PRODUCING BARRELS FROM BITUMEN: A POLITICAL ECOLOGY OF PRICE IN EXPLAINING THE CLASSIFICATION OF THE ALBERTA OIL SANDS AS A PROVEN OIL RESERVE

by

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A thesis submitted in conformity with the requirements for the degree of Master of Arts in Geography and Environmental Studies, Graduate Department of Geography, Program in Planning and Centre for Environment, UNIVERSITY OF TORONTO

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Abstract

In December, 2002, the oil sands of Alberta, Canada – earlier seen as an obscure, obstacle-ridden scientific project – were for the first time included in the Oil & Gas Journal’s year-end review of worldwide oil reserves. To explain this decision, the editors of this established trade magazine cited the basic neoclassical economic theory of price-driven resource substitution. This thesis contends, however, that the neoclassical theory explains little of how it became possible to profitably extract petroleum from Alberta’s bitumen-saturated sands. Merging insights from resources geography and Science and Technology Studies, it fleshes in much-needed detail and dimension to the neoclassical account by emphasizing the role of key actors and decision-makers, within the state and private sector, who have actively researched oil sands geology, pursued technological strategies, and negotiated environmental costs and regulations. The implication is that substitution between two materially different resources is rarely an independently propelled or inevitable response.
Acknowledgements

For the strongest parts of the work that follows, I owe a profound thank you to many for their knowledge, ideas, and support. First and foremost, Professor Scott Prudham has guided my initial confused and somewhat scattered ideas into more stable and confident arguments. For his ongoing encouragement and patient tutelage I am very grateful and hold great respect. I would also like to thank Professor Doug MacDonald for his highly engaging teaching style and willingness to help work through my ideas far beyond scheduled classroom time, as well as Professor Matthew Farish for the direction and motivation he has provided both on and off the soccer field.

My peers in the department have unequivocally added to and enriched what I have learned in formal academic settings. I wish to sincerely thank the older crew – Emily Eaton and Kate Parizeau especially, but so many more – for taking me under their wing and holding what seemed at times undeserved confidence in my abilities. With those I have struggled through the MA program with, I have learned so much – especially from drinks, discussions, and cultural/cottage events with Joanna, James, JJ, Julia, Vivien, Matthew, Dan, Jenny, and Max. I am confident that your amazing personalities will all find you success, whether in academia, or in your many other impressive pursuits.

The solid foundation on which I’ve been able to set upon this project is really my family. My dad and Helen generously provided a roof over my head while I wrote this thesis, as well as utmost patience with what turned out to be a much longer process than I originally intended. My mom is both a confidant and an incredible example; I am very proud to be reading her dissertation soon. I have always looked up to my brother, Anders, and with all his encouragement and genuine interest I continue to do so.

The time and resources I was able to devote to this thesis have hugely benefited from a Social Sciences and Humanities Research Council Joseph Armand Bombardier Scholarship (SSHRC scholarship no. 766-2008-0877). Further, the research underpinning it would not nearly be as thorough without the gracious financial support of my supervisor, Professor Scott Prudham, and of the Department of Geography, Program in Planning’s McMaster Trust Award, which enabled be to travel to the Provincial Archives of Alberta in Edmonton, and to Fort McMurray to actually see the Alberta oil sands.

It must be said that all mistakes, omissions, and limitations of this thesis are of my own doing.

And – finally – I owe a lot to Jonas for many illuminating long- and short-distance discussions, and for imparting to me the important and frightening meaning of the saying that thought happens ‘without a handrail’.
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<th>Full Name</th>
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<tbody>
<tr>
<td>AOSERP</td>
<td>Alberta Oil Sands Environmental Research Program</td>
</tr>
<tr>
<td>AOSTRA</td>
<td>Alberta Oil Sands Technology Research Authority</td>
</tr>
<tr>
<td>CAPP</td>
<td>Canadian Association of Petroleum Producers</td>
</tr>
<tr>
<td>ERCB</td>
<td>(Alberta) Energy Resources Conservation Board</td>
</tr>
</tbody>
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1 Introduction

The petroleum beneath the ground of north-eastern Alberta remained largely untouched since it was originally deposited, approximately over 100 million years ago, by the same east-west tectonic collision that thrust up the Canadian Rocky Mountains and the Rocky Mountain foothills (Mossop, 1980; Selby & Creaser, 2005). At that time, pressure from the uplifting Rocky Mountains forced mature, marine oils to migrate north and east up the sloped Western Canada Sedimentary Basin. Trapped by the Basin’s edge from traveling further, and sealed off from above by limestone shales, the oil saturated the sandstone deposits left over from Alberta’s ancient rivers, coating a thin film around the sand and clay grains (Head et al., 2003; Shuqing et al., 2008; Kleindienst, undated).

Over time the physical composition of this oil changed in important ways. Close to the surface, percolating waters leached the light components from the pooled oil, leaving it highly viscous and largely immobile at reservoir conditions (Mossop, 1980, p. 148; IEA, 2005; Clark, 1927). Beneath an encroaching mat of aspen and spruce forest and muskeg, microorganisms also worked to degrade the oil into a denser form, rich in sulfur, nitrogen, and metals (Shuqing et al., 2008; Redford & Meyer, 1989). On a more recent time-scale, certain First Nations and Métis people, including the Cree, Chipewyan, Prairie Dene, and Anzac Métis, pitched the seams of their canoes with the tar-like sands that seeped from the exposed banks of the Athabasca River (Alberta Energy and Utilities Board, 2000, p. 1; Chastko, 2004, p. 2). But it was not until the latter half of the 19th Century that the enigmatic material began to be transformed into an object of scientific and commercial investigation. Then, the first crude drills broke into the land in a vain

In December, 2002, the highly regarded international petroleum magazine the \textit{Oil & Gas Journal} accepted the sands as a proven oil reserve in their year-end worldwide reserves report for the first time, indicating that the possibility of producing this resource had, protractedly, been achieved (Radler, 2002). This critical revision was informed by reserves data compiled by the Alberta Energy Resources Conservation Board (ERCB) and publicized by both the Alberta Government and the Canadian Association of Petroleum Producers (CAPP), the latter the major trade association representing the oil and gas industry in Canada (Radler, 2002; Government of Alberta, 2003; Anderssen et al., 2008; EUB, 2000). Although the ERCB had and would continue to calculate crude bitumen reserves separately from crude oil reserves, in public releases the Alberta Government and CAPP incorporated the Alberta oil sands directly into their account of Canada’s proven crude oil reserves. As a result of this calculation, and as would over time be taken up in the press, in industry publications, and by major energy agencies, Canada’s oil reserves jumped from 4.8 to 180 billion barrels of oil, taking position

\footnote{Other forms of industrial activity were also attempted in the early 1900s, due mainly to the difficulties of extracting oil from the sands (Chastko, 2004, ch. 1). These stunted enterprises included: first, abandoning the oil entirely in favour of mining nearby salt deposits; second, deriving inputs for the manufacture of explosives from the sands; and last, turning the sands into a (largely unsuccessful as overly sticky) road paving and roofing material (Chastko, 2004, ch. 1; Carrigy & Kramers, 1973, p. 177; Oil Sands Discovery Centre).}
“second only to Saudi Arabia” among oil producing countries (Radler, 2002, p. 113; Anderssen et al., 2008; Gerth, 2003). Although some were skeptical of the sudden vaulting of Canada’s reserves by 175.2 billion barrels (Gerth, 2003; Olive, 2003), other commentators, such as the author of the *Oil & Gas Journal*’s reserves report, Marilyn Radler, reasoned that the previously ‘uneconomic’ resource could be shifted into the category of an established oil reserve due to increases in the commodity price for oil and, as a key factor in lowering the supply costs for oil sands projects, advances in technology (Radler, 2002; Knapp & Group, 2004; Anderssen et al., 2008). This reasoning reflects the underpinning of oil reserve classifications by the neoclassical economic theory of resource substitution, which assumes that a sufficient growth in the price of a finite resource as its stock is exhausted makes available a lower grade, less accessible, or otherwise substitutable resource (Pearce & Turner, 1990; Rees, 1990; Barnett & Morse, 1963; Hotelling, 1931).³

The straightforward understanding of resource extraction as rising and falling with movements in market price, however, has been shown to be overly mechanistic and relatively inattentive to the political-economic processes by which resource exploitation becomes possible (Bridge, 2003, 2007; Hayter et al., 2003; Bradshaw, 2007; Bakker & Bridge, 2006; Barham et al., 1994). In this vein, scholars within a broadly conceived resources geography have added much to understanding the complex terms of resource access and circulation. In this paper I combine insights from resources geography on the

³ In neoclassical economic theory, the relationship between market price and the technical ability to produce a resource is sketched in with fairly broad strokes. Essentially, it is assumed that the price mechanism is the ‘first mover’ with regards to the decision to extract a resource, and so long as the demand for a resource keeps up with the price path, a backstop technology will automatically be developed. That said, empirical studies do get into more detail as to the behaviour of backstop technology (Pearce & Turner, 1990, p. 276).
politics surrounding nature-based production with scholarship in Science and Technology Studies that examines the expansive and ongoing work that goes into stabilizing scientific and technological objects, among which I consider oil reserve estimates. Together these two increasingly overlapping literatures help to answer the broad research question informing this paper: *by what perceptions and practices does market price (and supply cost) appear as objective, or independent, evidence of the viability of resource extraction?* By perceptions, I refer to the relative values attributed by actors to the interwoven aspects of oil sands extraction, namely: geology, technology, ecology, and economics, as well as to the research and regulatory institutions that differentiate and govern these spheres. By practices, I refer to a specific set of government and industry regulatory decisions and procedures, including: law, policy, administration, collaborative research agreements, classifications, and calculations. Further, *to what extent have the oil sands become possible to produce simply because of a rise in the market price for conventional oil?*

My argument is that, while at a coarse-grained focus, oil sands development has paralleled steadily climbing oil prices, there are a number of factors that limit the explanatory power of the neoclassical account. First, in claiming that the price mechanism provides perfect information on resource scarcity, and at the same time that the degree of resource scarcity determines market price, the neoclassical account is overly simplistic, tautological, and does not explain the actual *process* of resource substitution. In particular, it does not account for the role of key actors and decision-makers, many within the state but also within the private sector, who have actively researched the unfamiliar and highly heterogeneous geology of the oil sands and pursued
technological strategies for their extraction. In identifying the series of perceptions, decisions, and practices that made oil sands extraction possible, this thesis makes the case that resource substitution is not automatic, but a malleable, contingent, and politically driven process. Further, the possibilities and constraints of resource substitution are shaped through investment and research decisions that drive down price over time.

But the institution of price and cost as metrics of the viability of producing the oil sands has been incomplete and subject to exceptions on all fronts. In the second stage of my argument, I show that the ability of market price and, implicitly, supply costs, to appear as independent evidence of the oil sands’ commercial viability has depended on government decisions and practices that have displaced the technological, financial, and ecological risks associated with the material differences of this petroleum resource. Rather than understand these exclusions as ‘externalities,’ an economic term for social costs that are created as external byproducts of private market transactions, I argue instead that they are better seen as constitutive of the commercial viability of oil sands projects. While the cost of producing the oil sands has represented the crystallization of information on oil sands geology and technologies of oil sands extraction, I show that this is not necessarily perfect information. Rather, it is information that is asymmetric and which involves some things counting and others not - such as, as I discuss, reclamation and other environmental costs. Although left out in the initial stages of decision-making, these exclusions continue at every point to present themselves to project economics and project boundaries, helping to explain why, despite triumphalist accounts stirred by the 2002 reserve classification, the economic viability technological feasibility of oil sands projects remain unstable.
The thesis is organized as follows. Chapters 2 and 3 respectively detail my research methods and a review of the secondary literature relevant to this study. Chapter 4 discusses the crystallization of geologic knowledge on the bitumen-saturated sands, emphasizing three periods markedly distinguished by geological discourses, government institutions, and economic values surrounding the production of commodities from the oil sands. In the fifth chapter I examine the process of technological innovation, which at many points did not respond to the price mechanism, as neoclassical economics would suggest, precisely because of the risks and uncertainties associated with the differences of extracting bitumen when compared to conventional oil extraction. In the sixth and final chapter I examine the environmental transformations that have resulted from oil sands extraction, showing how these have been constitutive of a particular form of viability for oil sands projects.

I rely mostly on documentary sources to excavate the practices of government and industry that have helped to shape supply costs and the 2002 reserve classification. I use the term documents in a broad sense to refer to the material traces left by governments, firms, and individuals (Scott, 1990; McCulloch, 2004). Where holes existed in the information provided by documents, I consulted public figures with expertise on a given issue, as well as secondary literature. The research also benefited from a trip to the Provincial Archives of Alberta in Edmonton, and to the peripheries of the Suncor and Syncrude oil sands sites and to the Oil Sands Discovery Centre in Fort McMurray, Alberta. In Fort McMurray I was able to experience first hand the perspectives of those drawn in by the pull of oil sands economic growth, as well as the busy back-and-forth of giant mining trucks contrasted with abandoned extraction technologies posted at the
highway’s edge – reminders of past obstacles and inefficiencies. These experiences reinforced the concreteness of the project, both animating and challenging my interpretation of documents.

The seeming inevitability of oil sands development has presented the foremost challenge to me in thinking through the research problem. Archival documents dating to the 18th century quote the first Europeans explorers of the area as speculating on a future when the black, sticky, tar-like sand they confronted would become an ‘economic resource’. Government and industry documents likewise take up and hold to this term, and numerous variants of it: ‘economic geology’ (Carrigy, 1959), ‘economic oil sands zone,’ and ‘economic time frame’ (Techman Ltd. & Rheinbraun Consulting GmbH, 1979). As a result, the shift from a resource to an economically viable oil reserve appears inevitable, and an alternate historical trajectory very difficult to imagine. Further, the terms of business-government fiscal agreements, technological extraction and processing methods, and environmental regulations also seem to an extent hemmed in by the material constraints of this relatively unfamiliar resource, and the long-standing dependence of the Alberta economy on a limited number of extractive industries (Barr & Smith, 1984, p. xvi).

It has been emphasized elsewhere, however, that the ability of economics to accurately represent the world it describes results from, to some degree, decisive acts or, perhaps more often, many slow, broad-in-scope, and iterative changes that institute a specific system of markets, money, and trade (Polanyi, 1977, 1992 [1957], 2001; Mitchell, 2002, 1998). This insight can help to confront the above two deterministic views of oil sands development in the following ways. In terms of the long history of
speculation on the economic potential of the oil sands, it can help differentiate between
the perceptions of the early explorers, scientists, industrialists, and government officials,
and those from the early 20th century on. Consequently, there is a difference between
what was considered a resource – especially an economic one – in earlier periods, and the
terms that would constitute such a resource now; it may have been inevitable that the oil
sands did become a profitable resource to extract, but the terms by which this happened
were not predetermined.

In terms of the second deterministic view – that the terms of project leases have
been limited by the material constraints of the resource and the dependency of the
province on a limited number of raw materials, I focus on the way regulations responded
to and interacted with the constraints and unknowns of oil sands extraction in such a way
that either resolved or weakened the ongoing viability of projects. This understanding
allows for shifts in the constraints and unknowns with changes in the mode of regulation:
“the framework of institutions, legislation and customary relations between corporations,
the state and activist groups,” that had formerly enabled firms to access oil sands leases
and that had contained social conflict over historic practices of waste disposal (Bridge,
2000).

The success with which I make these arguments is in part limited by the
information I was able to access. At the federal archives donors had closed collections
that could have provided alternate or more recent information on oil sands development.
At the provincial archives, freedom of information laws limited access to most
documents dated past the late 1980s, and due to time constraints I could not go through
the lengthy and uncertain process of asking for them to be opened. Where possible I
draw on the secondary literature that has been written on the subject to fill in these gaps, although the relative sparseness of more contemporary literature, combined with the time constraints of my own project, does not entirely resolve the unevenness of my data across historical periods.

Before reviewing the secondary literature I draw on for my exploration of oil sands viability, I wish to emphasize that while numbers – such as reserve estimates, market prices, and supply costs – give the appearance of objectivity, meaning they are provided as at once independent and impartial evidence of things, they too reflect codified values and the ongoing negotiations of competing interests and ideas (Poovey, 1998; Porter, 1995). My central aim in this paper is to show that the possibility of extracting petroleum from Alberta’s bitumen resources did not simply or automatically follow a rise in the market price for conventional oil. Bringing to light the supports and exclusions that have allowed bitumen to circulate within the conventional oil market opens up the normative question as to whether sizeable government funds could have been allocated to alternative, less precarious state-supported resource substitution responses, such as those that would decrease energy consumption or encourage renewable sources of energy.
2 Literature Review

The dominant explanation of how it became possible to profitably extract oil from the bitumen-saturated sands is that world oil prices reached levels high enough to support the higher costs of bitumen production. This explanation finds its basis in the neoclassical economic theory of resource substitution. In this section, I first detail the origins of this theory, which, as I discuss, is now standard in both modern, mainstream resource economics and in accounts of oil sands development provided by governments, industry, and most academics. I then turn to the two literatures that I rely on, to differing degrees, to add much-needed detail, dimension, and correction to the neoclassical economic model of resource growth. In the second part of this section I review the relevant literature within the field of Science and Technology Studies, whose main contribution to this study is its assertion that science and technology do not reveal impartial knowledge, but decisively shape the behaviours and objects that they study. On its own, Science and Technology Studies tend to falter in explaining the power relations involved in the production of scientific knowledge, especially as these relations change over time. Therefore, I turn in the third section to the main body of literature that I use to inform my study: resources geography, a revived line of inquiry that looks broadly at how the specific material qualities of a resource interact with the social and political context of its production. The result of this interaction is a trajectory of resource development that, far from automatic or independently propelled, is rooted in the biophysical properties and processes of the resource, and the historically and geographically specific regulations, institutions, and practices that surround its production.
2.1 The neoclassical economic argument of resource growth

Oil reserve classifications are based on the premise that a sufficient growth in the price of a finite resource as its stock is exhausted makes available a lower grade, less accessible, or otherwise substitutable resource (Pearce & Turner, 1990; Rees, 1990; Barnett & Morse, 1963; Hotelling, 1931). This premise reflects the underpinning of reserve classification systems by neoclassical economic theory. Originating in the 1870s, neoclassical economics formed as several professional, academic economists independently broke with their classical predecessors, who had followed Adam Smith in believing that the price of a commodity directly reflected the amount of labour performed to produce or acquire it. Neoclassical economists, including, prominently, William Stanley Jevons, Carl Menger, Philip Wicksteed, and Leon Walrus, instead posited that prices resulted from aggregated individual calculations of marginal utility; calculations of the increased satisfaction that individuals would gain by choosing one good or service over another, under constraints of income and choice. Price was therefore understood to be formed in the interaction between supply – the amount of a commodity that was available, now understood more as a product of technological progress – and consumer demand – the amount of a commodity required, determined by the constrained preferences of individual buyers (Pearce & Turner, 1990, p. 10). In truth, much more attention focused on the factors influencing consumption than on the supply side. This was the particular result of neoclassical economists’ increasing focus on theoretical economic problems, for which productive factors were simply assumed to exist in given
quantities – their existence determined by elements “outside the purview of economic analysis” (Blaug, 1997, p. 278).

Neoclassicists found that, in these theoretical economic models, the interaction between supply and demand tended towards equilibrium, and that the resulting price – rather than the observed physical quantity of a resource – could provide information to producers and consumers on the real-world scarcity of a commodity. The assumption of a constant equilibrium between supply and demand put to the fore the concept of resource substitution: it was thought that the increased production costs associated with a resource commodity that was becoming scarce would eventually make it desirable (‘optimal’) to begin to extract an equally costly substitute to that resource (Blaug, 1997, p. 280). Setting the groundwork for the new law of resource substitution was the idea of rational individuals who would satisfy their wants by allocating their scarce capital between substitutable goods, calculating which goods would contribute most to their individual satisfaction.

While scarcity therefore took on new permanence in neoclassical economic theory, at the same time the assumption that markets would, by themselves, effectively manage resources through ongoing substitution responses relegated scarcity to the sidelines of economic thought. Michael Perelman notes that
Despite the obvious importance of natural resources, economists have paid little attention to the subject. For example, the term scarcity appears in an article title only 27 times on JSTOR, a multidisciplinary database of scholarly journals that includes full archives up through July 2002 of 97 business and economics journals. Some of these journals have been publishing for more than a century (Perelman, 2007, p. 81).

Faith in the possibility for successful substitution became central to the sub-discipline of resource economics, and was effectively summed up by Harold Barnett and Chandler Morse who, in what is considered to be the “bible of resource economics” (Perelman, 2007, p. 82), wrote that, “Nature imposes particular scarcities, but not an unescapable general scarcity,” (Barnett & Morse, 1963). It should be stated that such optimism was not shared by the early neoclassical economists, but emerged later around the time of Howard Hotelling’s (1931) article ‘The Economics of Exhaustible Resources.’ Hotelling asserted that subsurface resources could be understood as interchangeable capital assets, “the value of which can be realized only by their extraction and release into the economy,” (Bridge, 2008, p. 391; Hotelling, 1931). Further,

Because of the tendency to discount future value relative to present value (as measured by the discount rate) a decision to leave minerals in the ground – i.e. to conserve mineral stocks – is rational only when there is an expectation that mineral prices will rise at a rate exceeding the discount rate (Bridge, 2008, p. 391).

This logic reinforced the possibility for seemingly endless substitution responses. While the absolute stock of a specific resource might be diminished, as resource prices

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4 In fact, one of the first neoclassical economists, William Stanley Jevons, was centrally concerned with the ability of supply and demand to settle at an efficient equilibrium. Jevons argued in The Coal Question that the heightened efficiency and economy of industry, spurred by recent technological innovations such as the coal blast furnace, were bound to exhaust Britain’s absolute quantities of coal (Jevons, 1865, p. 140-142). The famous ‘paradox’ he drew from this observation was that conservation gains made “in any branch of manufacture” would be outstripped by the overall expanded demand that the increased efficiency would generate, leading to faster inroads on the physical limits of the resource base (Jevons, 1865, p. 243). Jevons’ alarm about supplies of non-renewable resources proved at the time unfounded, as petroleum came to increasingly replace coal in the industrial machinery of Britain and North America.
increased over time with the real rate of interest the rising price trend would stimulate entrepreneurs to develop new technologies that would either make producing the original commodity more cost efficient, bring a new substitute into the fold of commodity circulation, or – what has been much less examined in the economic literature – lead consumers to economize, conserve, and recycle scarce resources (Rees, 1990).

However, critics have questioned the ability of price paths to accurately reflect resource availability, and the extent to which they do in fact bring about substitutes, new technologies, or behaviours that introduce greater economy in resource production and consumption (Norgaard, 1990, 1991; Perelman, 2007; Rees, 1990). In response, a large theoretical literature within economics has sought to expand explanations of resource supply to include a greater number of intervening parameters, such as ore quality, royalty and tax laws, governing institutions, consumer behaviour, and the deliberate attempts of foreign and domestic governments to alter prices and change the terms of access for resource extraction (Norgaard, 1990, p. 21; Hall & Hall, 1985). Despite that as a result the ‘conception in this [the theoretical economic] literature of a “[price] path” has become moot,’ the empirical economic literature has tended to ignore alternative indicators to price and cost when seeking to explain resource availability (Norgaard, 1990, p. 20). For example, the resource economists Partha Dasgupta and Geoffrey Heal defend the use of price as an efficient allocator of resources in the “belief…that for the purposes of developing a deep and intuitive understanding of the complexities of an economic system, it is best to abstract dramatically and consider only a skeletal

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5 These intervening variables all have particular resonance with the oil industry, where the quota and price-fixing activities of Standard Oil, the Texas Railroad Commission, the ‘Seven Sisters’ – the seven oil companies that dominated mid-twentieth century oil production, refining, and distribution, and the Organization of Petroleum Exporting Countries (OPEC), among numerous other actors, have been well-documented (Vietor, 1984; Yergin, 1992; Mitchell, 2007, p. 15; Philip, 1994).
representation of the key factors and their interactions,” (Dasgupta & Heal, 1979, p. 9). The postulate that resource substitution will follow rising prices has held its ground in modern, mainstream economics, especially prominent in arguments made by market optimists in ongoing debates over natural resource scarcity and the potential for sustained economic growth (Myers & Simon, 1994; Adelman, 1997; Solow, 1957, 1974).6

Following in this tradition, the Alberta Government, oil industry, government-industry research institutions, and certain academics who have approached the development of the Alberta oil sands have adopted and circulated the basic neoclassical explanation of oil production from the bituminous sands as an objective fact. The most empirically similar research to my project, the historian Paul Chastko’s (2004) Developing Alberta’s Oil Sands: From Karl Clark to Kyoto, likewise forms its central narrative around the determining impact of declining provincial and world supplies of conventional oil and rising prices of oil sands production. While Chastko does provide a well-researched 80-year history of the interactions of the state, the oil industry, and the scientific community in oil sands development, it is apparent that he distinguishes between these practices and the world petroleum market. He is also at times an unreserved booster of the economic returns of oil sands development. In fact, Chastko concludes his book apprehensive of the impacts the federal government’s ratification of the Kyoto Protocol to reduce greenhouse gas emissions might have on the supply costs of oil sands projects; and despite having based his book on rigorous archival research, he

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6 See Colander (2000) for a description of six important ways in which modern economics has parted ways with neoclassical economics (Colander, 2000, p. 135 – 136). For example, Colander notes that modern economics is now less concerned with maintaining equilibrium in resource supply and demand and more concerned with theoretical models of growth, as well as applied policy modeling. Still, many of modern economists’ base assumptions can be traced to neoclassical economics, in particular the use of price as providing both information and stimulus to economic actors.
neglects to examine archived files on the environmental impacts of oil sands development. In a similar vein, the University of Calgary economists Frank Atkins and Alan MacFadyen revisited the story of oil sands development, still unfurling after Chastko’s 2004 publication, in 2008. Writing in *The Energy Journal*, Atkins and MacFadyen interrogate whether the oil sands, despite its material and historical differences from most other petroleum reserves, is now a “resource whose time has come,” (Atkins & MacFadyen, 2008). Although its authors spend most of the article acknowledging the extensive government programs and research funding that have “deliberately encouraged high cost oil sands production while holding low cost conventional oil off the market,” they still conclude that the oil sands does not differ “in any meaningful way from other oil resources,” (Atkins & MacFadyen, 2008, p. 96). The reasoning behind this assertion is that, “In recent years, Alberta government policy has been largely consistent with this view [the view that reserves are “economically efficient to produce at current and anticipated prices”], as projects are assessed in light of market conditions,” (Atkins & MacFadyen, 2008, p. 96). In making this argument, the authors ignore the continuation and in many cases amplification of government-supported research, provincial government and business lobbying, and regulations and other practices that deliberately seek to influence the supply costs of oil. What the conventional neoclassical theory does not explain is why costs rise and fall, and how prices are ‘made’.

