

Urban Waste Sinks as a Natural Resource: The Case of the Fraser River

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Résumé de l'article

Le travail inconstant pratiqué sur les rivières pour en faire des systèmes naturels de traitement des déchets met en lumière un lien historique important entre les réseaux sanitaires, l'idéologie de conservation et les valeurs urbaines vis-à-vis de l'environnement au XX^e siècle. Les ingénieurs du début et du milieu de ce siècle supervisaient la transformation de l'espace et de la nature des villes nord-américaines au moyen de la planification et de la construction de réseaux d'assainissement et de drainage. Ce faisant, ils se sont appuyés sur des idées et des méthodes propres au mouvement de conservation technocratique, lequel prônait la gestion des ressources naturelles par des experts pour assurer leur utilisation positive maximale. Le contrôle de la pollution et la conservation étaient reliés par la doctrine de la « capacité d'assimilation », une notion dont se servent les ingénieurs pour décrire la capacité des eaux naturelles de diluer, de disperser et d'absorber les déchets urbains et industriels. Par l'intermédiaire de nouvelles représentations quantitatives de la nature, les ingénieurs sanitaires proposaient d'incorporer les processus naturels biophysiques aux réseaux technologiques pour évacuer les déchets. La rivière Fraser à Vancouver, dont les ingénieurs et les urbanistes ont fait un réservoir pour les déchets urbains, est un exemple de cette approche à l'égard du problème urbain d'évacuation des déchets. Cependant, la tentative de faire d'une rivière une sorte de « machine biologique » pour l'évacuation des déchets a entraîné des problèmes environnementaux à long terme dans l'estuaire de la rivière. À la fin des années 1960, cette pollution a fait l'objet d'un mouvement de protestation politique et sociale concernant l'exploitation et la dégradation de la rivière par les Vancouvérois qui adhéraient alors à de nouvelles valeurs environnementales.

Urban Waste Sinks as a Natural Resource: The Case of the Fraser River¹

Arn Keeling

Abstract

The discursive and material construction of rivers as natural waste-treatment systems highlights important historical connections between urban sanitary networks, conservation ideology, and urban environmental values in the twentieth century. Early-mid-century sanitary engineers oversaw the transformation of space and nature in North American cities through the planning and construction of sewerage and drainage networks. In doing so, they drew from the ideas and methods of the technocratic conservation movement, which advocated the expert management of natural resources to ensure their maximum beneficial utilization. Pollution control and conservation were linked through the doctrine of “assimilative capacity,” a concept used by engineers to describe the ability of natural waters to absorb, dilute, and disperse urban and industrial wastes. Using powerful new quantitative representations of nature, sanitary engineers proposed to incorporate natural biophysical processes into technological networks for waste disposal. This approach to urban waste-disposal problems is exemplified by the case of Vancouver’s Fraser River, which was enrolled by engineers and planners as a sink for urban wastes. However, the attempt to construct the river as a kind of “organic machine” for waste disposal resulted in long-term environmental problems in the river’s estuary. By the late 1960s, this pollution, along with Vancouverites’ changing environmental values, led to political and social protest over the exploitation and degradation of the river.

Résumé

Le travail inconstant pratiqué sur les rivières pour en faire des systèmes naturels de traitement des déchets met en lumière un lien historique important entre les réseaux sanitaires, l’idéologie de conservation et les valeurs urbaines vis-à-vis de l’environnement au XX^e siècle. Les ingénieurs du début et du milieu de ce siècle supervisaient la transformation de l’espace et de la nature des villes nord-américaines au moyen de la planification et de la construction de réseaux d’assainissement et de drainage. Ce faisant, ils se sont appuyés sur des idées et des méthodes propres au mouvement de conservation technocratique, lequel prônait la gestion des ressources naturelles par des experts pour assurer leur utilisation positive maximale. Le contrôle de la pollution et la conservation étaient reliés par la doctrine de la « capacité d’assimilation », une notion dont se servent les ingénieurs pour décrire la capacité des eaux naturelles de diluer, de disperser et d’absorber les déchets urbains et industriels. Par l’intermédiaire de nouvelles représentations quantitatives de la nature, les ingénieurs sanitaires proposaient d’incorporer les pro-

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Technological networks of sewers and waste-treatment plants provide crucial insights into the urban transformation of space and nature, despite—or perhaps because of—their subterranean, hidden locations and somewhat unsavoury nature. As the geographer Matthew Gandy asserts in his studies of New York and Paris, “To trace the flow of water through cities is to illuminate the functioning of modern societies in all their complexity.”² Sanitation was probably the most pressing environmental question facing North American cities in the century between 1850 and 1950, as urbanization and industrialization brought millions of people into novel and crowded living circumstances. The resulting problems of disease, dirt, and disorder spawned a series of scientific, technical, and social initiatives designed to mitigate the effects of urban population concentration. Among the most important of these developments was the planning and construction of waste-water disposal systems, beginning in the late-nineteenth century. Scholars tracing the history and geography of these systems emphasize the interplay of technology, environment, and social forces that shape them.³ Much of their work considers the influence on pollution control of debates about public health and urban environmental quality, and there is a considerable literature tracing the changing methods and technologies of sewerage and sewage treatment during the nineteenth and twentieth centuries.⁴ These developments are often portrayed as part of the “struggle for sewerage” in cities, and the gradual adoption of ever-greater levels of waste-water treatment to reduce public-health problems and environmental effects.

This emphasis on the politics of sanitary reform and technologies of sewage treatment obscures the ways in which urban nature has been incorporated into technological waste-disposal strategies. Natural systems have been typically seen as “outside” urban networks: as a receiving environment that is subject to pollution by waste-waters, or as a water supply requiring purification by artificial methods such as filtration or chlorination. By contrast, this paper explores how sewerage planning ideas and practices in the early twentieth century increasingly

blurred the boundary between technological systems and non-human, biophysical phenomena by promoting the controlled, rational exploitation of receiving waters as *part of* waste treatment and disposal structures.⁵ This anti-pollution strategy is captured in the concept of *assimilative capacity*, a term developed by chemists and sanitary engineers during this period to describe the ability of natural waters to absorb, dilute, and disperse wastes. Using powerful new quantitative representations of natural processes, sanitary experts refined this concept through the growing theory and practice of “stream sanitation.” Assimilative capacity exemplified what environmental historian Adam Rome has identified as the “new, complex vocabulary of pollution [that] developed with the rise of the industrial city.”⁶ While Rome described the emergence in the early twentieth century of the “recognizable modern sense” of pollution as a technical and legal term, I suggest that the “modern” concept of assimilative capacity also reflected a reconceptualization of pollution from “contamination” to “resource exploitation.” In other words, assimilative capacity came to be regarded as a resource—like forests or fisheries—that could be quantitatively measured and rationally exploited.

Recognizing this important discursive shift places urban waste-disposal planning in the context of conservation and resource-management history in North America. The idea of waste disposal and pollution control as matters of efficient resource utilization seems unfamiliar in light of contemporary concerns over environmental protection and ecological integrity. Yet, as several historians have recently pointed out, utilitarian attitudes towards water resources have long extended to their use as sinks for domestic and industrial wastes. In their research on nineteenth-century New England, Ted Steinberg and John Cumbler demonstrate how industrial discharges were defended as a “reasonable use” of natural waterways to promote industrial development.⁷ Similarly, public works historian Sarah Elkind suggests that, for urban sanitary engineers, sewage disposal was “much a question of resource control as was diverting water for other domestic or industrial uses.”⁸ Sanitary engineers adopted the rhetoric and ideas of conservation to promote assimilative capacity as the rational basis for pollution control and urban planning. As it was articulated in the early mid-twentieth century, conservation ideology promised that a better understanding of natural systems, innovative harvesting and processing practices, and improved economic management would ensure that natural resources provided “the greatest good for the greatest number over the longest time.”⁹ Like conservationists in other fields, engineers advocated planning and technical expertise to avoid the abuse of natural waters by indiscriminate waste disposal and to determine their most efficient uses.

The history of sewerage planning in Vancouver provides a compelling illustration of how the ideas and practices associated with assimilative capacity shaped waste treatment and disposal in a particular urban setting. For at least the first half of the twentieth century, techno-scientific discourses emerging from

the fields of urban planning, sanitary engineering, and resource management dominated discussions of environmental quality and pollution control in the Fraser River and ocean waters surrounding the city. Sewerage planners regarded the massive assimilative capacity of the river and its estuary as a resource for the efficient dispersal of wastes from the growing metropolis on its banks. This approach licensed the incorporation of the Fraser River’s biophysical processes into technological waste-disposal networks. Indeed, waste-disposal engineering turned the Fraser into what historian Richard White calls (with reference to the Columbia River) an “organic machine”: a natural system deeply interwoven with and transformed by human technological systems.¹⁰ These attempts to construct the Fraser estuary as a sink for wastes failed to account for its complexity and variability, resulting in long-term environmental degradation. Although some concerns over the use of the river for waste disposal emerged in response to earlier technical planning exercises, only from the 1960s onward did pollution problems and alternative discourses about urban nature begin to influence debates over sewerage planning and policy.

