Better Planning from Better Understanding: Incorporating Historically Derived Data into Modern Coastal Management Planning on the Halifax Peninsula

by

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History is the witness that testifies to the passing of time; it illuminates reality, vitalizes memory, provides guidance in daily life, and brings us tidings of antiquity.

-Cicero

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Abstract

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As the terrestrial and marine effects of climate change continue to intensify, the value of native habitats like coastal wetlands is becoming clear. A sound understanding of how these ecosystems work is of vital importance to managers as well as a variety of other stakeholders. Currently, the practice of assessing wetland loss lies almost entirely within the realm of the natural sciences. While historical ecologists and other social scientists offer valuable insight into the cultural and social influences that may have affected the current state of the environment in any particular region, this is generally where their contribution ends. Historians, for example, rarely venture into the realm of quantitative environmental analysis. This paper examines the challenges associated with using historically derived quantitative data to better understand coastal ecology, and how those challenges can be overcome. Using GIS technology combined with historical maps, this paper establishes baseline ecological data for the Halifax Peninsula as it existed at the end of the eighteenth century. The resulting model is used to answer a range of questions regarding the nature of the Halifax Peninsula near the end of the eighteenth century, how the ecology of the Halifax Peninsula has changed as the city has evolved through time, and the practical and theoretical management implications of incorporating historically derived data into the planning process.

Key Words: Halifax, Wetlands, Critical, Cartography, GIS, History, Maps, Coastal Management

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Part 1: Introduction

As the terrestrial and marine effects of climate change continue to intensify, the value of native habitats as a form of natural protection against a variety of ecological issues is becoming clear. Coastal wetlands, for example, not only provide protection against incoming storm surges and extreme weather, but also serve to improve water quality through the sequestration of various anthropogenic pollutants (Sousa, Lillebø, Pardal, and Caçador, 2011). In the United States, Costanza et al. have quantified the amount of protection that coastal wetlands can offer monetarily. They estimate that for all the American states, the value of salt marshes in terms of the protection they offer from storms is USD \$8,236 ha^{-1} (Costanza et al, 2008). These financial as well as ecological benefits have been largely accepted in both North America and Europe (L. Boorman, Hazelden and M. Boorman, 2002). As a result many governments, including the Government of Nova Scotia, are attempting to find suitable locations to preserve and re-generate coastal wetlands. To date, the Government of Nova Scotia, through the Department of Transport and Renewal, has restored four salt marshes, and plans are underway for the restoration of several more (Government of Nova Scotia, 2011).

Unfortunately, many of the areas that have been depleted of coastal wetlands still suffer from the same problems that caused those wetlands to fail in the first place. Cities continue to release effluent into estuaries; hydrological engineering projects continue to re-direct waterways changing flow and sediment patterns; and increasing populations of people in coastal areas all assert significant pressures on intertidal ecosystems. This ongoing changing of the landscape – as well as the length of time that anthropogenic factors have been influencing these habitats – has made obtaining accurate ecological baseline data an important yet complicated management objective. This information is vital to not only properly assess wetland loss in Nova Scotia, but to develop an effective management plan as well.

Currently, the practice of assessing habitat loss lies almost entirely within the realm of the natural sciences. While social scientists offer valuable insight into the cultural and social influences that may have affected the current state of the environment in any particular region, that is generally where their contribution ends. Historians for example, rarely venture into the realm of quantitative environmental analysis; determining the specifics about the physical geography of a landscape has always rested firmly in the hands of the natural scientists. In the United States, the primary sources of information being used to assess patterns in wetland and other key habitat loss are the National Wetlands Inventory, aerial photographs, and the Landsat Thematic Mapper (Bernier, Morton and Barras, 2006). While this information is useful, it is limited by the fact that the vast majority of records of this type do not date back to before the middle of the twentieth century. In North America by this time there had been over 250 years of European activity, and thousands of years of indigenous peoples affecting the landscape before that. People have been changing the landscape and ecology of North America for so long that reliable baseline numbers have become difficult to obtain.

The importance of establishing a well-grounded historical baseline cannot be overstated. Not only does it allow for a concrete data set to which modern numbers can be compared, but it also allows managers to observe changes to an area/ecosystem through time. Knowing exactly how the development of an area has progressed as human populations grow can help managers develop strategies for the future, and serve as a valuable resource for solving problems faced in the present. This paper will examine the concept that a better understanding of an area, based on quantitative historical data, will allow for a more efficient and well-informed management process. Using data derived from historical sources, baseline ecological data for the Halifax Peninsula as it was at the end of the eighteenth century will be developed. Once created and validated, the resulting model will be used to answer a range of questions regarding not only the nature of the Halifax Peninsula as it was near the time of British settlement and how it has evolved through time, but also how that information can inform management decisions.

Part 2: The Emergence of Quantitative History

Developments in Geographic Information Systems (GIS) as well as the re-discovery of important maps made by the British military have allowed historians, working in concert with natural scientists, to begin to offer more technical insights into the historical ecology of North America. To date, the most ambitious project attempting the integration of historical maps into the study of landscape ecology is the Mannahatta Project undertaken by Dr. Eric W. Sanderson and his colleagues between 1999-2009 (E. Sanderson, Fisher, Boyer, Huron, & LaBruna, 2009).The reasoning behind this project was summed up by Dr. Sanderson in his application to the Buckminster Fuller Challenge in 2011:

> Cities want to be sustainable but by and large don't know how. We seek to map the original, historic ecological landscape of New York City, the place where 8 million people live, and provide the best model of sustainability we can think of: ecosystems in nature (Sanderson, 2011, pg.1)

This work by Dr. Sanderson is one of the first studies that relies primarily on a specific historical document to help recreate historical ecology, and offers an interesting new perspective that could be useful to future coastal managers.

The Mannahatta project was based on the British Army Headquarters Map from the British occupation of New York during the American Revolution. It was an attempt to document, through historical research and ecological modeling, the landscape of Manhattan Island immediately prior to Henry Hudson's arrival on September 12, 1609 (Sanderson & Brown, 2007). After ten years of study, Sanderson and Brown (2007) determined that the British Army Headquarters Map: "provides an important, geometrically accurate and extraordinarily detailed window on the past environment of Manhattan (p. 566)." Sanderson and Brown (2007) are careful to caution the reader that all historic documentation needs to be carefully scrutinized, but on the other hand their research also established that with the proper amount of due diligence, historical documentation can be used to determine far more than social and political relationships. A well-constructed map, once it has been properly contextualized and verified, can offer highly useful data in the quest for a better understanding of the natural environment.

Part 3: The Management Problem

The management problem addressed in this research paper is: How can researchers, managers, and other stakeholders in coastal areas develop long term planning strategies, when in many cases the patterns and processes that they are trying to manage extend much farther back in time than is represented within the current data set? This understanding of past land use patterns and natural processes is vital if one hopes to plan properly. Research has shown that past land use can directly influence modern day species diversity, and that even if an area is currently being protected, historical land use can greatly influence the diversity and functioning of that ecosystem (Harding, Benfield, Bolstad, Helfman, & Jones, 1998) . Understanding the nature of the landscape that lies underneath a developed area is vital for a variety of stakeholders; from insurance brokers, to urban planners, to commercial developers, and beyond. This paper will explore how a more accurate understanding of the ecology of the Halifax Peninsula can be developed through the inclusion of historical cartographic evidence similar to that used in the Mannahatta Project.

Despite the calls for integration within fields of coastal zone management, in many cases the relationship between the natural and social scientists is more cooperative than truly integrated. As will be made clear below, while both the social and natural scientists agree that the work of the other is an important part of the management process, in many cases, each is still reticent to cross traditional academic lines. Natural scientists gather the data, and social scientists put that data into context in order to determine the best way to develop a successful plan. It is a cooperative, as opposed to an integrated model. Using data derived from historic maps of the Halifax Peninsula, this paper argues that in certain circumstances, managers would do well to turn to the social sciences to provide the raw data that has thus far been under the purview of the natural sciences. This study defines coastal wetlands according to the Government of Nova Scotia's 2009 *State of Nova Scotia's Coast Technical Report.* It states, "Coastal wetlands include tidal (salt) marshes, coastal fresh water wetlands (defined as those located within 2 km of the coast) and coastal saline ponds (CBCL Ltd., 2009, p. 215)." By combining existing scientific data and technology with a critical examination of historic maps as well as other archival sources, a more historically accurate picture of the state of wetlands on the Halifax Peninsula can be constructed.

In order to make the argument that the social sciences in general, and historians in particular, can make more concrete and quantitative contributions to the management of coastal resources, one must first understand the place that the social sciences currently occupy within the management framework. Once that has been established, the issues inherent in using historical documentation as a way to obtain quantitative data will be examined, followed by an explanation of why, despite these perils, certain maps can contain valuable information. The Halifax Peninsula will then be re-examined using carefully selected historical records. This re-examination will illustrate how historical cartographic sources, if properly vetted and understood, can provide managers with a more comprehensive understanding of the coastal environment than natural science alone.

Part 4: History and the Social Sciences in Coastal Management

Working within current management frameworks, the coastal manager will take data that has been provided by natural scientists, put it in the context of the local culture as determined by social scientists, and try to form policy in such a way that will result in the success of whatever project he or she is working on (Bowen & Riley, 2003; Colburn & Jepson, 2012). Managers also look to social scientists in order to help predict, given particular cultural circumstances, which of the myriad of management structures are likely to be the most successful for their specific situation (Allegretti, Vaske, & Cottrell, 2012). The social sciences tend to focus more on understanding the people, rather than the landscape itself.

In their article "Managing coastal resources in the 21st century," Weinstein et al. (2007) point out that many of the complications that arise when attempting to manage environmental problems are a direct result of social rather than ecological issues. Without a proper understanding of the social environment in which they exist, many biologically successful conservation projects have still failed, due to social upheaval (Chirstie, 2004). As a result, managers are focusing their attention more on the role of governance, participation and collaborative decision making in order to try and ascertain solutions that not only make ecological sense, but cultural sense as well (Tissier, Hills, McGregor, & Ireland, 2004; Weinstein et al., 2007; del Pilar Moreno-Sánchez & Maldonado, 2010). Because of this shift, one of the major criticisms of coastal managers that has arisen is that they focus too much on the socioeconomic aspects of environmental degradation, while not focusing enough on the more qualitative ecological data (Cheong, 2008; McFadden, 2007).

As well as managing current relationships, management researchers have looked to the social sciences to try and discern the social constructs that drive exploitation initially (Bird, 1987; Ludwig, Hilborn, & Walters, 1993). For example, Ludwig, Hillborn and Waters (1993) write that the consistent nature of human exploitation can be distilled down to four common features: 1. The prospect of wealth generates power, which is then used to promote further exploitation, 2. Scientific consensus is hampered by a lack of controls, 3. The complexity of a system precludes a reductionist management approach, and 4. Large natural variability masks the effects of overexploitation (Ludwig et al., 1993). In this case the social scientist has been called on to look at anthropogenic patterns that result in overexploitation in general, rather than determining the cultural nuances of a particular community of people.

To date, relatively few experiments have attempted to incorporate historical data systematically into modern day conservation management planning. The most common way that natural scientists attempt to conduct biological assessments is to establish what is known as a reference condition (Stoddard, Larsen, Hawkins, Johnson, & Norris, 2006). This method involves comparing a modern ecosystem to one that is 'untouched' by anthropogenic factors. This can prove challenging, because in many cases ecosystem attributes have been undergoing modifications since before modern research began (Naiman, Johnston, & Kelley, 1988). Unfortunately, the definition of what exactly a reference condition is varies from discipline to discipline, and in many cases debates result from a misunderstanding of terms rather than different perceptions of the data itself (Stoddard et al., 2006). There is another inherent problem with the establishment of reference conditions: in more extensively developed areas, it has become exceedingly difficult to find an untouched ecosystem with which to compare modern measurements (Nilsson, Jansson, Malmqvist, & Naiman, 2007). The problem of locating a pristine environment for comparative purposes is only going to become a bigger challenge in the future, and will result in managers having to make less well-informed decisions, as they attempt to develop site-specific management plans.

Attempts have been made to overcome this issue by using new modeling techniques. Of the few that exist, most rely on modern science to try and reconstruct historical ecosystems, as opposed to looking at primary sources from the time. Ganguli et al. (2011) for example, used studies of historical ground cover, herbivorous grazing patterns, and established disturbance patterns in order to develop a SIMPPLLE (SIMulating Vegetative Patterns and Processes at Landscape scaLEs) model. The SIMPPLLE model looks at how large disturbance events have affected the study area in the past, then takes those patterns and applies them to develop models of future developments within the ecosystem (Ganguli, Haufler, Mehl, & Chew, 2011). While it does mitigate the problem of having to establish a reference condition, the SIMPPLLE model does not attempt to establish a detailed picture of change over time as much as it attempts to understand natural themes. The SIMPPLLE model takes a generalized version of past events and applies those patterns to determine possible outcomes of management decisions.