It is clear that the accounts that view natural resource extraction mainly in terms of technological and market forces are unable to account for some important features of oil sands extraction in Alberta. The neoclassical approach is least able to explain why,
despite that feasible technologies to produce the oil sands were generally accepted to exist in the 1920s, and commodity prices for crude oil rose to levels in 1979 that had not been reached since 1864 and would not be reached again until 2005, oil production from the oil sands did not begin to consistently increase until the late 1980s – a period typified by internationally depressed crude oil prices (see Figure 5.2). At this fine grain of analysis, market price fails to explain both sustained entrepreneurial interest in the oil sands resource, and the timing of technological innovations that made it possible to extract and refine oil sands into synthetic crude oil and crude bitumen.

There are many reasons why the neoclassical economic explanation falls short in accurately representing resource availability. Three important weaknesses of this explanation can be distilled in the context of the Alberta oil sands. First, neoclassical economic models are unable to account for the ‘irrational’ or, moreover, the distinctly human characteristics of economic actors, that is, their fears, ambitions, and uncertainties. In the case of the oil sands, for example, uncertainty over whether supplies of heavy oil from Venezuela and Russia would crowd out oil from the oil sands lead the Alberta government to accelerate research on extraction technologies even during lengthy price depressions. Behaviour that falls outside the mold of individual maximizers is evident at more that just the individual scale; the relations between economic actors often are not included in neoclassical economic explanations. These relations may be characterized by economic actors holding imperfect information and/ or asserting unequal power over one another. In a similar vein, the economic anthropologist Susan Narotzky has rightly pointed out that neoclassical economics does not indicate

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7 In the technological theorist, Jacques Ellul’s words, “Technique, and especially economic technique, does not encounter man in textbooks but in the flesh,” (Ellul, 1964, p. 219).
what transactional relationships come to count in determining price (Narotzky, 1997). For example, Alberta’s desire to exploit the oil sands in part lead it to successfully campaign the federal government to devolve control of all subsurface resources to the province; oil sands development could have taken considerably longer had the federal government maintained control of the oil sands, or as I will discuss, a different commodity produced from the oil sands entirely. The diffusion of technologies across different institutions and social groups is another example of the importance of human relationships to resource availability.

The second problem is that neoclassical economics does not provide much detail on the process of price stimulus and technological innovation. The large capital investment and technical infrastructure required to extract a resource – roads, pipelines, extraction and upgrading facilities – can delay resource availability until significantly after a price increase (Perelman, 2007, p. 84). Larry Pratt wrote presciently of Alberta’s oil sands in 1976, “The very nature of the resource demands giganticism” (Pratt, 1976); the economies of scale required to produce the oil sands have required correspondingly sizeable machine technologies, labour forces, and pipeline networks to bring the oil sands to market.

A third problem is that models based on ongoing substitution responses ignore the material differences between the original and substituting resources. Moreover, the environmental implications of these material differences are not given much attention. As Judith Rees has pointed out, “For most minerals, the degree of environmental change escalates as lower quality deposits are worked, the scale of operations increases and modern mass-mining techniques are employed,” (Rees, 1990, p. 46). Rees goes on to
question “what sort of society would be produced if market forces were indeed able to prevent the physical exhaustion of stock resources and were allowed to do so unchecked by government activity,” (Rees, 1990, p. 46). The different composition of bitumen and the different ecological effects associated with its production have affected, and threaten to further affect, the timing of oil sands development – as exemplified by delays in the environmental impact assessment approval process and in the proposed moratorium on oil sands development.

For all these reasons, neoclassical economics provides at best an incomplete and at worst an inaccurate, even dangerous, picture of oil sands viability. Incomplete, because market imperfections (such as imperfect knowledge and imperfect competition) are so ubiquitous as to be the norm, not the exception (Rees, 1990). Moreover, in claiming that substitution at the margin between supply and demand can occur with no real change in other conditions – not the least of which are changes in regional ecologies – the theory that resources are made available simply by market forces obscures the negative impacts resulting from substituting higher quality resources, for those of different or lesser quality.

2.2 Studies of science and technology

One way to challenge the automatism of the neoclassical economic explanation is to look at the reserve classification as an artifact of sustained scientific and technical inquiry. This is the approach of the sociologists, anthropologists, historians, and geographers within the field of Science and Technology Studies (STS) who have argued
the need to historically and spatially situate the ideological claims and practices that help to create scientific facts and new technologies. The strength of this approach stems from its roots in the substantive critique of science and technology made by seminal thinkers such as Martin Heidegger and Jacques Ellul, who defined technology not as neutral instruments or as mere machines, but as a way of relating to the world that was itself infused with instrumentality (Heidegger, 1977; Ellul, 1964). STS has carried on this line of thinking to examine how specific scientific disciplines, techniques, and technologies have been objectified – or made to seem as though they were neutral and self-standing – through practices of instituting, measuring, and maintaining specific scientific and technological systems.

Of relevance to my examination of the perceptions and practices involved in representing oil sands viability as purely a function of market price is research in STS that looks critically at classification (Bowker & Star, 1999), numbers (Poovey, 1998; Porter, 1995), and scientific practice (Latour, 1996; Bowker, 1994). For example, Bowker and Leigh Star (1999) offer fertile insights as to why the transition from an unclassified resource to an oil reserve should matter:

> At the level of public policy, classifications such as those of regions, activities, and natural resources play an...important role. Whether or not a region is classified as ecologically important, whether another is zoned industrial or residential comes to bear significantly on future economic decisions. The substrate of decision making in this area, while often hotly argued across political camps, is only intermittently visible (Bowker and Leigh Star, 1999, p. 3).

Bowker and Leigh-Star (1999) describe classification, in its broadest sense, as a way of segmenting the world based on spatial, temporal or combined spatio-temporal characteristics (p. 10). They further identify three requirements of classification systems: they are grounded in consistent principles, their categories are mutually exclusive, and
they are complete, providing “total coverage” of the world they describe (1999, p. 11). However, the authors note that classification systems all falter in some way in meeting these requirements and that, moreover, the contours of these divisions are not grounded in abstract, natural principles, but are internally contested, negotiated, and – only if consensus is achieved - stabilized.

Once in place, however, classification systems exert a “material force” on the built environment, on political decisions, and on everyday life (Bowker and Leigh-Star, 1999, p. 12). Yet, despite the enormous implications of classification, the decisions and processes that go into it are often either concealed, or relegated to the background of its everyday operation. Aiming to counter the invisibility and taken-for-grantedness of many classification systems, Bowker and Leigh-Star discuss the need for what they term an ‘infrastructural inversion,’ whereby not only the ‘tubes and wires,’ or material infrastructure, is turned ‘inside-out,’ but so are the workings of the scientific, research, and political organizations that enable specific classificatory decisions.

From very similar approaches, many other scholars have examined the particular rules, both formal and informal, that structure technologies and practices. Arguing that, “While…numbers and systems of quantification can be very powerful, the drive to supplant personal judgment by quantitative rules reflects weakness and vulnerability,” (Porter, 1995, p. xi) Theodore Porter provides a highly useful examination of the use of numbers as a strategy to communicate and make decisions. Applied to the context of the oils sands reserve classification, STS can help to explain both the difficulties in comprehensively calculating the quantity of oil in reserve, and of the value of beginning with the reserve estimate when trying to make sense of the strategy to scale up oil sands
production. In the words of the U.S. Securities and Exchange Commission (SEC), “Given that they lie in deeply buried geological formations, oil and gas reserves are difficult to measure and, until a company extracts them, it can only estimate their volume,” (SEC, 2007, p. 5). This is acknowledged even at the highest level of reserve classification - ‘proved’ reserves – in that their associated standard is only 90%. However, once a number is assigned to a reserve, this uncertainty is often removed, as well as the perceptions, practices, and decisions that went into its production (Bowker and Leigh Star, 1999).

The focus of STS on a multitude of involved actors and stabilizing practices, particularly within the sub-discipline of Actor Network Theory (ANT), has been criticized for collapsing an uneven terrain of power relations into a flat, undifferentiated field of relations (Mitchell, 2002, p. 53). These weaknesses are evident in Bruno Latour’s early work, as he introduces a seemingly “limitless number of actors and networks, all of which are somehow of equal significance and power,” (Mitchell, 2007, p. 53). In Aramis, or The Love of Technology, for example, Latour describes the French effort to build Aramis, an automated train system that fused benefits from mass transit with the individual, detachable compartments of the automobile, allowing for continuous travel. Aramis took in approximately half a billion francs in state funding between 1969 and 1987, but was terminated in 1987, never progressing beyond testing stages. While the project’s demise was accredited to its inherent lack of technological feasibility and economic viability, Latour discredits this simplistic account. Yet, Latour fails to examine the contours of power relations between actors that often are embedded in large-scale technological projects. Further, this work fell short in providing strong explanations of
what is and is not possible in terms of scientific, technological, and economic change over time. More recent scholarship within STS has, however, has put greater emphasis on how power relations surrounding technologies come to define the results of particular projects (Sismondo, 2008).

2.3 Resources geography

There are three areas within what I will broadly refer to as resources geography that form the main body of literature I rely on to more pointedly analyze how it became possible to profitably extract oil from the oil sands. The first area is that undertaken by economic geographers on what have been termed ‘resource peripheries’ (Hayter et al., 2003), as a corrective to “the relative neglect of resource issues in contemporary economic geography” (Agnew, 2002, p. 585). Hayter et al.’s paper identified four institutional ‘dimensions’ that differentiate resource peripheries from cores, and that they identify as useful frames to analyze such spaces: “industrialism (economic dimension), environmentalism (environmental dimension), aboriginalism (cultural dimension) and imperialism (geopolitical dimension)” (2003, p. 17). More recently, Barton et al. (2007) have criticized Hayter et al.’s proposition that peripheries are incorporated into cores solely via industrialism. The authors instead argued that it was “the precise lack of industrialism” that made the resource periphery peripheral, and further proposed to replace the term ‘dimensions’ with the “use of a the broader and more dynamic term ‘productive transformations’ in order to evaluate changes in the nature, composition, orientation, and benefits derived from economic activities” in resource peripheries
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(Barton et al., 2008, p. 26). Bradshaw (2007) has also followed on Hayter et al.’s 2003 lead, approaching the complex integration of resource peripheries through an empirical account of the constantly changing ‘power-geometry’ in the Sakhalin offshore oil and gas plays in the Russian Far East (Bradshaw, 2007; Massey, 1993, p. 263). These studies are theoretically and empirically fertile to my study, and also point to the possible returns of research on so-called ‘non-conventional’ resource peripheries, and on a more pointed attempt to excavate how resource peripheries are primed to be integrated into global commodity markets.

Second, after a prolonged cultural turn in human geography, in the last five years renewed attention to the ‘materiality’ of nature has revived interest in resource geographies (Bakker and Bridge, 2006). 8 Perhaps the most relevant area of resources geography to my study is Bakker and Bridge’s (2006) reconstruction of a ‘critical resources geography’ that “addresses the analytical significance of concrete differences in the material world and the way these enable and constrain the social relations necessary for resource production” (p. 21). They outline an approach attentive to the specific ways in which society and nature, in dialectical relation, ‘coproduce’ a resource (Bakker and Bridge, 2006). This framework offers a way to understand how the specific materialities of bitumen and the knowledges and practices that surround it intersect to produce an oil reserve, or to produce ‘reclaimed’ land. In their words,

8 Materiality refers to “both the real, ontological existence and causal efficacy and agency within history, of those entities and processes we call ‘natural’” (Castree, 1995, p. 20).
Last, more specific detail on the role of social institutions in resource production can be gained from the Regulation School, and specifically those who have applied this line of thought to contexts of resource production. The basic premise of this school is that the stability or instability of a mode of regulation – the configuration between social relations and economic organization – is contingent on institutions and practices that contain and offset, for a time, the contradictions and crisis-tendencies of (capitalist) market forces {Boyer, 1990 #542}. This premise results in a shift from “a debate about whether there should be more or less state intervention,” to analysis of the specific institutional and organizational forms that regulations take in articulating social and economic life (Boyer, 1990, p. 105). Further, while state intervention was presented by neoclassical economists as simply a response to market failures (such as externalities, uncertainties, and risk-aversiveness), the regulation school counters that institutions operate according to the “pure logic of the market,” (Boyer, 1990, p. 105).

Neglect of the environmental processes underpinning commodity production within theories of social regulation has lead resource geographers to examine “the way nature is bound up into production is historically and geographically specific, and that the form and rate of this transformation determines whether and how underlying contradictions are expressed in social conflict,” (Bridge, 2000, p. 253). Drawing on O’Connor’s (1988) thesis of the ‘second contradiction’ of capitalism (O’Connor, 1988), many scholars have elaborated on how the production of nature results in two potential conflicts that undermine the profitability of capital: the first is the ‘underproduction,’ or degradation of nature itself; and the second, as Gavin Bridge (2000) has noted in the
specific context of mineral deposits, is the “emergence of organized resistance to the acquisition of new reserves and historic practices of waste disposal,” (p. 238). O’Connor’s thesis, and the many scholars who have taken it up (Escobar, 1996; Bridge, 2000; Prudham, 2005) is relevant to the possibility and economic profitability of oil sands development, in that the numerous traces left at the sites of oil sands mines have become the nexus of organized resistance to the historic waste disposal and containment practices of the oil sands industry.

As a newly revived area of inquiry, resources geography provides a strong foundation on which to examine the scientific, technological, and ecological aspects of oil sands production. In fact, realizing the imbrication of social practices, such as scientific research and technological innovation, with the power relations surrounding the extraction, control, and use of resources, an increasing number of resource geographers are combining insights from studies of science and technology with the traditional focus of geography on the political and ecological conditions of resource extraction (Braun, 2000; Demeritt, 2001). In the following section, I describe the research methods forming the basis of this study.
3 Research Methods

Because of the sensitive, private, or in many cases historical nature of much of the information surrounding the 2002 reserve classification, I anticipated that immediate, direct access to evidence, such as through the questionnaire, interview or through observation, would be either impractical or ineffective. Therefore, I based my research primarily on documentary materials, which are useful where “the researcher has no direct access to the situation in which the evidence was produced” and as a result “past behaviour must be inferred by its material traces,” (Scott, 1990, p. 4, 3). The material traces left by government in particular – archived records, policy documents, reports, and so on – have proliferated with the expansion of government bureaucracy in Western industrial states since the early 20th century. In Alberta, this expansion has closely paralleled the emergence of a developmentalist ethos towards the province’s resources – and in particular the oil sands – leaving many records in its wake.

The broad nature of the research question required that I consult documents at several different geographical scales, whose authorship spanned over a century. The shifting and complex ownership structure of the bitumen-saturated land in north-central Canada meant that information was held in eastern Canada – at the national archives and various university libraries – and at the provincial archives, specific departmental libraries, and universities in Alberta.9 I started out at Library and Archives Canada in Ottawa, Ontario, where I assumed an exploratory approach. Having never requested

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9 As I discuss later, beginning in the 17th century, the oil sands were held under the jurisdiction of Hudson’s Bay Company, then in the mid-19th, the Dominion Government of Canada, and, since 1930, under the Province of Alberta, though with certain aspects (trade, fisheries) still under federal control.
archival documents before, I learned the process and difficulties as I went along: I used a pencil and photocopying machine to record notes (later learning from Professor Farish I could have brought a digital camera and tripod), and running into numerous dead-ends: private donors had closed recent collections; certain collections were closed for privacy issues. Nevertheless, at the national archives I read reports written for the Alberta Oil Sands Environmental Research Program (AOSERP), which was the institution through which much of the foundational research on the environmental impacts of oil sands production was conducted. And I sifted through a file of telephone conversation records, newspaper clippings, and oil sands industry documents kept by the President of the Canadian National Railways, a company that not only at the time owned land in the oil sands, but also had a degree of power to decide which early projects would succeed or fail, based on where it set down its railroad tracks. The information I gathered at the National Archives, where I spent four days, gave me a first feel for the ingrainedness of the oil sands resource within the political and economic development, and even identity, of the provincial and, to a lesser extent, federal governments. It also introduced me to the important aspects involved in oil sands production – geology, technology, ecology, and economy – and provided a solid foundation for me to launch into more defined paths of inquiry.

My next step was searching the University of Toronto holdings, as well as ordering government reports via the university’s Interlibrary Loan (ILL) Services. In this respect, few other universities would probably be better suited for my research in terms of the scope of U of T collections and its ILL service. In the stacks of Robarts Library, the Engineering and Computer Science Library, and the Gerstein Science Information
Centre, I found reports by the Alberta Oil Sands Environmental Research Program (AOSERP), geological reports dating to the 1920s, proceedings of United Nations conferences on heavy oil and bitumen, as well as most, if not all, of the secondary sources written on oil sands development (to be fair, there are not many). In the Engineering and Computer Science Library alone there are two entire shelving units devoted to the oil sands; I wish I had the time to read more of these collections. Through the ILL Service, I gathered consultants’ reports on the environmental impacts of oil sands development, ‘supply outlooks’ and ‘industry updates’ published by the Canadian Energy Research Institute (a hybrid industry and government research institution created in the mid-seventies), promotional brochures, and deposit-specific government geological reports. While in Toronto, I also collected more macro-scale information and statistics from Statistics Canada’s Canadian System of Environmental and Resources Accounts, the Canadian Association of Petroleum Producers (CAPP), the U.S. Energy Information Agency, the BP Statistical Review of World Energy, the U.S. Securities and Exchange Commission (SEC), and the Canadian Corporate Security Administrators (CSA).

Throughout, I also searched academic journals for articles written about the oil sands. For a general overview of perspectives on the central issues surrounding oil sands development, I used the search terms ‘Alberta*’, ‘oil sand*’, ‘bitum*’, ‘tar sand*’ in various combinations, but for more specific journal articles I either came across these by searching specific terms that I was reading about at the moment – for example, ‘AOSERP’ or ‘greenhouse gas*’ and ‘oil sand*’. Like secondary sources, there was not an overwhelming array of relevant articles on the topic of the oil sands, and less so written from the social sciences. However, articles from the 1970s which predicted the
environmental risks involved with the current path of oil sands policy; articles written by economists that either upheld or subtly challenged the neoclassical paradigm of resource growth in relation to the oil sands; articles funded by AOSERP and AOSTRA which fleshed out contextual details of these programs; and more recent articles on the environmental costs of developing the oil sands – these have rounded out the information I gathered from government and industry documents. In addition to academic journal articles, I kept abreast of more recent provincial and federal government departmental reports, industry publications, and public relations campaigns.

By November 2008, however, I still felt there were large gaps in my research. A lot of what I had collected to date seemed to reinforce the story that the oil sands became accepted as a reserve simply because of a price adjustment; perhaps in part this was because many of these documents had received a seal of approval by the Alberta government and oil sands firms. I wanted still to find evidence of the key decisions that allowed price to make sense as an explanation for the possibility of converting the oil sands into a product equivalent, in end use at least, to conventional crude oil. I turned to the Provincial Archives of Alberta, which housed the Alberta Department of Environment fonds (records) and also the Alberta Oil Sands Technology Research Authority (AOSTRA) fonds. Broadly, I thought these files would introduce me to the day-to-day practices and decisions within the executive and bureaucratic arms of government, and within industry, and would allow me to peer behind the veil of the provincially sanctioned script of oil sands development.

With the generous support of my supervisor, and of the Department of Geography’s McMaster Trust Award, towards the end of January 2009 I traveled to
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Alberta, spending five days in Edmonton at the provincial archives and one day at the Alberta Department of Energy’s in-house library (in an aptly-titled building called ‘Petroleum Plaza’; see Figure 3.2), and a brief two days in Fort McMurray. Despite what I had learned at the national archives, I ran into further setbacks at the provincial archives. On my first day, I took two buses out into the Edmonton suburbs, arriving at the archives (see Figure 3.1) with a digital camera and tripod, only to find that these items were banned from the viewing room; photocopying, too, was not allowed, but had to be specifically requested. More frustratingly, the codes that I had copied from the archive’s Web site in Toronto did not match the accession numbers used at the archives, so I had to re-search the files I had previously marked. Then, once I had submitted the request forms, an archivist came over to my desk and invited me into a private room to speak with her. I received a very different speech than that of the archivist in Ottawa, who had worked with me to navigate the archive’s freedom of information laws and to access as much of information as possible. The provincial archivist told me how serious it was to request these items; how the process of accessing the files under the provincial Freedom of Information and Privacy (FOIP) Act could take approximately one month, and then it was uncertain if I would access the files at all; she also questioned why I wanted the files.  

As I left the archives at the end of the day, I felt discouraged that I would not be able to access any useful documents. At the time, I understood that the speech I had received could perhaps partly be explained by the unique opacity of states reliant on petroleum revenue, and their tendency to limit the scope of both representation

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10 The items in question were archived after the late-1980s; it seemed this was the cut-off point for files being subject to FOIP. The FOIP Act stipulates that all records received by the Provincial Archives of Alberta after October 1, 1995 are automatically subject to the FOIP Act (Provincial Archives of Alberta, Undated).
and contestation (Karl, 1997; Watts, 2001). Several weeks later, this line of thought would be reinforced as I read the Calgary journalist Andrew Nikiforuk’s polemic against the ecological and political implications of rapid oil sands development; Nikiforuk explicitly links the opaqueness of the Alberta government to the influence of oil sands revenue, writing that in 2006 the government enacted stricter freedom of information laws:

In 2006, Alberta’s Conservative government made it legal for its petropoliticians to lock away internal audits for fifteen years and for government ministers to keep their briefing binders out of public view for five years. Freedom-of-information requests take months and cost a small fortune to obtain. Most material arrives blacked out (Nikiforuk, 2008, p. 159).

That said, the roundabout documents I was able to review were some of the richest I would read throughout my research; for example, as I describe in chapter six, land reclamation files from the 1960s contextualized oil sands reclamation requirements within a long history of large-scale land disturbance by coal mining and conventional oil operations in the province. And towards my last days at the archives, I turned from using the online archival search to using the old card file system - which did open up highly relevant AOSERP and AOSTRA files that were not covered by FOIP, albeit they did extend only up to the mid-1980s.
Returning to Toronto, I began to write in earnest and at the same time to follow up on questions that came up as I worked through the research that I had gathered. As I
began to write Chapter 4, on the importance of the geological sciences to the reserve estimate, I held a telephone conversation with a Resource Assessment Specialist within the Geological and Reserves Group of the Energy Resources Conservation Board (ERCB) to clarify certain questions I had about how the ERCB determines reserve estimates. According to the colleague who referred me to him, the geologist I spoke with was “the key driver of oil sands resource/ reserve estimates and…instrumental in assigning reserves to the oil sands,” (personal communication with geologist at the Energy Resources Conservation Board. January 15, 2009). I sent many questions and requests via e-mail to librarians at the Alberta Department of Energy and Alberta Department of Environment, who graciously gave their time to respond to me. It is also important to mention that I sent out information requests that were denied: the Canadian Association of Petroleum Producers (CAPP) said it did not have someone available to speak with me by phone or to meet in person when I was in Alberta; when I was in Fort McMurray, I was told that Suncor’s tour guide had had a ‘family emergency’, and Syncrude said it had ended its practice of providing public access to its facilities (temporarily or permanently – I am not sure). Further, when asked if I could interview staff at Syncrude, the company’s Media Relations Advisor told me that, “Given that the Alberta government was very involved in the process by which the oil sands became recognized as a viable oil reserve, I'd suggest you contact Alberta Energy for an industry-wide answer to your question,” (personal communication with Cheryl Robb, Media Relations Advisor, Syncrude Canada Ltd. January 19, 2009). It was following this response that I contacted the geologists at the ERCB.

While I would have liked to go beyond the highway entrances to Suncor and
Syncrude (see Figure 3.3), my interactions with the representatives of CAPP and oil sands firms were useful in confirming both the centrality of the Alberta government to the reserve estimate, as well as the secrecy (and perhaps, it might be said, lack of democratic decision-making) that has surrounded certain efforts to scale up oil sands production. My visit to the Fort McMurray Oil Sands Discovery Centre, an unequivocally pro-oil sands museum funded primarily by the Alberta Department of Culture and Human Spirit and by individual oil sands firms, did expose me to the industry sponsored script of oil sands development, and its challenges. That said, I eventually did receive some responses from individuals within oil sands companies: in January 2009, in response to increasingly negative public perceptions of the Alberta oil sands industry, as surveys conducted by the Pembina Institute made widely known (The Pembina Institute, 2007a, 2007b), CAPP and oil sands firms launched a Web site discussion forum called ‘The Oil Sands: A Different Conversation’ (CAPP, 2009a). I had questions answered by several different oil sands firm representatives through this discussion forum.12

11 Interestingly, the Oil Sands Discovery Centre received large donations from oil sands firms for an expansion in September 2002, two months before the reserve classification (Oil Sands Discovery Centre, no date).

12 To view my questions if they are still available: my name on this forum is “geog student”.
As evident from the above discussion of the obstacles and barriers I confronted in my research, my analysis is first and foremost structured by what information was available to me. From all that I have gathered, the 2002 reserve classification resulted from closed-door meetings and decisions, and despite my efforts to look for some cracks into what really went on behind those doors, I have been relatively unsuccessful in illuminating the exact series of consultations that produced this classification. Nonetheless, I have identified what from my research seem to be the key interests and decisions that gave impetus to the reserve adjustment; itself only of symbolic importance for signifying these much wider efforts of scaling up oil sands production.

Second, the paper is undoubtedly influenced by the limits presented by my own knowledge, my bias, and my interpretation: the, admittedly, relative clean slate of
economic knowledge with which I started out on this project, which made reading documents like the Canadian Energy Research Institute’s supply outlooks a challenge; the obvious focus of my research on the environmental effects of oil sands production, certainly to the exclusion of other important effects; and the difficulties I had understanding what really was possible in terms of oil sands technologies and environmental practices; no doubt there are informed assumptions I made and questions I left open when it came to these ambiguities.

To address these limitations, I articulate and externalize my usage of documents and other types of research, including how different kinds of research relate to each other and how I have interpreted raw text and conversations. My emphasis on understanding the underlying meaning of a document in the chosen research methodology fits with a combined interpretive and critical epistemology. The interpretive approach tends to pull apart traditions, emphasizing how they are instituted through social action and discourse. This approach ties into my project’s analysis of the metrology of oil reserve accounting, and specifically how the Alberta oil sands resource became tied into this classification system. Yet, I also realize the interpretive approach’s inattention to the role of power, ideology, and conflict. These overtly political subjects are better addressed by the critical tradition, which can relate the use of discourse to the exercise of power (McCulloch, 2004, p. 46). The following chapter discusses the application of the geological sciences to the bitumen-saturated sands, exploring the interaction between the distribution of political power and the meanings that have been attached to the oil sands resource in making this resource intelligible to the economy.
4 ‘Geologizing’ the Oil Sands: Reading market price and supply cost into and out of the McMurray formation

When it comes to exploration in the oil sands, you can’t drill a dry hole. It’s there…We know where it is. They’ve outlined it. You don’t have any risk. But other conventional sectors around the world, there’s a huge exploration risk.

Greg Stringham, Vice-President of markets and fiscal policy at the Canadian Association of Petroleum Producers, as quoted in (Schorn, 2006).

