Silent Partners

The Origins and Influence of Canada's Military-Industrial Complex

Edited by Alex Souchen and Matthew S. Wiseman

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Victory at All Costs
Canada's Munitions Industry and the Environment during the Second World War

Alex Souchen

The summer of 1949 was marred by many forest fires. In August, roughly 230 were reported throughout Ontario and Quebec, where firefighters battled desperately to save homes, farms, and businesses.[1] In Quebec, residents in the villages of Terrebonne Heights and Pincourt, outside Montreal, prepared to evacuate while firefighters mounted a "last-ditch touch-and-go battle" against the conflagration. Fortunately, the winds shifted and they managed to contain the blaze on the outskirts of Terrebonne.[2] A few kilometres away, another fire threatened the town of Sainte-Thérèse, but here the efforts to extinguish the inferno were complicated by a special type of hazard left over from the Second World War: unexploded ordnance.

As the fire inched closer to Sainte-Thérèse, it engulfed some of the lands that had been home to one of the largest munitions factories in Canada during the war. Situated on over five thousand acres outside the town, and known as the Bouchard plant, the factory was operated by a private military contractor, Defence Industries Limited (DIL), and entirely funded by the federal government's Department of Munitions and Supply (DMS). The Bouchard plant was exceptionally productive: it filled more than 76 million projectiles between September 1941 and June 1945.[3] Yet the final output tells only part of the story, because munitions production was a complex and dangerous undertaking. Each shell was a self-contained technological system comprised of a variety of working parts and energetic materials that had to be manufactured and calibrated according to precise specifications or else they would fail to detonate on target. Quality controls were stringent and sample batches were tested regularly at the nearby St. Maurice proof range; but many failed to explode, especially early in the war, when the DMS rapidly expanded capacity with inexperienced workers. As a result, the St. Maurice proof range became littered with "thousands of dud shells" that were set off by the forest fires in 1949. According to one *Globe and Mail* report, the explosions were visible ten miles away.[4]

Over two hundred soldiers-turned-firefighters battled the blaze near Sainte-Thérèse, but shrapnel and a lack of water slowed their efforts. Fortunately, though, changing weather patterns eased the situation, and by 25 August the fires near the old Bouchard plant and proof range were under control. The incident,

however, highlights a significant but under-appreciated element in the history of Canada's military-industrial complex (MIC): the environment. Notwithstanding Matthew Evenden's work on aluminum production and hydroelectricity in Canada, Canadian historians have generally overlooked the environmental impact of Canada's industrial front during the Second World War.[5] Instead, their focus gravitates to other important subjects, such as women, consumerism, labour, and material outputs.[6] As a consequence, this has obscured appreciation for the central role of the environment in industrial mobilization and planning, as well as for the ecological changes wrought by munitions production and its associated commodity chains. This chapter seeks to uncover and untangle this history within the Canadian context, and in doing so, it draws inspiration and perspective from ongoing scholarly explorations of the environmental history of warfare and militarization in the Global North.[7]

This chapter makes two interrelated arguments. First, following the string of Allied defeats in Europe and Asia between June 1940 and February 1942, the federal government was forced to take drastic emergency actions to mobilize the nation's entire military, financial, and industrial resources for war. This emergency spurred an unprecedented integration of public and private enterprise, through the DMS's wide and pervasive mandate, to support and sustain a large military force and munitions industry, no matter the cost or obstacle. For the duration of hostilities, the DMS made the business of war as productive as possible for its empire of war contractors. Using the production of chemicals, explosives, and ammunition filling as an example, this chapter shows how political, economic, scientific, and military interests intersected to forge the foundations of Canada's MIC.

The chapter's second argument delves into the environmental history of Canada's industrial front by exploring how the environment shaped – and was reshaped by – munitions production. When locating new war factories, officials were limited by geographic, resource, and logistical factors. To expedite production, planners were primarily confined to Ontario and Quebec because ordnance factories needed access to pre-existing transportation infrastructures and manufacturing capacities, a steady labour supply, and underdeveloped land. As a result, they built factories around Montreal and Toronto or on the outskirts of nearby towns, where land was cheaper to expropriate and public safety hazards were minimal. Site selection was further refined by another environmental factor that scholars have not adequately addressed: access to water. Water was crucial to every stage in the production of chemicals, explosives, and ammunition, so it was no coincidence that every munitions factory was located close to a major body of water: millions of gallons were piped into production every

day, while the effluents and emissions were discharged into the nearby lakes, rivers, soil, and air. Thus, Canada's MIC tapped into the nation's immense freshwater reserves to expedite production and simplify disposal.

Once production sites were selected, the factories themselves reshaped the surrounding environments in myriad ways. The construction of new railways and roads, buildings and storehouses, dormitories and amenities, and drains and proof ranges permanently altered landscapes and environments. What had once been fallow fields, forests, farmlands, or traditional hunting grounds were rapidly developed for industrial purposes and armaments production, no matter their impact on Indigenous and settler communities. Throughout the war, the volume of chemicals, acids, explosives, and other toxic substances flowing through these sites not only posed serious health and safety hazards for workers, but also contaminated the buildings, machinery, and adjacent ecosystems. At the end of hostilities, when the boom of wartime expenditures dried up and the DMS orchestrated the shutdown of its factories, the ecological consequences of munitions production transcended the availability of funds and the sometimes porous decontamination efforts, the lasting scars of which were cast in sharp relief by the forest fires of 1949. Yet, in other cases, the boom of wartime investments established new cities or towns that sprang up around factories and survived the bust of postwar budget cuts, job loss, and demobilization. Thus, what had been conceived of as a temporary emergency and wartime necessity carried forward tangible legacies and permanent environment changes.

