combined sewer system are diverted to harbour during heavy rains to avoid overloading the Woodward Plant [13]
	▪ Improvements: upgrades to the region of Halton's Skyway WWTP resulted in measurable improvements to water quality; Hamilton has begun to capture direct sewage discharges and upgrade their three WWTPs. (estimated to take min. 15 years at approx. $480 million to meet RAP delisting objectives) [14]
	▪ Non-point Sources: agricultural, automobiles
GEOMORPHOLOGY	▪ Harbour Elevation: 74m above mean sea level [15]
	▪ Downtown Hamilton: Hamilton Harbour to the north, Niagara Escarpment to the south, Dundas Valley to the west and Red Hill Valley to the east.
SUFFACES:	Almost continuous development is characterized by impermeable surfaces, associated with groundwater recharge and storm water run-off problems

EROSION:
- Some erosion problems in river valleys below escarpment; significant erosion problems due to construction [16]
- Shoreline: erosion of harbour and sand bar due to wave action and currents

MANIPULATION:
- Surficial Alterations: non-point source run-off from the watershed, point source discharges, dredging have resulted in bottom materials, consisting largely of mud, silt and clay, replacing the extensive stretches of sand and gravel bottom in the harbour (especially in the past 100 years) [17]
- Lake Bottom Scars: dredging, ship anchors – recirculation of contaminants [18]
- Organic Alterations: organic bottom materials that once covered Cootes Paradise are now limited, due to infilling and burying

ORGANIZING PRINCIPLE: NATURAL - BIOTIC

PLANT LIFE

ORIGINAL CONDITION:
- Wetland vegetation formed important ecosystems for maintenance of biodiversity in species of birds, fish and wildlife; also filtered sediment and nutrients that improved water quality [19]

DEGRADATION:
- The shoreline communities in Hamilton (including marshes, ponds, bluffs, and beach strands) are threatened by development, shoreline reconstruction, and environmental degradation. Significant areas include: Cootes Paradise, Hamilton Harbour, Hamilton Beach Strip, Van Wagner's Ponds & Marshes, and Community Beach Ponds [20]
- By 1980s Cootes Paradise vegetation cover had dropped 85% from original state [21]

REGENERATION:
- 145 km^2 or 29% of the Hamilton watershed is designated as environmentally sensitive area (including the 3.7 km^2 Cootes Paradise Marsh) [22]
- RAP published in 1992 which began implementation of regeneration [23]

EXISTING:
- 340 ha of habitat are restored at six sites around the Harbour. Improvements in water quality resulted in: 170 ha of aquatic plants returning to the harbour; an increase from ten native plant species in Cootes Paradise to 18 species [24]

WILDLIFE

ORIGINAL CONDITION:
- Fish: area provided habitats for atlantic salmon, herring, lake trout, whitefish, sturgeon and northern pike. [25]
- Pike and Bass accounted for 15% of all Lake Ontario catch (1900) [26]
- Mammals: provide habitat to many significant species such as bear, bobcat, timber wolf, cougar [27]

DEGREDATION:
- Fish: eight species which formerly occurred in Hamilton Harbour – Cootes Paradise Complex are considered extirpated in the region; one subspecies (blue pike) is extinct [28]
- The fish of the urbanized streams (Red Hill, Stoney and Fifty Creeks) are generally depauperate (<10 species/ stream) due to diminished habitat diversity, construction of culverts and channels, extreme fluctuations in stream flow, and poor water quality [29]
- Changes to range, distribution and abundance of fish species are attributable to changes in temperature and flow regimes following construction of the four reservoirs (1966-1971) [30]
- Birds: five species which previously occurred in the region are considered extirpated; one other species is now extinct [31]
- Mammals: bear, bobcat, timber wolf, lynx, American elk, cougar, river otter are all extirpated in the region [32]

REGENERATION:
- Cootes Paradise: set aside as provincial wildlife sanctuary 1927; habitat for over 50 species of nesting and migrating birds; crucial spawning ground and nursery for fish; amphibians populations have grown since 1994; Fishway provides barrier to Carp against pollution entry [33]

- Fish Habitat: Increase of spawning, nursery and sheltered areas along shoreline using gradual sloping, shoals and small islands [34]
- Birds: three species that were previously extirpated has re-established breeding patterns as a result of reintroductions [35]

EXISTING CONDITION:

- Fish Populations: 85 species in the region; 75 are native (25 of which are considered highly significant- rare or very local); 10 are not native and include sports-fish [36]
- Fish Distribution: 34 species (40%) are restricted to the Hamilton Harbour and Cootes Paradise as well as adjacent streams; 18 of these belong to the 25 regionally significant species; a few non-native species now account for a large proportion of the fish biomass in Hamilton Harbour and Cootes [37]
- Bird Populations: 162 birds currently breed in the region; seven of which are non native; 52 are highly significant (51 of which are rare native species and one uncommon colonial-nesting species that nests only at Hamilton Harbour); 52 other native species are considered moderately significant in the region; 17 species are considered nationally and provincially significant (at their northern range); four species are considered vulnerable in Canada; six fish-eating water-bird species have formed breeding colonies in the harbour (including: gulls, terns, herons and cormorants) [38]
- Mammal Populations: 38 native species (seven considered rare in the region, five are considered regionally uncommon) and three non-native; deer and racoon numbers are high; others include: fox, coyote, beavers, rabbits, weasels, mink, squirrels, skunks, rats, bats and mice [39]

ORGANIZING PRINCIPLE: CULTURE

POPULATION:

- 490,268 (growth of 4.8% from 1996-2001) [40]
- Population density 438.9/ km sq [41]

LAND USE:

- Primary land use: industrial and residential; secondary: commercial, institutional (McMaster University, hospitals, and Mohawk College)
- Land Area: 1,117 km sq; primarily built area [42]
- Total Private Dwellings: 194,154 [43]
- Recreation Areas: 14 conservation areas (managed by Hamilton Conservation Authority), 7 conservation areas managed by Conservation Halton), the Royal Botanical Gardens including Cootes Paradise [44]

HARBOUR USE:

- Shoreline: the south and east shores are primarily industrial and port lands; the west end of the south shore is shared between rail and public uses (Pier 8 marks the division between recreation and industry); the north shore is largely residential with two cemeteries
- Recreation: eliminated all save berths for pleasure boating - still a major use [45]

WATER USE:

- Domestic Water Supply: furnished largely from Lake Ontario; prior to 1860 Hamilton relied on wells and springs [46]

TRANSPORTATION:

- East-west Roads: King and Main streets define the downtown; Barton and Burlington streets define the industrial waterfront
- North-south Roads: Bay, James and John streets link downtown to the new public waterfront; Wellington, Victoria, Wentworth, Gage, Kenilworth and Parkdale streets terminate at Burlington Street to the north
- Public Transportation: Go Transit stops downtown; public buses provide service to the majority of the municipality
- Trails: Trans Canada Trail (includes: Lake Ontario Waterfront Trail, Hamilton Harbour Waterfront Trail, Escarpment Rail Trail), Bruce Trail and Regional Trails (includes: Dejardins Trail, Hamilton Beach Trail, Red Hill Valley Trail) [47]

ORGANIZING PRINCIPLE: INDUSTRY

HARBOUR USE:
- Shipping, industry; historical priority has always been given to navigation [48]

ECONOMY:
- Over 500 firms are directly or indirectly involved in the steel and iron industry: scrap, electricity, natural gas, oil refractories, oxygen, transportation services, waste disposal services, construction and maintenance services, office supply, consulting services [49]

PRODUCTION:
- Hamilton has 6.6 million tonnes of steelmaking capacity (over 40% of Canadian total) – another 2.4 million tonnes of capacity is located within 50 km radius [50]

WATER USE:
- Industrial Water Supply: 2.3 million cubic meters are withdrawn daily (mostly for cooling water processes in the steel mills) 96% of this used to return to the harbour, but this has dropped to zero [51]

EDUCATION:
- McMaster University: full service university including a steel research centre and joint programmes with Dofasco focused on steelmaking research [52]
- Mohawk College: technical institution; offers steel and metallurgy based programs [53]

TRANSPORTATION
- Road: Barton and Burlington streets, smaller local roads and private roads facilitate the transfer of material and goods to rail and highways
- Rail: Railink facilitates transfers among national, local and private rail lines
- Water: port lands provide international connections to the industrial land

NATURAL RESOURCES:
- Ground transportation surrounds the harbour; the sand bars of Lake Ontario and the glacial Lake Iroquois provide natural bridges for rail and roadways to major regional population and production centres
- In addition to the opportune location, Hamilton provides valuable natural resources: water and raw material extraction from the escarpment

HISTORICAL SIGNIFICANCE:
- Following the construction of the Burlington Ship Canal and the Dejardins Canal, urban centres began to develop around the harbour facilities. Industrial, commercial and residential developments grew along the system of railways and highways that radiated from the head of the lake.

ORGANIZING PRINCIPLE: ENERGETICS

ENERGY FLOWS:
- Overall Energy Balance: food web, trophic structure
- Use: largest user is industrial (coal, electricity, raw materials); municipal use is significant (electricity)
- Generation: no major production in the region (aside from Stelco and Dofasco coal power); limited diversity of source [54]
- Distribution: low efficiency; hydroelectric production centre in Niagara; fossil fuel production at Nanticoke and Lakeview [55]
- Alternative Research: Hamilton Community Energy, a business unit of Hamilton Utilities and 100% owned by the City of Hamilton, recently launched a 12 MW thermal and 3.5MW electricity CHP plant adjacent to a high school feeding 124°C water through a series of underground pipes to 8 buildings up to 1.5 km from the plant. The electricity will be used by the city; any excess sold to the public grid [56]

WASTE FLOWS:
- Generation: municipal and industrial waste streams enter regional systems
- Transport: detrital matter is high via water and wildlife; waste disposal was untreated until the 1960s [57]

A4. HAMILTON HARBOUR MANAGEMENT UNITS

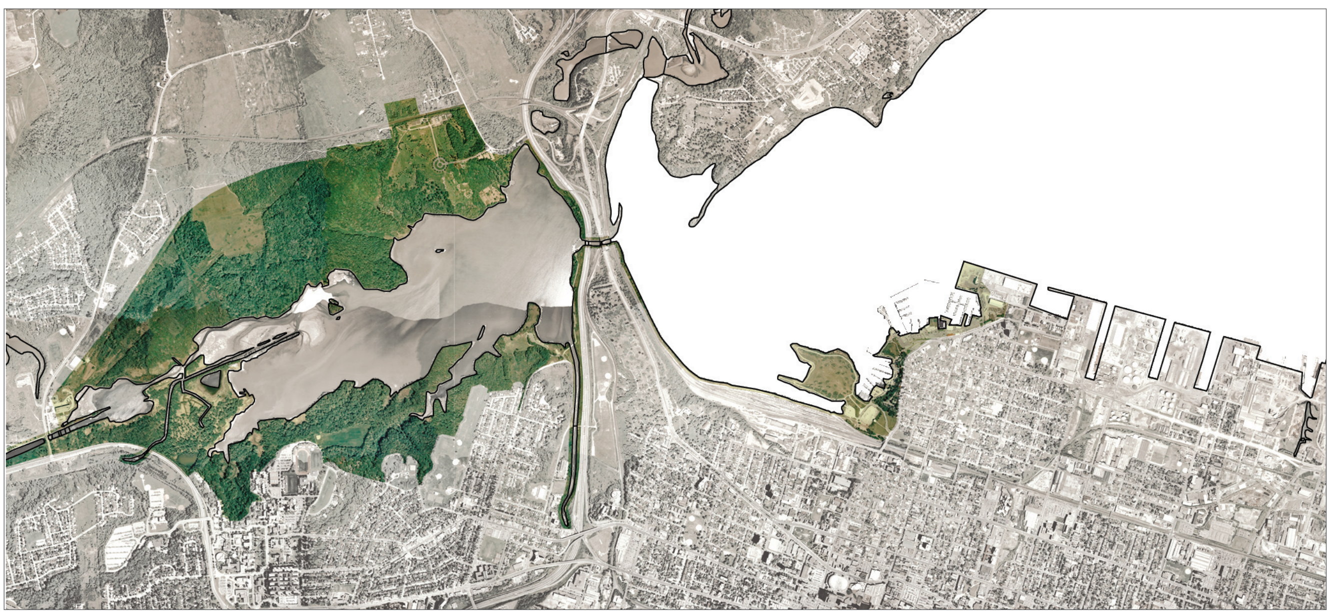
MANAGEMENT UNIT 1: Cootes Paradise + Recreation Zone