It is critical to understand the history and context of the idea of assimilative capacity, since it shaped both domestic and industrial pollution-control policy in North America for much of the twentieth century. As an approach to urban environmental problems, assimilative capacity illustrates the deep connections between urban sanitary reform and discourses of conservation and resource management. While historians typically associate the conservation movement with forestry, fisheries, agriculture, and other commodity resources, it also contained a significant urban dimension.¹¹ Urban sanitary improvements, often considered in light of the politics of moral and civic reform in the Progressive era, also reflected the trends towards expertise, efficiency, and bureaucratic management that dominated resource conservation efforts for decades afterwards. As leaders in the “conservation crusade,” engineers, including urban and sanitary engineers, significantly influenced conservation ideology.¹² Thus, an examination of the methods and ideas of sanitary engineers also contributes to our understanding of scientific conservation, emphasizing the way in which quantitative representations of nature and utilitarian ideology were combined to frame environmental problems and their solutions. Using the Vancouver example, I demonstrate how these ideas reshaped actual urban landscapes and aquatic environments. But, as the Vancouver case also reveals, by the 1960s changing urban environmental values associated with environmentalism began to challenge the dominance of technocratic conservation approaches to water and waste.



Before the 1960s, few challenged the premise that waste disposal constituted a legitimate, even necessary use of the Fraser. The high-volume Fraser, too muddy for use as a domestic drinking water supply, seemed ideal for the convenient disposal of sewage, stormwater and industrial wastes. The river, which drains over 230,000 square kilometres of British

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Columbia, flows through a widening valley just above the province's major urban agglomeration, the Greater Vancouver region.¹³ This section has been intensively modified by human activity. As the river enters its delta and estuary at New Westminster, it is lined with residential and commercial developments, wood-products manufacturers, chemical plants, industrial estates, and shipping facilities. The river splits here to embrace the island city of Richmond between its North and South (or Main) arms; shortly before reaching the ocean, the smaller North Arm forks again to form Sea Island. At its mouth, the river's average discharge to the Strait of Georgia ranges from a winter low of 750 cubic metres per second (cms) to a massive 11,500 cms during summer freshet. In spite of this powerful outflow, tidal influence in the Fraser estuary is detectable dozens of kilometres inland, at times even reversing the river's flow. The historic social, economic, and ecological importance of the Fraser is undeniable: in both pre- and post-colonial periods, it has served as a trade and transportation route, as the creator of the fertile soils of the agricultural valley region, and as the host to culturally and economically significant anadromous salmon populations. As a broad-shouldered, working river, the Fraser embodied the aspirations of twentieth-century British Columbians for "progress" and "the Good Life" hewn from a rough wilderness—of a modern, urban civilization prospering from the transformation of nature.¹⁴

River dumping of wastes was common practice throughout North America. All too often, however, it resulted in the contamination of water supplies, the spread of infectious diseases, and the degradation of watercourses.¹⁵ Like many other North American cities around the turn of the twentieth century, the growing city of Vancouver looked to sanitary engineers for solutions to the problems of waste disposal and disease control. Sanitary engineering first emerged in Europe as the technical arm of the public health and sanitary reform efforts of the mid-late-nineteenth century.¹⁶ As their ideas and influence spread to North America, sanitary engineers became influential in the growing urban-planning community and municipal bureaucracies in the United States and Canada.¹⁷ Sanitary engineers proposed technological answers to urban environmental problems, designing underground networks of water-supply and sewerage pipes and researching methods of waste disposal and water treatment. This approach appealed to the technological optimism of Progressive-era municipal and social reformers, who believed that society could control nature through planning and technology to produce a salubrious, beautiful, and efficient urban environment.¹⁸ Sanitary engineers also embraced the principles of economic efficiency and expert planning in resource utilization that were characteristic of the conservation movement.¹⁹ As Canadian conservation historian Michel Girard points out, scientific progressives in the conservation movement did not regard nature as something vital or sacred, but rather as "an infrastructure controlled by the State."²⁰ In Canada, according to Alan Artibise and Gilbert Stelter, "conservation and urban improvement came to be seen as opposite sides of the same coin" by members of the short-lived Canadian Commission of

Conservation (1908–1921).²¹ The commission's urban planning journal *Conservation of Life* was emblematic of the connections between expert discourses of urban planning, social reform, and natural resource management.

The doctrine of assimilative capacity brought together urban sanitation and conservation ideals in the project of waste-disposal engineering. This concept arose from efforts to place the evaluation of urban water-quality and pollution problems on a firm scientific footing. English sanitary engineers and chemists, who were engaged in highly politicized pollution debates during the latter half of the nineteenth century, began to investigate and refine long-standing notions of water's "self-purifying agencies."²² This described the ability of flowing water that had received waste to recover to "natural" conditions over time and space. Sanitarians studying problems of sewage disposal had long relied on these "agencies" to estimate dilution factors necessary to prevent "nuisance" conditions and to avoid public-health risks. Yet the processes of stream self-purification were poorly understood, and considerable dissension existed around their measurement. Lamenting this lack of knowledge in its 1901 interim report, the British Royal Commission on Sewage Disposal declared, "We consider it of the utmost importance that the simplest possible means should be provided for adequately protecting all our rivers . . . and that scientific experiments should be carried on in order to ascertain all the real dangers of pollution, against which [rivers] should be protected."²³

Researchers developed and refined such a test in the early decades of the twentieth century: the measurement of biological oxygen demand, or BOD. The selection of this parameter reflected the growing recognition that, along with contamination by pathogenic bacteria, the reduction of dissolved oxygen levels in waste-receiving waters constituted a major pollution problem. Chemists in Britain and the United States devised a laboratory test to measure this effect over a five-day period, leading to the standard measurement of "BOD₅."²⁴ This measurement was subsequently incorporated into a general theory of stream self-purification by the American biochemist Earle Phelps and sanitary engineer H. W. Streeter. The Streeter-Phelps "oxygen sag curve" formula provided the first general, quantitative model of aquatic pollution.²⁵ This formula calculated the rate of oxygen consumption in a polluted stream through the decomposition of organic wastes, and the estimated re-aeration or recovery process over distance and time, given certain waste characteristics and environmental conditions. This method also overcame the variation in environmental conditions by providing a theoretical basis for predicting the assimilative capacity of particular water bodies.

The BOD test and oxygen-sag curve revolutionized sanitary engineering and pollution control by providing a standardized, replicable measurement of environmental conditions, as well as a basis for universal, numerical standards of water quality. As a fellow sanitary engineer later reflected, "A giant step forward had been taken, because the Cincinnati group had been willing

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to forsake both the laboratory and the field for the desk, and the B.O.D. bottles and burettes for a table of integrals, a slide rule, and a drafting board."²⁶ Aesthetic criteria, such as smell, taste, and appearance declined in importance as these "objective" evaluations of water quality became accepted. These tests "marked the transition from folklore to a scientific approach to sewage treatment practices and requirements and heralded the opening of an era of rapidly developing and increasingly sophisticated technology."²⁷ The development of standard metrologies consolidated the authority of engineers over the evaluation and selection of appropriate sanitary technologies, based on their "scientific approach."²⁸

While the BOD test could be seen as imposing biophysical limits on the use of dilution as a waste-disposal strategy, Phelps and other sanitary engineers typically regarded it as the measurement of a kind of natural resource. Engineers viewed streams, lakes, and oceans as bundles of uses or resources that must be wisely and efficiently employed—in the parlance of the Progressive Era, "conserved"—but not recklessly exploited or abused. The conservation of water resources extended to the utilization of this "assimilative capacity" for waste disposal.²⁹ Phelps articulated this principle in testimony before the 1914 International Joint Commission hearings into the pollution of boundary waters between Canada and the United States: "Nature has provided in those streams a mechanism for oxidizing sewage which is precisely the mechanism we use in artificial purification . . . and that should be utilized, and not only utilized but conserved. By overloading the resource we fail to make use of it at all . . . proper utilization of that natural resource does not mean its unrestricted use."³⁰ Other leading Canadian and American sanitary engineers at the IJC hearings concurred, proposing pollution control be based on scientific management and conservation principles, with appropriate "safety factors" added to protect public health and other uses of waterways.³¹

Phelps promoted this approach through his decades of work with the International Joint Commission and the U.S. Public Health Service, becoming one of the most influential sanitarians of the early twentieth century.³² The most comprehensive statement of the technocratic ideal of assimilative capacity appeared in Phelps's 1944 text *Stream Sanitation*. In it, he outlined the methods used to assess assimilative capacity and to adjudicate between competing water uses. Using the metaphor of a balance sheet, he proposed that a stream's "assets and liabilities" could be calculated to ensure it remained "solvent" in oxygen: "The economics of sewage disposal, true disposal and not mere discharge into the stream, involves that study of economic design of a structure to function in a given manner efficiently and without objectionable results, so well known to the engineer. But the 'structure,' in this case, is the treatment plant *plus the stream*."³³ In this formulation, the natural physical and biochemical processes in the stream are wedded to technological systems as a kind of "organic machine" for waste disposal. In proposing this approach to waste management, Phelps rejected both simplistically restrictive water-quality standards and the

careless expediency of simple "dilution": "Only in this way shall we achieve the true conservation of a natural resource."³⁴

Although Phelps was perhaps its best-known proponent, assimilative capacity quickly became a widely endorsed concept among sanitary engineers and pollution control officials around North America. The Tennessee Valley Authority's chief of stream sanitation hailed "the waste assimilative capacity of a stream [as] a valuable natural resource"; noting the near-universal adoption of BOD as a measure of stream "cleanliness," the distinguished engineer and sanitarian Abel Wolman nevertheless warned against excessive and expensive efforts to "purify" waste-receiving waterways.³⁵ For sanitary engineers, if the assimilative capacity of streams could be measured and rationally exploited, then conservation ideology dictated that it *must* be, in the name of the wise use of natural resources. As Canadian engineer A. L. Van Luven wrote in a special issue of the *Engineering Journal* in 1960, stream conservation implied the "informed, conscientious management of resources; it is development as well as protection; it is use as well as saving."³⁶ The notion of preserving "pristine" natural conditions for aesthetic or moral reasons made little sense under this logic. Rather, sanitary engineering and the principle of assimilative capacity formed the basis for a purely technical approach to water pollution problems, and the efficient and economic management of water resources.