Forging a Military-Industrial Complex

When Canada declared war on Nazi Germany on 10 September 1939, its armed forces were ill-prepared to fight. The interwar period had not been kind to the Canadian military, as political leaders slashed budgets and spent money elsewhere to relieve the social and economic dislocation of the Great Depression. When Germany invaded Poland on 1 September, the Canadian Army and part-time militia numbered fewer than fifty thousand troops, and they trained with weaponry left over from the First World War. The situation was no better in the other services, as the Royal Canadian Navy had ten barely modern warships, and the Royal Canadian Air Force could muster only 92 aircraft and 120 trainers.[8] The prospects of Canada making major military contributions to the Allied cause seemed remote, especially given its stagnant economy and deficits in technical expertise in defence production. These deficits made officials in the British War Office leery of awarding major contracts to Canadian firms early in the war, save for several "educational" orders for Bren guns, 25-pounder field guns, 3.7-inch shells, and 800,000 pounds of trinitrotoluene (TNT).[9]

At first, the war policies of Prime Minister William Lyon Mackenzie King's Liberal government mirrored the nation's military and industrial feebleness. Ottawa intended to limit its liabilities for overseas military deployments, not only because it lacked a well-armed military to send, but also because such commitments could result in mass casualties, conscription, and financial debts, thereby endangering national unity, as it had a generation earlier.[10] However, the haunting legacies of the First World War's conscription crisis soon gave way to new traumas, as the string of Allied defeats – stretching from the Fall of France in June 1940 to the Japanese conquest of Southeast Asia in early 1942 – shook the British Empire and the Allied cause to their very foundations.[11] The deteriorating situation necessitated drastic political, economic, and strategic interventions to facilitate the rapid emergence of a military-industrial complex in Canada. The emergency compelled the King government to mobilize for total war, the end results of which were astounding by comparison to their meagre prewar origins. By 1945, Canada possessed one of the largest air forces and navies in the world, and an army of over five infantry and armoured divisions serving overseas. Out of a total population of about 11.5 million, approximately 1.1 million Canadians enlisted in the armed forces, and over 1 million others worked in a bustling wartime economy, brought back to life by the seemingly endless stream of war contracts and federal funding for weaponry and equipment.[12]

At the heart of this "rags to riches" transformation in military and industrial fortunes was the DMS. A civilian agency, formed in early 1940 and headed by C.D. Howe, a fifty-five-year-old American-born engineer and Liberal MP for Port Arthur, Ontario, the DMS gained extraordinary powers to mobilize, ration, and coordinate all production inputs, expertise, materials, and machinery in the Canadian economy. Under Howe's leadership, and backed by the War Measures Act, the DMS redirected the flow of goods and resources away from normal civilian consumption patterns, pouring nearly everything into munitions procurement, especially after Japan's onslaught in December 1941. Government intervention ensured that military needs reigned supreme for the duration of hostilities. Through a myriad of resource controllers for coal, steel, electricity, timber, chemicals, rubber, and other essential industries, along with commodity and price administrators in the Wartime Prices and Trade Board, Canada's MIC took root across the country.[13]

The scale and speed of industrial mobilization would not have been possible without the sudden infusion of experts who populated the growing number of programs, committees, and controls. Their recruitment was a central dynamic of Canada's fledgling MIC, since they would otherwise have remained employed at universities or private companies had the DMS not

needed their immediate services. Whether hand-picked by Howe and his advisors or recruited by reputation and other personal connections, the scientists, economists, engineers, lawyers, technocrats, and business executives who joined the DMS played an instrumental role in expediting production programs, many of which were highly technical in nature and beset by numerous start-up challenges and obstacles unique to the Canadian situation. This group of professionals quickly gained the moniker "dollar-a-year men" because wartime propaganda celebrated their contributions and service, supposedly rendered for the token fee of one dollar per year. However, in reality, the talent was loaned to the government while parent companies paid most of their salaries.[14]

To better acclimate his new army of experts, with little experience in governmental procedures, Howe formed an "executive committee" composed of an inner circle of advisors whom he trusted implicitly. This select group oversaw much of the department's daily operations, staffing, and policymaking. In other words, the so-called minister of everything was a master delegator, who relied on trusted subordinates to worry about the details and get results, while he concentrated on high-level decision making and smoothed over any jurisdictional conflicts that resulted from his department's expanding operations and unusual structure.[15] With businessmen-turned-bureaucrats running the show, their experiences, attitudes, and approaches were brought to bear on the seemingly infinite assortment of tasks and challenges involved with industrial mobilization. In the end, they designed the administrative and procurement branches of the DMS to function more like corporations than government agencies, so they could better integrate into the free-market economy and harness the dormant capacity of private industry, especially during the war's early phases.[16]

Howe and his dollar-a-year men did everything possible to make the business of war profitable and productive. Through various direct and indirect investment programs, roughly $3.5 billion was funnelled into the economy. To incentivize war production for private industry, special depreciation allowances were offered to companies with defence contracts, so they could write off conversion expenses, such as plant expansions, renovations, or purchases of single-purpose machinery with low postwar value.[17] Moreover, the DMS opted for "cost-plus" contracts in its dealings with private industries, in which it agreed to guarantee loans or directly finance the "cost" of production and pay contractors a little extra for completed work. This "plus" took the form of a fixed management fee, award-per-item, or a percentage of the total.[18] These measures prompted the private sector to invest roughly $1 billion into war production or about a third of total expenditures on Canada's industrial front.[19]

However, the cost-plus system was also open to abuse, as contractors could inflate their start-up and production expenses to turn a larger profit or double up on other conversion incentives. In 1941, an investigative report written by the Special Committee on War Expenditures and Economies concluded that cost-plus contracts were the most expensive type to issue. Despite this fact, DMS officials saw little alternative but to sacrifice cost efficiency given the deficient capacities of Canadian defence industries and the mounting Allied defeats.[20] As Howe boldly proclaimed in June 1940, when instructing his staff to take all necessary actions to increase production, "We have no idea of the cost but before this war is over everything will be needed so let's go ahead anyway. If we lose the war nothing will matter ... If we win the war the cost will still have been of no consequence and will have been forgotten."[21]