Why then, is it important for managers to develop a more nuanced understanding of a historic landscape, if a general sense of past events can offer reliable predictions about the results of future management decisions? The answer lies in the fact that in many cases, events that have happened before will not necessarily happen in the same way again. This is especially true in a coastal or marine environment. Due to the almost inconceivable number of variables that are present in natural aquatic systems, simply knowing what has happened on a broad level could result in misinterpretations that will hamper accurate predictions about the future (Wohl, 2005). Furthermore, in certain cases a return to the 'pristine' state of an ecosystem might not be the best course of action for a manager to take. In fact, trying to restore and ecosystem to the way it was can be precisely the wrong course of action. In many instances, the factors that degraded that ecosystem in the first place are still impacting the project area (Nilsson et al., 2007; Wohl, 2004). In cases like these, managers would be better served to try and develop a detailed understanding of the original state of the ecosystem, attempt to determine how the anthropogenic factors involved have affected that ecosystem over time, and use that information to determine the best path forward.

It is clear that the integration models commonly in use today take the form of a braid, with the separate strands of social and natural sciences working together but remaining separate and independent entities. In certain circumstances, managers need to be able to achieve an understanding of an environment originating further back in history than the natural sciences alone can provide. In these cases, lines between the roles of the natural and social scientist can be blurred in order provide managers with as complete an understanding of the project area as possible.

Part 5: Critical Cartography and the Perils of Old Maps

Before integrating historical documentation (which in this case consists primarily of historical cartography) into modern management plans, the manager must first be well aware of the challenges that are inherent in dealing with old maps. Aside from problems of scale and distortion, experts in the field have also studied the impact of more esoteric aspects of cartography. Since the 1980's the field of critical cartography has emerged as an influential force on the study of maps, questioning their accuracy as real and relevant depictions of the world (Edney, 2007).

One cannot discuss the field of critical cartography without examining the work of J. B. Harley. Harley was writing in response to what he felt was the undue amount of 'positivism', or scientific hyper objectivism that he felt had overrun modern cartography (Henrikson, 2003). While an extensive investigation of the work of J.B. Harley will not be undertaken in this paper, a general understanding of his arguments will prove useful if one hopes to include any sort of historical cartography in the development of their management plan. In *Surveyors of Empire,* Hornsby summarizes Harley's contribution to cartography when he wrote that Harley "shifted the study of maps away from antiquarian concerns with description and cataloguing towards explaining the role that maps play in society" (Hornsby & Stege, 2011 p.7). Applying the philosophies of thinkers like Michel Foucault, Jacques Derrida, and Edward Said to the study of cartography brought Harley to the conclusion that there was no such thing as a purely objective map. Harley believed that every map suffered from both deliberate and unconscious distortions which were entirely dependent on the context in which the maps and the mapmaker existed (Harley, 2001; Hornsby & Stege, 2011). Harley expressed this idea himself when he wrote:

> Behind the map maker lies a set of power relations, creating its own specification . . . By adapting individual projections, by manipulating scale, by over enlarging or moving signs or typography, or by using emotive colors, makers of propaganda maps have generally been the advocates of a one-sided view of geopolitical relationships (Harley, 2001 p. 63)

Harley believed that since this distortion was inherent in any maps creation, the true value of the map lay in the interaction between the reader and the map, as opposed to between the map and the area it was purported to represent (Lennox, 2010).

For Harley, a map was nothing without context. In fact, he outlines three specific areas where context must be established if one hopes to properly understand any sort of historical map: the cartographers context, the context of other contemporary maps, and the context of the society within which the map was created (Harley, 2001). More than that, Harley examined how the science of mapmaking existed as a way to both increase and maintain power within the context of western imperialism and capitalism (Grim et al., 2002). According to Harley, if one is to truly understand the map that one is examining, one has to understand its place in relation to supporting the position of whatever power created it.

Harley was not without his critics however. Robert Baldwin pointed out that many of the methods used by Harley to deconstruct his subject matter could also be turned on Harley himself, accusing him of academic empire building. Baldwin argues that Harley's views "could be reduced to the drive for academic power and its trappings, its grants, endowed chairs, publishing contracts, awards, and so on (Baldwin, 1989 p.90)." Barbara Belyea noted that Harley's knowledge of Foucault and Derrida came largely from commentaries and translations, rather than directly from the authors writings themselves (Belyea, 1995). Belyea goes on to assert that this second hand knowledge resulted in an awkward understanding of both Derrida and Foucault, that led Harley to look for a social theory that the two philosophies simply do not provide (Belyea, 1995).

One of the sharpest criticisms of Harley's work was authored by J.H. Andrews and selected as the introduction to *The New Nature of Maps: Essays in the History of Cartography,* a posthumous published collection of some of Harley's most influential essays. Andrews critically examines Harley's assertions of the dangers of cartographic positivism, his idea of silences within maps, and how much focus Harley puts on the extraneous ornamentation of maps, as opposed to the main content. Despite all this however, Andrews concludes that while it may not be perfect, Harley's philosophy still serves as a "stimulus to thought in readers who might otherwise have remained unselfconsciously empirical (Harley, 2001 p. 32)." While certainly open for criticism, the work of Harley did show that maps should not be assumed to be accurate representations of whatever it is that they are depicting. This is not to say that they are *certainly* inaccurate, but merely that without context and verification one cannot simply assume that what a map is showing is, in fact, the truth.

One academic whose research was influenced by the works of Harley was Matthew H. Edney. If one considers the opinions of Harley at one extreme of the spectrum, and the traditionalists at the other, Edney takes the middle road. Dr. Jeffers Lennox writes, in what is arguably the definitive work on the subject, that:

> Traditionalists believe that maps have a relationship only with the territory they represent, while critical scholars believe it is the reader/map interaction that defines cartography's value. Following in Harley's footsteps, Edney argues that cartography requires a combination of these positions (Lennox, 2010 p. 16).

Edney saw that the while there are certainly distortions caused by inherent bias in the mapmaking process, maps can still represent a physical reality that can be useful for a variety of different reasons. The work of Edney is of particular use in the context of this paper because of his commentary on so-called British 'imperial maps.' Despite the fact that Edney dismisses the idea of the imperial map as a distinct "cartographic category "(Edney, 2009 p. 14) , Edney recognized early on that even within the new framework laid out by Harley , mapmaking and imperialism are, at their core, both fundamentally concerned with territory and knowledge (Edney, 1997). The challenge for the British, as highlighted by Edney, were the contradictions that existed between the British desire for universal geographic knowledge, and their actual ability to produce it (Fisher, 1998). In North America, for example, the Native Americans were largely excluded from the British mapmaking dialogue. This is because they were not considered to be an integral part of the imperial quest to dominate the new colonies (Edney, 2009). The exclusion of the Native peoples from the mapmaking process allowed certain collaborations that had occurred 'on the ground' to: "undergo radical reformulation and reconfiguration according to European ideals and cartographic conventions (Edney, 2009 p. 40)."

The overarching theme that is pointed out in much of Edney's work is the fact that imperial mapmaking was oftentimes messy (Ludden, 1998). The British mapmaking process was the result of many different surveys, from various people, with different skill levels and background. Even once an initial map had been created, it could be, and often times was, altered by the powers in Europe in order to better serve the cause of imperialism. Once again, this does not mean that the maps were entirely inaccurate; more that one has to be conscious of the types of features being portrayed on a map, and understand the context in which they were created.

For Atlantic Canada, the work of Dr. Jeffers Lennox provides the most detailed examination of the impacts that the issues raised by Harley and Edney had on cartography in the Maritime region of North America. Lennox asserts that cartography was used in Nova Scotia as: “a powerful and multi- faceted tool, capable of illustrating past possessions and projecting future claims (Lennox, 2010 p. ix).” He illustrates how maps were used as a method of emphasizing an imperial past, as a way of negotiating between the British, French and Indigenous populations, to attract colonists, to aid in military campaigns and defense, and develop civil works projects. Dr. Lennox shows how the battle for territory in Nova Scotia and L’Acadie serves as a microcosm for all the various ways that maps can serve to influence social, political, and spatial reality that had been previously developed by Harley and Edney (Lennox, 2011).

Lennox also demonstrates how, in some cases, both British and French authorities came to rely on shifting perceptions of geography to both inform and enforce land claims and treaties(Lennox, 2010). One of the most pertinent examples of this malleability is illustrated by the conflict over the terms outlined in the Treaty of Utrecht:

> The undefined limits set by the Treaty of Utrecht were bound to conflict with France’s rich cartographic materials . . .. There were two major concerns: first, the French would be prevented from fishing within 30 leagues east of Sable Island; second, the southern limits of Acadia as listed in article twelve were unclear and did not correspond to those indicated on French maps. Moreover, the memoir’s author was suspicious that the British were conveniently adjusting their maps to correspond to their desired location of Sable Island to exclude France from the region’s fishery (Lennox, 2010 p. 57).

Lennox’s work highlights the fact that cartography in Nova Scotia was prone to the distortions described by Edney and Harley, as the contest between the French, British, and Mi’kmaq to establish a dominant presence in North America developed.

It is clear then, that the use of historical cartography in the practical forum of coastal management is fraught with challenges. The concepts conceived by Harley, developed in terms of British imperialism by Edney, and applied regionally by Lennox, illustrate how many maps cannot be taken at face value. How then, can the coastal manager hope to get any practical use out of a document that has been so thoroughly portrayed as an animal of political whim and convenience? The next section of this paper will examine how in many cases, many of the stressors that made certain maps decidedly unreliable, actually served to improve the accuracy of others.

Part 6: Reconstructing the Map - Putting Cartography Back into a Practical Context

According to Harley; "The basic rule of historical method is that documents can only be interpreted in their context (Harley, 2001 p.37)." Since Harley sees maps as texts to be interpreted in the same way as any other historical document, then this rule must also apply to historical maps as well. Harley uses this premise to illustrate how many maps contain errors and omissions that tend to suit the convenience of the mapmaker or the commissioning authority. Lennox illustrates Harley's point in the context of Nova Scotia when he describes the negotiations that took place between the French and the British in 1720 over Canso and the associated fishing grounds:

> Pulteney reported that at the conference the French agreed not to fish within 30 leagues east of Sable Island and presented a map of those fishing boundaries. On the map they had drawn a line starting 30 leagues east of Sable Island and travelling southeast. A second line extended directly west from Sable Island to Nova Scotia hitting the

> province well south of Canso, thereby leaving the region open to French fishing . . . France's commissaries had even created false maps to support their arguments (Lennox, 2010 p. 96).

There can be little doubt that the meaning of maps can be greatly affected by the reasons for which they are created. What must be made clear however, is that Harley tends to focus on the negative effects that putting a map into context can have on its perceived accuracy. There are however, certain circumstances in which having an accurate reflection of the landscape would be the key purpose of a map, and in these cases context could serve to support the veracity of a map, as opposed to acting as an argument against it.

Eighteenth century Nova Scotia provides a clear example of when context points towards a need for more accurate maps. In the aftermath of the Seven Years War, the British needed to develop a more precise understanding of the lands they had captured. As a result, they invested heavily in an extremely large and sophisticated mapping operation (Hornsby & Stege, 2011). Another contributing factor to the development of accurate maps in Nova Scotia, is that that as maps became a more important part of negotiations between the French and English. Both countries were working hard to expose cartographical flaws within the others maps in order to bolster their own bargaining positions (Lennox, 2010). In an area as closely watched as Nova Scotia, it was becoming easier than ever to expose and dismiss inaccurate maps.

Harley argues that, in many cases, features were omitted from publicly available maps for strategic, military, or public relations purposes (Harley, 2001). Sure enough, examples of this can be seen in early maps of Nova Scotia as well. Lennox (2010) provides an example of such omissions when he notes that in a 1749 map of Nova Scotia, created by Thomas Kitchin for the general public: " 'Ind. Vil.' marks the location of Mi'kmaq settlements, but none are placed along the Atlantic coast. There was a Mi'kmaq Mass House on the Shubenacadie by this time (P.234)." Lennox explains in great detail why this particular type of omission was made, but for the purposes of this paper it is enough to understand that the intended audience for a map could greatly affect the way it portrayed a given area.