Cootes Paradise exists as 915 acres of shallow water and marshland. Although designated as an ecological preserve in 1927, urban and industrial development continued to degrade ecology until 1980 when 85% of its original vegetation had been lost.[1] Upon the implementation of the Hamilton RAP the wetlands have shown promising signs of recovery. The Waterfront Trail has connected Cootes to the new development along to Pier 8 increasing public waterfront access and recreation amenity. Renewed public use, education and involvement continue to increase awareness and consequently ecological health of the area.

A4.1

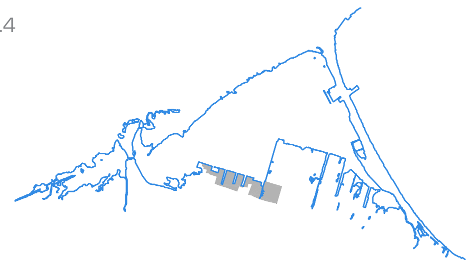
A4.1. Waterfront Management Unit 1
A4.2. Aerial: Cootes Paradise + Recreation Area
includes waterfront trail, park development, Piers 5 through 8 and Bayview Park - Scale 1:50,000
A4.3. Cootes Paradise
photo taken from eastern shore

A4.2



A4.3

A4.4



A4.5

A4.4. Waterfront Management Unit 2
A4.5. Aerial: Piers 8 to 15 - Scale 1:50,000
A4.6. Pier 10
photo taken from Burlington Street

MANAGEMENT UNIT 2: Piers 8 - 15

Under the management of the Hamilton Port Authority these relatively small piers are some of the oldest remaining in the harbour. Port use is dominated by shipping and small industries and the majority of the land is restricted from public use.

Pier 8 forms the division between the public redevelopment to the west and industrial developments to the east. A sailing association and yacht club occupy its western half, while the eastern half forms the start of shipping activities. Piers 8 and 10 serve as overseas terminals with general cargo facilities. Piers 11, 12 and 14 provide general, dry and liquid bulk shipping terminals, as well as industrial uses.[2] Small firms engage in activities such as steel fabrication, various manufacturing, brewing, recycling and trucking as well as bulk material handling, storage and distribution.

Pier 15 is a key location on the industrial waterfront that provides opportunity for development on open brownfield land, while containing the most dense and diverse group of business on its developed portions. It also shelters Sherman Inlet, one of the few remaining natural shoreline elements, and as such suggests possibilities for wetland regeneration.

A4.6

MANAGEMENT UNIT 3: Stelco (Piers 16 - 18)

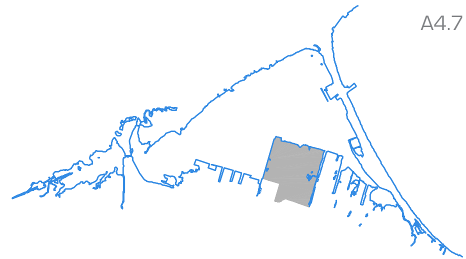
Stelco, founded in 1910, is a fixture in Hamilton Harbour and one of the largest employers in the area. The firm has extensive port and steel making facilities, and together with Dofasco constitutes the largest production of steel in Canada.[3]

As an integrated steel mill its manufacturing processes rely on coal, blast furnaces and basic oxygen furnaces that create significant pollution problems. Consequently, the 1,110 acres of port land occupied by Stelco has been made increasingly toxic throughout the mill's history. The entire facility and shoreline remains restricted to the public due to safety and liability issues related to certain aspects of the process, as well as health concerns related to historic and existing pollution issues.

Poor management, strained union relations, limited environmental practices, and outdated technology have all contributed to Stelco's move toward bankruptcy protection. The company requires significant restructuring and modernization; however significant infrastructure and a strategic location remain as significant assets.

The Stelco lands figure prominently within the harbour, just as its structures serve as constant markers in the city skyline. The pier has played a pivotal role in both positive and negative aspects of Hamilton's growth and its current condition is representative of both the city's problems and potentials. Speculation and potential redevelopment of this property are critical to the formulation of new sustainable systems within the harbour.

A4.7

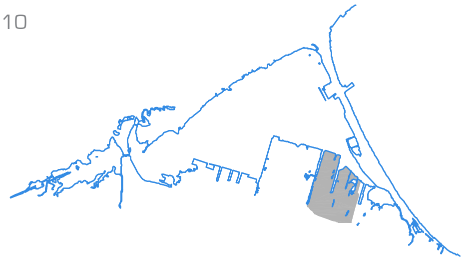


A4.8

A4.7. Waterfront Management Unit 3
A4.8. Aerial: Stelco Inc. Hamilton - Scale 1:50,000
A4.9. Stelco Inc. Hamilton
photo taken from Pier 14

A4.9

A4.10



A4.11

A4.10. Waterfront Management Unit 4
A4.11. Aerial: Dofasco Inc. Hamilton - Scale 1:50,000
A4.12. Dofasco Inc. Hamilton
photo taken from Industrial Dr.

MANAGEMENT UNIT 4: Dofasco (Piers 20 – 22)

Dofasco, founded slightly later than Stelco in 1912, has played an equally large role in Hamilton's industrial history, and currently employs greater numbers. Its port facilities are almost as extensive and its steel making facilities are more extensive, with a higher production output on just 730 acres of port land.

Although Dofasco is also considered an integrated steel mill, it has replaced some older equipment with an electric arc furnace, which has reduced their raw material use and pollution contribution, while increasing their recycled content. Despite these changes, much of its land and processes remain toxic, and its property is completely restricted to public use.

Collaborative management, incentives and profit sharing have helped Dofasco develop agreeable employee relations with its union-free labour force. The company has also begun to address environmental issues by decreasing emissions, reducing energy use, reusing by-products and investigating in new technologies. Progressive strategies have created the largest, most successful steel producer in Canada, as well as the largest scrap metal recycler in Canada, yet a great deal of progress is still required to approach true sustainability.

A4.12

MANAGEMENT UNIT 5: Piers 23 - 28 + Windemere Basin

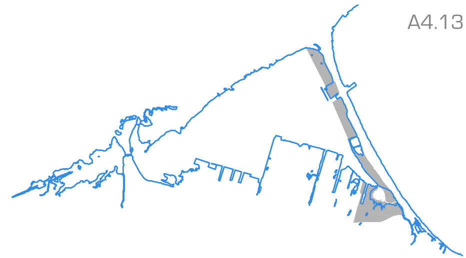
This unit includes the most recent port land developments in the harbour which are managed by the Hamilton Port Authority. It also contains a diverse range of uses on the Burlington Sand Bar, a feature that factored prominently in the development of Hamilton and now provides an important conduit for rail and highway routes, as well as the vital Burlington Shipping Canal.

Piers 23 through 27 offer general, liquid and dry bulk shipping facilities.[4] Manufacturing, processing, storage, construction and other industrial activities also take place on adjacent lands. Pier 26 and 27 are not fully developed. Pier 28 offers public amenities such as Fisherman Pier and a boat launch. Facing Lake Ontario, various beaches and residential neighbourhoods occupy the sand bar.

The Canadian Centre for Inland Waters, instituted in 1967 near the shipping canal, provides a base for many research and monitoring groups including the Hamilton Remedial Action Plan.[5]

Windemere Basin, the outlet for Red Hill Creek, has been subjected to considerable industrial and municipal contamination. Remediation initiatives have begun and the basin offers significant potential for wetland regeneration.

A4.13

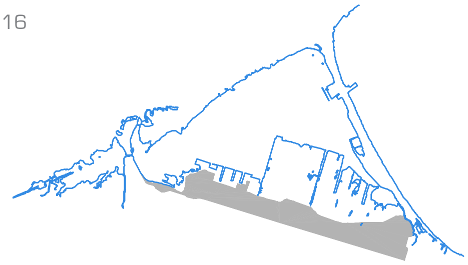


A4.13. Waterfront Management Unit 5
A4.14. Aerial: Windemere Basin + Piers 23 to 27: Canadian Centre for Inland Waters and Expansion Areas - Scale 1:50,000
A4.15. Windemere Basin

A4.14

A4.15

A4.16



A4.16. Waterfront Management Unit 6
A4.17. Aerial: Industrial and Residential Areas located between Barton St. and Burlington St. - Scale 1:50,000
A4.18. Intersection of Strachan St. and Ferguson Ave. public land among residential, industrial, and rail properties)

MANAGEMENT UNIT 6: Barton Industry

This unit extends along the southern edge of the harbour between Burlington Street and Barton Street. Accessed by public roads, its land use consists of older residential neighbourhoods, rail yards and small industrial firms, including the bankrupt steel producer Slater Steel. Commercial activities occur in several small pockets, a large mall along Barton, and a recovering commercial strip along James Street, which connects the downtown to the new public waterfront.

Public streets, mixed use, and small industrial units may provide insight into the synthesis of natural, cultural industrial systems.

A4.17

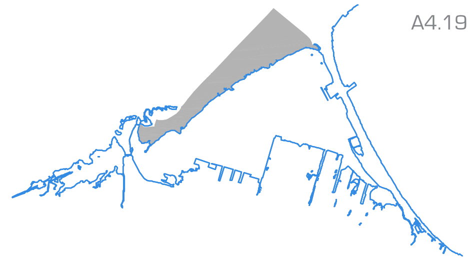
A4.18

MANAGEMENT UNIT 7: Burlington Shore

The northwest shore of Hamilton Harbour is governed by the City of Burlington, within the Region of Halton. The area is largely residential with some commercial activity and some parks. A large private golf course and two cemeteries, Woodland and Holy Sepulchre, exist as significant barriers to public use and waterfront access.

Lasalle Park, the associated marina, and Bayshore Park provide some public function along the waterfront. In addition some trails have been constructed in the area, but currently no continuous waterfront trail exists.

