ENGINEERING MODERN EGYPT:

WATER AND TECHNOLOGY AT THE ASWAN HIGH DAM

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"There is no river that flows anymore from mountain to sea without being…equipped in speech-making instruments."

-Bruno Latour

Introduction

In the fall of my junior year at Brown I enrolled in two classes that would become powerfully transformative experiences. In *Physical Processes in Geology*, Professor Jan Tullis' introduction to geology, I learned to analyze earth's processes, their histories, and their connections to one another. In *Bioethics and Culture*, Professor Sherine Hamdy's medical anthropology seminar, I explored the theoretical ramifications of medical technologies and their effects on individuals and societies. While the syllabi of these courses could not have looked more different—the former contained textbook readings and problem sets, the latter book-length ethnographies and reading responses—I found myself equally engaged in both. Initially, it seemed that they demanded different types of thinking. In geology, I interpreted maps and drew stratigraphic sections; in anthropology, I watched documentaries and wrote critiques of anthropological literature. In time I would realize that both courses were asking me to do the same thing: dig beneath the surface of complex problems to analyze and communicate their intricacies.

The connection between the courses was sealed when Professor Tullis lectured on Egypt's Aswan High Dam and its effects on Professor Hamdy's native Egypt. When I later mentioned the dam to Professor Hamdy, the look in her eyes made it clear that there was more to this dam than its effects on the Nile's flow. Throughout the semester I engaged both professors in discussions about the dam—its reasons for being built, its technical specifications, its impacts on Egypt. The more I explored the dam the more curious I became, for it quickly emerged that the dam was a contested structure with a complicated history and profound impacts on the people and geography of Egypt.

That semester winded to a close, but my interest in the dam endured. I read articles about its upcoming 40th anniversary. I explored other large dams and activist movements that are emerging to resist them. One year later, when I decided to write a senior thesis, I returned to the Aswan High Dam. As a student of Science and Technology Studies (STS) with long-standing interests in earth systems and human cultures, I saw in the dam a rich topic for in-depth study. The story of the High Dam is the history of technology, the management of natural resources, the legacy of colonialism, and the politics of science. It has been researched by fluvial geomorphologists, forced migration experts, fresh water ecologists, and development critics. I wanted to explore where these disparate approaches intersected. Specifically, I wanted to understand the political decision-making processes that produced the High Dam, the environmental impacts of the dam's operation, and the complex links between the two.

I approached my research with a number of specific questions in mind:

- How did the construction of the dam reconfigure political power and social relations in Egypt?

- How did Egypt's legacy of colonialism and its movement into post-colonial independence influence the politics surrounding the dam?

-Who held the authority to build and control the dam, and by what mechanisms was this authority achieved, maintained, and promulgated?

- What kinds of political factors drove the decision to build the dam, and how did they influence the process of planning, designing, and constructing it?

-What kinds of impacts has the dam exerted on the Egyptian environment and population? Were these impacts predicted and, if so, how were they justified?

- How did different understandings of and views on "nature" influence the decisions of planners and the responses of outside observers?

To answer these challenging questions I began acquiring as much literature as I could find. I consulted engineering studies on the technical specifications of the dam, histories of the period written by people involved in the dam's construction, academic literature on political economy and development, and primary source documents including pamphlets and images published by the Egyptian government. I cast a wide net, trusting that by exploring a vast range of sources I could accomplish two goals. First, I wanted to get to the bottom of two pressing questions: why was the dam constructed and what impacts have resulted? Second, I wanted to observe and compare how scholars from different disciplines have attempted to answer these questions. What I found was that the decision to build the dam was influenced not solely by technical considerations but also by political actors, discourses, and ideologies. These influences on the decision-making process enabled the building of a large dam that consolidated the management of Egyptian water into a single monolithic entity that has exerted severe consequences on the geography of Egypt and the welfare of its people.

I also found that the issues presented by the construction of large dams are not unique to Egypt. Water resource management is, at root, an attempt to use technology to enroll river systems in the creation of bodily safety, economic value, and social welfare. It is practiced in some form in virtually every society on earth, and its history is in many ways a history of human technology and the relationship between humans and earth. It is inherently ecological, and studying water management requires thinking ecologically on biological, political, and human levels. It strikes at the heart of persistent philosophical questions on the nature of human technology and the ethics of industrial growth.

The more I read the more I found dams to be deeply contradictory. It was hard not to feel inspired by the power of human ingenuity when looking at images of enormous dams; these structures are pinnacles of human engineering might and awe-inspiring in their grandeur. At the same time, I found it equally hard not to feel dismayed by the negative consequences of large dams. Large dams devastate ecosystem health; they displace millions of people; and they destroy communities and heritage sites. I have emerged from my study of the Aswan High Dam with a complicated picture of why the dam was built and what impacts it has exerted on social, economic, and environmental systems in Egypt. In an era in which virtually all of the world's major rivers have been obstructed by large dams, I have come to believe that understanding these technological artifacts is a necessity if we are to learn from past mistakes and create smart water management strategies for the future. As global consumption of natural resources continues to increase and earth's climate continues to change, it seems to me that we have no choice.

A Guide for Readers

The first chapter of this thesis will introduce the Aswan High Dam: its physical structure, its history, and its impacts on the people and geography of Egypt. It will look at the Egyptian government's justifications for building the dam, the history of the dam's planning and construction, and the physical mechanisms by which the dam acts on the Nile River and Valley. It will conclude with a review of attempts by academics to answer the basic question: why did Egyptian politicians agree to build the Aswan High Dam knowing full well that it would produce major negative effects?

In the second chapter I will present my argument that the decision to build the High Dam in spite of its predicted consequences was rooted primarily in its symbolic import. Drawing from period-era primary sources I will argue that from its outset the dam project was both a plan for regulating the Nile's water and a symbol of Egypt's independence from foreign colonial rule. I will explore how the Egyptian government leveraged the dam's symbolic power to create domestic support for the project and to increase its regional influence, focusing specifically on the role of nationalist and post-colonial discourses in framing the dam as a tool for producing a "modern" Egyptian state. Finally, I will argue that the Egyptian government's discursive production of "modernity" in Egypt influenced its decision to overlook technical concerns with the dam and silence those who raised them.

The final chapter of this thesis will look closely at what the case of the Aswan High Dam reveals about the difficulties of implementing sound water management strategies. I will expand my analysis to include large dams more generally and their broader implications for industry, government, and society. I will explore how the politicization of water management, the growth of a dam-building industry, and the increasing commodification of water have encouraged nations to build large, centralized dams rather than small, dispersed management technologies. Finally, I will introduce theories of materiality from science and technology studies to provide a new framework through which to understand large dams. I will show how applying theories of materiality to the practice of hydraulic engineering could create more sustainable water management strategies with reduced negative impacts on communities and ecosystems.

Chapter 1. Taming the Nile: The History of the High Dam and its Effects on Egypt

The Aswan High Dam is a massive edifice of rock, metal, and cement that stops the flow of the Nile River six miles north of Aswan, Egypt. Constructed over ten years between 1960 and 1970 by a labor force of over 34,000 workers, the dam measures a staggering 5000 meters wide, 111 meters tall, and 1300 meters thick (The Brookings Institution 1973). It contains 44 million cubic meters of building material. The dam serves one fundamental purpose: to store the Nile's waters for regulated release. Since 1970, every drop of water flowing through the Nile, from its source in the highlands of Ethiopia to its terminus in the

Mediterranean Sea, has flowed through the gates of the Aswan High Dam under the control of Egyptian irrigation authorities. It would appear that the Egyptian government has established total control over the flow of the Nile, the longest river in the world.

The High Dam was conceived in the early 20th century by Greco-Egyptian engineer Adrian Daninos, who presented it to Egypt's Revolutionary Command Council (RCC) on July 30th, 1952, just seven days after the group of Army Officers staged their takeover of the Egyptian monarchy (The Brookings Institution 1973). The idea was compelling: having suffered the consequences of the Nile's highly variable seasonal flood since antiquity, Egypt stood to gain unprecedented security through the control of the Nile's flow. Since the beginning of agriculture in Egypt sometime around 5000 BC, extreme floods had exerted horrific consequences on Egyptian civilization (Butzer 1976). Periods of overly strong or weak flooding had led to famine, death, anarchy, and war. Mythologies and cultural beliefs had sprung up around the deadly effects of the Nile's flood, and for millennia Egyptians had lived in fear and awe of the powerful and capricious river. The High Dam offered the RCC the possibility of eliminating the dangers posed by the Nile's inconsistent flow through technological management. Already, British colonial authorities had constructed a low dam at Aswan to regulate the Nile's flow for irrigation. For a group of Egyptian Army Officers seeking to unite Egypt into a strong independent state, increasing control of the Nile River became understood as an obvious means of consolidating administrative power and building strong government institutions.

The Egyptian government provided three specific reasons for building the dam: to control dangerous floods by detaining excess water in its reservoir, to store water from periods of high flow for release in times of low flow, and to use released water to generate hydroelectric power (White 1988). Once in place, the dam would prevent dangerously high floods from harming Egyptian agriculture and industry by storing excess water in Lake Nasser. In addition, the government could use the dam to regulate the release of water throughout each year. On average, 80% of the Nile's annual flow comes between August and October and 20% comes during the rest of the year (Waterbury 1979). Once built, the dam would allow the Egyptian government to store the "untimely" water of the wet summer months for release during "timely" periods of dryness or agricultural demand, increasing agricultural yields and Egyptian food security. Finally, all of the water passing through the dam could be used to spin hydroelectric turbines, which the government projected would produce around 10 billion Kilowatt-hours of electricity annually for Egyptian people and industry (Waterbury 1979). Driven by these three goals, the RCC commissioned studies on the dam's feasibility and cost and began searching for the funding necessary for its materials and labor.

As Egypt sought financial and technical support in the mid-1950s, the funding of the dam became a site of Cold War geopolitical jockeying between the United States and the USSR. Governments of both nations viewed Egypt as strategically important for its proximity to Israel and Middle Eastern Oil and saw in Egypt's fledgling government an opportunity to influence the politics and economics of the Middle East and North Africa. While the governments of the U.S. and the U.K. were first to offer aid to Egypt, US Secretary of State John Dulles withdrew the U.S. offer in July 1956 after Nasser recognized China's communist government, in violation of Dulles' policy of communist containment. Within seven days, Dulles' withdrawal of support for the Aswan High Dam precipitated the Suez Crisis of 1956, in which the Egyptian government nationalized the Suez canal and prompted a multinational armed conflict in which Israel invaded Egypt through the Sinai peninsula with support from France and the U.K. Watching the events of 1956 from afar, the USSR stepped into the funding vacuum by offering Egypt extensive financial and technical support for the project. On October 23rd 1958, Nikita Kruschev, leader of the USSR, informed Egypt that the USSR would lend Egypt 1.2 billion dollars for the dam's construction and provide a contingent of hydraulic engineers, technicians, and planners to help in the project's execution (Waterbury 1979). With funding and technical support secured, Egypt broke ground on the dam on January 9th, 1960, nearly eight years after Daninos had presented the plan to Egypt's revolutionary government.