In constructing waste disposal in streams as resource use, assimilative capacity displaced earlier notions of purity, filth, and morality associated with pollution, replacing them with seemingly neutral, scientific representations of nature. This process reflected the growing cultural authority of science as an arbiter of natural knowledge and the belief in the objectivity of quantitative representations of society and nature. Whether in social science disciplines such as sociology and psychology, or in scientific ones such as ecology and engineering, expertise became closely allied with predictive models and mathematical formulas.³⁷ Sanitary engineers enhanced their claims to expertise and authority over urban nature by promoting technical solutions to pollution problems such as sewage and smoke. Biological oxygen demand and assimilative capacity provided engineers with what geographer David Demeritt calls an "enframing device." In his study of the development of quantitative forest measurements around the turn of the twentieth century, Demeritt links statistical methods with the growing influence of scientifically trained foresters and state bureaucracies over forest-conservation practices. He describes how quantitative and cartographic representations of forests advanced particular views of forests as "objective" truths about natural conditions.³⁸ Similarly, the quantitative measurement of assimilative capacity provided sanitary engineers and state officials with the authority to manage, restrict, and allocate access to natural waters for waste disposal, in the name of conservation.

The two major sewerage planning exercises undertaken in Greater Vancouver, in 1911–1913 and 1950–1953, demonstrate how this emerging technocratic view of water as a waste-

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disposal resource shaped a particular urban landscape. In commissioning a comprehensive study of sewerage problems in 1911, Greater Vancouver communities aimed to correct the problems of inadequate stormwater drainage and poorly devised sewage outfalls that had resulted in polluted creeks and shorelines.³⁹ A regional sewerage committee hired R. S. Lea of Montreal, a respected sanitary engineer and McGill University professor of civil engineering. Along with American partner Freeman Coffin, he had assisted in designing sewerage projects in Massachusetts, Prince Edward Island, Nova Scotia, and Quebec. To determine Vancouver's sewerage requirements, Lea studied the impact of sewage disposal on surrounding waterways, including the Fraser, combining measurements of local currents, tides, and stream flow with contemporary theoretical notions about water's "self-purifying agencies." Concern for the valuable Fraser River fisheries focused attention on the river's ability to absorb and disperse oxygen-depleting wastes. Citing British and American precedents, Lea stated that "in so far as [experience and research] relate to the widely practiced [sic] custom of disposal in rivers, it points to the general conclusion that a flow of six or seven cubic feet per second of well aerated water, per 1000 people contributing sewage to the stream, is sufficient for satisfactory assimilation."⁴⁰ Although Lea considered the "mischievous complications" of site-specific factors, including the interplay of ocean tides and river discharge in the Fraser estuary, he remained confident that well-planned outfalls and ample dilution would overcome any difficulties. Indeed, following conservation ideology, Lea argued that, where conditions permitted, the discharge of untreated sewage constituted a logical and beneficial use of nature.⁴¹

Based on his observations and the principle of assimilative capacity, Lea's plan projected a rationalized hydrology onto the landscape, incorporating the region's liminal spaces into a technological waste-disposal network. Lea proposed the construction of a network of underground pipes, largely approximating the natural drainage of the region, to transport waste waters to the edges of urban space where they could be safely discharged without treatment into appropriate receiving waters. For wastes reaching the Fraser, he recommended deep-water effluent outfalls to ensure oxygen-depleting organic wastes were swept away by the river's strong current. Anticipating increasing volumes of waste from growing communities, Lea proposed that discharges to the low-volume North Arm of the Fraser could eventually be diverted westward through an interceptor sewer to the mouth of the river at Point Grey (figure 1). Quickly adopted by municipal authorities, this plan guided sewerage and drainage construction in the region for the next thirty-five years. Although sawmill owners on the Fraser subsequently raised concerns about sewage reaching the North Arm and tainting log booms stored there, they were reassured by provincial health officials that tidal action would prevent the contamination of the river and logs.⁴²

In 1950, regional sanitary officials launched a second comprehensive planning initiative in response to mounting concerns

about the strains placed on the Lea-designed system of urban population growth and geographical expansion.⁴³ The Greater Vancouver Sewerage and Drainage Survey committee consisted of Vancouver's city engineer E. A. Cleveland, and two imported authorities, sanitary engineers Charles Gilman Hyde and A. M. Rawn of California. Like Lea before them, these investigators regarded the problem of pollution control as a matter of the efficient exploitation of urban waterways. As the head of the survey, Rawn drew from his long experience as Los Angeles County Sanitation District's chief engineer, where he had overseen the development of that metropolis's ocean-outfall sewage disposal system. He averred that, "because it can act as a natural treatment system, [the ocean] should be used for this purpose with respect to sewage."⁴⁴ Beginning in the 1920s, Rawn had devised and published survey methods for the prediction of the effects of sewage in salt water and estuarine environments.⁴⁵ He recalled, "Prior to Sanitation District experimentation, there was very little accurate knowledge of the rate of diffusion of fresh water in salt water, consequently little was known or could be determined, in advance of actual operation, about the spread of a sewage field in sea water before its disappearance as such."⁴⁶ Rawn's research combined oceanographic observations with calculations of the dilution and dispersal of a "sewage field" in the near-shore environment. These measurements and representations not only provided a method for sanitary engineers to determine the assimilative capacity of particular water bodies for the purposes of pollution control, but also contributed to theoretical developments in the study of estuarine circulation.⁴⁷

Studies undertaken by the Vancouver sewerage survey mobilized a variety of agencies, instruments, and individuals to construct a synoptic view of the estuary. To assess the assimilative capacity of Vancouver-area waters, Rawn required detailed hydrological and effluent-quality information: "The ability of rivers within the Greater Vancouver Area to receive sewage without unsanitary and obnoxious results is directly related to the rate of flow and to the concentration of dissolved oxygen present, as well as to the quantity and composition of sewage involved and to the upstream and downstream uses of the river."⁴⁸ The survey compiled data on water quality and stream-flow characteristics of the Fraser River. In addition, detailed oceanographic surveys were conducted in collaboration with the Pacific Oceanographic Group of the Fisheries Research Board of Canada and the federal Hydrographic Service, among other organizations.⁴⁹ This research, called the Fraser Estuary Project, fused basic science with the practical engineering problem of sewage disposal. Fisheries oceanographers collected and analyzed water samples from dozens of locations, and measured tidal currents and their velocities in the Strait of Georgia and Burrard Inlet. Aerial photographs and float tests documented the movement of Fraser River discharge, particularly from the polluted North Arm, across the surface of the strait and into Burrard Inlet. Finally, researchers constructed a scale model of the Fraser River estuary,

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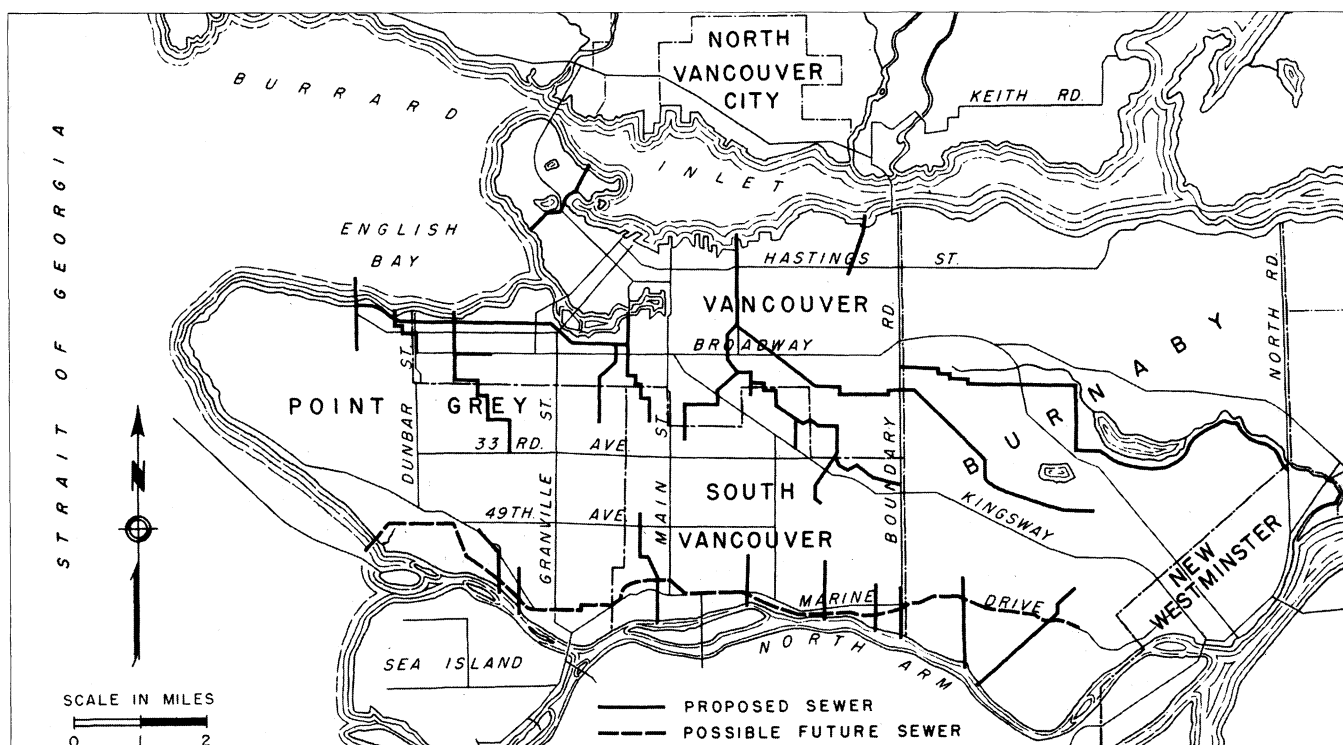


Figure 1: R. S. Lea's design for the trunk sewer system of Burrard Peninsula, 1913. The sewer routes largely approximate the natural drainage of the region, and the outfalls aimed to take advantage of the assimilative capacity of surrounding waters.