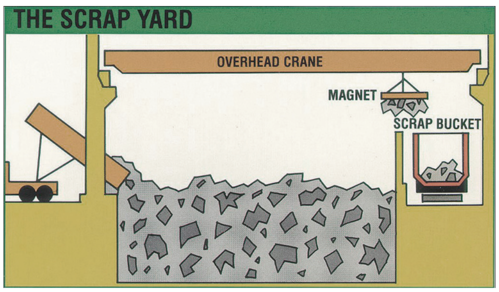
A4.19



A4.19. Waterfront Management Unit 7
A4.20. Aerial: Burlington Shore - Scale 1:50,000

A4.20

A5. STEEL PRODUCTION



A5.1

STEP ONE Scrap steel is delivered by truck and tipped into the mill's scrap pit which has a capacity of 18,000 tonnes - carefully divided into four grades held in separate bays. That's enough to feed the mill for two weeks. STEP TWO According to the demands of the furnace production schedule, the various grades are loaded into scrap buckets for transfer by rail trolley into the melt shop.

STEEL MINI MILLS: A RECYCLING SUCCESS STORY

There are several mini mills in Australia and quite a few in the USA and they produce a considerable amount of steel from what is essentially quite a small plant. So what is a mini mill?

A mini mill is a steel production facility that uses an electric arc furnace to melt the scrap steel. In contrast, the traditional Integrated Steel mill has blast furnaces or basic oxygen furnaces using iron ore and coke as the basic ingredients with some scrap thrown in. Although some integrated mills have electric arc furnaces for specific purposes, the arc furnace is the key component of a mini mill.

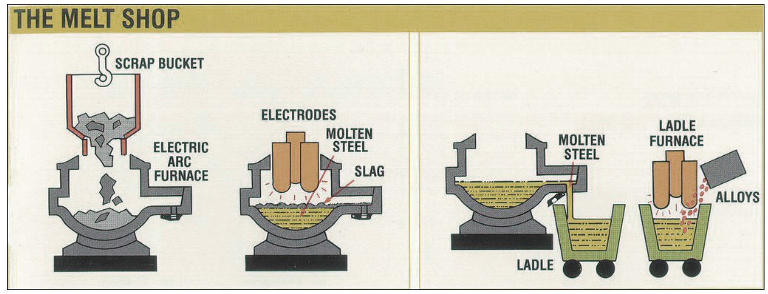
Over the past 20 to 30 years, there has been substantial growth in mini mills. In 1970, mini mills accounted for less than 10% of US steel production. These early mills typically produced between 100,000 and 300,000 tonnes per annum, with the number of grades of steel and product types kept to a minimum. In 2001, mini mills produced nearly half of the steel shipped by United States mills. Nor is it stopping there. Mini mills are no longer mini, with production capacities now approaching 1,000,000 - 2,500,000 tonnes per annum while still using a single but now quite large arc furnace. In addition, the list of grades of steel produced and product types has increased considerably.

North American carbon steel mini-mills continue to be among the most competitive steel makers in the world. Some idea of the growth in productivity can be obtained from the following figures. In 1983, integrated mills were producing about 200 tonnes of steel per employee, rising to approximately 700 tonnes in 1996. The latest mini mills are claiming 4,000 tonnes per employee.

Although arc furnaces use large amounts of electric energy to heat the steel scrap, there is a significant saving on raw materials. For every tonne of steel recycled, there are 1.25 tonnes of iron ore, 0.5 tonne of coal and about 20kg of limestone saved.

As the name would indicate, mini mills have a relatively low steel production capacity when compared with integrated steel mills but they can be accommodated comfortably on just a few hectares. Because they do not need to be located near a railway or water transportation facilities, mini mills have a much wider range of suitable geographic locations.

The factors driving mini mill location are an adequate supply of electricity, scrap availability and a local market for products.



A5.2

STEP THREE In the melt shop, a crane lifts the scrap bucket and empties its 80 tonne load into the opened arc furnace. The melting and refining stages are conducted at 1600°C. As the scrap is melted by the electric arcs, fluxes are added to form a slag on top of the molten steel. Oxygen is then injected by lance through the slag, into the molten steel. The resulting chemical reactions cause the slag to absorb most of the impurities from the steel. Those impurities that are not transferred to the slag are exhausted as fumes for cooling and collecting via the mill's fabric filter bag system.STEP FOUR When the steel has reached the required temperature and chemistry it is tapped into a ladle for transfer to the ladle furnace area. In the ladle furnace there is more refining to be done - this time through selective addition of alloys. In the ladle, the temperature of the molten steel is increased and maintained by electric arcs mounted in the ladle furnace cover.

While mini mills are more specialised in the types and quality of the steel produced, the wastes are similar to those from iron and steel making. The major difference in mini mill waste is increased concentrations of toxic metals in dust, sludge and slag, due to the scrap metal used as the input. Stainless steel scrap for example, is high in nickel and chromium, while other steel scrap may often have a coating of zinc, tin, nickel, lead or chromium.

Certain scrap may need to be chemically or physically treated before entering the arc furnace to remove its coating (eg, de-galvanising) before being processed into new steel and it is here that the mini mill metallurgist has to exercise some of his magic. To take an unknown mix of scrap steel and finally produce a certifiable grade of new steel requires considerable expertise and yet it is all in a day's work for the mini mill metallurgist.

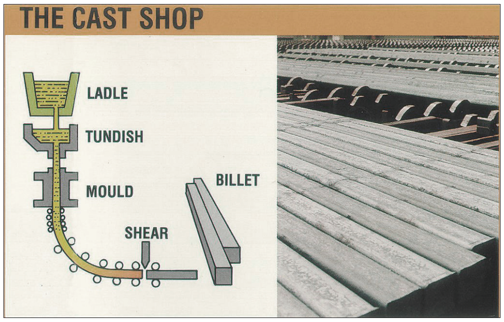
Finally, as most mini mills are located in large cities, great care is exercised in maintaining the required environmental controls. Indeed, environmental factors dominate the design of any modern mini mill.

Electric arc furnaces

The arc furnace has been in use for nearly 100 years as a method of making steel. Originally confined to small (several tonne) furnaces for the production of highly specialised steels, recent developments have seen the arc furnace growing in size and popularity as technical problems have been overcome and reliable sources of cheap electricity have become widespread.

In the last 15 years or so, the arc furnace has undergone something of a renaissance as technical innovations have led to very significant improvements in productivity, steel quality and operating cost. These developments have proceeded to the point where the arc furnace is now the preferred, low capital, flexible route for the production of a significant proportion of flat products and almost exclusively, long products.

The modern electric arc furnace consists of a refractory lined steel shell or hearth that holds the scrap charge while



A5.3

STEP FIVE When the required alloys have been added and exact specifications have been reached, the molten steel is taken to the cast shop where it is poured into a tundish from where it flows into a series of water-cooled moulds to form continuously cast billets. The 127mm square partially solidified billet strands are further cooled by direct water spray in a secondary cooling zone. While they are still hot, however, they are cut into 12-metre lengths by automatic hydraulic shears. The billets are then air-cooled before being carried by overhead cranes fitted with electromagnets into the outdoor billet stacking yard.

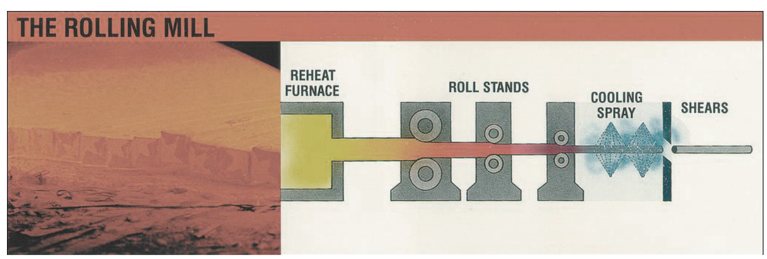
STEP SIX Billets are fed into a natural gas-fired furnace where they are reheated to rolling temperature of about 1150°C. The billets are fed through a series of rolling mill stands where they are reduced and formed into various sections and sizes, such as angles, reinforcing bars and wire rod. The rod and bar products produced in the mill are cooled by water sprays and air before being sheared to customer specified lengths.

it is being melted and retains the liquid steel until it is ready to tap. The walls above the liquid steel level are typically water-cooled, replaceable copper panels. The furnace has a water-cooled roof that can be swung aside to allow for scrap recharging.

In most cases, loading of the furnace is carried out via overhead clamshell buckets or baskets. All types of scrap and scrap substitutes can be added in this manner. Sometimes charge carbon and fluxes (lime and dolomite) are also added in this manner.

The preferred method of adding smaller input materials is via a conveyer belt, loading into the "fifth" hole in the furnace roof. This is known as continuous charging. The number of buckets required to reach the specified tap weight will be determined by the scrap charge density.

Arc furnaces can be either AC (three electrodes, each with its own phases) or DC (single or twin electrode). In an AC furnace, the roof has at least five openings, one for each of the three electrodes, one for fume evacuation and the abovementioned "fifth" hole.



A5.4

Electric arc furnace

In an AC furnace, the current path is from the electrode tip to the bath and back to the next electrode in the phase rotation. In a DC furnace, the current passes from the electrode through the bath to a return electrode in the furnace hearth.

The electrodes are made of graphite manufactured to have special properties of conductivity combined with high strength at high temperatures. The electrodes are consumed in the process and need to be continually replaced. This is achieved by "slipping" or lowering the electrode through the holding arm into the bath and adding a new section to the top. This is done by screwing electrode sections together.

Electrical power is supplied from a substation, then to a step-down transformer. The furnace also has its own transformer that serves to alter the furnace electrode voltage. These voltage "taps" are usually selected automatically but they may also be adjusted manually by the furnace operator. The electrode voltage determines the arc length and therefore the power applied to melt the steel.

A5.5

STEP SEVEN After shearing or coiling, products are transferred to the mill's finishing area for straightening, bundling, strapping and dispatch to customers.

As conditions inside the furnace are constantly changing, it is necessary to continually reposition the electrodes to maintain the desired arc current and power setting. This is normally achieved by constantly measuring the impedance (voltage divided by current) and feeding this back to a control system that will raise or lower the electrode arms as the conditions inside the furnace change.

Oxygen is used to assist in refining the steel by burning off impurities such as phosphorus. A lime-rich slag is used to collect this and other unwanted elements and provide a base material to be foamed by the evolution of carbon monoxide and carbon dioxide gases. This foamy slag helps improve energy efficiency by preventing unwanted radiation of the unshielded arc to the furnace roof. The foaming action causes the slag to be continuously flushed from the furnace up until tap time.

The molten slag also helps in suppressing the considerable amount of noise produced by the electric arcs.

When the appropriate steel chemistry and temperature have been achieved, the steel is tapped either through a spout or a submerged taphole, into a ladle and then on to a ladle furnace for secondary treatment.

Furnaces manufactured by EMCI for example may be bottom tap design or conventional design with standard or current conducting electrode arms. EMCI's electric arc furnaces also feature hydraulic circuitry that allows for rapid electrode travel and fast back tilt to minimise slag carry-over.

Rooty Hill's mini mill

To illustrate the operation of a typical mini mill, we now look at the One Steel plant at Rooty Hill in Sydney, NSW. This is quite a small facility and yet the very first thing that stands out is the small size of the actual Melt Shop and electric arc furnace itself in comparison to the overall size of the whole facility.