If the price mechanism was able to provide perfect information on the scarcity of a resource to resource allocators, “their behaviour and the economic indicators it would generate would reflect the scarcity”; there would be no need for information on the physical quantity of the resource to inform decisions on resource allocation (Norgaard, 1990, p. 19). That the observed physical quantity of bitumen in the sands, not market price, was the first instigator of decisions to extract oil from the bitumen-saturated sands is evidenced by the two-century history of geological surveying in the sands. Further, the information available to market actors has often been imperfect, resulting from a profoundly political process through which knowledge of the unfamiliar and highly heterogeneous sands has been made known over time.

In this chapter, I trace the Alberta governments’ collection, enumeration, and mobilization of the observable physical quantities and geologic qualities of petroleum within the sands. Far before conventional oil supplies in the province had peaked, the Alberta government funded extensive geological studies that in fact introduced market parameters into subsurface bitumen deposits, resulting in discrete parcels of economic information such as bitumen saturation and bitumen pay thickness – vertical sections of
rich bitumen deposits – that established an equivalency between bitumen deposits and conventional crude oil.

By 1999, the cumulative work of geologists, engineers, and economists within the Alberta government had translated highly heterogeneous oil sands deposits into an estimate of 175.2 billion barrels of established crude bitumen reserves. To scale up oil sands production by attracting large-scale capital investment, the Alberta government and the oil sands industry, represented by the Canadian Association of Petroleum Producers, lobbied to include the reserves of crude bitumen as proven oil reserves within U.S. and internationally recognized oil reserve classification systems. In the process, the Alberta government and CAPP had to alter the rules of these classification systems to accommodate the material differences of the oil sands when compared to conventional crude oil.

The chapter is structured in three parts. First, I sketch in more detail the origins and purposes of the first oil reserve classification system, the American Petroleum Institute’s first distinction between oil resources and reserves, to show that reserve classifications and the geological sciences that underpin them are not neutral tools, but are informed by an uneasy balance between the economic interests of government and industry in rationally exploiting a resource, while maximizing the profit gained from its production. I then relate these classification systems to the history of geological evaluation in the Alberta oil sands, leading to the reserve figure publicized in 2002. I focus specifically on the internalization of the logic of profit maximization and maximum efficiency within the geological sciences and government institutions that have surrounded the production of commodities from the oil sands. Third, I outline the process whereby the oil sands were accepted as a proven oil reserve by U.S. energy
agencies, and then discuss the implications of this process for the role of market price in making possible oil sands development.

4.1 Conserving resources, estimating reserves: origins and purposes of oil reserve estimates and classification systems

The limits of the neoclassical explanation of resource viability are evidenced by the origins and purposes of the first formal reserve classification system: that enacted by the American Petroleum Institute (API) in 1925. An examination of the evolution of the API system brings to light three main roles of contemporary oil reserve estimates and classifications: (i) to counter fears of oil scarcity and provide a basis for long-term government and business planning; (ii) to provide a medium for firms to secure investment capital and to demonstrate financial stability to investors; and (iii) to provide data to control oil production and to stabilize market prices. As symbolic resources, reserve estimates and classification systems may also be used by the oil industry to demonstrate scientific expertise and to achieve the trust of government regulators and the public. Together, these functions disprove the neoclassical argument’s identification of market price as the first mover of resource availability by outlining the numerous decisions and practices that are required to attract investment capital and to create stable investment regimes to rationally exploit a resource, while maximizing the profit gained from its production.

The first move to impose a formal classification of oil reserves was undertaken by the American Petroleum Institute (API) after the First World War. The API, a trade association organized in 1919 to advance the interests of the oil industry to the U.S.
Government,\textsuperscript{13} as well as to field intra-industry conflict, was coming under increasing scrutiny by preservationists, United States Geological Survey (USGS) geologists, and academics on the grounds of gross waste and mismanagement of the petroleum resource.\textsuperscript{14} In 1925, in part as a response to worst-case fears that government might take ownership of the industry as a public utility, but more immediately to supply information to the Federal Oil Conservation Board (FOCB), the API appointed a Committee on Proved Reserves and Productive Capacity, in shorthand the Committee of Eleven (Wildavsky & Tenenbaum, 1981; Olien & Olien, 2000; Vietor, 1984). The Committee of Eleven reported its findings in May 1925 in a short booklet titled \textit{American Petroleum Supply and Demand}. This report made the first distinction between short-term reserves: oil that had either been found or could be inferred to exist by drilled wells and which was considered “technologically feasible to recover at existing prices,” and long-term resources: a more all-encompassing term for the combination of proven reserves and oil only presumed to exist, including what was both “economic and noneconomic” to produce (Wildavsky & Tenenbaum, 1981, p. 172). By making this distinction, the committee sought to refute preservationists’ and geologists’ cries of oil scarcity, as well

\textsuperscript{13} During the war, the Wilson Government had brought together leading oil executives in the Petroleum War Service Committee (PWSC) to advise it on oil matters (Nordhauser, 1973; Vietor, 1984). Following the end of the war and criticisms by anti-monopolists that the PWSC was allowing the industry to accomplish through the “mantle of Patriotism what was impossible through greed,” (Davis, D. H., 1974, 47 – 48; Wildavsky & Tenenbaum, 1981, p. 169), the PWSC was dismantled. The members of the PWSC then became the first Board of Directors of the API (Nordhauser, 1973). Besides simply advancing the interests of the oil industry, the API continued to serve the important function of providing government with data and statistics. In view of how unreliable reserve estimates were known to be, the API offered a valuable third perspective, in addition to the perspectives of bureaucrats within the USGS and Bureau of Mines (Olien & Olien, 2000, p. 163).

\textsuperscript{14} The conservation of national natural resources was taken up with urgency during the Progressive Era, which dated roughly from the late 19\textsuperscript{th} Century to the mid-1920s. Demeritt (2001) provides an excellent and highly relevant explanation of the burgeoning concern with the conservation of the nation’s forests in light of the emergence of new quantitative and statistical practices: “The Progressive-era conservation movement inaugurated sweeping changes in U.S. environmental attitudes and policies…Conservation was a slippery term…But by 1900 many Americans were convinced of its necessity. This belief owed much to a new quantitative picture of the nation’s forests as a finite and fragile resource in need of government protection,” (Demeritt, 2001, p. 435).
as to reassure the public that the oil industry’s interest in conservation – albeit which was for major oil producers long-term profit maximization\(^\text{15}\) – was compatible with that of the nation and its consumers (Olien & Olien, 2000, p. 157).

However, the API’s reserve classification system was not purely an instrumental device, serving only the will of a powerful and unchallenged industry. As David Demeritt demonstrates in the context of the Progressive Era timber-famine debate, to stave off government regulation and secure the industry’s legitimacy it was necessary for timber companies to adopt the same “self-effacing, scientific terms as the claims of ardent conservationists,” (Demeritt, 2001, p. 453). Likewise, in the same period, oil companies were compelled to respond to the new quantitative picture of oil scarcity provided by an expanding class of engineers and geologists, particularly within the United States Geological Survey (USGS) and U.S. Bureau of Mines. In 1908, the first survey of the nation’s petroleum resources by the USGS had estimated the total quantity of remaining oil between 10 to 24.5 billion barrels, which it was estimated that the nation would exhaust between 1935 and 1943 (Wildavsky & Tenenbaum, 1981, p. 13). By 1919, the USGS had revised this figure downward to a more alarming 6.9 billion barrels (Wildavsky & Tenenbaum, 1981, p. 61). The API’s 1925 report was an automatic response to these “grossly inaccurate” estimates (API, 1925, p. 43 – 45 as quoted in Olien, 2000 #603). Responding in the same highly technical, quantitative terms as their critics, *American Petroleum Supply and Demand* provided its own inventory of U.S. oil reserves, identifying 5.3 billion barrels in producing wells and proven acreage in the reserves category. In the much larger category of resources, the API identified 26 billion

\(^{15}\) According to Nordhauser (1973), “‘Major’ oil companies in the 1920s included the Standard Oil Group, which manufactured 10 per cent of American gasoline, and the dozen or so giant corporations which produced another 24 percent. The remaining third of U.S. manufacturing was handled by 350 small or ‘independent refiners.’” (p. 54).
barrels in the ground, when price would justify secondary recovery methods; and, should prices rise even higher, 100 billion barrels of petroleum liquids from oil shale and another 600 billion barrels of liquids potentially available from coal and lignite deposits (Olien & Olien, 2000, p. 164). The API’s relatively high reserve and resource estimates refuted claims of oil scarcity in the same mechanical terms in which they were expressed, while implying that heightened regulation of the industry to implement preservation measures was unnecessary.

Reserve estimates and classifications also provided mechanisms to communicate with bankers who had less specialized knowledge of petroleum extraction. In the 1930s oil companies were able to compare the results of their evaluation techniques with past production histories, subsequently using these comparisons to convince the financial community that their geologists and engineers could accurately estimate how much oil was underground (Wildavsky & Tenenbaum, 1981, p.175). As a result, bankers became more comfortable using reserves data to decide whether a petroleum outfit would be able to service a loan. In part the greater currency of reserves data resulted from advances in subsurface mapping techniques, as seismic, electrical, and radioactive technologies made 'visible' greater depths – up to 12,000 feet in 1934 – of the underground (Wildavsky & Tenenbaum, 1981, p. 62; Hubbert, 1934, p. 20). But loans only became widely available after the API institutionalized a Permanent Committee on Proved Reserves in 1936, which published reserve estimates in its annual Blue Book. The Blue Book cemented a new interest for the American oil industry in collecting and calculating statistics and data relevant to oil production, as stable reserve figures became necessary to finance increasing extraction costs (Zimmermann, 1957).
A third, indirect role of API reserve estimates and classification was in controlling oil production and stabilizing market prices. Oil found in the early 20th Century was typically ‘light,’ or of low viscosity. Combined with the ‘law of capture’, a provision of U.S. property law that gave land owners rights to any oil and gas resources raised on their land, regardless that the oil or gas may have migrated from underneath someone else’s land, the fugacious nature of oil resulted in the rapid, uncontrolled draining of oil wells by competing firms (Bowker, 1994, p.721; Olien & Olien, 2000; Wildavsky & Tenenbaum, 1981). While in the early to mid-1920s large industry reserve figures provided scientific rationale against government involvement in the oil industry, later in the decade as oil from new fields in California, Oklahoma, and East Texas gushed onto the market, and as the Great Depression sharply reduced the demand for oil, major oil company executives began to base reserve figures on the same geological theories of resource scarcity that they had previously opposed, in order to support what became seen as necessary production control through government-business cooperation (Nordhauser, 1973; Olien & Olien, 2000; Bowker, 1994). The API institutionalized a system of estimation, a committee on reserves, as well as an array of geographic subcommittees that were moderately successful in stabilizing reserve estimates and production over time. However, as Wildavsky and Tenenbaum (1981) make clear, this simple classification system “institutionalized the oil industry’s definition of conservation: Whereas to a preservationist conservation meant making oil

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16 In 1889, the Supreme Court of Pennsylvania was the first to apply the Law of Capture, also called the Rule of Capture, to the petroleum industry. As detailed by David Breen, “In Westmoreland Natural Gas Company v. DeWitt, oil was likened to wild game, which English game law decreed could be captured by right by whoever found, or could lure, game on his land…This concept also carried within it the old English common-law tradition that applied to underground water,” (Breen, 1993, p. xi). In Canada, the Law of Capture gained explicit authority in Borys v. Canadian Pacific Railway and Imperial Oil Limited, 1953 (Breen, 1993, p. xii).
last longer, to industry it means keeping the price up to mete out oil in a stable fashion to conserve the industry,” (Wildavsky & Tenenbaum, 1981, p. 173).

For all these reasons, by the mid-Twentieth Century oil reserves assumed a prominent role both in industry planning and government policy-making. They also became a point of contact between industry professionals – often geologists – and public officials and decision-makers. Crucially, however, oil reserves embodied a shifting and uneasy relation between the interests of industry towards profit maximization and the interests of government in the ‘rational’ exploitation of resources – which although at times being synonymous with profitability, also had to answer to broader societal interests, such as long-term resource availability.

4.2 ‘Geologizing’ the oil sands: reading science, politics, and economics into and out of the McMurray formation

In Canada, the competing ideals of profit maximization and rational exploitation were introduced into the subsurface through institutions, regulations, and government and industry practices that made resources intelligible to the market. The conduit of these ideals was geological science, which became particularly significant in making unfamiliar and heterogenous bitumen deposits known to the economy. In this section I detail the process by which market parameters became instituted in the bitumen-saturated sands, culminating in the crude bitumen reserve estimated by the Alberta Energy Resources Board in 1999.

To do this, I rely in the framework developed by the geographer Bruce Braun who has detailed how an emerging discourse of geology in the late nineteenth century brought
Braun relates the ability for federal and provincial governments to administer new rules and regulations for the mineral lands of Canada’s west coast to Bruno Latour’s account of how European cultures achieved familiarity with distant lands and peoples via ‘cycles of accumulation.’ These ‘cycles’ refer to spatio-temporal periods in which objects were physically transported – either as specimens or as representations such as “maps, sketches, measurements, and other ‘inscriptions’” – to a limited number of European ‘centres of calculation,’ where objects collected on voyages could be combined, compared, and processed into new knowledge. (Braun, 2000, p. 18; Latour, 1987). Braun identifies two cycles through which Canada’s vertical territory became known: the first beginning with ‘mineralogy,’ the description and classification of minerals, and the second cycle ending with ‘geognosy,’ a branch of mineralogy concerned with the classification of rock formations (Braun, 2000, p. 20). By the end of the 19th century, geologists brought stratigraphical sketches and maps back to the federal Geological Survey of Canada in Ottawa and to various provincial mining bureaus. There, these inscriptions were differently translated into museum exhibits, school curriculum, and other mediums that would familiarize the population with the geological landscape, as well as into new, albeit constantly revised, property tenure regimes to encourage efficient mineral extraction. Towards the same ends of efficiency and improvement, governments also enlarged their mandates and apparatuses for collecting statistical data on the emergent geological, economic, and human facets of mineral production (Braun, 2000).

Braun’s article provides a useful framework for understanding how it became possible to ‘see’ underground oil sands deposits as reserve accumulations differentiated by economic and technological viability. However, the ongoing and intensified
collection and combination of knowledge of underground rock masses since the end of the 19th century, where Braun’s article ends, requires that a third, subsequent cycle be grafted on to Braun’s model: ‘exploration geophysics.’ Exploration geophysics is a younger, far less easy to define science fusing mathematics, geology, and engineering with new technologies that could ‘sample the earth’ without – theoretically – having to dig wells or bear witness to exposed rock strata (Bowker, 1994, p. 28 - 29; Hubbert, 1940, 1934). In what follows I show how three historic periods characterized by evolving geological sciences and government institutions surrounding the oil sands influenced the pace, scale, and value of developing the oil sands.

Table 4.1 provides Braun’s (2000) diagram of the forms of collection, calculation, and combination that lead to the accumulated knowledge of subsurface minerals and rock strata by the close of the 19th century, updated with a third, subsequent cycle that has brought about contemporary knowledge of commercial reserve deposits. The descriptive
and taxonomical methods of mineralogists in Braun’s first cycle were similar to those used by the first Europeans who ‘discovered’ the oil sands.\footnote{Despite that petroleum is not classified as a mineral, early inquiry into its properties may be likened to mineralogy. This is because, as Braun notes, knowledge of minerals eventually evolved into knowledge of geology – a discipline which became central to studies of petroleum. Further evidence of the importance of mineralogy to geology is provided by one of the more famous geologists, M. King Hubbert, who was trained and concerned first and foremost with “products of the mines,” setting the groundwork for his later writing on petroleum depletion (Hubbert, 1934, p. 18; 1940).} From the first European siting of the oil sands in 1792 by the fur trader Peter Pond until Sir John Richardson’s tour of Athabasca in 1848, accounts of the oil sands were descriptive, jotted down in the journals of fur traders, map makers, and northerly explorers. The black, sticky material presented itself to these men at seepages where bitumen lay near the surface, as well as along the exposed banks of the Athabasca River as they traveled by in canoe. Having no aids to enable them to see beyond surficial deposits, the Europeans who came into contact with the unknown material wondered at its smell, state, and texture – delving, in the case of Alexander Mackenzie, as far as 20 feet into a surficial deposit using a wooden pole (Ferguson, 1985, p. 12). Like the French explorer La Pérouse who, as Braun details, was content to sketch the profile of the Pacific coast from his ship at sea, during the first cycle Europeans crafted together knowledge of the sands at a distance from larger underground accumulations, according to the techniques, instruments, and theories available to them.

In naming and classifying the material, Europeans in the first cycle mediated between their experience of the sands and the existing knowledge and nomenclature available to them. Peter Pond termed the outcrops he saw ‘tar sands,’ it can be assumed in reference to the man-made material that had come to circulate as a major commodity in Europe and its colonies, used, as the First Nations and Métis used the new material encountered by Pond, for sealing wooden ships (Ferguson, 1985; Syncrude, 2006; North,
1985). On his voyage a decade or two later, Alexander Mackenzie compared the material in its heated state to the smell of sea coal, but classified the sticky component of the sands as bitumen, due likely to his greater scientific training (Ferguson, 1985, p. 12). The regular siting of the sands and the genuine novelty of the material attracted interest in the collection of field notes and specimens during the first cycle of accumulation, but inquiry during this period was restricted to anecdotal descriptions of the behaviour of surface outcrops.

In the late 19th century, stratified subsurface oil sands deposits came into focus of the Canadian government, which had been formed as a confederation of four provinces in 1867. The ability to see subsurface oil sands deposits resulted from an interconnected scientific, technological, political, and economic process. In 1842, the science of geology became formally practiced in Canada within a non-permanent, quasi-governmental agency. Shortly after Confederation, in 1869, this agency was institutionalized as the Geological Survey of Canada (GSC) and given the mandate to collect an inventory of the nation’s physical resources (Zaslow, 1975). Following the transfer of Rupert’s Land

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18 I refer here to the growth of a specifically Enlightenment science of geology. As Guntau notes, “As for almost all other sciences, it can be demonstrated that geological knowledge has existed from the earliest periods of the history of mankind,” (Guntau, 1978, p. 280). Two broad strands of geology characterize the pre-Enlightenment period: the first strand arising directly from the long history of mining, handed down orally; the second strand only indirectly arising from the experience of mining, instead more connected to ideational or religious aims. Guntau traces the origins of this second strand “from Greek natural philosophy, through Islamic natural knowledge and scholasticism, down to the physico-theologians of the eighteenth century,” (Ibid.). The difference between these older strands of geology and Enlightenment geology is that the latter became more continuous, systematic, and more tied to the exploration of mineral deposits. The growth of a geological science in the 17th and 18th centuries in Europe had been influenced and informed by a number of other developments, namely: the expansion of European colonies; the founding of mining academies (in addition to classical universities) in Germany, Russia, Mexico, and Paris; and intensified exploration and production of raw materials (Braun, 2000; Guntau, 1978).

19 Rupert’s land comprised 2.5 million square miles in the north-western interior of present day Canada, including part of what is now the Province of Alberta. Between 1670 and 1869, these lands staged as trading territory for the Hudson’s Bay Company. The characterization of Rupert’s Land as a “seemingly endless tract of forest, tundra, and prairie” (Davis, R. C., 1988, p. 1) – a perfect site for a “fur-trading
from the Hudson’s Bay Company to the Dominion government in the same year, the government began to approach the problematic of administering the Athabasca area for settlement and commerce (Barr & Smith, 1984, p. 1; Ferguson, 1985, p. 12; Braun, 2000).

During an 1882 expedition, Dr. Robert Bell estimated for the first time the quantity of bitumen contained in the oil sands. Bell was a major figure within the GSC for over thirty years, having gained extensive geological expertise through fieldwork and earlier training at Queen’s and Edinburgh University. During his 2,000-mile circuit of the Athabasca region, Bell applied “correct geological thinking” that "vast quantities of somewhat altered petroleum" in the sands had arisen from the Devonian limestones which underlay the Athabasca area (Bell as quoted in Ferguson, 1985, p. 15). By pointing out that this altered petroleum had “asphaltic” properties, Bell’s work implied the potential that this petroleum could be transformed into a more familiar and marketable oil.20 Advancing this theory further, Bell argued that a valuable liquid
c
empire” – was set out by European geographers and cartographers in the 1500s (Ruggles, 1988, p. 17). The almost singular use of this land for fur trading was in fact maintained by the Company through policies that discouraged settlement and agriculture, activities which were generally antithetical to the fur trade (Francis, 1988, p. 253). The exclusion of mass settlement on Rupert’s Land can partly explain the ownership structure for oil sands leases that developed. Although extractive industries have since had to negotiate terms of access with private landholders on many mineral and oil-bearing lands – particularly in the U.S, but also just south of the Athabasca region – few such individual negotiations were necessary for oil sands leases. Of course this is complicated and problematic due to the indigenous population in the area that long preceded the Hudson’s Bay Company. The Crown owns approximately 81 percent of Alberta’s mineral resources; the remaining 19 percent are ‘freehold’ mineral rights held either by individuals, companies, or by the Crown on behalf of First Nations or as national parks (Government of Alberta, 2009). From 1873 to 1930, the land and mineral resources of the former Rupert’s land were administered from Ottawa by the Department of the Interior (Breen, 1993, p. 4).

20 Until 1900, the dominant product refined from petroleum was kerosene, “with light and heavy lubricants, naphthas and medicinal oils the minor ones,” (Chandler & Hikino, 1990, p. 92). Despite the fluidity with which I use the term ‘oil’, and as I will further discuss, the specific makeup and uses of petroleum products, and of oil sands in particular, have shifted in response to changes within and outside the oil industry, and, in the context of the oil sands, internal and external to Alberta. Consequently, what Bell considered marketable oil was certainly different than the synthetic oil and crude bitumen currently refined from the oil sands, which is further processed into gasoline, jet fuel, plastics, detergents and fibers such as nylon and polyester (CAPP, 2008). Chandler states, “A strong demand for gasoline came only after 1900,” (Chandler & Hikino, 1990, p. 92).
petroleum resource was probably still “imprisoned in great quantities and may be found by boring,” (Bell as quoted in Ferguson, 1985, p. 16). For the next twenty years, Bell’s argument about the likelihood of underground pools of trapped bitumen guided a sizeable federal research effort in the sands. By the end of the 19th century, the GSC had drilled a series of wells, in one case to a depth of 1,770 feet, had enlisted a GSC chemist to conduct chemical tests on oil sands samples, and had produced its first estimate of the volume of bitumen in the sands – 30 million tons (Clark & Blair, 1927, p. 7; Ferguson, 1985, p. 21). However, in 1898, after having found no pools to confirm Bell’s theory of underground petroleum deposits, the GSC abandoned drilling work and expeditions in the Athabasca region (Ferguson, 1985, p. 21). The initial enframing of the oil sands as a light, liquid petroleum, however, was difficult to displace in the GSC, and even after federal drilling had stopped, sustained a speculative rush of entrepreneurs to the region (Parker, 1980, p. 17).

The expansion of the federal bureaucracy and, in 1905, the establishment of the provincial government of Alberta increasingly replaced the influence of distant European politics and knowledge on the oil sands, or at the least acted as an important mediator between European imperatives and the oil sands resource.2122 The growth of the Canadian state and the demarcation of provincial boundaries around the largest oil sands deposits introduced new, and often conflicting imperatives for research on the oil sands. Conflict resulted in particular from an exceptional provision in the constitution governing Crown Lands within the Prairie Provinces of Alberta, Manitoba, and Saskatchewan.

21 This distancing was compounded by the early discovery that European mining techniques did not translate well to the oil sands, despite their applicability to other North American mineral deposits (Chastko, 2004, p. 6).

22 This points to one potential weakness of Braun’s (2000) article. It does not account for the negotiation in Europe of what should be collected in Canada, or how the existing frames of knowledge in the minds of European explorers were formed.
Despite that Section 109 of the 1867 *British North America Act* granted provincial control over non-renewable natural resources, under the *Dominion Lands Act* of 1872, the Crown Lands in Alberta, Manitoba, and Saskatchewan (together the former Rupert’s Land) were kept under federal jurisdiction. Not until the 1930 ratification of the *Constitution Act*, and the passing of the *Natural Resources Transfer Acts* the same year, were these lands and the resources they contained transferred to the Prairie Provinces. Consequently, in the first two decades of the 1900s, the federal government took charge of most research on the oil sands. Sidney Ells, a federal Mines Branch geologist, undertook much of this work. In 1913, Ells surveyed 185 miles of river frontage and, using a hand-auger, took 200 core samples (see Figure 4.1), which he then barged out from the McMurray area to the Mellon Institute, "a respected engineering school located at the centre of the American oil and coal producing region in Pittsburgh, Pennsylvania," (Ferguson, 1985, p. 24). Using information gained from the Mellon Institute, Ells reported that the term “tar sands” was inaccurate, and arguing instead that the sands were “silicates impregnated with bitumen,” labeled them “bituminous sands,” (Ferguson, 1985, p. 24). However, the Mines Branch became hesitant to pursue research after 1917, when the considerable challenges of turning the sands into a road paving material and petroleum product (the two uses thought possible) were brought to light, and as the end of the First World War reduced Canada’s perceived need for strategic resources (Ferguson, 1985, p. 24 - 29).
In the 1920s, the decade prior to the land transfer, Albertans in key scientific and policy-making roles became increasingly critical of the federal government for not prioritizing development of the oil sands, channeling the wider conflict over ownership and control of the province’s resources (Ferguson, 1985, p. 31-33). A notable example of provincial-federal tensions occurred in 1920, over how to classify the resource. At issue in the classification was the sands’ economic value, resonating with Braun’s observation that the intelligibility of resources rendered by geological observation was crucial to the mobilization of capital and resources, as Albertan officials were well aware. Specifically, in 1920 the federal industrial research council had endorsed the findings of two McGill University scientists that oil sands samples contained “ingredients belonging to the naphthalene series” (Ferguson, 1985, p. 33; Chastko, 2004, p. 12). The implication was that naphthalene oils could be used as road paving material, but unlike the asphaltene series – the classification made earlier by Dr. Robert Bell and Sidney Ells, they could not
be produced as more valuable ‘petroleum oils’. Dr. Henry Marshall Tory, President of the University of Alberta and a scientist with a long interest in the sands, responded angrily to the federal research council over this classification. Drawing on the analyses of the University of Alberta chemistry professor Adolph Lehmann, whom Ells had provided with oil sands samples, Tory correlated the sands with the asphaltic California petroleums, “not those of the paraffin hydrocarbons found in Pennsylvania, which would have been more familiar to the McGill chemists,” (Ferguson, 1985, p. 33). The province, in conjunction with the University of Alberta, then decided to go it alone in oil sands research, scaling up funding to the Scientific and Industrial Research Council of Alberta (SIRCA) that had been founded in 1919. The first provincial government research organization in Canada, SIRCA aimed to “assist the province in pursuing broad goals of economic development and diversification,” (Ferguson, 1985, p. 31 - 32). Housed at the University of Alberta in Edmonton, the Research Council was mandated to document Alberta's mineral and natural resources for industry (Alberta Research Council, 2008).