It is clear that maps were drawn with a purpose in mind. It follows then, that if one could find a map that was created specifically to offer an accurate depiction of a landscape - drawn by a respected cartographer, for an audience that has a vested interest in that landscape - then that map should represent the landscape as accurately as possible for the time. In Nova Scotia during the late eighteenth century and early nineteenth century there were two groups that would require this type of map: the military and the civil engineers. The military were working to get a better strategic understanding of newly acquired territory. British maps at this time were also beginning to develop more scientific underpinnings. Techniques of trigonometry and triangulation were being developed by British military surveyors throughout the empire (Edney, 1997). While there were certainly maps being developed for international diplomacy as well as the general public, some of the most detailed maps were created specifically for the military. The maps that the military were producing in order to develop a strategic understanding of the region, were generally topographical in nature and tended to focus on geographical features of strategic significance (Harley, 2001). Many of these features such as wetlands, rivers, high points, and forests can also serve as indicators of ecology and landscape (Sanderson & Brown, 2007). It is these features that will be examined in this study.

While not necessarily offering the same level of detail in regards to the natural environment as the military maps, the plans drawn by civil engineers in urban areas like Halifax still had to depict natural features, as far as they affected property lines and development projects. When looked at in conjunction with the earlier[1] military maps, the maps made by civil engineers serve to illustrate how major environmental features within urban environments change as the city around them develops. Accuracy was equally important to civil engineers as it was to military surveyors, but for different reasons. While the military needed to know the location of natural features for strategic purposes, the engineers strove for similar levels of accuracy for personal and professional ones. An effective and enthusiastic surveyor was well respected, and enjoyed advancement opportunities both professionally and socially. Edney (1997) describes the opportunities for British Surveyors as such: "By 'doing science' the surveyors would also enhance their social standing, could possibly be elected into scientific societies, and might even attain 'genteel' status. Overall, they would achieve financial security (p.147)." All these opportunities depended largely on one's reputation for being an effective and conscientious surveyor. If one can determine whether or not a surveyor was highly regarded within the wider community, then that is a dependable indicator of how trustworthy any map they had a hand in creating will be.

It is now clear that while there are certainly a myriad of challenges associated with deriving data from historical maps, there are cases when it makes sense to trust them as well. It has been shown that in certain instances, both military and civil engineering

[1] As they will generally be addressed together, "earlier maps" refers to Des Barres (1779) and Blaskowitz (1784), while "later maps" denotes the Morris (1841), Hopkins (1878) and modern (2012) data sets.

[2] An example of this this tendency to take sole credit for work that was not necessarily

maps offer the potential for accurate depictions of physical space despite the biases and politics of those that created them. As such, this project will examine and compare two maps created specifically for the military and two maps created for civic purposes. In the end however, the creation of any map depends on the skill of the person who created it. The next section will examine the four specific maps studied for this project, and the people who created them.

Part 7: The Maps and Their Makers

One must be very careful when selecting the types of maps that are used to try and extract reliable quantitative data. As early as 1929, the necessity of not only understanding the visual data represented on the map, but also the context in which it was written, was highlighted by J.A. Williamson when he wrote: "It is impossible to be dogmatic about the evidence of maps unless we know more than we commonly do about the intention and circumstances of those who drew them (Williamson, 1929 p.279)." This section will introduce the mapmakers who created the four principal maps used in this study, and will explore the broader contexts in which they were created.

Map # 1 – The Harbour of Halifax (1779): J.F.W. Des Barres

Along with his fellow British Army Officer Samuel Holland, Joseph Frederick Wallet Des Barres was responsible for the most significant surveys of North America in the eighteenth century (Hornsby & Stege, 2011). Des Barres is probably most well known for being the principal architect of *The Atlantic Neptune,* a collection of maps and nautical charts that was published between 1774 and 1802 (Hornsby & Stege, 2011). The map used in this study comes from the plates used in *Atlantic Neptune.*

Although the map used in this study was published in 1779, the survey of Halifax was likely done some time before that. Versions of the map appear as early as 1777, and at the time of publication, Des Barres was in London administering the production of *The Atlantic Neptune* (Webster, 1933). In fact, it is entirely possible that Des Barres did not actually do the surveying of the Halifax Peninsula himself, as he had a tendency to sign his name to the works of others when he was publishing for political reasons (Pedley, 2005).[2] Politics and personality aside however, the appearance of the Des Barres map of Halifax within *The Atlantic Neptune* serves as a solid affirmation of its accuracy. *The Atlantic Neptune* was considered to be one of the best collections of charts, plans and views ever published (Canada. Dept. of Fisheries and Oceans. Communications Directorate, 1985) and its maps effectively served both military and civilian purposes for over fifty years.

Map #2 – A Plan of the Peninsula upon which the Town of Halifax is Situated, shewing; the Harbour, the Naval Yard, and the several Works constructed for their Defence (1784): Captain Charles Blaskowitz[3]

Created in 1784, the Blaskowitz map represents one of the earliest detailed surveys of the entire Halifax Peninsula. While little is known about his origins, it is clear that by the time he produced this map in 1784, he was an established and respected surveyor. In fact, Des Barres included maps initially surveyed by Blaskowitz in the *Atlantic Neptune*. Blaskowitz arrived in America around 1761, and became a salaried member of Samuel Holland's team in 1764. He then rose through the ranks from

[2] An example of this this tendency to take sole credit for work that was not necessarily entirely his own can be found on Pg. 132
[3] The information on Blaskowitz being somewhat scattered and scarce, all of the bibliographic information in this section comes from Mary Sponberg Pedley's *The Commerce of Cartography.* The University of Chicago Press. London. 2005.

Draftsman, to Volunteer Surveyor, to Assistant Surveyor, and by 1775 he had attained the rank of Deputy Surveyor. When the American Revolutionary War broke out in 1776, Blaskowitz joined the Guards and Pioneers, of which Holland was a founding officer. This post allowed him to actively carry on his military surveys up and down the East Coast under the command of Samuel Holland, and with a team of eleven men supporting him.

While Blaskowitz's movements after the Seven Years War remain unclear, what is certain is that his maps were created with military and administrative purposes in mind. When he again turned his hand to Halifax in 1784, producing both a map of the naval yard as well as the peninsula, he did it with the eye of an experienced and well-respected surveyor. Blaskowitz knew the importance of being on location and was well practiced at converting well-measured observation into accurate maps.

Map #3 - The City of Halifax (1841) – John Spry Morris

The last Surveyor General of Nova Scotia, John Spry Morris was the final member of the Morris family to occupy a position that had been held by them for just over a hundred years (Whittier, 1968). Assuming the role of Surveyor General from his father, Charles Morris III in 1831, John Spry Morris held the post until it was merged with the position of Commissioner of Crown Lands in 1851 (Chard, 2000). In comparison to his father, grandfather, and great-grandfather, relatively little is written about John Spry Morris. Despite the fact that he held the senior surveyors position in Nova Scotia for twenty years while simultaneously acting as the Commissioner for Crown lands until 1854, no substantial biographical information on the man seems to have been produced.

The map that is credited to him shows a city in transition from wartime outpost to provincial capital. Survey lines and property boundaries are beginning to take the place of natural features, and a coastline that was once depicted as intricate and complicated takes on a smoother profile. Topography is no longer included, and while natural features still figure quite prominently into the map, it is clear that they are depicted only in relation to how they interact with what was a growing and expanding city.

Map #4 – City Atlas of Halifax Nova Scotia: From Actual Surveys and Records (1878): Henry W. Hopkins

The inclusion of this map into the study marks the end of a transition from military to civil mapmakers in Halifax. Henry W. Hopkins was a civil engineer who was known primarily as a producer of some of the best city maps and plans in the United States (Ristow, 1985). In conjunction with his older brother Griffith, Henry ran the G.M. Hopkins company which produced over 175 city and county atlases for places like New England, New York, New Jersey, Pennsylvania, Halifax and Montreal to name a few (Barrett & Erling, 2009). The fact that Hopkins is a civil engineer, rather than a military surveyor, is reflected in the fact that while there is a massive amount of detail provided about the city of Halifax itself (civic addresses, types of buildings, property owners etc.), details about the natural environment are considerably less conspicuous. Aside from major water features, Hopkins does little to illustrate topography, forest cover, or other ecological features. Unlike Blaskowitz and Des Barres, the Hopkins map portrays Halifax as something that was separate from the landscape, rather than an entity that needed to be situated within it.

That being said, the Hopkins map is still useful to obtain a picture of the Halifax Peninsula, as it was 129 years after it was founded. Pertinent data can be obtained about changing coastlines and watercourses, offering important insight into change over time. The lack of information about wetlands in the Hopkins map could be attributed as much to a shift in focus of the mapmaker, rather than a change in the area being mapped. When studied in conjunction with other maps, the Hopkins map provides important details about how the development of the City of Halifax affected the peninsular ecology.

Part 8: The Halifax Peninsula – A Case Study

I) Initial Research:

When first exploring the idea that historic cartography could provide useful ecological data, the initial challenge was trying to determine if there were in fact, maps that could serve as accurate early representations of the Halifax Peninsula. The first map that was unearthed was the Blaskowitz map (1784). In order to ensure that the Blaskowitz map was contextualized properly, its validation was split into three sections based on the three cartographical contexts outlined by Harley (2001): the cartographers context, the context of other maps, and the context of society. If the Blaskowitz map could be validated in these three ways, then it would present a much stronger case for its accuracy once the digitization process was complete. The first step was to establish the legitimacy of Blaskowitz as a cartographer, and to put his mission into the broader context of the society in which he was working. After research had determined that Blaskowitz was, in fact, a legitimate surveyor with a reliable body of cartographic work, his map could be examined in relation to other contemporary cartographic sources.

It was determined that the first step in establishing this cartographic context, would be to compare the Blaskowitz map with as many other representations of the Halifax Peninsula from the same time period as possible. Through research done in the Provincial Archives of Nova Scotia, The National Archives of Canada, The Halifax Municipal Archives, and the National Archives of Great Britain, forty-one maps representing different portions of the Halifax Peninsula were located. Once identified, the maps were then scanned with a flatbed scanner when possible. If scanning was not possible, they were recorded with a fourteen mega-pixel digital camera. Certain maps were also converted directly into digital image files from microfiche.

In the cases where flatbed scanners had been used, maps that were too large to be contained within one image were re-assembled using Microsoft's ICE photo-stitching program. If the maps had been digitally photographed it was determined that while the distortion on the individual images was relatively small, the compounding of that distortion as they were re-assembled was too great to provide any sort of useful analysis. Therefore, if a map was photographed in sections, those sections were analyzed individually rather than re-assembled and examined collectively. Once they had been converted into either JPG of TIFF images, these digital pictures could then be added as layers into the ArcMap Geographic Information System (GIS).

II) Georeferencing:

Once the images had all been added to the GIS, they were georeferenced using the Halifax Regional Municipality Geodatabase (HRMGD) released in May 2012, and made available through the Dalhousie Geographic Information Center. The majority of the georeferencing used the data in the *Streets* feature class. As the *Streets* feature class consisted of line data, the assumption was made that the lines representing the streets should correspond as closely as possible to the middle of any streets or intersections portrayed in the image being georeferenced.

In the interest of minimizing further distortion to the maps, the decision was made to only use first-order affine transformations to bring the historical maps into line with the modern data. Transformations were used rather than re-projections due to the fact that while it may be preferable to register the maps to the appropriate projection and then re-project the Data, in many cases the original projection was not known. While an initial concern, research showed that in most cases the error associated with ignoring the projection over the size of a mapped area, is generally smaller than the positional error associated with digitizing paper maps in general (Bolstad, 2008). This being the case, all the digital images were transformed so that they, as much as possible, conformed to the modern data layers. These layers employed the Transverse Mercator projection and used the NAD 1983 CSRS UTM Zone 20N projected coordinate system. In most cases, the digitized maps could be transformed with a reasonable amount of accuracy by using between two and five control points. Any more than that and the transformation would move beyond affine, into second order polynomial transformations. This would have introduced an unacceptable level of distortion into to the original image. If an image could not be brought into line with the others using a first order transformation, and maintaining a Root Mean Square (RMS) error of less than ten, it was discarded at this time. Using this method the maps selected for further digitization were georeferenced

RMS Errors	
Des Barres - 1779	0.00
Blaskowitz - 1784	6.10
Morris - 1841	8.40
Hopkins - 1878	1.50

Figure 1 - RMS errors after georeferencing

with a minimal RMS error of between 0 and 8.4 (See Figure 1). A visual examination of the documents indicated that while specific details may vary, there were certain themes that ran through the various representations of the Halifax Peninsula that merited further investigation.