By 1970 the dam was completed, and soon after it began exerting major effects on the flow of the Nile, the geography of the Nile Valley, and the people of Egypt. The first effects were those that had motivated the Egyptian government to build the dam in the first place. Within one year agricultural production increased as more water became available for irrigation, and new crops were introduced as land was converted from old methods of basin irrigation to perennial irrigation. Perennial irrigation allowed Egyptian farmers to reap three harvests per year rather than one, a boon for Egypt's food security and agricultural productivity. In 1972, the Nile's flood was exceedingly low, and the government released water stored from the previous two years to keep Egyptian crops alive. This action was critical: without the stored water it is likely that Egypt would have experienced large-scale suffering and death resulting from shortages of food and water (Waterbury 1979). Another immediate effect of the dam's completion was the delivery of electricity to power-hungry industries and much of the Egyptian population. In the years leading up to the dam's completion, demand for electricity by Egyptian households and industries had been growing by around 15% per year. Nasser's government, seeing in electrification an opportunity to better reach the Egyptian population through televised broadcasts, was particularly interested in electrifying every Egyptian household. Once completed, the hydroelectric station at the

High Dam enabled Egypt to meet its burgeoning power needs (Shmidt 1988). Soon after the dam's completion, it seemed as though it had met the goals outlined by Nasser's government. In May 1973, Deputy Director of the High Dam Authority Ahmad Daud summed up the official view of the project: that the dam's benefits to agriculture and flood protection had already more than covered the costs of its construction (Waterbury 1979).

The dam fulfilled the Egyptian government's goals of flood control, enhanced irrigation, and power generation, but it also exerted severe effects on Egypt's geography and population that were not planned for by Nasser's government. Some of these effects were predicted by Egyptian scientists and engineers but not adequately addressed by Nasser's government; others were seemingly unforeseen. Historians tend to divide these effects into two categories: geomorphological effects and human effects. Geomorphologically, the dam exerted three major negative effects: the trapping of the Nile's silt by Lake Nasser, the loss of water by evaporation and seepage, and the decline in water quality due to salinization, pollution, and runoff. On the human level , the dam exerted two major negative effects: the displacement of the Egyptian Nubians and the rise of disease amongst Egypt's rural population. Together, the dam's negative externalities—geomorphological and human alike—call into question the wisdom of constructing the dam by revealing the hidden costs of its construction.

The trapping of the Nile's silt behind the High Dam, a drastic and unprecedented alteration in the river's sediment transport regimen, has exerted severe effects on the quality of Egyptian soil and the morphology of the Nile delta. While the Aswan Low Dam, completed by the British in 1902, also served to block the Nile's waters, its release gates were designed specifically to allow the free passage of sediments. As a result, the Low Dam trapped a negligible quantity of Nile silt. The mechanics of blocked sediment transport are simple: as water flows into Egypt it carries a suspended load of silt and mud eroded from highlands upstream. As this water enters Lake Nasser it slows to a halt, and its sediment load precipitates out and accumulates on the lake's floor. When water is finally released from the lake through the dam, it contains virtually no suspended sediment: between its entry into Lake Nasser and its release from the dam, Nile water's sediment concentration falls from 1600 to 50 parts per million (White 1988). Before the dam was constructed, the Nile transported between 60 and 180 million tons of sediment annually (White 1988). Since the dam's completion, virtually all of this sediment has been impounded in Lake Nasser.

Prior to the dam, 10% of the sediment that flowed into Egypt flooded onto agricultural land while 90% was deposited onto the Nile's delta; since the dam's completion, the impoundment of Nile silt has exerted major impacts on both (Postel 1996). Rich in nitrogen, potassium, phosphorous, and organics, the Nile's volcanic sediments have been described as "the most fertile soil on the face of the earth" (Ahmed 1960a: 143). They have been the mainstay of Egyptian agriculture since its beginnings in antiquity, and they have allowed Egyptian agriculture to thrive amidst harshly arid conditions. Without these sediments flooding onto Egypt's agricultural land, Egyptian farmers have been forced to apply tens of thousands of tons of chemical fertilizers onto their land each year to recreate the nourishing effects of the impounded silt. Even with the application of these fertilizers, soil quality has continued to decrease because fertilizers cannot replace the texture and drainage of Nile sediment, which contains around 30% fine sand, 30% clay, and 40% silt (Ahmed 1960a). Further degrading Egyptian soils is the problem of salinization, which results from the evaporation of water from poorly drained fields and which has worsened since the dam's construction.

The impoundment of the Nile's sediment has also led to the widespread erosion of Egypt's Mediterranean coast, which has been built up over geological time by layers upon layers of Nile sediment. Prior to the dam, the Nile delivered 60 million to 180 million tons of sediment to the Nile's delta every year (White 1988). Since the dam's construction, this sediment no longer reaches the Nile's delta or Egypt's Mediterranean coast. The result of sediment deprivation has been severe coastal retreat in the region of the Nile Delta. One former delta village, Borg-el-Borellos, now resides more than 2 kilometers out in the Mediterranean Sea, and many coastal residents have been forced to relocate due to rising waters (Pearce 1992). Without the Nile's sediment load the coast of Egypt will continue to retreat rapidly; combined with the anticipated sea level rise that global climate change is projected to bring, this encroachment of the Mediterranean's waters on the Nile Delta will lead to major losses of habitable and cultivable land as well as the displacement of millions of Egyptians.

The dam's second major negative externality is the loss of water from Lake Nasser through evaporation and seepage. The rate at which water evaporates is a function of air temperature and wind speed. Lake Nasser is situated in Southern Egypt where average air temperatures are consistently high and where strong winds blow frequently across the landscape. These climatic conditions lead to substantial evaporative losses from Lake Nasser, estimated to be between 8 and 13 billion cubic meters per year. In addition to evaporation, the reservoir experiences substantial seepage through the porous sandstone beds that comprise its floor. Seepage is a function of the permeability of the underlying rock, the height of the water table below the reservoir, and the hydrostatic pressure present in this water table. Because Lake Nasser's floor is highly porous and the pressure gradient of its underlying water table favors downward flow, the reservoir loses an estimated 5-7 billion cubic meters of water per year through seepage (Waterbury 1979). Taken together, evaporation and seepage extract an estimated 13 to 20 billion cubic meters of water per year from the Nile. On average, the Nile transports 84 billion cubic meters of water per year, of which Sudan withdraws around 18.5 billion per year leaving Egypt with 65.5 billion per year. The water losses precipitated by the dam thus represent between 20 and 30 percent of Egypt's annual water supply, an enormous loss in an arid region chronically short on water.

The final significant physical effect of the dam has been a precipitous decline in the Nile's water quality due to increasing salinity, runoff of chemical fertilizers, and algal blooms fed by these chemical wastes. Water salinity has increased due to evaporation from Lake Nasser and poor agricultural practices. When water evaporates from Lake Nasser, its salt concentration increases; while water molecules evaporate away, salt molecules remain present in the remaining water. When water enters Lake Nasser it contains 200 parts per million of Sodium Chloride (NaCl). When it flows through the dam it contains 220 parts per million, and by the time it reaches Cairo it contains 300 parts per million (Waterbury 1979). While this level of salinity is not inherently bad, it is detrimental to Egyptian agriculture when combined with the poor drainage that plagues Egypt's agricultural land. When poorly drained fields are irrigated with saline water, the irrigated water evaporates, leaving the remaining water even more saline. If the water evaporates completely, the field is left covered by a dried out layer of salt. This salt seeps into topsoil, reducing its fertility and yield. While not directly causative of Egypt's salinity problems, the High Dam has amplified them measurably (Waterbury 1979).

Runoff of the chemical fertilizers now necessary to maintain agricultural productivity has further reduced the quality of the Nile's water by causing eutrophication, an ecological process by which the concentration of nutrients in a body of water increases stimulating increased plant growth. Increases in plant mass and plant decomposition lead to anoxic (low oxygen) conditions in water, which destabilize established ecosystems and prevent animal life from surviving. In the Nile, eutrophication due to heavily fertilized agricultural runoff has led to the increased growth of algae and phytoplankton in the Nile and subsequent declines in fish and aquatic organism populations. This has had consequences for the Egyptian fishermen, many of whose livelihoods have disappeared since the dam's completion. The plant matter growing in the Nile has also clogged water filtration systems, impeded drainage of agricultural land, and reduced water quality for municipalities drawing drinking water from the Nile. As Egyptian agriculture continues to require massive applications of fertilizers, pesticides, and other agricultural chemicals, the quality of the Nile's water will continue to decline.

Beyond its physical consequences for the geography and hydrology of the Nile Valley, the Aswan High Dam has exerted major, life-altering consequences on the people of Egypt. Most notably, it has caused the displacement of the Egyptian Nubians and an increase in Schistosomiasis in rural Egypt. Lake Nasser covers an area of over 5000 square kilometers, some of which was formerly inhabited by Egyptian Nubians, an ethnic minority group with a long history in the region. Before the dam's completion, government planners arranged to resettle the estimated 50,000 to 60,000 displaced Nubians in eight villages 20 miles north of Aswan. However, these settlements were so poorly planned that the Nubians immediately experienced a severe famine requiring emergency intervention by the World Food Programme (Biswas 1978). Sudden, hastily planned displacement has led to numerous forms of documented stress amongst Nubians. These stresses range from the physiological, evidenced by increased morbidity and mortality, to the psychosocial, evidenced by pervasive grief over lost lands, to the sociocultural, evidenced by the loss of traditional community structures (Scudder and Colson 1982). The dissolution of their communities and local leadership due to the trauma of forced migration, the reduction in their cultural inventory due to the flooding of their ancestral lands, and the loss of their economic prosperity due to their displacement from fertile lands have all conspired to worsen the condition of the Nubians.

The High Dam has also exerted deleterious health effects on Egyptian society by causing an increased incidence of Schistosomiasis amongst rural Egyptian populations. Schistosomiasis is a parasitic disease carried by a snail-like blood fluke that enters human bodies through skin and lodges in urinary tracts and intestines. The effects of Schistosomiasis infection are debilitating to human health and include symptoms ranging from fever and diarrhea to severe abdominal pain, kidney and liver disease, and internal bleeding (Malek 1972). If untreated, Schistosomiasis, known locally in Egypt as Bilharzia after the German scientist Theodore Bilharz who first identified the parasite, can cause death due to the accumulated effects of the above symptoms. *Schistosoma* flukes thrive best in shallow aquatic environments containing abundant organic matter; as a result, Schistosomiasis is highly prevalent in irrigated regions where agricultural workers spend their days wading through shallow, organic-rich bodies of water. One of the Egyptian government's chief goals in building the High Dam was to convert millions of acres of agricultural land from basin irrigation to perennial irrigation, which leaves irrigation water standing in fields throughout the year. The result of their success in doing so is that the land area conducive to fluke growth and the population at risk of schistosomiasis have both increased precipitously. Epidemiological data confirms that as areas have shifted from basin to perennial irrigation their incidences of schistosomiasis have risen drastically. In four areas surveyed over a three year period after the dam's completion, schistosomiasis rates increased from "10 to 44%, 7 to 50%, 11 to 64%, and 2 to 75%." (Biswas 1978: 291) In these same areas, average life expectancy (excluding infant mortalities) hovered around 27 years for males and 25 years for females (Biswas 1978: 291).