Greater Vancouver Sewerage and Drainage Survey, *Sewerage and Drainage of the Greater Vancouver Area*, British Columbia, A. M. Rawn, Charles Gilman Hyde, and John Oliver, Board of Engineers (Vancouver: VDJSD, 1953), 264.

on which they reproduced variations in stream flow and tidal conditions in the lower section of the river in order to model the dispersal of entrained sewage.

These activities provided the critical technical concepts and representations of nature that enabled the incorporation of natural systems into technological networks. Based on their observations, in 1953 the committee proposed a revised regional waste-disposal design centred on the Fraser estuary. Echoing urban planners' rationalization of space in the city by use, the plan "zoned" shores and shore waters to be preserved for aesthetic and recreational purposes, such as English Bay, and those defined as sinks for waste, such as the Fraser River estuary.⁵⁰ The overriding imperative to prevent further pollution of Burrard Inlet, Vancouver harbour, and English Bay entailed the proposed interception of all northbound sewage from Vancouver and parts of neighbouring Burnaby, and its transmission southward through a deep tunnel to a treatment plant at Iona Island at the mouth of the Fraser River near the municipality of Richmond (figure 2). Much of the sewage draining southward to the Fraser, particularly to the North Arm, was also targeted for diversion to Iona. There, primary treated sewage would be discharged via an open channel across Sturgeon

Bank into the Strait of Georgia.⁵¹ Where raw sewage disposal was still permitted (notably, into the Main Arm of the Fraser from New Westminster, Richmond, and parts of Burnaby), submerged outfalls were planned that took advantage of the river's tremendous flow.

In effect, these studies of the Fraser estuary's assimilative capacity "naturalized" the spatial arrangements of sewer pipes, treatment plants, and effluent outfalls proposed by the Rawn team, making them appear as the inevitable product of abstract engineering principles and empirically observed hydrological conditions. At public hearings and in the press, the authority of engineering and scientific expertise was invoked to overcome any objections to the Rawn plan. Promoting this use of the river to reluctant residents of neighbouring municipalities, regional sewerage officials rhetorically asked, "When it comes to designing a complicated plant, who do you listen to: your next-door neighbors [sic] or skilled engineers?" They urged the public to join the experts in "think[ing] of the action of fresh water from the Fraser River on the south, the movement of currents and the out-going tide, and a channel cut three miles out to Sturgeon Bank, well away from the shore, as parts on a giant flushing machine."⁵² Over the protests of Richmond

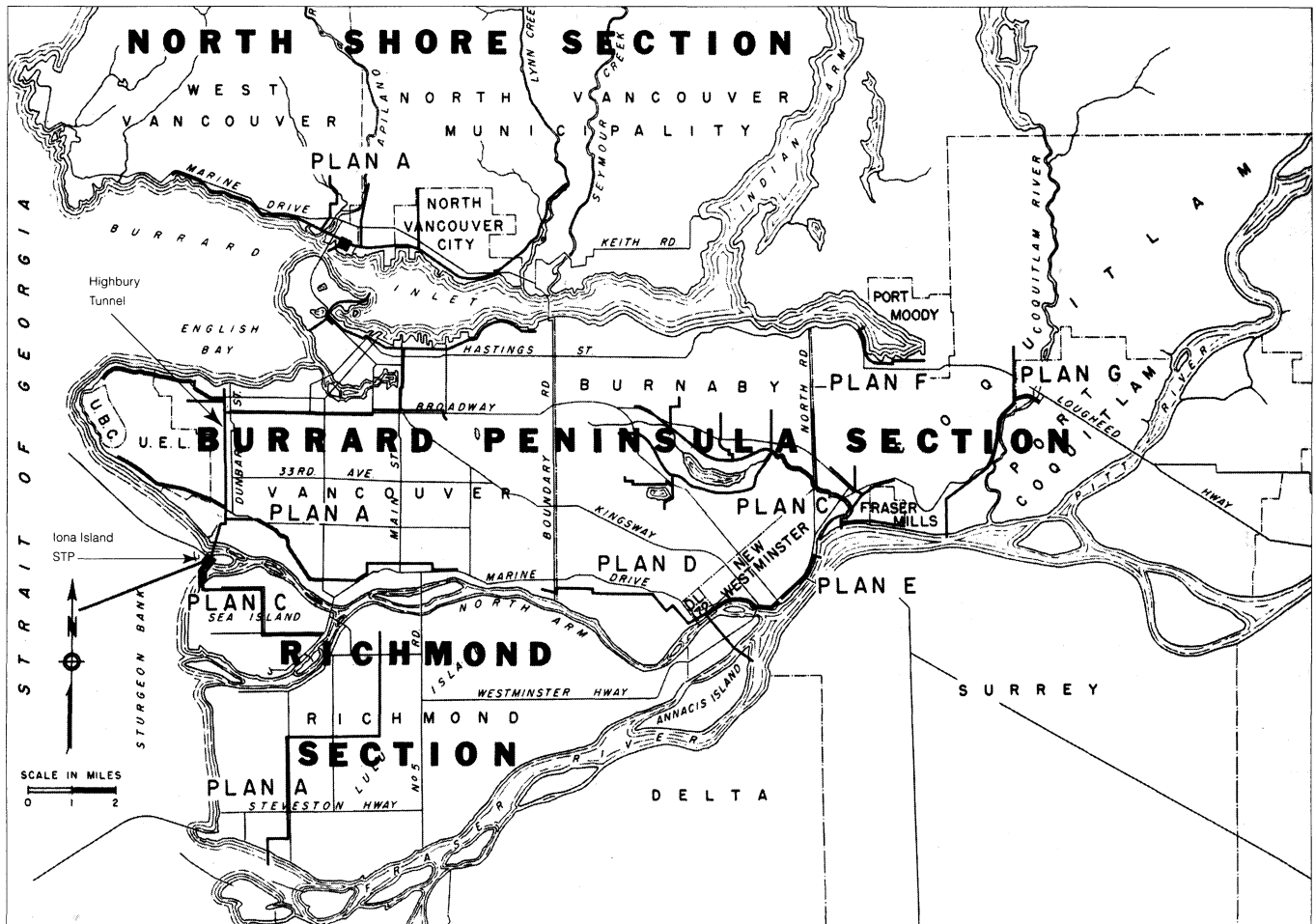


Figure 2: The revised sewerage strategy for Greater Vancouver focused on the Fraser River and estuary. Note the location of the Iona Island Sewage Treatment Plant and its open-channel outfall, extending across Sturgeon Bank.

Greater Vancouver Sewerage and Drainage Survey, *Sewerage and Drainage of the Greater Vancouver Area*, British Columbia, A. M. Rawn, Charles Gilman Hyde, and John Oliver, Board of Engineers (Vancouver: VDJSDB, 1953), 208.

municipal officials, the Rawn plan was endorsed by the regional sewerage authority and the provincial government as the template for sewerage development for the next fifty years.

The strategy of exploiting the river's assimilative capacity was consolidated in the early 1970s with proposals to build two additional primary sewage treatment plants on the Fraser. By this time, however, many urbanites had begun to question the dominant technocratic discourse of waste management. To some degree, their concerns were spurred by worsening environmental conditions in the Lower Fraser. Already in the 1950s and early 1960s, various government water-quality studies in the Fraser estuary indicated at least "moderate" pollution in the river's North Arm.⁵³ By the late 1960s, water sampling indicated depressed levels of dissolved oxygen and high coliform bacteria counts in parts of the Lower Fraser.⁵⁴ Certain sections

of the North Arm were appalling: as a 1970 Vancouver Health Board report described, "[a] pungent odour was present at several [sewage] outfalls and foreshores. The foreshores were usually black-brown in colour and the presence of gas bubbles, presumably methane gas, indicated decomposition. Much of the sewage is held in the surrounding area by incoming tides only to flow freely in the river when the tide is outgoing. Several lumber mills have reported large buildups of faecal matter on their log booms."⁵⁵ In addition, the "giant flushing machine" envisioned by engineers at the mouth of the Fraser had become a giant cesspool. There, the open outfall channel from the Iona Island sewage treatment plant discharged millions of litres per day of primary-treated effluent to shallow waters along Sturgeon Bank. Local residents decried the stench and foul waters in the vicinity of the Iona treatment plant.⁵⁶ Provincial legislators from the riverside communities of Richmond and New Westminster

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introduced lurid descriptions of this “slimy swamp” and displayed samples of sewage-laden effluent on the floor of the B.C. legislature.⁵⁷

As public environmental awareness surged in the “Age of Ecology,” many urbanites began to protest the use of river and ocean waters as a sink for wastes. Public agitation for improved waste treatment for the Lower Fraser in the 1970s became a “mighty sewage struggle” that pitted “engineering technocrats” against an emerging “ecological consciousness.”⁵⁸ Sportsmen, fisheries workers, community groups, and environmentalists joined ecological arguments with affective appeals to “save” the Fraser. These groups challenged the cool certainties of technocratic environmental managers by appealing to both ecological science and the symbolic importance of the river. They were joined by fisheries scientists and ecologists, whose studies of environmental conditions in the Lower Fraser raised concerns about the effectiveness of waste treatment using assimilative capacity.