As the war progressed, the DMS shifted from covering start-up costs and pump-priming industrial expansion to sustaining an economic juggernaut. By March 1943, the government took over almost all of Britain's wartime investments in Canada and funded production through its Mutual Aid Program, Canada's version of Lend-Lease. Unlike in the 1930s and early war years, when the British government largely bankrolled Canada's defence-industrial base, the Mutual Aid Program fully nationalized procurement: Ottawa now paid for all Allied orders in Canada, allocating over $2 billion worth of production through the DMS by war's end.[22] The net results of this public-private partnership were staggering. By 1945, the DMS stood atop an empire of war contractors that manufactured enough "bits and pieces" to mass produce 800 naval and cargo vessels, 16,000 aircraft, 800,000 vehicles, 50,000 armoured vehicles, 1.5 million firearms, and approximately 4.6 billion rounds of ammunition and shells.[23]

Mobilizing Explosives Production

When private industry could not or would not meet the demands of the war effort, Howe's DMS increasingly took the lead and directly subsidized expansion by establishing over twenty-five Crown companies to produce or regulate essential materials. DMS officials also established the War Industrial Expansion Program, investing $700 million into the purchase of machine tools and other precision instruments and financing the construction of 33.5 million square feet of floor space at roughly 170 locations across the country, including almost 12.4 million square feet for chemicals, explosives, and ammunition-filling plants.[24] These initiatives and subsidies were important to Canada's early MIC, as Crown companies were formed across many important sectors of the economy. Some birthed entirely new industries in Canada, such as the Polymer Corporation and synthetic rubber in Sarnia, Ontario, but others greatly expanded and

diversified existing industries.[25] The chemicals and explosives program organized by the DMS is one such example. Although Canada's meagre armaments industry had survived the austerity of the interwar years, its expertise and capacity were woefully inadequate despite the nucleus provided by British educational orders.[26] Nevertheless, the war emergency forced a rapid expansion in an industry composed of only a small number of companies that were capable of manufacturing and filling ordnance on such a large scale.

As a result, the DMS took more assertive actions through its Chemicals and Explosives Production Branch. This branch predated the formation of the DMS and was originally conceived and funded by the British to supplement production needs early in the war. When the DMS took over in 1940, the branch's responsibilities steadily expanded over a range of important duties, including the distribution of contracts and orders, research and development, logistics and storage, and machinery and chemicals.[27] The branch also coordinated production and research programs with its American and British counterparts, as well as with scientists and engineers employed by the National Research Council (NRC) and Canadian universities working on defence projects.[28]

This close cooperation yielded many dividends, as Canadian deficits in expertise and machinery were ameliorated by training secondments to Britain and the United States, and by loans of equipment and production techniques, made available through the increasing integration of Allied armaments programs.[29] Moreover, as historian Donald Avery shows, scientists and academics at Canadian universities mobilized their expertise, as funding for military research and development brought major technological breakthroughs in radar and proximity fuses, as well as in the development of chemicals and explosives. Canadian scientists were instrumental in the development of RDX, an explosive compound more powerful than TNT, and according to the official history of the DMS they also pioneered the prilling of ammonium nitrate, a powerful explosive and artificial fertilizer.[30] Prilling, or transforming ammonium nitrate into small pellets, made it ideal for transportation and explosives production, and later as a fertilizer in agriculture – thereby signalling an exponential boom in postwar food production.

The war's deepening crisis in 1940 and 1941, when German and Japanese victories mounted across all fronts, prompted an unavoidable expansion in plant capacities. However, this added considerably to the branch's already enormous portfolio, so it became necessary to create another organization. On 23 July 1940, the Allied War Supplies Corporation (AWSC) was formed by the DMS to supervise the construction, management, and operation of new government-run factories. Based in Montreal and headed by Harold Crabtree, a wealthy businessman and president of Howard Smith Paper Mills, AWSC quickly

became a critical nerve centre in Canada's industrial war effort. Staffed by many lawyers, engineers, business executives, and other experts, it worked in tandem with the Chemicals and Explosives Production Branch by managing the operational elements of production: it oversaw the network of factories that manufactured almost all the contents and components needed to fill shells, detonators, bombs, and ammunition.[31]

By the end of 1943, AWSC had grown into a formidable empire of forty-one government-owned or -operated plants occupying over 12 million square feet of industrial floor space, stretched across five provinces. The factories financed through AWSC totalled seventeen chemical plants, five military explosive and propellant plants, nine ammunition-filling plants, nine ammunition storage magazines, and one bomb plant. Another ten commercially owned factories were also involved in the program.[32] The total output was diverse and substantial. By war's end, AWSC factories had produced four types of propellants, four types of explosives, and twenty-five types of chemicals. They also filled several types of fuses and detonators, six types of mortar bombs, five types of grenades, four types of 20 mm small-arms ammunition, three types of depth charges, and twenty-four types of artillery shells (complete with cartridges, primers, caps, and detonators).[33] At its peak, the whole chemicals and explosives program employed about fifty thousand workers and produced approximately ten thousand tons of chemicals and explosives per week. By June 1945, over 2 million tons were manufactured in total.[34]

In creating an empire of chemicals and explosives factories, AWSC officials relied on a network of subcontractors to manage all daily operations at each facility. The single-most important subcontractor was DIL, a subsidiary of the chemicals and explosives company Canadian Industries Limited (CIL), formed in September 1939 to separate military and commercial orders. Ottawa's relationship with CIL, which was itself a subsidiary of the American company DuPont and the British Imperial Chemical Industries, was one of necessity and circumstance: apart from Dominion Arsenals in Quebec City and Lindsay, Ontario, CIL was the only firm in Canada with the experience and potential capacity to meet the war's heavy demands.[35]

At the confluence of political, economic, and defence interests, DIL became the posterchild of a wildly prolific production program, born from the close cooperation of public and private enterprises. Through the DMS and AWSC, the federal government paid for everything related to production (the lands, facilities, machinery, resources, supplies, worker salaries, and everything else), so it owned the means of production and did not pay to acquire the finished products from DIL. Instead, DIL made its money through management fees: the state paid it to design, construct, and operate the factories, hire the labour

force, monitor health and safety protocols, and fill production quotas outlined in its contracts.[36] Not only did DIL operate some of the largest and most productive factories in the Canadian war effort, it integrated all the commodity chains necessary to sustain munitions production at a high level. Throughout the war, and with the government's financial backing, DIL built up logistical networks to feed resources, products, and expertise into every stage of production.