To be sure, Schistosomiasis has plagued Egyptian populations since ancient times, and the High Dam is in no way primarily causative of Egypt's current Schistosomiasis problems. In 1965, before the dam was completed, epidemiologists estimated that 40% of Egyptians were afflicted with schistosomiasis and that it was costing the Egyptian economy the equivalent of 80-100 million British pounds per year (Biswas 1978). But while the dam may not be entirely responsible for Egypt's major schistosomiasis problems, it has certainly exacerbated them. By enabling the conversion of over 800,000 acres of land from basin to perennial irrigation, the Dam has created the ecological conditions driving the observed rise of schistosomiasis in Egypt (Waterbury 1979). Without major public health efforts, the negative health outcomes, reduced life expectancies, and increased costs associated with Egypt's increasing schistosomiasis prevalence will continue to plague Egypt into the future.

While the Aswan High Dam has fulfilled the Egyptian government's goals of flood protection, irrigation expansion, and power generation, it has done so at the expense of the bodily health of the Egyptian people and the ecological health of the Nile Valley. Many of the dam's consequences were easily predictable; indeed, some were predicted by Egyptian scientists and government officials. The dangers of silt impoundment, salinization, and evaporation and seepage were well known to the Egyptian government, as was the fact that tens of thousands of Nubians were going to be displaced by Lake Nasser. The decline in water quality and the increase in schistosomiasis could have been predicted easily based on hydrological and epidemiological knowledge available at the time. Knowing that the dam's construction would result in severe negative externalities, what prompted the Egyptian government to build the dam rather than explore alternative, less drastic management schemes?

Since the dam's completion in 1970, scholars from across academia have attempted to understand the Aswan High Dam: its reasons for being built, its relation to larger geopolitical and economic trends, and its theoretical implications. Environmental historians, civil engineers, political economists, and development scholars have all studied the dam through their own disciplinary lenses, each theorizing the dam in specific, sometimes conflicting ways. In the following paragraphs I will explore the ways in which these scholars have understood the High Dam, Nasser's decision to build it, and its lasting consequences on the people and environment of Egypt.

Historians and political scientists have tended to see the High Dam as a physical manifestation of President Gamal Abdel-Nasser's hegemonic rule over Egypt, material evidence of his consolidation of Egyptian power into a technocratic, centralized government. This understanding of the dam is rooted in the fact that Nasser had a choice between two large-scale irrigation schemes, one of which offered the same beneficial effects of the High Dam without the negative environmental externalities. This second project, the Century Storage Scheme, would have controlled the Nile's water through a network of dispersed, decentralized mechanisms spread across the Nile Valley (Waterbury 1979). Conceived by the British during the early 20th century as a plan for manage the entire Nile Basin as one political and hydrologic unit, this project would have avoided many of the Aswan High Dam's negative impacts by storing water in Lake Victoria, which is less prone to evaporation and seepage. But while this plan would have engendered less water loss and fewer negative externalities, it would not have produced as compelling a physical structure as the dam, as great a degree of centralized control, or as large a quantity of hydroelectric power. Historians have argued that Nasser's decision to build the High Dam instead of the century storage scheme stemmed from his desire to control the Nile's water through centralized rather than decentralized mechanisms as a way of creating government stronger control over the nation's water supply (Waterbury 1979).

To support this understanding of the dam, historians and political economists have invoked the theory of "hydraulic civilization," first articulated by Sinologist Karl August Wittfogel to describe an observed connection between water infrastructure and social organization. The thrust of Wittfogel's theory is that large-scale water management systems compel centralized government power: that control over water begets control over people. Historian Joachim Radkau writes: "hydraulic engineering offered ambitious rulers the chance, very early in the history of state formation, to do something that would increase their power and revenues" (Radkau 2008: 90). Once in control of water, governments of hydraulic civilizations could act as " powerful hydraulic sponge[s]," continuously absorbing new social and economic functions consolidating political control (Radkau 2008:91). While Wittfogel focused primarily on ancient societies in southeast Asia, his theory extends easily to the case of the Aswan High Dam.

By building a monolithic hydraulic engineering system, Nasser could boost the power and stability of his central government. Administering large engineering works requires coordinated technical management and thus an organized, centralized regime; upon the dam's completion, centralized technocratic control would be necessary to avert water scarcity and food shortage. It would quickly follow that Egyptians would fall into an obedient lock-step behind their government. In a society reliant upon hydraulic infrastructure, writes British engineer William Wilcox, "it is easy to understand how method, order, and obedience to a properly constituted authority very soon develop themselves"

(Pearce 1992: 80). Understanding how this dynamic works, governments build hydraulic schemes like the High Dam to consolidate political control, writes historian Joachim Radkau: they "expand the systems of artificial irrigation…as a way of expanding [their] own power" (Radkau 2008: 91). Once governments understand this, "reasons for expanding systems of irrigation and water protection [can] always be found" (Radkau 2008: 90). According to science writer Fred Pearce, "everywhere large water projects are both the consequence of and the justification for authoritarian government" (Pearce 1992: 345). The Aswan High Dam, historians seem to agree, was central to Nasser's efforts to consolidate long-term political control over the Egyptian state, its resources, and its people (Beattie 1994, Fahmy 2002, Pearce 1992, Waterbury 1979).

While historians tend to attribute Nasser's choice of the High Dam over the century storage scheme to his desire to consolidate control into a single centralized mechanism, political economists assert that his decision may have been based on larger geopolitical calculations (Waterbury 1979). The evidence for this view lies in the fact that the proposed Century Storage Scheme crossed numerous national boundaries: if built, it would have spanned several nations including Sudan, Ethiopia, and Uganda, and most of the engineering works would have been built in these upstream nations. The political economic view holds that Nasser categorically rejected the idea of the Century Storage Scheme out of fear of ceding control of Egypt's water supply to upstream nations, which were still under various forms of foreign occupation and which had strategic goals that did not accord with Nasser's (Waterbury 1979). This decision would have been both pragmatic and nationalistic: allowing upstream nations to control the Nile Valley would have reduced both Egypt's ability to secure water for itself while also reducing its influence in the region. "Whoever controls Lake Victoria controls the destiny of Egypt," Nasser asserted in a speech on the dam, echoing his criticism of British control over the Suez Canal and strongly implying that Egypt alone would determine its destiny (Fahim 1981:13). From the political economic perspective, the Century Storage Scheme was a non-starter, and building the High Dam was Egypt's only logical choice.

In addition to studying the political calculus behind Nasser's decision to build the High Dam, academics have studied discourses and ideologies that informed Egypt's decision to build the dam in spite of its predictable negative consequences. The field of environmental history has tended to frame the Aswan High Dam as a case study in the problems of "human exceptionalism," that is, the tendency of humans to view themselves as separate from nature and capable of controlling it. Environmental historians argue that Nasser and Egyptian government engineers, operating under the assumption that human engineering works could control the Nile into submission, never conceived of the river as being capable of "pushing back" or resisting control. The "natural" river could be employed for human purposes. Their conception of the river as a natural phenomenon easily dominated by human engineering prevented them from seeing the river for what it is, a dynamic system whose responses to human interventions are hard to predict and harder to resist. Driven by industrial hubris and an urgent need to "catch up" to the West on science and technology in order to achieve post-colonial independence, the government pursued its plan under the fundamentally false premise that its engineering works—its concrete, metal, and rock—could reshape the river's morphology to meet its economic goals.

In addition to this widespread discourse of control, a popular sentiment amongst Egyptian civil engineers and land-use planners that water flowing into the Mediterranean was "water wasted" helped create strong support for centralized hydraulic engineering. Taken together, discourses on "waste" and "control" formed a powerful new political narrative:

Egypt is wasting water, government engineers argued, a waste that could be stopped through hydraulic engineering. The discourse of "waste" surrounding the Nile's water predated Nasser's regime; it arose first during British colonial rule when British engineering authorities realized that the "wasted" water flowing into the Mediterranean could be used to irrigate cotton fields for the benefit of British textile manufacturers. These British authorities were the first to conceive of the Nile not simply as a river but as a "political and hydrological planning unit," and British discourses on the Nile were confined to one specific purpose: securing British economic interests by managing the Nile's water (Tvedt 2004: 7). Through their starkly mercantilist lens, the British viewed the Nile's discharge into the Mediterranean Sea as a "terrible waste of nature;" they bristled as they watched "fortunes [flow] by" their own cotton plantations and factories (Tvedt 2004: 21).

First articulated by the British, the notion that the Nile's outflow was wasted profit remained prominent as the RCC began ruling the Egyptian state. "We are throwing into the Mediterranean an average of about 32 billion cu.m. every year," lamented an informational pamphlet published by the Egyptian government in 1967, with the clear implication that alternatives existed (UAR 1967: 4). Just as science and technology had enabled the colonial occupation of Egypt, so too would it emancipate Egypt from its economic and cultural subjugation. As the fledgling RCC consolidated control over Egypt in the early 1950s, the parallel notions that water was being continually wasted and that technology existed to stop it conspired to create a pervasive belief amongst high-level government officials that large-scale engineering works could solve the problems of the Nile's variable flow while increasing the river's usefulness to the Egyptian people.

A review of historical literature on the High Dam reveals that domestic political consolidation, international power politics, discourses on controlling nature, and beliefs that the Nile was being "wasted" all played prominent roles in Nasser's decision to build the High Dam. Taken together, these geopolitical and ideological forces led Nasser away from the Century Storage Scheme, which although technically, socially, and environmentally sound posed unacceptable international political risks and was unlikely to produce centralized, technocratic government rule. These factors led Nasser to embrace the Aswan High Dam, which seemed to offer the economic benefits of the Century Storage Scheme, domestic control of the Nile, and a path towards centralized technocratic rule.

Chapter 2. Engineering Modernity through Technoscientific Practice

Was Egypt's decision to build the Aswan High Dam a domestic power play? A geopolitical calculation? An expression of a pervasive sentiment that nature could be controlled and appropriated through engineering technology? Historians assert, with good evidence, that these political and ideological factors influenced Nasser's decision between the High Dam and the Century Storage Scheme. But while they correctly account for the role of these factors in Nasser's decision making, historians leave unquestioned the notion that Nasser's decision was primarily a technological one: a choice between two technologies intended to produce the same engineering outcome. According to dominant historical narratives, Nasser's primary goal was to control the Nile's flow and his choice of the dam over the Century Storage Scheme was a secondary, political judgment. These narratives assume that while building the dam provided Nasser with an opportunity to consolidate regional influence, it was at root an engineering project designed to produce hydraulic control. Historians have left this assumption unquestioned, instead focusing on the political and economic contexts of the dam's construction and, more recently, its social and environmental effects.

