Water Soft-path Application in Industrial Systems: A Pulp and Paper Case Study

by
Elizabeth Hendriks

A thesis
presented to the University of Waterloo
in fulfilment of the
thesis requirement for the degree of
Master of Environmental Studies
in
Environment and Resource Studies

Waterloo, Ontario, Canada, 2007

Authors Declaration for electronic submission of a thesis

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ABSTRACT

Freshwater availability, allocation and quality are increasingly becoming a concern in Canada. Canada's apparent availability of abundant freshwater is not what it was thought to be. With increasing competition for water sources and inadequate management systems water use and management approaches are being re-examined. While urban and municipal water uses are highly studied, Canadian industrial water use is not. Despite that industrial water use is understudied, the Canadian pulp and paper industry is a major user of water and contributes to quality water issues where mills are located. This thesis is divided into two equally important parts. First, this research seeks to understand the influences and prevailing conditions on the decision-making framework of pulp and paper mills. Second, it seeks to understand how the prevailing conditions affect the applicability of the water soft-path concept in the pulp and paper industry. It will contribute to the literature of Canadian industrial water management.

This research specifically examines the applicability of the water soft-path concept under the stresses and realities of the systems of influence identified as market forces, policy and regulation, and technology faced by the Canadian pulp and paper industry. Corporate culture was an implicitly common thread that ran through these systems of influence. A variety of methods were used in this study including, a literature review conducted by themes, surveys, interviews, analysis of archival data and backcasting were used as the methodological approaches. The literature review was conducted by themes of water management, technology, market forces, regulation and corporate culture. Surveys were conducted to gain water use data from specific mills but a low response rate required a widening of the research boundaries. Interviews were conducted with government officials, industry representatives, and environmental non-governmental organizations. The interviews contributed to the boundary setting and understanding of the influences that impact decision-making for industry. The analysis of archival data was to better understand how water use in pulp and paper mills has changed through the years. Understandably the systems of influence (market forces, policy and regulation, and

technology) work independently and together to create a complex environment in which decisions on water use in pulp and paper mills are made. The complexity of the decision-making framework is great and the barriers to water soft-path application difficult.

Market forces are less capable of addressing environmental externalities such as water. Regulation and policy has yet to address water use in industry. Technology does provide an important opportunity for efficient water use and application of the pulp and paper industry. Ultimately, the Canadian pulp and paper industry is in a redefining moment where opportunity exists to create a new direction and approach to water use in the Canadian pulp and paper industry.

ACKNOWLEDGEMENTS

I have many wonderful people to thank for guiding me through this thesis process. I would like to thank Dr. Paul Kay for his genuine insight, support, and supervision throughout the course of this research. I would also like to thank Dr. Sarah Wolfe and Dr. Jennifer Lynes for their incredible patience, editing capabilities, and invaluable mentorship support. When I could not see the forest for the trees or the trees for the forest they showed me a clearing. I would like to thank my parents, David and Barbara Hendriks for the years of support, countless phone calls and technical support. Thank you for encouraging in me, free thought and determination. I would like to thank Patrick Mayne for supporting and loving me in all my endeavours. The community of friends that I have developed at Waterloo have been the dynamic support needed throughout the research process and I will cherish them for years to come. Finally, I would like to thank the Environment and Resource Studies Department at the University of Waterloo and the Walter and Duncan Gordon Foundation. Without the extremely generous financial support I would have completed this research with a waif like figure.

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CHAPTER I: INTRODUCTION

Doing business in today's world is becoming increasingly complex where environmental, social and economic drivers are at the forefront of challenges. Problems, such as environmental issues, can no longer be understood in isolation from the social and economic realms. While the problems are multifaceted, so are the solutions. For example, alternative solutions for water use challenges in the context of industrial operations must be understood within the wider decision-making framework of the business. It is vital to understand the greater influences on industry to understand the complex nature of the applicability of solutions.

1.1 RATIONALE

Concerns about freshwater availability are growing both globally and within Canada. Although it has been a long-held belief that Canada has an overabundance of freshwater, many are now realizing that the availability is not as plentiful as it may have seemed. Climatic variability, population pressures, contamination of aquifers and water distribution relative to those population pressures are various indicators that there are increasing pressure and competition for water resources. While 84 percent of the Canadian population lives along the southern border, 60 percent of water supply flows north to the Arctic Circle (Environment Canada (EC), 1998, 5). This "geographic mismatch" is compounding the allocation challenges (Brandes et al., 2007, 282). As well, industrial and municipal pollution pressures are threatening water quality, which has been increasing the awareness of water management and water policy issues.

In Canada, several factors indicate growing stress on water resources. There are growing clusters of high population density, especially in the lower Great Lakes region, which are also sites of increasing demand for high quality fresh water for municipal-residential needs. Approximately 82% of Ontario's population receives its drinking water from municipal water works and 66% of that population depends on the Great Lakes basin for drinking water (Conservation Council of Ontario (CCO), 2006). Across Canada, water retention in soil is reduced due to urban sprawl or agricultural drainage. Natural fluctuations in water levels and long-term changes in precipitation resulting from climate change have affected water availability in the Great Lakes Basin (CCO, 2006). Too much water withdrawn from watersheds is affecting ecosystems and biodiversity of aquatic ecosystems. It also can also impact drinking water quality because less water returned to the environment decreases dilution capabilities in rivers and lakes (Canadian Environmental Law Association, 2004). Yet, over-consumption continues, through residential, industrial, agricultural and commercial uses. If Canada's water sources continue to be used at current rates it is evident that growing stress on water resources will continue. Water use in all sectors of Canadian society need to be re-examined to ensure the most effective strategies are adopted for long term water sustainability.

Industry, agriculture and municipalities are increasingly competing for supplies, and the need to consider matching water quality to end use requirements is growing. This research specifically focuses on the pulp and paper industry for several reasons. There is a major gap in academic knowledge of Canadian industrial water use. There is a lack of understanding of self-supplied users. There are few data reported on water use in the pulp and paper industry and little government action to govern water use for industrial users.

Also, there are environmental concerns specific to the Canadian pulp and paper mills. According to Christie and McEachern (2000, 3) Canadian pulp and paper mills are the largest water users and create the most water pollution among all industries within Canada. Mills across the country are situated on rivers or lakes that are important to the watershed and therefore impact downstream uses. In certain provinces, such as Ontario and Quebec, some mills are located in more highly populated watershed areas and are in a unique socio-economic position as population pressures and competition for scarce water resources increase. Mills that are located in northern areas may not be facing increasing competition but they are still largely responsible for the same environmental degradation.

Pulp and paper mills are often located in areas identified as "Areas of Concern" by the Great Lakes Information Network (GLIN, 2006). According to Natural Resources Canada (NRCan) (2005), there are three major environmental issues associated with the discharge from pulp and paper mills: regulatory toxicity compliance; potential effects on fish reproduction; and correct regulatory environmental monitoring. As Christie and McEachern (2000, 17) explained, "Water pollution can severely hurt local economies. When water quality is degraded by pulp mill effluent, communities suffer lower ecological productivity and the loss of recreational opportunities". Mill effluent continues to be a major threat to aquatic ecosystems in all of Canada. It is evident these industries have much to gain from a paradigm shift in water management to practices with less impact.

In light of allocation concerns and industry impacts, water management paradigms and alternative drivers to efficient water use need to be examined in the pulp and paper industry. Gleick (2000) and the Rocky Mountain Institute (RMI, 2005) identify that traditional management approach to water, i.e. supply-side management, has been very beneficial to humankind. Large water infrastructure and intricate planning have allowed for greater human development and less waterborne disease (Baumann et al., 1998: Grigg, 1996). Large infrastructure in industry has allowed for greater production to meet a growing demand for paper products. There are four major characteristics of supply-side management:

1. Building more infrastructures to meet growing demand.
2. Demand focuses on providing quantity of water, and not necessarily a specific quality of water. This demand approach leads to high quality drinking water provided for all functions.
3. There is the assumption that water is used only one time (for example, in an industrial system, water is sent through the system once and released back into the environment rather than being recycled).
4. Lastly, the larger the infrastructure, the better it has been able to supply water vast quantities of water (RMI, 2005).

In the pulp and paper industry, where process water, is vital water supply has been an incredible achievement.

Despite the social and economical advances allowed by supply-side management, the increasing cost of such infrastructure, the environmental damage, and political and economic uncertainty are decreasing the feasibility of such water management approaches. In the pulp and paper industry the energy costs of supplying vast amounts of water are increasing economical burdens to the detriment of the industry.

In contrast, demand-side water management (DSM) focuses on reducing demand for water as opposed to supplying more. Curran and Leung (2000, 18) stated that DSM is “reducing the demand for a service or resource, rather than automatically supplying more of the service or resource being sought”. Brooks (2004b, 9) stated it is “greater efficiency in use together with some reallocation among uses”. The important themes found in DSM are reduction and efficiency, with a focus on decreasing the demand with efficient technologies. It uses tools such as policy revision, regulations, consumer education, market tools and efficient technology. The objective of demand-side management is to reduce total demand for water (Brooks, 2004b; Gleick, 1998). Rather than the building of more large infrastructures (e.g. dams), DSM seeks to reduce water use through technical efficiencies or behavioural changes.

Complementary to demand-side management is the emerging concept of soft-paths. The soft-path concept emerged from work in energy (Lovins, 1977), and evolved more recently to work in water (Gleick, 2000; Brooks, 2004a). The soft-path goes beyond just water efficiency to challenging water use demand patterns. The water soft-path concept seeks to understand not just the provision of the resource but the service it provides (Brooks, 2005: Brandes and Brooks, 2005). Other key elements to the soft-path concept are: the shift of focus from water quantity per se to the services performed by water; the matching of quality to end-use service; the inclusions of ecosystem need; conservation of quality and quantity; and the use of the methodology of backcasting (Brooks, 2005; Brandes and Brooks, 2005). Backcasting creates a future goal and requires managers to work back from the goal to develop a management system that will achieve it.