In part, changing scientific understandings of water pollution fuelled challenges to the doctrine of assimilative capacity. The measurement of toxic constituents in waste waters improved in the 1950s and 1960s, as new technical instrumentation and laboratory methods were developed to detect chemicals and identify their effects. This expanded the range of quantitative measures of pollution and assimilative capacity beyond the traditional parameters of BOD and bacterial contamination.⁵⁹ In the 1970s, the question of toxic contaminants largely supplanted the issue of bacterial contamination or oxygen demand as the most significant environmental threat in the Fraser Estuary. A new and disturbing pattern surfaced of the long-term, sub-lethal environmental degradation caused by waste discharges from both domestic and industrial sources through the accumulation and concentration of toxic chemicals in sediments and animal tissues. The accumulation of toxic chemicals was first identified as a concern in the Sturgeon Bank area of the Fraser Estuary, around the Iona treatment plant outfall.⁶⁰ Subsequent studies confirmed that the accumulation of toxics in the estuarine environment posed a significant, though as yet not fully understood, environmental hazard.⁶¹ Scientists at the University of British Columbia’s Westwater Research Centre publicized the issue of toxics through their research, a lecture series, and a 1976 book, *The Uncertain Future of the Lower Fraser*.⁶²

But changes to sewage-treatment policy, however slow in arriving and haphazard in their implementation, were in large part the expression of the changing environmental values of Vancouverites. As historian Samuel Hays explains, threats to iconic landscapes or waterways, such as Chesapeake Bay or Puget Sound in the United States, played an important role in stimulating environmental action based on shared local perceptions and sense of identity.⁶³ Vancouverites increasingly questioned whether the Fraser River, so much a part of regional history and identity, was an acceptable place for domestic wastes. A brief by the B.C. Wildlife Federation to a 1967 provincial Pollution Control Board hearing on the Fraser typified these

sentiments. While mainly concerned with recreation and wildlife protection, this sportsmen’s organization also raised the wider question of the urban relationship to nature. The group’s brief contended that “the mere fact that people know the river is . . . showing an undesirably high level of bacterial contamination, [and] the knowledge that it could be receiving industrial and domestic effluents that could be harmful to fish and wildlife, detracts from the quality of the total regional environment.”⁶⁴ *Vancouver Sun* outdoors columnist Lee Straight echoed these fears: “What we’ve lost and must recover soon is a big, rich river with clean, grassy banks not licked by swirling garbage and buffeted by acres of drab logs. I’d be glad to get back a clean Fraser without the fishing. Something tells me that if we don’t restore that river sooner than planned, we’re all lost.”⁶⁵

This sense of environmental loss extended to the Fraser’s working landscape and its historic commercial fishery. Led by fishermen’s union organizer T. Buck Suzuki, fisheries workers launched a campaign in the 1960s to force the Pollution Control Board to curb pollution in the Fraser, in spite of the board’s assurances that fish stocks were unaffected by sewage.⁶⁶ Local fishermen had long complained that polluted conditions in the North Arm had virtually eliminated fish passage through its waters. In December 1971, dozens of fishing boats joined environmentalists in a floating protest of a proposed primary treatment plant on the Fraser River at Annacis Island.⁶⁷ Suzuki also raised concerns about the health of fishermen’s “workplace” on the river: “Fishermen working the lower Fraser encounter ever-increasing amounts of domestic sewage entangled in gillnets and considerable concern has been expressed for the health of men working in these conditions.”⁶⁸ These arguments linked environmental threats to salmon, their livelihood, with threats to human health and well-being.

The impact of domestic waste waters on the aquatic environment became a potent issue for newly formed urban environmental groups in this period. The Richmond Anti-Pollution Association (RAPA), which formed in 1968 in response to that city’s plan to discharge raw sewage to the Fraser River, denounced the attitude that “the solution to pollution is dilution.”⁶⁹ The group aggressively lobbied regional and provincial officials, demanding advanced treatment of all sewage and industrial wastes reaching the Fraser. In 1969, RAPA was joined in 1969 by the Scientific Pollution and Environmental Control Society (SPEC), which quickly became the most prominent anti-pollution organization in the province. The following year, SPEC issued its explosive *Fraser River Report*.⁷⁰ Using data compiled by students, it was an instantly controversial examination of river pollution from both industrial and domestic sources. *Vancouver Sun* columnist Bob Hunter (and Greenpeace co-founder) endorsed the report, writing that it documented “a river in its death throes . . . being killed by industry, by cheap treatment methods, by lack of foresight and concern, by governmental ignorance.”⁷¹ Encouraging concerned members of the public to become “Fraser savers,” environmental groups focused intense pressure on pollution-control authorities over the perceived

threats to the Fraser of sewage and industrial wastes.⁷² These efforts forced municipal and provincial governments to reconsider the region's waste-disposal strategies. Amidst considerable controversy, in 1975 the provincial cabinet forced the GVSDD to upgrade the Annacis Island treatment plant to secondary treatment, and created a special committee to investigate the ecological impact of sewage and toxic chemicals on the Fraser River.⁷³ "The environmental movement of the 1970's has had a great impact on perceptions of pollution by sewage," B.C. oceanographer and pollution scientist Michael Waldichuk reflected. "[These perceptions] have necessitated . . . a very close look by environmental scientists and engineers at all the environmental and ecological effects of sewage, and have led to designs of systems for treatment and disposal that would minimize these effects as much as possible."⁷⁴

Although fierce critics of the philosophy of assimilative capacity, urban environmentalists were not anti-modernist reactionaries. As "conservationists" themselves, many of these groups did not oppose the use of the Fraser River for various purposes, including shipping, fishing, recreation—even waste disposal. But they departed from a strictly utilitarian conservation ideology by infusing non-material and ecological values into their assessments of the river. Environmentalists rejected the technocratic vision of the Strait of Georgia and Fraser River as a "giant flushing machine" and advanced the notion of regional waters as a "living river": an integrated environment that sustained valuable and meaningful aquatic life. Such a system, they argued, could not be reduced to the calculus of dissolved oxygen levels or tidal cycles. But rather than rejecting science, critics attempted to displace the exclusive authority of engineers by challenging the discourse of assimilative capacity on scientific terms. Environmental groups employed ecologists and other scientists as consultants to conduct studies of environmental conditions in the river. They advocated technological solutions, such as advanced waste treatment and effluent de-chlorination facilities, to address environmental problems.⁷⁵ These interventions were key in reorienting approaches to sewage disposal away from assimilative capacity as a natural resource, and towards the precautionary principle of avoiding potential environmental degradation by requiring optimum levels of treatment and thorough environmental monitoring and enforcement.⁷⁶

By 1980, although pollution problems persisted in the Fraser and their resolution remained controversial, a significant shift in perceptions and approaches had occurred. Instead of a convenient repository for urban wastes, for many the Fraser had become a "river of tears": a beloved watershed under continued threats from pollution and government indifference.⁷⁷ Ongoing pollution problems in the Fraser estuary only reinforced these sentiments. A 1980 public inquiry held by the Pollution Control Board (PCB) heard evidence of heavy-metal concentration in marine organisms in the estuary, as well as concern over periodic and localized oxygen depletion.⁷⁸ Without better waste treatment, pollution enforcement and the control of industrial inputs, observed PCB chairman C. J. G. Mackenzie, "the

ultimate fate of the Lower Fraser and its estuary is that it will be trampled to death within another generation."⁷⁹ As if to confirm Mackenzie's fears, later that year a major fish kill occurred near the mouth of the Fraser River, attributed to an episode of severe oxygen depletion in the shallow waters of Sturgeon Bank. Regional sewerage officials pleaded guilty to charges under the *Fisheries Act*, receiving fines of \$5,000 each.⁸⁰ In sentencing the officials, Judge Philip Govan reflected that river pollution was, at root, a "small 'p' political problem, one which governments of every political stripe and every level must grapple with in the first instance. But the priorities of these governments must be guided by the demands of the electorate; it is they who must put sewage treatment plants ahead of bridges, stadiums, dams or other monuments."⁸¹ The sentence, and Govan's comments, underscored changing environmental values in Vancouver that increasingly sought to harmonize urban development with ecological integrity.



Accustomed to regarding pollution control in the stark terms of environmental abuse and protection, contemporary observers may fail to appreciate the very different way this problem was regarded in the past. Sanitary engineers in early mid-twentieth-century North America saw themselves primarily as conservationists, not defenders of nature. They sought to advance the goals of public health and environmental quality by improving the efficiency of urban technological systems. By enrolling natural systems in waste-disposal networks, they exhibited an instrumental view of urban nature as a kind of resource amenable to rational exploitation. As David Stradling has suggested in his study of the urban smoke-abatement movement, examining the connections between the ideology of conservation and the emerging discourses and practices of urban sanitary reform provides important insights into both movements.⁸² Sewers and smokestacks, not just forests and fish, figured prominently in the conservation crusade to remake nature and society in the industrial age. While many urban reformers framed sanitation and environmental issues through the traditional moral and aesthetic discourses of pollution and purity,⁸³ sanitary engineers successfully promoted their unique authority to control and manage urban nature based on a scientific approach to environmental problems. In this sense, the doctrine of assimilative capacity that dominated twentieth-century sewerage engineering represented an important departure from the casual, nineteenth-century reliance on dilution. As with other conservation concerns, science and engineering provided an apparently value-free method of evaluating environmental problems in order to transcend politics in the distribution of environmental benefits.