III) Secondary Analysis:

Before a more detailed digitization was undertaken, a digital elevation Model (DEM) of the Halifax Peninsula was created. There were two versions of this model developed using two different files and two different tools in the ArcMap program. The justification for this step was that even though elevations will have changed over time, on the whole, the general topography of the Halifax Peninsula would not have varied a great deal since 1749. Using contour data at the scale of 1:1000 the "Topo to Raster" tool was employed to create a raster image from the line file. The file was then re-symbolized to create an image of the Halifax Peninsula that was shaded to illustrate the variations in elevation.

Similarly using the elevation spot height data provided in the HRMGD, also at a scale of 1:1000, the "Create TIN" tool was engaged to create a Triangular Irregular Network (TIN). The TIN was also shaded to indicate various changes in elevation over breadth of the Halifax Peninsula. Using these two DEM's, the Blaskowitz map was overlaid in order to see whether or not the topography depicted in the early maps corresponded with the elevations as depicted by the modern data.

IV) Digitizing and Editing:

Once the digital files had all been brought into ArcMap, a selection of maps then had to be chosen for further digitization. During this process, a collection of feature classes for each map were created to allow for a more qualitative examination of features such as wetlands, coastline, major watercourses and minor watercourses. While it is recognized that it would have been ideal to digitize all of the maps in the interest of getting a larger sample size, due to time constraints this was not possible. This being the case, the four maps described in the *Maps and their Makers* section were chosen to undergo a more thorough analysis. The chosen maps were all digitized manually at a resolution of 1:1,500. The exact features that were digitized depended on the individual maps. In the earlier maps for example, watercourses are separated into major and minor watercourses, while in the later maps, all watercourses are depicted with the same symbol. There were, however, certain measurements that could be made on all four maps, and might serve as valuable measures of change over time. These features were: total area of the Halifax Peninsula, total length of surface water courses, length of coastline, number of lakes/ponds and total area of lakes/ponds.

Wetlands are only explicitly demarcated in the earlier maps. While neither Blaskowitz nor Des Barres includes a legend explicitly stating what symbol is used to depict wetlands, comparisons with other similar maps offer a clue. In the British Headquarters Map used by Sanderson in the Mannahatta Project, all of the areas that were symbolized as seen in Figure 2 were determined to be either

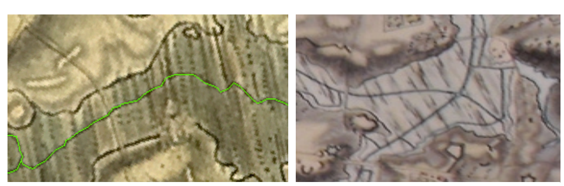

Figure 2 - Wetlands as portrayed by the Blaskowitz (left) and the British Headquarters Map (Right) (Sanderson, 2009).

wetland or estuarine communities (Sanderson, 2009). The Blaskowitz map uses a similar symbology in its depiction of Nova Scotia. This being the case, all areas depicted as seen in Figure 2 were considered to be in the category of wetland habitats. The symbol used by Des Barres to depict wetlands differs from the other two maps, however the symbol is distinctive enough and located in such areas as to indicate that it is also identifying wetlands. In order to obtain their location and area, polygons were created outlining the wetlands as represented by both Des Barres and Blaskowitz. The high points in the wetlands were then traced on a separate layer. In order to obtain the final area of the wetlands on the Des Barres and Blaskowitz maps, the erase tool was then used in order to remove the data falling within the high points layer from the polygons in the wetlands layer. Lake and Pond features were also removed from the wetland polygons, providing an accurate calculation of wetlands on the Halifax Peninsula as depicted by the earlier maps in 1779 and 1784. With the digitization process complete, specific measurements and calculations could be undertaken in order to compare the historical maps to each other, as well as compare the Halifax Peninsula as it was at the end of the eighteenth century, to how it exists today.

V) Analysis:

The four selected maps of the Halifax Peninsula now existing in digital form, the quantitative analysis could begin. For each of the four maps, measurements were made of the area of the peninsula, length of coastline, length of surface watercourses, and number/area of ponds using the 'Statistics' tool. As mentioned above, the area of wetlands was also determined for the Des Barres and Blaskowitz maps also using the 'Statistics' tool. This provided a quantitative picture of each map individually.

In order for any meaningful comparisons to take place, all of the maps and their associated features needed to be clipped to the same extents. As the Des Barres map covered the smallest area, it was chosen as the point of comparison. Because the original scan of the Des Barres map is of an entire page, rather than just the map itself, there is a small area around the map boarder that needed to be eliminated. In order to ensure the highest possible level of accuracy, rather than simply using the existing extents of the layer, a new layer was created using a polygon entitled 'DesBarres_Extents.' 'DesBarres_Extents' traced the borders of just the map portion of the scanned document. This polygon eliminated the boarder area around the map (See Figure 3). All of the other maps and their associated feature classes were then clipped to match 'DesBarres_Extents', so that all comparisons were being done on the same area of the Halifax Peninsula.

Figure 3 - Des Barres map: original scan and with "DesBarres_Extents" polygon overlaid

It was using these new layers that a real picture of how the ecology of the Halifax Peninsula, and especially the watercourses and wetlands, changed during the first 130 years of European Settlement. These measurements were all collected into a spreadsheet where they could be properly compared. As will be explained in more detail below, there was an acceptably high level of similarity between the two early military maps, so they were averaged together to form one set of baseline numbers representing the earliest data available for the Halifax Peninsula. From that baseline, the formula *=(new value - baseline value)/ABS(baseline value)* was employed to calculate the percentage difference between the historical baseline, the Morris map, the Hopkins map, and the modern data set.

VI) Results:

Establishing a Baseline

Before change over time could be examined, a determination needed to be made as to whether or not the two earlier maps were similar enough to be considered as a historical baseline to which the later maps could be compared. In order to make this determination, the two maps were clipped to the same extents, and then compared to determine if they offered similar depictions of the Halifax Peninsula. Right away, it became clear that there were certain features that would prove more valuable for comparison than others. For example, any measurements of the length of the coastline, did not provide the level of accuracy that is needed to obtain reliable quantitative numbers. Even though a standard protocol for tracing the coastlines was maintained (all coastlines were digitized taking the furthest demarcated seaward boundary as the coast), the variability in the coastline left too much room for error. Over the same area of the peninsula, the coastline was measured to be 18.03% longer on the Blaskowitz map, than it was when drawn by Des Barres. This is largely due to the fact that even when digitized to the same scale and georeferenced, there is no reliable way to get a precise sense of how the various cartographers defined exactly what constituted coastline. The result was a series of very precise measurements, which cannot be considered particularly accurate. Even if a standard form of measurement could be located, the differences in high and low water over the course of the survey period make obtaining specific and reliable numbers difficult. It became clear that the different maps all represent the coastline at different levels of detail. While in each case the general shape of the Halifax Peninsula, as well as its major features was consistent, the differing levels of detail made meaningful comparison difficult.

The difficulty experienced in this study in obtaining an accurate coastline measurement emphasizes one of the major challenges in dealing with old maps, a lack of standardization. For example, when comparing both the Blaskowitz and the Des Barres maps, there is a definite distinction between major and minor watercourses. In both maps, the major watercourses consist of two lines shaded blue in between, while the minor watercourses are symbolized by a thin black line (see Figure 4). Unfortunately, whether a watercourse was delineated as major or minor seems to have been entirely under the discretion of the cartographer. By not having a set of standards, the two depictions of watercourses by Blaskowitz and Des Barres vary widely. Furthermore, by 1841 the two categories have been eliminated altogether, with all watercourses being depicted by one symbol. According to the Blaskowitz map, there were 3397.57 m of major watercourses on the Halifax Peninsula in 1784, while only five years earlier Des Barres had it depicted as 6687.35, a difference

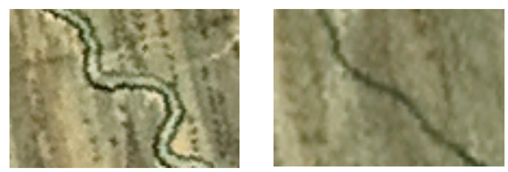

Figure 4 - Major and Minor Watercourses as portrayed by Blaskowitz

of 49.19%. Similarly, Blaskowitz records 22490.93 m of minor watercourses, while Des Barres only counts 16025.67 m, a difference of 40.34%.

It is obvious that a difference in scale and cartographer makes determining specific details about these watercourses difficult. What is interesting however is if one examines the total length of watercourses on the Halifax Peninsula, the discrepancy between Blaskowitz and Des Barres drops dramatically. If one ignores the division of major and minor and simply looks at watercourses as a whole, then within the extents of the Des Barres map, Blaskowitz drew a total of 25807.71 m of watercourses while Des Barres map depicts a total of 22713.03 m, dropping the difference between the two maps down to 13.98%.

It is clear that in terms of fine detail, old maps can leave something to be desired. Where these maps begin to provide useful numbers is when one looks at them as broad representations of the area as a whole. As mentioned above, when measuring coastline, the numbers produced were precise, but not necessarily accurate, as the level of detail that they depicted varied so widely. If one takes those digitized coastlines, and uses them as one boundary when measuring the area of a defined section of the peninsula however, the maps begin to produce more useful results. For example, when measuring coastline, the difference between the length depicted by the Blaskowitz map and the Des Barres map was 18.03%. If one measures the difference in *total area* of the section of the peninsula represented by the Des Barres map however then the difference between Des Barres and Blaskowitz drops to 0.21%. While the specific details may vary, the overall picture of the Halifax Peninsula as depicted by these two men is very similar.

A coinciding result can be seen within the watercourse data. As mentioned above, the total difference between the length of watercourses in the Des Barres and Blaskowitz maps was 13.98%. If one eliminates the intricate twists and turns of the watercourses however, and just looks at linear measurement, that percentage drops considerably. For example, if one measures the linear distance between the outlet of Freshwater Brook, a major feature which figures prominently in all four of the digitized maps, and the location of its first major fork (see Figure 5), the difference between the Blaskowitz and the Des Barres maps is only 8.97%, or 35.14 meters. Once again, while the finer details may differ, if one considers the maps on a slightly broader scale, patterns emerge that can provide modern researchers with an improved understanding of the hydrogeomorphology of the Halifax Peninsula.

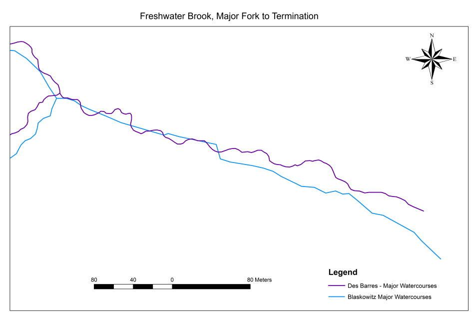

Figure 5 - Map of the bottom section of Freshwater Brook as depicted by Des Barres and Blaskowitz

Finally, by overlaying the newly digitized watercourses onto the modern day elevation data within the TIN model, a better understanding of where these watercourses were and their hydrology can be obtained. By looking at these waterways in relation to elevation, flow direction, catchment areas, and headwaters can all be determined, offering stakeholders a wealth of new information about what is going on beneath the surface of the streets of Halifax. Using this method, the study was able to identify four major watercourses that drain the Halifax Peninsula. Of these four, Freshwater Brook is the most prominent and well known. It ran from what is now the corner of St. Albans Street and Clifton Street, across the peninsula, to its outlet near the intersection of Barrington Street and Inglis Street. It then entered the harbour under a manmade crossing that was known for years as the “kissing bridge”. The second major watercourse also starts at St. Albans and Clifton (it would appear that the intersection of St. Albans and Clifton marks a point on the peninsular divide), and flows down the hill roughly along Young Street before forking out at Agricola Street and draining into the harbour on either side of where the Iriving Shipyards are currently located. The third and fourth watercourses drain the Western side of the peninsula. Various minor watercourses flowed into the low-lying area associated with the modern day railway cut, and then joined one of the two more major streams that either flowed North into the Bedford Basin or South into the Northwest Arm.

Aside from watercourses and peninsular area, the other feature of use to anyone with an interest in understanding and managing the natural environment is the depiction of wetlands. As with the coastline and the watercourses, while the fine details may differ, the general location and overall size of the wetlands correspond well on both maps. Within the area of the Des Barres map, Des Barres records 82.39 ha of wetlands, and Blaskowitz outlines 83.66 ha, a difference of only 1.53%. Once again, while the particular details may differ, the general patterns and locations of features are remarkably consistent between the two earlier maps.