It is important to stress that water use, in industry, in and of itself is not the problem. Water use becomes a concern coupled with high consumption where water is not returned to the ecosystem or is returned in a degraded state. High water use also requires more energy to be allocated to treatment. High water use with over consumption aggravates allocation issues, quality concern, ecosystem requirements, and possible impacts of climate change. The aggravating factors are underlining a drive to better understand water use in the pulp and paper industry.

1.2 PURPOSE STATEMENT AND RESEARCH QUESTION

The purpose of this study is two fold. First, this research aims to understand the systems of influence within which the Canadian pulp and paper industry works and how these impact the decision-making framework. Secondly, the thesis explores how the decision-making framework, in the context of water management, forms barriers and opportunities to the applicability of a new water management approach – the water soft-path concept.

The focus on pulp and paper mills addresses a void in knowledge of industrial water use. Of industrial users, pulp and paper mills have the highest process water usage to total water use ratio (Boardley and Kinkhead, 2006). Process water is the water used in the industrial system rather than the water used for activities such as cleaning and drinking. Canada has been, and continues to be, very economically dependent on forest resources and products. The pulp and paper industry contributed three percent to the GDP in 2006 (according to the Forest Products Association of Canada (FPAC), 2006). The forest products industry continues to play a critical role in the Canadian economy ranking ahead of oil and the automotive industry in contribution to the GDP (FPAC, 2007). If the industry is to continue to play a large role in GDP contribution, in the face of water challenges and environmental uncertainty, approaches to sustainable operations need to be explored.

In a discussion of corporate environmental commitment Lynes (2004, 45) describes "systems of influence" as dimensions that influence decision-making of environmental management. In this thesis, three systems of influence were explored to understand what barriers and opportunities for water management shifts exist in the pulp and paper industry. Renn (2001) uses four broad systems of influence political, economic, science, and social. In this research, the systems of influence—market forces, regulation and policy, technology—are pared down. The systems of influence work both independently and together to create a complex environment within which decision-making for water management is situated. These systems of influence have been examined to understand the applicability of the water soft-path approach concept in the pulp and paper industry. Threaded throughout these three systems of influence is a social influence identified as corporate culture that shapes the interactions of the systems of influence.

The following two research questions form the basis of this research:

1. What are the prevailing conditions in market forces, policy and regulation, and technology that influence the Canadian pulp and paper industry decision-making framework?
2. What are the barriers to, and opportunities for, introducing a soft-path approach to water management in pulp and paper mills?

The research is presented in two research questions but research question one is needed to understand and answer research question two.

1.3 OUTLINE

The remainder of this introduction outlines the thesis.

Chapter II reviews the literature of both research questions. The first part of the literature reviews the systems of influences as the prevailing conditions in the Canadian pulp and paper industry decision-making framework. The second part of the literature review introduces the major components to the second research questions. Water management, including supply-side, demand-side, and soft-path concepts provides the context for the case study. The last section in the literature review focuses on the case study, the pulp and paper industry and the relevant pulping methods used. Chapter II ends with a conceptual framework that places the research within a broader academic context.

Chapter III provides the methodological framework. The framework is an explanation of how and why this research has been carried out. It includes an explanation of the research design, tools and research outcomes. As well, the scope and challenges of the research are included in this chapter.

Chapter IV provides the analysis of the system market forces as a prevailing condition and a major system of influence in the decision-making framework. The chapter addresses the current fluctuating economic situation faced by the pulp and paper industry and the barriers faced by decision makers. The chapter addresses, in an economically uncertain industry, how to use economic tools to provide incentive for the water conservation strategies as opportunities for promoting a development path. Given the uncertainty of the boom and bust economy and the under-pricing of water in, economic tools such as pricing are proposed as a method to motivate behavioural change. The pricing structure that is proposed compensates for ecological values.

Chapter V: The regulation and policy system is very much connected to the market forces as a system of influence in the pulp and paper decision-making framework. An analytical framework is used to compare the current status quo with more desirable regulation and policy. The gap between policy and action identifies the barriers and opportunities to conservation strategies.

Chapter VI discusses the technology barriers and opportunities involved in the pulp and paper process, and improvements and efficiencies that have already been accomplished. There is an analysis of water use and consumption per tonne of product. The data are used to understand recent trends in water use and consumption. These trends are compared to best available technologies and water savings with best available technology. These trends allow a clearer understanding of conditions faced by decision makers in the pulp and paper industry.

Chapter VII draws together the major themes from chapters III – VI. This chapter addresses the findings in the three systems, major themes, further research recommendations and conclusions.

CHAPTER II: LITERATURE REVIEW

This chapter explains both the literature relevant to this research as well as the conceptual framework of the research. The following literature review provides the background knowledge to both research questions. A literature review of the systems of influence to set the context for research question one. The literature review to set the context for research question to discusses water management paradigms. The water management paradigms are explained in a consecutive manner from supply-side management to demand-side management and finally the water soft-path concept. The conceptual framework places the research in the broader context of the literature. The conceptual framework provides a visual explanation of where the research fits into the water management literature.

2.1 SYSTEMS OF INFLUENCE

"Systems of influence", a term adopted from Lynes (2004), are external factors that influence decision-making in an organization. Renn (2001), in reference to policy making, identified four subsystems that influence decision-making in public policy. These subsystems are political, market, science and social (Renn, 2001, 428). The political subsystem refers to policy, regulation and bureaucracy. Decisions in industry are to a certain extent based on institutionalised procedures within a political culture. The market subsystem includes monetary incentives and rewards. Decisions in the economic subsystem are based on cost-benefit balance. The social subsystem refers to interactions between groups. Decisions are based on an exchange of interests and values of the actors involved. These subsystems all have structural characteristics that impact operations.

Renn (2001) also noted that rarely are problems limited to one subsystem. These subsystems create the complex environment in which these systems impact decision-making frameworks.

These subsystems are closely aligned to the systems of influence uncovered in this research during the literature review and interviews. The political subsystem was narrowed to regulatory and policy. Science is specific to technology and the economic subsystem is narrowed down to market forces. The social subsystem Renn (2001) discussed is implicit in corporate culture, which underlies all the systems of influence as the common thread throughout them all. No priority sequence is suggested, because all systems play a significant role and impact the other systems in the decision-making framework of the pulp and paper industry. The market forces, regulatory and policy, and technology systems worked in conjunction with each other to provide the environment in which decisions are made in the pulp and paper industry.

Corporate culture is a system of influence that underlies all the systems. It is formed by the "values, attitudes, perceptions, politics, educational background, and personalities of employers and employees, which determine that organization's behaviour and reaction to stress or to opportunities" (Thompson, 2002, 16). Corporate culture explains the way in which "things are done" in an organization. Both corporate culture and the cultural context in which an organization can operates as key indicators of the success of the uptake of new ideas and operation standards (Thompson, 2002). Corporate culture as a system of influence is important to this research because it is the underlying influence that determines the uptake of the soft-path concept and influences the interactions between all systems of influence.

The literature of the systems of influence as they apply to the case study of the pulp and paper industry in Canada are described below. The systems of influences are the overriding powers that dictate development paths for pulp and paper mills across the country. The literature review of market forces, and policy and regulation focus on the external enironment because they are broader systems of influence. The technology literature review focuses directly on the pulp and paper industry because it provides the context of the case study and involves a narrow range of technology.

2.2 MARKET FORCES

Market forces, as a system of influence, is the economic environment in which a business makes decisions. The analysis of market forces for the Canadian pulp and paper industry was adopted from a situation analysis that describes the prevailing conditions of the industry. A situation analysis is an analysis of the current market forces, the business's competitive position and its current performances (Best, 2000). A situation analysis includes the market demand, competitor analysis, customer analysis, performance metrics and competitive position. In this research, market demand and competitive position comprise the market forces of the pulp and paper industry. Market demand and competitive position best describe the prevailing conditions of the Canadian industry and impact the decision-making framework of pulp and paper mills.

2.2.1 Market Demand

Market demand dictates the size and growth of an industry. Decisions about forest resources and use are made in the context of national and global market forces. The forest industry of Canada is part of a boom and bust economy that many natural resource sectors face. Boom and bust economies are markets of products that move in a cyclical manner. Porter (1980, 239) contends that "as maturing industry adjusts to slower growth, the rate of capacity addition in the industry must slow down as well or overcapacity will occur." Older companies are slow to shift and "overshooting of industry capacity relative to demand is common. Overshooting leads to a period of overcapacity, accentuating the tendency during transition toward price warfare" (Porter, 1980, 239) Boom and busts are increasingly linked to global market demands and fluctuations. The threat of a global economy makes it increasingly difficult to adopt full cost accounting in industrial production and inclusion of environmental costs.

2.2.2 Competitive Position

Competitive position of an industry includes the market share a company has within an industry sector. The competitive position is determined by factors such as price/quality and cost/value of a the product. Currently, the Canadian pulp and paper industry is facing what some are calling "The Perfect Storm" (FPAC, 2006a, 4; CBC, 2007). Major trends combined are having a disastrous effect on the industry. The wave of mill closures from 2003 and increasing into 2006 have been the result of a strong Canadian dollar, low-cost competition, and high fibre costs (FPAC, 2006a). Canadian operations are making a great effort to stay competitive with global competitors despite strong productivity performance (FPAC, 2006a). Low-cost competition from Asia and Latin America is a result of low-cost fibre and labour. High fibre costs are a result of restrictions to fibre and forest policy increasing the costs of Canadian fibre (FPAC, 2006a). These trends are pushing the industry into a major renewal and reconstruction period.

2.2.3 Economic Instruments

The prevailing conditions of market forces provide a long list of barriers to the application of water management innovation. Morrison and Gleick (2004, 1), water experts from the Pacific Institute, provided an excellent summary of the unique difficulties facing corporations:

> Corporations and institutional investors face their own specific challenges relating to water. In some cases, these problems will lead to decreases in water allotments, more stringent water quality regulations, growing community activism, and increased public scrutiny of water-related corporate activities. All of these factors may impact site selection, license to operate, productivity, costs, revenues, and ultimately, profits and corporate viability. Water-related risks now pose a potential multi-billion dollar threat to a wide variety of businesses and investors.