In this chapter I will use primary source evidence to suggest that the dam was never merely an engineering work designed to produce hydraulic control or economic growth but also a national symbol through which Nasser's regime discursively produced a "modern" Egyptian state. By analyzing period-era speeches and government publications I will show that Nasser's decision to build the dam was rooted not simply in the dam's political or engineering functions but in the symbolic power created by its monolithic material presence and reinforced by state-controlled media discourses. Finally, I will reveal how the power of the dam's symbolism politicized the scientific atmosphere in Egypt, preventing a full and accurate accounting of the costs and benefits of the dam's construction.

Producing "Modernity" in Egypt: The High Dam as Symbol

While the RCC championed the Aswan High Dam as a means of creating prosperity through engineering practice, the dam was never merely an engineering project. From its conception it was a material signifier imbued with a powerful national symbolism and a profound discursive power that strongly influenced Nasser's decision to build it. In the eyes of the RCC, the dam was physical proof that Egypt was a strong nation determined to build its economy—and regional influence—through investments in major hydraulic projects. Within the dam's imposing physical structure lay a powerful opportunity to usher in a new era of modernity for Egypt through the enlisting of technoscientific practice in the process of growth and development. The dam's status as a symbol of Egyptian modernity—and its influence on the scientific atmosphere in Egypt—shaped the planning and decision-making processes involved in building the dam as well as official and popular attitudes toward the project.

The idea that major infrastructure projects can serve as symbols of national modernity predates the High Dam and is not unique to Egypt. The symbolic power of large dams became widely understood with the Tennessee Valley Authority's (TVA) construction of the Hoover Dam in 1931 (McCully 2001). Intended to water the Southwest's deserts, create jobs for citizens, and signify "greatness, power, and domination" to the international community, the Hoover dam revealed the capacity of dam building to catalyze economic development, boost agricultural production, and inspire national pride. (McCully 2001: 3) Through the domestic patriotism it spawned and the international press coverage it achieved, the Hoover Dam showed the world that large dams could build "not just irrigation and power systems, but nation-states themselves" (Mitchell 2002: 44).

The TVA's dam building both emerged from and reinforced the notion that prosperity and modernity emerge inexorably from the implementation of "modern" engineering technology. Large dams, writes dam expert and activist Patrick McCully, are "expressions of the dominant ideology of the technological age: icons of economic development and scientific progress" (McCully 2001: 2). Offering to jumpstart nations' domestic economies and boost their international profiles, large dams offer a compelling path toward the economic and technological modernity that mark the era of late capitalism. For nations emerging from the economic and cultural subjugation of 20^{th} century colonialism, the prospect of economic progress through technological modernization was particularly attractive. Large dam building was a fast, seemingly straightforward path toward a technological economy the expertise for which had already been developed.

Inspired by the TVA, the Egyptian government saw hydraulic engineering projects as a way to "engineer" modernity. Emerging from a position of economic servitude, the nation sought to leverage its primary resource—fresh water—to develop itself into a prosperous, independent state. Like other colonial states, Egypt had itself been exploited by engineering projects intended to increase production for the benefit of its occupying power. In 1902, the British built the Aswan Low Dam to boost cotton production for the benefit of English textile manufacturers. Over the next three decades they heightened this dam twice, each time to increase agricultural yields for Great Britain's export market (Tvedt 2004). Finally assuming control over its own natural resources, the Egyptian government viewed the very modes of hydraulic control used to exploit colonial Egypt as models for creating an independent domestic economy and a "modern" technological state. Understanding the capacity of large dams to serve symbolically as "shining monuments to progress and prosperity," Egyptian planners conceived of and promoted the Aswan High Dam as Egypt's one-way ticket to economic and technological modernity (McCully 2001: 18).

The ability of the Aswan High Dam to symbolically produce a "modern" Egyptian state strongly influenced Nasser's final decision to build the dam. Ostensibly, the goals of the RCC's revolutionary government were to equitably redistribute economic goods within Egyptian society, reduce class differences and the marginalization of peasantry, and promote agricultural and industrial production (Waterbury 1979). But beneath the surface there was always more at stake: Egypt—then the United Arab Republic (UAR)—was a new player in regional and international politics, and its leaders sought to signal through their actions that Egypt was politically and economically strong. The decision to build was made in the context of "a new and unknown regime seeking to establish its credibility," and the Aswan High

Dam promised to show the world that Egypt would no longer accept "economic backwardness and international dependency" (Waterbury 1979: 98).

From the dam's conception, the Egyptian government employed its symbolism to produce a "modern" Egyptian state. In official publications and political speeches, the Egyptian government framed the High Dam as both a driver of and monument to Egyptian independence and modernity. The RCC situated the dam as Egypt's statement to the world—and its own people—that the Egyptian Republic would no longer accept economic or cultural subjugation by meddling colonialist powers. The dam, spoke president Anwar El Sadat at the Dam's dedication in 1970: "is an expression of aspirations for freedom and peace for peoples…who resist colonialist exploitation and imperial subjugation" (Waterbury 1979: 113). "The High Dam's major value," reads an information pamphlet published by the UAR's information administration in 1967, "lies in that it represents the determination and free will of a nation, looking forward in pride and dignity and insisting on translating into practical action the aspiration of the people for a better standard of living" (UAR 1967: 3). Not simply a material instrument, the dam would serve, semiotically, as a "symbol of Egypt's will to resist imperialist endeavors to destroy the revolution" (Waterbury 1979: 108).

The UAR's informational bureau was instrumental in promoting the High Dam as a symbol of Egyptian independence and strength, and their 1967 pamphlet on the High Dam provides insight into the Egyptian government's goals in building the dam. Published in English, which the British had established as the language of science and progress, the pamphlet was aimed at promoting the dam's physical grandeur and operational capacity to domestic and international audiences. Through textual and pictorial depictions of the dam, anti-colonial rhetoric, and comparisons between the dam and major world monuments, the pamphlet seeks to impress its readers by appealing to their senses of scale and largesse.

Equally concerned with delineating the engineering functions of the dam and establishing it as a harbinger of and monument to Egyptian modernity, the pamphlet's priorities mirror those of the UAR government itself.

To highlight the imposing dimensions of the dam, the pamphlet compares the High Dam to smaller structures around the world, emphasizing its superiority to well-known hydraulic engineering works and national monuments. "The quantities of iron and steel required for the construction of the [dam]…will amount to 140 thousand tons," the pamphlet details, "or about 20 times the quantity of steel work in the Eiffel Tower in Paris" (UAR 1967: 3). "The total quantity of water stored is estimated at 157 billion cubic meters," the pamphlet continues, "or about 6 ½ times the capacity of the Hoover Dam in America" (UAR 1967: 5). By situating the High Dam as a bigger, better version of projects in economically powerful Western states, the informational pamphlet suggests that Egypt, like these nations, was a "modern" state on the cutting edge of water resource management. And by comparing the dam to purely symbolic national monuments such as the Eiffel tower, the information administration underscored the dam's symbolic status as the marker—and producer—of the "modern" Egyptian state.

Beyond promoting Egypt's entry into modernity to curious international observers, the UAR's 1967 information pamphlet aimed to build strong domestic support for a project that would be expensive, long-lasting, labor-intensive, and drastically different from previous strategies for managing the Nile's water. To do this, the information administration framed the Aswan High Dam as a modern-day successor to the Great Pyramids at Giza: a monument to Egyptian grandeur that would inspire pride in all Egyptians. Their 1967 informational pamphlet explicitly compares the dam to Egypt's ancient pyramids, even implying that the "new" pyramid outdoes the old: "the total quantities of the various materials required for the construction of the dam…are estimated at 43 million cubic meters, enough to build 17 pyramids the size of Cheop's great monuments at Giza" (UAR 1967: 16). Nasser reinforced this comparison between pyramids and dam in his speeches, in which he framed the project as a continuation of and extension to Ancient Egypt's building legacy: "in antiquity, we built pyramids for the dead. Now we will build pyramids for the living." (Fahim 1981: 14).

The rhetoric of technological modernity and national pride articulated in the UAR's 1967 information pamphlet and by Egypt's leaders was reinforced in popular media discourses, which portrayed the dam as the solution to a wide range of Egyptian problems and a reclaiming of Egypt's building heritage. In film and television from the era, phrases like "our fathers built the pyramids, and we are building the dam" were frequently repeated (Holz 1968: 231). Cinematic movies depicted young couples in love walking past the partly-constructed dam and other industrial sites, images that in retrospect seem comical but at the time were part of larger efforts by Egyptian media to promote the dam amongst Egyptians (Stone 2009). In the 1997 film *Four Women of Egypt,* Egyptian writer Safynaz Kazem highlights this unbounded optimism about the dam by portraying herself as a woman traveling through Europe who answers the frequent question "Do you have *this* in Egypt?" with the stock answer: "After the High Dam we will!" When someone asks if they have snow in Egypt, she replies, unthinkingly, with this same answer. In the background of the scene, the filmmaker depicts old footage in which confetti rains onto Nasser's motorcade, appearing, indeed, like snow (Rached 1997). By framing the High Dam project as a revival of Ancient Egypt's building legacy, a solution to myriad Egyptian problems, and Egypt's entry into a technological modernity, Nasser, the UAR's information administration, and Egypt's state-controlled media promoted amongst Egyptians the view that building the High Dam would restore the pride of ancient Egyptian civilization while delivering the benefits of late-capitalist modernity.

This symbolism was never officially articulated as a justification for the dam's construction, yet the symbolic import of the High Dam permeated the dam's planning, promotion, and construction. Nasser, the dam's most vocal and visible supporter, summed up the dam's symbolism in a dedication speech on May 14th, 1964:

> Here are joined the political, social, national, and military battles of the Egyptian people, welded together like the gigantic mass of rock that has blocked the course of the Ancient Nile." (Waterbury 1979: 98)

"The dream which has long been cherished by all Egyptians is now being realized at Aswan," begins the UAR information administration's pamphlet on the dam (UAR 1967: 3). From its conception to its completion, the dam led dual lives as a technical instrument of hydraulic engineering and a powerful symbol of Egypt's entry into modernity.

Science through the Technonationalist Lens

At the same time as the Nasser was framing the project as a national monument marking Egyptian power and determination, numerous Egyptian scientists were expressing grave concerns about the physical and ecological consequences of the dam's construction. These scientists, many of them state employees working in an atmosphere characterized by strong nationalism and heavy-handed government, explored two specific consequences of the dam's construction: the impoundment of the Nile's silt and the storage losses from Lake Nasser. Examining experimental data on these physical processes to determine their potential to negatively impact Egypt, some scientists began questioning the wisdom of building the dam and raising concerns about its inevitable long-term consequences. Nasser's regime, viewing scientific assessments of the dam project through a nationalistic lens, viewed these negative findings as distractions and acted to ignore, suppress, or discredit them. With the High Dam strongly identified with the aspirations of the Egyptian regime, criticizing it became a subversive, treasonous act.