Even though the maps may not reveal the exact nature of the coastal wetlands present on the Halifax Peninsula by themselves, they still offer new insights as to the extents of those wetlands at the end of the eighteenth century. Furthermore, the work of Sanderson (2009) shows how this information, when combined with more rigorous scientific study, can form the basis of a detailed understanding of the types of wetland that existed on the Halifax Peninsula. If one considers the similarities in the two earlier maps, the subsequent development patterns as depicted in Morris and Hopkins, as well as the fact that when placed over the TIN model, the wetlands correspond well with the low lying areas on the peninsula, it is logical to conclude that the wetlands portrayed by Blaskowitz and Des Barres are a reasonably accurate representation of the physical environment.

These initial results show that as long as researchers focus on broader categories like watercourse length, total peninsula area, and total wetland area, the two older maps corroborate each other well. This being the case, the various measurements taken from these two maps were combined and averaged in order to create a historical baseline, to which the 1841 (Morris) map, the 1878 (Hopkins) map, and the modern data set could be compared (See figure 6). Unfortunately, the comparative baseline is only valid on the smaller area covered by the Des Barres map. That being said, the high level of corroboration, as well other supporting evidence that will be discussed below, points to the accuracy of the Blaskowitz map as a representation of the Peninsula as a whole.

Average Baseline Blaskowitz and Des Barres combined and averaged	
Major Water Courses (m)	5042.459961
Minor Water Courses (m)	19217.90519
Total Watercourses (m)	24260.36515
Coastline Length (m)	7751.55434
Total Peninsula Area (sq. m)	5687666.025
Total Wetland Area (sq. m)	830249.9173
# of Ponds	4.5
Total Pond Area (sq. m)	5276.959711

Figure 6- Average of Des Barres and Blaskowitz Measurements. Yellow indicates primary categories for change over time comparison

Change Over Time

Once the historical baseline had been established, it was then possible to incorporate the Morris map, (1841) the Hopkins map, (1878) and the modern GIS data

(2012) in order to get a better understanding of how the major aquatic ecosystems on the Halifax Peninsula have changed over time. By using the three categories highlighted in yellow (Figure 6), a picture of how the landscape of the peninsula changed during the first 129 years of European settlement was developed.

In the case of the Halifax Peninsula, the percentage of change in wetlands between the baseline and today was straightforward. According to the Provincial Wetland Inventory, there are no wetlands currently on the Halifax Peninsula (Government of Nova Scotia, 2004). This means that no matter what the original numbers were, the loss will be calculated at 100%. That being said, what is interesting when comparing the baseline to the later maps, is looking at how the settlement patterns tend to mirror the landscape as portrayed by Blaskowitz and Des Barres. If one looks at the Hopkins map for example, even if wetlands are not explicitly depicted, the areas that have been settled often border right along the edge of the wetlands as depicted in the two earlier maps (See Figure 7). It is important to acknowledge that by 1878 there was already a significant amount of what was depicted as wetland that had been developed, but the larger tracts of wetlands had either been set aside as common property, or had remained largely empty. Since Hopkins and Morris do not explicitly demarcate marshy land, finding specific numbers to quantify change through time is difficult, especially since none of the original wetlands remain. The fact that the settlement patterns on the later maps clearly relate to the areas depicted

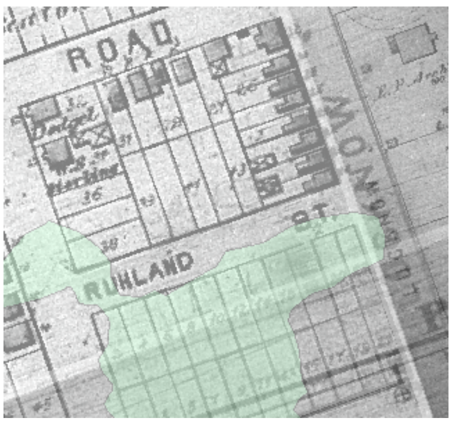

Figure 7 - Detail of Hopkins map (1878) overlaid with wetlands as depicted on the Blaskowitz map (1784). Notice the lack of development on the marshy land

as marshlands in Des Barres and Blaskowitz however, serves to re-enforce these older representations of where the wetlands were, and adds more credence to the overall historical picture provided by the earlier maps.

The next features to be examined were the watercourses on the Halifax Peninsula. As explained above, only the total length of the watercourses was analyzed. This analysis reveals that there was a relatively rapid alteration of watercourses after the beginning of British settlement. By 1841, 82% of the surface waterways had disappeared from the maps, and by 1878 the reduction had increased to 87.98%. When compared to other major cities in the region, this is a decidedly dramatic transformation of the landscape. St. John's in Newfoundland for example, continues to maintain three open rivers within the city limits, as well as a series of smaller waterways similar to those that have been eliminated in the Halifax landscape. While it was certainly a dramatic change, when put into context, this rapid taming of the peninsular waterways actually makes logical sense. St. John's is a city that was developed incrementally, over time, by a series of different settlers. This is markedly different from Halifax, which was a deliberate project undertaken by the British Government in order to establish a more permanent military presence in North America. Halifax was planned by the British Board of Trade and Plantations, supported by Parliament and funded by the British Government (Akins, 1895). According to Akins (1895) the British government offered potential settlers transport to the colony, support for twelve months, as well as the tools and expertise necessary to build a successful outpost. Of equal importance was the fact that since this was a planned community, there were professional engineers, surveyors, and the manpower offered by the military on hand in order to aid in the transformation of the peninsula from wilderness into a thriving coastal town (Akins, 1895). As far as their ability to use culverts, infill and eventually sewers in order to increase the amount of useful land on the peninsula is concerned, the British engineers would have been well schooled in the art of land reclamation. This is largely due to the fact that the latter part of the eighteenth century marked the end of the golden age of British canal building (Clarke, 2005). By the time the development of Halifax was underway, most of the large canal projects in Britain had been completed, leaving a legacy of engineers who were familiar with many of the technical challenges inherent in controlling the peninsula's waterways. Similarly, the resources made available by Great Britain, made initiatives like the 1757 bounty offered for sowing land with grass and growing grain and potatoes possible, further encouraging the population to improve the landscape (Akins, 1895). This technical expertise, combined with the ability of the administration and settlers to focus almost entirely on land reclamation and development allowed the city planners to design the city they wanted, as opposed to one limited by the landscape. This ability to modify the Halifax Peninsula is reflected in the very orderly and grid-like structure of the oldest parts of the city, as opposed to the to the much more fluid design of a city like St. John's, Newfoundland (see Figure 8).

Figure 8 - The neighborhoods around the oldest standing structures in Halifax and St. John's. Courtesy of Google Maps.

In fact, more than just facilitating the development of Halifax, the presence of the military actually served to encourage it. As the importance of Halifax grew, the need to expand the city simply to support the continuously arriving troops helped push the development of Halifax in those early years (Akins, 1895).

While the surface waterways were certainly disappearing, even in 1878 there were vestigial remains that attest to the fact, that the major watercourses depicted in the earlier maps were located where Des Barres and Blaskowitz had drawn them. For example if one looks at the water features present in the downtown core in 1878, it is obvious that they fall very much in line with Freshwater Brook, the major drainage route for the South end of the Halifax Peninsula (See Figure 9). What becomes clear is that once the British decided to make Halifax a permanent settlement, they wasted no time in developing the land. By 1878, much of the peninsula had already been altered in preparation for development, with only the largest watercourses remaining. Even at this later date however, Freshwater Brook remained a dominant feature on the landscape; this is despite the fact that it was incrementally modified and buried by development. The final result of this gradual burial of surface watercourses means that of the 24260.37 m of rivers and streams depicted by Des Barres and Blaskowitz at the end of the eighteenth century, only 152.1 m remain today: a loss of 99.37%.

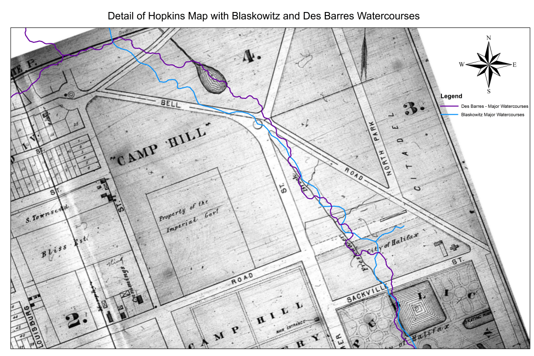

Figure 9 - Detail of the Hopkins map overlaid with watercourses described by Blaskowitz and Des Barres illustrating the correlation between the older watercourses and the more modern water features

The final feature compared in order to observe change over time, was the total area of the Halifax Peninsula. Once again, all maps were clipped to the Des Barres extents in order to ensure an accurate comparison. If the watercourses depict an era of rapid development, the total area analysis shows that the expansion of the peninsula itself was slower to occur. Today, the section of the modern Halifax Peninsula that corresponds to the Des Barres map is 10.08% larger than it was at the end of the 1700's. By the end of 1878, however, it had only grown 2.77%. If one looks at the entire peninsula as drawn by Blaskowitz, as opposed to the averaged historical baseline, the difference between the modern and historical area of the peninsula comes out to be 7.91%, illustrating that the Halifax Peninsula as a whole, has grown about the same amount as the downtown core. While the general numbers indicate that the peninsula has grown, a visual inspection highlights three main areas that have been developed since 1878: the downtown core (See Figure 10), the modern Halifax Shipyards and at the North end near the old Africville site. That being said, in much the same way that the influence of the engineers and the military was seen in relation to the alteration of the water courses, both Des Barres and Blaskowitz show that even as early as the end of the eighteenth century, the coastline had already undergone extensive alterations. The decision of the British Admiralty to develop a careening wharf at Halifax in 1758 is certainly one of the most dramatic examples of this development (Gwyn,

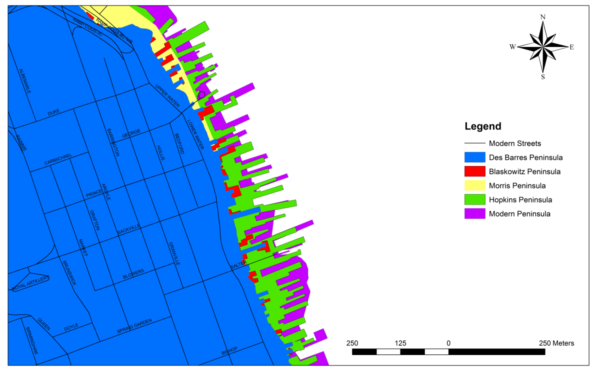

Figure 10 - The coastline as it has developed over time

2004), but historical record shows that even before the construction of the first naval yard significant alterations had occurred. The first major pier, large enough for ships up to 200 tons, had already been constructed by July of 1749 (Akins, 1895), and in 1755 Vice-Admiral Edward Boscawen hired Barnard's wharf to moor his sloops (Gwyn, 2004). It is clear that development progressed rapidly on the waterfront of the Halifax Peninsula, and that fact is borne out by both the Blaskowitz and Des Barres maps which show a significantly developed coast at the end of the eighteenth century. Once again, the older maps prove that while the details might differ, broader patterns can be detected.

At this point it is important to mention another feature that was digitized, but not given much attention in this analysis: ponds. The ponds in Halifax have been excluded for two main reasons. The first is that due to unknown factors, ponds seem to be the one area where Blaskowitz and Des Barres vary widely in their depictions. According to Des Barres, there is one pond in the area covered by his map with a total area of 3653.23 m^2. Within the same area, Blaskowitz has eight ponds with a total area of 6900.70 m^2, a difference of 88.89%. It is quite possible that changing weather patterns did, in fact, result in more small ponds and lakes in 1784. Looking at historical meteorological data in order to determine whether or not this is the case, however, falls outside of the scope of this paper. Whatever the cause, the discrepancy between the two statistics is far to great to provide any sort of reliable baseline, and as such the ponds must be excluded from comparative study.

The second reason that ponds have been excluded from the general analysis, is because of the fact that the appearance and disappearance of ponds does not seem to follow any specific pattern. Aside from the fact that most of the modern ponds exist along the routes of the older watercourses (see Figure 8), it appears as if ponds were created as they were needed, and then drained when they were not. While an examination of exactly what circumstances led to the creation of certain ponds, and the removal of others would make an interesting study, it also falls beyond the scope of this paper. As far as environmental managers are concerned, the real value of being able to see the changing nature of ponds is the ability to determine which, if any, are natural features. Knowing where ponds have been can also help explain development patterns in certain areas. By examining ponds, the researcher is moving away from the more general scope propounded in this paper and towards a level of specificity that is difficult to corroborate with existing evidence. For an example of a major pond that appeared and disappeared over the period examined by this study, see Figure 11.