Historically, Canada has been quick to use a control and command method towards industries like the pulp and paper industry (Wilson, 1981; Doern and Conway, 1994). Subsidies for infrastructure such as roads and energy are the main form of economic instruments used. Although, there is a wide variety of economic instruments that can be used to motivate a change in behaviour of industry. In Canada, a considerable barrier to conservation programs in industry is the lack of pricing for water use and framework for self-supplied users. An opportunity that can be used as an alternative to the current pricing structure is full-cost accounting. Full cost accounting includes assigning a dollar values to both positive and negative externalities. Negative externalities as defined by Hackett (1998, 312) are, "uncompensated costs borne by others in society as a consequence of a buyer/seller transaction". The pulp and paper industry creates an external cost by discharging polluted effluent as well as withdrawing water from the ecosystem.

To address externalities, economists use the concept of Pigouvian tax. This tax addresses external costs such as natural capital. The tax is used as a method of internalizing the price of natural capital and reimbursing society (Hackett, 1998). There are impacts of this tax. In theory, the increased cost of a product leads to fewer products being produced and sold at higher prices; but profit-maximizing firms then have incentive to find alternative production methods. There is also the benefit of tax revenue (Hackett, 1998; Baumol and Oates, 1975). This tax revenue can be beneficial for government's burden in infrastructure building and maintenance and remedial projects. The theory is that if cost of externality is significant, private enterprise will find it profitable to eliminate it (Baumol and Oates, 1975). Water pricing would be a form of this tax.

There are arguments against the Pigouvian tax to correct externalities. Shrogren (2007, 235) argues that, "correcting one failure in the presence of many failures does not guarantee an increase in economic welfare". While taxing the use of natural capital may not increase economic welfare but it does address environmental welfare. Pricing externalities is a step in bridging the two imperatives of economics and environment.

To bridge market forces and environmental needs, it has long been argued to utilize market approaches to complement regulation (Doern, 1990; Renzetti and Dupont, 1999). Doern (1990, 2) argued that regulation and market approaches are the "essential environmental partnership of the 1990's". It is now 2007 and that partnership has yet to come to fruition with respect to water use.

There are three main arguments identified by the business sector against the tax. First, another tax could be seen as a tax grab by government. Secondly, business does not want to pay more than others for polluting. Finally, in a global economy, there may be a sense of injustice as competitors continue to pay nothing for the same polluting activities (Doern, 1990). These arguments are being over-ridden as more and more business turn a profit with environmental good work practices.

2.3 REGULATION AND POLICY

Regulation and policy are strategies used by the government to manage people or business activities. At the root of environmental policy is what Doern and Conway (1994) call the "double dynamic". These environmental strategies are needed for managing a healthy society but there are two competing dynamics. First, there is a struggle between stakeholders over what can be and should be done to deal with environmental problems and policy. And secondly, the biophysical realm is constantly changing, is unpredictable and yet vital for human survival. It is in this difficult "double dynamic" that decision makers must form effective regulation and policy.

The following is a theoretical background on the governing strategies of policy and regulation in Canadian water policy. Governments use a broad range of strategies to organize sectors of society. Strategies can include public policy, regulations, or both that are implemented to provide leadership or direct actions to other sectors of societies, in this case, industry. According to Brooks (2004a, 16) public policy is, "the broad framework of ideas and values within which decisions are taken and action, or inaction, is pursued by governments in relation to some issue or problem". Strategies that are regulatory act as the tool to implement the ideas and values of a public policy. Regulations governing the discharge from pulp mills implemented at the federal level and permit-to-take-water programs implemented at the provincial level were examples of regulations meant to enhance water and environmental policies in the Canadian context.

Environmental and economic policies in the present political-economic system show conflicting priorities in different policy fields. In environmental policy, the priority is to protect the environment using regulation and guidelines to set the agenda. In economic policy, priority is to govern and protect business operation using economic instruments such as tax incentives and subsidies. Conflicting federal and provincial initiatives, such as tax incentives versus subsidies and the Pulp and Paper Effluent Regulations, appeared inevitable. The result of these competing interests is an inadequacy to deal with the environmental, economic and social consequences of failed government strategies (Boyd, 2003; Brooks, 1989). It is important to understand the underpinning framework of these differences.

Competing interests of industry and environmental public policy fields are, in part, a result of the division of power between the federal government and provincial governments. The division of power defines how government strategies are designed and implemented. In the case of water, the division of responsibility and the resulting strategies are complicated for two reasons. First, the very nature of water is that it flows along geographical features and not necessarily along political lines. Second, water plays a vital role in all aspects of economic, environmental, and social development (EC, 2004a).

The Constitution Act (1867) set the division of power concerning water between the federal and provincial governments. Navigation and shipping, sea coast and inland fisheries, and trans-boundary waters were federal responsibility, and water as a natural resource was provincial responsibility. This division continues to cause conflict in implementation of legislation and policy due to the very nature of water as a cross-cutting theme in many activities (Hughes, 1998). Federal jurisdiction is meant to act as a guide and to complement the provincial jurisdiction. This framework of federal-provincial division of power in theory ensured that all aspects of water were under the responsibility of one or another level of government. The division of power was important for two reasons: it provided accountability; and it reduced redundancy in the bureaucracy of governing water resources.

The Constitution Act was crafted during a period of resource abundance. As population in Canada grew and water increasingly became a concern, difficulties in jurisdictional division and power emerged. Water, at the provincial and municipal level, is also managed by self-supplied users or municipal users. Ninety per cent of industrial users are self supplied and in the absence of a policy or regulatory framework to address self-supplied water users there is an unmeasured area of water use (Policy Research Initiative (PRI), 2006a). The lack of framework for self-supplied users makes regulatory and policy analysis challenging in that it does not fall in the historical realm of Canadian policy approach.

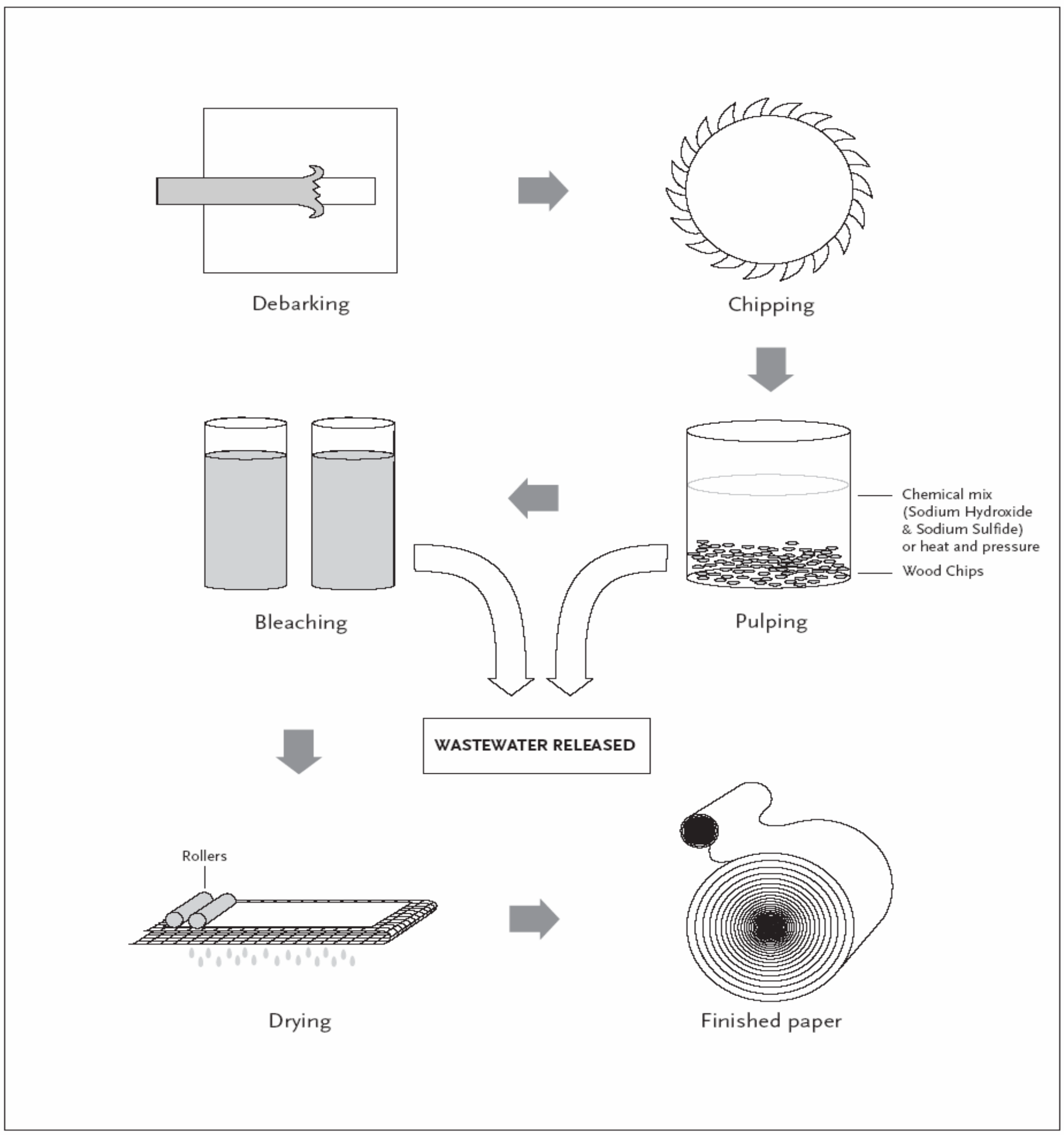
2.4 TECHNOLOGY

The pulp process can be divided into three general categories: mechanical, chemical, and thermo-mechanical (or chemical-mechanical) (Christie and McEachern, 2000). Historically pulp and paper mills were found on large bodies of water because the industry process requires large quantities of water. The focus on water-efficient technologies and water use reduction comes from a variety of factors. Water use in industry, specifically in Europe and North America, was highlighted in the public's attention because of serious effluent issues in the 1980s with increasing awareness brought on by the environmental movement. This awareness became a strong impetus to move towards more environmentally efficient technologies (Browne et al., 2001; Sonnenfield, 2002). As the public’s attention grew regarding water quality, so too, did the emphasis on elimination of liquid effluent, water use and dependency on large bodies of water (Browne et al., 2001). The basic pulp and paper process is explained in the following section.