In the years following the Egyptian government's decision to build the dam, numerous scientists and engineers raised concerns about silt deprivation, arguing that the impoundment of the Nile's silt would compromise the dam's success and lead to long-term problems. Ali Fathy, supervisor of the reservoir of the old Aswan Dam and professor of irrigation at Alexandria University, expressed grave concerns about the effects of the dam on civil structures built downstream of Aswan. While the Nile's flow had always posed dangers to structures built on the Nile's banks, Fathy argued, the High Dam would drastically increase the risk to these structures, the cost of their repair, and the danger they would pose to citizens (Waterbury 1979). Abd al-Khaleq, Egypt's Minister of Irrigation, and Sayyid Marei, its Minister of Agriculture, shared Fathy's concern about the dangers to downstream structures but were even more concerned about the effects of silt deprivation on the quality of Egypt's soil. "I say in all candor and as loudly as possible," wrote Marei in 1952, "I am worried, extremely worried, because of the threat to the fertility of our soils" (Waterbury 1979: 129). "The need for Nile silt will always be felt," concluded Abdel-Aziz Ahmed, chairman of Egypt's Hydro-electric Power Commission and technical consultant to its Ministry of Public Works (Ahmed 1960a: 144).

In addition to their worries about silt deprivation, Egyptian scientists were concerned that the creation of a large reservoir at Aswan would lead to severe water losses by evaporation and seepage. The issue was not new: Harold Hurst, a British hydraulic engineer formerly in charge of managing the Egyptian Nile, had said of evaporative losses at the

Aswan Low Dam years earlier that "unless they are small, the site is not suitable for over year storage" (Ahmed 1960a: 148). The Egyptian government was keenly aware of the danger of evaporative losses: in a 1959 water sharing agreement with recently independent Sudan, a prelude to the dam's construction, Egyptian negotiators wrote off 9 billion cubic meters of water per year to evaporative losses from Lake Nasser alone. Already over 10% of the Nile's annual flow of 84 billion cubic meters, this figure was considered "much too conservative" by some worried Egyptian engineers (Waterbury 1979: 123).

One concerned engineer, Abdul-Aziz Ahmed, sought to more accurately predict losses by evaporation from Lake Nasser by conducting a series of experiments on the relationships between air temperature, wind velocity, and evaporation. Based on his empirical data and statistical analysis of climate records, Ahmed calculated that the true evaporation rate from Lake Nasser could be up to 54% greater than earlier estimates, or 14 billion rather than 9 billion cubic meters per year (Ahmed 1960b: 197). Acting on the lake's large surface area, the high temperatures, low humidity, and fast wind speeds at Aswan threatened to create water losses unjustifiable even by the dam's promised effects. 14 billion cubic meters of lost water represented 17% of the Nile's total flow and 21% of Egypt's allotted water, and Ahmed argued in conversations with peers and government authorities that the dam's purported gains were not worth sacrificing over 1/5th of Egypt's annual fresh water.

In addition to water losses by evaporation, Ahmed was concerned with the loss of water by seepage through the reservoir's porous sandstone floor. Before the Aswan High Dam, the issue of reservoir seepage had received little scientific or governmental consideration; indeed, it appears that Ahmed was one of the first engineers to study it rigorously using experimental data, records from other reservoirs, and statistical methodologies. Based on the results of this research, Ahmed concluded that the high porosity of the reservoir's floor combined with the hydrostatic pressure gradient pulling water away from Lake Nasser threatened to siphon vast volumes of water from the reservoir. The voluminous Libyan aquifer underlying the reservoir, Ahmed concluded, stood to absorb "many [billions] of cubic meters of water…a considerable portion of the Nile discharge" (Ahmed 1960b: 190).

Analyzing the results of his experimentation on both seepage and evaporation, Ahmed came to believe that the dam presented such great geomorphological and hydrological risks that its purported benefits could not possibly be justified. In Ahmed's worst-case scenario predictions, Egypt stood to lose almost all of its yearly water: "It would not seem inconceivable that the course of a large river could be blocked and the flow entirely interrupted," he argued in a 1960 paper (Ahmed 1960b: 196). "To what extent the High Dam reservoir would approach that extreme it is difficult to say," Ahmed conceded, but even in his best-case scenarios Egypt stood to lose more than a quarter of its yearly fresh water allotment (Ahmed 1960b: 197). Ahmed's point was simple: when dealing with such an important resource of which even small losses could exert severe consequences, every short-term and long-term potentiality demands comprehensive consideration by scientists and planners. Realizing that Egypt was about to irreversibly alter the river that for millennia had been the backbone of its agricultural, industrial, social, and administrative functioning, Ahmed argued that the project demanded exhaustive study and deliberate precaution. Hoping to communicate his fears and concerns to Egyptian policymakers, Ahmed gathered his findings and opinions and submitted them in a report to then-Minister of Irrigation Musa Arafa and other prominent engineers within Nasser's regime. In it, he implored the Egyptian government to conduct a rigorous and comprehensive study of water losses and silt impoundment to determine the full scope of the dam's potential consequences for Egypt's short-term and long-term futures.

Ali Fathy, Sayyid Marei, and Abdul-Aziz Ahmed, all well-known and widely-respected government engineers, voiced deeply-held concerns about the technical and environmental consequences of building the High Dam. Their concerns implicitly—and explicitly in the case of Ahmed—suggested that these consequences were not worth the dam's purported benefits and that by extension the dam project should not move forward. Nasser's regime, viewing these concerns with skepticism and hostility, ignored most of them and suppressed some. Ali Fathy, who submitted dozens of technical memoranda to the RCC and to Nasser himself detailing concerns about the effects of silt deprivation on civil structures and soil fertility, never received a response or even an acknowledgement that his concerns had been considered. The official view on fertility loss was that the Nile's sediments were replaceable by chemical fertilizers, which could be mass produced at low cost using power from the High Dam's generator (Waterbury 1979). These fertilizers, introduced to Egypt by the U.S. in the 1950s, promised to benefit Egypt agriculturally and the U.S. economically. As far as downstream civil structures, if Egyptian labor could build something as formidable as the High Dam it could certainly repair damage to bridges and barrages.

When Ahmed submitted his initial report to the minister of irrigation, he was met with the same skepticism and disdain as Fathy but was seen as more threatening. Minister of Irrigation Musa Arafa told Ahmed that his analysis had been reviewed by government engineers and deemed flawed and that he should reconsider his data and his criticisms of the dam (Waterbury 1979). In the mean time, Arafa demanded that Ahmed turn in all copies of his report to the government for "safe-keeping" (Waterbury 1979: 120). The official view on water losses was that the Nile would lose roughly 9 billion cubic meters by evaporation, as outlined in the 1959 water sharing agreement. The Egyptian government was not interested in revising this previously established figure or considering Ahmed's contention that Lake Nasser's losses "appear to be so great as to make the High Dam of doubtful benefit" (Ahmed 1960b: 181).

Faced with dissent by competent government engineers on the wisdom of building the High Dam, Nasser's regime retrenched and quietly considered the dam's technical specifications. Many members of the regime were army-trained engineers with backgrounds in water management and civil engineering, and none held the illusion that the dam would be technically perfect. But instead of investigating the full range of the dam's potential shortcomings and negative consequences, they ignored and suppressed evidence of what they deemed the negligible possibility that the dam's ecological or human costs would outweigh its projected economic and symbolic benefits. Early in the dam's planning, the government had encouraged discussions on the geological and ecological effects of the dam. When major concerns began emerging from these discussions, Nasser and high-level government officials moved to discourage and suppress them (White 1988). Viewing the dam's effects through the lens of Egyptian nationalism and in light of the dam's promise to bring modernity to Egypt, the RCC chose to discuss them privately with no attempt at transparency or public participation. Predictably, the Egyptian government dismissed their importance as overestimated and ignored them in the dam's planning and construction. These concerns, though serious, were not ultimately strong enough to overcome the Egyptian regime's desire to employ the dam as a "speech-making instrument:" a driver of and monument to technological modernity in Egypt (Latour 2005: 34).

Abdul-Aziz Ahmed, frustrated by his government's dismissal of his results and discouragement of scientific debate on the dam, decided in October 1959 to submit a copy of his report and empirical data to a British engineering society, the *Institution of Civil Engineering*. His submission was published soon after in the form of two scientific journal articles: "Recent Developments in Nile Control" and "An Analytical study of the storage losses in the Nile Basin, with special reference to the Aswan Dam reservoir and the High Dam Reservoir (Sadd-El-Aali)" (Ahmed 1960a, Ahmed 1960b). In November 1960, one year after quietly submitting his findings, Ahmed traveled to London to present them to an audience of scientists and engineers from around the world. In publishing his papers and publicizing his dissent in London, Ahmed became the first Egyptian official to break the government-imposed silence on the dam's dangers and negative effects. His actions, already subversive, were especially controversial due to his choice of England, Egypt's former occupier, as the venue for his denouncement of the dam. His marriage into a land-owning Turkish family, another enemy of Nasser's revolution, did not help his case.

Surprised and outraged by Ahmed's public airing of dissent, Nasser's regime viewed Ahmed's decision to publish his criticisms abroad as a subversive, treasonous act. Through their control of media, Egyptian officials ensured that Ahmed's betrayal did not reach the Egyptian people, and they quickly took measures to disgrace and discredit him on both personal and professional levels. In 1964, state officials rescinded a State Prize for Outstanding Achievement that Ahmed was slated to receive (Waterbury 1979). When Ahmed wrote the Deputy Prime Minister protesting this action and demanding just recognition, his protests received no reply. In an interview I conducted with Leila Ahmed, his daughter, I discovered that when Ahmed grew sick in the mid 1960s, he found it perpetually difficult to acquire his medications from state-run pharmacies (Ahmed 2010).

When Leila applied for a passport to leave Egypt for study at Cambridge, her papers were lost and her visa mysteriously delayed (Ahmed 2010). From his "betrayal" of the Egyptian government 1959 to his death in 1967, Ahmed's life was marked by public disgrace, professional discrediting, and the harassment of his family,

After Ahmed published his dissent, the Egyptian government moved quickly to discredit his methodologies and to devalue his findings. Harold Hurst, a former friend of Ahmed's, and a group of Soviet hydrologists released a reply to Ahmed's papers. Repudiating Ahmed's techniques and their experimental results, they argued that Ahmed had miscalculated the seepage losses from the Aswan Low Dam and then extrapolated this incorrect figure to measure potential losses from the High Dam (Shibl 1971). This mistake, they argued, rendered his annual seepage figures greatly exaggerated and unworthy of consideration. From the perspective of the Egyptian government, the issue was settled. In decades since, Western scholars have revisited Ahmed's dissent and looked upon it more favorably: while "in several ways they have been unconfirmed," wrote political economist John Waterbury in 1979, his ideas have not been proved wrong enough to "deprive them of all validity" (Waterbury 1979: 123). And while the validity of his claims on seepage and evaporation remains contested, their truth status is ultimately less important than what their treatment reveals about the scientific and political atmosphere in Nasser's Egypt and the influences of symbolism and ideology on the high-level decision-making processes that led to the dam's construction.