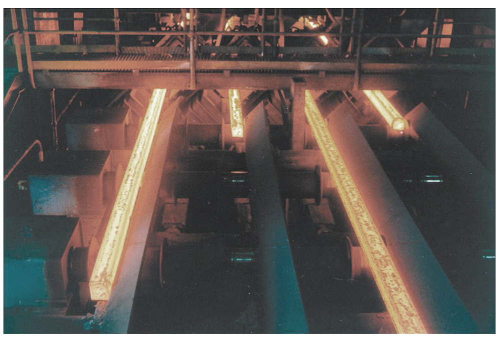
The 60-tonne electric arc furnace has been coaxed by an ingenious and industrious staff into taking 80 tonnes of scrap in a single feeding. It is this "small" furnace, working on a continuous basis, that produces the vast stacks of steel in the Rooty Hill mill; some 500,000 tonnes per annum, 200,000 tonnes of which is sold as bar stock. Here then is a very efficient operation by any standard.

The furnace consumes large amounts of electricity, the actual rating being 62MVA (equivalent to 62 megawatts). The magnetic fields surrounding the furnace is so strong that the video monitors in the nearby control room flicker continuously in spite of serious efforts to shield them. How the staff manage to watch these flickering images continuously defies comprehension. We assume that the computer monitors will shortly be upgraded to LCD monitors which would cure the problem completely!

To enter the melt shop and confront the electric arc furnace in full song is to finally come face to face with Dante's Inferno. Housed in a towering, dark, windowless building, blackened internally by years of fumes and dust, the furnace presents an eerie sight. Crouching in one corner and tied to the Melt Shop building by a staggering array of cables of all sizes - cables that soar loftily up into the inky blackness of the dimly lit, almost invisible ceiling - the furnace resembles some prehistoric fire-breathing monster chained down to prevent its escape.

The Monster within

To confront this monster, the visitor is given earplugs, glasses and a woollen jacket. Roaring and spitting and emitting an intense light so bright that it can only be viewed through special glasses, and heat that is fearsome to the extreme, one is immediately struck with the thought that those who care for this monster are special people. To office workers who confront nothing more daunting in their working day than a hot cup of coffee, here is a different world indeed.



A5.6

All the steel from the Rooty Hill mill is first produced as continuously cast billets such as these emerging from the tundish via water-cooled moulds. The extreme heat rising from these billets has to be experienced to be believed yet it is a pale shadow of that from the electric arc furnace.

Control of the furnace is a delicate operation. To begin, the scrap steel input is carefully prepared to stringent quality standards by suppliers. Composed largely of old car bodies, washing machines, fridges and the like, combined with structural steel from demolition sites, waste and off-cuts left over from other steel mills, the input is a disparate mix. For example, car bodies and white goods (fridges, etc) will have been shredded to remove all paint and plating so that they are completely unrecognisable.

From this raw material, the metallurgists at the mill will eventually produce certified grades of steel used in such industries as construction, farming and transport. The mix in the electric arc furnace must therefore be continuously monitored and adjusted by the addition of other raw materials such as burnt limestone and dolomite, carbon, ferro alloys, oxygen and nitrogen.

Feeding the electric arc furnace continuously with a stream of scrap that may on occasions still contain an unknown quantity of impurities, in spite of careful sorting, can lead to eruptions that may spit molten steel across the melt-shop floor. Looking after the furnace is certainly not a job for the fainthearted!

The Main Steps

There are five major steps in the transformation of scrap into graded steel at the Rooty Hill steel mill.

(1) The carefully graded scrap is delivered by truck to the mill's scrap pit which measures 100 x 23 x 6 metres deep. It is capable of holding up to 18,000 tonnes, enough to feed the furnace for about three weeks.

(2) Depending upon the demands of the furnace production schedule, the various grades are loaded by electromagnetic crane into scrap buckets for transfer into the melt shop.

Interestingly, all the electromagnetic cranes in the plant have battery backup, for safe depositing of loads in case of power failure.

(3) In the melt shop, a crane lifts the scrap bucket and empties its load into the opened arc furnace. The furnace capacity is 80 tonnes and the number of buckets required to load the furnace depends on the scrap density. The furnace is manufactured by Danieli, Italy. Bath diameter is 5.5 metres and the tap weight is 75 tonnes. By the way, the electrode diameter is 550mm.

The melting and refining stages are conducted at 1600°C. As the scrap is melted by the electric arcs, fluxes are added to form a slag on top of the molten steel. Oxygen is then injected by a lance through the slag, into the molten steel.

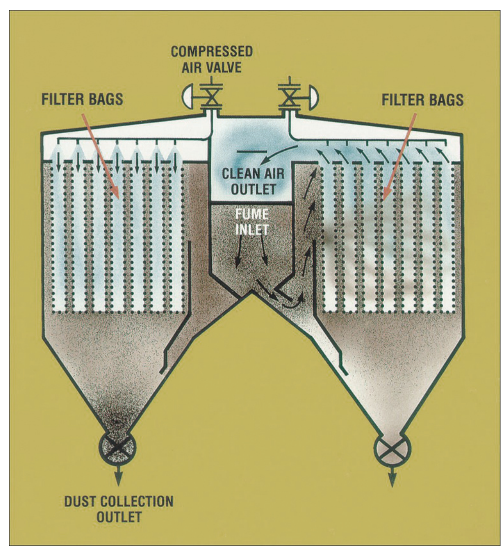
The resulting chemical reaction causes the slag to absorb most of the impurities from the steel. Those impurities that are not trapped in the slag are vented for cooling and collecting via the mill's fabric filter bag system.

The time from charging to finish of a batch is 44 minutes and tap-to-tap time is 56 minutes.

(4) When the steel has reached the required temperature and chemistry, it is tapped into a ladle for transfer to the ladle furnace area. The ladle furnace is again manufactured by Danieli and is a

A5.7

The billets are later reheated prior to being fed to the rolling mill to produce a wide variety of sections such as angles, reinforcing bars (rebar) for concrete, round bars, flats, fencing wire and so on.



A5.8

Fumes generated in the mill are treated in the bag filtration plant. This acts like a gigantic vacuum cleaner to remove dust and particles before release to the atmosphere. The righthand bag is operational while the other is on standby.

12MVA, bottom-stirring furnace featuring 350mm electrodes. Power consumption is 15kWh/liquid tonne.

(5) In the ladle furnace there is more refining to be done, through selective addition of alloys. When the required alloys have been added and exact specifications have been reached, the molten steel is taken to the cast shop where it is poured into a tundish from where it flows into a series of water-cooled moulds to form continuously cast billets.

The continuous caster is a Danieli, four-strand billet caster with either 121mm or 127mm sections. The extrusion rate of the billets varies between 2.9 - 3.1 metres per second, the maximum sequence length being 36 hours. The square partially solidified billet strands are further cooled by direct water spray in a secondary cooling zone. While they are still hot however, they are cut into 12-metre lengths by automatic hydraulic shears. A fully laden furnace will produce approximately 88 billets.

The billets are then air-cooled before being carried by overhead cranes fitted with electromagnets into the outdoor billet-stacking yard. It is interesting to note that steel loses its magnetic properties above 600°C so cooling must be well under way before the steel billets can be handled with electromagnets.

Rolling into finished stock

As stated earlier, of the approximately 500,000 tonnes of steel billets produced at the Rooty Hill mill, approximately 200,000 tonnes are sold as raw billets to other steel mills. The remainder is processed into lengths of various shapes and sizes.

The rolling process begins with the billets being reheated in a natural gas-fired recuperative walking hearth furnace where they are raised to the rolling temperature of about 1150°C. Billets are then fed through a 16-stand 800kW rolling mill with a throughput of 270,000 tonnes per annum.

Here they are reduced and formed into such shapes as reinforcing bar for the building industry, angles and flats for construction and transport and wire rod for the fastener and wire industries. The rod and bar products produced in the rolling mill are cooled by water sprays and air before being sheared to customer specified lengths. Shearing is carried out on-the-fly by a swinging-arm guillotine, the finished stock moving through the shears at 13 metres per second.

After shearing or coiling, products are then transferred to the mill's finishing area for straightening, bundling, strapping, identification and dispatch to customers in the Sydney area. The plant's warehouse area can accommodate up to 18,000 tonnes of finished product.

Environmental considerations

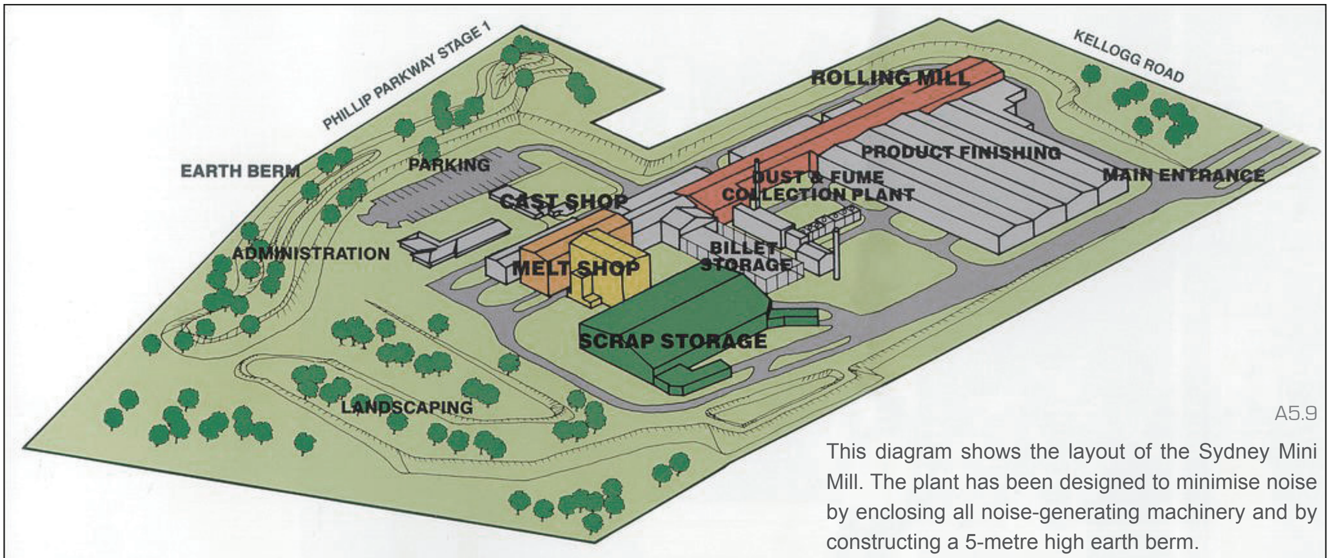
As the mill is located in the heart of a Sydney residential suburb, housing the electric arc furnace obviously required considerable care, as indeed did the whole mill. The seven hectares of mill buildings are located in the centre of a 27-hectare landscaped area.

Soundproofing the Melt Shop and all noise generating plant required the use of 320mm thick, sound-absorbing precast concrete wall panels. Soundproofing is further enhanced by surrounding the entire plant with a 5-metre high solid earth berm, created from some 63,000 cubic metres of topsoil material.

An air-monitoring station near the site incorporates a high volume sampler and dust fallout gauge, as well as wind-direction and wind-velocity meters. During mill operation, fumes generated are removed from the building and filtered through thousands of filter bags housed in the mill's baghouse. Designed to handle a total volume of 730,000 normal cubic metres of fumes per hour, the bags act like a gigantic vacuum cleaner to remove dust and particles to levels well below the limits set by the NSW Clean Air Act.