While early explorers had seen the oil sands as a fairly homogeneous resource, between 1920 to 1935 scientists within the Research Council of Alberta collected, compared, and analyzed core samples, enabling them to view the large vertical and lateral variations of bitumen deposits. Karl Clark led the research group on the oil sands, and his methods and findings have been well documented (Clark & Sheppard, 1989; Research Council of Alberta et al., 1963; Ferguson, 1985; Chastko, 2004). However, these accounts tend to emphasize the technological achievements of Clark (such as the patented Clark hot water extraction process) and generally do not draw attention to the

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23 The University of Alberta was established in 1908, by Dr. Tory and Alexander Cameron Rutherford, the first Premier of Alberta.
significance of Clark’s research in making the oil sands intelligible to the economy. Before moving on to a discussion of how the current reserve estimate was enabled through the importing and application of geophysical technologies by government and then industry, I will emphasize three implications of geological work in terms of how the oil sands were made known to the economy.

First, beginning with the intuitive premise that “commercial development will be controlled to a large extent by the availability of commercial grades of material,” (Clark & Blair, 1927, p. 12), Clark and Blair set out to determine the variability of bitumen content within and across deposits. They selected thirty-five “representative bituminous sand exposures,” then trenched, photographed, profiled, and cut into layers the exposed strata, shipping individual cuts to their laboratory in Edmonton.

Clark and Blair’s conclusions on the geology and chemistry of the oil sands, outlined in Part I of the three-part report summarizing their work between 1923 and 1925, provided well-defined properties found to influence the variations in bitumen content, including the coarseness of the grain, water saturation, and specific gravity (Clark and Blair, 1927; see Table 4.2). Indicating the highly variable and still unfamiliar nature of the oil sands, the authors stated that “The distillation tests show that the bitumen content of the bituminous sands is not a definite product that can be described in a few words, or by one set of values of experimental tests,” (Clark and Blair, 1927, p. 68).

A crucial implication of this natural variation can be drawn out from a key premise of the literature on extractive industries: because non-biologically based industries such as oil extraction are fixed in space and cannot increase the productivity of their material inputs, their organization is profoundly shaped by variations in the grade or quality of raw materials (Boyd et al., 2001; Bridge, 2000; Barham et al., 1994). This
insight points to the second move in making the oil sands intelligible to the economy: combining knowledge of the heterogeneous properties of the oil sands into knowledge of homogeneous deposits not only extensive in area, but also especially intensive, or highly saturated, with bitumen. Working towards this end, Clark and Blair determined that, while bitumen contents varied widely – from one or two percent in some samples to seventeen and a half percent in others, within ‘normally well impregnated sands’ saturation was almost always between 10.5 to 13.5 percent of the total sands volume. Further, in the final section of their report, titled ‘Favourable Locations for Commercial Development’, the authors identified specific underground areas that they expected would reveal well-saturated deposits, such as: along un-eroded river valleys, near McMurray, and along the Athabasca River (Clark & Blair, 1927, p. 73).
Certainly, the easy slippage of Clark and Blair between what Braun refers to as the ‘visual language of geology’ and the “speculative language of ‘value’,” was common to this cycle of accumulation (Braun, 2000, p. 24). Characteristically, the 1927 report, in addition to determining what combination of grade thicknesses and existing transportation facilities would produce favourable sites for commercial development, sought to provisionally answer key questions of whether existing excavating machinery, such as the steam shovel, could handle the viscous sand, and also the commercial products that could be distilled from the bitumen. In terms of commercial uses, the authors noted Ells’ continued work on using separated bitumen for road paving material, as well as the “indefatigable” efforts of Thomas Draper, president of The McMurray

<table>
<thead>
<tr>
<th>Property</th>
<th>Variation</th>
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<tbody>
<tr>
<td><strong>Bitumen content</strong></td>
<td>Full range from 1 or 2% to 17 1/2%; 10.5% – 13.5% within “normally well impregnated sands”</td>
</tr>
<tr>
<td><strong>Specific gravity</strong></td>
<td>Higher (up to 1.040 to 1.060) for top beds of bituminous sands, lower (~1.004) in some samples &amp; 1.000 for bitumen seepages</td>
</tr>
<tr>
<td><strong>Coarseness</strong></td>
<td>Fine to coarse. Fine-grained sands found at the bottom of uniform beds, and contain more bitumen than coarse grains.</td>
</tr>
<tr>
<td><strong>Water saturation</strong></td>
<td>The presence of water, associated with silt or clay, found to be the ‘outstanding factor’ influencing low bitumen saturation</td>
</tr>
<tr>
<td><strong>Sulfur content</strong></td>
<td>4% - 5%, high sulfur contents likely the cause of high specific gravities</td>
</tr>
<tr>
<td><strong>Vertical extent</strong></td>
<td>Higher bitumen contents in deeper deposits, due to water-washing at tops of formations</td>
</tr>
<tr>
<td><strong>Lateral extent</strong></td>
<td>Pronounced – exposures within a mile of each other bear little resemblance to each other. Bitumen in central and southern deposits heavier than in northern</td>
</tr>
</tbody>
</table>
Asphaltum and Oil Company, in demonstrating the use of the material for pavement construction, notably at the Edmonton Exhibition Grounds (Clark and Blair, 1927, p. 9). However, Clark in particular wavered in his support of using the sands for road surfacing. While a significant part of his research effort within the Road Materials branch had been directed towards this application,\textsuperscript{24} his 1927 report with Blair, and a later independent 1929 summary report on road paving, pointed to the necessity of developing industrial demand for bitumen as a motor fuel and lubricant (Ferguson, 1985, p. 49). Partly this was a result of a two-month tour Clark had taken in 1926 of American and Canadian petroleum refineries. Although at that time these refineries were awash in oil and suffering from falling oil prices, their operators reaffirmed to Clark the long-term market potential for the oil sands (Ferguson, 1985, p. 46).

Ferguson (1985) goes so far as to note that “Some might inquire if the focus on commercial development slightly warped research, with the result that some preliminary questions about the properties of the bitumen remained unsolved too long,” (Ferguson, 1985, p. 56). Yet, despite the infiltration of Clark and Blair’s geological research with economic parameters like market demand, there was no mention of a numerical quantity of oil reserves, or of their economic value, in their 1927 report. Nor would there be any public estimation of total oil sands reserves or market value by any government-sponsored agency for the next thirty years. In fact, in 1949, Blair, who had since moved on from the Research Council to become an international consultant, was commissioned to report on the immediate and future economic viability of oil sands production, as well

\textsuperscript{24} By the end of the 1920s, the Scientific and Industrial Research Council of Alberta had “settled into an organized and systematic” form (Ferguson, 1985, p. 51). One result of this heightened organization was the establishment of specialized research divisions: Fuels (coal), Geology, Soils, Natural Gas, and Road Materials (tar sands). While Ferguson states that the naming of the section involved in oil sands research ‘Road Materials’ was “misnamed,” (Ibid.) this name correctly shows the current privileging of this end use.
as to suggest ways of improving the plant’s profitability and production volumes (Chastko, 2004, p. 83 - 84). During his evaluation of the Alberta Research Council’s Bitumount operation, it became apparent to Blair that there was a serious lack of data “for determining the economic or engineering merit of the process for which a pilot plant has been set up,” (Blair as quoted in Chastko, 2004, p. 84). A particular data omission that concerned Blair, and acted as an obstacle to his assessment, was on the site’s geological qualities, according to Blair’s request, “any stratification in the quarry, an analysis of the bitumen and of the sand, any variations in quality that are sufficient to affect operating costs,” (Blair as quoted in Chastko, 2004, p. 84). Blair reported in 1950 that Government drillings, while proving a “vast deposit,” were “inadequate to appraise the total bitumen,” (Blair, 1950, p. 13), even in the better-known Athabasca River area.

Blair’s recommendations that future government work define the areal extent of bitumen deposits and the quantity of oil potentially recoverable with present methods (Blair, 1950)25 spurred heightened geological research in the oil sands (Mellon et al., 1956; Carrigy, 1959, foreword). Each summer from 1953 to 1955, the Research Council sent out a geological party with instructions to map the geology of the McMurray formation, which had been identified as the key bitumen-impregnated strata in 1917 by F.H. McLearn within the GSC (McLearn, 1917). In 1957, Maurice Carrigy resumed this work and compiled the first public table of petroleum resources of the McMurray oil sands (Carrigy, 1959). Drawing on federal, provincial, and corporate exploratory drilling and sampling records, and extrapolating these to other areas with comparable topography and geology, Carrigy calculated that 1.67 billion barrels of oil were recoverable by

25 Although, Blair did reference particularly saturated reserve deposits of more than 100 million barrels per square mile, and noted “Government has thus far established something of the magnitude of the deposit,” (Blair, 1950, p. 6).
surface mining methods and at least 200 billion barrels within the McMurray formation could be expected to be produced given “advances in technology to create favorable economic circumstances” (Carrigy, 1959, p. 61).26

By the end of the second cycle, a geological vision of the oil sands had developed through painstaking government research, private entrepreneurship, and technological mobilization. Combining with shifts in the perceived value of the resource, these practices enriched the McMurray strata with increasingly detailed information on bitumen extent and saturation, and began to abstract from this detail to match the demands of industrial uses. However, despite the strategic importance given the oil sands during the First and Second World War, and the high oil prices of the immediate post-WWI period, without government assistance, the early entrepreneurs eventually abandoned their makeshift production facilities (Parker, 1980, p. 23). The number of barrels of bitumen extracted from the sands by both private entrepreneurs and government researchers remained relatively small throughout this period, and so did estimates of established reserves. As I will elaborate in the next section, for the current established oil reserve to come about – in the order of 1.7 trillion barrels versus 1.7 billion – the techniques of collecting reserves data, as well as the political, financial, and scientific institutions governing oil sands leases, had to be reorganized to see this heightened economic and technological potential within the McMurray formation.

Geophysical techniques, which include seismic, electrical, and radiation logging, enabled government and firms to confront the material differences of the oil sands in more efficient and exact ways. Once their accuracy had been demonstrated in U.S.,

26 At the same time, Carrigy subdivided the McMurray formation into three informal successions: a lower McMurray fluvial, a middle McMurray estuarine channel and point-bar, and an upper McMurray coastal-plan succession (Carrigy, 1959; Langenberg et al., 2002).
Russian, and French oil fields (Lawyer et al., 2001; Bowker, 1994), these new information sources were quickly adopted by the Alberta Petroleum and Natural Gas Conservation Board, the precursor to the current Energy Resources Conservation Board. However, geophysical techniques were not applied to the oil sands until the late 1970s, when the Alberta Government enacted policies to scale up oil sands production. Their application was by no means singularly responsible for the 2002 reserve estimate, but did represent the diverse technologies and expertise drawn on in the late 20th century to confront the material constraints of oil sands production and to attract investment in the oil sands.

Geophysics is in many ways more difficult to define than the disciplines of geology and mineralogy. A younger science, geophysics fuses physics, geology, and engineering with new technologies that can ‘sample the earth’ without – theoretically – having to dig wells or bear witness to exposed rock strata. A useful definition of this rather amorphous field is provided by M. King Hubbert, one of the field’s early proponents:

> Geophysics is not just a “borderland field” between two sciences; on the contrary, it is the process whereby the knowledge and techniques of the more fundamental science, physics, are borrowed and employed in solving the problems of the more dependent science – geology. Geophysics therefore embraces a large part of the two sciences taken together. (Hubbert, 1940)

By more recent and more critical accounts, however, Hubbert’s definition presents an overly linear understanding of the combination of local knowledge with new institutions, infrastructures, and technologies that enabled geophysical measurement. For example, Geoffrey Bowker has shown in his sociological account of the French oil exploration company, Schlumberger, that the company’s electric logging measurements only
‘worked’ once the company had itself worked to make the subsoil and the company’s representation of it converge. The distance between representation and reality had to be constantly narrowed by practices such as gaining access to sites amenable to geophysical techniques (semi-porous rocks, without salt domes); creating a new space and time around the well hole (via road networks, constant production times); and mediating between the divergent requirements for specificity and corporate secrecy in industrial patents. Bowker’s description of the development of exploration geophysics in the early 20th century expresses the numerous expertise and technologies mobilized to bridge the gap between the invisible subsurface and the petroleum industry’s desire for visibility:

The scientists who followed in the footsteps of the wildcat drillers bootstrapped themselves into the oil industry. Because there was effectively no predefined discipline of prospecting for oil and judging a field, specialists from a wide range of tangential disciplines used every weapon available to them. They had to work quickly, since the scramble for oil meant instant riches to those who found the slightest edge. They had to work secretly, since often the only advantage one held was a bit of local knowledge or a wrinkle in the interpretation of a graph. (Bowker, 1994, p. 3-4)

In the 1920s and 1930s, geophysics emerged as one tool among many, including geology, by those who explored for and extracted petroleum, particularly as deposits that had presented direct, surface proof of their existence had increasingly already been developed (Bowker, 1994, p. 21), and as the petroleum industry became larger, more standardized, and oriented towards competitive advantages gained through innovation and large-scale organization (Chandler & Hikino, 1990).

However, geophysics differed from previous sciences in two related ways. First, it became imbued to a greater degree than geology, or mineralogy with commercial interests and imperatives. In the case of electric logging, Conrad Schlumberger experimented with sending electric currents through materials of different resistances in a
basement bathtub of the École des Mines in Paris, before the outbreak of the First World War. After the end of the War, Conrad and his brother Marcel quickly transformed their technique into an international oil exploration company servicing the petroleum industry. Schlumberger (the company) did so in part by maintaining in absolute secrecy their knowledge of operators’ wells, keeping oil producers and even their field engineers in the dark about their ‘two measurements that worked’, and, as mentioned, leaving specific details of method out of their patents (Bowker, 1994). Through these practices, which Bowker terms ‘infrastructural work’, Schlumberger gained operators’ trust, who in turn allowed them to enter into their oil fields and gain more experience. Consequently, Schlumberger was able to demonstrate the accuracy of its methods in American oil fields and the previously suspect technique became the norm; for example, by 1938 approximately 98% of Californian oil wells were being logged and about 80% of these logs were by Schlumberger (Bowker, 1994, p. 101). In fact, many state mining bureaus eventually mandated that firms acquire a Schlumberger log to ensure that a deposit was efficiently produced (Bowker, 1994, p. 101 - 103). And in the case of the massive East Texas field (mentioned in section 4.1), Schlumberger measurements became central to managing the perceived overproduction and waste associated with “untrammeled drilling,” (Bowker, 1994, p. 72). Similar histories correspond to the development of seismic and radiation logging techniques. They emerged from the collusion of certain French and German university, government, and academic scientific laboratories, where researchers subsequently attained patents, formed companies, and using Bowker’s term, ‘bootstrapped’ their way on to the oil field (Lawyer et al., 2001). The secrecy and competition characteristic of geophysics diverged significantly from the purported values of transparency and replicability of ‘pure science’ (Shapin & Schaffer, 1985), and
The second way in which geophysics differed from prior sciences was in the greater detail, or more accurately, the more particular detail it provided of the underground. In contrast to geological core analysis, which relied on pulling up samples of the earth and interpreting whatever rocks, soil, and plant and animal detritus were brought up with them (see, in the context of the oil sands Mellon, 1956), exploration geophysics to a greater degree determined in advance what would be seen, by adjusting the intensity and direction of the electrical currents, seismic waves, or radioactive waves emitted. More specifically, currents and waves were sent downward with the express purpose of logging pay thickness, porosity, and water saturation; thus ideally enabling log interpreters at the surface to separate out economic from non-economic petroleum accumulations. Of course, as Bowker (1994) notes and most geophysical studies reference, geophysical techniques required previous knowledge of the kinds of structures and strata to pass currents and waves through (Henderson et al., 1989; Pullin et al., 1987). But over time geophysical logging became seen as more objective evidence of subsurface oil deposits than geological coring; in the case of electric logging “it led to a curious reversal whereby getting your hands dirty by sampling the oil sand was seen as providing useful psychological reassurance and getting an electrical log was the real material evidence,” (Bowker, 1994, p. 129). The exclusion of local reservoir conditions (i.e. the decreased importance of the properties of soil and strata above and below ‘pay zones’) enabled by geophysical measurement further added to the emergent objectivity of commercial oil deposits. Wrapped up with its commercial use, the heightened specificity of subsurface knowledge produced by geophysics served three beneficial ends: it was of
“great assistance to geological mapping; a vital aid in reservoir definition; and the taking of logs helps to avoid the bypassing of “thin” pay zones,” (Breen, 1993, p. 220).

Geophysical techniques were first used to explore and define oil sands deposits in the 1970s. Their importance in identifying oil reserve accumulations in the sands resulted from three main factors, in addition to the general advantages outlined above: first, the heterogeneous biophysical properties of the oil sands, which made geological interpretation difficult; second, the mandate of the Alberta government for efficient resource development that lead to the incorporation of geological and geophysical data into oil sands regulation; and, third, the differing needs for stable reserves data by the institutions that then began to fund, collect, analyze, and disseminate this knowledge. Further, similar to how Schlumberger measurements only ‘worked’ once the company had itself worked to make the subsoil and the company’s representation of it converge, it was only possible for the Alberta government to differentiate oil sands reserves by technological and economic potential by infiltrating oil sands deposits with economic parameters.

First, government and industry were motivated to apply geophysical techniques, primarily seismic and electric, due to the unfamiliar and heterogeneous biophysical properties of the oil sands. During the 1970s, Esso Resources Canada Ltd. and Shell Oil Co. of Canada were the first to intensively apply seismic logging on their respective Cold Lake and Peace River leases (personal communication with resource assessment specialist within the ERCB, March 17, 2009). Although the Great Canadian Oil Sands (GCOS) consortium had researched and explored its leases in the 1950s and 1960s prior to applying to the Board for the construction of the first large-scale oil sands production facility, the consortium had not used geophysical prospecting. Probably, this was
because its leases featured surface deposits of bitumen that had previously been explored in detail. However, the bitumen saturations at Cold Lake and Peace River oil sands areas had been found by the ERCB to underlie 1,500 to 2,600 feet of sediments and glacial drift, and it had not been within the scope of previous Board studies to assess the commercial recovery of bitumen from these deposits (ERCB, 1973a, 1973b). Although conventional oil is buried this deep or deeper, the heightened need for geophysical techniques lay in the immobile character of bitumen. Whereas conventional oil flows or may be pumped to the surface, greater effort must be directed towards extracting bitumen from its in situ environment. Approximately 82 to 90 percent of oil sands deposits are buried at depths greater than 75 metres (Hein & Cotterill, 2006, p. 87), and are either not possible or not considered economic to produce via surface mining. Geophysics has therefore been intensively employed towards the development of in situ thermal extraction techniques (Pullin et al., 1987).

That said, geophysical logs have been collected for surface deposits since at least the 1980s, and are especially important in organizing production so as to most efficiently extract the highest bitumen grades (Hoffman et al., 1990; Langenberg et al., 2002; Hein & Cotterill, 2006, p. 88). While a general difficulty with samples attained by drilling and coring conventional oil wells is that they come to the surface altered from their in situ state, the sampling problem is particularly acute in the oil sands due to their

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27 The GCOS consortium was initiated by Oil Sands Ltd., the successor of Robert Fitzimmons’s International Bitumen Co., which had operated from the late 1920s to 1937 about 40 miles north of Fort McMurray. In 1944, the provincial government partnered with Oil Sands Ltd. when Fitzimmons’ International Bitumen Company collapsed. An experimental plant was then operated at Bitumount by the provincial government from 1948 to 1955. In late 1954, Oil Sands Ltd. was re-formed as Great Canadian Oil Sands and struck agreements with Sun Oil Company of Philadelphia, Abasand Oils Ltd., and Canadian Oil Companies Ltd. The agreement with Abasand Oils Ltd. was strategic, as it was realized that Abasand (formally owned by Max Ball, and then operated as a joint federal and private enterprise) owned a promising lease – lease No. 4, at Mildred-Ruth Lakes (Breen, 1993, p. 441 – 445; Parker, 1980, p. 17 – 18; Chastko, 2004, p. 105 – 106). As a former private development and federal research site, it can be assumed that lease No. 4 was one of the more systematically surveyed oil sands sites.
“cohesionless character” (Macrides & Kanasewich, 1987; Carrigy, 1959). This is compounded by the heterogeneity of oil sands deposits, sketched at a basic level, though accurately, by Karl Clark and Sidney Blair, which has been noted as a major difficulty in interpreting the geology and estimating the bitumen distribution of the oil sands (Xu & Xhopra, 2008, p.1186). Consequently, in order to guide industrial organization around unfamiliar and heterogeneous oil sands deposits, “prudent operators will use seismic technologies to gather information they can’t from other sources, or to replace drilling,” (personal conversation with resource assessment specialist within the ERCB, February 3, 2009).

Geophysical techniques were clearly useful to the oil sands industry, but they also complemented the mandate of oil sands regulators for efficient resource development. Similar to the API, the Energy Resources Conservation Board (ERCB) internalized a definition of conservation as the maximization of oil production over the long term. The ERCB was established in 1938 as the Petroleum and Natural Gas Conservation Board (PNGC) to rationalize the rapid and chaotic draining of Turner Valley, Alberta’s first major conventional oil field, discovered in 1914. After years of intense industry opposition, the PNGC was given the authority to implement a prorationing system for Turney Valley and to collect geological, well, and reservoir data from operators as the basis for its ability to enforce the system (Breen, 1993, p. 220). The Board moved to incorporate new technologies and techniques, in fact much faster than agencies fulfilling similar roles elsewhere, including the Texas Railroad Commission (Breen, 1993, p. 221 - 222). In 1942, the Board began to enforce the existing provision that companies submit drilled cores to its offices. And in 1943, it amended its Drilling and Production Regulations to say that operators could be directed to take an electric log and that copies
of all geophysical logs, whether or not taken at the Board’s direction, had to be submitted to the Board. The first oil sands firms fought to be exempted from the prorationing system (Breen 1993, p. 446), but nonetheless were required to report data they acquired from all drilled wells. The 1978 Oil Sands Regulations state, “The permittee shall furnish to the Minister or to his authorized representative a complete copy of every log taken of each hold drilled and such other information, data and reporters pertaining to the examination as the Minister may from time to time require.” (Government of Alberta, 1978). The regulations now outline guidelines for seismic and electrical evaluation, which must be obtained on all leases sections where wells are not drilled (Government of Alberta, 1978, 3.d). Towards the same purpose of efficient oil production, firms are required to drill one well in each section of their lease, in an even and uniform pattern, and, in the case of seismic, must have at least 3.2 kilometres of seismic line for sections in which wells are not drilled (Government of Alberta, 1978). Supported by legislation requiring firms to conduct a minimum level of evaluation on their leases, geophysical techniques provided efficient and exact information that could be used to govern oil fields at a distance, without shipping bulky cores or having to visit each site in person.

A major consequence of legislation requiring the transfer of geological and geophysical knowledge from firms to the ERCB is that reserves data have increasingly represented the codified history of oil sands exploration and production.28 According to the senior advisor of the oil sands section within the Alberta Geological Survey, who administered the oil sands reserve adjustment, the reserve increase resulted from two particular production practices: first, almost twenty years of in situ production in Cold

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28 In fact, the Board does not collect or process geophysical data, it relies entirely on interpreting data submitted by firms.
Lake and Peace River; and second, the existence of commercial operations in both the Wabiscaw and McMurray formations (personal conversation with resource assessment specialist within the ERCB, February 3, 2009). He prefaced his explanation of the newfound commerciality of the oil sands by saying, “re-evaluation was not a response to oil prices going up,” (Ibid.). Instead, the entry of companies to areas other than Cold Lake and Peace River “gave us confidence to develop [figure in] a larger area,” (Ibid.).

An important step in combining the rich information obtained by graphical and logged records into knowledge of commercial reserves deposits was therefore the creation of institutions with mandates, like the American Petroleum Institute to the south, to collect, analyze, and disseminate oil reserves data over time. From the beginning, two main institutions collected hydrocarbon reserves estimates in Alberta: the Energy Resources Conservation Board and the Canadian Association of Petroleum Producers (Tanner et al., 1986, p. xv).29 However, the ERCB and the Canadian Association of Petroleum Producers (CAPP) have historically diverged in their estimates of oil sands reserves. As discussed above, the ERCB books reserves on the basis of approved projects, when the necessary wells have been drilled and completed, and, since 1999, have extrapolated their technological and economic potential to geologically similar areas. In contrast, CAPP’s reserves data have been based at times on their instrumental use for member firms. For example, during the 1960s, CAPP’s estimates were as much

29 I am using their current names, but both have changed names often since their inception. The ERCB was, as mentioned, first the Petroleum and Natural Gas Board, then the Oil and Gas Board, the Energy Resources Conservation Board, next the Energy Utilities Board, and is now again the Energy Resources Conservation Board. The Canadian Association of Petroleum Producers was founded in 1927 as the Alberta Oil Operators’ Association and reorganized in 1929 as the Oil & Gas Association of Alberta. In 1938 the Association merged with the Petroleum Producers’ Association (created the previous year by independent oil producers) to form the Alberta Petroleum Association. In 1947 the name was changed to the Western Canadian Petroleum Association; in 1952 WPCA amalgamated with the Saskatchewan Operators’ Association, to become the Canadian Petroleum Association; and most recently in 1992 merged with the Independent Petroleum Association of Canada to form the Canadian Association of Petroleum Producers (Glenbow Archives, 1948 - 1992 ).
as 15 to 20 percent higher than those of the ERCB, partly because they booked established reserves from enhanced recovery techniques earlier than the ERCB, but also, it was speculated, to take advantage of the reserves-based prorationing system, which determined company’s allowable production by their reserve holdings (Tanner et al., 1986, p. 47 - 48). In addition, CAPP uses its data less than the ERCB for long term planning, and more to garner investor capital.

More so than CAPP, however, the ERCB has been instrumental in using geological and geophysical techniques to make the oil sands economically intelligible. In the 1970s the ERCB set up rules and mathematical formulas that were intended to exclude subjective judgment and local context from reserve evaluation. For example, in the early 1970s, the Board employed geologists and engineers to introduce formal thickness and cut-off saturation criteria for proven bitumen reserves. Bitumen deposits less than 1.5 metres in thickness and that saturated less than 3 percent of sand weight were considered technologically and economically unrecoverable, and excluded from reserve calculations (ERCB, 1973a, 1973b). However, evidence suggests that these cut-off points were not uniformly used; in a 1985 review of its Wolf Lake project, BP Canada was extracting oil from sands of an “economic minimum of 8%” bitumen saturation per weight,” (Czaja et al., 1985, p. 3). In 1999, perhaps in recognition that firms were not more efficiently, or thoroughly, developing their leases, the ERCB increased the minimum saturation cut-off to 6% and the thickness cut-off to 3.0 metres for deposits produced by surface mining, and has since applied these criteria to all mined and in situ produced deposits. Rather than being seamlessly read out of the underground, the Alberta government has infiltrated the oil sands with economic parameters, consulting
with oil sands firms to determine which accumulations are economically feasible to produce.