At its heart were the factories in Nobel, Ontario, de Salaberry and Beloeil, Quebec, and Transcona, Manitoba, which manufactured the chemicals needed to produce explosives (such as nitric and sulphuric acid), as well as the explosives and propellants themselves. By the end of hostilities, these factories produced over 144,000 tons of TNT, 120,000 tons of cordite, 66,000 tons of nitrocellulose powders, and 4,400 tons of Tetryl.[37] Furthermore, ammonium nitrate was manufactured at three other government-subsidized plants across the country, though the factory operated by the private corporation Consolidated Mining and Smelting in Trail, British Columbia, was the largest. Thanks to generous government subsidies and contract provisions (that allowed Consolidated to retain ownership of all plant expansions after the war), it increased production to over 150 tons per day, and collectively, ammonium nitrate manufacturers churned out more than 475,000 tons for explosives and another 314,000 tons for agriculture.[38] The output from chemical factories was directed into Canada's network of ammunition-filling plants, and DIL operated several in Ontario and Quebec, including one in Pickering, Sainte-Thérèse, Montreal, and Saint-Paul l'Ermite (known as the Cherrier plant and taken over by DIL in 1944). All told, DIL produced 346,000 tons of military explosives, 71,000 tons of chemicals, 2.889 billion rounds of ammunition, and filled almost 183 million projectiles during the Second World War.[39]

Locating Production Sites

Canadian historians have long argued that the distribution of war contracts and the geography of Canada's industrial front, more generally, were shaped by Liberal political and economic priorities, as well as by Howe's personality and ideology. Prior to the war, defence procurement was stunted by a lack of political will, scandals, and virtually no funding, which left Canada unprepared and set the stage for unprecedented state interventionism. Consequently, when mobilizing the war economy and awarding contracts, Howe and his dollar-a-year men had little choice but to experiment with what they had on hand, and they justified concentrating production facilities in Ontario and Quebec on the basis of the war emergency and the expediency of using established businesses and pre-existing infrastructure. In effect, it was easiest to rely on the know-how and

capacity of the private sector across many different industries, while simultaneously using public funds to kick-start economic recovery from the Great Depression.[40]

However, not everyone was convinced. As historian Ernest Forbes showed in his work on industrialization in the Maritimes, the actions of the DMS "consolidated disparities" across Canada's many regions, which disproportionately favoured Ontario and Quebec, the key electoral districts in federal politics. Using the distribution of contracts for shipbuilding and government assistance in the steel industry as examples, Forbes uncovered a distinct pattern of preferences for businesses in central Canada over the Maritimes and its strategic position in the Battle of the Atlantic.[41] Forbes's findings echo earlier complaints from critics, who decried central Canada's prominence over other regions and its unfair advantages in federal investments and defence contracts. During the 1940s, conservatives, social democrats, and provincial authorities grew uneasy about the encroachment of federal powers in provincial affairs, the assimilation of prominent Tory industrialists into government, and the use of public funds to expand corporate monopolies.[42]

Although an undeniable corporate and regional favouritism was ingrained in the way that Howe conducted DMS affairs, we must be cautious in generalizing uniform patterns and applying them equally to every industry. Some industrial sectors were outliers and deserve more nuanced critiques, as the chemicals and explosives production example clearly demonstrates. In effect, the manufacture of these death-dealing instruments depended more on logistical and environmental factors than on partisan politics. In fact, as historian Pierrick Labbé points out, the DMS never sought to distribute contracts and production sites fairly. Instead, its chemicals and explosives program was conceived with various pragmatic considerations in mind that were linked to short-term increases in productivity, while any concerns for long-term economic consolidation and political advantage were negated by the supposedly temporary nature of wartime necessities. Indeed, according to J.R. Donald, the director of Canada's Chemicals and Explosives Production Branch, the need for such a large-scale ammunition and explosives program would evaporate once victory was achieved, thereby implying that this impermanent creation was devoid of long-term utility.[43]

In the case of ammunition and explosives production, considerations for transportation, geography, labour supply, costs, and pre-existing capacities reigned supreme. When locating and constructing munitions factories, AWSC and DIL officials were confined to regions with well-developed transportation networks. Expansive and continuous access to local and national railways and roads was essential because large shipments of

resources and finished products would move in and out of war factories, and also across the American border. Since these networks were already built near Canada's major industrial hubs, officials narrowed their site selections to the regions surrounding Montreal and Toronto. Locating factories near these metropolitan areas also offered ready access to Canada's steel and chemical industries, other manufacturing capacities, abundant energy sources, and a steady supply of labour.

All of these factors incentivized the distribution of ammunition and explosives production in Ontario and Quebec, especially since some factories were already established in those provinces prior to the war. By the end of 1939, British funds had paid for orders and plant expansions at CIL's ammunition plant in Brownsburg, Quebec, and chemical plant in Beloeil.[44] Moreover, the British government originally contracted DIL to build and operate the de Salaberry and Nobel plants early in the war, the latter of which was particularly advantageous since CIL's predecessor had produced explosives there during the First World War, and some of the old foundations were still viable and incorporated into the design of the new facility.[45]

Yet access to transportation infrastructures, industrial capacities, and labour markets was tempered by other financial and geographic considerations that further refined site selection. Given the spatial requirements for each factory and the dangerous nature of their outputs, planners had to be mindful of wider public safety concerns and on-site security requirements, as well as the costs for acquiring title to the land. This meant that it was not preferable to locate production sites directly in urban centres or to fully integrate them into major transportation arteries. Instead, it was best to construct the factories in the suburbs of major cities or the outskirts of small towns, where connections to transportation and resource networks could be built and monitored. For instance, one of DIL's competitors, the General Engineering Company (Canada) (GECO), which established a specialized factory for filling detonators and fuses in Scarborough, Ontario, operated a public transit system to bring workers to the plant. Four main bus routes linked the factory to Toronto, with terminal stops at Yonge Street and St. Clair Avenue, Bloor and Church Streets, and Victoria Park Avenue and Danforth Road. In March 1943, to relieve congestion on buses, a fifth route was added between the plant and Eglinton Avenue and Yonge Street.[46]