The mini mill also recycles all of its processed water before it passes to the sewer, to standards set by the Water Board. Site runoff is strictly controlled via a separate drainage system feeding into settling ponds where sediment collects before clear water runs into nearby Eastern Creek.

So there it is. Rooty Hill is one of several mini steel mills in Australia and is relatively small by the standards of such mills overseas but it still manages to produce half a million tonnes of steel per annum.



A5.9

This diagram shows the layout of the Sydney Mini Mill. The plant has been designed to minimise noise by enclosing all noise-generating machinery and by constructing a 5-metre high earth berm.

Source:
Bob Young: Steel Mini Mills: A Recycling Success Story. Silicon Chip On Line (www. siliconchip.com.au) Issue 161. 13 Feb. 2002.

All photos and diagrams courtesy BHP Steel.

A6. STEEL: INDUSTRIAL ECOLOGY

Ingredients of Steel

Iron Ore
Iron ore is a rock that contains iron combined with oxygen. It is sourced from mines around the world. Some of the world's highest quality iron ore comes from Australia.

Coke
Coke is made from coal. Once mined, the coal is crushed and washed. Coal is then baked in coke ovens for about 18 hours. During this process, by-products are removed and coke is produced.

Flux
Flux is a term which describes minerals used to collect impurities during iron and steelmaking. Fluxes used by BHP Steel include limestone and dolomite. The flux causes a chemical reaction and the elements not needed for steelmaking combine to form slag.

Molten Iron
Iron is the main ingredient needed to make steel in the Basic Oxygen Steelmaking process. Molten iron is made from iron ore and other ingredients in a blast furnace.

Scrap Steel
Scrap steel comes from many different sources because it is very easily recycled. Some scrap comes from within the Steelworks, where it might have been damaged or is at the end of a batch of one type of steel. It also comes from old car bodies, old ship containers and buildings that have been demolished.

Another source of scrap can be found in our homes. Steel cans (food cans, pet food cans, aerosols, paint cans, etc.) are collected as part of council kerbside collections and can be recycled an infinite number of times.

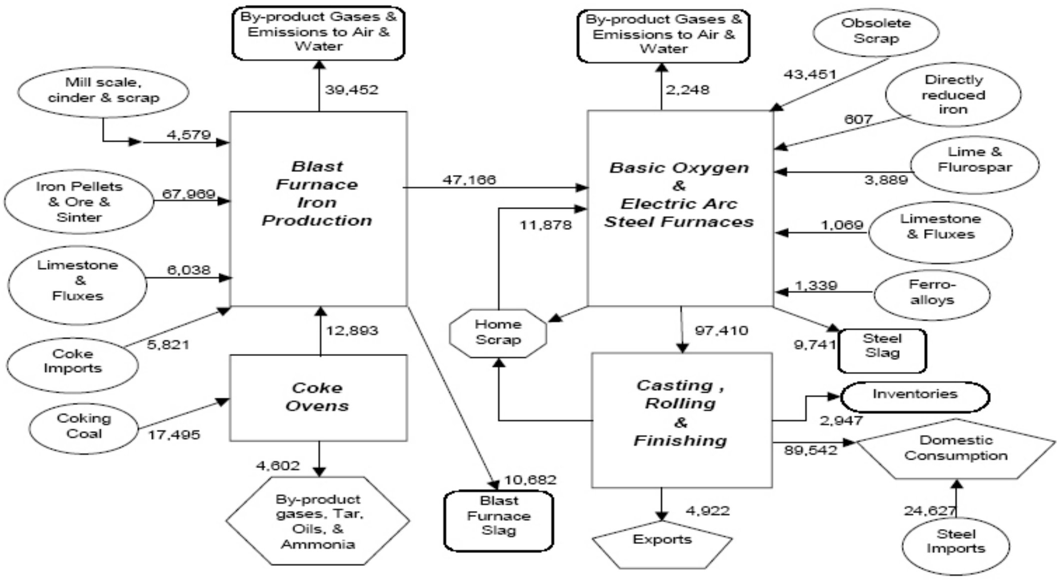
Alloying Materials
Alloying materials are used to give the steel special properties and make different types of steel. Alloying materials can be added as elements, like manganese, aluminium and nickel, or as compounds of iron.

Source: www.bluescopesteel.com

The steel industry provides a classic example of an evolving industrial ecosystem. During the late 19th and early 20th century, integrated steel plants in Pittsburgh and Chicago provided neighboring communities with coke oven gas for lighting and district heating. Today, these plants recycle off-gases to generate steam and electricity within the plant. By-product coke ovens were also a major source of petrochemicals during this era before modern petroleum refining became prevalent. Post consumer recycling is also important with roughly 50 percent of all steel in the US coming from recycled scrap steel. Like the Kalundborg case discussed by Ehrenfeld and Gertler (1997), these loop–closing activities slowly developed over time as firms identified and characterized waste sources and sinks. Steel companies in the US followed a similar course but were driven more by intense competition from producers both home and abroad.

Technological innovations have always been important in steel making (Barnett and Crandall, 1986). Steel mills use one of two types of furnaces to make new steel. Both furnaces recycle old steel into new, but each is used to create different products for varied applications.The first, the basic oxygen furnace (BOF), uses about 28 percent steel scrap to make new steel.The other 72 percent is molten iron produced from blast furnaces, which require iron ore from mines, limestone from quarries, and coke from batteries of ovens. The BOF furnace produces uniform and high quality flat-rolled steel products used in cans, appliances, and automobiles. The other type of steel making furnace, the electric arc furnace, melts virtually 100 percent steel scrap to make new steel. Steel minimills using these furnaces now produce nearly 50 percent of total US steel production. This steel is used primarily to make products that have long shapes, such as steel plates, rebars and structural beams. Steel minimills are far less capital intensive than integrated mills because they do not require blast furnaces and coke ovens. Their reliance on steelscrap also affords them an environmental advantage in lower energy and virgin material consumption.

Minimills have entered the last domain of integrated steel, employing thin slab casting that can yield relatively high quality sheet steel. This additional competitive force comes at a time when many integrated steel firms are seriously reevaluating their



A6.1

Figure: Material flows in the US iron and steel industry, 1999

plants in light of the recent regulations controlling toxic emissions from coke ovens. Most existing methods of producing coke generate fugitive emissions that contain potentially carcinogenic substances, such as benzene soluble organics (BSOs). A variety of strategies, some entailing additional investment and/or higher operating costs, can reduce these emissions. Considine, Davis, and Marakovits (1992) conducted a study estimating the benefits and costs of coke oven regulations, incorporating closure decisions and new technology adoption, and found that investment in new coking technologies is profitable under the new regulations.

In fact, Inland Steel recently built a large battery of coke ovens using the Thompson nonrecovery process, heralded as a possible clean technology breakthrough. This design allows the controlled burning of coal that destroys the Benzene Soluble Organics (BSOs) and other potentially carcinogenic compounds contained in the offgases of the coking process. There are, however, relatively large amounts of sulfur dioxide emissions from the waste heat, which can be recovered via heat exchangers and used to produce steam for electricity generation.

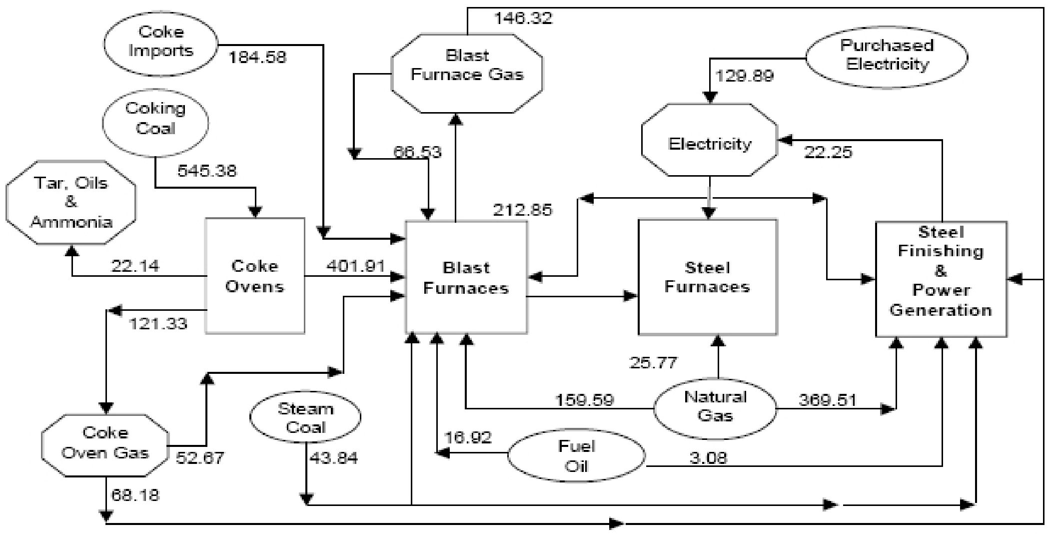
Several other new iron and steel making technologies could either substantially reduce or eliminate coke consumption. Pulverized coal injection (PCI), replacing up to 40 percent of the coke needed in iron making, is widely used in Europe, Asia, and Japan and is now gaining favor in the United States (McManus, 1992). Natural gas injection is a similar technology being promoted by the Gas Research Institute (Brooks, 1992).

There are also three new steel making technologies that could totally eliminate the need for coke. First, there is direct reduction (DR), a coal or natural gas-based iron making process, that produces an iron substitute for scrap in electric arc furnaces. Another coke eliminating option is the Corex process, which does not require coke and produces a large volume of waste heat that can be used to cogenerate electricity. Finally, there is direct steel making (DSM), a process that could eliminate the need for coking and iron making in traditional integrated steel mills. Unlike PCI, DR, and COREX, this technology is currently not under commercial development.

The strategy of converting waste energy and materials into useful products is central to industrial ecology. The steel industry provides numerous examples of loop closing at the process, plant, and industry level.

A6.2

Figure: Energy flows in the US iron and steel industry in petajoules, 1999



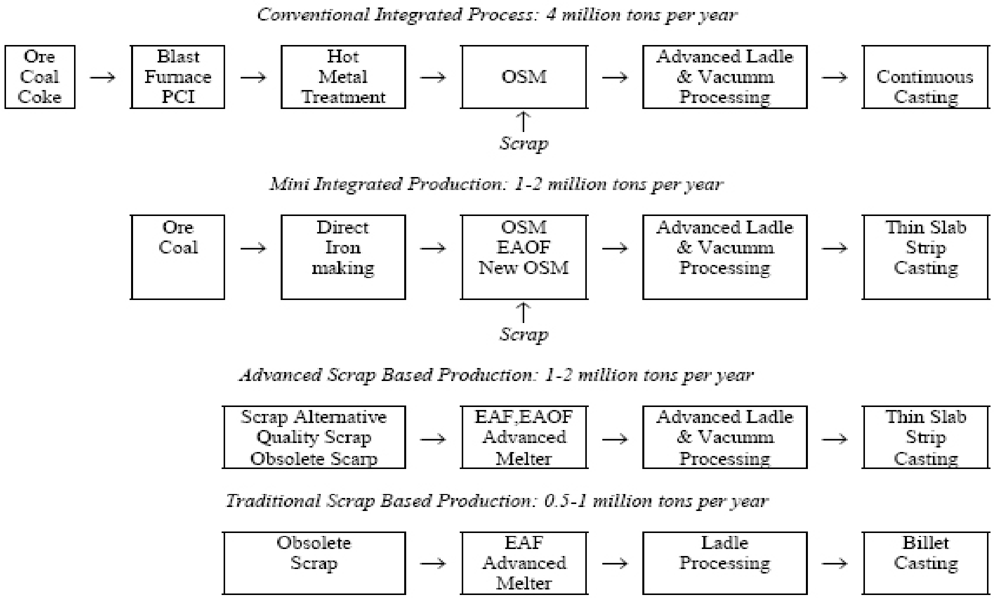
Competition and recent environmental regulations are inducing technological innovations that are transforming metal refining and smelting. The steel industry has been evolving from highly capital intensive, batch processing production technologies to less capital intensive, continuous processing systems that are cleaner and more energy efficient. There are many indications suggesting that this transformation is accelerating. Moreover, faced with ever more stringent environmental controls, many firms are redesigning their production process to eliminate pollution or to utilize wastes as resources. This strategy is gaining hold in many industries and is likely to become more widespread as firms learn that reducing pollution in some cases may lower energy and material costs. Investments in new technology often hold the key to these cost savings. Understanding the key characteristics of these technologies and their prospects for commercial development is the primary objective of this chapter.