As the Vancouver example demonstrates, the conservationist approach to urban waste-water disposal transformed urban space and nature, both materially and discursively. Historian of technology Rosalind Williams has argued that, "in the creation of [technological] structures, nature is understood primarily as *space*, and the system as *a means of organizing space*. Nature is not a means to the creation of a product, for the 'product' in this

case is the creation of a second nature, of a cultural landscape from the given physical one."⁸⁴ The incorporation of the Fraser estuary into technological waste-disposal networks exemplifies Williams's assertion. The exploitation of the river's assimilative capacity amounted to a spatial and temporal strategy of pollution control and resource utilization. Since the river's self-purifying mechanisms operated over distance and time, calculations of assimilative capacity aimed at predicting the extent and duration of "pollutional" effects. Sanitary engineers aimed to optimize the spatial arrangement of waste-treatment and disposal technologies in order to make best use of this resource. In a sense, this was a utopian view: assimilative capacity sought to banish pollution not by stopping the practice of waste disposal, but by perfecting it. Thus, the Lea and Rawn systems diverted waste waters from across the region to a relatively small number of points, where they could either be discharged into deep or fast-moving waters, or receive minimal treatment before disposal. But the critical reliance of these systems on the river's assimilative capacity was overwhelmed by the geographic concentration of contaminated waste waters at fewer locations. While the reshaping of the regional hydroscape through capital- and technology-intensive systems corrected the uncontrolled disposal of wastes and the resulting local pollution of creeks, beaches, and ditches, it ultimately created a situation of long-term and intensive environmental degradation at one of the most ecologically sensitive places in the region, the Fraser Estuary.

The degeneration of the estuarine environment coincided with growing environmental awareness and a shift in urban environmental values. The rising chorus of opposition in 1970s Vancouver to the exploitation of assimilative capacity provides insight into the urban politics of conservation and environmentalism. For Vancouverites, the Fraser River became the repository of new environmental values associated with postwar environmentalism. Historian Samuel Hays suggests that the shift towards amenities and quality of life issues was central to the "urban environmental awakening": "People engaged in expanding the role of nature in modern society and hence their own quality of life, aim[ed] not to 'return' to an earlier nature but to 'advance' to an enhanced role for nature in an urban society."⁸⁵ Urbanites increasingly appreciated the amenity and ecological values of urban waterways. Clean rivers brought nature into the city; polluted rivers symbolized urban alienation from nature. Ironically, the desire in the environmental era to repair the relationship between the city and nature distantly echoed the impulse towards urban planning and reform that animated early-century conservationists, including sanitarians. But the evolving concerns and attitudes of urbanites also illustrated the transition within the conservation movement from the embrace of technocratic management and control to an emphasis on the protection of environmental quality and the preservation of non-material values in nature.⁸⁶

This perspective on the history of sewerage planning and politics disrupts the view of urban sanitary history as simply the gradual achievement of treatment and environmental protec-

tion. Rather, sewerage and drainage, like parks, roads, wildlife, and other elements of urban nature, exemplify the contested and complex transformation of space and nature in the modern city.⁸⁷ Attention to this aspect of urban environmental history also helps explain the persistence of these environmental problems in contemporary cities. Today, several major Canadian cities continue to discharge raw sewage to adjacent waterways, and others, including Vancouver, struggle with overloaded treatment and disposal systems.⁸⁸ A historical perspective reveals how these problems arose not merely out of ignorance or misuse, but rather emerged from the strategies and attitudes of past planners and engineers. Further research into how the doctrine of assimilative capacity influenced pollution-control practices around North America may open up new theoretical and empirical insights into one of the twentieth century's most pressing and ubiquitous environmental problems, water pollution.

Notes

1. Much of the research for this paper was conducted for my dissertation, "The Effluent Society: Water Pollution and Environmental Politics in British Columbia, 1889–1980" (PhD diss., University of British Columbia, 2004). Financial support was provided by Social Sciences and Humanities Research Council doctoral and post-doctoral fellowships. This research was ably guided by dissertation committee members, especially my supervisor, Graeme Wynn. Participants in the University of Saskatchewan's History Workshop Series discussed and commented on an earlier version of this paper. John Thistle, Stephen Bocking, and two anonymous referees offered helpful comments on this version.
2. Matthew Gandy, *Concrete and Clay: Reworking Nature in New York City* (Cambridge: MIT Press, 2002), 22; see also Matthew Gandy, "The Paris Sewers and the Rationalization of Urban Space," *Transactions of the Institute of British Geographers, New Series* 24, no. 1 (1999): 23–44.
3. Martin V. Melosi, *The Sanitary City: Urban Infrastructure in America from Colonial Times to the Present* (Baltimore: Johns Hopkins University Press, 2000); Joel A. Tarr, *The Search for the 'Ultimate Sink': Urban Pollution in Historical Perspective* (Akron: University of Akron Press, 1996); Sarah S. Elkind, *Bay Cities and Water Politics: The Battle for Resources in Boston and Oakland* (Lawrence, KS: University Press of Kansas, 1998); Steven J. Burian, Stephan J. Nix, Robert E. Pitt, and S. Rocky Durrans, "Urban Wastewater Management in the United States: Past, Present, and Future," *Journal of Urban Technology* 7, no. 3 (2000): 33–62.
4. Prominent examples include Suellen Hoy, *Chasing Dirt: The American Pursuit of Cleanliness* (New York: Oxford University Press, 1995); Melosi, *Sanitary City*; Dale H. Porter, *The Thames Embankment: Environment, Technology, and Society in Victorian London* (Akron: University of Akron Press, 1998); Joel A. Tarr, "Decisions about Wastewater Technology, 1850–1932," and "Water and Wastes: A Retrospective Assessment of Wastewater Technology in the United States, 1800–1932," in Tarr, *The Search for the Ultimate Sink*; Joel A. Tarr and Terry F. Yosie, "Critical Decisions in Pittsburgh Water and Wastewater Treatment," in *Devastation and Renewal: An Environmental History of Pittsburgh and Its Region*, ed. Joel A. Tarr (Pittsburgh: University of Pittsburgh Press, 2003). For Canadian perspectives, see Douglas Baldwin, "Sewerage," in *Building Canada: A History of Public Works*, ed. Norman R. Ball (Toronto: University of Toronto Press, 1988); Douglas O. Baldwin, "The Campaign against Odors: Sanitarians and the Genesis of Public Health in Charlottetown, Prince Edward Island (1855–1900)," *Scientia Canadensis* 10, no. 1 (1986): 72–82; Catherine Brace, "Public Works in the Canadian City: The Provision of Sewers in Toronto 1870–1913," *Urban History Review / Revue d'histoire urbaine* 23, no. 2 (Mar. 1995): 33–43; Jennifer Read, "A Sort of Destiny": The Multi-Jurisdictional