Land was cheapest to expropriate outside urban centres. This was crucial given the spatial needs of munitions factories. The Nobel site was originally situated on 975 acres north of Parry Sound, which were purchased from CIL at a bargain price of $10 per acre.[47] Four of the major filling plants sprawled for thousands of acres and comprised hundreds of structures and amenities,

predominately erected as temporary buildings between 1940 and 1942. For instance, the Bouchard plant spanned over 470 buildings across 5,111 acres, whereas the Cherrier plant occupied 1,350 acres and had 345 buildings. The GECO plant was situated on 332 acres with 162 buildings. DIL's Pickering Works eventually consisted of over 440 buildings on 2,500 acres that were expropriated from local farming families at an average price of $125 per acre. The families were not happy about the small return for their land, but the needs of the war effort outweighed their protests.[48] Those families, though, made out far better than others. Outside Sarnia, some of the traditional lands of the Aamjiwnaang First Nation were taken over by the Polymer Corporation and other petrochemical companies and converted into Canada's "Chemical Valley." The resulting pollution and persistent health hazards have scarred generations since the war.[49]

Furthermore, underdeveloped land on the edges of cities and towns provided a natural spatial and security buffer that limited any collateral damage from accidental explosions or incursions from spies and saboteurs. Although fears of enemy agents were largely exaggerated, the dangers from explosions were always present at filling plants and, especially, at the chemical plants. On 18 November 1940, just two months into operations, three workers at the Nobel plant were killed when an explosion ripped through two buildings used for acid treatment in the manufacture of TNT.[50] The disaster was the first in Ontario and set production back a few weeks, but it was far from unique. Ammunition-filling plants also housed many energetic hazards and mechanical dangers that proved especially perilous to inexperienced workers. At the Bouchard factory, approximately 36,000 minor injuries (such as strains, cuts, bruises) occurred throughout its operational life, from August 1941 to December 1945. The frequency of accidents involving major injuries (lacerations, amputations, burns, fractures, and fatalities) was brought under control after the first eight months of operations when 111 incidents occurred. By contrast, 169 major injuries took place over the following forty-five months.[51] Similar trends were found in other factories. At Brownsburg, there were 90 major injuries during the war, though most were concentrated in 1941 and 1942 when production expanded considerably.[52]

By far the most decisive consideration in site selection was access to water. This fact, however, has not been adequately addressed in the historiography, as scholars studying Canada's industrial front make only tangential references to the environment. This obscures the centrality of water (and the environment more generally) to Canada's MIC. Water was an essential input at all stages of production. At the chemical and explosives plants, it was needed in the manufacture of sulphuric and nitric acids, and it was used to control the temperature

of chemical reactions during the production process. Moreover, the purity of TNT depended on a thorough washing of the final product with a sulfite solution. Washing TNT removed unwanted isomers and residual dinitrated toluene that stabilized the explosive compound. Without this final washing, the crude TNT was liable to detonate spontaneously.[53] Given these requirements, it is no small wonder that every chemical and explosive factory was located near a source of water.[54]

Water was also omnipresent in the filling plants. Although statistics are not available for every site, Pickering Works, on the shores of Lake Ontario, consumed over 1 million gallons per day for all operational purposes, including drinking water, toilets, and for cleaning shells, machinery, and facilities.[55] Water was also integral to workplace safety, as employees were surrounded by toxic chemicals and combustible hazards. All were subject to stringent safety protocols that were designed to prevent accidents. Before entering the "clean" side of factories (where explosives were filled), they left their clothes and possessions in locker rooms and donned special coveralls, rubber shoes, and headscarves. They were not allowed to wear jewellery, to smoke, or to carry metallic objects and anything else that might cause a spark on the clean side.[56] When handling TNT and other high explosives, workers were trained to limit contact with masks, goggles, and gloves, as the toxic dust, fumes, and residues could be inhaled, ingested, or absorbed through the skin, causing sickness, skin irritations, liver damage, and in fatal exposures, toxic jaundice.[57] However, photographic evidence suggests that some of these precautions were not always followed (Figure 1.1). After each shift, foremen and supervisors ensured that all workers showered on-site to rinse off the contaminants and explosive residues that had collected on their bodies and hair. The uniforms were then laundered on-site and readied for the next shift.[58]

These health and safety protocols were augmented by the factory's layout and equipment. In rooms where TNT was handled, fans improved ventilation, and dust-proof hoods were installed on the transfer hopper, a machine that broke down clumps of TNT into flakes before they were melted and poured into shell casings.[59] Moreover, every building had water piped throughout its rooms for fire prevention, and emergency showers were always located adjacent to acid treatment areas and other danger zones. Water was needed for production purposes as well. Rooms and equipment were constantly washed with cleaning solutions, not only to protect staff, but to maintain machinery in peak working condition and minimize cross-contamination from foreign substances.[60] Particular attention was devoted to the TNT melter and ammonium nitrate incorporator. Every day at noon, both machines were shut down for a thorough

Figure 1.1 Assembly-line staff use pouring pots to fill shells with liquid TNT. Note the large storage kettle operated by two men at the left. This was where the TNT was kept warm before pouring. Few workers are wearing goggles or masks, and the ventilation comes from the windows at the right. | Provided by the Town of Ajax – P070-000-281, Ajax Archives.

flushing with hot water. Workers were careful not to create too much extra steam when hosing down the melter's interior since that would activate the emergency safeguards controlling temperature and "trip the water deluge valve ... and flood the entire building."[61] These safeguards were designed to prevent accidents or malfunctions from spiralling out of control, but it should not go unstated here that water was always considered the primary countermeasure in emergency situations.

Aftermath

Since munitions factories consumed such large volumes of water, they required a "sink" or drain for the resulting wastewater. Contamination was the inevitable by-product of production, and it carried a heavy environmental toll. Each stage of production introduced many toxic chemicals, acids, explosive residues, and other types of hazards into the water flowing through the facilities and then into the environment. When locating and building factories, DIL and AWSC planners sought to harness the proximity of rivers and lakes, not only for production purposes, but also for their dilution capacities. Therefore, Canada's MIC

tapped into the nation's immense freshwater resources to engineer a convenient solution for effluent disposal while simultaneously expediting wartime production. In doing so, it militarized landscapes and reshaped environments at production facilities.