We begin our discussion by providing an overview of the production process to establish a context for our discussion of new iron and steel production technologies. With the recent large capacity additions by steel minimill companies in flat rolled sheet production, there is increasing concern about the availability of iron bearing raw materials. As a result, new iron making technologies, iron waste recovery systems, and steel scrap purification techniques are under development that could potentially offer steelmakers more flexibility in their raw material choices. Further down the production line, the success of thin slab casting appears to be ushering in developing strip-casting technologies.

The distinction between integrated plants and steel minimills is beginning to blur. Steel plants in the United States are either traditional ore based integrated plants producing high quality sheet and strip products or traditional scrap based electric arc furnace (EAF) plants producing bars, wire, structural shapes, and other long products.

A6.3

Figure : Future steel plant configurations



PCI -- Pulverized coal injection
EAOF — Electric arc oxygen furnace
New OSM—Conventional or continuous refining with scrap preheating
Advanced Melter — Fossil fuel or hybrid melter with scrap preheating
Source: (Freuhan, R.J., et. al., 1995)

A6.4

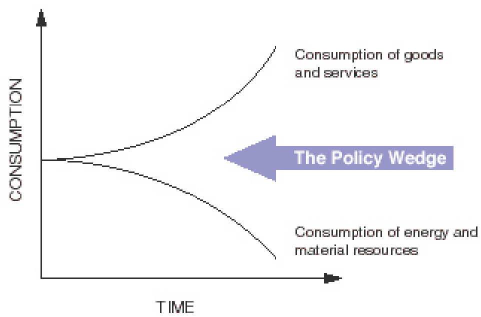
Table: Resource use and environmental performance of steel refining technologies

Material requirements	Units	Basic Oxygen	Electric Arc
Liquid iron	tons	0.763	
Scrap	tons	0.327	1.093
Flux	tons	0.025	
Oxygen	tons	0.1	0.04
Energy requirements			
Electricity	kwh	101	430
Natural gas	mcf	0.049	
Coke oven gas	mbtu	0.048	
Air emissions			
Carbon monoxide	lbs	0.139	
Carbon dioxide	lbs	269.194	
Dust	lbs	0.0655	0.7065
Hydrocarbons	lbs	0.00073	
Nitrous oxide	lbs	0.04259	0.303
Particulate matter < 10 microns	lbs	0.02877	0.05
Sulfur oxides	lbs	0.00342	0.07
Water emissions			
Iron	lbs	0.01356	
Suspended solids	lbs	0.06178	
Zinc	lbs	0.00165	
Solid wastes			
Slag, ash	lbs	240	265
Sludge	lbs		66
Lead	lbs	0.00001	

Source:
Timothy Considine, Christopher Jablonowski, Donita Considine. **The Environment and New Technology Adoption in the US Steel Industry**. Final Report to National Science Foundation & Lucent Technologies. May 15, 2001.

All figures and tables courtesy of source.

A7. INDUSTRIAL ECOSYSTEMS: CASE STUDIES



A7.1

Figure: `Dematerializing' the Economy.

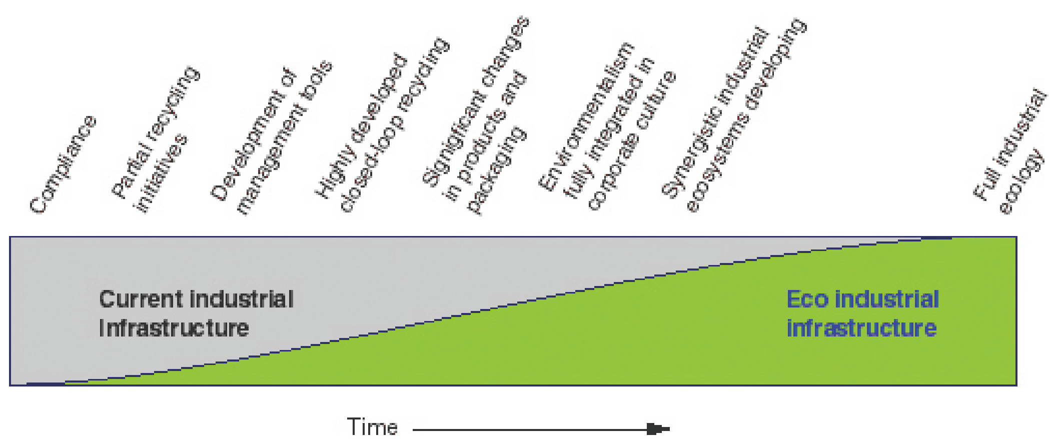
INDUSTIAL ECOSYSTEM

With a rising global population and ever increasing levels of consumption among developed and developing countries, pressure on the earth's many ecosystems and the biosphere as a whole, promises to continue to mount well into the foreseeable future. Even many optimists-those who are convinced that technology will resolve most of our impending resource shortages-are beginning to recognize that there is a need for significant increases in the efficiency of resource use in developed countries in order to accommodate the rising consumption and production in developing countries.

Increasing levels of consumption at the limits of the biosphere's capacity to provide resources will require dramatic improvements in resource use efficiency. Substantial reductions in the amount of resource throughput per unit of output is referred to as dematerialization.

A7.2

Figure: The Emergence of an Eco-Industrial Infrastructure.



In order to move towards an 'eco-industrial infrastructure' significant technological advances will be required. Four generations of environmental technology have been identified by the International Institute for Sustainable Development-remediation, abatement, pollution prevention and sustainable technologies. The latter two types of technology, which are the least developed, have an important role to play in facilitating industrial ecology linkages and helping society move towards industrial systems that achieve the goal of '0 - waste' or 100 percent efficiency.

A7.3

Table: The Four Types of Environmental Technologies.

	Point of Application	Characteristics	Examples
Remediation Technologies	•symptoms •damaged resources or environments	•after the fact •costly •range from low tech to high tech	•soil remediation •toxic site clean-ups •water treatment
Abatement Technologies	•pollutant capture or treatment at end-of-pipe	•captures or treats pollutants before release •consumes capital, energy and resources •generates waste steam •fairly costly	•flue gas desulfurization •sewage treatment plants •catalytic mufflers
Pollution Prevention Technologies	•industrial process design •product design or composition	•changes product or process or reduce or prevent pollution •more cost effective that abatement •reduced waste steam	•chlorine-free paper •cyanide-free electroplating •lead-free gasoline •industrial process design
Sustainable Technologies	•alternate product or service	•multiple benefits:environmental, economic, social, resource efficiency	•efficient lighting •recycled paper •renewable energy •bio-cosmetics and drugs

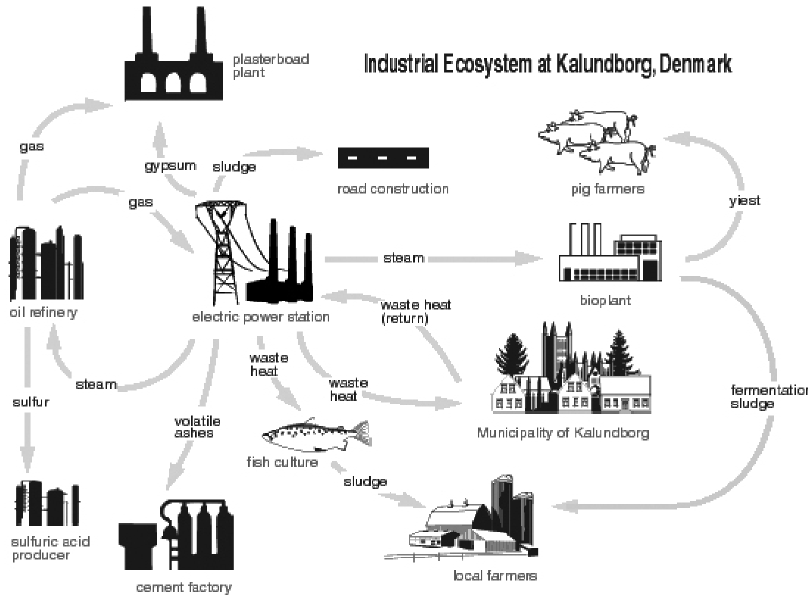
INDUSTIAL ECOLOGY CASE STUDY 1: Kalundborg, Denmark

At Kalundborg, steam and various raw materials such as sulfur, fly ash and sludge are exchanged in what is the world's most elaborate industrial ecosystem. Participating firms each benefit economically from reduce costs for waste disposal, improved efficiencies of resource use and improved environmental performance. For example, gas captured from the oil refinery which had previously been flared off is now sent to the electrical power station which expects to save the equivalent of 30,000 tonnes of coal a year.

By the year 2000, Denmark, a clear international leader in promoting sustainable development, will establish regulations that require that virtually ail discharges by industries be in the form of products that can serve other useful purposes.

INDUSTIAL ECOLOGY CASE STUDY 2: Burnside, Nova Scotia

One of the Canadian pioneers of industrial ecology is Professor Ray Côté of Dalhousie University. He has helped to establish industrial ecology linkages in a large industrial park located in Burnside, Nova Scotia.The primary role of the Cleaner Production Centre is to promote and facilitate the 'greening' of the over 1,200 businesses



A7.4

Figure: Flow Diagram of Industrial Ecosystem at Kalundborg.

located in Burnside, eastern Canada's largest industrial park. The services the Centre provides include: promoting materials and energy conservation through audits; searching for technologies to improve resource use efficiency for business clients; facilitating packaging waste reduction through waste audits; and identifying and facilitating waste and energy linkages between firms. Industrial ecology relationships will be promoted by the Centre, in part, by the creation of a waste exchange. Examples of actual and potential 'symbiotic' relationships in the park include:

-Recycling of corrugated cardboard which is collected by a company located in the park and sent outside for reprocessing into liner board.

-The reuse of a computer company's excess polystyrene by a packaging firm.

-A variety of recycling and reuse firms dealing with toner cartridges, ribbon re-inking, tire re-treading and furniture refurbishing.

-Potential for a silver recovery program for the printing industry (25 printing firms are located in the park) by combining resources to purchase a silver recovery systems.