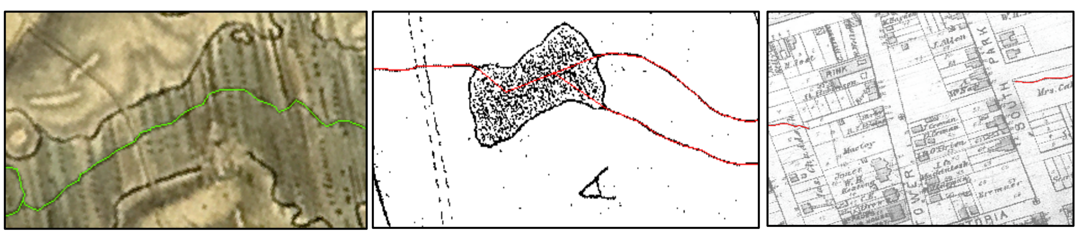

Figure 11 - Details of Blaskowitz, Morris, and Hopkins maps showing the area known as Smith's Pond in 1784,1841,and 1878

The results of this study portray the first 131 years of settlement at Halifax as a busy time of rapid urbanization. This pattern is reflected in the population of the city. When it was founded in 1749, approximately 2,500 settlers populated the town. By 1841 the population had grown by to a total of 15,000, an increase of 12,500 people (Ruffman & Findley, 2007). In contrast, Saint John, New Brunswick only had a population of 4500 in 1810 (Acheson, 1985) , almost 200 years after the first permanent settlement in 1631

(The Catholic Archivist Group, 2012). While the lack of infill in the early stages of development indicates that space was not a problem, the speed with which the land itself was engineered to make it more suitable for settlement illustrates the ambition and urgency that characterized the early years of the development of Halifax. The engineers of the city changed the natural streams and brooks into ornamental water features and ponds, while local entrepreneurs dammed them for a variety of reasons. The presence of the military and the support of the British Government provided the resources for wetlands to be drained, low areas to be filled, and larger watercourses to be bridged and eventually buried. All of these factors were a vital contribution to building the foundations of the city, as it exists today. By looking at the way that the Halifax Peninsula has changed over the years, managers and other stakeholders will now be able to make more informed decisions about everything from coastal resource management, to public works projects.

Part 10: Management Implications

Implications for Management Theory

While the above analysis was done for a very specific place, as a case study it highlights several ways in which historical data can be incorporated into the planning stages of the coastal management process. As discussed above, while the work of social scientists is no doubt valued by marine managers and natural scientists, it is still largely confined to dealing with the relationships among people, rather that specific aspects of the environment itself. The data provided by the Halifax Peninsula case study illustrates that in certain circumstances, social scientists could move beyond their traditional roles, and add substantive data to the planning and management process that has historically fallen under the purview of ecologists or environmental planners.

There is no doubt that one of the largest problems faced by environmental managers in general, and coastal/marine managers in particular is a decided lack of resources (Canadian Council of Ministers of the Environment, 2010; Nature Canada, n.d.; Perron, 2005). In light of this fact, managers have to make every effort to allocate the scant resources that they do have in the most efficient way possible. If incorporated into the initial planning stages of a project, the understanding of an ecosystem that is provided by historical documentation can aid managers in deploying any limited resources at their disposal with minimal wasted effort. The Halifax Peninsula case study shows how old maps could provide a range of resource managers/planners with information that may result in better decision-making.

The work done on the Halifax Peninsula has also shown how, when properly selected and vetted, historical maps can increase understanding of everything from the mechanics of watersheds, to coastline erosion, to the location and size of coastal wetlands. It is possible that studies like the one completed for this project could provide this information at a considerably lower cost than would be associated with obtaining the same amount of data through the natural sciences. If one excludes time spent, the total material cost of this study was approximately $70, which is a considerably smaller investment than natural scientific methods like remote sensing or flying Lidar which typically costs around $3,500 USD + $1.49 USD per acre (Stennett & Wade-Grusky, 2008).

In Canada, there can be no doubt that funding cuts have forced natural scientists responsible for obtaining the data so depended on by coastal and marine managers, to pick and choose when and where they gather data more carefully (CBC Information Morning Nova Scotia, 2011). At the same time as these cuts are taking place, the Canadian Government has also decided to switch from an ecosystem-based management to a bioregionalism approach as the working strategy for environmental management. While a debate over the merits of bioregionalism as opposed to ecosystem-based management falls outside of the scope of this paper, the foundation for both of these philosophies is a strong scientific understanding of how large ecosystems interact with each other across landscapes (D. F. Boesch, 2006; McGinnis, Woolley, & Gamman, 1999). What this means is, that scientists are losing the resources to properly decipher the intricacies of large ecosystems, at precisely the same time that managers will be asking them to provide that understanding. In certain cases, historical documentation could provide an alternative to managers in order to fill that gap.

The second advantage that incorporating historically derived data into coastal management planning can offer is that it can increase the managers understanding of change over time. On the most basic level, the Halifax Peninsula case study illustrated how, by using historical data, a reliable reference condition can be obtained in places like the Halifax Peninsula where it would normally be exceedingly difficult. This reference condition is essential for environmental scientists and managers if they hope to successfully carry out any sort of comparative study. Beyond the establishment of a reference condition, however, the incorporation of historical documentation can also serve to offer a more nuanced version of exactly how the changes highlighted by that reference condition have occurred. This is important because many current management frameworks take the past into account, but work on the hypothesis that the observed change followed a constant and therefore predictable pattern (Turner, 2000).

The problem with this hypothesis, is that anthropogenic change has been found to be anything but constant and not necessarily predictable (Olsen, Tobey, & Kerr, 1997). The truth of Olsen, Toby and Kerr's assertion that anthropogenic change is not predictable is borne out by the Halifax Peninsula case study as it pertained to watercourses. As was shown above, in of 2012 there has been a total loss of 99.37% of the surface watercourses in comparison to the historical baseline. If one were to assume that the loss was constant, then the manager would have to base watercourse management planning on an expected loss of 2.32% a year in relation to the established baseline.[4] This is not at all an accurate reflection of what actually happened. The Halifax Peninsula case study shows that 88% of the watercourses were already gone by 1878. The change was intense and rapid, not slow and constant. The appropriate course of action for dealing with slow steady change is very different from a plan dealing with a rapid change that has already run its course. These nuances are not necessarily captured by the natural sciences alone, but are essential for providing managers with the regional understanding necessary to develop effective planning strategies.

Thirdly, the incorporation of historical data can also support Canadian coastal and marine managers as they come to grips with this new emphasis on bioregionalism. One of the major benefits of a bioregional approach is that it takes an extended temporal scale into account (Ryan, 2012). If researchers are able to come to a more thorough, and in

[4] Formula for predicted annual loss: 2012 –[(1784+1779)/2]/99.37

many cases more accurate understanding of how a bioregion has developed, they will be better equipped to understand why it acts the way it does, and plan accordingly. This strategy of developing a better sense of history has been attempted before, but in areas that did not have the benefit of documentation like the maps used in the Halifax Peninsula case study. For example, researchers in the South Pacific have realized that rising sea levels and ineffective land management pose a threat to their sensitive ecosystems (P. Nunn, 1990). They also found that, in many cases, planning for the future is hampered by an ignorance of changes in the past. Due to a lack of formal documentation, the researchers turned to interviewing local long term residents in order to develop a better understanding not only of how things have changed, but also what might have caused those changes (P. Nunn, 2000). Coastal managers in developed areas like Nova Scotia have a significant resource in these old maps. The understanding so diligently sought by Nunn (2000) in the South Pacific through hours of interviews can be obtained quickly and with a higher degree of certainty through the incorporation of historically derived data.

This study looked at three very specific aspects of the Halifax Peninsula: watercourses, wetlands and total area of the Peninsula. This was largely due to time constraints, as well as the fact that much of the primary research was done under the supervision of Province of Nova Scotia’s Protected Areas and Wetlands Branch. Because the focus was on coastal wetlands, the decision was made to pick three practical and measureable aspects of the peninsula, a better understanding of which, would benefit the coastal management community. Over the course of research, however, it became clear that the opportunity exists to develop similar models for hydrological comparisons, as well a terrestrial ones. At the same time as the British and French were making maps of their newly acquired territories, they were also taking great care to map the waters that surrounded them (Hornsby & Stege, 2011). In fact, over the course of doing research for this project, a map dated 1711 and created by the French cartographer Delabat was located which depicts the Halifax Harbour with associated depth soundings (see Figure 12). It appears that there were accurate maps of the waters around Nova Scotia before there were accurate maps of the land itself. Currently, seabed mapping is being used by scientists and marine managers for a variety of purposes, such as: stock assessments, determining areas suitable for cold-water coral protection, and the effects of sea floor habitat on lobsters (Duraan Muanoz et al., 2009; Geraldi, Wahle, & Dunnington, 2009; Kostylev, Courtney, Robert, & Todd, 2003). The establishment of a historical reference condition and a better understanding of change through time would benefit these studies as well. There is every reason to believe that the understanding provided to coastal managers through this analysis of the terrestrial maps, could be translated into the marine realm, providing similar insights to marine scientists and managers as well.

Figure 12 - Detail of Delabat Map (1711) showing depth soundings off of Point Pleasant.

Practical Management Implications

The question that remains is: does this broad understanding provided by the historical data actually have practical management applications? The results of this case study indicate that indeed it does. Through the strategic inclusion of historically derived data into the development of management plans, the methodology developed in this study has implications and applications beyond the theoretical. When employed as a tool to be used alongside existing techniques, the types of information gleaned by this study can serve to enhance the effectiveness and efficiency of many of the archeological, management, and environmental assessments that necessarily occur within Nova Scotia and beyond. One example of how having a more effective broad understanding of the peninsular ecosystem as a whole could achieve increased efficiencies for managers comes in the area of development. All major developments on the Halifax Peninsula have to take into consideration the stipulations of the Special Places Act, the purpose of which is to:

> Provide for the preservation, protection, regulation, exploration, excavation, acquisition and study of archaeological and historical remains and palaeontological [sic] sites which are considered important parts of the natural or human heritage of the Province (Government of Nova Scotia, 1989)

The result of the Special Places and Protection Act is that large development projects need to obtain a Heritage Research Permit, and have an archeological assessment completed before final permission is given to develop a site (Nova Scotia Museum, 2012). The way that this process works at the moment is that a potential site is picked, and then that specific area is subjected to more focused research. This research then determines whether development on that site would cause undue harm to important ecological and historical aspects of natural or human heritage (Government of Nova Scotia, 1989). [5]

[5] An example of how this process occurred in relation to the Halifax Sewage Treatment Facility can be found at http://www.halifax.ca/harboursol/documents/halifax_archaeology_001.pdf

There are inefficiencies and omissions in this process that could be alleviated by using the methodology developed in this paper. Firstly, by picking a site before having any understanding of what is underneath it, developers risk investing significant time and resources into a project that was doomed to fail from the beginning. If those same developers use information similar to that obtained in the Halifax Peninsula case study, they will be able to pick a site not only based on modern suitability, but historical suitability as well. This would mitigate the risk of developers coming across an unexpected piece of significant history that could result in a stop work order being issued, as is mandated by Section 13 of the Special Places and Protection Act (Government of Nova Scotia, 1989). Similarly, the insight provided by the methodology developed in this paper in terms of change over time, could provide stakeholders with a valuable resource in determining what kind of archeological assessment is necessary for a particular site. By using historically derived data, any given location on the Halifax Peninsula can be easily observed through time. This knowledge could result in better-informed and timelier decisions about the likelihood of finding significant archaeology, and therefore what type of archaeological assessment is necessary.

The other issue with the permit process as it stands, is that the guidelines for an archeological resource impact assessment only specify that context must be established for a specific site (Nova Scotia Department of Communities Culture and Heritage, n.d.). Nowhere in the guidelines does it ever indicate that the site under investigation needs to be placed within the greater context of the ecosystem in which it is located. This broader context can provide a variety of stakeholders with important information that might not be clear when simply looking at one individual site in isolation. For an example of how understanding the broader context of a site, as provided by the methodology developed in this paper, could provide stakeholders with important information on new developments, one need only examine the case of the Peninsula Place Condominium Development in Halifax. This particular building is notorious for having problems with flooding in its underground parking lot (Power, 2008). While many explanations for this flooding have been offered, if one looks at the site within the greater context of the Halifax Peninsula, one major reason for the inundations becomes obvious. The Peninsula Place development is located directly over what used to be the outlet for Freshwater Brook, the major drainage path for almost the entire South end of the peninsula. While an archeological assessment might have revealed the presence of the Freshwater Brook, without the broader context of exactly how significant it was to the Halifax ecosystem, developers appear to have constructed the building with insufficient drainage in order to properly deal with the volume of water passing through the site. This is just one example of how developing a broader understanding of an area, through data derived from old maps, could have helped inform the decisions of the developers, tenants, insurance agents, and a host of other stakeholders. The research done in this study highlights the fact that no one site can exist in isolation from its surrounding environment, and that if a broader definition of 'context' is established, then it could greatly increase the effectiveness of both archeological and environmental assessments.