Effluent disposal was a key part of operational efficiency: factories could produce munitions only as fast as they could discharge the wastewater. TNT and cordite were particular concerns. The manufacture of TNT is water-intensive at both ends of production, and the effluent from purification and washing is called "red water," whereas "pink water" is generated by washing facilities and machinery. Both terms refer to the varying shades of red created by the complex mixture of organic constituents, non-symmetrical isomers, and nitroaromatic compounds and associated salts. The darker the red, the higher the concentration of contamination. Red water, in particular, is toxic, carcinogenic, and mutagenic, and it does not biodegrade easily. If left untreated, its contents will persist in the environment, contaminating soil and groundwater and causing long-term ecological and public health problems.[62]

To deal with TNT effluent, Canadian planners followed American and British precedents by constructing a series of interconnected drains and ditches at each site. The drains took in wastewater and other production runoff from inside the buildings and piped it to outfalls that emptied into several "tributary ditches" that flowed into a larger "main" ditch. These outdoor sewers were not enclosed. Instead, they were left open-faced so that the effluent was exposed to sunlight, which aided in decomposition as the polluted water traversed through the tributaries and main ditches that criss-crossed the site. Each ditch had baffles, catchment tanks, and holding ponds that collected the heavier particles and residues in the sediment; scientific experts and technicians expected the remaining contaminants to be diluted by the main ditch before emptying into the closest body of water.[63] At the de Salaberry plant, the ditches flowed directly into the St. Lawrence River. At Nobel, effluent from TNT, nitroglycerine, and cordite production flowed through practically the entire site before draining into either Simmes Lake or toward the holding pond, aptly named "Guncotton Swamp," before flowing down "Guncotton Creek" into "Guncotton Bay" on Parry Sound.[64]

Some munitions factories required more elaborate arrangements. The Transcona facility, located on eight hundred acres southwest of Winnipeg, is one example. It was situated on the outskirts of town, in an area devoid of major waterways, so engineers had first to connect the plant to the Greater Winnipeg Water District aqueduct, which allowed it to take in approximately 10 million gallons of water every day for manufacturing sulphuric acid, nitric acid, and cordite (some of its main outputs). However, this one-way system did not allow

for effluent disposal. Thus, before production could even start, a massive ditch was dug to connect the facility to the Red River, over twelve kilometres away. By the spring of 1941, approximately 188,000 cubic yards of dirt was excavated through the North Transcona and East Kildonan neighbourhoods.[65] To shorten construction, engineers designed the ditch to empty into Bunn's Creek, which took the effluent the rest of the way to the Red River. In 2010, the Winnipeg Trails Association seized upon the popularity of the Second World War and opened the "Cordite Ditch" hiking trail bordering a portion of the old effluent channel, just south of the Transcona Railyards.[66] The project celebrated Winnipeg's wartime contributions and, ironically, provided a space for wildlife conservation next to a former sewer, which had moved an enormous volume of wastewater, laced with toxic substances and explosive residues, through residential and industrial areas.

Although the scale of development at Transcona was unique, effluent and water pollution were common issues at every factory. For instance, CIL commissioned a pollution study at the Brownsburg ammunition plant in 1956 to document the state of the West River, adjacent to the property. The report concluded unequivocally that the river was "polluted and unfit for aquatic life."[67] The deleterious situation, however, originated from wartime practices, as the report surmised that the river was at its worst in 1944–45, when a combination of low water levels and a lack of environmental regulations caused high concentrations of lead and acids to be discharged into the river. According to historical data on the river's flow and estimated production outputs at the plant, the amount of water was not sufficient to dilute the contamination: the concentration of lead in 1944–45 probably reached 2.4 ppm or about twenty-four times the "allowable concentration" according to the 1956 standards for safe drinking water (which the report's author used as a benchmark in his study).[68]

In the decade after the war, little was done to modify disposal methods, though staff monitored the river's flow to ensure that discharges were at least nominally proportional to expected dilution thresholds. As historian Jamie Benidickson shows, until the 1970s there was considerable reluctance and laxity on the part of federal and provincial governments to regulate water pollution, and since many municipalities pumped untreated sewage into nearby rivers without recourse, the effects of industrial wastes hardly merited more stringent oversights.[69] The engineers, scientists, and explosives experts who designed the drainage systems and perfected production processes showed little regard for the ecological consequences and contamination of explosives production. Instead, they were confident in their systems and reliance on dilution, though the end of hostilities exposed the limitations of their thinking.

The wartime emergency had overridden all considerations and prioritized rapid expansion, but as the volume of production increased, so, too, did the pollution. By 1945, most factories had been in operation for over thirty-six months, churning out chemicals, acids, explosives, and complete munitions every day. As a result, entire buildings and areas were "impregnated" by explosive residues lodged in the wood, piping, panelling, and concrete. Thus, before any factory could be shut down, converted, or dismantled, its building materials, machinery, equipment, and landscapes had to be decontaminated. In July 1945, Howe created the Plant Decontamination Committee (PDC) to oversee the postwar cleanup at surplus factories. Under the supervision of the PDC, war contractors and experts from the ammunition and explosives production branches in the DMS desensitized facilities and equipment before turning the properties over to the War Assets Corporation (WAC) for final disposal.[70]

To decontaminate the buildings and equipment inside factories, workers followed strict protocols. At the GECO plant, they used a combination of vacuums, high-pressure water hoses, and cleaning solutions of sodium sulphite and acetone.[71] After every room was thoroughly scrubbed from floor to ceiling, the metallic equipment was relocated and steamed to remove any remaining residues, the plumbing and airducts were flushed or removed for incineration, and the linoleum floors were upturned and systematically washed. Spot tests were made using matches or small controlled fires (called "flashing"), which could be dangerous depending on the level of leftover residues.[72] Anything that could not be cleaned or was too forgone was brought to the factory's burning ground. At every production site in Canada, certain areas were reserved for the destruction of production wastes and waste explosives by incineration.[73] Following the war, these burning grounds were used for destroying the cleaning solutions, wood, flooring, brick, topsoils, filters, piping, and any other contaminated materials. At the GECO plant, more than 6,800 tons of contaminated materials were set on fire in its proofing yard, and the polluted soil was later removed by bulldozers and trucked to a nearby garbage dump.[74]