2.4.1 The Pulp and Paper Process

The process of turning trees into paper is conceptually fairly simple (Figure 2.1). Logs are debarked and chipped. By various pulping process the wood chops are mixed with solution, pressurized or placed under extreme heat until the wood is reduced to pulp, which is then bleached and rinsed several times. The bleaching process differs depending on the pulping method used. Finally, the pulp is pressed and made into paper.

Figure 2.1: Schematic illustration of the pulp and paper industry



Christie and McEachern (2002).

All pulp and paper processes start with the same resource—wood—and serve the same purpose—to separate the different fibres in the wood. Paper production uses both hard and soft woods. Softwood fibres provide strength, to paper while hardwood fibres provide smooth and opaque surfaces. Hardwood fibres, because they have less lignin, are easier to bleach and therefore have higher quality brightness (Blum, 1996). Lignin is the glue-like substance that holds the cellulose together in a tree and increases the rigidity. Cellulose is the long, strong fibres that form the skeleton of the plant wall and is the ideal substance for paper making (Blum, 1996).

Wood and chip preparation involves transportation to site, debarking and chipping. Water use in this initial wood preparation is very mill-specific and related to mill processes, climatic conditions, and availability of freshwater or suitable waste water (Strattow and Gleadow, 2001). According to Strattow and Gleadow (2001) and the North American Industrial Classification System (NAICS, 2003) water is used for log transport from storage to wood room, thawing, washing, debarking, debris collection, and cleaning.

From the chipping process the wood is then transported to the pulping process. Three major methods are used for pulping chemical, pulping and thermo-mechanical. With contrasting water use, energy use, yield, and quality of yield (Table 2.1).

Table 2.1: Pulping Processes

	Mechanical	Chemical	Thermo-mechanical
Water Use	low water use	high water use	medium water use
Energy Use	highest energy use	low energy use	medium energy use
Yield	high yield	low yield (more organic waste)	medium yield
Quality of Yield	high quality	high quality	Higher quality

Adapted from Christie and McEachern, 2006; Boardley and Kinkhead, 2006.

It is important to note that the contrast in Table 2.1 can be misleading without a better understanding of the role that energy prices and quality of yield have on determining the suitability of a pulping process. Mechanical pulping, despite the high yield and low water use, is not the preferred pulping process. Due to high and increasing energy prices, it is the least profitable pulping technique. In Canada, thermo-mechanical is the dominant technique because it provides an economically satisfying balance between input and output (Boardley and Kinkhead, 2006).

Process water for all three pulping mills is an important aspect of quality control. The water used in the pulping process must be of a certain quality depending on the paper product being produced. Water can be recycled but also requires purifying (Brown et al., 2001).

2.4.2 Mechanical Pulping

Mechanical pulping uses machines and heat to break down the lignin and free the cellulose for paper making. Wood is pressed against grinders, at high temperatures, and the lignin and the cellulose are physically separated (Christie and McEachern, 2000; Environmental Protection Agency (EPA), 1997). Of the pulping processes, mechanical pulping uses much more energy (1 900 – 2 900 kilowatt hours of energy/tonne of pulp), but less chemicals and water (Christie and McEachern, 2000, 9), than other processes. Mechanical pulping produces a lower quality pulp because it is not as effective in removing the lignin. Due to the higher content of lignin the final paper product yellows when exposed to light (EPA, 1997). Unlike chemical pulping, mechanical pulping does not require the same chemical intensity. Mechanical pulping does produce great yields; the weight of the pulp is 90 – 98 % of the weight of wood chips (Christie and McEachern, 2000).

2.4.3 Thermo-mechanical pulping

Thermo-mechanical pulping is the process in which both mechanical heat and chemicals are used to break down lignin. The wood is debarked, chipped and cleaned of any contaminants (metal) and sent to the thermo-mechanical refiners. The refiner process produces both heat (steam) and pulp. The process, simplified, is that the pulp enters the refinery and is pushed between two disks. While one disk lies stationary the other spins at 3 200 RPM. Plates on the disks grind the wood fibres creating intense friction and boil the water instantaneously (Irving, 2004). Heat from the friction of the disks cause the wood chips to explode. The product is then sent on and the steam created from the process is sent to a cyclone machine. This cyclone machine separates the remaining fibres from the steam. The steam is recycled and the pulp carries on to a screening process. Fibres still too large are separated out and refined again (Irving, 2004). It produces less yield to mechanical pulping but more yield to chemical pulping.

2.4.5 Chemical Pulping

Chemical pulping, as the term suggests, uses chemical processes to recover the cellulose. There is a wide range of chemical processes and chemicals that can be used. Kraft mills are the most common chemical pulping mill. In chemical pulping the wood or chips are ‘cooked’ in a digester, which contains a solution of chemicals that dissolve the lignin, leaving behind the cellulose (Christie and McEachern, 2000; EPA, 1997). It does produce a lower yield (40 -50% by weight) compared to mechanical pulping, but produces a stronger pulp (Christie and McEachern, 2000 9). While chemical use is high in both the pulping and bleaching process and water use overall is much higher, energy requirements are significantly lower, currently making it much more economically viable (Christie and McEachern, 2000).

2.4.5 Washing, Bleaching and Paper Making

From the pulping processes, just described, the pulp is sent through a washing process, the bleaching process, and finally the paper making process. The washing process is a series of washers and screens that the pulp moves through. This step also acts as a product control where excess liquid including water, chemicals and lignin are separated and sent back through a recovery process (EPA, 1997).

All pulp, regardless of the process, is sent through a bleaching process. As discussed previously, the process is dependent on the quality of pulp produced. There are several types of bleaching process. Elemental chlorine bleaching is the most common, but elemental chlorine free bleaching and totally chlorine free bleaching processes are also used. They have a less detrimental effect on the local ecosystem as discharge effluent. Elemental chlorine bleaching (ECB), one of the more common bleaching processes, uses chlorine and hypochlorite to turn pulp a bright white. This process generates chlorinated pollutants such as chloroform, dioxins and furans. These pollutants are discharged into the wastewater stream. Elemental chlorine free bleaching (ECF) replaces chlorine with chlorine dioxide as the bleaching agent and removes hypochlorite from the system. The ECF process reduces the amount of chlorinated pollutants in the wastewater stream but does not remove it completely. Finally, totally chlorine free (TCF) uses no chlorinated bleaching agents in bleaching process for pulp. TCF uses oxygen and peroxide, eliminating chlorinated pollutants in the wastewater stream (EPA, 1997)

The final stage from pulp to paper is the paper-making stage. The pulp is poured onto large rollers and any remaining and excess liquid is pressed from the pulp. In this stage there can be a range of product water. Product water is the water incorporated into the product and not returned to the environment (true consumption). For example, in commercial printing paper there is 9% water content (Environmental Manager of Canadian Mill, June, 2006)

2.5 WATER MANAGEMENT PARADIGMS

2.5.1 Supply-side Management

As noted in Chapter I, the need for an alternative water management method is situated within the larger global water crisis. Water is essential to human survival. Postel (2002) argues that the combination of rising water demand and ecosystem alteration has depleted supplies. Water does not obey national borders and variations in water availability happen naturally but are also intensified by human activities (Hunt, 2004). Water stress and scarcity around the world are increasingly prevalent and are aggravated by natural and social allocation systems (Hunt 2004). Hawkin et al. (1999) warned that humans are increasingly becoming dependant on scarce water supplies.

The increasing water crisis around the world has driven the need for sustainable water use. Gleick (2000, 131) defined sustainable water use as "the use of water that supports the ability of human society to endure and flourish into the indefinite future without undermining the integrity of the hydrological cycle or the ecological systems". Sustainable water use provides an overarching goal in which to organize our management systems.

Water resources management as defined by Grigg (1996, 14) is the "application of structural and non-structural measures to control natural and man-made water resources systems for beneficial human and environmental purposes". The increasing environmental concern over current water projects, the high economic cost and political uncertainty are creating a change in the philosophy of water management. Gleick (2000) identified three current drivers of water management that are undercurrents to the water crisis: population growth, changing standards of living, and the continuing expansion of irrigated agriculture. Brooks (2005) identified two more drivers, the importance of ecological in-situ services (fishing, recreation and transportation), and impacts from climate change.

Traditionally, water resource management relied on supply-side approaches characterized by the use of large, centralized infrastructure (RMI, 2005). There is a major reliance on large infrastructure such as the purification plant, major piping systems, and a highly industrialized sewage treatment plant. The Rocky Mountain Institute (RMI 2005) described four major characteristics of traditional water management: build to demand; demand as a matter of quantity; one-use; and bigger is better. Build to demand means that as demand increases so too does the capacity to provide. Demand as a matter of quantity ensures that supplied water is of high quality and unconnected to the service and quantity needed for the end-use. The one-use (throughput) characteristic describes the linear systems approach. The linear approach means that water is used only once and returned rather than recycled or reused for other services such as rinsing or transportation. Lastly, the larger and more centralized the system the better. Traditionally, larger systems were the status quo development route but with increasing costs of infrastructure and the strain of budgets this is no longer the case.