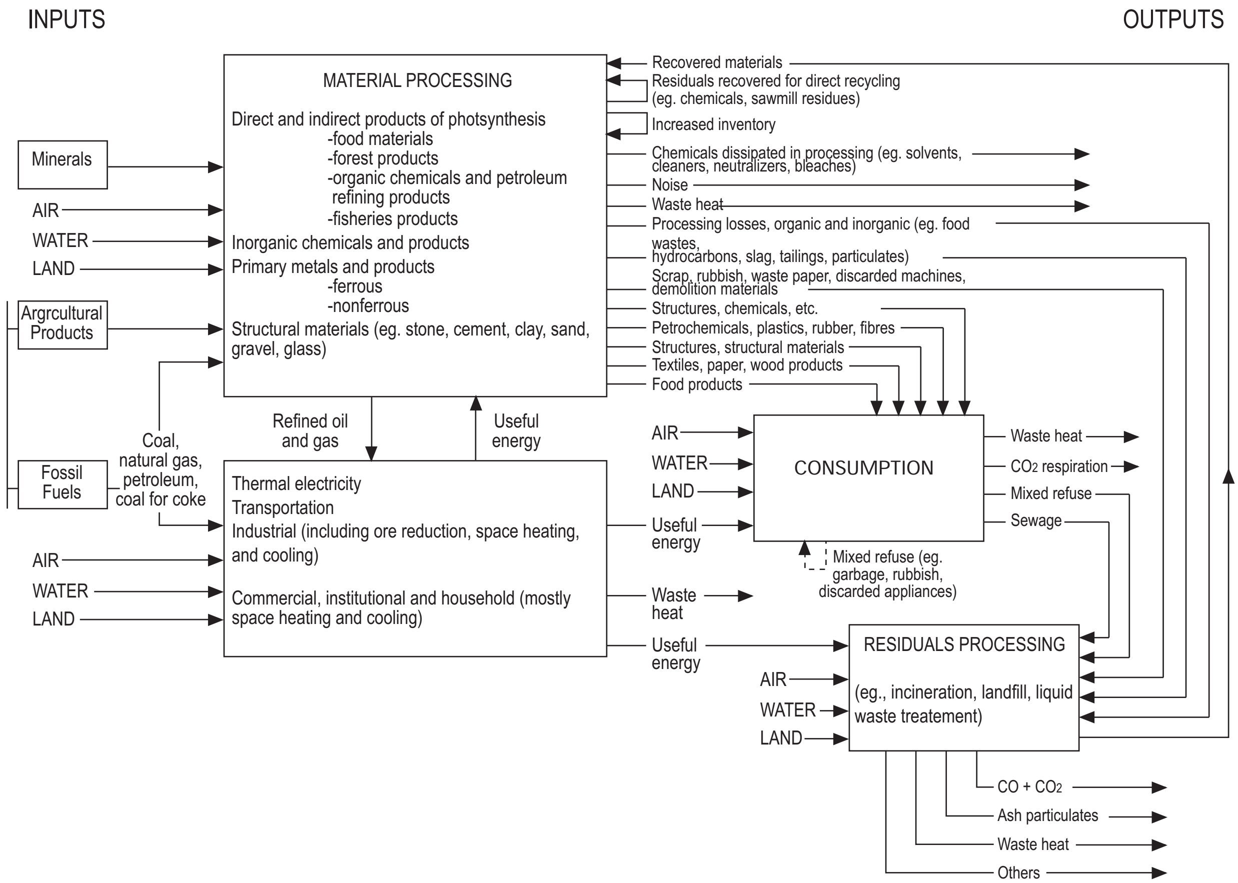
-Potential for a paint exchange among the 21 firms that either use paint in their processes or distribute paint to customers. Roughly 5038 litters of paint are currently wasted each year with a total value of $52,000. Establishing a "paint swap" program could reduce this waste.

-Potential for a chemical exchange among the 19 firms that either manufacture, distribute or retail chemicals.

Source: Steven W. Peck. **Industrial Ecology: From Theory To Practice**. [Online] Available: http://newcity.ca/Pages/industrial_ecology.html (1 May 2005). Presented to: the Environmental Studies Association of Canada meeting at the 1996 Learned Societies Conference in St. Catherines, Ontario.

A8. MATERIAL PROCESSING

THE INPUTS + OUTPUTS THROUGH THE BUILT ENVIRONMENT



A8.1

Source: Ken Yeang. **The Green Skyscraper: The Basis for Designing Sustainable Intensive Buildings**. Munich: Prestel Verlag (1999).

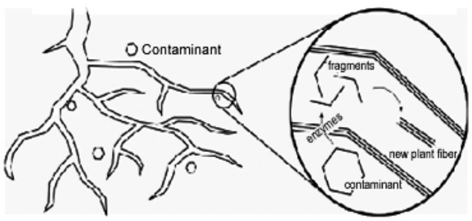
A9. REMEDIATION METHODS

PHYTOREMEDIATION FOR ORGANIC CONTAMINANTS

Organic contaminants (specifically hydro-carbons that contain carbon and hydrogen atoms) are common environmental pollutants. There are several ways that plants can be used for the phytoremediation of these contaminants: *phytodegradation, rhiz-odegradation, and phytovolatilisation.*

A9.1

Figure: Destruction of Organic Contaminants by Phyotodegradation.



Enzymes in plant roots break down (degarde) organic contaminants. The fragments are incorporated into new plant material.

Phytodegradation

Phytodegradation, also called phyto-transformation, is the breakdown of contaminants taken up by plants through metabolic processes within the plant, or the breakdown of contaminants surrounding the plant through the effect of compounds (such as enzymes) produced by the plants. Complex organic pollutants are degraded into simpler molecules and are incorporated into the plant tissues to help the plant grow faster (Figure 1). Plants contain enzymes (complex chemical proteins) that catalyse and accelerate chemical reactions. Some enzymes break down and convert ammunition wastes, others degrade chlorinated solvents such as trichloroethylene (TCE), and others degrade herbicides.

Rhizodegradation

Rhizodegradation, also called phyto-stimulation or plant-assisted bioreme-diation/degradation, is the breakdown of contaminants in the rhizosphere (soil surrounding the roots of plants) through microbial activity that is enhanced by the presence of plant roots and is a much slower process than phytodegradation. Micro-organisms (yeast, fungi, or bacteria) consume and digest organic substances for nutrition and energy. Certain micro-organisms can digest organic substances such as fuels or solvents that are hazardous to humans and break them down into harmless products in a process called biodegradation. Natural substances released by the plant roots – sugars, alcohols, and acids – contain organic carbon that provides food for soil microorganisms and the additional nutrients enhance their activity. Biodegradation is also aided by the way plants loosen the soil and transport water to the area.

Phytovolatilisation

Phytovolatilisation is the uptake and transpiration of a contaminant by a plant, with release of the contaminant or a modified form of the contaminant from the plant to the atmosphere. Phytovolatilisation occurs as growing trees and other plants take up water and the organic contaminants. Some of these contaminants can pass through the plants to the leaves and evaporate, or volatilise, into the atmosphere. Poplar trees at one particular study site have been shown to volatilise 90% of the TCE they take up.

PHYTOREMEDIATION FOR METAL CONTAMINANTS

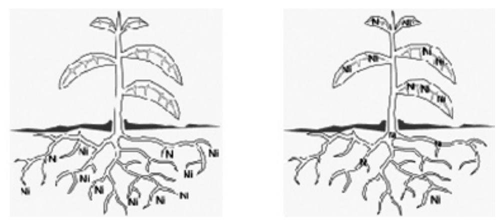
At sites contaminated with metals, plants can be used to either stabilise or remove the metals from the soil and groundwater through three mechanisms: *phytoextraction, rhizofiltration*, and *phytostabilisation*.

Phytoextraction

Phytoextraction, also called phytoaccumulation, refers to the uptake of metals from soil by plant roots into above-ground portions of plants. Certain plants, called hyperaccumulators, absorb unusually large amounts of metals in comparison to other plants. After the plants have been allowed to grow for some time, they are harvested and either incinerated or composted to recycle the metals. This procedure may be repeated as necessary to bring soil contaminant levels down to allowable limits. If plants are incinerated, the ash must be disposed of in a hazardous waste landfill, but the volume of ash will be less than 10% of the volume that would be created if the contaminated soil itself were dug up for treatment. Metals such as nickel, zinc, and copper are the best candidates for removal by phytoextraction because the majority of the approximately 400 known plants that absorb unusually large amounts of metals have a high affinity for accumulating these metals. Plants that absorb lead and chromium are currently being studied and tested.

A9.2

Photo: Enclosed Phytoremediation Tests in Canada



A9.3

Figure: Uptake of Metals (Nickel) by Phytoextraction

Rhizofiltration

Rhizofiltration is the adsorption or precipitation onto plant roots of conta-minants that are in solution surrounding the root zone. Rhizofiltration is similar to phytoextraction, but the plants are used to clean up contaminated groundwater rather than soil. The plants to be used for cleanup are raised in greenhouses with their roots in water. Contaminated water is either collec-ted from a waste site and brought to the plants or the plants are planted in the contaminated area, where the roots then take up the water and the contaminants dissolved in it. As the roots become saturated with contaminants, they are harvested. For example, sunflowers were successfully used to remove radioactive contaminants from pond water in a test at Chernobyl, Ukraine.

Phytostabilisation

Phytostabilisation is the use of certain plant species to immobilise contaminants in the soil and groundwater through absorption and accumulation by roots, adsorption onto roots, or precipitation within the root zone of plants (rhizosphere). This process reduces the mobility of the contaminant and prevents migration to the groundwater or air, and also reduces bioavailability for entry into the food chain. This technique can be used to re-establish a vegetative cover at sites where natural vegetation is lacking due to high metal concentrations in surface soils or physical disturbances to surficial materials. Metal-tolerant species can be used to restore vegetation to the sites, thereby decreasing the potential migration of contamination through wind erosion and transport of exposed surface soils and leaching of soil contamination to groundwater.

THE USE OF PHYTOREMEDIATION FOR HYDRAULIC CONTROL OF CONTAMINANTS

Plants can act as hydraulic pumps when their roots reach down toward the water table and establish a dense root mass that takes up large quantities of water. Poplar trees, for example, can transpire between 50 and 300 gallons of water per day out of the ground. The water consumption by the plants decreases the tendency of surface contaminants to move towards groundwater and into drinking water. The use of plants to rapidly uptake large volumes of water to contain or control the migration of subsurface water is known as hydraulic control. There are several applications that use plants for this purpose, such as riparian corridors/buffer strips and vegetative caps.

Riparian corridors
Riparian corridors (the term 'riparian' means 'located on the bank of a river') or buffer strips are applications of phytoremediation that may also incorporate aspects of phytodegradation, phytovolatilisation, and rhizodegradation to control, intercept, or remediate contamination entering a river or groundwater plume. In a riparian corridor, plants may be applied along a stream or river bank, while buffer strips may be applied around the perimeter of landfills. Applications of these systems prevent contamination from spreading into surface water and/or groundwater.

Vegetative cover
Vegetative cover (or a vegetative cap) is a long-term, self-sustaining cap composed of soil and plants growing in and/or over waste in a landfill. This type of cover is an alter-native to composite clay or plastic layer caps. Plants control erosion and minimise seepage of water that could otherwise percolate through the landfill and form contaminated leachates. In addition, a vegetative cap can be designed not only to control erosion and seepage of water, but also to enhance the degradation of underlying materials in the landfill.