At DIL factories, the advent of peace signalled a rush to downsize and demobilize – much to the consternation of the PDC. DIL employees showed little interest in desensitizing materials and equipment, as the company was not enthused about salvage and recovery costs. Therefore, it moved swiftly to tear down surplus factories and often resorted to area burning and other inexpensive shortcuts. At the Pickering plant, area burning included whole buildings, and any unneeded structures with thick concrete walls were toppled over and buried in large pits.[75] Similar tactics were used at the Bouchard factory, where DIL requested blanket permission to demolish or burn entire buildings and to destroy contaminated equipment. The PDC refused, citing opportunities for salvaging

lumber and building supplies for resale, but DIL proved less than accommodating. In September 1945, it reported the destruction of $192,000 worth of assets from Production Line No. 1, and subsequent reports from company officials recommended destroying another $700,000 worth of materials and equipment from the other three lines. In October, a special meeting was arranged between PDC and DIL officials to clarify the testing standards for contamination levels, cost estimates for salvage work, and acceptable justifications for destroying Crown property.[76]

Outside the munitions factories, the landscapes were also polluted, but the dangers could be difficult to locate. Lax record keeping and personnel turnover deprived technicians of first-hand knowledge of problem spots, and toxic residues were often difficult to remove or were hidden by years of neglect or by brush that sprouted back over time. Unexpected discoveries were not uncommon, such as when fifteen to twenty pounds of Tetryl pellets (a toxic yellow crystalline powder used in detonators) exploded during a burn at the GECO proofing yard in July 1945.[77] Area burning was a useful strategy for locating the invisible hazards, but it was not universally applicable. In those instances where burning was too dangerous, such as near the storage magazines or the entrances to production lines, war contractors resorted to excavating the topsoils with bulldozers and shovels to avoid missing anything.[78]

Unexploded ordnance was another concern, especially at proof ranges, since a dud shell's velocity could bury it deeply underground, rendering it inaccessible to clearance technicians years later. The St. Maurice proof range was a particular problem for the PDC. The costs to clear it by area burning were estimated to be about $50 to $65 per acre, leaving the final price tag somewhere between $100,000 and $125,000. The cost was high because personnel had to prepare the whole two-thousand-acre site "for an ordinary farmers' slash," and once the fires died out, a shielded bulldozer was needed to plow the charred ground to unearth buried ammunition.[79] Given the steep costs, the PDC chairman referred the matter to his superior, G.K. Sheils, deputy minister of the DMS, who recommended foregoing "fuller decontamination" and limiting clearance to the building area, roads, and other access points. This left most of the range and its many unexploded bombs untouched, until the forest fires swept through in 1949.[80]

The drainage systems at Nobel and Transcona were the largest and most expensive problems for the PDC, as both plants were shuttered and scheduled for disposal after the war. At Nobel, technicians had difficulty decontaminating the solvent and acid storage tanks, so eventually they resorted to packing them with combustible materials and lighting a controlled burn to clean them out. Similar improvisation characterized the treatment of the nearby effluent

ditches for TNT, nitroglycerine, and nitrocellulose. In early 1946, the PDC ordered the "flushing out" of the entire drainage system, as well as the additional precautions of extensive area burning, the dredging of contaminated soils and sediments, and the use of prima cord to detonate any hidden explosive materials. In the spring, the site was handed over to the WAC and its contractors finished up the work.[81] At Transcona, DIL implemented its experiences from Nobel, with the result that operations moved more smoothly as its personnel worked quickly to blast out and burn the ditches. To save time and money, DIL recommended filling in the nitrocellulose settling pond with loads of dirt, but the PDC concluded that this would not bury the explosive residues at a depth preventing future recoveries or accidents. Instead, it ordered the pond drained and the sediment "treated [burnt] to remove the hazard" before it was filled in.[82]

Despite these measures, the PDC was well aware that its remediation tactics were untested over the long term. Therefore, it could not guarantee that DIL and other contractors had cleaned up every explosive hazard or iota of contamination. In February 1946, its officials noted that any future construction located near munitions factories, and especially the Transcona and Nobel sites, was liable to encounter residual explosive materials.[83] As an additional precaution, it paid for the installation of fences and warning signs on the shores of Parry Sound at Guncotton Bay after technicians made a final sweep in the spring of 1946.[84] More recently, anecdotal evidence collected by concerned citizens has confirmed the PDC's earlier predictions. In the Nobel area, it is not uncommon for grenades and shells to appear on the beaches of Parry Sound and Georgian Bay, hunters share stories about deformed animals, and parents frequently warn their children about the dangers of swimming and fishing in the nearby Simmes Lake.[85]

In other cases, decontamination efforts achieved different objectives. For instance, three large munitions plants (the Villeray and Verdun Works in Montreal, and the John Inglis plant expansion in Toronto) were decontaminated, cleared, and renovated to offer small and medium businesses industrial floor space for manufacturing civilian goods. During a time of severe economic dislocation and steep rental prices in major cities, these low-rent "multiple tenancy" initiatives (operated through the WAC) provided important opportunities for over eighty companies and generated over six thousand jobs producing a host of new goods, from electrical equipment and glassware to clothing and processed foods.[86] Such tactical-to-practical conversions of old munitions factories demonstrate a tangible legacy of Canada's MIC, as defence dollars had built up an infrastructure and capacity that yielded spin-off civilian benefits in peacetime.