Historically, the supply-side management approach has allowed for significant progress in human development. Over the past century as population expanded and water use increased so too did urban systems including water infrastructure (Baumann et al., 1998). Grigg (1996, 4) characterized water resource management as an “engineering task – build dams, lay pipelines, install pumps and operate systems”. The big infrastructure approach has been quite successful in aiding development and sanitation in today’s modern world, but its functionality and economic effectiveness are less than desirable (RMI, 2005; Gleick, 2000). The expansion of supply-side infrastructure had very pragmatic roots, but in the twenty-first century the focus is becoming much more political (Hunt, 2004). As previously discussed, traditional water management or supply-side management, while it has contributed to major human development, is increasingly becoming inadequate due to the expense of large infrastructure, political viability and water shortages.

To begin constructing a new approach it is important to deconstruct common misconceptions of water use and management. Baumann et al. (1998) details five misconceptions of water.

- One misconception is that while water is a necessity to life it is not a necessity to urban life. Water use, Baumann et al. (1998) argued, is not solely fixed to one's needs but also subjected to tastes, fashions or desires.
- The right measuring tool is important to understand water use properly. Per capita use as an indicator of water use is problematic as a measurement tool in that it excludes measurement of income, price, and industrial uses, inland growth, precipitation, and urban cluster patters.
- An entrenched misconnection is that users do not respond to water pricing.
- Misinformation points towards an over-watering of urban landscapes but it is in fact irrigation practices that continue to be the overwhelming large water user.
- Finally, the belief that water conservation will lead to negative fiscal impacts is a misconception causing barriers to conservation practices.

These misconceptions of water are not just ingrained in the supply-side approach but bureaucracies and inform environmental and economic policy formation

Supply-side management as an approach to water management systems continues to be inadequate in the face of water problems because it does not take into account availability, competition, environmental impacts, and costs (Brandes and Ferguson, 2003: Figuères, 2003). An important and often overlooked characteristic of supply-side is the expensive infrastructure for large-scale water development projects (Baumann et al., 1998). In the pulp and paper industry infrastructure is costly. Water conservation programs can assist industry in reducing dependency where the resource is scarce, reduce the capital cost of supply or effluent treatment facilities, or improve energy efficiency and reduce operating costs (Paprican, 2005).

2.5.2 Demand-Side Management

As previously discussed, there are growing barriers to supply-side management. In order to address these problems, attention is shifting towards promoting efficiency aimed at reducing short-term pressures for water supply and meeting future needs by essentially managing demand through conservation and increasing the ability to reallocate water among users (Brandes and Ferguson, 2003).

Curran and Leung (2000, 18) defined demand-side management (DSM) as, “reducing the demand for a service or resource rather than, automatically supplying more of the service or resource being sought”. Brooks (2004a, 3) explained demand management as “any measure that reduces average or peak withdrawals from surface or ground water sources without increasing the extent to which wastewater is degraded”. A third definition of demand management according to Brooks (2004b, 9) is, “greater efficiency in use together with some reallocation among uses”. All three definitions incorporate the important themes of reduction and efficiency with a focus on affecting the demand and not the supply of water. A water management system must reduce the overall quantity of water used and increase the efficiency of the water that is being used. It aims at providing more service for less water.

Gleick (2000, 131) included the following characterizations for DSM: meeting human needs for drinking water and sanitation services; meeting basic ecosystem needs; the use of non-structural alternatives to meet demands; applying economic principles more frequently; new supply systems that are flexible and efficient; multi-stakeholder decision-making process. Furthermore, there are two more important aspects to DSM increasing the productivity of water through improved efficiency (Gleick, 2000). First, improved efficiency of water maximizes the use of the water provided, i.e., more use per drop of water. Second, conservation behaviour decreases demand on water supply (Brooks, 2004a). By modifying consumer behaviour and increasing productivity, conceptual changes are made to reduce water need and not just physical adaptations to meet demand such as pipes and dams.

Demand-side management has a plethora of benefits not just to the urban dweller but to communities as whole, utilities, companies, the environment, and the economy (RMI, 2005). Demand-side management can provide benefits such as a healthier environment, strong economy and improved human health. These benefits can be attributed to the comprehensive approach of DSM (Brandes and Ferguson, 2004; RMI, 2005). Brandes and Ferguson (2004) provided a comprehensive list of additional benefits of demand management. The benefits are illustrated in Table 2.2 grouped into the three areas listed above – environment, economy and human health.

Table 2.2: Additional Benefits of Demand Management

Environment	• Improved ability to adapt to uncertainty such as climate change. Investment in DSM tends to be diversified and incremental and more flexible than supply-side option which tend to be diversified and incremental and more flexible.
Economy	• Lower energy use such as for household water heating and pumping • Reduced chemical use in treatment processes • Reduced need for energy water restrictions and associated inconvenience during periods of drought. • Reduced need for the large, up-front grants or loans required in many supply-side projects • Enhanced revenue generation from by-product recovery, such as reclaimed water reuse. • Increased industrial competitiveness the incentives in DSM to encourage more efficient water use can lead to lower business costs and evaluation of other efficiency improvements, thus increasing competitiveness. • Increased Economic Activity.
Human Health	• Improved demand forecasting, and reduced risks associated with demand uncertainty (drinking water availability) • Improved participatory approaches leading to better public stakeholder relationships than currently exist with centralized supply-side decision-making. • Greater incentives for accounting and monitoring and therefore better control over the throughput of water and waste water systems.

Adapted from: Brandes and Ferguson (2004)

Brandes and Ferguson (2004, 17) identify four misconceptions, which they call "entrenching factors" distinctive of DSM:

- There continues to be a misconception that reduction of water use can compromise one's standard of living.
- DSM requires a level of government regulation that in the ideals of a free market society is repulsive.

- For DSM to work there is a need for predictable and stable revenues and there is a sense that DSM is not as predictable.
- Finally, there is concern that DSM savings would be unreliable and/or supply insubstantial revenue.

The barriers to DSM identified by Brandes and Ferguson (2004) are lack of comprehensive cost/benefit models for DSM, and lack of funding for adequate DSM programs. The overcapitalization entrenching factors support the supply-side water management paradigm through the planning and political sphere (Brandes and Ferguson, 2004). These "entrenching values" continue to be difficult barriers to overcome for demand-side management. Furthermore, there are many attitudinal, financial, data and information, and administrative barriers that continue to be ignored or not understood (Brandes and Ferguson, 2004).

2.5.3 Water Soft-Path Concept

The soft-path concept of water management stems from demand-side management and is a more holistic concept management of water resources. Demand-side management continues to focus on "how" water is used accepting current consumption patterns. Rather than focusing on "how" we use our water, the soft-path approach encourages an understanding and evaluation of "why" we use the quality and quantity of water for different services (Brandes, 2005) By understanding the services needed, the opportunities for alternative methods of providing those services are widened. The soft-path concept holds that demand for the resource is not for the resource itself but for the services it provides (Brooks, 2004a; Gleick, 1998; Lovins, 1977). The goal is sustainable water use, defined by Gleick (2000, 5) as, "the use of water that supports the ability of human society to endure and flourish into the indefinite future without undermining the integrity of the hydrological cycle or the ecological systems that depend on it".

The terms hard-path and soft-path have emerged as descriptors for the traditional resource path and the new alternative path, respectively. The adjective "hard" refers to physical infrastructure and design used to manage water. The adjective “soft” refers to socio-political choices and decentralized technologies. When referring to the soft-path for water, Gleick (2002, 3) describes it as,

> the non-structural components of a comprehensive approach to sustainable water management and use, including equitable access to water, proper application and use of economics, incentives for efficient use, social objectives for water quality and delivery reliability, public participation in decision-making and more.

The water soft-path approach is conceptual, requiring ideological and behavioural changes as opposed to structural and physical changes.

Soft-path analysis as an alternative analytical tool developed after the energy shortages of the 1970s (Brooks, 2004a). Amory Lovins (1977) wrote the ground breaking, *Soft Energy Paths: Towards a Durable Peace* and provided the theoretical background of soft-path discussion. The soft-path concept requires a series of socio-political choices rather than technical and economic choices and is based in the socio-political structure of a resource system (energy) that leads us to a vital political difference between hard and soft-paths (Lovins, 1977). He offered two insights into the commonly-held assumptions about resource use. First, Lovins (1977, 7) disconnected economic growth from increased energy use, and the “relationship between energy use and prosperity”. This disconnection was vital to understand if one wishes to promote a management approach that espouses efficiency as one of its main tenets. His second insight was that “energy is but a means to social ends; it is not an end in itself” (Lovins, 1977: 4). Lovins suggested that it was not the energy in and of itself humans want, but the services energy provides. The example Lovins (1977) provided was oil. Humans do not want crude oil but the transportation services the burning of oil provided. This distinction is the crux of soft-path thinking—trying to look at the service provided and not the resource itself. The energy soft-path would use highly efficient technologies and small-scale renewable energy resources such as wind power, photovoltaic and hydrogen cells (RMI, 2005). In the soft-path approach to water management, the services water provides, such as industrial cleaning or cooling, would be examined, and recycled or recirculated water would be used as appropriate.

Other key concepts of the soft-path concept suggest that the soft-path approach is normative. It is normative in that both environmental protection and conservation and sustainability (social and economic equity) are imperative in the goals (Brooks 2005, 85). In other words, there are environmental and sustainability standards being explicitly followed in the soft-path. Brooks (2005) argues that the process to reach the end goal in soft-path analysis and traditional analysis is the socio-political choices of governance of resources.

Further principles of the soft-path approach aim to resolve the supply-demand gaps, match quality of resource to end use, and use backcasting in the methodology (Brooks, 2005: 87). Supply-demand gap means appropriate match of supply to the demand. By reducing demand, less supply is needed and therefore less infrastructure, withdrawal of water from the environment, and up front capital cost. By matching quality of water to the end use, supply of high quality water can be reduced. It is possible, for instance, to use grey water, recycled from other sources, for toilets. Supplying grey or recycled water is more cost efficient than supplying highly treated water. A desired future creates a goal in which to frame policies, technologies and behaviours.