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- Response to Sewage Pollution in the Great Lakes, 1900–1930," *Scientia Canadensis* 22–23 (1994–1995): 103–129.
5. A post-structural Marxian interpretation of these processes is offered in Maria Kaika and Erik Swyngedouw, "Fetishizing the Modern City: The Phantasmagoria of Urban Technological Networks," *International Journal of Urban and Regional Research* 24, no. 1 (Mar. 2000): 120–138; Erik Swyngedouw, "The City as Hybrid: On Nature, Society and Cyborg Urbanization," *Culture, Nature and Society* 7, no. 2 (June 1996): 65–80.
6. Adam W. Rome, "Coming to Terms with Pollution: The Language of Environmental Reform, 1865–1915," *Environmental History* (July 1996), 7.
7. John T. Cumbler, *Reasonable Use: The People, the Environment, and the State, New England 1790–1930* (Oxford: Oxford University Press, 2001); Theodore Steinberg, *Nature Incorporated: Industrialization and the Waters of New England* (Cambridge: Cambridge University Press, 1991).
8. Elkind, *Bay Cities and Water Politics*, 3.
9. This phrase is from Gifford Pinchot, head of the U.S. Forest Service and central exponent of conservation ideology, cited in David Stradling, ed., *Conservation in the Progressive Era: Classic Texts* (Seattle: University of Washington Press, 2004), 8. Key discussions of conservation ideology include Stephen Fox, *John Muir and His Legacy: The American Conservation Movement* (Toronto: Little, Brown and Co., 1981); Samuel P. Hays, *Conservation and the Gospel of Efficiency* (Cambridge: Harvard University Press, 1958); Clayton R. Koppes, "Efficiency, Equity, Esthetics: Shifting Themes in American Conservation," in *The Ends of the Earth: Perspectives on Modern Environmental History*, ed. Donald Worster (New York: Cambridge University Press, 1988); Roderick Nash, ed., *The American Environment: Readings in the History of Conservation* (Reading, MA: Addison-Wesley, 1968).
10. Richard White, *The Organic Machine: The Remaking of the Columbia River* (New York: Hill & Wang, 1995).
11. David Stradling, *Smokestacks and Progressives: Environmentalists, Engineers, and Air Quality in America, 1881–1951* (Baltimore: Johns Hopkins University Press, 1999); Robert Gottlieb, *Forcing the Spring: The Transformation of the American Environmental Movement* (Covelo, CA: Island, 1993), chap. 1.
12. Hays, *Conservation and the Gospel of Efficiency*, 123–127.
13. This description of the Lower Fraser is compiled from Richard C. Bocking, *Mighty River: A Portrait of the Fraser* (Vancouver: Douglas & McIntyre, 1997), chap. 10; Graeme Wynn and Craig E. Colten (Lanham, MD: Rowman and Littlefield, 1992); Craig E. Colten, *An Unnatural Metropolis: Wrestling New Orleans from Nature* (Baton Rouge: Louisiana State University Press, 2005), chaps. 2–4; Cumbler, *Reasonable Use*; Edward K. Muller, "River City," in *Devastation and Renewal*.
14. Bruce Hutchison, *The Fraser* (Toronto: Clarke, Irwin & Co., 1950); Arn Keeling and Robert A. J. McDonald, "The Profligate Province: Roderick Haig-Brown and the Modernizing of British Columbia," *Journal of Canadian Studies* 36, no. 3 (Fall 2001): 7–23.
15. For example, see Craig E. Colten, "Illinois River Pollution Control, 1900–1970," in *The American Environment: Interpretations of Past Geographies*, eds. Lary Dilsaver and Craig E. Colten (Lanham, MD: Rowman and Littlefield, 1992); Craig E. Colten, *An Unnatural Metropolis: Wrestling New Orleans from Nature* (Baton Rouge: Louisiana State University Press, 2005), chaps. 2–4; Cumbler, *Reasonable Use*; Edward K. Muller, "River City," in *Devastation and Renewal*.
16. Jean-Pierre Goubert, *The Conquest of Water: The Advent of Health in the Industrial Age* (Oxford: Polity, 1989); Porter, *The Thames Embankment*; Melosi, *Sanitary City*, part 1; Rome, "Coming to Terms with Pollution."
17. On the development of sanitary engineering in North America, see Martin V. Melosi, "Sanitary Engineers in American Cities: Changing Roles from the Age of Miasmas to the Age of Ecology," in *Effluent America: Cities, Industry, Energy, and the Environment* (Pittsburgh: University of Pittsburgh Press, 2001); Stanley K. Schultz, *Constructing Urban Culture: American Cities and City Planning, 1800–1920* (Philadelphia: Temple University Press, 1989), pt. 4; Tarr, "Decisions about Wastewater Technology." On sanitary engineers in Canada, see Alan F. J. Artibise, "Building Cities," in *Building Canada*, ed. Ball; Baldwin, "Sewerage"; B. Sinclair, N. R. Ball, and J. O. Petersen, *Let Us Be Honest and Modest: Technology and Society in Canadian History* (Toronto: Oxford University Press, 1974), 244–249.
18. Martin V. Melosi, "Environmental Reform in the Industrial Cities," in *Effluent America*, 214–215, 222, 224; Stradling, *Smokestacks and Progressives*, 58–59; M. Christine Boyer, *Dreaming the Rational City: The Myth of American City Planning* (Cambridge: MIT Press, 1983), 15–17; J. Rodney Millard, *The Master Spirit of the Age: Canadian Engineers and the Politics of Professionalism, 1887–1922* (Toronto: University of Toronto Press, 1998).
19. Tarr, "Water and Wastes"; Terence Kehoe, *Cleaning Up the Great Lakes: From Cooperation to Confrontation* (DeKalb, IL: Northern Illinois University Press, 1997), 22–23. The principle of efficiency guiding pollution control and resource conservation is explored in connection with the petroleum industry in Hugh S. Gorman, *Redefining Efficiency: Pollution Concerns, Regulatory Mechanisms, and Technological Change in the U.S. Petroleum Industry* (Akron, OH: University of Akron Press, 2001).
20. "comme un équipement public contrôlé par l'État." Translation mine.) Michel Girard, *L'écologisme retrouvé: Essor et déclin de la Commission de la Conservation du Canada* (Ottawa: University of Ottawa Press, 1996), 29.
21. Alan F. J. Artibise and Gilbert A. Stelter, "Conservation Planning and Urban Planning: The Canadian Commission of Conservation in Historical Perspective," in *Consuming Canada: Readings in Environmental History*, eds. Chad Gaffield and Pam Gaffield (Toronto: Copp Clark, 1995), 158–159. See also Girard, *L'écologisme retrouvé*, 177–192; Thomas I. Gunton, "The Ideas and Policies of the Canadian Planning Profession, 1909–1931," in *The Usable Urban Past: Planning and Politics in the Modern Canadian City* (Ottawa: Carleton University Press, 1979); Walter Van Nus, "The Plan-Makers and the City: Architects, Engineers, Surveyors and Urban Planning in Canada, 1870–1939" (PhD diss., University of Toronto, 1975).
22. Christopher Hamlin, *A Science of Impurity: Water Analysis in Nineteenth Century Britain* (Berkeley: University of California Press, 1990).
23. Royal Commission on Sewage Disposal, *Treating and Disposing of Sewage: Interim Report* (London: Royal Commission, 1901), xii.
24. Dissolved oxygen in water is critical for supporting aquatic organisms. Organic materials in water are broken down through bacterial action, which consumes dissolved oxygen. Since the oxygen-consuming decay of materials takes place over time, the standard measure is BOD_x, where *x* is the number of days (usually five) over which the test is run. Normally, the test is conducted by the collection of samples that are then stabilized at 20 degrees Celsius, and a comparison of the dissolved oxygen levels between the samples before and after the test period yields the measure of the BOD of the effluent. BOD may be affected by other factors such as salinity, temperature, and toxic chemicals that inhibit the growth of oxygen-consuming bacteria. For useful definitions of BOD, see "Biochemical Oxygen Demand (BOD)" in William Ashworth, *The Encyclopedia of Environmental Sciences* (New York: Facts on File, 1991), 42–43, and Allan M. Springer, *Industrial Environmental Control: Pulp and Paper Industry* (New York: Wiley-Interscience, 1986), 6–7.
25. Joel A. Tarr, "Industrial Wastes, Water Pollution, and Public Health, 1876–1962," *The Search for the Ultimate Sink*, 366–369.
26. Gordon M. Fair, "Water Pollution Research and the Revolution in Science and Technology," *Advances in Water Pollution Research*, ed. B. A. Southgate (New York: Macmillan 1964), 1:xv. The importance of this formula to contemporary engineering practice is underscored by the detailed historical and technical review in C. R. Forsberg, "Water Pollution" (master's thesis, University of Saskatchewan, 1943).
27. John M. Sidwick, "A Brief History of Sewage Treatment: 2; The Royal Commission," *Effluent and Water Treatment Journal* 16, no. 4 (1976): 199.