4.3 From resource to reserve: the government and industry lobbying effort to fit the oil sands within U.S. and international oil reserve classification systems

In December, 2002, the esteemed and deeply rooted industry trade publication the *Oil & Gas Journal* accepted the oil sands as a proven oil reserve in its annual worldwide reserves report; on April 9, 2003, Alberta’s Energy Minister Murray Smith received a letter from the U.S. Energy Secretary stating that its Energy Information Administration would also count Alberta’s bitumen deposits as crude oil reserves (Radler, 2002; Anderssen et al., 2008). In response to these decisions, on June 18, 2003, the *New York Times* published an article opining that the oil sands reserve was itself “built on sand” and “far from scientific,” (Gerth, 2003). A *Toronto Star* article followed up on the *Times* story on June 29, 2003, accusing the Alberta government of having “fun with fossil fuel figures,” (Olive, 2003). Neil McCrank, then Chair of the Alberta Energy Resources Board defended the ERCB’s calculation in an editorial written on June 24, 2003 in the *National Post*, concluding that, “we stand behind our numbers,” (McCrank, 2003a). Which view was correct – was the reserve estimate unscientific, representing the projected power of a powerful industry lobby, or was the figure an accurate, impartial portrayal of ‘the way things really were’, backed by rigorous quantitative rules that excluded subjective judgment?

I will argue that it was both, and that this answer is highly significant to uncovering the limited role of market price in the reserve classification. First, and most
immediately, the reserve estimate was the direct result of an “aggressive lobbying campaign,” (Anderssen et al., 2008) by the oil sands industry, and advanced by the Canadian Association of Petroleum Producers. Marilyn Radler, the author of the Oil & Gas Journal’s 2002 reserves report explicitly told the New York Times that the 175.2 billion barrel figure came to her from CAPP. While the details of this campaign, which from the available evidence was an elite-level effort that took place behind closed doors, remain obscured, a description by the Oilsands Review of a campaign in the summer of 2006 to raise awareness and capital in the U.S. for oil sands projects can shed light on the effectiveness of CAPP and the Alberta government’s lobbying efforts:

In the final analysis, Alberta’s summer full-court press in Washington yielded a variety of positive dividends. Some of the cloudiness that still surrounds the oilsands as a legitimate resource disappeared, replaced by a better understanding of the play. In terms of energy supply generally, clarity around the volume of Canada’s exports was enhanced, (Whitelaw, 2006).

Somewhat contradicting the idea that the price mechanism directly instigated the resource substitution response, Gregory Stringham, then Vice-President of CAPP, said of the reserve figure, ”We were pushing for it [the reserve estimate] to be used,” and “Now that it is there, it's more real,” (Gerth, 2003).

However, this view ignores the long history of government geological surveys that read economic information into and out of the bitumen-saturated sands. Radler and likely other private investors and public officials would not have accepted the large reserve estimate from CAPP had these figures not been supported by the Alberta government’s rigorous quantitative data and methodology. In this sense, Neil McCrank provides a necessary counter explanation to the instrumental view of the classification:

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30 The Oilsands Review is a home-grown trade magazine, generally supportive of industry, available by paid subscription and at the Oil Sands Discovery Centre.
I note that the crude bitumen reserve numbers reported by the EUB [now ERCB] are accurate, independent estimates based upon detailed technical and geological analysis of data obtained from thousands of wells drilled in the oil sands (McCrank, 2003b, p. 1).

It was precisely because the geological sciences that studied the bitumen-saturated sands had already been infiltrated with market instrumentality that CAPP could take hold of this established figure. In fact, for its own purposes, CAPP uses a more conservative methodology for its estimate of the oil within the sands, which as of 2002 stood at 12 billion barrels (Gerth, 2003); the larger figure was exclusively the result of ERCB studies. The reserve estimate did not come out of ‘thin air,’ but from a specific configuration of scientific institutions, regulations, and practices – representing a shifting and often uneasy balance between profit maximization and rational exploitation – that made bitumen deposits intelligible to the market.

Nevertheless, it was a large leap between the terminology used by the Alberta government and CAPP – ‘crude oil reserves’ – and by the ERCB – ‘crude bitumen.’ To understand how it became possible to extend projections of technological viability for specific deposits outwards in space and in time, and to consider crude bitumen as an equivalent product to crude oil, I next turn to the drivers of technological change in the oil sands.
5 Developing the Technical Infrastructure: The historical political economy, and ecology, of technological change in the oil sands

Digging the bitumen out of the ground, squeezing out the oil and converting it into synthetic crude is a monumental challenge. It requires vast amounts of capital, Brobdingnagian technology, and an army of skilled workers. In short, it is an enterprise of epic proportions, akin to the building of the pyramids or China’s Great Wall. Only bigger.


According to the neoclassical economic paradigm, a high resource price combined with expectations of advantageous future prices and costs stimulate profit-motivated firms to accelerate the extraction of higher cost resources. In such a perfectly working market economy, firms respond to the price mechanism by developing more efficient technologies for scarce resources, as well as by moving on to less accessible, lower grade, or otherwise substitutable resources (Pearce & Turner, 1990, p. 295 - 296; Rees, 1990). An example of this logic is provided by the two sharp increases in petroleum prices in 1973 and 1979. During these market ‘shocks’, real crude oil prices rose to their highest point on record, save an exceptional year in 1864 (BP, 2008). The anticipated impending scarcity of the petroleum resource provoked widespread and wide-ranging substitution responses, of the kind predicted by neoclassical economic theory; for example, steam, water, and natural gas injection became more widely practiced to increase the productivity of conventional oil wells, marine technologies were introduced to move oil production deeper offshore, and sizeable funds were funneled into research

31 There is also a third response: the introduction of economy, conservation, and recycling. Importantly, this response is mentioned far less in the resource economics literature, and in Alberta government documents, than technological innovation and resource substitution (Rees, 1990, p. 41; Baumol & Wolff, 1981).
and development programs for photovoltaic cells (Boyd et al., 2001, p. 563; Levy & Kolk, 2002; Furtado, 1997; Grant, R. M. & Cibin, 1996; Gray & Eberspacher, 1994; Cibin & Grant, 1996). Symptomatic of this diversification strategy, in the 1960s and 1970s many of the large integrated oil majors turned their gaze to the Alberta oil sands.

Despite the seeming straightforwardness if not seductiveness of the narrative of market equilibrium, economists and social scientists alike have observed that market imperfections are the norm, not the exception, and that, characteristically, the 1970s oil shocks lacked many of the features of a perfectly working market economy (Debeir et al., 1991; Adelman, 1997; Rees, 1990; Yergin, 1992). As has been well noted, for example, the immediate cause of the price increases was price-fixing among the Organization of Petroleum Exporting Countries (OPEC). Putting this cause aside, however, and focusing the lens on the real attempts of government and industry in Alberta to rapidly commercialize their substitutes to conventional oil – synthetic crude oil and crude bitumen – reveals that, during the 1970s, the quantities of these substitutes delivered to market did not respond much to prevailing high oil prices. In fact, innovations in oil sands technology came at a considerable delay from price increases (see Figure 5.1). Attempting to move beyond an understanding of the process of technological innovation for the oil sands as rigidly within or as somehow exceptional to the rational workings of the market economy, in this chapter I trace the exact government

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32 The offshore industry emerged in the 1950s with MacDermott and Zapata’s drilling and production systems in shallow depths - 15 to 30 metres – in the Gulf of Mexico. Technological change in the 1970s and 1980s allowed offshore rigs to drill in depths over 100 metres (Cook, 1985; Furtado, 1997).

33 One major deviance from such a ‘norm’ is the very existence of oil supply shortages, which – arguably more than high oil prices – endowed gravity and immediacy to consumer responses during the shocks. The U.S. government in particular was impelled to respond to material decreases in oil supplies (compounded by population growth and increasing oil consumption in certain states) with federal price controls and a national rationing program for transportation fuel from 1974 to 1975 (Vietor, 1984, p. 244).
and industry perceptions and practices that made large-scale oil sands development technologically possible.

My general argument, following that throughout this paper, is that technological change in the oil sands resulted from government policies and institutional practices that shouldered and displaced the technological, financial, and ecological risks associated with the material differences of this petroleum resource. Specifically, I argue that the Canadian subsidiaries of the large integrated oil majors were not the main protagonists in the story of scarcity-induced technological innovation in the oil sands, as market optimists would suggest. Instead, technologies were, to a large degree, founded on the provincial and federal governments’ long trajectory of applied oil sands research, erected by a state-supported, public-private research program: the Alberta Oil Sands Technology Research Authority (AOSTRA), and were buttressed by a framework of legal and financial provisions outlining the terms of research collaboration and transfer between AOSTRA, Canadian universities, oil producers, as well as numerous other industry consultants and engineers. The notion that this research effort was guided simply or predominantly by market forces loses traction when analyzed in light of the continuous government support (in the form of time, energy, land, and money) endowed to research programs, the collaborative organization of research and industrial structure, and the timing of technological changes, which came at a considerable delay from oil price increases. In taking account of these factors, my aim is not to dismiss the logic of the neoclassical economic theory of substitution entirely, but to make the case that it has only made sense as an organizing principle for the oil sands through political, regulatory, and inter-firm practices that have been set up to offset the high risks and uncertain returns of attempts to subsume the oil sands to industrial processes and production schedules.
I organize this chapter as follows. First, I sketch the state of oil sands technologies at the time of the major price increase in 1973. As I discuss, this period was characterized by equipment breakages, discontinuous supplies of bitumen to processing plants, as well as competitive inter-firm relationships that restricted the transfer of technical knowledge between oil sands project operators. Second, I examine the response of the Alberta government to the high oil prices of the 1970s, focusing particularly on the technological research program – the Alberta Oil Sands Technology Research Authority (AOSTRA) – it enacted to accelerate innovations in bitumen extraction, refining, and distribution. This research program was driven by a specific developmental ethos of the
provincial government that shouldered much of the risks of technological research for firms, and pressed forward on research even during price depressions. Last, I conclude by analyzing the timing of the technological innovations that decreased supply costs, and that, in this way, were integral to the 2002 reserve classification.

5.1 Sunk capital and sinking machines: antecedents to collaborative research institutions

In June 1960, during a time of relatively stable though by no means favourable conventional oil prices, the Great Canadian Oil Sands (GCOS) consortium brought the first commercial scheme for synthetic crude oil production in front of the Alberta Energy Resources Conservation Board. Also in attendance at the hearing were other major oil sands leaseholders: Cities Service, Richfield Oil, and Imperial Oil. These companies, who would go on to form the Syncrude consortium in 1966, criticized almost every aspect of the GCOS proposal; insisting that the oil sands terrain would not support the heavy mining equipment proposed by GCOS, that the project was based on inadequate research, and that its processing systems were flawed (Breen, 1993, p. 455). Imperial Oil in particular had begun research on the oil sands in 1924 and like other companies was concerned that, if allowed, the GCOS project would effectively occupy the five percent ceiling on oil sands production that had been enacted by the provincial government to protect conventional oil producers (Chastko, 2004, p. 113). However, diverging from the

34 From 1947 to 1970, the benchmark price for crude oil varied by only US $0.37, in nominal dollars. In fact, oil prices reached their highest level during this period between 1958 and 1959, and from then declined until 1971 (BP, 2008).
35 Although established on Canadian soil, Imperial Oil became a subsidiary of Standard Oil of New Jersey (now Exxon Mobil) in 1898; Cities Service Company (now Citgo and Occidental Petroleum) and Richfield Oil (now a subsidiary of BP) were both founded in the U.S.
company’s initial opposition, in a telephone conversation with the President of Canadian National Railways on September 24, 1962, a week after GCOS received approval from the Alberta government, the CEO of Imperial oil William Twaits said the following:

As far as the application of Great Canadian and their partners is concerned, the Imperial interests decided to let them go ahead and learn the hard way. (Very confidentially, the Alberta government invited Imperial to intervene but Imperial decided that a direct intervention would require them to expose a great deal of their research work which they have done and which they are, of course, not willing to disclose.  

Whether Twaits was saving face or not is unclear. But Twait’s claim of letting GCOS ‘learn the hard way’, while keeping Imperial’s research secret, points to the competitive organization of research and technological innovation in the early period of commercial approvals, as well as the challenges of extracting oil from unfamiliar and heterogeneous bitumen deposits.

In terms of the challenges presented by the material differences of the oil sands when compared to conventional crude oil, Syncrude’s initial indictments against the proposed GCOS plant proved prescient. While the plant did produce the first synthetic oil barrel of any non-conventional oil deposit worldwide, the project ended up costing double its original estimated capital cost of $110 million (Alberta Government et al., 2006, p. 21). The problems faced by GCOS mostly stemmed from the inability of its extraction and processing technology to subordinate the geophysical properties and processes of the oil sands, long recognized as a key obstacle facing non-biologically based industries (Barham et al., 1994; Bridge, 2000; Boyd et al., 2001). Equipment sunk


37 Despite, Twaits’ uproar, there were clear reasons why the government rejected its initial application. Like all the others, except that of GCOS, submitted to the Board, Syncrude’s application had been for a pilot project and, further, Syncrude had not raised the necessary financing (Breen, 1993).
in the muskeg and had to be retrieved; during extreme winter temperatures the plant froze up; the plant caught fire; bucket-wheel excavators broke down; and sand wore away at bucket-wheel teeth and clogged conveyor belts (Alberta Government et al., 2006, p. 21 – 22; for photos of bucket-wheel excavators and conveyor belts see Figure 5.2 and 5.3, respectively).38 With hindsight, Twaits seemed justified in saying that Great Canadian was surrounded by consultants “some of whom are not as expert as they try to make out.”39

Yet, the Syncrude plant, which began operating ten years after GCOS, closely resembled the GCOS plant in its extraction technology (Heron & Spady, 1983, p. 143). Syncrude gained approval to begin developing its oil sands lease in 1974 – a year after the 1973 price increase, and began to operate in 1979 – the year of the second major price increase, but still, like GCOS, relied fundamentally on the hot water extraction process developed by Karl Clark in the 1920s. The most visible difference was the heightened scale of Syncrude mining operations when compared to GCOS: GCOS (now Suncor) was by late 1970s producing 57,000 barrels of synthetic crude oil per day; Syncrude was constructed to produce 129,000 barrels, roughly double the output. Consistent with this one-to-two ratio, whereas Suncor chopped into the sides of its mine faces with two giant, self-propelled bucket wheel excavators, each the size of a half-football field, Syncrude scooped out the sand with four walking draglines, each the full length of a football field (see Figure 5.4). Syncrude’s draglines then deposited the sand into piles – called

38 Extending in latitude from 56º N to 59º N, the oil sands region receives very high solar radiation in summer and very low solar radiation in winter. This accounts for swings in ambient temperatures of 80ºC: from plus 30º C in the summer to minus 50 º C in the winter (Smith, 1981, p. 8).

windrows – which were then picked up with bucketwheel reclaimers, deposited into dragline hoppers (see Figure 5.5), and likewise transported to the main plant via a system of conveyor belts. Another main difference was that Suncor used delayed coking; it upgraded the sand in batches, while Syncrude used a continuous upgrading process, known as ‘fluid coking’, which simultaneously cracked bitumen into liquid products while using burnt coke as the energy source to power the cracking process (Heron & Spady, 1983, p. 144). While the fluid coking process yielded ten percent more liquid products than delayed coking, the resultant API gravity was two to six degrees more viscous than the synthetic oil produced at Suncor: the quality, and market value, was lower. The heightened volumetric production of the Syncrude plant was the direct result of its greater scale; Syncrude was still subject to the same challenges in rationalizing production (i.e. by attaining continuous feedstock to processing plants) as Suncor: deploying machinery in extreme temperatures and on unstable landscapes; adapting conventional mining equipment to the abrasive, viscous sands; and efficiently separating the bitumen from the sand, clay, minerals, and metals in which it was enmeshed.
Figure 5.2 A bucket-wheel excavator operating on a working face. Photo of the Suncor (formally GCOS) lease. Source: (Techman Ltd. & Rheinbraun Consulting GmbH, 1979).

Figure 5.3 A conveyor transport site on the Suncor lease. Source: (Techman Ltd. & Rheinbraun Consulting GmbH, 1979).
Figure 5.4 A bucketwheel reclaimer on the Syncrude lease during winter. *Source:* (Techman Ltd. & Rheinbraun Consulting GmbH, 1979).

Figure 5.5 Photo and diagram of a dragline hopper. *Source:* (Techman Ltd. & Rheinbraun Consulting GmbH, 1979).
Due to the large capital and long lead times required to construct the technical infrastructure for oil sands extraction, during the 1970s price shocks no new firms began commercially developing an oil sands lease, and the two major consortiums which were operating, Suncor and Syncrude – the latter heavily supported by the federal and provincial governments – still continued to face major barriers to augmenting production. Further, Suncor and Syncrude had confronted immediately and directly high variations in bitumen saturation and pay thickness by gaining access to leases with the richest, closest to the surface deposits. Because production could only be scaled up by augmenting the efficiency of existing plants, or by extending production outwards in space (laterally or vertically), increasing the efficiency of surfacing mining and finding technological processes to extract deeply buried bitumen, which comprised 82 to 90 percent of the total known bitumen deposit, became the two primary objectives of the technological research program set up to increase synthetic crude oil and bitumen production.

5.2 The objectives, operations, and results of AOSTRA

In 1971, Peter Lougheed’s Conservative government ended thirty-six years of Social Credit rule, promising to reduce Albertans’ dependency on government and on multi-national companies, to return control of the province’s resources, and resource rents, to Albertans, and to accomplish all of this as much as possible through the private sector (Wood, 1985). As part of this broad mandate, and as an opportunistic response to the 1973 oil price increase, in 1974, Lougheed announced ‘Project Energy Breakthrough’, whose main feature was the Alberta Oil Sands Technology Research
Authority (AOSTRA), a quasi-independent agency mandated to confront “the critical technological barriers impeding the commercial development of the Alberta oil sands,”\(^\text{40}\) By examining the technological changes emerging from the objectives and operations of AOSTRA, this section takes an initial step towards destabilizing technological innovation in the oil sands as the direct outcome of market forces. Instead, as I argue, technological research and innovation was driven in large part by a specific developmental ethos of the provincial government that shouldered much of the risks of technological research for firms. In doing so, the government had to carefully mediate the contrasting interests of firms and government in technological development.

As outlined in the 1974 *Oil Sands Technology and Research Authority Act* and the 1975 amendment to this Act, AOSTRA was mandated, first, to support research into recovery, processing, and transportation technologies, and second, to act as a mechanism to compile, assess, and disseminate information on these technologies. The legal clauses of this Act clarified that technologies had to be both ‘efficient and economic’, and that research into the technological methods for ‘environmental conservation’ was to accompany that on recovery and processing operations. Through its finer-grained objectives and the specific forms of support and cooperation that AOSTRA proceeded to encourage and maintain, the authority was instrumental in introducing formal economic parameters into the oil sands production process, offsetting the high risks of technological research, and accelerating profitable means of extraction.\(^\text{41,42}\)

AOSTRA’s legal mandate had a structuring effect on its more fine-grained, day-to-day research objectives, but, perceptibly, so did the obstacles of in situ production, the variations of raw material grades, and the differing ease of recovery of deeply buried deposits. In 1976, “the six most important objectives of the Authority” were listed as follows:  

1. At least one in-situ recovery process for each major oil sand reservoir type.  
2. More effective, efficient, and environmentally acceptable upgrading technology.  
3. Resolution of major technical problems of current surface mining technology.  
4. Evolutionary increases in percent recovery from in-situ processes.  
5. Alternative surface extraction technology.  
6. Conversion of oil sand and heavy oils into higher valued petroleum and mineral products.  

These objectives spanned all links in the ‘hydrocarbon commodity chain’ (Bridge, 2008, p. 394), from extraction to the production of higher value commodities. Concerning extraction, it was realized that there would be no one ‘technological fix’ for the geophysical obstacles to bitumen recovery, but that because the motivations behind technological innovation were economic considerations – specifically, profit-maximization (firms) or the maximization of resource rents (governments), technologies would be “site specific to the particular leased area” (Heron & Spady, 1983, p. 145). The focus on researching technologies to upgrade oil sands into higher value commodities towards the end of this chain represented a priority of the Lougheed government to diversify and promote long-term development of the provincial and regional economy. In other words, AOSTRA was to help overcome the ‘staples trap’ that had so far left the provincial economy largely reliant on a few raw material exports (namely, coal, oil, and wheat), by creating opportunities for domestic processing and a diversified industrial base.

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AOSTRA’s objectives were ambitious.

The central challenge was using sizeable public funds to contribute towards the public good, while providing specific competitive incentives for firms to participate in cooperative research. AOSTRA’s framework of public-private technological research and dissemination were founded on ‘appropriability’ mechanisms, which were worked in to three important aspects of AOSTRA’s operations: the choice of its leadership and staff, the ownership of its technology and technical information, and the organization of its university research. However, within these areas, the tensions between research for public benefit and research for private gain had to be continuously addressed and negotiated.

A first mechanism used to facilitate technology transfer to firms, while ensuring research was broadly in the public interest, was the choice of Board members and contracted staff. Because of the highly technical and specific nature of AOSTRA’s research, and moreover the goal of “future commercial application,” the most suitable employees were recognized as those who already had experience researching the oil sands in the private or public sectors. This was a limited pool. Yet in the early operation of AOSTRA, there were attempts to strike a balance between public and private

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44 Generally, within capitalist societies, and speaking particularly in the context of government reliance on the firm, the ‘public good’ is understood as the creation of capital and of jobs (Brooks & Stritch, 1991). From this approach, Lougheed’s goals, discussed at the beginning of this section, of returning control of the province’s resources and resource rents to Albertans can be understood as being valued for their ability to create capital and jobs within the province. Again, this takes us back to the question of the limits and possibilities of using resources, and resource rents, as the locus of stable, long-term regional economic development and employment (Innis & Innis, 1956; Innis, 1956; Auty, 1995a, 1995b; Prudham, 1998; Howlett & Brownsey, 2008b; Brownsey, 2008; Bridge, 2008).

expertise. For example, the first search for an AOSTRA chair – the only member of the Board to be employed on a full time basis – was conducted using an international executive search firm, in order to avoid the selection of a political appointee (Hester & Lawrence, 2007, p. 22). The appointed chair, Dr. Clem Bowman, was an engineer who had previously worked for Imperial Oil’s research labs in Sarnia, Ontario, had helped to develop Syncrude’s extraction processes, but at the same time was known as an “independent investigator who was not afraid to express his opinions, even when those were not in the best interest of the companies he worked for,” (Hester & Lawrence, 2007, p. 22). In 1977, when Frank Spragins, previously a senior executive within Syncrude, and Dr. E.J. Wiggins, prior Director of the Alberta Research Council, were both appointed as Board members, Clem Bowman privately wrote the Honourable Don Getty, then Minister of Energy and Natural Resources, advising him “If you do decide to make an announcement [on the appointments], I would recommend both men be included to show a balance is being maintained between private and public sector appointments.”

As it turned out, AOSTRA board members and contracted staff predominantly would have backgrounds within the oil industry, as consultants to the oil industry, or within the Alberta Research Council, or some mix of the above, often concurrently because AOSTRA in its early operations did not hire full-time staff. As AOSTRA grew in size, it did hire permanent staff, reaching a maximum of thirty, whose salaries were often jointly paid by AOSTRA and individual firms (Hester & Lawrence, 2007, p. 24 - 25). AOSTRA was a site where public and private expertise inter-mixed, and the boundaries between these two spheres became blurred.

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A second, more direct, mechanism by which AOSTRA sought to reconcile the different motivations between public research and private gain was through collaborative field projects, financed on a 50/50 basis by AOSTRA and industry. In 1976, the government issued a call for oil sands proposals to the Alberta oil industry, selecting five projects to jointly undertake from a total of twenty-one applications received. The successful applications were as follows:

- Shell Canada Limited (Peace River)
- Amoco Canada Petroleum Ltd. (Athabasca – Gregoire Lake)
- BP Canada Limited (Cold Lake)
- Numac Oil and Gas Ltd.
- In-Situ Research and Engineering Ltd.

From the perspective of the firms involved, these projects were expected to lead directly to commercialization, and in this sense were valued because they would create “blueprint knowledge”: a term used in the economic literature to describe specific guidelines that enable firms to produce a good (in this case a deposit) at either a reduced cost or at a higher quality (Verspagen, 1992, p. 637 - 638). In contrast, for the Alberta government these projects were valued in a broader sense for providing the general knowledge needed to develop each major oil sands deposit: knowledge that could “be used not only by the entrepreneur who develops it explicitly, but also by other firms in the research sector,” (Verspagen, 1992, p. 638). In this way, it was important for AOSTRA to keep ownership of the “technical know-how and patent rights arising from these projects,” as it would enable them to license technical information and new process technology to other industry...

In an interview conducted by two United Nations consultants researching public-private partnerships, Bowman recollected the initial resistance of firms towards this proposed, and fairly novel, organization of technological ownership (Hester & Lawrence, 2007, p. 25):

This is when the tough part started…the Alberta government required that AOSTRA own any new technologies developed, a condition that, in the beginning, companies weren’t comfortable with...The other companies just decided to back off until Amoco cut a deal…Amoco was really the first company to understand that they didn’t need ownership rights, they just needed use rights.

Once the agreements for the projects were in place, however, AOSTRA came under scrutiny from firms not participating in AOSTRA for its policy of protecting its information from public disclosure. Bowman noted the following in a letter to the Honourable Don Getty, realizing the irony of the position he was in:

It is interesting that the private sector, who have largely restricted the flow of information in the past, now believe that technology generated with public funds should be made available to them at no cost. The question we have asked ourselves is, if the private sector is able to protect its technology, why is not the public sector able to do the same? It is important to realize that because of the nature of the process technology (well completion techniques, steam pressures, air/steam ratios, etc.) the major beneficiaries of freely disclosed Authority technology would be the large oil companies, not the general public.

In fact, technology sales and licensing would only ever make up a fraction of AOSTRA’s income (see Figure 5.6) and thus the public derived little benefit from this particular practice. Really it was the motivation for firms to participate in AOSTRA, and thereby to invest in technological research and development, which was being protected.

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50 Consistent with the choice to give firms a ‘time-lead’ on innovations in order to enable them to profit from the innovation, AOSTRA agreed to keep some technologies confidential for up to thirty-five years – agreements which have yet to expire (Hester & Lawrence, 2007, p. 30).