The case of Abdul-Aziz Ahmed is a unique window into the politicization of the scientific process under Nasser's heavy-handed Egyptian rule. While the Egyptian regime was initially encouraging of engineering studies on the feasibility and wisdom of building the High Dam, they pulled back their support as soon as engineers such as Ahmed began questioning the dam's utility. Both Ahmed and Ali Fathy alerted the government about the dam's potential consequences, but neither received responses and their concerns were largely ignored. Only when Ahmed published his findings in London were his ideas taken seriously, and only insofar as the government sought to discredit them. In assessing the scientific evidence supporting and opposing the dam's construction, Egypt's ruling regime relied on those studies that supported its goals in building the dam while ignoring those that contradicted them. Critical studies by Ahmed and Fathy were marginalized and discredited; those by Soviet consultants and prominent government engineers Harold Hurst and Yusuf Simaika were endowed with "expert" status.

Through their politically-informed reliance on certain studies and rejection of others, the Egyptian regime crafted a selective body of "credible," state-approved scientific evidence that, in turn, supported fully and uncritically the regime's plan to build the dam. Through their promotion of encouraging studies and suppression of everything else, the Egyptian regime created the appearance that a strong scientific consensus supported building the dam. In reality, there were numerous scientists expressing strong, empirically-rooted opinions calling into question the wisdom of the dam's construction. These dissenting voices were silenced and suppressed from public debate by the same government that filled popular media—particularly television and cinema—with technonationalist rhetoric and enthusiastic endorsements of the dam. The influence of political factors on the process of designing and building the High Dam was ultimately rooted in the profound symbolism of the dam, in light of which scientific objectivity and long-term impact prediction were secondary concerns.

Given the dam's status as a material embodiment of Nasser's aspirations for Egyptian modernity and a personification of Nasser himself, technical criticisms of the dam were not seen solely as such. Negative assessments of the dam were treasonous statements against the Egyptian regime, criticisms of Nasser himself, and betrayals of the larger Egyptian population. Even studies focused solely on the dam's technical aspects could not approach the neutrality necessary to measure the dam's true impacts; even if they could, the entirety of Egypt's government was "collectively determined to overlook any signs" of the dam's deleterious side effects, imposing "serious institutional restraints on participation in the decision-making process" (Fahim 1981: 165). Within this politicized scientific atmosphere, "objectivity from any quarter was either ignored or doomed" (Waterbury 1979: 115). Dam critic Ali Fathy, frustrated by his government's recalcitrance, called this phenomenon the "High Dam Covenant," which he defined as an unspoken agreement amongst Egyptian government officials that concerns about the dam were to remain unacknowledged and unspoken (Waterbury 1979). As the High Dam project proceeded, the High Dam Covenant became sacrosanct. Violating it became profane and punishable, as Ahmed discovered when he published his criticisms in 1960.

The result of the High Dam Covenant and political atmosphere from which it emerged was that numerous avoidable mistakes were made during the dam's planning and construction phases. These mistakes arose from policy choices rooted in ideological and political considerations, which were themselves rooted in the powerful symbolism conferred by the High Dam. The political and ideological pressure driving the dam's construction led to plans being made with what the IBRD, the world bank's predecessor, called an "incident haste" (Waterbury 1979: 102). The pace of planning and construction was such that "the reasonably balanced combination of the political and the technical in the execution of big development schemes, designed to avoid the waste of scarce resources, was undermined" (Fahim 1981: 165). The Egyptian government's dismissal of technical concerns and rushing of the dam's construction produced a dam riddled with unintended though widely predicted consequences. Evaporation from Lake Nasser, for instance, has been a huge problem for Egyptian water managers, as predicted by Ahmed in his 1960 papers. The dam's externalities, some of which were predicted in advance and largely avoidable, attest to the "primacy of political consideration determining virtually all technological choices" to the detriment of the ecological and social well-being of the Egyptian state and people (Waterbury 1979: 5). Through a politicized planning process and a hastily planned construction effort, independent Egypt reshaped the Nile in its own image: that of a large, dispersed system controlled autocratically through a monolithic locus of unchecked centralized power.

Chapter 3. Towards a New Management Paradigm: Obstacles and Opportunities

The case of the Aswan High Dam reveals the power of political and ideological factors that influence the management of water resources as well as the deleterious consequences that can result. Assessed critically, it also points to some major obstacles to the implementation of sound resource management policy today. In this final chapter I will explore some broader implications of the case of the Aswan High Dam, focusing on three major factors driving the continued construction of large dams in spite of their social and ecological impacts. First, I will discuss how the politicization of large dam projects prevents the accurate accounting of the full range of their impacts. The lack of data on the impacts of large dams, a direct result of government attitudes and actions, facilitates the continued construction of large dam projects. Second, I will discuss how the rise of what I call a hydraulic/political/industrial complex drives the building of large dams by creating powerful political and economic incentives to "build big". Third, I will explore how the increasing commodification of water resources, exacerbated by scarcity and the act of damming itself, encourages large dam building by providing new frameworks for assigning value to water resources. After elucidating these obstacles to the effective management of water resources, I will conclude by suggesting that theories of materiality drawn from Science and Technology Studies (STS) can provide a new paradigm through which to assess hydraulic engineering practices. Ultimately, careful scholarship and a theoretical re-framing of large hydraulic projects may help prevent the impacts to people, ecosystems, and sustainable futures that have for so long accompanied them.

Assessing Impacts: Political and Practical Challenges

The construction of large dams today results in part from a lack of comprehensive data on these projects' true costs and benefits: economic, environmental, social, or otherwise. In Egypt and elsewhere, the lack of data on the full consequences of large dams stems directly from a dearth of political will to collect and analyze this data. In the decades since 1970, public pressure has mounted behind efforts to measure and remedy the dam's negative side effects. Particularly since Nasser's death, more Egyptians are questioning whether the dam has fulfilled Nasser's promises of creating a "modern" Egyptian state. While few Egyptians have seen newfound prosperity, many have realized that Nasser's government bears responsibility for the dam's shortsighted planning and negative impacts. Aware of the disjuncture between government rhetoric on the dam and the everyday realities of the dam's effects on Egypt, Egyptians have become more critical of Nasser's regime and its authoritarian rule over Egypt (Fahim 1981: 165). Many have come to believe that the dam was "unequal to the problems it was designed to solve" and that the Egyptian government acted shortsightedly in its decision to plan and build it (Waterbury 1979: 151).

Despite the increased visibility of the dam's negative consequences to Egyptians, the Egyptian government has taken little action to assess the full range of the dam's impacts on Egypt. To be sure, the dam has achieved some of its engineering goals, including the expansion of cultivated land, the control of the Nile's flood, and the generation of hydroelectric power. Yet it hasn't accomplished these goals to the degree promised by Nasser and it has engendered a variety of social and ecological externalities that continue to act on the Egyptian people and landscape. But even amidst a political atmosphere much more critical towards Nasser and his central planning, the Egyptian government has yet to conduct a large-scale, transparent, integrative assessment of the full range of the dam's impacts on Egypt. The reasons for this are primarily political: politicians have little to gain and a great deal to lose in conducting impact assessments that they know might undermine government credibility and public support.

In Egypt, initiatives to comprehensively analyze the dam's impacts have remained politically unpopular because of their potential to highlight the Egyptian government's poor planning and complicate future management strategies. Problems that are acknowledged publicly need to be addressed publicly, and addressing problems means admitting fault, spending money, and potentially losing support. Egyptian public officials, well aware of the dangers of holistically evaluating the dam, remain silent on the dam's problems while highlighting its purported successes. The evaluation efforts that the Egyptian government has pursued have focused on confirming the value of the dam's work rather than exposing its shortcomings. Even these studies have been incomplete due to chronic shortages of research money and political will. The result of politicians' lack of incentive to assess the dam's impacts—and the impacts of other hydraulic projects the world over—has been a "total blackout" of information on the dam's effects and the effects of large dams more generally (Fahim 1981: 165). This blackout prevents planners, engineers, and academics from learning from the successes and failures of large hydraulic projects such as the Aswan High Dam.

The few assessments of the High Dam's impacts completed by government and industry have been predictably positive in their conclusions. These studies have focused almost exclusively on the economic gains wrought by the dam and the dam's impressive technical specifications. Comments by the president of the American Society of Civil Engineers, an independent group, illustrate this tendency to highlight economic impacts while trivializing others: "in the light of the dam's benefits to a needy people, the so-called ecological effects appear to be nominal" (Fahim 1981: 40). Official attitudes have been equally optimistic: in May 1973, Deputy Director of the High Dam Authority Ahmad Daud proclaimed that in three short years the dam's benefits had already exceeded its costs (Waterbury 1979). In 1979, Egypt's Minister of Irrigation asserted that "Egypt's Aswan High Dam is bringing prosperity to the country but without the side effects so many feared" (Fahim 1981: 40). Viewing the dam project through a nationalistic, technocratic lens, the Egyptian government has maintained the illusion that the dam's gains drastically outweigh its externalities. Their attitude of complacency has, in turn, reinforced the trend of not studying the dam and the belief that the dam's worth is unassailable.

The lack of impact analysis is not solely political: while political factors have hindered the accurate assessment of the dam's impacts, so too have the practical difficulties of conducting impact analyses in the first place. These practical difficulties are not unique to Egypt: large rivers are highly complex systems, and it is as yet impossible to accurately measure the full range of their responses to engineering interventions. Not just a modification of a hydrological system, the High Dam constitutes an intervention in ecological, economic, and social systems, and it is difficult to weigh its effects on these systems with any standard impact assessment methodology. Some of the dam's effects are immediate- or short-term, such as the generation of hydropower and the conversion of basin-irrigated regions to perennial irrigation. Other effects are medium- or long-term, such as the depletion of sediments from the Nile's delta or the salinization of Egypt's agricultural land. Many of the dam's effects are unquantifiable in traditional economic terms: the importance of the connection between the Nubian people and their ancestral lands, the beauty of the Nile's water flowing over its now-submerged cataracts, the history of the ancient monuments flooded by Lake Nasser. It is inherently difficult to valuate these intangible effects individually and more difficult to weigh them against one another, and no agency within the Egyptian government holds capacity to do so effectively (White 1988). Is it even possible to measure all of the dam's tangible and intangible effects, and can this be done across different temporal frames? Ultimately, even the most rigorous impact assessments could not be entirely conclusive, as the dam will continue to exert new effects into the future.