From the current year a methodology known as backcasting is used. The term "backcasting" was coined by Robinson (1982) to describe the approach of exploring the feasibility and implication of achieving certain future desired end points. Backcasting stands in contrast to forecasting in which the goal is to provide projections of future conditions. The rational for backcasting is twofold. First, forecasting attempts to illustrate what the future will look like, based on present conditions, while backcasting typically indicates the implications of different policy goals and the feasibility of different future scenarios (Robinson, 1982). The ability to predict the future is strongly constrained in forecasting by humans' inability to do so with any certainty. Secondly, even if the future were predictable, the most likely future is not always desirable (Robinson, 2003). Backcasting ultimately allows one to explore the desirability and feasibility of alternative futures and not just the likelihood of future conditions. The added benefit of backcasting is described by Anderson (1991, 607) as: “embrac[ing] wider environmental and social responsibilities through a more circumspect appreciation of current knowledge and hence a more flexible and responsive policy agenda”.

Backcasting is a tenet of the soft-path concept. It provides the clearest methodology of testing current systems of influence on the desired future of “no new water”. In response to policy challenges in the European Union, Wilderer (2006) contends, “[t]here is today a greater incentive than ever to explore new ways of problem solving . . . as we absorb the implications of the world’s water crisis, it becomes clear that we need to explore avenues that are overlooked in traditional research methods”. Backcasting, in the past, has been used as a conceptual analysis and technical application by-passing the social application (Anderson, 1991; Robinson, 1982; Dreborg, 1996). Backcasting, ultimately, is a tool that is part of the soft-path and is a new of problem solving.

In the first part of the backcasting process, an end point is a date chosen in the future as the time frame to achieve a set goal. Generally, an end point of 20-30 years is chosen. An end point 30 to 50 years in the future allows for economic turnover without unnecessarily constraining the analysis (Robinson, 1982). Generally, shorter time frames constrain the end point, and current trends and policy and analysis of unconventional futures is less useful. On the other hand, with a longer end point (e.g., 60 years) the analysis becomes more tentative (Robinson, 1982). The basis of the end point is usually a future with a low-demand society, which, as outlined by Robinson (1982, 337), is one “that relies entirely or very nearly, on renewable energy flows”.

After the end point is chosen and clearly defined, the baseline needs to be understood. The baseline is the current context in which the problem is found. The baseline data should include current water use, current technologies, and regulation, market and policy frameworks. Finally, one works back from the future goal (end point) to the current baseline and makes advances in policy, economies and technologies that will ultimately lead to achieving the future set goal.

The soft-path concept, while originally conceived and applied to energy, can be extended to other resources such as water (Brooks, 2004a). He distinguished one similarity and five differences between water and energy. Water and energy are similar because the growth of these two resources was historically coupled to economic growth (Brandes and Ferguson, 2003; Brooks, 2004a). This tie to economic growth has been severed, but during the industrial revolution both water and energy were heavily relied on as indicators to track economic growth (Brooks, 2004a, 17).

Of the major differences, there are added barriers to the application of the soft-path for water, but also differences that assist the application to water. The first major difference is that unlike energy, water supply does not have any prominent and political technologies connected to it like nuclear power. The development of the soft-path energy concept came out of the need for an alternative to nuclear power and bombs. While some water technologies may have negative local side affects, e.g., large dam structures, there is not the same technical motivation (Brooks, 2004a, 18)

Another major difference between the two resources is the conversion and refining process. The treatment of water is a simpler technology with less water loss to the system. Energy, on the other hand, requires major input and the conversion and refining processes are energy intensive (Brooks, 2004a, 18). The following three differences between water and energy make a more complex case for soft-path approaches to water management.

Unlike energy, water has an inherent value in and of itself, because energy is not a product by itself, but is produced through a complex system. There are ways in which humans use water for the service it provides (e.g., waste removal) but there is value in water on its own. There is value in lakes, rivers, water, beautiful waterfalls, waterfront properties and beaches (Brooks, 2004a, 19).

The issue of quality arises in both energy and water soft-path analysis. While energy quality can be expressed in thermodynamic units, water quality does not have a similar measure (Brooks, 2004, 19). Also, there is a major difference in the quality of the resource required for human use. Water is ingested by humans and oil, is not.

The last difference between water and energy is “the recoverability and reusability of water” (Brooks, 2004, 19). Energy changes many forms before reaching the end use and with that there is more energy loss that has no real economic interest. Water, on the other hand, is much easier to recover and reuse, for instance in industrial zero-discharge systems.

Increasing water use productivity refers to the amount of water used to produce one unit of any good or service (Boardley and Kinkhead, 2006). There are a variety of benefits to using water more efficiently and productively including:

- Prevention or reduction of conflict among water users sharing a common source
- Protection of environmental flow and healthy aquatic ecosystems
- Increase in water availability for new growth and development
- Increase water users ability to withstand impacts of low-water conditions from inherent weather variability and climate change
- Conservation of energy and raw materials improving business profitability
- Enhanced wastewater treatment efficiency and reduced environmental emissions; and
- Enhanced leverage with other jurisdictions on issues relating to shared waters

(Boardley and Kinkhead, 2006, 13)

The important element of soft-path analysis is the identification of the services a resource provides. Water is important because it provides the service of sanitation, not because it is able to flush a toilet. Another example is that water is essential for proper nutrition through food growth, not for irrigation in and of itself (Brooks, 2004a, 29). There are methods to provide all these services with less water or even a different quality of water or no water at all. It is critical to understand what is actually needed for a service in order to provide water that is an appropriate quality and quantity for the end goal.

The “entrenching values” identified by Brandes and Ferguson (2003) as barriers for demand-side management can also be applied as barriers to implementation of the soft-path concept. Further barriers to water soft-path and water conservation, such as those identified by Lovins and Lovins (1998), were categorized by Jordaan and Stevens (2006) into five types: attitudinal and perception barriers; organizational and administrative barriers; resource-related and financial barriers; data and informational barriers; and policy, regulatory and governance barriers. These barriers are conceptual and speak to the structures of management approaches rather than technical barriers because conservation changes the objective of water management (Jordaan and Stevens, 2006).

Attitudinal and perception barriers must be considered in regards to corporate culture. Corporate culture is the way in which individuals or groups perceive or understand problems. These perceptions are often value-laden and determine the success of conservation efforts (Jordaan and Stevens, 2006). Examples of attitudinal and perception barriers include perceived fear of decreased economic gain in industry (Wolff and Gleick, 2002); and greenwashing, where marketing is used to green wash an industry practices (Jordaan and Stevens, 2006).

Organizational and administrative barriers are barriers in operation procedures. That is, conservation concepts may go against the grain of industry administration values and procedures. The operational barriers could result from fragmented administration, a lack of integrated conservation plans and infrastructure plans, and a resistance to long-term solutions rather than short-term solutions (Jordaan and Stevens, 2006).

Resource-related and financial barriers are very real and often result from complex economic models that fail to include the full cost of environmental inputs (Jaffe and Stavins, 1994; Lovins and Lovins, 1998). Examples of these barriers include the need to maintain sufficient revenues; need for predictable and stable revenue or false/absent price signals (Jordaan and Stevens, 2006).

Data and informational barriers are important in all sectors for managing Canada's water resources (Rosolen, 2006). Examples include a lack of complete information; a lack of standardized reporting methods; and a lack of comprehensive cost/benefit models (Jordaan and Stevens, 2006). This thesis examines these barriers more fully.

Policy, regulatory and governance barriers are also discussed at lengths in this research. In Canada, changes to policy and regulation often come on the heels of a crisis, but proactive policy and precautionary changes seem to be more difficult to accomplish (Jordaan and Stevens, 2006). Examples of these barriers include the gap found between science and policy; prescriptive policies that leave no room for innovation and creativity; lack of political will; and poor enforcement.

2.3 CONCEPTUAL FRAMEWORK

The conceptual framework is the structure that situates the research question in the broader academic concept. Figure 2.1 depicts the conceptual framework and the relationship between key concepts, ideas, and informing theories for this research.

The underlying assumptions of this research are:

- The soft-path concept is a more holistic and successful method than current water management practices in providing sustainable water use.
- Industry needs to be evolving towards sustainable water use as the greater community moves towards more sustainable living.
- The three systems that most significantly impact the framework of water management are technology, market forces, and regulation and policy.

The soft-path paradigm is the larger informing theory. It provides the driver for the subsequent research. The three systems of influence (market forces, regulation and policy, technology) impact each other and ultimately decision-making frameworks. Corporate culture, which underlies all three systems of influence, is an influencing system in and of itself and impacts all three respectively. The goals of this research are to understand these forces alone and how they interact together to better understand the potential for implementation of the water soft-path concept.