52 Ibid.
AOSTRA also attached terms to the university research it funded in order to make it more relevant to the private sector. Throughout the operation of the program, there was some focus on basic research of oil sands behaviour and chemistry. For example, studies were conducted on the “McMurray basal clays, strength characteristics of the oil sands, [and] settling characteristics of clays in the Clearwater and Upper McMurray formations,” (Heron & Spady, 1983, p. 146). Increasingly, however, explicit mechanisms were set in to encourage applied research. In 1980, for example, AOSTRA helped to establish a Master’s degree in Oil Sands Engineering at the University of Alberta; in the same year, the University Access Program was established, through which firms could obtain use rights to a single university project at five percent of a single program cost, or twenty-five percent of the total program cost; and in 1981 AOSTRA invited companies to become financial and technical participants in university programs (AOSTRA, 1981, 1982). With regards to the latter, AOSTRA stated that “Industry participation assists university researchers in identifying important research targets and also puts the companies in a position to rapidly commercialize the results” (AOSTRA, 1982, p. 10).\(^53\) Like the results of research jointly conducted by AOSTRA and companies, all patents of AOSTRA-funded university research were owned by AOSTRA, and professors could not publish their results until a delay (six months) after the completion of the research program, although funded Doctoral and Master’s students were allowed to publish results in their theses before this time.\(^54\)

\(^{53}\) As of March, 1982, roughly a year after starting this program, twenty-three companies had elected to become participants in university projects (AOSTRA, 1982, p. 10).

It is worth dwelling a bit more on the exact mechanisms and perceptions that underlay university-funded research on the oil sands. First, it must be said that this practice was not new: the University of Alberta had been the site of applied oil sands research since the 1910s, and Henry Marshall Tory, one of the University’s founders had been a particularly strong advocate of oil sands development (see Chapter 4). Yet the integration of university science with industrial innovation in the 1970s was of unprecedented degree, and the practice of aligning the education function of the university with corporate ends, through curriculum, supervision, lectureships, and dissertation topics, was fairly novel in the province.\(^{55}\) Second, the particular ways in which education was aligned with the dictates of oil sands science and technological innovation demonstrated that the allocation of state funds towards industrial research was necessarily a political decision, one that took funds away from other ends. In this context, it is pertinent to note that AOSTRA scholarships and fellowships were “significantly higher in value than comparable Scholarships provided by the Province of Alberta.”\(^{56}\) After consulting with the University Co-ordination Council (made up of the Presidents of the three Alberta universities), AOSTRA approved two-year scholarships of $6,000 for the first year and $7,000 for the second year, and fellowships of $15,000 per year; the Killam Awards for the previous year – some of the most competitive

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\(^{55}\) During this period, the integration of university and industrial science for the oil sands was also of heightened scope: in 1976, AOSTRA established professorships in oil sands technology at the University of Alberta, the University of Calgary, and the University of Lethbridge. The first professorship at the University of Lethbridge enabled the appointee to devote approximately 75 percent of his time to research studies on the oil sands (Source: Provincial Archives of Alberta. (1976) “AOSTRA Scholarships and Fellowships” Letter from C.W. Bowman to The Honourable D.R. Getty, Alberta Minister of Energy and Natural Resources. Communication no. 1830. August 27, 1976. GR 1982.165 file 279). At one point, there were over 80 professors were involved in research and teaching with regards to the Alberta oil sands, and over 500 students had obtained advanced degrees in related fields (Unknown author, unknown date, p. 43).

scholarships in Alberta – ranged from $5,800 to $6,400, and “The normal province of Alberta Graduate Scholarships” were “certainly below these figures.”57 The perception was that “Many of these individuals will eventually enter the industrial research sphere,” (AOSTRA, 1989). That the university was a suitable place for workplace training for the oil sands industry, was accepted by both AOSTRA and the Alberta university leadership.

The injection of government funds into AOSTRA and the channeling of these funds into individual AOSTRA and joint AOSTRA-industry projects were continuous, pressed through even during price depressions. To understand the significance of this funding, it is useful to look at the type of government funds given to AOSTRA over the course of its operation. According to a librarian within the Alberta Department of Energy, however, the total value of funds given to the authority is an “ongoing question within the Department” (personal conversation with Alberta Department of Energy Librarian, January 29, 2009). Reasons for the elusiveness of a price for the cumulative work of this government institution may stem from the following factors: first, its shift from a quasi-independent agency to its incorporation under a series of government departments, beginning with the rationalization of the provincial bureaucracy that followed Ralph Klein’s election in 1992; second, the fact that AOSTRA’s funding sources were numerous – for example, although never achieving the hoped-for goal that by 1989 the authority would be funded entirely by the sale of its proprietor technology, AOSTRA did generate its own income through technology licensing and sales (see

57 In fact, the university presidents were the first to recommend the precise values of AOSTRA’s scholarships and fellowships that the authority later decided on. Source: Provincial Archives of Alberta. (1976) “AOSTRA Scholarships and Fellowships” Letter from C.W. Bowman to The Honourable D.R. Getty, Alberta Minister of Energy and Natural Resources. Communication no. 1830. August 27, 1976. GR 1982.165 file 279.
Last, while a quasi-governmental agency, AOSTRA was not subject to the same oversight as provincial departments; the only occasions for external evaluations of the authority being a highly technical annual report to the Alberta Legislature and the chairman of AOSTRA’s annual presentation of accomplishments to the Executive Council (Hester & Lawrence, 2007). A final reason for the ambiguity of costs may also be that when AOSTRA requested additional funds to participate in the higher-than-expected number of applications it received, especially in its early period, these requests were generally granted by Lougheed’s government. In 1974, for example, AOSTRA was established with research funds of $100 million for a set five years of operation; in 1977, the government had increased the authority’s funding to $144 million; an additional $174 million was added between 1977 and 1980 to continue support to existing in situ operations and begin new projects; in 1979, following the second oil shock, the program received $75 million to research enhanced oil recovery of conventional oil and heavy oils; and in 1987 – in the throes of the mid-eighties oil price depression (see Figure 5.1) – AOSTRA took in its highest government funds to date in one year: $67,327,125.

Although originally intended as a five-year program, AOSTRA lasted twenty-six years, until being dissolved in 2001 under the Alberta Energy Research Institute (AERI), where oil sands technological research continues.

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60 As I will further emphasize, this figure does not account for industry, university, or other institutional funding to AOSTRA projects. It likely also undercounts contemporary costs of oil sands research within AERI, and does not include government funding to other institutions researching technological aspects of oil sands production: the Alberta Energy Research Institute (AERI); the Canadian Energy Research Institute (CERI); the Canadian Centre for Minerals and Energy Technology (CANMET); and the Imperial Oil-Alberta Ingenuity Centre for Oil Sands Innovation at the University of Alberta, among other research programs. Interestingly, while an arm’s-length institution from the Alberta government, AOSTRA’s bookkeeping was more transparent and more detailed than that of many of these newer organizations.
By tracing the documentation of AOSTRA’s funding from all sources (including technology sales, but excluding industry funds) from its existence as an autonomous agency in 1974 through to 2008 in its current dissolution under AERI, I calculated that government funding to AOSTRA and AERI to support oil sands research has totaled just under a billion dollars, or approximately $872,185,923 (nominal dollars), roughly about 97 percent of which was government revenue.\footnote{I wish to thank the Head Librarian of the Alberta Department of Energy for pointing me in the direction of these sources, and for giving up the better part of her day to accommodate and encourage my requests.} The scale and significance of this project was effectively captured in 1980 by Merv Leitch, then the Minister of Energy and Natural Resources, who remarked, “This is one of the single largest research and development programs ever launched in Canada,” (AOSTRA, 1980, p. 5).

![Figure 5.6 AOSTRA Funding Sources, 1977 – 2008.](image-url)
5.3 The timing of technological change

Somewhat contradicting Lougheed’s goal of reducing public and private reliance on government, instead of an effective springboard for independent industrial innovation, AOSTRA never succeeded in untethering industry from state support. Numerous government-funded institutions continue with specific mandates to reduce the capital and operating costs of the oil sands industry: the Alberta Energy Research Institute (AERI) in Calgary, Alberta is one; another is the CANMET Centre in Devon, Alberta, whose National Centre for Upgrading Technology had a 2001 – 2002 budget of $8.1 million, funded in decreasing order by the federal government, Alberta government, industries, and universities (Doern & Kinder, 2007, p. 97). Particularly during lurching and depressed oil prices, government support has been integral to the development of new technologies for oil sands extraction and upgrading.

In fact, of the two major technologies that drastically improved the supply-side economics of oil sands projects, market forces can partly explain only one. This technology is the use of large mining trucks that made possible the development of low-grade copper and gold ores in the U.S. As higher grade deposits were depleted, firms developed more efficient technologies to offset the higher production costs of extracting lower grade ores (Bridge, 2000, p. 245). The 320-ton dump truck introduced in the U.S. in 1997 has since evolved into 400-ton mining trucks, the largest fleet of which trawls the muskeg-cleared oil sands (Finning, unknown date). These trucks have significantly

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62 In a similar vein, the National Oil Sands Task Force, an amalgam of government – mainly the Alberta Chamber of Resources – and the oil industry – optimistically asserted in 1995 that it could rely independently on private sources of investment, including foreign pension funds and Japanese multinationals, to scale up oil sands production. One industry leader stated, “We are dead set against any handouts. This means no grants, loans, subsidies or other artificial inducements,” (NTFOSS, 1995).
decreased the costs of supplying oils sands plants with extracted bitumen from those incurred by the often-broken conveyor system (personal conversation with resource assessment specialist within the ERCB, February 3, 2009).

Second, and outside of the immediate influence of market forces, was the unexpected discovery of “wormholes” – rarely described in more technical terms – that lead to higher production rates from the same amount of bitumen-saturated sand. In the 1970s and 1980s, AOSTRA-supported projects in the Cold Lake area had been “ridden with problems caused by extreme wear on the pumps used to bring bitumen to the surface due to the presence of sand,” (Dunbar et al., 2004, p. 18). The specific challenges of existing projects spurred development of the progressive cavity pump, which by producing sand along with the bitumen, especially early in a well’s life, was conducive to higher production rates. This was because a system of preferential fluid flow paths, or “wormholes,” was formed and expanded as the sand was produced (Dunbar et al., 2004, p. 18).

Finding workable configurations of underground pipelines, steam pressures, steam to air ratios, water and solvents in various combinations did not result of rising oil prices, but from muddling through existing projects – many of which were supported at least in part by the Alberta government. As Timothy Mitchell has argued, the technical expertise in large-scale state projects is not gained through some abstract notion of market-lead progress, but is worked out on the ground; “the projects themselves [form] the science,” (Mitchell, 2002). Symptomatic of this trial-and-error process, the Chairman of AOSTRA would imply in his five-year review (AOSTRA, 1980, p. 2):

I wish I could report the discovery of a single magic process that would unlock all of Alberta’s huge oil sands resources economically. Although I am not able to do this, I can report that significant progress has been made in many areas, and an unparalleled dedication of Canada’s technical and scientific capabilities has taken place.
The most commonly used extraction techniques today are the cyclic steam pressurization extraction technique, developed by AOSTRA for the Peace River deposit, and the cyclic steam stimulation extraction technique, which was developed by AOSTRA for the Cold Lake deposit, and evolved into the Steam Assisted Gravity Drainage (SAGD) technology (Dunbar et al., 2004, p. 19). These technologies gave the ERCB confidence to adjust the oil sands reserves figure to 175.2 billion barrels (personal communication with resource assessment specialist within the ERCB, February 3, 2009). However, by the time these technologies were researched, piloted in the field, and then ready for commercialization, the first two oil shocks had passed and the third oil shock had ushered in what is widely referred to in the Alberta energy sector as the “restrained period” of oil sands growth (personal conversation with resource assessment specialist within the ERCB, February 3, 2009).

A final example to illustrate that the price mechanism did not bring forward the most cost-effective or efficient technology may be provided by the Alberta Taciuk Process (ATP), conceived by the Alberta engineer William Taciuk (AOSTRA, 1977). The Taciuk process had a number of advantages to the Clark hot water extraction process: it recovered a much higher percentage of the bitumen; it used a heated kiln instead of water-washing, so did not produce tailings ponds; and the economics of the process were less sensitive to the size of the plant, so could allow smaller commercial projects (AOSTRA, 1977). Beginning in 1984, AOSTRA repeatedly noted in its annual reports that the ATP was ready for ‘scale-up’ and that it was soliciting participation from industry: “A field demonstration plant would be an essential intermediate step in

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63 Firms that wish to use SAGD on their leases must pay the Alberta government licensing fees of $1.2 million, although licensing revenue has yet to cover the province’s investment in this technology (Hester & Lawrence, 2007, p. 39).
preparation for a full scale oil sands commercial plant,” (AOSTRA, 1990, p. 26). Yet, unable to obtain industry participation, the Taciuk process was never instituted on a commercial scale in the oil sands, although it has “continued to attract widespread interest for its spin-off applications in hydrocarbon waste treatment and cleaning of contaminated soils,” (AOSTRA, 1991, p. 10). In particular, the Taciuk process would have had significant environmental benefits, notably the elimination of tailings ponds. Although the reason for its lack of commercialization would later be cited as ‘economic’, there had been considerable tests conducted by AOSTRA demonstrating its viability. Its lack of implementation sprang in part from the separation of technological and environmental research and regulation: “For the most part, environmental benefits from technology development programs undertaken previously by AOSTRA have been supplemental to the broader goals of enhanced economics, resource utilization and removal of technological roadblocks to resource development,” (AOSTRA, 1991, 1992). In the following chapter, I turn to the environmental regulation of oil sands extraction, arguing that the ecological degradation resulting from oil sands production are not external from the economic and technological viability of oil sands projects.
6 Defining Oil Sands Environmental Impact, Discovering Supply Cost

The conception and arrangement of the economy as a self-contained sphere requires from the beginning, and at every point, in every interaction and exchange, the maintaining of a difference between the monetary and non-monetary, the economic and the personal, the public and the private. This process of differentiation, very fuzzy and uncertain in its details, precedes and makes possible the effect of the economy as a self-contained sphere. In this broader sense, then, what is depicted as the non-economic is implicated at every point in the creation of the economy.

(Mitchell, 1998, p. 93)

This in fact is called, what we will call, direct operating costs and is not to be construed with the costs of producing a barrel of anything.

Representative of Petrofina Canada Ltd. in 1977 proceedings held before the ERCB

The previous two chapters have discussed how it became possible to profitably extract oil from the bitumen-saturated sands. Knowledge of the heterogeneous and unwieldy sands was translated into economic information as government and industry separated economic from non-economic bitumen deposits and introduced technology as a factor in accelerating the conversion of the oil sands into synthetic crude oil and crude bitumen. In this chapter, I turn from the information that has come to count in the determination of price, to a more encompassing understanding of price that accounts for its exclusions, or what has been left out. These exclusions, such as the material below and above the oil sands economic strata (i.e. aspen and spruce forest, underground aquifers, the Athabasca river, migrating waterfowl, air), as well as uneconomic technologies, have not been factored into economic models. Yet, as I argue, these ‘non-

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economic’ entities have, at every point, been implicated in fixing the oil sands as an economically viable, conventional oil reserve.

In this chapter I examine how supply costs have been shaped by decisions of how to research, regulate, and cost certain known, uncertain, or at times incalculable aspects of oil sands production. Rather than understand the bio-/geophysical transformations that have resulted from these decisions as ‘externalities,’ an economic term for social costs that are created as inefficient by-products of private market transactions, I make the case that they are better seen as constitutive of the commercial viability of oil sands projects. At a basic level, the particular metabolism of oil sands production has relied on the input of land, energy, water, and human work, as well as the output of waste streams, in the form of gaseous emissions, solid by-products, and liquid tailings. Neoclassical economics may have been more justified to theorize such industrial inputs and outputs as external to economic processes when the scale and pace of their impacts were less pronounced. However, as the bio-/geophysical changes underpinning oil sands extraction have increasingly exceeded the assimilative capacity of the Athabasca environment – due in large part to the material differences of this petroleum resource, the practice of isolating project economics from certain of the ecological conditions of oil sands extraction has become the locus of increasing social opposition in Canada and internationally. In the 1960s and 1970s, government and industry efforts to contain social opposition and the ecological effects of industrial extraction resulted in the adoption of regulations based on cost-benefit analysis, and from the 1980s to the present, regulations based on the idea of sustainable development. Yet, in failing to meaningfully reshape the boundaries between the economic and non-economic aspects of industrial
extraction, these modes of re-regulation have prolonged and accentuated the challenges to the continued profitability of oil sands production.

The chapter is organized as follows. First, I examine the historical and geographical contexts as well as regulatory response to the emerging concern with ‘the environment’ in Alberta during the 1960s and early 1970s. As I discuss, due to the historic practices and processes of industrial mining in the province, this regulatory response took the form of new laws to protect and reclaim the renewable resources associated with non-renewable resource extraction. Second, I identify and assess the key decisions of how to research, regulate, and cost the oil sands taken by both provincial and federal governments beginning from the 1970s, using as a starting point AOSTRA’s counterpart – the Alberta Oil Sands Environmental Research Program (AOSERP). Last, I discuss the current challenges to the historic modes of resource extraction and production in the oil sands, focusing specifically on the bio-/geophysical transformations that have re-presented themselves in recent years to project viability, largely because of being displaced from oil sands project economics in the initial stages of development. I conclude that the success of recent challenges to the environmental practices of oil sands firms hinges on going beyond the identification of unpaid costs, to question the perceptions, practices, and judgements upon which nature-based markets are formed.

6.1 The emergence of industrial environmental regulation in Alberta

Regulations for the environmental impacts of the oil sands industry were deployed within an existing framework of mining regulations in the province. This
framework stretched back to the early 20th century, when, as discussed in Chapter 3, the rapid and often chaotic removal of resources had given rise to a new concern with ‘conservation’, understood to mean both profitable and efficient resource extraction. In 1911, for example, the Commission of Conservation on Lands, Fisheries and Game, and Minerals reported to the Governor-General of Canada with more than fifty pages of recommendations for the conservation of Dominion and Provincial mineral resources. The primary recommendation, stressed constantly, “was the need to impound or otherwise store mining waste so that, eventually, residual values could be obtained by reprocessing,” (Unknown author, 1982). And, at once differentiating, though finding common ground between the economic and natural effects of industrial mineral extraction, the commission noted that “The practice of dumping tailings and slag into the rivers represents a two-fold evil — the loss of valuable mineral and the pollution of streams,” (Government of Canada & Commission of Conservation, 1911, p. 412). In the ‘first wave’ of concern with the effects of industry, regulation of the ecological and market aspects of mineral extraction took the same form; the key metrics governing both being profitability and efficiency.

This approach to mining regulation profoundly transformed the Alberta landscape, so that by the mid-1950s and 1960s the province was pockmarked with abandoned tailings ponds, clear-cut and strip-mined land, and polluted watercourses: the legacies of abandoned oil and gas wells and coal mines (Alberta Environment, 1999).65 These effects lead to land use conflicts between mining industries, on one side, and, on the other, municipalities, farmers, and foresters in areas of resource extraction, as well as

advocates of wildlife, water conservation, and recreation. In 1963, in response to these conflicts, the Alberta Government passed the Surface Reclamation Act, the first provincial legislation in Canada to require that oil, gas, and coal mining sites be reclaimed to an ‘equivalent capability’ before they could be abandoned (Alberta Environment, 1999, p. 3). The establishment of the Land Conservation and Reclamation Council (LCRC) followed the Act, composed of representatives from different provincial Departments who were responsible with enforcing the Act’s guidelines.

Yet as the Act and its enforcers failed to substantially improve industrial practices, select bureaucrats within renewable resource departments expressed increasing frustration at the historic prioritization of mining activity over alternate land uses within the province. Their critiques focused exactly on where the boundaries defining the economic benefits and costs of mining projects had been drawn. One report, for example, argued that the “problems arising from present or past mining activities” had resulted from “too narrow an application of resource economics.” It was further elaborated that, although the benefits of alternate land uses such as recreation were “difficult to quantify or evaluate because all the economic benefits are indirect,” the greater permanence of their economic returns and “their enhancement of the physical and mental well-being of individuals which is necessary to keep them economically

68 Provincial Archives of Alberta: Unknown author and unknown date. The Potential Effects of Mining and Quarrying on the Quality of Surface Resources. GR 1979.015 box 324 file D.8, p. 1. (Note: although the significant details of the authorship and date of this report were not available, its location within the same file as similar reports and reference to it by the Conservation and Utilization Committee strongly indicate that it fits within this time period and context).
productive,” justified their consideration in land use decisions and mining procedures.\textsuperscript{69} Another report, issued in 1967, discussed the land use issues to be considered in future applications for coal mining in Crowsnest Pass. The author, G.M. Smart of the Alberta Forest Service, noted “In the Vicary-Racehorse area, damage has been greater than necessary, notwithstanding the efforts of this Department to prevent it.”\textsuperscript{70} Smart went on to describe the specific expressions of “physical devastation” resulting from strip mining and underground extraction, noting, for example:

Mining in the steep, narrow valley of Vicary Creek has created a situation where it is virtually impossible to separate the watercourse from the mining operation in a manner that will prevent stream pollution. The settling ponds through which water from the main mine is passed before being allowed to enter the creek, are not wholly effective. Finer suspended materials do not settle out in these ponds and remain in the water.

Smart further catalogued that no vegetation had been established on worked areas, sedimentation of Vicary Creek was destroying fish habitat and food supply, precipitation had been observed to contain iron compounds (‘yellow boy’), and the air was “so full of coal dust at times that one can only see a few feet.”\textsuperscript{71} Attaching and referencing a recent report documenting U.S. government reclamation and rehabilitation programs, Smart recommended new legislation requiring mining companies to submit ‘restoration deposits’, on a per acre basis for strip mining and on a flat sum or per ton deposit basis for underground mining. Their purpose would be to guarantee compliance from mining firms and make funds available in case of default. In this way, the second wave of concern with the effects of mining on the natural environment resulted in calls to expand

\textsuperscript{69} Ibid., p. 6.
\textsuperscript{71} Ibid.
the calculation of mining costs and at the same time to consider the benefits of alternate surface uses.

Despite widespread support to alter the cost and practice of resource extraction to incorporate and contain certain ecological transformations, such as through land reclamation, the tendency to consider only market price and supply costs in mining decisions was difficult to displace. As early as 1967, municipalities, farmers, and foresters expressed concern that the Land Conservation and Reclamation Council (LCRC) was ineffectual. As a particular expression of the Council’s ineffectuality, in 1968 G.M. Smart noted that, although his report was “issued about one year ago,” “no progress has been made towards implementing any of the recommendations.” As a result, on May 25, 1969, six years after the Surface Reclamation Act was passed, a committee was struck to recommend “measures to improve regulation and control of activities affecting surface renewable resources.” The Reclamation Sub-committee of the Conservation and Utilization Committee was set up and appointed with a select group of bureaucrats from the renewable resource departments of the province, including the fish, wildlife, and forest land use branches of the Department of Natural Resources; the water resources and agriculture branches of the Department of Agriculture, among other planning and energy representatives. The committee, bringing to light the above-mentioned reports, proposed establishing a permanent Reclamation Board to replace the

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75 Ibid.
Land Surface Reclamation Council, on which both renewable and non-renewable resource agencies would be represented (“for it [reclamation] to be handled exclusively by a non-renewable resource agency leaves much to be desired”). Further, they introduced a more encompassing notion of conservation, on top of the prior exclusive focus on reclaiming degraded land:

In this context, the term “reclamation” is meant to include preventative measures required to reduce or prevent damage to surface renewable resources during the course of an operation, as well as reclamation of the land following completion.77

The 1973 Land Surface Conservation and Reclamation Act, which built on many of the committee’s recommendations, legislated that mining firms would have to first file an operating and reclamation plan, which would then have to be approved by the Reclamation Board, and finally secured, as G.M. Smart had suggested, by a deposit or performance bond. The general aim was to institutionalize measures to protect other resources throughout the course of the mine operation, in recognition that such measures had historically not been factored into market calculations of project viability:

The Sub-Committee realizes that objections will be made by some mine operators on the grounds that reclamation requirements might be too expensive. The Sub-Committee is aware that in some areas the mining industry is marginal and that enforcing proper reclamation procedures might make the mining operations uneconomic. The Sub-Committee is strongly of the opinion that this is no excuse for not carrying out proper reclamation.78

The Sub-Committee further raised the possibility that the government could consider subsidizing reclamation. However, the broad aim was to enable firms to “better estimate

77 Ibid., My emphasis.
78 Ibid.
costs and take the economic factor of reclamation into account when planning operations or investment.”

Thus, by the 1970s new regulations were enacted to contain the ecological effects of historic mining and conservation practices, and these regulations aimed to perceptibly shift the borders previously drawn between what constituted an economic and an ‘uneconomic’ resource. These shifting priorities in Alberta, influenced also by growing international concern towards a new object called ‘the environment’, coalesced to form a new institution mandated to regulate the ecological effects of industrial processes in the province. In 1971, two years before the Land Surface Conservation and Reclamation Act was passed, the Alberta Department of Environment was formed with a mandate to “promote a balance between resource management, environmental protection, and the quality of life.” At its inception, this Department was given jurisdiction over pollution prevention and control, water resources management, and land conservation. With regards to each of these fields, the Department’s founders stated three important commitments, relevant to the current ecological regulation of the Alberta oil sands. It was noted: first, that pollution standards “would not, under any circumstances” be “less stringent that those set by the E.P.A. in the United States or those set nationally in Canada”; second, that the Government recognized a “preferential use of water as follows: domestic, municipal, irrigation and other agricultural purposes, industrial, water power and other uses”; last, that the development of resources would be “undertaken in a way that there will not be lasting scars on the face of the land when the resources are

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exhausted. As I will subsequently discuss, each of these commitments has been ceded in the context of oil sands extraction, resulting in two underlying contradictions that have the potential to undermine the profitability of the oil sands industry: first, the degradation of nature itself and, second, the emergence of organized resistance to the oil sands industry’s historic practices of waste disposal. What institutional perceptions, practices, and relations produced these systematic failures?

6.2 Mapping the failure of environmental regulation in the Alberta oil sands

A preliminary answer to these questions may be located in the assumption of cost-benefit analysis that by weighing purely market costs and benefits against environmental ones, the price of a resource can be made to capture and then mitigate important environmental impacts. However, like neoclassical economics, cost-benefit analysis overlooks the negotiation of the contours of market costs between the institutional actors involved in market formation; it is premised upon the inherent logic and dynamism of an objectively demarcated entity called ‘the economy’ (Polanyi, 1977; Mitchell, 1998, 2002). With reference to this process of negotiation, costing the environmental impacts of oil sands extraction has hinged upon deciding what aspects of the Athabasca environment to first research and, in turn, how to regulate particular known – and unknown – effects. In examining these successive decisions, I argue that the conception of the economy as a self-contained object, within cost-benefit analysis and more recently sustainable development, has structured a nature-based production process significantly

81 Ibid., p. 6 – 9.
dislocated from the time and space necessary to evaluate and control the socio-ecological impacts associated with oil sands development.