Development considerations aside, being able to quantify aspects of an ecosystem like wetland loss, as was done in this Halifax Peninsula case study, can also have implications for the conservation community. By understanding how much wetland has been lost, managers can begin to identify the value of the lost ecosystem services that have occurred through wetland and stream conversions (Brazner, 2012b; Boesch, Josselyn, & Mehta, 1994). This value can be calculated both monetarily, as it was in 2008 by Costanza et al., or ecologically. Regardless of how one decides to valuate wetlands, understanding where, and generally how large they were in any given area can offer managers more insight into potential restoration projects, what type of restoration might have the greatest chance of success, and whether or not restoration really is the correct course of action to take. While it is recognized that wetland restoration on the Halifax Peninsula itself is unlikely, the Halifax Peninsula case study shows how, in certain circumstances, historically based data can be used to push the understanding of a region back to before natural scientists began to keep formal records.

It should be clarified that this study is in no way suggesting that use of historical data should be used as a replacement for the data provided by the natural sciences. Rather, historically derived data should be seen as a way to enhance and focus both scientific study and management planning. As has been made clear above, historical data can lack fine detail and accuracy. On the other hand, by incorporating social scientists in their understanding of the land, as well as the people, managers can obtain the broader understanding necessary in order to create and maintain the most efficient and effective management plan possible.

Part 11: Conclusion

It is well understood in any branch of management that a better understanding of what, or who, is being managed will result in more effective planning and execution (Coombs, 1998; Davis & Heineke, 1994; Maltsman-Tseikhin, Moricca, & Niv, 2007). The work done on the Halifax Peninsula provides strong evidence to support the argument that coastal managers, as well as other stakeholders should seriously consider historical documentation as a way to augment their understanding of natural environments. While it is acknowledged that in many cases the types of documentation used in this study do not exist, in situations where it does, it can provide managers with a level of ecological understanding that would be negligent to ignore.

There can be no doubt that when one decides to look into historical data as a way of achieving a higher level of understanding, the utmost caution needs to be exercised. The work of Harley, Edney, and Lennox illustrates how without the proper context, an old map is not much more than a detailed piece of art, and a potentially misleading one at that. The farther back one goes in time, the harder that context is to establish, and the more dubious the information portrayed on that map becomes. The information behind the making of a map is just as, and in some cases more important than the information portrayed on it (Edney, 2007; Harley, 2001; Lennox, 2010). That being said, if appropriate background information can be obtained, and the context properly established then it can serve to bolster the reliability of a map, and increase its legitimacy as a source for developing an ecological history. This context was established for all four maps in the Halifax Peninsula case study, and the result is a much clearer biogeographic picture of the Halifax Peninsula at the end of the eighteenth century.

The other important aspect of drawing understanding from old maps that was highlighted by the Halifax Peninsula case study, is the recognition of the kinds of information historical maps cannot provide, namely fine detail. While every effort was made to minimize the amount of error within the GIS data, a certain amount of distortion is inevitable. Despite the fact that the four maps used for the in depth analysis have all been captured using either flatbed scanners, or digitized directly from microfiche, many of the other maps that were georeferenced in the primary research stages were captured using a digital camera. In these cases, the type of camera, the curvature of the lens, the angle of the camera, and even the plastic sheeting that protects many old maps can all add to the distortion and associated error when bringing maps into any GIS system (Yamamoto, Jeong, & Takagi, n.d.).

Similarly, while every effort was made to ensure that the digitization effort was standardized, there can be no doubt that since it was all done by hand, a certain amount of distortion occurred in that process as well. The exact location and number of points used to trace a line, the GIS technician's interpretation of exactly where a feature begins and ends, or even whether a digital line follows the inside, outside or middle of the line it is tracing, can all have an effect on the accuracy of the digitized version of the map. Finally, even if every effort is made in order to minimize distortion in the digitization process, one has to assume a certain amount of error in the original map itself. While these maps were incredibly accurate and immense feats of cartography, to assume that they were absolutely perfect would be foolish. Any small error made by the surveyor or the cartographer will undoubtedly get magnified during the digitization process.

It is for these reasons that the use of data drawn from historical sources should be used to provide managers with a large-scale understanding, as opposed to determining specific details. For example, one of the major features on every map that was analyzed in the Halifax Peninsula case study is Freshwater Brook. The exact path and length of the brook varies somewhat in each depiction, and determining the reasons for these variations would be incredibly time consuming. Are the variations in the brook's path due to the natural migrations that surface watercourses can experience over time (Axel Kemna, 2008)? Are they simply inaccuracies in cartography and digitization? Or has the river been shifted by civil engineering projects? In depth study would be needed to answer these questions, and while it is certainly possible, in terms of practical management applications, the manager would have to determine if the benefit was worth the cost. The strength of historical documentation is not in demonstrating the exact path that a particular geographic feature took, but in bringing to light the fact that the feature existed at all. This knowledge can provide managers with the understanding to make sure that they ask the right questions when putting together a management plan. If it is determined that the exact course of Freshwater Brook over the years is something of critical importance, then the natural scientists would have to take over with more in depth surveys. Even in this case, however, historical data can still be useful by providing those scientists with a better idea of the necessary extent of their surveys, so as to be as efficient as possible.

One area of analyses that does benefit from the ability to make precise measurements of the features on old maps, is when one is using multiple sources from the same era. As illustrated by the Blaskowitz and Des Barres maps, if two or more maps from similar time periods covering similar geographic regions can be located, then they can be digitized and measured separately. The datasets emerging from those measurements can then be compared in order to determine how closely the different representations relate to each other. If it turns out, as it did in the case of Blaskowitz and Des Barres, that the maps are quite similar, then the datasets can be combined and averaged, resulting in a well grounded baseline that will benefit both managers and natural scientists alike.

It is important to note that the analyses undertaken in this study were limited to coastal areas, watercourses, wetlands and ponds largely due to time constraints. The four key maps analyzed in this study contain a wealth of information that has not to date been digitally entered into the GIS. Elevations, the extent and density of settlement, and the nature of transportation networks are all examples of information that exists on these maps, but has not, as of yet been subjected to critical analysis. Similarly, for the features that have been entered into the system, there is a range of analyses and calculations that could be conducted to provide an even more detailed picture of how all the various biogeographic features of the Halifax Peninsula interact with each other. Now that the data has been digitized, it will be available for further analysis when the resources become available. This study has just scratched the surface of what can be done with this information.

In the eighteenth century, cartographers were making maps of Nova Scotia in order to ensure that the legacy that they had fought so hard to create was understood, and could be maintained for future generations. In essence, marine and coastal managers today are trying to develop workable management plans for the very same reasons. Historic cartographers and modern coastal managers also face similar challenges. Both parties were, and are, subject to social, scientific, financial, and political stressors that make a complicated job even harder. By using the information provided by early cartographers, modern managers can achieve a better understanding of the ecosystems being managed, improving their chances of success. Social scientists have the ability to not only offer insights into the people and politics involved ecological systems, but also into the ecosystem itself. There is no doubt that when it comes to the precise structure and function of an ecosystem that the natural sciences do, and should play a dominant role. That being said, the information provided by historically derived ecological data could help ensure that managers direct those scientists in such a way as to perform their role as efficiently as possible.

The philosophy behind integrated coastal zone management (ICZM) has been described as: "developing methods through which the complexities of the coastal zone can be understood by stakeholders to improve the sustainable management of coastal systems (McFadden, 2007 p. 429)." In order to achieve this understanding, considerable effort has been made to draw on the expertise of both the natural and social scientists. The management community has certainly profited from this cooperation, however real integration has yet to be achieved. While no doubt much more porous than they used to be, there are still definite walls set up which divide the issues tackled by each side. The natural scientists handle the land and the social scientists handle the people. In order for the full benefits of integration to be realized, the ability of each group of scientists to offer fresh insight into issues traditionally handled by the other should be recognized. This study has focused on the social scientists venturing into the world of the natural scientists; however, there is no reason why those roles could not be reversed. By incorporating historically derived data into the development stages of a management plan, coastal managers can take a step beyond cooperation and into the realm of truly integrated management.

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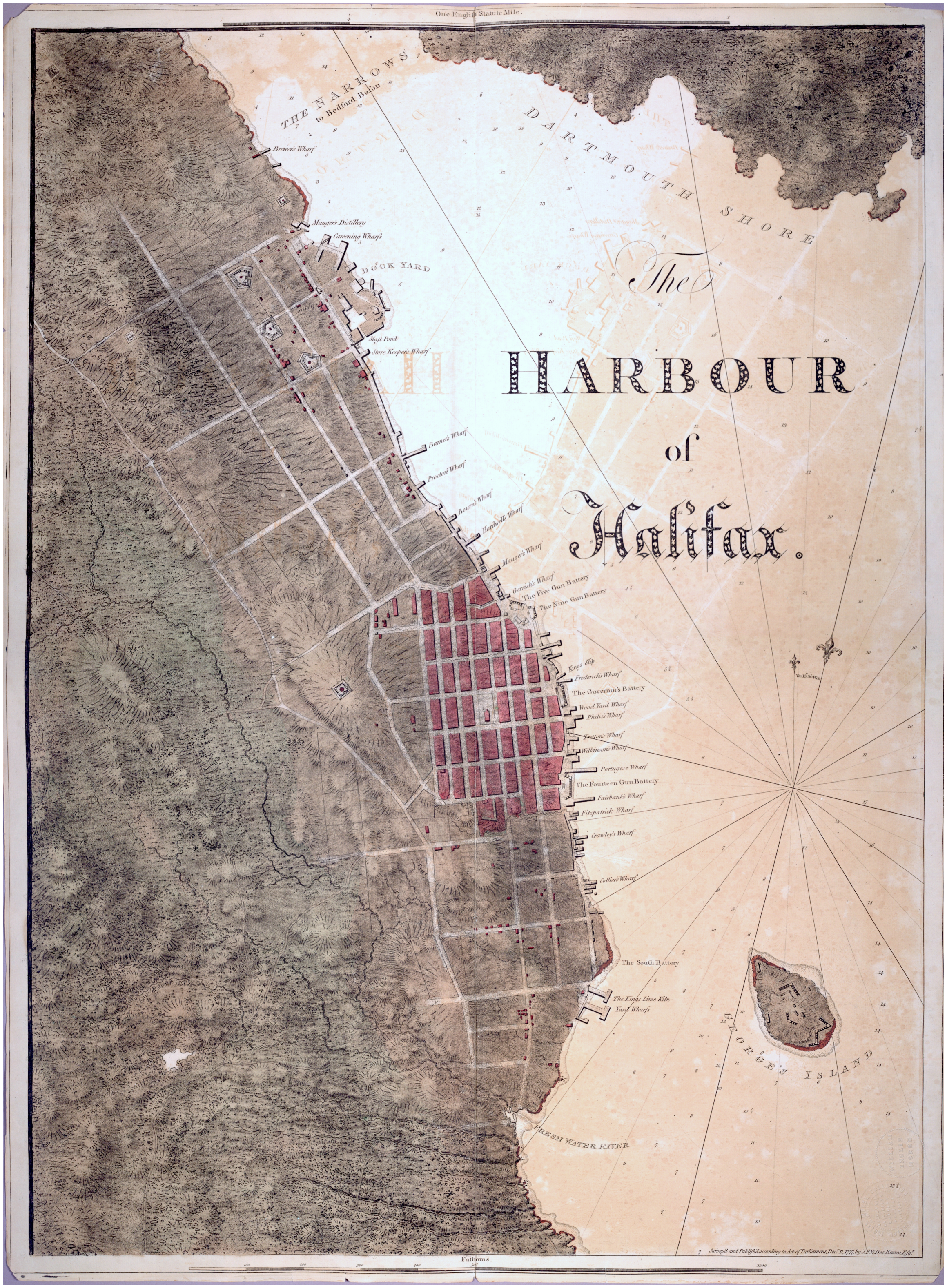
Appendix A: List of All Maps Examined for Initial Research