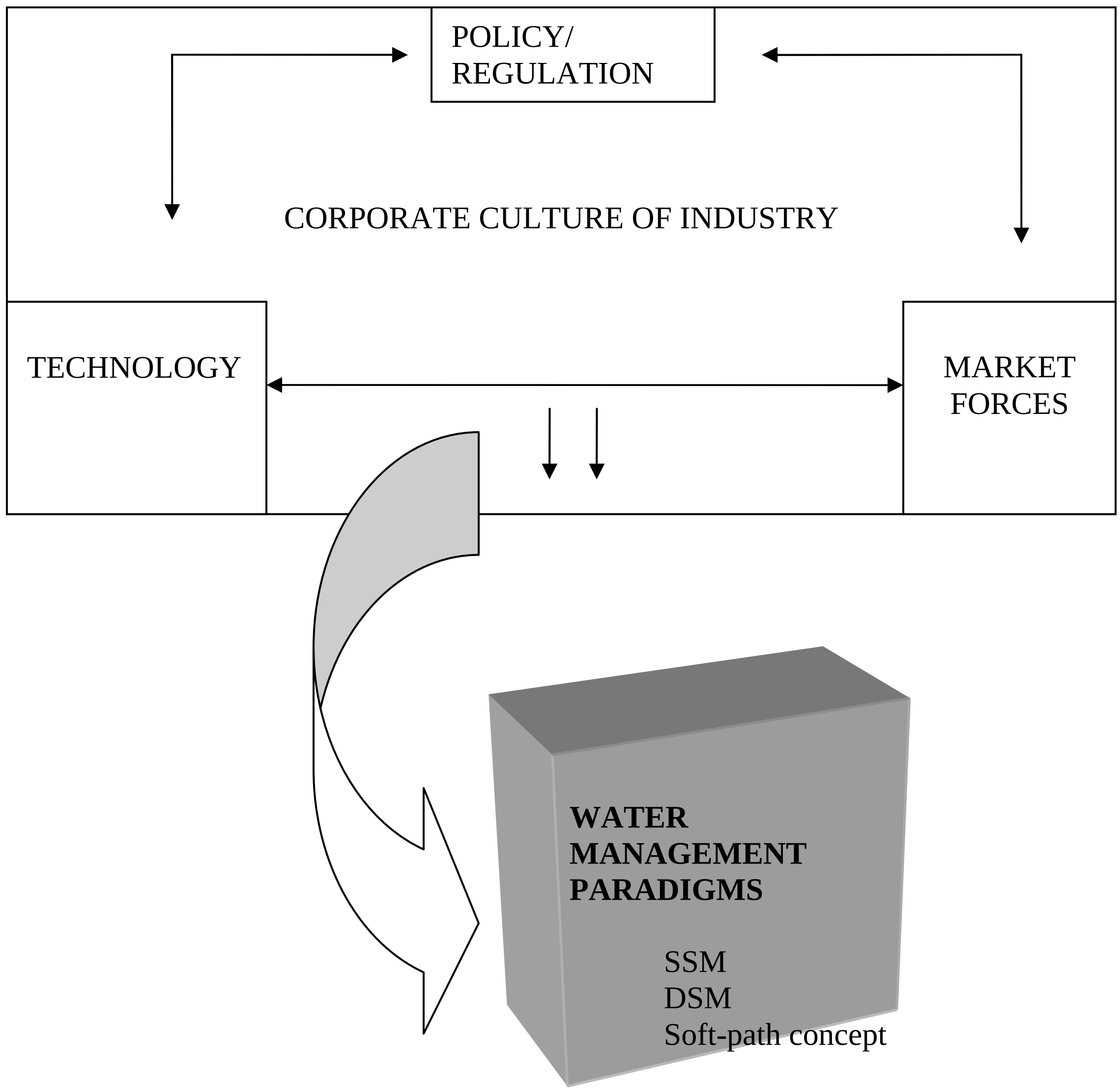


Figure 2.2: Conceptual framework of systems driving water management paradigms

2.7 CONCLUSION

The rising environmental and water challenges internationally and in Canada suggest a need to seek out an alternative method of managing water. This research explores the applicability of the water soft-path concept in the face of the complexities of market forces, policy and regulation, and technology.

Market forces and policy and regulation, and technology have been identified through the methodology as systems of influence. A fourth influence is corporate culture, which is a common thread running through all the systems of influence. These systems work together and independently to create the complex decision-making framework in which the Canadian pulp and paper industry must make decisions. Decisions of water use and water management are also situated with the complex systems of influence creating both barriers and opportunities to application of new water management approaches.

More specifically, to understand the prevailing conditions of the pulp and paper industry it is key to understand the role of the market forces and the boom and bust economy of the natural resource sector. Understanding these economies includes the importance of competitive positions and external economic stresses. In Canada, the industry is being faced with the "perfect storm" (FPAC, 2006a; CBC, 2007). The perfect storm refers to the strong Canadian dollar, the low-cost competition and the high fibre costs throwing the industry into a highly volatile position.

Market forces are tightly connected to regulation and policy. In the conflicting policy fields of economic and environment, satisfactory efforts towards efficient water use management have been sorely absent. The inadequacy of both policy arenas' to address water issues creates a vacuum for industrial water use policy and necessitates action. Regulation and policy frameworks need to be considered and evaluated under the lens of the larger socio-economic and environmental context.

Technology provides an obvious but important part of the equation. To understand the pulp and paper industry, one must understand the industrial process. In Canada, there are three main pulping methods that are described in this chapter. Although there are only three pulping methods, the characteristics and technical opportunities within each are incredible.

The systems of influence create the prevailing conditions in which the water soft-path concept is investigated. Water management paradigms have evolved over humankind history. As resources become restrained it is important to look towards a better way of managing precious resources such as water. The water soft-path concept calls for a radical but necessary shift from supply-side management and an improvement upon demand-side management.

The following chapter will address the methodology of this research. It will address how and why the research was conducted.

CHAPTER III: RESEARCH DESIGN

3.1 INTRODUCTION

This chapter discusses the methodological design of this research. Primarily, it provides the explanation of how and why the research was conducted. It begins with a description of the scope of the research. The scope provides the boundary of the study. The next section defines terms that are important when discussing water use and help explain the scope of the industrial system. In the last section, the design of the study is discussed including major methodologies used, sites and major methodological limitations. Figure 3.1 provides a schematic of the research design. It includes the research question, tools used to answer the research the research questions and overview of the details of the design and method used to examine the research questions and outcomes.

The research was conducted in two parts to address both research questions. The first research question was researched using interviews and a literature review. By pinpointing and understanding the prevailing conditions in research question one, research question two was addressed. The tools used to answer research question two included archival data, interview, literature review and surveys. The research questions were addressed within the case study of the pulp and paper industry in Canada.

Figure 3.1: Schematic of Research Design

Research Questions:

1. What are the prevailing conditions in market forces, policy and regulation, and technology that influence the Canadian pulp and paper industry decision-making framework?
2. What are the barriers to and opportunities for introducing a soft-path approach to water management in pulp and paper mills?

Tools:

Literature Review – conducted by themes
Water management paradigms and water management in industry in the pulp and paper industry, market forces, policy and regulation, technology, and corporate culture/ corporate greening.

Surveys - Conducted to gain water use data
Sent to Ontario mills only (4 out of 20 received)

Interviews

10 conducted with government officials, industry representatives, environmental non-governmental organizations.

Analysis of Archival Data

Pulp and Paper Annual Directory (1980, 1982, 1996, 2000, 2007)

Outcomes:

- Understanding the prevailing conditions in market forces, policy and regulation, and technology that influence the pulp and paper industry decision-making framework.
- Understanding the applicability of the water soft-path in the pulp and paper industry given the prevailing conditions of market forces, policy and regulation, and technology.
- Insight into the important relationships and interaction between the three systems of influence.
- Insight into how these systems in turn, impacts the decision-making process for water management.

3.2 SCOPE

The scope of this study focused on water quantity used in pulp and paper mills in Canada. While pulp and paper mills were large dischargers of water effluent, total quantity of pollutants depends on the quantity of water used (i.e., if water has to be chemically treated prior to use in the manufacturing process, lower water intake would translate into fewer polluting inputs being used) (Renzetti and Dupont, 1999). Water quality was only examined as a secondary benefit to reduction of overall water use. All three basic pulping practices —chemical pulping, mechanical pulping, and thermo-mechanical pulping—are considered. The three processes required different inputs (energy, chemical, water) and outputs, but all required a vast amount of water (Christie and McEachern, 2000: Kemmer, 1979).

The three systems of influence— market forces, policy and regulation, and technology — examined were selected through a mixture of a literature review and interviews. Corporate culture was not considered as a stand-alone system of influence for three reasons: it is an implicit thread in all systems of influence; interviewees did not identify it as a major system of influence; and the scope of this thesis did not allow for in-depth research.

3.3 SITES

This study focused on Canadian pulp and paper mills. It is important to consider mills across the country because there are different factors influencing mills. A province-wide study would have provided too little data on mill water use, environmental standards, and operating standards. A country-wide study provided a larger pool of case studies including technical advancement, corporate cultural advances, and regulatory and policy successes. As well, northern mills have different barriers than southern mills. In northern communities, given small population and density issues, the drivers for sustainable water use are different than for their southern counterparts. In southern communities, mills were located in higher populated areas with more competition for the water resources and a higher impact on the community at large.

Since mill technologies and pulping processes are similar around the world, there is applicability of the study to mills elsewhere.

3.4 KEY TERMS

The paper industry (code 322), according to the North American Classification System (NAICS) (2002),

> Comprises establishments primarily engaged in manufacturing pulp, paper and paper products. The manufacture of pulp involves separating the cellulose fibres from other impurities in wood, used paper or other fibre sources. The manufacture of paper involves matting these fibres into a sheet. Converted paper products are produced from paper and other materials by various cutting and shaping techniques.

Water use actually comprises several distinct components, and it is important to maintain those distinctions. The following definitions (EC 2004b) were used in this research, to differentiate values reported by industry.

- Water intake is the total amount of water withdrawn from a source for a particular activity over a specific period of time. This measurement represents the demand by the particular use on the specific location. Water intake does not include water recycled. It is also sometimes called water use.

- Water consumption is the difference between water intake and water discharge. It is the water removed from the source and not returned at or near the site of withdrawal.

- Gross water use represents the total amount of water used during a process. Gross water use equals water intake plus water recycled.

- Recycled water is the difference between gross water use and water intake and is the amount that recirculates in any given system. The recycling rate is the number of times that the water is re-circulated and indicates the efficiency of a particular water use.

Water intake and water discharged can be measured in an industrial system. Water consumption is calculated by subtracting water intake and discharge. Recycled water, if known, allows one to calculate the gross water use by adding water intake and recycled water.

Unfortunately, there was not a consistent use of terminology among sources reporting water use. Government sources reported data using gross water use, water intake, or water consumption, while industry often reported water use and consumption synonymously (Paprican Research, Personal Communication, April, 2007). In this study, mills reported either water consumption or water use (also known as water intake). For clarity, this research used water intake/water use, water consumption, and gross water use data.