6.2.1 Research

Before being able to regulate and cost the environmental effects of existing and proposed oil sands plants, it was realized that a large amount of research would be needed to generate information on the area’s renewable resources, particularly as they would be impacted by the Clark hot water extraction process (Intercontinental Engineering of Alberta Ltd., 1973; Smith, 1981). Prompted by internal scientific reports issued in late 1973 within the provincial and federal Environment ministries, advising much the same thing, the governments of Alberta and Canada began negotiations in 1974 for a joint research effort on the “social and technical environmental problems resulting from oil sands development,” (AOSERP & Environment Canada, 1977). In 1975, the Alberta Oil Sands Environmental Research Program (AOSERP) was initiated with a mandate to accumulate “the information necessary to an understanding of the characteristics of the biophysical environment (baseline states) on which could be based research to elucidate the processes and assimilative capacity of air, land, and water,” (Smith, 1981, p. 16 - 17). As evident from the language of its mandate, AOSERP was focused on static – ‘baseline’ – states; its key task being to catalogue whether the Athabasca environment could contain the ecological impacts resulting from dynamic, though bounded economic processes.

82 This would be undertaken, similar to AOSTRA, in an interdisciplinary and cooperative fashion among Federal and Provincial agencies, industry, universities, and other institutions (Smith, 1981, p. 17).
AOSERP’s focus on baseline states, combined with its diffuse, highly technical committee system produced detailed knowledge on localized environmental effects that would occur within relatively short time spans (Smith, 1981). For example, a study sponsored by its hydrology committee found that the GCOS Tar Island tailings pond’s dike filtration system was releasing 198 kg of organic carbon into the Athabasca river per day,83 a quantity which, in combination with other toxins, was later found to be acutely lethal to rainbow trout and brook sticklebacks.84 Its results were also highly compartmentalized; a characteristic that remained relatively unchanged as AOSERP was reorganized from a committee structure to one based on different environmental ‘systems’ (land, air, water, and humans) in its second year.85 Following this reorganization, for example, studies under the heading of land system research singled out rodents such as the red-backed vole and the deer mouse as potential pests in reforestation, especially as these mammals were found to “erupt into large populations every three to four years,” (Smith, 1981, p. 49). As a last example of AOSERP’s focus on already-occurring, discipline-specific states, the activities under air systems research remained relatively unchanged throughout AOSERP’s operation; air quality and meteorological monitoring under both resulted in detailed knowledge of the emission rates from operating oil sands plants, although the effects on the surrounding vegetation and fauna were studied only on a “casual basis”, and those on the added emissions of

85 The 1977 AOSERP Policy and Direction restructured AOSERP from eight technical research committees into four broader research areas: the Land, Water, Air, and Human Systems (Smith, 1981, p. 18 – 22). The purpose of this restructuring was to make research more responsive to policy changes and more useful to resource managers.
future oil sands plants, not at all (Smith, 1981, p. 98). To a large extent, these fragmented research projects resulted from the priorities of research participants, who originated, as in the Alberta Oil Sands Technology Research Authority (AOSTRA), from the oil sands industry and from Albertan universities. As a result of the mandates, compartmentalized structure, and participant interests within AOSERP, the environmental effects of oil sands production that became known were generally effects that could already be measured and were, at various scales, the effects of existing oil sands plants.

Other variables associated with oil sands production were more difficult to quantify, as they did not relate to baseline conditions, but to effects of future assumed industrial development. Key among the uncertainties was the possibility for land reclamation. It was true that certain important aspects of reclamation had been researched. For example, it was found that one of the main problems associated with reclaiming an oil sands mine would be that, due to the significantly larger volume of materials produced by the hot water extraction process when compared with the void area, the elevation of a reclaimed mining area could be more than 60 feet higher than the original terrain. A second studied problem was the permeability of the spent sand which, it was found, could be one hundred times that of the original oil sand and therefore an unstable medium for revegetation or reforestation. Yet beyond this research, a central unknown was the behaviour of the tailings ponds produced from hot water extraction; a

86 At a second planning workshop for AOSERP, it was noted “Many of the projects can be seen to have a practical end point. However, many others are, in our opinion, the result of the scientists’ desire to focus on his particular specialized field, or his desire to test a certain methodology or equipment. In terms of AOSERP’s objectives, the decision to fund this type of research is regrettable.” Provincial Archives of Alberta. Speech by Bill Cary, Chairman of the oil sands environmental study group. AOSERP Second Planning Workshop. September 30, 1976. GR 1987.191 box 1, file S.P.17.8 – AOSERP – Planning Workshop.
1973 study contracted by the Alberta Department of Environment stated, “It is not known at this point how much settling will actually occur with time,” (Intercontinental Engineering of Alberta Ltd., 1973, p. 77-79). Due to the lack of progress towards solving this problem, but also that it was later perceived as a cost that should be born by operating firms, the responsibility for reclamation was removed from AOSERP’s mandate in 1979 and put within its own provincial technical advisory committee (Smith, 1981, p. 99). Although at a 1976 AOSERP workshop it was predicted that, “There are going to be a large number of acres reclaimed by 1985,” by 1985, there was still neither a dewatering method for the tailings ponds or a dry extraction process that would prevent them, and there remained, as with previous coal mining operations:

the potential for effects on waterfowl and the danger of leakage, or in the worst case dike rupture, leading to the contamination of the Athabasca River and its tributaries in the immediate area, and serious impacts on downstream surface waters.

The impact of tailings ponds on waterfowl was another relatively unknown variable in scaled-up oil sands production. In 1974 Syncrude contracted an inventory of birds on and near its lease, which used a helicopter to survey the bird populations below. Due to the fact that data was not checked against ground surveys, and also the broader incalculability of bird migration, settling, and breeding patterns, the results admittedly

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88 In the last chapter, I discussed the Alberta Taciuk dry extraction process, which though being optimistically backed for several years by AOSTRA, was later deemed ‘uneconomic’ by government and industry.
contained inaccuracies and omissions. Yet, the report did catalogue the casualties of existing production:

The bitumen-covered carcasses of 20 to 30 birds (shorebirds and ducks) and two bitumen-covered ducks, still alive, were discovered at this small (two to four acres) pond [the Lower Camp Tailings Pond] on August 6, 1974.

More speculatively, it was predicted that:

This area may increasingly be used by shorebirds as a stopover area during migration. Additionally, these shallow ponds will thaw earlier than the lakes and may be used in the spring by large numbers of migrating ducks if there is little open water available on the lakes.  

Although it was difficult to pin down the future behaviour of such complex changes, the general outlines of future effects on wildfowl, provided the ongoing expansion of tailings ponds, became known through directed research projects.

Other effects within AOSERP’s jurisdiction remained unanswered questions: the uptake of atmospheric emissions and heavy metals in vegetation and water bodies; the potential for acid precipitation due to sulfur dioxide emissions; the incidence and impacts of toxins on human health; and the cumulative effects on regional water, land, and air systems.

There were several reasons why these uncertainties persisted. As I have mentioned, research projects were often fragmented: oriented towards site-specific problems for firms, or towards the specific interests of university researchers. In addition, AOSERP was never given a pointed research direction from government, beyond collecting baseline data. It also suffered from a lack of coordination between its own divisions and with regards to external agencies, as well as an accompanying lack of

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91 Ibid.
information exchange.\textsuperscript{92} But, as one observer intimated, these factors were only secondary symptoms of a larger constraint: the generalized lack of government or industry support for AOSERP.\textsuperscript{93} To take this further, both the provincial and federal governments established clear policies, supported with generous budgets (recall Lougheed’s ‘Project Energy Breakthrough’), to accelerate the economic and technological viability of oil sands development. Biophysical transformations, in contrast, were perceived as almost wholly separate from project viability. This was most evident in the barring of AOSERP from researching the behaviour of non-renewable resources (i.e. oil sands); a restriction that also “eliminated the possibility of research into any aspects of oil sands technology,” (Smith, 1981, p. 14).

This uneven support was most perceptible in the different funding given to AOSERP and AOSTRA. In comparison to AOSTRA’s five-year initial budget of $100 million, AOSERP was established with a ten-year estimated cost of $30 - $40 million.\textsuperscript{94} The discrepancy was noted in a five-year review of AOSERP:

\begin{quote}
In the case of the Athabasca oil sands, it is difficult to arrive at a precise estimate as to total environmental research funding, but it appears that a figure of $30 million since 1960 would be a reasonable approximation. Over the same period, it would seem that about $3 billion has been invested in oil sands development. The environmental research investment therefore appears to be about 1\% of the investment total,” (Smith, 1981, p. 110).
\end{quote}

Such a discrepancy may have been justified by the different nature of the programs’ research, and so a more important trend is that during the six-year period 1977 to 1983,
AOSTRA’s funding increased, from under 10 million dollars per year to over 40 million, while AOSERP’s funding decreased from 3.3 million dollars in 1977 to 1.9 million dollars in 1983 (see Figure 6.1).

![Figure 6.1](image)

**Figure 6.1** Comparison of Government Funding to AOSTRA and AOSERP, 1977 – 1983. *Source:* AOSERP funding 1975 to 1979 - (Smith, 1981, p. 18); AOSERP funding 1980 – 1983 - Personal communication with librarian at Alberta Department of Environment, February 5, 2009; AOSTRA funding - see Figure 5.6.

This divergence occurred despite that AOSERP’s funding level was recognized to directly influence its ability to confront the effects of oil sands development on the Athabasca environment, as expressed at a 1976 AOSERP planning workshop by the Chairman of the Oil Sands Environmental Study Group:

> We would recommend, therefore, that should Alberta and Canada decide to indeed step up the development phase by using policy instruments, both those AOSERP partners would also substantially accelerate the annual funding level for the research program to ensure that environmental research keeps pace with the scenario. The research results will be needed just that much faster by the regulator and the industry.\(^{95}\)

In 1980, AOSERP was absorbed within the Research Management Division of the Alberta Department of Environment, where after 1983 its financial records were either not calculated or not made public. Even so, in 1985, the Director of the Research Management Division, H.P. Sims, announced to the attendees of a Workshop on Oil Sands and Heavy Oil that a major constraint to AOSERP’s ability to, again, “keep pace” with industrial development was a lack of resources, in terms of both budgets and ‘manpower,’ particularly as “research continues to face increased complexity and the accompanying increased expense.”

Sims assessed that

Despite the positive aspects of oil sands industrial development and related environmental research, we are still in a precarious situation with respect to maintaining environmental quality.

To conclude, while not factoring directly into government or industry’s perception of oil sands viability, certain of the environmental effects of oil sands extraction were, to various degrees of precision, known to them in the early stages of large-scale oil sands development. Knowledge of these ecological effects was the result of explicit decisions, including research direction, organization, and funding. Contrasting the state of these elements with those of AOSTRA, the technological research institution discussed in the previous chapter, shows the limited funding, but also time, space, and direction given to environmental research, which can be understood to have compromised the government’s ability to evaluate the combined long-term socio-ecological impacts of scaled-up oil sands production. As I will next discuss, the weakness of the integration and application of AOSERP’s research, combined with the general disjuncture of

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97 Ibid., p. 17.
environmental research and environmental policy from the calculation of the technological and market viability of oil sands projects, also limited the ability of governments to control the impacts of oil sands development.

6.2.2 Regulation

Because of the timing of environmental research and the persistence of environmental unknowns, many regulations were put in place after the first large-scale oil sands plants had begun operation – and in this case in a piecemeal and ultimately partial way. This was the case with GCOS, which started construction in 1962, one year before the passing of the Surface Reclamation Act, and also with Syncrude, which closed its agreements with the Alberta and Canadian governments in 1976, before AOSERP had made significant conclusions. Yet even as AOSERP reports catalogued increasing ecological effects, later oil sands projects were approved without clear plans to solve them or factor them into project design.

Although certain of AOSERP’s research findings on measurable and already-occurring ecological effects were translated into regulations, these ultimately failed to contain ecological effects within project boundaries, or within the assimilative capacity of the Athabasca environment. Notably, AOSERP research on the GCOS oil sands plant resulted in regulations for tailings pond seepages and sulfur dioxide emissions. GCOS had originally submitted plans for a 40-foot dike using dug out material to store its tailings; it soon found that more storage for tailings was required, and in 1967 was approved by the Energy Resources Conservation Board to use tailings sand to raise the
elevation of its Tar Island dike to 1070 feet. In November 1974, a GCOS monitoring program (which had been legislated under the Clean Water Act) found that drains at the base of the dike were collecting approximately 425,000 gallons per day of seepage. Theoretical calculations suggested that of this seepage some 30 - 45% was either flowing through the foundation unnoticed, or finding its way through the dike bank to the Athabasca River. After a scientific enquiry into the subject, supported by the above-mentioned AOSERP research, the Alberta Minister of the Environment, D.J. Russell ordered GCOS to begin constructing an interim procedure to collect the drainage water and recycle it through the tailings pond. In addition, Russell stated that “when operations similar to GCOS are contemplated, particularly with large tailings ponds, the impact of seepage be evaluation and criteria be established beforehand.” However, the interim procedure for tailings collection in fact became permanent; ‘containment systems’ are still the method used to control seepage from tailings ponds, and were the seepage control technologies used by Syncrude when it began operating in 1978 (Suncor Energy, 2009).

99 However, as of 2008 the GCOS Tar Islands tailings dike was 325 feet – lower than the 1070 feet authorized by the ERCB(Nikiforuk, 2008).
102 Following the AOSERP report that discovered GCOS dike seepages in quantities that were acutely toxic to rainbow trout and brook stickleback, a charge was laid under the federal Fisheries Act against GCOS for depositing deleterious substances within a watercourse. However, because fish mortality was only observed in the dike drainage and discharge samples, but not in the river samples, and also because the fish used in the test were rare in the river waters, the charge was dismissed (Hunt & Lucas, 1980, p. 113).
Sulfur dioxide emissions also eluded the regulatory mechanisms of government. In 1973, partly in response to the clouds of dust surrounding coal mines, the Clean Air Act was passed requiring firms to obtain licenses specifying the maximum permissible concentration of contaminants they could emit into the surrounding air. As under the Clean Water Act, these licenses also imposed monitoring and reporting requirements on industrial operations. In 1978, after pressure from environmental groups (Seifried, 1977, p. 273), GCOS was charged under the Act for breaching the sulfur dioxide emissions set out in its license. A review of the case by the Canadian Institute of Resources Law recounted the outcome as follows:

The company admitted the breach, but argued that an emergency had made a flaring of the stack more prudent than shutting down the plant. The ERCB license permitted flaring in the case of an emergency, and on this basis, the defense was accepted (Hunt & Lucas, 1980, p. 113).

Yet, the Institute criticized this decision on the basis that it privileged the operating conditions set out by the ERCB over the laws of the Department of Environment:

As has been pointed out, the difficulty with this result is that the use of a smokeless flare tip would have prevented the problem altogether. This argument was rejected by the court on the ground that the Clean Air Act did not specifically require a smokeless flare tip. Thus, the result appears to be that an administrative permission contained in the ERCB approval, which is not necessarily in conflict with a clean air regulation, can override the latter. This underscores the necessity for liaison between the two agencies (Hunt & Lucas, 1980, p. 113).

Far from a temporary phenomenon, the emission rates of GCOS continued to exceed the allowances outlined in its operating license. For example, a 1985 AOSERP report found that GCOS and Syncrude were together emitting on average 646 tonnes of sulfur dioxide per day – 6 more tonnes per day than their combined allowance.¹⁰⁴

The environmental standards set out in the 1973 Syncrude agreement became those upon which subsequent oil sands regulations were based. When later firms applied to operate under the Clean Air Act and the Clean Water Act, their agreements covered an effective period of five years, as was the case with Syncrude. Larry Pratt described the extended fixity of these acts as a ‘concession’ that limited the ability of government to regulate the “largely unknown environmental hazards of large-scale tar sands projects,” (Pratt, 1976, p. 131). Pratt also recognized it as an important move by oil corporations to have governments absorb the risks and costs associated with oil sands development (Pratt, 1976, p. 132), a motivation that was made clear in the Syncrude closing agreements by William Yurko, then Minister of the Alberta Department of Environment, in a letter to Frank Spragins, President of Syncrude, and later Chairman of AOSTRA:

> We trust that the above assurances will permit Syncrude to alleviate and perhaps minimize any apprehensions in regard to changing environmental requirements which can drastically affect the economic viability of the project.  

While performance standards under the Clean Air and Clean Water acts were subject to later negotiations, as evidenced by the addition of dike catchment basins and sulfur dioxide control technologies, regulations under the Land Surface Conservation and Reclamation Act were codified in the “Syncrude criteria of surface reclamation” and endured unchanged despite being ineffectual. For example, during the 1977 ERCB Development. AOSERP Report HY 2.4. GR 1987.191 box 1 file SP 16.5 – AOSERP Hydrology Technical Committee Budget.


hearing on an application by Petrofina Canada Ltd. and four other partners for bituminous sands leases in the Daphne-Calumet area, an interlocutor from the Department of Environment questioned the consortium’s representatives on the design of their proposed development, particularly concerning the viability of surface reclamation: whether the consortium would be able to control subsurface water drainage; “the mass of accumulation of solid and liquid tailings”; and whether they had a definitive reclamation plan. Despite that the consortium had submitted the required mining plan, its description of practical steps towards reclamation were vague, and in fact leant towards the recognition that such a feat would be improbable:

Q You stated that technologically proven processes are applied throughout; would you consider the proposed tailings treatment system as technically proven and successful?
A …We would certainly consider tailings disposal, if that is what you are referring to, as being something that has taken place in industry as well as this industry for a long period of time.
Q We are concerned about the fact that it is very questionable if they can ever be reclaimed, if the sludges will dry out enough to permit the equipment, reclamation equipment to get back on there; of course it is very questionable if they can ever be re-excavated.
A We share the very same concern. We are not terribly optimistic that this can be returned, that the tailings pond area can be returned to a dry land surface; and in our application we have in fact indicated at this point what we see, rather than a dry land surface, is a lake area. We would intend to make certain that the clarified water layer at the top of the tailings pond was of suitable quality to meet environmental requirements. We at this point find it difficult to believe that a dry land area could be obtained. However, on the other hand, we see no reason why we should not pursue in the immediate and long range future whatever potential technological breakthroughs may arise in an ultimate dry land surface.
Q These fresh water lakes would be over the migratory bird flyaways and it is a serious question that the water would contain toxic elements from the affluent [sic] and therefore poisoning aquatic wildlife; I am thinking of your naptha, bitumen, salene water.

The Petrofina (now TotalFina) oil sands mine received initial approval, but was in fact never built; instead, Petrofina and Hudson Bay Oil & Gas Ltd. bought a 10% share of Syncrude from the Alberta government (Humphries, 2008, p. 9). But this dialogue has
wider significance for showing how projects were approved without clear ideas of how to meet regulations, or factor them into project design. While regulations for known effects established precise pollution allowances – which were followed to varying degrees of compliance, more uncertain effects remained obstinately unregulated, their fate put into the hands of technological progress that was slow to come, and under-funded.

6.2.3 Costs

Certainly, ‘leaky’ industrial processes are ubiquitous, extending far beyond the patch of bitumen-heavy land in northeastern Alberta, and they are often associated with economic actors deferring the full costs (such as arduous regulatory burdens) of producing or consuming a good. But, as Michel Callon and Timothy Mitchell have argued, “a lot of work and expense goes into achieving these acts of exclusion,” (Mitchell, 2002, p. 290; 1998; Callon, 1998). As they further argue, such exclusions no more disappear than are displaced, still forming a significant part of the act of market exchange:

when the calculation of the economy excludes not only much that is informal or clandestine, but also the ‘external’ aspects that occur within what is considered formal and regulated, the exclusion is not exceptional or secondary in significance (Mitchell, 2002, p. 290).

Viewed from this perspective, the stated supply costs of producing a barrel of synthetic crude oil and crude bitumen have been informed by research and regulatory decisions and upheld by a complex array of pollution allowances, legislative decisions, and institutional
hierarchies and relationships. While the monetary values of these supporting elements may not be their most important characteristic, a rough sketch of these unaccounted costs can cast light on the failure of supply costs to contain the environmental transformations resulting from oil sands production. In this sub-section I describe three instances in which the “constitutive outside” of the economy – the rules, negotiations, informal activities, and, not least, the environmental changes supporting the economic viability of oil sands projects – have played a determining effect on the market price of the oil sands (Mitchell, 2002). I elaborate first on the cost of regulation, then on the costs of environmental changes – and here I focus specifically on land reclamation, and, last, the role of business lobbying in the determination of supply costs.

A key example of the ingrainedness of such exclusions within the act of producing a barrel of synthetic crude oil or crude bitumen has been the cost of regulation. Despite that the Alberta government had been involved in regulating the conventional oil and gas industry since the 1930s, the Canadian Institute of Resources Law found that both staff time and administrative overhead were steadily increasing across all departments involved in oil sands regulation as oil sands applications and production were scaling up. Although the exact cost was difficult for most departments to quantify, the Alberta Forest Service (a marginal department when it comes to oil sands regulation) noted that, over a three-year period, its costs for directly supervising oil sands operations had increased by over $15,000 (Hunt & Lucas, 1980, p. 140-141). It is beyond the scope

108 ‘Supply cost’ is “the constant dollar price needed to recover all capital expenditures, operating costs, royalties and taxes and to earn a specified return on investment” (Dunbar et al., 2004, p. 71). As the contingency of this definition makes clear, supply costs are based on a set of key assumptions: the discount rate, the inflation rate, the U.S. – Canada exchange rate, the price of natural gas, the per barrel price differential between West Texas Intermediate at Cushing, Oklahoma and blends at Edmonton or Hardisty, as well as the price of condensate and diluent.
of this paper to account for the current cost of oil sands regulation, but some indication of its magnitude may be given by the activities of the Alberta Ministry of Sustainable Resource Development (SRD), under whose jurisdiction the provincial forestry division now falls. In consultation with the ministries of Energy and Environment – the main departments responsible for oil sands regulation, SRD is completing a joint inventory of natural resource and environmental information in the province, developing a Land-use Framework for oil sands development, and “reviewing oil and gas development activities to identify and reduce policy and regulatory overlaps, inconsistencies, and gaps” (Alberta Sustainable Resource Development, 2007, p. 16). Regulatory costs have therefore sprang not only from differentiating what industrial practices and processes to monitor and control, but also from the costs of dealing with the historic absence of regulations regarding certain ecological effects – as evidenced in the current priority given to integrated land management (MacKendrick & Davidson, 2007).

Certainly, the add-on costs of pollution control have also been acutely felt by the oil sands industry. A recent example of such additional costs is provided by Syncrude’s Emission Reduction (SERP) Project – a project designed in 2003 to confront the lasting problem of high sulfur dioxide emissions produced during the coking process.109 With an initial estimated cost of $772 million to the Syncrude partners, as of September 2008 the consortium revised the cost of introducing new scrubbing technologies to $1.6 billion. It was stated that this adjustment was due mainly to inflationary pressures on the cost of labour (Gandia, 2008); costs which do not distinguish between projects oriented towards environmental or ‘non-environmental’ ends, and which are no where present in stated supply costs.

109 ‘voluntary’ project; though do doubt pressure from government.
At the same time that the costs of regulation have increased, however, as already discussed at length, the regulatory framework has failed to prevent the degradation of certain renewable resources, representing the second and most expansive instance of unaccounted costs. The early decision-making process that enabled the proliferation of tailings ponds provides a particularly visible illustration of these costs. In 1979, a report contracted by the Alberta Department of the Environment optimistically concluded that, if reclamation plans were incorporated in mining design from the beginning, “a standard of reclamation practices approximating those routinely accomplished in Western Europe” could be achieved, “though it is recognized that many physical, climatic, and operational differences exist” (5-89). The consultant firms, one German and the other from Calgary, identified three possible levels of reclamation activities, determined by the quality and method of prepared soil manufacture, transport, spreading, and of revegetation. At a cost of $0.025 to $0.056 per barrel, the minimum level of reclamation was based on the “most economical” time frame, “minimal effort” in overburden and muskeg selection, and it allowed for the presence of residual wet tailings ponds at the end of a plant’s operation. In contrast, at $0.121 to $0.185 per barrel, and then $0.119 to $0.193 per barrel, the improved and enhanced levels, respectively, incorporated reclamation as a priority in itself (see Table 6.1). At the improved level, reclamation work would have “a direct influence on mine design and operating cost,” and tailings ponds would be thickened and reclaimed fully after mining. At the enhanced level, the reclamation objectives became “dominant in mine design and determination of operating cost.” Further, at this highest level, soil would be prepared and spread at a minimum depth of one metre, overburden obtained from ‘especially selected sources known as “muskeg mines”’ and the extraction
process would produce dry tailings, so that the landscape would at no point have tailings ponds (Techman Ltd. and Rheinbraun – Consulting GmbH, 1979, p. 4-3, emphasis added). While more than once the consultants denied the normatively better results of the enhanced, in comparison to the improved and then minimum, level of reclamation, clearly this classification scheme spoke to more than just the rigour of the techniques employed (as was put forward cautiously by the consultants). There was plenty of evidence that the consultants privileged the enhanced level: their first recommendation was for emphasis in reclamation research to be shifted from revegetation to the “optimization of mining and tailings disposal schemes that maximize the creation of dry reclaimable land,” (Techman Ltd. & Rheinbraun Consulting GmbH, 1979, conclusions) – understandably, as it was presupposed that only dry areas could be revegetated and reclaimed.\footnote{It bears emphasizing again that a dry tailings extraction process was seen as essential to land reclamation: “Currently it is possible to think only in terms of reclaiming dry land...The maximum area of dry reclaimable land surfaces is obtained when an extraction plant producing dry tailings is employed...The extraction plants assumed at the Enhanced Level use a high temperature, unhydrous process producing a dry mixture of sand and fines as tailings,” (Techman Ltd. & Rheinbraun Consulting GmbH, 1979, p. 10-9).}
Table 6.1: Per Barrel Cost of Reclamation Activities for Twelve Mine Plans. Source: (Techman Ltd. & Rheinbraun Consulting GmbH, 1979, p. 10-33)

<table>
<thead>
<tr>
<th>Mine Size and Type</th>
<th>Level of Reclamation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Minimum</td>
</tr>
<tr>
<td>60,000 b/d (Dragline)</td>
<td>0.04</td>
</tr>
<tr>
<td>60,000 b/d (Bucket Wheel)</td>
<td>0.04</td>
</tr>
<tr>
<td>120,000 b/d (Dragline)</td>
<td>0.05</td>
</tr>
<tr>
<td>120,000 b/d (Bucket Wheel)</td>
<td>0.03</td>
</tr>
<tr>
<td>240,000 b/d (Bucket Wheel)</td>
<td>0.06</td>
</tr>
</tbody>
</table>

Table 6.2 Overall Costs – Including Reclamation Activities - Per Barrel of Crude Bitumen for Twelve Mine Plans Source: (Techman Ltd. & Rheinbraun Consulting GmbH, 1979, p. 10-32)

<table>
<thead>
<tr>
<th>Mine Size and Type</th>
<th>Level of Reclamation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Minimum</td>
</tr>
<tr>
<td>60,000 b/d (Dragline)</td>
<td>2.24</td>
</tr>
<tr>
<td>60,000 b/d (Bucket Wheel)</td>
<td>2.24</td>
</tr>
<tr>
<td>120,000 b/d (Dragline)</td>
<td>2.13</td>
</tr>
<tr>
<td>120,000 b/d (Bucket Wheel)</td>
<td>1.66</td>
</tr>
<tr>
<td>240,000 b/d (Bucket Wheel)</td>
<td>1.82</td>
</tr>
</tbody>
</table>

Table 6.3 Abandonment Costs Compared with Total Supply Costs of Crude Bitumen at Plant Gate for Five Oil Sands Projects. Source: (Dunbar et al., 2004, ch. 7)

<table>
<thead>
<tr>
<th>Project</th>
<th>Undiscounted Abandonment Costs</th>
<th>Discounted Abandonment Costs</th>
<th>Total Supply Cost at Plant Gate (CANS/b)</th>
<th>Equivalent WTI Price (US$/b, 2003)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 Mb/d Athabasca SAGD Project</td>
<td>0.05</td>
<td>0.01</td>
<td>15.64</td>
<td>25.10</td>
</tr>
<tr>
<td>30 Mb/d Cold Lake CSS Project</td>
<td>0.08</td>
<td>0.01</td>
<td>17.99</td>
<td>25.12</td>
</tr>
<tr>
<td>100 Mb/d Athabasca Mining and Extraction Project</td>
<td>0.04</td>
<td>0.01</td>
<td>15.48</td>
<td>24.97</td>
</tr>
<tr>
<td>100 Mb/d Integrated Athabasca Mining, Extraction, and Upgrading Project</td>
<td>0.09</td>
<td>0.01</td>
<td>30.50</td>
<td>24.90</td>
</tr>
<tr>
<td>4,500 b/d CHOPS Project</td>
<td>0.07</td>
<td>0.03</td>
<td>14.51</td>
<td>21.57</td>
</tr>
</tbody>
</table>

111 All tables rounded to two decimals.
It is difficult to compare the costs of the three reclamation standards set out by Techman and Rheinbraun consultants (see Table 6.1 and 6.2) with the current reclamation costs paid by oil sands operators, due to the fact that these costs were never regulated into the price of producing a barrel of synthetic crude oil or crude bitumen.\textsuperscript{112} Abandonment costs, which have been calculated on a per barrel basis, are supposed to be based on the total cost of reclamation, but they are more used as a security deposit to protect the public against having to pay for reclamation at the end of an operation’s life. In its Annual Information Form, Suncor states that it pays $0.03 per barrel for abandonment costs; the Canadian Energy Research Institute states that, according to the project type and size, abandonment costs vary from $0.04 to $0.09 per barrel (see Table 6.3). Canadian Natural’s Horizon project, on the other hand, does not pay a cost per barrel, but a flat-sum reclamation deposit for the entire disturbed land area. The most comparable costs to the consultants’ admittedly much older system is provided by a representative from Canadian Oil Sands, who has stated that the company contributes $0.132 for every barrel of its share of Syncrude production towards reclamation, just above the lower-end of the improved level of reclamation (although, accounting for inflation, the current cost would be much less, at $0.11 in 1979 dollars).\textsuperscript{113} While, broadly speaking, they all comply with the security regulations outlined in the Land Surface Conservation and Reclamation Act, neither abandonment costs, flat-sum costs, or

\textsuperscript{112}This leads the Pembina Institute, an environmental non-governmental organization active in researching the impacts of oil sands projects, to conclude that, """"Information about reclamation costs, the calculation of liability bonds and the frequency (if any) of third party validation of reclamation plans are not publicly available or readily accessible,""""(Grant, J. et al., 2008).

the $0.132 per barrel reclamation cost fulfill the enhanced level of reclamation set out by Techman and Rheinbraun; none represent the dominance of reclamation objectives in mining design, or, in the case of oil sands mining, the elimination of tailings ponds.