These spin-off benefits also extended beyond the confines of the factory buildings, as the wartime influx of labour, capital, and development spurred lasting environmental changes in surrounding regions. For example, the DIL Pickering plant brought an influx of over nine thousand workers to the area during the war, but initially the region was almost entirely devoid of accommodations and amenities. Therefore, defence expenditures stimulated the construction of more than just railroads, ditches, magazines, pumping stations, and production lines: homes, dormitories, cafeterias, recreation centres, hospitals, parks, stores, schools, and other amenities followed. By the midsummer of 1941, so much mail was flowing in and out of the small prewar Pickering post office that DIL established a satellite branch inside the factory. A naming competition was organized, and though most workers referred to the sprawling facility colloquially as "Dilco" or "Dilville," these popular nicknames lost out to the famed exploits of HMS *Ajax* during the Battle of the River Plate in December 1939. Henceforth, the region would be known as Ajax.[87]

Defence expenditures remapped more than just placenames in Canada, as military spending spawned permanent development, urbanization, and industry. By 1942, in Ajax, roughly six hundred families had moved into the housing built near the factory, and the number of children steadily increased. As a result, DIL established the Lord Elgin School and paid its staff of one principal and eight teachers. The school was completed in October 1942, just after the first church was erected, and in May 1943, the first grocery store opened its doors. Following the war, a large portion of the Ajax plant was taken over by the University of Toronto's Faculty of Applied Sciences, where it trained veterans for civilian careers (see Figure 1.2).[88] In 1948, the federal government's new Central Mortgage and Housing Corporation (CMHC) took over development in the area, acting as the de facto municipal government until the province established one in 1950. Through the CMHC's efforts, several Canadian, British, American, and Swedish companies moved to Ajax in the late 1940s, which sustained employment in a region that "would otherwise be a ghost town" following the end of munitions production.[89] Ajax managed to navigate the boom-and-bust pattern of wartime expansion better than other places, as a more balanced economy emerged from a near total dependency on defence spending and war contracts. Such a transition demonstrates, not only how a cycle of "defense dependence" emerged in Canada, but also how the nation's MIC profoundly affected the environment.[90] The confluence of political, military, and financial resources altered landscapes and demographic patterns to fundamentally reshape the ecological history of many regions across the country.

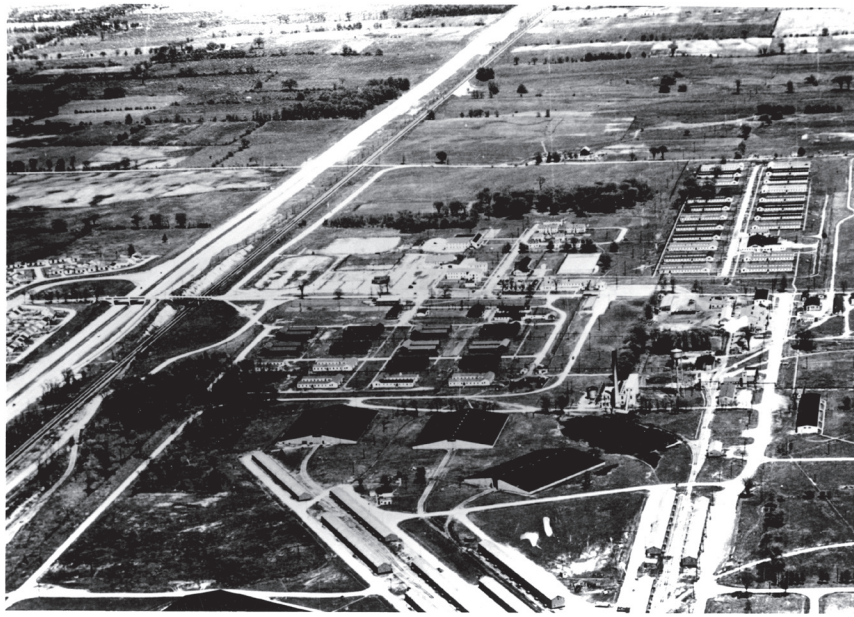

Figure 1.2 Aerial photograph of the University of Toronto's Ajax Campus after the war. The wartime houses are on the left. The DIL buildings-turned-classrooms are near the centre. | Provided by the Town of Ajax – P230-001-040, Ajax Archives.

Conclusion

Between 1940 and 1945, the DMS established a productive munitions industry that added considerably to Allied arsenals. The deteriorating military situation from 1940 to 1942 necessitated radical political, economic, and strategic interventions to facilitate the rapid emergence of what O.J. Firestone, deputy director-general of the Economic Research Branch in the DMS, later termed Canada's "wartime industrial structure."[91] The symbiotic partnership between private and public enterprise entwined political, military, industrial, and academic interests to forge the foundations of Canada's MIC during the 1940s.

The remarkable achievements of Canada's industrial front materially aided the Allied cause, as approximately 70 percent of all output went to other countries, with the British receiving the largest share.[92] Canadian factories were key contributors to the global arms trade and imperial supply channels, but they were almost entirely dependent on export markets and artificially high wartime demands. Canadian defence production was thus far in excess of future military and domestic requirements. This imbalance was thrown into sharp relief once hostilities ended and Mackenzie King ordered a rapid demobilization, deep cuts to defence spending, and widespread disposal operations for surplus munitions

and supplies. The postwar retrenchment of the armed forces made large-scale munitions manufacture in Canada unsustainable over the long term, particularly as the American and British governments shifted focus to domestic production.[93]

When Germany and Japan were defeated, the vast empire of munitions plants operated through the DMS was shut down or converted into peacetime production. A small rump of plants, technology, and expertise was consolidated under the mandate of a new Crown company, Canadian Arsenals Limited (CAL), founded in September 1945, which oversaw a truncated postwar armaments industry until it was privatized completely in the 1980s. The de Salaberry and Cherrier plants, among others, were transferred to CAL, as a smaller but permanent defence-industrial base took root in Canada to supply the ongoing needs of the Canadian military and international clients – a theme discussed by other chapters in this collection. The environmental impact of Canada's munitions industry remains an open question, despite the increasing scope of government regulations against pollution over the latter half of the twentieth century. The ecological degradation and disruptions, as well as the contamination and public safety risks caused by munitions factories, were the by-products of wartime necessities and key elements of Canada's home front contributions to Allied victory; but they also left hazardous legacies for all Canadians growing up in the long shadow of the Second World War.

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