Title	Author	Date	Location
Plan de la Baye de Chibouqudou ou Rivierre Saine a la Coste de la Cadie en la nouvelle France	Delabat	1711	PANS V6/239-1711
A Plan of The Harbour of Chebucto and the Town of Halifax	M. Harris	1749	PANS F/240-1749
Plan of the Town of Halifax in Nova Scotia	ng	1750	PANS F/240-c.1750's
Harbour of Chebucto	ng	1750	PANS F/239-1750
The Chart of Chebucto Harbour on the Coast of Acadia or Nova Scotia with the Plan of the Town of Halifax	John Rocques	1750	PANS F/240-1750; V6/240-1750
A Plan of Chebucto Harbour, Engraved for the Magazine of Magazines	M. Harris	1750	PANS f/240 - 1750
A Map of the South Part of Nova Scotia and its Fishing Banks	T. Jefferys	1750	PANS v6/240 - 1750
A Chart oF Halifax Harbour	ng	1759	PANS V6/239 - 1759
A Chart of the Harbour of Halifax in Nova Scotia with Chebucto Bay and Cape Sambro.	Charles Morris: Surveyor; Thomas Jefferys: Engraver	1759	PANS V6/239 - 1759 Halifax
A chart of the Harbour of Halifax in Nova Scotia; with Jebucto Bay and Cape Sambro also the islands, ledges of rocks, shoals & soundings. Survey'd by order of His Excellency Brigadier General Laurence, Governour of the Province of Nova Scotia: by Charles Morris, Chief Surveyor, Published by command of the Right Honourable the Lords of Trade & Plantations, for the benefit of the trade and navigation of Great Britain and its colonies. London engraved by Thomas Jefferys, Geographer to the King. London, printed for & sold by Robt. Sayer & Jno. Benentt No. 53 in Fleet Street, as the Act directs. 25t March 1775. [Plate] IX. Dedication: To the Right Honourable George Dunk Earl of Halifax...this chart is...inscribed by...Thos. Jefferys. [cartographic material]	Charles Morris	1775	Natioanl Archives of Canada. Online. http://bit.ly/MOSe3j
Halifax	Des Barres	1779	Dalhousie Special Collections (Courtesy of the GIS center)
A Plan of the Peninsula upon which the Town of Halifax is Situated	Captain Charles Blaskowitz	1784	PANS V6/240 - 1784; National Archives of Great Britain CO 700/NOVA SCOTIA49B
A Plan of the Naval Yard at Halifax	Captain Charles Blaskowitz	1784	PANS V6/240 - 1784
Plan of the North Suburbs, Halifax, N.S.	ng	1784	PANS R.E.O. A-7
Peninsula of Halifax	NG	1800	PANS V6/240 C. 1800; R.E.O. Y. 19
Sketch Showing the Propose Situation of the work of the defense of the Peninsula of Halifax	J. Maclauchlan	1807	PANS R.E.O. Y-11; V6/240 C. 1807
Plan of the Peninsula and Harbour of Halifax	Johng G. Toler	1808	PANS R.E.O. y-26 - H1(sub) 8/239 1808
Plan of Smith's Tan Yard in Halifax Nova Scotia	John G. Sater?	1815	PANS V6/240 - 1815
Plan Showing the situation og Maugers Beach and of the tower partly built thereon, also in yellow, the site where a light house should be placed to best answer the purpose of assissting vessels to Enter te Harbout of Halifax	G. Nicoloas Boloand (?)	1826	PANS R.E.O. Y-15
Plan of the Peninsula and Harbour of Halifax	Nicols	1826	PANS R.E.O. A-87
Halifax, N.S.	N.G.	1828	PANS R.E.O. Y-25; V6/240 c. 1828
Plan Showing in yellow The Ordnance Ground Near Fort Massey	ng	1828	PANS R.E.O. A-17
Plan of the Town of Halifax including North and South Suburbs	T.M. Tocort	1830	PANS V6/240-1830
Plan showing the common belonging to the Town of Halifax, Nova Scotia.	Gustavus Nicolls, Colonel Comg Rl. Engineers.	1830	Canadian National Archives H3/241/Halifax/1830(1920)
Plan of Military Property in and Around Halifax		1831	PANS v6/250 - 1831
The City of Halifax	John Spry Morris	1841	HRM Municipal Archives CR10-022: City of Halifax 1841
Plan of the Proposed Halifax Waterworks	ng	1844	HRM Municipal Archives w-8-3298
Plan and Profile of Freshwater Brook from Cunard to South Street showing proposed change of direction and improvements	ng	1844	HRM Municipal Archives W-8-3298
Fuller Plan of the City of Halifax	Fuller	1851	HRM Municipal Archives CR10-021: 1851 Fuller Plan of the City of Halifax
Halifax, N.S.: Plans of the Naval Property also the Ordnance Land at Fort Needham	N.G.	1851	PANS R.E.O. A-15
Sketch of the Ordnance Land at Point Pleasant	ng	1851	PANS R.E.O. A-24
Approach to Halifax	Wolsey	1854	PANS R11630-1378-X-E
Plan as Called for by the Inspector General's Circular		1857	PANS R.E.O. A-18
H.M. Naval Yard, Hospital and Admiralty House	W.A. Hendry	1859	PANS V6/240 - 1859
Steeles Pond - Halifax	ng	1863	PANS R.E.O. A-31
Halifax County	A.F. Church	1865	HRM Municipal Archives
Peninsula of Halifax	Col. Burnaby R.E.C.	1870	PANS R.E.O. Y-27
Hopkins Atlas	Hopkins	1878	PANS MFM #9697
Halifax Harbour	Wolsey	1886	PANS R11630-1316-X-E
Halifax, Historical Plan Isthmus between Bedford Basin and N.W. Arm	G. McLaren (1946)	1751 - 1761	PANS V6/239- 1751/61
Plan of that part of the Church of England, Glebe-adjoining the Dutch Village (Metro Halifax)	ng	ng	PANS V6/239 - UND

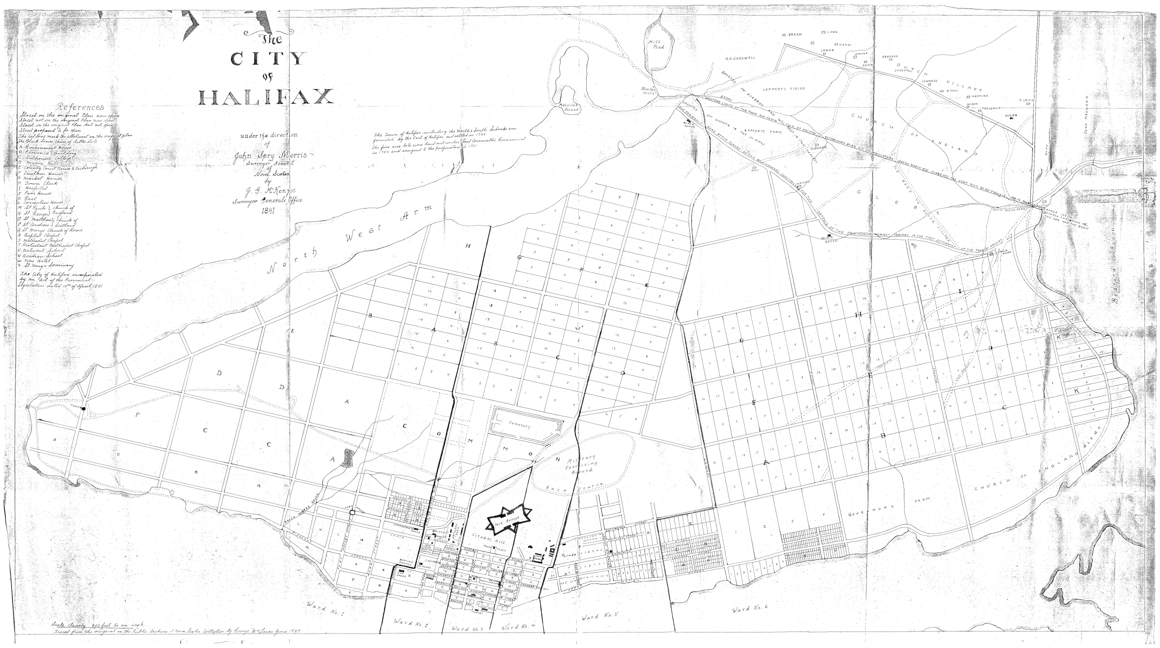
Appendix B: The Four Principal Maps

Map # 1 – The Harbour of Halifax (1779): J.W.F. Des Barres

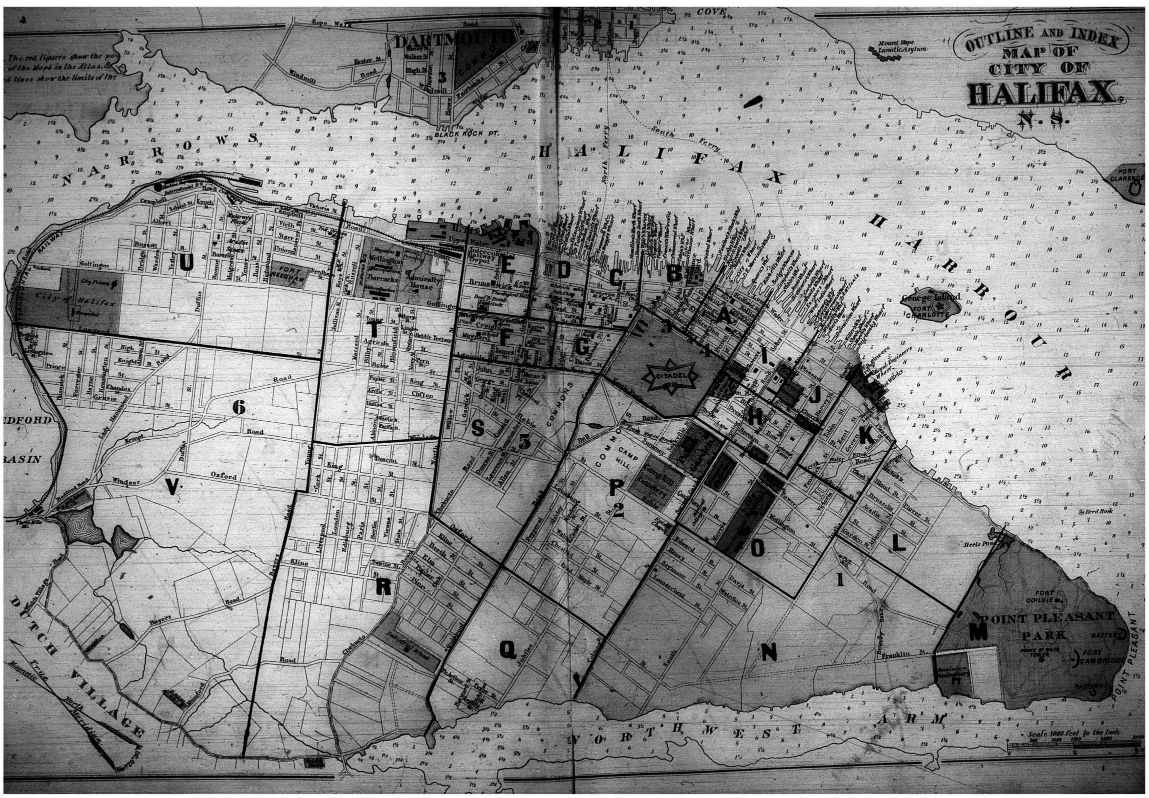


Map #2 – A Plan of the Peninsula upon which the Town of Halifax is Situated, shewing; the Harbour, the Naval Yard, and the several Works constructed for their Defence (1784): Captain Charles Blaskowitz

Map #3 - The City of Halifax (1841) – John Spry Morris



Map #4 – City Atlas of Halifax Nova Scotia: From Actual Surveys and Records (1878): Henry W. Hopkins[6]



[6] This is a photo of the index sheet for the Hopkins Atlas. The analysis was done on the scale of the individual plates, however as there are over 20 of them it would be impractical to reproduce them all here.

Appendix C: The Data

All of the data that was used in the Halifax Peninsula case study can be found on the attached USB Key. In order to access this data, the user must be on a computer that is running the ArcGIS software. This software is available on all 160 computers in the Killam Library Learning Commons. Dalhousie faculty and students can also download ArcGIS onto their own personal computers by accessing the link below:

https://software.library.dal.ca/index.php?page=2

In order to access the above link, the user must be connected directly to the Dalhousie network, either on campus or via the VPN.

Once ArcInfo has been loaded onto the computer, insert the USB key.

In order to access the GIS Data, double click on *“Shortcut to Mike Reid - Final Project - GIS Data”*

To access the spreadsheet with the final numbers and calculations, double click on *“Final Project Official Numbers”*