With political and practical factors making an integrative cost benefit analysis nearly impossible, people are left to decide for themselves whether the dam's beneficial effects are worth more than its consequences to Egypt's land, water, and people. This is a fundamentally political decision because people's perceptions of the impacts of a hydraulic project depend more on their "personal interests, views, and biases" than any data-based assessment of costs and benefits (Biswas 1978: 285). Engineers, concerned primarily with the structural integrity and technical performance of projects, view projects such as the Aswan High Dam as technological triumphs to be celebrated and copied. Economists, concerned with economic growth and regional development, assess projects through the lens of "efficiency and regional income distribution" (Biswas 1978: 295). Environmental and social scientists, concerned with ecological and social impacts respectively, tend to view projects such as the High Dam in terms of their negative externalities. Because different constituencies apply different criteria to the assessments of hydraulic projects, a given project is likely to be hailed as a success by some and derided as a mistake by others.

Judgments of the dam's effects and accounts of its history are also informed by national and industrial ideologies. Those who see large-scale water engineering projects as material embodiments of national strength have tended to downplay the High Dam's technical shortcomings and negative impacts on Egypt. Those who advocate small-scale, local resource management have tended to highlight the dam's negative externalities while dismissing as "mere façade" the dam's purported benefits (Radkau 2008: 90). National governments, whose reputations ride on the symbolic and practical successes of their projects, tend to paint only the most positive pictures of the performance of their large dams. Even the worst projects are whitewashed, writes Middle East water scholar Tony Allen: "Unviable projects have been sustained as national fantasies" and thus "cannot be gainsaid without an intolerable loss of face by the national leadership" (Pearce 1992: 121). Ultimately, assessing hydraulic projects is an inherently political practice: the legacies of dams are shaped not by their consequences but by how these consequences are framed and by whom. Because governments hold more power to shape discourses than most other actors, their accounts of their dam projects achieve privileged truth status and obscure the realities of these projects' effects.

New Incentives to Build: The Hydraulic/Political/Industrial Complex

A second factor driving the continued construction of large dams worldwide is what I call the hydraulic/political/industrial complex, a conglomeration of government and industry actors that posits large-scale hydraulic engineering as a panacea to economic "backwardness" around the world. The ideology of the hydraulic/political/industrial complex is rooted in what development critics Norman Uphoff and Warren Ilchman term the "religion of development," a worldview that dichotomizes the world into "modern" and "traditional" realms and sees the "traditional" as primitive, backward, and in need of modernization (Uphoff and Ilchmann 1972). Within this dichotomous framework, large hydraulic projects are viewed as mechanisms through which pre-modern nations can become modern, and hydraulic technology is marketed as a means to transform unproductive traditional economies into machines of modern economic growth. The idea that hydraulic technology can itself produce modernity and prosperity is appealing, for it offers developing nations the capacity to develop quickly without significant economic or social restructuring.

The hydraulic/political/industrial complex is further driven by an ideology held widely amongst engineers that privileges the solving of technical and economic problems over the health and welfare of ecological and human systems. Engineering training is by definition highly technical, and it often contains little focus on the larger contexts in which engineering projects are implemented. Engineers are "not interested in understanding things for their own sake," wrote Max Horkheimer, "but in accordance with their being fitted into a scheme…the engineer's mind is that of industrialism in its streamlined form" (Worster 1992: 57). Because hydraulic engineers are not concerned with factors other than the specifications and performances of their structures, "social and environmental consideration have often been sadly neglected" during the planning and construction of large dams (Biswas 1978: 285). Engineers' myopic focus on the technical is exacerbated by governments' desires to use engineering works as symbols of national determination and prosperity. In Egypt, where Nasser situated the High Dam as the cornerstone of Egyptian modernization, engineers achieved levels of prestige and power unheard of before Nasser's rule (Waterbury 1979). As the architects and designers of Nasser's symbol of Egyptian grandeur, these engineers were given free reign over a planning process that in retrospect lacked long-term planning and sensitivity to human and ecological concerns.

In Egypt and elsewhere, hydraulic-political-industrial complexes emerges when the vast political control that dams confer onto state governments combines with the immense corporate profitability of dam building to produce staggering incentives for policy makers to build large dams. As we have seen, dam building is expensive: the final cost of the Aswan High Dam totaled over one billion US dollars, and newer dams cost considerably more (Waterbury 1979). Large dams require planning, materials, and labor, much of which is supplied by private corporations contracted by state governments. In order to remain solvent and prosperous, these corporations rely in part or whole on governments to produce a stream of revenue-generating dam projects. Take, for example, the American fertilizer companies for whom the construction of the High Dam would create an enormous source of profits. These companies, acting to secure their economic interests, were instrumental in lobbying the U.S. government to fund the High Dam's construction (Mitchell 2002). Just as governments derive political power from building large dams, corporate interests earn money from the decisions by politicians to build them. The two form a positive-feedback loop: as governments build large dams they fill the coffers of dam building corporations, which in turn "reinvest" their capital in the political futures of politicians willing to champion the construction of new hydraulic projects. The hydraulic-political-industrial complex is a sociopolitical process with profound implications for economies, geographies, and communities: it is a site at which "scientific knowledge, technological invention, and corporate profit reinforce each other in deeply entrenched patterns that bear the unmistakable stamp of political and economic power" (Winner 1980: 126). The result of this dynamic is a world landscape dotted with tens of thousands of large dams, a body of world rivers of which few flow uninterrupted from source to delta, and an unnamed, uncounted mass of people displaced by rising waters.

(Com)modifying Water: Creating Value Through Hydraulic Engineering

The third force driving the construction of large dams worldwide is the increasing commodification of freshwater resources—a force that both contributes to and is reinforced by the building of large dams. Water resources are fundamentally different from other resources in that they are integral to the survival and health of the earth's biosphere. The necessity of water to life, particularly human life, infuses water management with a moral dimension not present to the same extent in the management of other less vital resources. Built around human needs, water management strategies are auspiciously predicated on "projections of future population growth, per-capita water demand, agricultural production, and levels of economic productivity" (Hunt 2004: 39). Because these variables will continue to grow with the global population and its increasing consumption of resources, so too will global demand for fresh water. The result will be a looming gap between demands for fresh water and its availability.

One consequence of water's increasing scarcity—and its increasing management through hydraulic engineering—is that it has been resignified as a market commodity and interpellated into a global economic system controlled by governments, corporations, and private actors. To be sure, water has always held value, particularly in areas marked by water scarcity or predominantly agricultural economies. But the impoundment and rationing of water by modern, centralized government and corporate authorities has reshaped the valuation of water by incorporating it into economic culture in a more measurable, quantifiable way. When a river runs unimpeded from source to terminus, the water within it is difficult to value using standard economic logic. The water is doing no useful work, and it is not readily apparent how much or what kind of work the water could potentially do if engineered.

In contrast, once a river is dammed the value of its water can be calculated by measuring the amount of work or production capable of being extracted through the controlled release of its water. Whether water is used to drive a hydroelectric turbine producing sellable power or an irrigation system producing marketable food, it becomes a cultural object which can be assigned economic value and incorporated into a larger economic matrix. As humans modify the course of rivers, they commodify the water within them. Dam building thus exemplifies what I call the "(com)modification" of nature: through the act of hydraulic engineering—the modification of a river system—water is imbued with commodity value that it did not previously hold. In Egypt, this process is visible in the discourses of "waste" that surrounded both the Low and High Dams: the pervasive sense that the Nile's outflow was being "wasted" reveals how the imperative to increase water's usefulness in creating economic value begets the technological modification of river systems.

The interpellation of water into a transnational system of political and economic capital has driven the construction of large dams to the detriment of the human communities and ecological systems. While the economic value of water flowing through a dam can be quantified by economists, the impacts of large dams are hard to valuate in strict economic terms. How much is earth's ecological health worth, and how would we make such a calculation? Does it hold inherent value, or is it only valuable in terms of its usefulness to humans? In the case of Egypt, what are the monetary values of heritage sites drowned under Lake Nasser, delta villages lost to coastal erosion, communities plagued by schistosomiasis? Because the economic values of cultural and ecological systems are incommensurate with the tangible economic benefits of building a dam, dams almost always win out in formal cost benefit analyses. As earth's freshwater becomes more scarce, its commodity value will continue to increase and with it the stakes of attempts to manage, store, and utilize it through hydraulic engineering (Hunt 2004: 40).

Opportunities for Sustainable Water Management

Looking to the future, it will be the responsibility of scholars, policymakers, and water resource managers to overcome the obstacles that have plagued water management for decades. Numerous forces stand in the way of sustainable and responsive water management, from the difficulty of assessing the impacts of past projects to the machinations of the hydraulic/political/industrial complex to the (com)modification of fresh water resources. Large dams have become ingrained in development models and engineering practice, and for over half a century they have become a dominant tool for managing the flow of large rivers. As large dams have proliferated the world over, more data has become available on their short- and long-term impacts. Much of this data indicates that large dams are ruinous to river ecosystems, social communities, agricultural lands (White, Waterbury, McCully). In response to this, an international movement has emerged in opposition to the construction of new dams. Through their lobbying, education, and activism, organizations such as International Rivers, Friends of the River Narmada, and American Rivers have raised new awareness about the dangers of large dams and the necessity of stopping their construction. While these organizations have achieved some political success, the construction of large dams continues today. Despite the increasing availability of information on the negative impacts of large dams, governments and industry remain committed to building them. How can we, as scholars, intervene in the practice of building large dams in a way that highlights their complexity and discourages their future construction?

In this final section I will suggest that theories of materiality from the field of Science and Technology Studies (STS) offer new ways of approaching large dams that hold the power to reconfigure decision-making processes around the broader impacts of these projects, ultimately discouraging their future construction. First, I will use theories of nature and environment from STS to disband dominant narratives positing dams as conquests of the "natural" by the "cultural." Second, I will use Bruno Latour's conception of "things" from *Making Things Public: Atmospheres of Democracy* (2005) to reframe dams as expansive sites of material and discursive practice rather than engineering structures contained within their physical corpuses. By understanding dams at "things"—approaching them as the multifaceted, variegated actors that they are—planners, policymakers, and engineers can begin to make better management decisions based on more complex, nuanced thinking.

Most discourses on hydraulic engineering—particularly those within engineering and planning communities—articulate dams as physical entities separate from the river systems in which they are installed, technological mechanisms through which humans control the flow of water. This view emerges from dominant narratives on "nature" and "culture" holding that culture is a "thing of man" while nature is "outside, free, unspoiled, raw" (Bennett 1993: 8). Within this binary system, the "natural" is a site for "cultural" exploitation, and the economic utilization of nature's bounty is a marker of human technological progress (Bennett 1993: 8). It is easy to see how the Aswan High Dam case might fit into this dichotomous paradigm of nature/culture relations. Before the High Dam was built, the Nile was arguably a much more "natural" phenomenon: it flooded in variable cycles, carried silt-laden water, and changed shape continuously. By contrast, today's Nile isn't "natural" at all: its flow patterns are regulated by a massive engineering work controlling every drop of water that flows into the Egyptian Nile.