Certainly, the low cost of reclamation bonds is in part a result of firms avoiding the full associated costs of oil sands production. In response to the 1979 study, for example, oil sands firms – Syncrude, GCOS, and Shell Canada – expressed an unwillingness to embrace the uncertainty associated with higher reclamation standards to a similar degree that they accepted the high risk and uncertain returns of technological development. A representative of GCOS, for example ultimately dismissed the consultant’s recommendations based on its reliance on as-yet unproven techniques:

Care must be taken to use the cost figures presented by the study as rough comparison costs only. This is due to the extensive use of futuristic unproven techniques, omission of many minor costs and the necessarily incomplete treatment of costs required to implement the Improved and Enhanced concepts.¹¹⁴

Even after it was claimed that major technological and economic uncertainties had been more or less resolved, justifying the 2002 acceptance of the oil sands as a viable oil reserve, the costs of reclamation have not been publicly calculated, suggesting that these costs are not fully present in the course of oil sands operations. During the 2008 Joint Panel Hearing for the Kearl Oil Sands Mine Project, Imperial Oil indicated it did not know whether reclamation was economically feasible. This ambiguity came through in a remarkably similar exchange to the 1979 Petrofina hearing, this time between Imperial’s witness Mark Little and a lawyer acting for the Alberta Energy and Utilities Board (Grant, J. et al., 2008, p. 46):

¹¹⁴ Mr. W.L. Cary, representative of Great Canadian Oil Sands Ltd., Comments from members of the steering committee respecting the final report of Techman Ltd. and Rheinbraun Consulting GmbH. Source: (Techman Ltd. & Rheinbraun Consulting GmbH, 1979).
Q Panel, I’m looking in this next question for a dollar figure on a per hectare basis. And I don’t know if you can provide a response, but I’ll try you. What would Imperial be required to commit on a dollar per hectare basis to the implementation of a landform design that captures the end land use requirements for stability, watershed design and natural appearance? We’re talking about overburden dumps here.
A MR. LITTLE: Sir, we don’t have that information with us.
Q Is it readily available, Mr. Little, or does it not exist?
A No, it does not exist.

But the costs of reclamation have not simply been evaded. Recent postings on the discussion board for ‘Canada’s Oil Sands: A Different Conversation’¹¹⁵ have brought out the ongoing costs to firms, beyond abandonment costs, flat-sum security deposits, and per barrel reclamation costs. These include specific reclamation initiatives – like Suncor’s current initiative to close its West Side tailings pond, research costs – particularly for wetland reconstruction, and the costs of stakeholder consultation. More importantly, Alberta’s Auditor General has raised concerns as to whether Canadians are adequately protected from the liabilities of reclamation, considering both the uncertainty surrounding it and the limited costs currently allocated towards reclamation (Grant, J. et al., 2008, p. 44). The research effort by Pembina to unearth some of these costs provides a good indication of the extent of this liability (Grant, J. et al., 2008, p. 44):

Total oil sands security in the [Alberta Environmental Protection Security] fund is $468 million, on a current disturbance footprint of around 42,000 ha. This represents $11,142 per hectare...It has been suggested that for revegetation to be successful the planting of 10 plants per square metre is required. The cost of reclamation for revegetation alone is therefore $200,000 per hectare...The estimate given by Syncrude about the reclamation certification costs of Gateway Hill is another example of [the] true costs of reclamation. Syncrude did not have a breakdown for the cost of Gateway Hill, which was the first reclaimed site to receive a reclamation certificate. However, in 2006 Syncrude spent a total of $30.5 million on reclamation activities on 267 ha. That breaks down to about $114,000 per hectare.

¹¹⁵ This Web site was created as a public relations campaign by oil sands firms and the Canadian Association of Petroleum Producers (CAPP).
These unaccounted costs have upheld the hot water extraction process, but as the case of reclamation demonstrates, have not necessarily resulted in all-around lower costs for oil sands production.\textsuperscript{116}

Last, environmental transformations which by their absence from regulation and supply costs have made possible current oil sands viability, have shown themselves at the seams, provoking business and government lobbying to prevent them from being factored into per barrel supply costs. While elite-level lobbying between oil sands industry leaders and government officials, characteristically secretive and unreported, has been carried out throughout the history of negotiations on the terms for at least the large-scale oil sands plants,\textsuperscript{117} outside lobbying efforts have become particularly vocal – and costly – as federal and international governments have moved to enact binding caps on national greenhouse gas emissions (GHGs). During the lead up to the federal government’s ratification of the Kyoto Protocol,\textsuperscript{118} which was in fact ratified in December, 2002 – the same month that the \textit{Oil & Gas Journal} accepted the oil sands as a proven oil reserve – the Canadian Association of Petroleum Producers (CAPP) joined with other broad-based

\begin{footnotes}
\footnotetext{116}{Although, irrespective of mine size, reclamation costs were predicted to increase with the level of reclamation standard worked towards (see \textit{Figure 6.2}), the overall, per barrel supply costs were in fact expected to be lower at the enhanced level than at the minimum and improved levels for larger (120,000 and 240,000 barrel per day, versus 60,000 barrel per day) operations. These reduced costs were due mainly to the fact that the high costs of dewatering tailings sludge, which were incurred at the improved level of reclamation, were avoided at the enhanced level (at the minimum level tailings ponds were allowed to proliferate, and reclamation activities by themselves were consequently almost 10 cents cheaper than at the enhanced level at most mine sizes). That said, because at the enhanced level major amounts of reclamation would have been done early in the life of the mine, on a discounted basis the costs at the enhanced level were expected to be higher (Techman Ltd. \& Rheinbraun Consulting GmbH, 1979, p. 10-36). So, the exclusions that supported a particular oil sands supply cost did not simply result in lower costs for market actors, as those optimistic towards the possibility for ecological modernization have pointed out.}


\footnotetext{118}{Ratifying the Kyoto Protocol, in theory, locked Canada into its prior commitment of a 6\% reduction in GHG emissions below 1990 levels.}}
\end{footnotes}
business associations and manufacturing and resources trade associations to form the Canadian Coalition for Responsible Environmental Solutions (CCRES) (MacDonald, 2003). CCRES wrote letters to federal and provincial minister, issued news releases, launched French and English websites, appeared in front of Parliament and at federal standing committees, and broadcasted a television campaign at an estimated cost of $225,000 a week, for several weeks, in an effort to convince government and the public of the costs they would bear by ratifying Kyoto, such as capital flight, job losses, and higher gasoline prices (MacDonald, 2003). In fact, CAPP was one of the more vociferous of the coalition’s members, writing its own letters to elected officials and issuing its own reports, arguing “that since it functioned in an international market, oil and gas could not pass on increased operating costs,” (MacDonald, 2003, p. 23). And, in the last months as ratification seemed increasingly likely, in September 2002 the Alberta government launched its own $1.5 million campaign to weaken public support for Kyoto. Excluding the costs of greenhouse gas emissions, which have eclipsed sulfur dioxide emissions in the scale and scope of the environmental transformations they cause and of the social opposition to their continued release, has likewise elicited lobbying costs and activities at larger scales – from lobbying the U.S. government in Washington to international climate negotiations in Kyoto to Copenhagen (CAPP, 2009b). These costs and activities may be secondary to the act of extracting synthetic crude oil and crude bitumen, but they are by no means external to the very possibility of producing this resource.

Lobbying may succeed, to varying degrees and for varying stretches of time, in displacing even the more contentious and widespread environmental transformations.
But it does not resolve the deeper, underlying causes of these changes, which continue to challenge the historic practices of calculating supply costs. These underlying causes stem, first and foremost, from the different material nature of the oil sands. All petroleum compounds are made up of chains of hydrogen and carbon atoms – in the case of crude oil, in the typical ratio of five carbon atoms to twelve hydrogen atoms \((C_nH_{2n+2})\). However, bitumen is considerably more carbon intensive when compared to crude oil, and when upgraded releases a higher quantity of gaseous carbon dioxide as the extra carbon atoms bond during the upgrading process (Centre for Energy, 2009). While 75 percent of greenhouse gases associated with oil sands production are emitted during extraction and upgrading (Shiell, 2007, p. 8), including emissions of carbon dioxide from 400-ton trucks during surface mining, greenhouse gases are also emitted at later stages of oil sands production: for example, methane rises from tailings ponds as naptha and other mixtures of pentanes and hexanes, used as diluents in the extraction process, are released into tailings ponds and digested and expelled by bacteria (OSTRF, undated). Consequently, it has been estimated that oil sands greenhouse emissions range from 1.24 to 3.06 times higher than conventional oil production (Farrell & Sperlin, 2007, p. 54; Woynillwicz et al., 2005; Hester & Lawrence, 2007, p. 12). And it is predicted that carbon dioxide emitted from the oil sands will reach 16 percent of total national emissions by 2020 (CBC News, 2008), or around 49 million tonnes of carbon dioxide equivalent per year: “the scale of these emissions is such that offsetting them would consume three-quarters of the carbon credits available worldwide through the Kyoto Protocol’s Clean Development Mechanism,” (Bridge, 2008, p. 18; Footitt, 2007). Thus, while the emissions of synthetic crude oil are roughly comparable to conventional oil at
final combustion (Farrell & Sperlin, 2007, p. 54), the by-products of bitumen production exceed the assimilative capacities of the atmosphere at increasingly larger scales.

A second underlying challenge to continued oil sands development is the social opposition to historic practices of waste disposal in the oil sands, which is coalescing to, for example, form new regulations to determine and allocate the costs of emitting greenhouse gases. In 2002, with Kyoto ratification, oil sands supply costs were predicted to rise in the magnitude of $US 6 per barrel – by itself the recovery cost of Middle East oil. Compounded by the U.S. government’s withdrawal from the Kyoto regime, this add-on cost would effectively “price Alberta non-conventional reserves out of the North American and world market,” (Brownsey, 2005, p. 216). However, CAPP successfully lobbied the federal Minister of Natural Resources, Herb Dhaliwal, committing his government to subsidize any greenhouse gas reduction costs above $15 per tonne and to keep the total reductions required by the oil and gas sector at no more than 15% below business as usual expectations for 2010 (MacDonald, 2003 #1064, p. 17). When Stephen Harper’s federal conservative government replaced Paul Martin’s Liberal government in 2005, oil sands firms were required to reduce the intensity of greenhouse gas emissions per barrel produced, but not their overall emissions, and could pay into a technology fund in lieu of making GHG reductions. Nevertheless, the recently passed U.S. Clean Energy and Security Act, though without the more stringent low-carbon fuel standard, will impose higher costs on oil sands producers, as Canada will have to adopt a “comparable” system of carbon credits to enable synthetic crude oil and crude bitumen to be sold south of the border (McCarthy, 2009 #1070; McCarthy, 2009 #1069). At the same time, the Alberta government has allocated $2 billion to support “unproven” carbon capture and
storage (CCS) technology for two oil sands upgraders and a clean-coal power plant (McCarthy, 2009). In fact, the Alberta Government has been involved in developing CCS technology since at least 1992. All the while as it was actively negotiating Kyoto commitments with provincial and federal governments, it was researching “innovative ways of reducing, disposing, or using carbon dioxide,” in anticipation of a new regulatory regime for greenhouse gases (Alberta Energy, 1993; 1998, p. 13). Part lobbying tactic and part realistic understanding of the ongoing threats to oil sands economics, CAPP has also indicated that its lobbying efforts against factoring in a high price for oil sands GHG emissions will continue:

“We’re delighted that low-carbon fuel standards are not in the Waxman-Markey bill,” said Tom Huffaker, vice-president of environment and policy at the Canadian Association of Petroleum Producers. “But we’re resisting dancing on the table because we know this is a work in progress,” (McCarthy & VanderKlippe, 2009).

I have identified these three instances in which costs associated with oil sands production have been displaced, presenting themselves at different times or in different places, to carry through my argument that oil sands supply costs are not objective, externally determined objects. Making oil sands production, in its current form, competitive with that of conventional crude oil has relied on an extensive framework of supports: regulatory burdens; decisions to let tailings ponds expand while methods for tailings settlement remained unknown; and public and private lobbying against intergovernmental agreements to phase out the emission of greenhouse gases. As Timothy Mitchell has argued, these “constraints, understandings, and powers that frame the economic act” are at once the “condition of possibility of the economy and the condition of its impossibility” (Mitchell, 2002 391). In the case of the Alberta oil sands,
these supporting elements have enabled oil sands production in its historic and current forms, but the costs they work to exclude always threaten to return to project economics. This emphasis on the materialities of the bitumen-saturated sands has differed from the standard neoclassical account in its focus on how the unruly material world is wrestled with in determining supply costs; it is neither nullified nor controlled by the rise and fall of the price mechanism.

By way of a conclusion to this chapter, I summarize these persistent supporting elements, or what I term ‘ecological overflows’, with reference to the Alberta Department of Environment’s three initial commitments to balancing resource management, environmental protection, and quality of life.

6.3 Defining oil sands environmental impacts, discovering supply costs

For a market to function, economic actors need to determine in advance its boundaries or ‘frames’: what costs to include, how to allocate them, and how (if at all) to address the unintended effects of market production and exchange (Callon, 1998). Markets based on the extraction of raw materials carry specific problems because they are governed by their own bio-/geophysical laws (such as the thermodynamic transformation of matter) that are not completely compatible with market forces (such as supply and demand for one particular commodity) (Bridge, 2000; Prudham, 2005). Thus, in negotiating the operating agreements for oil sands projects – whether formally or in day-to-day practice, governments and oil sands firms faced the imperative of framing supply costs, in the context of environmental regulation, by establishing allowances for
the ‘right to pollute’, extending time frames for reclamation, and in certain cases displacing the costs attached to particular emissions. These historic practices of framing oil sands supply costs have upheld the continued use of particular extraction technologies, such as the water-intensive Clark hot water extraction and in situ steam injection processes, and the at times fragile viability of project economics. In this way, environmental transformations are in no way separate from the functioning of markets in synthetic crude oil and crude bitumen.

At the same time, the act of framing oil sands supply costs, through research, regulations, and cost decisions, has brought with it two ‘ecological contradictions’: the first is the degradation of nature itself; the second is the emergence of organized resistance to historic practices of waste disposal (Bridge, 2000). Both threaten to challenge the continued viability of oil sands project economics. First, the ‘ecological overflows’ threaten to make the required inputs of historic forms of extraction and upgrading scarce, notably, available water and energy. Second, social opposition to oil sands production has proliferated as oil sands production has scaled up. This has taken the form of activism by environmental non-governmental organizations (ENGOs) such as Greenpeace, the Pembina Institute, and Ecojustice (formerly the Sierra Legal Defence Fund); opposition to the pace and scale of oil sands development by those who live within Alberta (The Pembina Institute, 2007a, 2007b); a call for a moratorium on oil sands development by certain oil sands firms, scientists, ENGOs, and Alberta citizens (Ebner & Scott, 2008); and U.S. legislation that likely will exclude or raise the cost of Alberta bitumen from specific U.S. markets (McCarthy & VanderKlippe, 2009).
With reference to the Alberta Department of Environment’s initial three commitments, the origins of this opposition can also be traced back to the failure of the regulatory framework to contain ecological overflows within the assimilative capacity of the Athabasca environment. First, rather than equally or more stringent than those of the EPA, pollution standards in Alberta have not only breached, but also been subject to intensive lobbying to exclude them from international pollutant standards, such as the Kyoto Protocol for greenhouse gas emissions. Second, breaking its promise of maintaining a preferential system of water use, overwhelming evidence suggests that regional and extra-regional fish habitat and drinking water is being heavily contaminated by the seepage of effluents, including poly-cyclic aromatic hydrocarbons, into the Athabasca river and surrounding water bodies. Last, although certain industry figures have optimistically asserted that, “You come back in thirty years, you won’t know this has been here,” (McNulty, 2007), the proliferation of tailings ponds without any demonstrated dewatering process portends to a more negative outlook – including lasting scars on the face of the land.

In sum, proliferating ‘overflows’ have exceeded the boundaries of supply costs, and point to a failure in the mode of regulation in the Alberta oil sands. In no way, however, were these effects external to the decision-making process that has scaled up oil sands production. In sharp contrast to the received wisdom that negative externalities imply social costs that are simply not taken into account by private decision-makers, both government and industry officials have made a whole series of decisions and interrelated practices that have directly displaced these increasingly known, though uncontrolled, impacts from the calculation of oil sands supply costs. It has been these
series of judgements and decisions, rather than prevailing market price, which have determined the particular form of oil sands viability.
7 Conclusions

Who ordered the scale of the market? And who demands that everything be weighed on it alone?

(Heidegger, 1999, p. 168)

I have argued that the classification of the Alberta oil sands as a proven, conventional oil reserve was not simply the outcome of market forces, but the culmination of a long trajectory of practices and decisions that made the geological, technological, and ecological aspects of oil sands production economically intelligible. These practices resulted in new, discrete parcels of information such as bitumen saturation and pay thickness, bitumen recovery rates for extraction technologies, and economic standards of land reclamation that have determined the specific form of oil sands supply costs and the possibility of their production. In these ways, equivalency between synthetic crude oil and crude bitumen, on the one hand, and conventional crude oil on the other, has been achieved through framing the rules, boundaries, and institutions by which the oil sands can qualify as a conventional oil reserve. These frames have enabled market price and supply cost to take on the character of objective evidence of the viability of oil sands extraction.

At the same time, however, framing the oil sands as an equivalent substitute to conventional crude oil has required that the federal and Alberta governments and the oil sands industry displace the material differences associated with the oil sands resource and its ecology. From the neoclassical economic perspective, and the perspectives advanced by many government departments and oil sands firms, these supports and displacements
have an external or at most a tangential relation to the supply costs of oil sands projects. Disagreeing with this logic, I have provided evidence of the extensive and often-expensive supports upholding oil sands supply costs. Most long-standing, these supports have taken the form of geological surveys that far exceed those typical for conventional petroleum deposits, as well as ‘full-court’ media relations efforts by the Alberta government, and behind them the Canadian Association of Petroleum Producers, to convince U.S. energy agencies to classify the bitumen-saturated sands as proven oil reserve; and to convince regulators to allow firms to count crude bitumen in their securities filings. Following closely on the heals of geological surveys have been government-supported technological pilot programs that off-set the risks and uncertainties associated with bitumen extraction and refining. The project-specific knowledge and technologies gained during these pilot programs from inserting bucket wheels, excavators, pipelines, steam, water, and solvents in various arrangements and combinations have influenced the timing of technological changes and the supply costs of oil sands projects. Last, likely the most visible and publicized of the displaced effects of oil sands production have been the environmental impacts of bitumen extraction and refining. In the last chapter, I described at length the ongoing, government-supported technological and environmental research programs; government and industry lobbying efforts to exclude known costs of preventing environmental degradation from per barrel supply costs; and environmental regulations that have been breached by oil sands operators and only loosely enforced by regulators. By separating out and treating the economic aspects of oil sands production as if they were stand-alone, concrete things, geological research, technological pilot programs, and environmental regulations have set
the groundwork for the proliferation of these displaced effects, casting them as ‘non-economic’ or residual.

Considering all of these unaccounted costs, impacts, and practices, a major question that remains is whether the Alberta oil sands are, inherently, an economically profitable resource to extract. I acknowledge that I have not answered this in the paper, and nor will I offer a conclusive answer here. Partly, this reflects a limit of my research, as trying to account for all of the ‘true’ costs of oil sands extraction would far extend the limits of my knowledge of the discipline of economics, as well as the available time (and space) for this thesis. Moreover, I will argue that, consistent with my approach in this paper, there are no ‘true’ economics of oil sands projects; meaning that the economics of oil sands projects are not stand-alone objects, but are contingent on a particular set of relations between the actors involved, and their perceptions and practices towards the bitumen-saturated sands. Seen in this way, the extraction of an oil-equivalent from the bitumen-saturated sands has been profitable, as expressed on the balance books of oil sands firms, some of whose parent companies list among Fortune 500’s most profitable companies worldwide. But, as it currently stands, this profitability rests on a system of supports whose contingency and instability are evident at many points.

Returning to the 2002 reserve classification, we can understand that the lobbying effort to accept the oil sands as a viable oil reserve was at odds with the objective, mechanical account of resource substitution provided by neoclassical economics. By explaining the impetus for resource substitution almost exclusively in the existence of a favourable relationship between prevailing market price and oil sands supply costs, the neoclassical account does not explain why such a sustained and geographically specific
campaign would have been required. Essentially, it is a tautology; there is little account of how resource substitution happens, how it happens, as well as where, when, and in what manner that it does. But then we are still left with the significance of the reserve estimate that was brought by Alberta officials to the U.S. Energy Information Agency in Washington and the *Oil & Gas Journal* in Houston. This was undoubtedly a politically and financially motivated process. Moreover, by emphasizing its importance, I mean to convey that it was not just a number or a classification that resulted in the heightened production and ecological impacts in the bituminous sands, but what that classification was about: a relationship between business and government that not only limited input into the decision-making process of deciding on the pace, scale, and form of oil sands production, but also how its ecological impacts would be regulated and managed. The large oil reserve number was certainly a strategy to convince distrusting or distant actors, but at the same time it did not come out of thin air; it was the result of a long history of perceptions and practices that objectified price as a way of knowing and organizing development around of the oil sands resource.

Several implications of this research may be distilled. First, I would venture that substitution between two materially different resources is rarely an automatic or independently propelled response. Despite that, over the long term oil sands development has risen with the market price of conventional oil, the fact that this substitution response has taken the better part of a century does not offer a convincing example of the automatism of the neoclassical model of price-drive substitution. Importantly, this puts into question the argument that renewable sources of energy cannot occupy a significant portion of the energy picture due to the long lead times and large
capital required for their development. Bitumen deposits and renewable energies alike take time, infrastructure, and constant ‘nurturing’ by governments and firms (Bridge, 2007). Recasting the process of substitution in this way counters the idea that resources are interchangeable capital assets, whose material differences can be nullified by the price mechanism.

Second, at a political level, this research has made a case for the worth of turning government and business institutions ‘inside out’ to identify the perceptions and practices that produce specific outcomes, in this case a large oil reserve estimate. With regards to political and business institutions in Alberta, it has shown that the scaling up of oil sands production has been an opaque, minimally democratic process that has at many points gone against the stated desires of bureaucrats and public stakeholders who have been consulted on oil sands projects.

Last, theoretically, this paper has argued the benefits of combining detailed studies of specific technologies and scientific practices with attention to the power relations that structure the trajectory of resource development. This approach has cut a midway between, on the one hand, the nakedly instrumental view that the oil sands reserve estimate was unscientific, reflecting simply the interests of a powerful industry trade association and a boosterish provincial government, and on the other, the opposing view that the figure was an objective, impenetrable fact, excised of subjective judgment. Accounts that attribute outcomes ‘merely’ to power relations instead of price fluctuations are no better or less tautological than the neoclassical economic explanation. This approach does not imply that real changes are not needed in the regional and international system of reserves classification – for both political and ecological reasons. In the case
of the Alberta oil sands, increasingly dangerous political and socio-ecological transformations have resulted from a resource development model that has separated out and valued profit maximization above all other aspects implicated in the production of nature.

It is unlikely that the bitumen would or should have stayed underground. As this thesis has argued, however, the pace, scale, and effects of it being brought to the surface were not determined by an abstract, independently propelled price mechanism, but – at least in part – by the perceptions and practices of a developmentalist provincial government in combination and contestation with a powerful industry, both looking to maximize profits from this unfamiliar and highly heterogeneous resource.
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