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28. Sharon Beder, "Pipelines and Paradigms: The Development of Sewerage Engineering," *Australian Civil Engineering Transactions*, 35, no. 1 (Mar. 1993): 79–85. <http://www.uow.edu.au/arts/sts/sbeder/sewage/paradigms.html>.
29. The term *assimilative capacity* was but one of several terms to describe this natural resource. To some degree, *self-purification* continued to be used. Other terms included *abruptive* or *assimilation* capacity, or *purifying mechanism*. For consistency, I will use the term *assimilative capacity*.
30. International Joint Commission, *Pollution of Boundary Waters*, Proceedings of conference with sanitary engineers, New York City, May 26–27, 1914 (Washington: IJC, 1914), 40.
31. Ibid. See International Joint Commission, *Résumé of Testimony of Consulting Sanitary Engineers in the Matter of the Pollution of Boundary Waters* (Washington: Government Printing Office, 1914); International Joint Commission, *Final Report of the International Joint Commission on the Pollution of Boundary Waters Reference* (Washington: Government Printing Office, 1918). For context and other aspects of the IJC pollution of boundary waters reference, see Read, "A Sort of Destiny."
32. Tarr, "Industrial Wastes," 366–369.
33. Earle B. Phelps, *Stream Sanitation* (New York: James Wiley and Sons, 1944), 186. Emphasis in original.
34. Ibid., 187.
35. M. A. Churchill, "Waste Assimilative Capacity of Streams," in *Proceedings of the 1st Sanitary Engineering Conference*, Vanderbilt University Department of Civil Engineering (Nashville: Vanderbilt University, 1962), 137–138; Abel Wolman, "An Inquiry into Standards Proposed for Stream Cleanliness" [1940], in *Water, Health and Society: Selected Readings*, ed. Gilbert F. White (Bloomington, ID: Indiana University Press, 1969), 110–111.
36. A. L. Van Luven, "A Study of the Use, Conservation and Pollution of Water Resources," *Engineering Journal* 43 (June 1960): 87–95. Other articles in this issue, written by engineers and pollution control officials from across Canada, outline similar attitudes towards pollution and assimilative capacity and include a survey of the work of engineers in Greater Vancouver: T. V. Berry, "Pollution Control in the Lower Mainland Communities of British Columbia," 46–55.
37. Theodore M. Porter, *Trust in Numbers: The Pursuit of Objectivity in Science and Public Life* (Princeton: Princeton University Press, 1995); Jan Golinski, *Making Natural Knowledge: Constructivism and the History of Science* (Cambridge: Cambridge University Press, 1998).
38. David Demeritt, "Scientific Forest Conservation and the Statistical Picturing of Nature's Limits in the Progressive-Era United States," *Environment and Planning D: Society and Space*, 19, no. 4 (2001): 431–59. Linda Nash outlines a similar argument with regard to water in "The Changing Experience of Nature: Historical Encounters with a Northwest River," *Journal of American History* 86, no. 4 (Mar. 2000): 1600–1629. See also James C. Scott, *Seeing Like a State: How Certain Schemes To Improve the Human Condition Have Failed* (New Haven: Yale University Press, 1998), chap. 1.
39. Vancouver's sewerage history is explored in greater detail in Arn Keeling, "Sink or Swim: Water Pollution and Environmental Politics in Vancouver, 1889–1975," *BC Studies* 142/43 (Summer/Autumn 2004): 67–99.
40. R. S. Lea, *Report by R. S. Lea to the Burrard Peninsula Joint Sewerage Committee*, rev. ed. (1913; Vancouver: Vancouver and Districts Joint Sewerage and Drainage Board, 1917), 14.
41. Ibid., 16.
42. These concerns, raised repeatedly in the 1930s, are recorded in letters to the provincial public health officer, cited in file 1, box 20, and file 4, box 16, GR-0132 Health Department, British Columbia Archives and Records Service (hereafter cited as BCA).
43. Greater Vancouver Sewerage and Drainage District (hereafter cited as GVSD), *Sewerage and Drainage of the Greater Vancouver Area*, British Columbia (Vancouver: GVSD, Sept. 1953).
44. Quoted in Michael Waldichuk, *Sewage Pollution in British Columbia in Perspective*, Canadian Industry Report of Fisheries and Aquatic Sciences No. 153 (Ottawa: Department of Fisheries and Oceans, 1984), 6.
45. A. M. Rawn and H. K. Palmer, "Pre-Determining the Extent of a Sewage Field in Sea Water," *Transactions of the American Society of Civil Engineers* 94 (1930): 1036–1081. See also Willis T. Knowlton, "The Sewage Disposal Problem of Los Angeles, California," *Transactions of the American Society of Civil Engineers* 92 (1928): 984–993.
46. A. M. Rawn, *Narrative: C.S.D.* (Los Angeles: County Sanitation Districts of Los Angeles County, 1965), 172.
47. See, for instance, Rawn's commentary on Bostwick H. Ketchum, "The Flushing of Tidal Estuaries," *Sewage and Industrial Wastes* 23, no. 2 (1951): 208–209, and the discussion in *Water Quality Criteria* (Sacramento: California State Water Pollution Control Board, 1952), 43–47.
48. GVSD, *Sewerage and Drainage*, 124.
49. Ibid., chap. 8. On the establishment of the joint study, see, Minutes of meeting between Pacific Oceanographic Group and Vancouver and Districts Joint Sewerage and Drainage Board, 21 Apr. 1950, file 1, 63-F-5, Add. MSS 1257, City of Vancouver Archives (hereafter cited as CVA).
50. This "zoning" approach to urban pollution problems is echoed in Ken Cruikshank and Nancy B. Bouchier, "Blighted Areas and Obnoxious Industries: Constructing Environmental Inequality on an Industrial Waterfront, Hamilton, Ontario, 1890–1960," *Environmental History* 9, no. 3 (2004): 464–496. On Canadian urban planning and the rationalization of space, see sources in note 21, and Edward Relph, *The Modern Urban Landscape* (Baltimore: Johns Hopkins University Press, 1987). On zoning and planning in Vancouver, see Graeme Wynn, "The Rise of Vancouver," in *Vancouver and Its Region*, eds. Graeme Wynn and Timothy Oke (Vancouver: University of British Columbia Press, 1992).
51. Sturgeon Bank is a shallow, tidally inundated area at the mouth of the Fraser River formed by the river's sediments. The open channel was designed to carry the wastes further out towards the open water of the Strait of Georgia during low tide. It was assumed that ample mixing would occur during high tide, when the channel was covered by water, to prevent pollution. See GVSD, *Sewerage and Drainage*, 155–156.
52. See display advertisements in *Vancouver Sun*, 14 Aug., 21 Aug. 1958. Rawn, Hyde, and other experts also appeared at a public hearing into the plan: see British Columbia, Pollution Control Board, *Transcript of Hearing before the Pollution-Control Board*, Sept. 5–6, 1957 (Victoria: The Board, 1957).
53. British Columbia Research Council, *Fraser-Thompson River System Water Quality* (Vancouver: BCRC, 1952). See also the work of the Dominion-Provincial Fraser River Board's pollution committee, documented in files 5–6, box 5, GR-0132 Department of Health, BCA. Other studies are listed in Fisheries Development Council, *Summaries of Fisheries Research on the Pollution Problem* (Vancouver: Department of Fisheries, August 1965).
54. British Columbia, Pollution Control Board, *Pollution and the Fraser* (Victoria: Department of Lands, Forests, and Water Resources, 1967). These concerns were also documented in Arnie Myers, "Sewers Have No Sex Appeal—So Pollution Goes On," *Vancouver Sun*, 11 Sept. 1965.
55. Report by L. Percival to J. A. Stringer, sanitary control officer, 22 July 1970, 2, file 17, box 146-C-2, City of Vancouver Health Department files, CVA.
56. "Suit Cites Sewage Pollution," *Vancouver Sun*, 21 Nov. 1969.
57. British Columbia, Legislative Assembly, *Debates and Proceedings* (23 Mar. 1970), pp. 719–720, 729 (E. LeCours and D. G. Cocke, MLAs); Moira Farrow, "Iona Plant Effluent Blamed for Pollution," *Vancouver Sun*, 22 Nov.

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1973. Ironically, neither Richmond nor New Westminster treated their sewage, but disposed of it directly to the Fraser.
58. Rod Morgan, "A Mighty Sewage Struggle," *Vancouver Sun*, 10 Dec. 1970; this controversy is discussed in more detail in Keeling, "Sink or Swim."
59. Joel A. Tarr, "Industrial Waste Disposal in the United States as a Historical Problem," *Ambix* 49, 1 (Mar. 2002): 14–16; Tarr, "Industrial Wastes," 376–378.
60. See G. Tanner, G. Trasolini, and L. Nemeth, *A Study on Wastewater Characteristics of Greater Vancouver Sewage Treatment Plants and Major Sewers* (Vancouver: Environmental Protection Service, Dec. 1973).
61. B.C. Research, *Summary of the Effects of the Annacis Island Sewage Discharge on the Water Quality in the Fraser River* (Vancouver: B.C. Research, 1978); scientists with the International Pacific Salmon Fisheries Commission undertook a series of studies in the early 1970s into the toxicity of municipal sewage and chlorinated effluent to salmon. For a listing, see John F. Roos, *Restoring Fraser River Salmon: A History of the International Pacific Salmon Fisheries Commission, 1935–1985* (Vancouver: Pacific Salmon Commission, 1991), 179–180.
62. Anthony H. J. Dorsey, ed., *The Uncertain Future of the Lower Fraser* (Vancouver: Westwater Research, 1976); "The Answer Is Yes," *Vancouver Sun*, 26 Apr. 1976.
63. Samuel P. Hays, *Beauty, Health, and Permanence: Environmental Politics in the United States, 1955–1985* (New York: Cambridge University Press, 1987), 36–37.
64. "Submission by the BCWF to the Pollution Control Board Public Hearing on the Report Pollution and the Fraser," Aug. 1967, file 3, box 112, Roderick Haig-Brown Papers, University of British Columbia Special Collections and University Archives Division.
65. Lee Straight, "Lee Straight," *Vancouver Sun*, 3 Dec. 1971.
66. Norman Hacking, "Pollution Worries Fishermen," *Vancouver Province*, 7 Apr. 1967; Ron Rose, "I won't rinse my dishes in that slime anymore," *Vancouver Sun*, 30 Aug. 1967. The United Fishermen and Allied Workers' Union was prominent in the fight over Fraser pollution: see "In This Day and Age?" *Vancouver Sun*, 16 Feb. 1967.
67. "Sewage Treatment Plant Draws Angry Protests," *Vancouver Sun*, 4 Dec. 1972.
68. Canada, House of Commons Standing Committee on Fisheries and Forestry, *Minutes of Proceedings and Evidence*, 21 Apr. 1969, 534; Ron Rose, "Sludge, Stench Clog Fraser Cruise," *Vancouver Sun*, 21 Aug. 1970. These concerns were shared by shoreworkers, longshoremen, and fishery support workers: see their 1974 petition to the provincial Pollution Control Board, file 2, box 18, acc. no. 88-0407 Environmental Appeal Board, BCA.
69. Standing Committee on Fisheries and Forestry, *ibid.*, 833; "Fraser Sewage Plan Protested," *Vancouver Sun*, 17 July 1968; "Pollution Foes to Protest Richmond Sewage Dumping," *Vancouver Sun*, 23 July 1968.
70. Society for Pollution and Environmental Control, *Fraser River Report* (Vancouver: SPEC 1970).
71. Bob Hunter, "Bob Hunter," *Vancouver Sun*, 28 May 1971. See also the editorial "Is Half-Safe Safe Enough?" *Vancouver Sun*, 9 Feb. 1971.
72. The "Fraser Savers" campaign was launched against the primary sewage treatment plant at Annacis Island on the Fraser: see the B.C. Environment Council circular, file 2, box 18, acc. no. 88-0407, BCA. See also "Compromise Made on Sewage Plant," *Vancouver Sun*, 13 February 1974; "A Dark Cloud," *Vancouver Sun*, 24 Apr. 1976; "Getting Polluted," *Vancouver Sun*, 25 May 1976.
73. Government of British Columbia, Lieutenant-Governor in Council, "In the Matter of the Appeal—Pollution Control Act. Greater Vancouver Regional District—Annacis Island Plant," Apr. 21, 1975, box 18, acc. no. 88-0407, Environmental Appeal Board, BCA.
73. Waldichuk, *Sewage Pollution in British Columbia*, 11.
74. See, for instance, the briefs filed by environmentalists opposing the construction of a primary treatment plant at Annacis Island, cited in box 18, acc. no. 88-0407 Environmental Appeal Board, BCA, and a study by the B.C. Environment Council: Reid Pate and Paul Cardwell Jr., eds., *Fraser Estuary Study Project* (Vancouver: BCEC, 1972).
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85. Gottlieb, *Forcing the Spring*, 157–158; Hays, *Beauty, Health, and Permanence*, 70.
86. Tarr, ed., *Devastation and Renewal*; Gandy, *Concrete and Clay*; and Matthew Klinge, "Urban by Nature: An Environmental History of Seattle, 1880–1970" (PhD diss., University of Washington, 2001).
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