Despite the appeal of this dichotomous model, to see projects like the Aswan High Dam as examples of "culture" controlling or appropriating "nature" is to reduce their complexity and to deny them their full dimensionality. Since humans have inhabited the Nile Valley, the Nile has never been a strictly "natural" phenomenon: employed for irrigation and drinking from the earliest days of Egyptian civilization, the Nile has always been a hybrid entity characterized by the mingling of the natural and the technological. As political theorist Timothy Mitchell asserts in his landmark study *Rule of Experts,* "The river already was as much a technical and social phenomenon as a natural one" (Mitchell 2002: 34). Technology and human civilization have coevolved within and around "natural" systems, and through social and technical interaction these systems have ceased being "natural" at all. Ironically, it is only through the technological management of these systems that the "nature" within them is revealed. "Nature was not the cause of the changes taking place" during the construction of the Aswan High Dam in Egypt, Mitchell points out; on the contrary, nature "was the outcome" (Mitchell 2002: 35).

If dams do not fit squarely in the idealized model of technological culture controlling natural systems, then what exactly do they represent and how can they be theorized? The main problem with seeing large dams as an imposition of culture onto the realm of nature is that it situates them as objects: fixed artifacts defined by their material makeup and physical presence. This grossly misrepresents the reality of large dams, structures which, as I have argued, are not and have never have been solely physical or material entities. From their conceptions to their completions, large dams are always already both material and semiotic entities, mechanisms for controlling water's flow and symbols of strength, ingenuity, and control. Viewing large dams as objects reduces them to inert blocks of rock and concrete anchored to riverbeds to block the flow of water. As the case of the High Dam illustrates, large dams are much more than that: they are physical nodes around which politics, people, money, power, science, discourse, and belief all cluster and converge, blur boundaries and shape one another. They are alive with symbolism and rich with semiotic import, and they cannot be reduced to their unidimensional material presence.

In his essay "From *Realpolitik* to *Dingpolitik* – or How to Make Things Public," Bruno Latour deplores the weakness and poverty of the conceptualization of "objects" and introduces in their place his concept of the "thing," which he defines as a "certain type of archaic assembly" or a pattern "of emotions and disruptions, of disagreements and agreements" (Latour 2005: 22, 15). Most simply, a "thing" is a material entity that transcends its materiality, an object that refuses to accept "objecthood," a clustering of material and semiotic practices into a loosely bound multidimensional whole. Unlike objects, "things" are never done; they are actors as much as they are entities and they act, play out, and unfold indefinitely. To reduce "things" to objects is to deprive them of their dimensionality, to strip them of their agency. As Latour states in *Dingpolitik*, objects have for too long been seen as "matters-of-fact," representations that are "unfair to them, unfair to science, unfair to objectivity, unfair to experience" (Latour 2005: 19). Because they are more "interesting, variegated, uncertain, complicated, far-reaching, heterogeneous, risky, historical, local, material, and networky" than ordinary, mundane objects, "things" demand more respect, more study, and more critique (Latour 2005: 19).

Applied to the practice of dam building, Latour's conception of "things" holds the power to spawn a new paradigm of hydraulic engineering in which dams are viewed not merely as technological objects but as expansive sites of material and discursive practice. By understanding dams at "things"—and approaching them with the caution and respect that they demand—planners, policymakers, and engineers would make smarter management decisions based on more complex, wide-ranging criteria. Viewing dam projects as expansive interventions in hydrologic, geographic, economic, and social systems would change the processes of modeling their potential consequences and deciding whether these consequences are justified. Rather than simply calculating the economic or agricultural gains to be reaped from a dam's construction, hydraulic planners would consider the role of ideologies driving the dam's construction and the ethical implications of the project's implementation. They would consult scientists, anthropologists, and development scholars to understand the full range of the dam's impacts on ecological, social, and economic systems. These impacts, modeled over short and long time scales, would be at the center of political decisions on whether or not individual dams should be built. Proposed dams that threaten the health of ecosystems or communities should be rejected as too "costly," regardless of their economic benefits. Reconceiving large dams as "things" is not difficult: it is as simple as not taking them at face value and, instead, working to fully understand their implications before rather than after their construction.

While the reframing of large dams as "things" offers a path of resistance to their continued construction, it would be naïve to argue that a new material-semiotic paradigm for assessing proposed dams would halt the construction of large dams. Ideology will always influence the process of planning and building dams, and governments will continue to privilege short-term symbolic and economic gains over long-term ecological and social costs. In China, no impact prediction study or pre-construction assessment would have halted the construction of the Three Gorges Dam, which was completed in 2008 and which has already displaced over a million people. Even in India, where democracy and public participation are strong, the controversial Narmada River Development plan continues to move forward. But while a new paradigm for theorizing dams may not stop governments' endeavors to build big, it would certainly be helpful to them in the planning and execution of their projects, the consequences of which they will have to manage for decades, perhaps centuries, to come. While not guaranteed to stop the construction of large dams, re-conceiving them as material-semiotic "things" that act across wide spatial scales and multiple temporalities promises to create a more critical dialogue around the practice of planning and building large dams.

By providing a new theoretical framework through which to understand and assess large dam projects, Latour's theory of "things" creates a bridge between academic discourses on materiality and the practice of managing water. Water resource management, long the realm of technocrats and engineers, offers theorists of science and technology a unique opportunity to activate their specialized knowledge by bringing it to bear on the preservation of earth's water resources and the safeguarding of its communities and ecosystems. It offers

Archaeology and Science and Technology Studies, frequently confined to the ivory tower, the chance to become active in policy making, government administration, and resource management. As we confront new water management challenges from scarcity to pollution to privatization, those who study the dynamics of how science and technology work hold an unprecedented opportunity to shape the future of resource management through smart scholarship, strong activism, and informed participation. Given the magnitude of the problems facing the world's fresh water resources, it should be our goal—indeed, our responsibility—to do so.

Conclusions:

The first thing that I realized when I began researching and writing this thesis is that understanding large dams requires analytical approaches from across the sciences, the social sciences, and the humanities. On the scientific level, basic knowledge of engineering, geomorphology, and ecology are necessary in understanding what dams do and how they effect river basins. On the humanistic level, understandings of history, media, and culture are crucial to assessing why dams are built and how they are promoted and justified. The social sciences—anthropology, political science, sociology, economics—offer frameworks for evaluating how dams affect people on the individual and societal levels. Ultimately, large dams are sites at which all of these disciplines intersect, and an interdisciplinary approach to understanding them sheds more light than any disciplinary approach could on its own.

What science and technology studies (STS) contributes to the study of large dams is the bringing together of these diverse approaches in a critical and open-minded way. Science and technology studies focuses not simply on how to understand problems such as resource management but on how different disciplinary actors attempt to do so and why different approaches fail or succeed. Scientists, engineers, historians, archaeologists, media theorists, economists: all work within different, sometimes contradictory intellectual frameworks, each with its own history, methodology, and community. Interdisciplinary by definition, Science and Technology Studies offers a forum for new dialogues between disparate disciplines and the creation of more comprehensive, more accurate accounts of the complexities of water management. Sustainable water management strategies for the future will not emerge from one discipline acting alone; to create and implement these strategies, politicians and planners will have to combine knowledge and methods from across academia. If the work of protecting and managing earth's resources is expected to succeed, it will be an inclusive project synthesizing knowledge and methodologies from across the sciences, the social sciences, and the humanities.

There is some good news. Most academic disciplines have evolved significantly since the Aswan High Dam was planned and completed, and the pace of large dam construction has slowed since the 1980s in large part due to efforts by activists and academics. (McCully xxviii.) But despite this hopeful trend, the reality is that large dams continue to be built to the detriment of people, ecosystems, and the sustainable futures of the nations that build them. In recent years, China has completed the Three Gorges Dam while Brazil and India have continued planning the Belo Monte dam and the Narmada Dam Project respectively. These projects, all massive in scale, will exert deleterious effects on the people and ecosystems of China, Brazil, and India alike. They will transform the geography of the river basins in which they are situated, displace millions of people, and cause untold consequences for decades, if not centuries. While there are strong local resistance movements fighting the construction of these dams, their efforts are not as strong as the political and economic power held by planners, government officials, and corporations. These actors, viewing dams as technological objects rather than "things," are making powerful decisions that cannot be reversed

The case of the Aswan High Dam reveals what can happen when a nation attempts to "engineer" modernity through hydraulic engineering. While determining the most effective way to achieve post-colonial development is far beyond the scope of this thesis, it is clear that using large dams to spur this sort of development comes with severe social and environmental costs. While these costs can be written off in the short-term as necessary for the creation of growth and quality of life, they have a way of growing over time to become permanent, intractable problems. Decisions to build large dams cannot be taken lightly, for the legacies of these decisions are significantly longer than the lives of those who make them. While political atmospheres change, large dams are constants. They demand continual management, and their negative impacts persist indefinitely.

As we move forward into a new century that is projected to bring severe water scarcity, increased resource consumption, and rising global temperatures, the necessity of managing our water resources wisely continues to grow. But as things currently stand, we cannot expect governments or corporations—the two biggest players in dam building—to abandon large dams or to create responsible, sustainable water management strategies. Studying the impact of large dams and spreading awareness of their dangers will fall in part on academics: on scientists, social scientists, and humanists with the courage to speak truth to power and the smarts to do so effectively. Their critical inquiry will in turn depend on the safeguarding of academic freedom in the university, which is itself threatened by some of the same state and corporate factions invested in the continued construction of large dams. The future of earth's water resources is in no small way the future of human prosperity, and it is in the hands of the world's academics, engineers, and policymakers to achieve a sustainable balance between the needs of our bodies and societies and the health of earth's rivers and ecosystems.

Before dams were ever constructed, rivers constantly changed paths: they were dynamic, continually evolving systems defined by transformation and flux. Like rivers, our societies and practices change course over time. Our political, economic, and social systems evolve and take on new shapes; indeed, the history of human civilization is one of constant adaptation and reorganization. But unlike rivers, whose transformations are governed purely by physical laws, we enjoy some degree of choice over the direction in which our human systems evolve. We can change our day-to-day habits, our natural resource management strategies, and our relationship to the landscapes that surround us. We can create more sustainable relationships between social practices and earth systems, and with sufficient political will we can do so rapidly. Knowing that we have these choices imbues our actions with a profound ethical dimension, for it is entirely within our power to create a more sustainable world. Whether we will choose to do so remains uncertain, but what is clear is that that such a transformation will require a transnational, cross-cultural, species-wide effort. I hope that with this thesis I have made my own small contribution to this effort, and I look forward to contributing more in the future.

M.E.C.

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