Source: United Nations Environment Programme. "Phytoremediation: An Environmentally Sound Technology for Pollution Prevention, Control and Remediation" [Online] Available: www.unep.or.jp/ietc/Publications/Freshwater/FMS2/2.asp (1 May 2005).

WETLANDS

Wetlands are environmentally sensitive areas that are adapted for variable hydrologic conditions.

Constructed treatment wetlands are used to treat wastewater by mimicking the processes seen in natural wetlands.

Constructed treatment wetlands are engineered systems that differ from natural systems.

Free water surface wetlands operate with a water depth of 3" to 18".

Subsurface flow wetlands are designed to maintain the entire depth of the water column within the soil media.

In a subsurface flow wetland the water level is not visible at the ground.

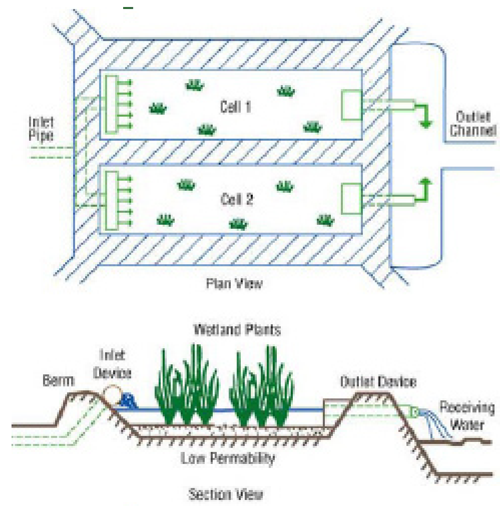
FREE WATER SURFACE FLOW AND SUBSURFACE FLOW WETLANDS

Two general types of wetlands are typically constructed for waste-water treatment: free water surface flow (FWS) and subsurface flow (SF) wetlands.

In a FWS wetland, water is generally introduced above the ground surface, and flows through the wetlands at depths averaging less than 6 inches, ranging up to 12 inches (Figure 1). FWS wetlands may contain islands that are at or above the typical water surface, and small, deeper areas, up to 8 feet. However, these deeper areas will not support wetland vegetation.

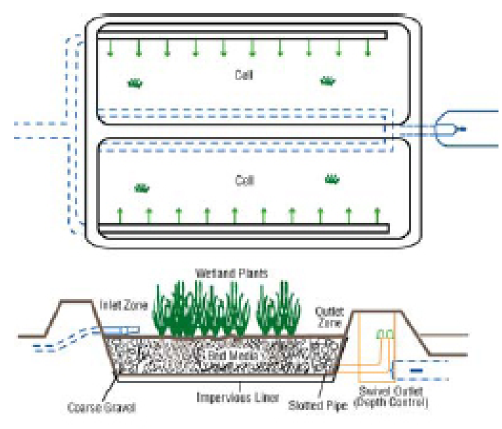
FWS wetlands are often divided into cells either by earthen berms, concrete, or wood to help direct flow and insure that maximum contact between water and wetland plants. Wetland plants can be established by seeding or transplanting. If a significant source of wetland seed exists nearby, and if the topsoil used in the treatment wetland contains enough propagules, it may be unnecessary to seed or plant the wetlands. Maintenance of a FWS wetland may include periodic burning of the vegetation in the treatment wetland, monitoring and adjusting the water surface elevation, keeping the inflow and outflow structures clear of debris, and sediment removal when necessary.

In a SF wetland, water is introduced into a gravel medium through a perforated pipe or other underground dispersal system. SF wetlands may contain up to 4 feet of gravel, and the water surface elevation is maintained just below the top surface of the gravel. Generally wetland plants must be planted into a SF wetland because the gravel substrate is often not conducive to seed germination and establishment. Maintenance of a SF wetland may include periodic burning of the vegetation in the treatment wetland, monitoring and adjusting the water surface elevation, keeping the inflow, outflow, and dispersion pipes clear of debris, and sediment removal when necessary. SF wetlands are often difficult to maintain because the underground pipes may be subject to clogging and the gravel surrounding the pipes may become clogged with sediment.



A9.4

Figure: Plan and Profile of Typical Free Water Surface Wetland.



A9.5

Figure: Plan and Profile of Typical Subsurface Flow Wetland.

Source: The Colorado Constructed Treatment Wetlands Inventory. [Online] Available: http://www.state.co.us/oemc/programs/waste/wetlands.htm (1 May 2005). Prepared by: The Governor's Office of Energy Management and Conservation.

A10. STELCO INC.

STELCO TROUBLES TIP OF ICEBERG

Crisis prelude to competitive assault

by: Godron Pitts
Source: THE RECORD.COM   Friday, January 30, 2004

The crisis pounding beleaguered Canadian steel maker Stelco Inc. -- and other aging warriors of the North American steel industry -- is just a prelude to a competitive assault that will hit this continent by about 2010.That is when China, now a huge net importer of steel, should turn into a net exporter, and start displacing domestic production in Russia, setting off a global chain reaction that will raise the heat on producers in Canada and the United States.

“We’re only just getting a foretaste of that now,” said Bruce Simpson, managing partner of McKinsey & Co. in Canada and a veteran consultant to large industrial companies. “There will be increased pressure at the end of the decade.”

That scenario suggests that to survive, Stelco must undergo change that extends far beyond even the radical restructuring undertaken by some U.S. steel makers, which have been able to offload big chunks of their huge “legacy costs,” such as pensions and health benefits.

The champion of this U.S. strategy is Wall Street financier Wilbur Ross, who with the support of organized labour, assembled remnants of several insolvent integrated steel makers, saved a fraction of the jobs, and reduced costs by shifting pension burdens to government.

That strategy looks smart now, with the steel market on the upswing from much stronger demand and rising prices. But Stelco is not benefiting because it delayed the painful restructuring, leaving it with uncompetitive costs compared with U.S. integrated rivals. Now, it must do the necessary slashing in bankruptcy protection.

Also, unlike rival Dofasco Inc., Stelco did not make a pronounced shift to higher-value-added products -- and Dofasco, as well, is a non-union shop.

But while radical restructuring may be critical now, it is just a palliative, not a cure, people who study the industry say.

The Wilbur Ross solution is “a short-term to intermediate-term fix but not a long-term fix,” says Bob Crandall, a scholar with the Washington-based Brookings Institution, a think tank.

“Getting rid of legacy costs certainly helps buy you a wee bit of time,” says Mr. Simpson of McKinsey, who sees the needs of the steel industry as transformative rather than just emergency cost cutting. “But the underlying performance of the companies still has to improve dramatically.”

Mr. Simpson, who would not comment on specific companies, says he believes North American producers can produce steel for the long term but only by undertaking three broad initiatives:

They must build a strong track record of operational performance, which includes taking costs out and boosting customer service and quality. That is the only way they can satisfy their sophisticated customers -- the big auto makers -- who are making more demands of suppliers because of intensifying competition in their own markets.

They have to be better than anyone else in their customer segment. Mr. Simpson says steel is a commodity but producers can do certain things to “de-commoditize” their products, thus adding value. That often means superior customer service, such as responding quickly on product lead times or building in technical support.

They must have really good assets. That means reliable, efficient equipment, low-cost labour and cost-effective energy and materials. “What we see in steel is that a large number of companies have assets built 50 to 60 years ago,” he says, which leaves them with a big structural disadvantage.

Mr. Crandall says the challenge for the big integrated producers remains largely technological. Integrated firms such as Stelco rely heavily on traditional blast furnaces, which require heavy capital outlays for periodic maintenance and renovations.

“The cost of making steel has come down dramatically through the electric furnace route used by the new mini-mills,” he says. Stelco’s current woes, he adds, are just the latest chapter in “the long, inexorable decline of the integrated producers in North America.”

He also attributes this decline to rich labour contracts negotiated by past CEOs, and a dearth of entrepreneurship in the recent history of the steel industry.

What is hurting Stelco and other slow-moving producers is dramatically lower-cost steel, Mr. Crandall says, which is actually good news for the economy. “But it is bad news for Hamilton, Pittsburgh, Youngstown, Buffalo and so forth.”

Mr. Simpson ties much of the industry’s future to how well it adapts to China, which at present is going through extraordinary infrastructure development, which requires massive imports of steel.

But the Chinese are quickly building production capacity that soon will outstrip domestic needs. First, they will supply more Russian needs, pushing Russian steel into Western Europe -- and setting in motion a scramble for markets.

He emphasizes that a competitive rival also looms in Brazil, which is closer to North America and quickly building steel capacity, as well.

STELCO EYES MERGER, SALE

Hamilton may be part of bigger company

by: Mike Pettapierce
Source: The Hamilton Spectator   Saturday, Sept. 13, 2003

Fred Telmer, interim chief executive at Stelco, doesn't pull any punches in a wide-ranging interview in his office overlooking the harbour and the steel mills. He talks about a much downsized company that is planning to dump many of its assets and could be a takeover target. He scotches the notion of Stelco filing for bankruptcy protection -- saying the total debt of about $600 million is "well-structured and is manageable" -- but he doesn't discount the potential for layoffs at some point.

"It is a confusing, unattractive bag of assets," says Telmer, 65. "What do you do about it? Well, you reach in and pluck out what's good and enhance this. "We're going to have to be part of something bigger. We may merge (with an alliance partner). We may be bought. We won't be buying, at least in the short term .... We have to get ourselves prettied up first." Telmer tenders an analogy for the fate of Stelco: it could resemble the Ford Oakville plant, which is part of the larger Ford empire.

Stelco is undergoing an extensive review, a strategic report divining what should be kept and what should be sold. Telmer says people may "call it strategic but it's really a fix-em-up plan." At the core of the plan are the two linked and integrated plants of Stelco Hamilton and Stelco Lake Erie in Nanticoke. That's where blast furnaces and basic oxygen furnaces make top-end steel from liquid iron.

Both steelmaking "front ends" are modern. Stelco Hamilton also has the "back end" high-value, cold-rolled and rust-resistant galvanized mills. Stelco Lake Erie is the hot-rolled jewel of a facility, with a $150-million upgrade yet to come. The review will look at the product lines at both plants. It will figure out which non-core parts of Stelco's empire will go. An Alberta minimill (which makes steel from melted scrap) will likely be sold by November. Another minimill near Montreal may also go on the auction block.

The review will accelerate what has been evolving for years. Hamilton will make steel slabs for Lake Erie and finish them later. Lake Erie will hot-roll the steel and ship much of it back overnight, via a dedicated rail link, to Hamilton for further processing. That means aging facilities such as the 1946-era hot mill in Hamilton, will disappear. The bar mill, whose steel goes into the steering, suspension and other components of a vehicle, likely will stay. The two Stelwire units could also be up for sale.

The review will likely be done in time for Stelco's new president, expected to arrive in the next two months. A head-hunting firm is looking both within and outside Canada for a new CEO. The candidate may come from steel, more likely from the heavy-manufacturing sector. Along with appointing a new leader, Stelco is hoping to be cash-positive by the start of next year -- with no need to draw down from bank lines.

We need somebody ... who can listen to them and be perceived as someone who is listening and who can provide leadership. "This company has been around since 1910. One way or another, it's going to be here in 2010."

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