3.5 DESIGN OF STUDY

Social research is often conducted through deductive theory (Bryman and Teevan, 2005). Deductive reasoning was a key approach that informed this research. Literature and the state of freshwater management in the Canadian context (refer to rationale and literature review) clearly indicate a need for an alternative water management approach. The role the pulp and paper industry plays in the Canadian landscape (economic, social and environmental) provided an important case study in which to understand the applicability of the soft-path concept. The research was approached with two research questions because both were integral in understanding the broader environment in which water management concepts flourish. To understand the applicability of a concept one must understand the prevailing conditions faced by the case study. Interviews and a literature review were used to identify the prevailing conditions, and understand the prevailing conditions for research question one (What are the prevailing conditions in market forces, policy and regulation, and technology that influence the pulp and paper industry decision-making framework?). Literature review, interviews, archival data and surveys where used to provide data for research question two (What are the barriers to and opportunities for introducing a soft-path approach to water management in pulp and paper mills?)

3.5.1 Literature Review

A literature review was undertaken to gain an understanding of the prevailing conditions of the systems of influence. From the literature review opportunities and barriers for greater efficiency and conservation in the systems of influence were identified. The literature review was conducted by theme. Table 3.1 provide examples of the literature surveyed for each theme.

3.5.2 Surveys

A survey was sent to 20 mills in Ontario, but only four responses were received. The initial objective of this survey was to gain quantitative data on water use practices in Ontario mills. Follow-up conversations were made with these four mills. The original focus of this research was to be a provincial study. Given the lack of responses and data available for Ontario mills the thesis scope was increased to include mills across the country. University of Waterloo Office of Research Ethics (ORE) clearance was attained for these surveys. Refer to Appendix A for a copy of the survey. The survey results of the 4 returned survey were used as data in Chapter VI.

Table 3.1: Literature Surveyed by theme

Theme 1: Water management paradigms, water management in industry

- Academic literature
- Industry technical reports

Theme 2: Technology

- Paprican, National research centre special reports.
- Journals such as *Pulp and Paper International* , *Pulp and Paper Canada, Forests Products Association of Canada*
- Government special reports

Theme 3: Market Forces

- Academic literature
- Industrial economic reports
- Statistics Canada

Theme 4: Policy and Regulation

- Non-Governmental Organization (NGOs) review of water policy documents.
- Federal and Provincial Government Acts, policy, regulation, reports.

Theme 5: Corporate culture/ corporate greening

- The Forest Products Association of Canada (FPAC) annual reports
- Paprican, National research centre special reports.
- Journals such as *Pulp and Paper International* , *Pulp and Paper Canada, Forests Products Association of Canada*

3.5.3 Interviews

Interviews with key informants were used to gain access to up to date baseline data both in technology in water management and water-use practices. Interviews conducted with industry experts informed the technical understanding and provided data sources for water use. Interviews conducted with government officials provided an understanding of the policy and regulatory environment. Interviews conducted with non-governmental organizations and financial institutions provided alternative perspectives.

Interviews were used to set the boundaries of this research because experts working within the field would be the most knowledgeable on major factors impacting the pulp and paper industry.

Semi-structured interviews were used to allow greater flexibility in questions and to provide greater opportunity for the interviewee to explain priority issues. Denzin and Lincoln (1994) suggest semi-structured interviews provide a greater flexibility than structured interviews for gaining information in a qualitative study. Key concepts to be aware of included the environment in which the interview would be set; presentation of both oneself and one's work; locating informants; and establishing rapport (Denzin and Lincoln 1994).

Interviews were conducted with experts from each system, such as pulp and paper employees, CEO of an industry association, technical experts, Government of Canada employees, and financial experts. Informants were identified during the literature review or through interviewee suggestions. A total of ten interviews were obtained. Table 3.2 provide details of the ten interviews conducted. Table 3.3 provides examples of interview questions divided by theme. Seven more non-formal communications were made at industry workshops attended by government, environmental non-governmental agencies, and industry representatives (FPAC, 2006b). These non-formal communications held form the perspective and opinion of this research.

Table 3.2: Interviews

Position, location	Type of Organization	Date of Interview	Length of Interview	Method of Interview
Branch head	Federal Government	July 7th, 2006	One hour	In person
Civil Servant	Federal Government	July 7th, 2006	45 min.	Phone
Executive Director, National	Environmental non-governmental organization	July 18th, 2006	One hour	In person
Senior Executive, national	Deloitte Financial Institute	July 9th, 2006	One hour	In person
Researcher, Quebec	Industry Research Institute	October, 11th, 2006	Half hour	In person
CEO, National	Industry Association	October 15th, 2006	_____	Email
Superintendent, Ontario	Mill	June 15th, 2006	One hour	Phone and email
Manager, Ontario	Mill	October 4th, 2006	_____	Email
Environmental Manager, Ontario	Mill	June 15th, 2006	45 min.	Phone
Environmental Manager, Quebec	Mill	July 17th, 2006	One hour	In person

Table 3.3: Sample interview questions by theme

Decision-making Process

- What drives the decision-making process in pulp and paper mills
- What motivates change?

Mill Profile

- What type of mill does your company operate?
- What products does the mill produce?
- How long has the mill been in operation?

Mill Data

- How much water is withdrawn daily or yearly for mill processes?
- How much water is returned, consumed and recycled in the mill processes?
- Is the company ISO 14000 certified?
- Is ISO 14001 a driver for improved water management?
- Is mill water self-supplied or from a municipal source?
- Is the company charged for the water it uses?
- What level of water treatment system is in place at the mill?

Systems of Influence

- Are mills required to comply with a permit-to-take-water
- What other regulation requirements are required by the provincial or Federal government that monitors water use?
- What drives technical innovations?
- What market forces could motivate change in decision-making process?

3.5.4 Archival Data

Archival data provided a historical trend of water use. Data were retrieved from The Pulp and Paper Industry Journal, *Pulp and Paper Annual Directory* for 1980, 1982, 1996, 2000, and 2007. This source provided a consistent reporting of water use in pulp and paper mills through the years. The directory has been published for 133 years (Personal Communication, Pulp and Paper Journal manager April, 2007). It included data, obtained by surveys, of mill name and location, contact information, water use, source, production capacity, and environmental certification. The four directories (1980, 1982, 2000, and 2007) were selected to gain a range of datum for water use. The oldest volumes were selected based on availability and reporting of water data was sparse prior to 1980. The 1996 datum was selected because it could be compared with the 1996 Industrial Water Survey conducted by Environment Canada, and 2007 was the most recent directory available. Data were reported in a variety of volume units including US gallons, litres, and metric tonnes, and time units of minute, day and years. All data were converted into cubic meters per tonne of product per year.

Response rate for the 2007 directory was approximately 75%. Of the 111 mills only 36 reported both water use and production capacity. It is important to note that in these directories water consumption and water use are used interchangeably (Paprican Researcher, personal communication, 2007).

3.6 METHODOLOGICAL LIMITATIONS

This research encountered four methodological limitations. These limitations do not reflect the value of the results but are addressed to acknowledge the challenges that arose through out the process.

3.6.5 Limit to Wider Application

In the backcasting methodology the future goal can be chosen for any case study but the baseline situation will be different depending on standards of the mills (retrofitted), government policies or regulations, industries willingness to participate, and NGO pressure. Due to the scope of this research, wider applications would be limited to countries or mills found in similar economic, political and regulatory standards such as the Nordic countries, Australia or the United States of America.

3.6.6 Boundary of Study

Boundaries to this study were set by data availability, time, and resources. A full lifecycle of pulp and paper was not considered because of the lack of data available of water use. Three mill operations (chemical, mechanical and thermo-mechanical) were used so as to increase the technical audience the research would be applicable to. The three systems (market forces, policy and regulation, and technology) were chosen because those are the leading forces that impact decision-making structures in management.

3.6.7 Water Use Data

There is no standardized reporting method for the collection of water use in pulp and paper mills. Neither federal nor provincial governments collect such data in a regular or methodological way. The data were drawn from a variety of sources such as association statistics and journal directories. The main source was the *Pulp and Paper Canada 2007 Annual Directory*. This directory was published December 2006 by the *Pulp and Paper Canada Journal.* Of approximately 175 mills in Canada, 130 responded to the survey the journal mailed out (personal communication with assistant editor, February, 2007). Of the 130 mills that responded, 111 mills were applicable to this study.

Due to the lack of standardized definition for water use, water intake, use, gross use and consumption seemed to be confused when reported. Often consumption data were larger than use or intake. Given knowledge of the pulping process, and the synonymous use of the terms gross use, water consumption, and water intake, it was necessary to differentiate each datum based on the numerical value. As an example, 8818m^3/t and 112 m^3/t were reported for water "use" in the same year (1996) and same pulping process from different mills. The first value can reasonably be assumed to be gross water use and not intake or consumption.

3.6.8 Survey Challenges

The original plan of this research was an Ontario provincial study. After twenty surveys were sent to mills across the province only four were returned. Due to low response rates and feedback from interviewees the research was broadened to a national scale. Data of water use could be used but wasn't necessarily representative of a cross-country study. Data requested regarding policy and regulation was unusable for a national study.

3.7 CONCLUSION

The research questions of this thesis were answered by using four different approaches—surveys, interviews, literature review, and archival data. The outcomes of this research led to the understanding of applicability of the water soft-path concept in Canadian pulp and paper mills.

The research contributed to knowledge in the following ways:

1. The research provided insight into the important relationships and interaction between the three systems of influence.
2. The research provided insight into how these systems in turn, impact the decision-making process for water management.
3. Finally, the research explored the feasibility of different future scenarios through the lens of water management.

The results provide decision makers in both government and industry alternative approaches innovative water conservation management. Policy makers will become more informed and better able to work towards constructing sustainable policies that will improve the health and management of Canadian waters. The provision of technical information will enable the industry to better work towards improving its environmental practices, corporate social responsibility, and environmental compliance. The method of backcasting provides a clear goal to which decision makers can work. The research also provides further testing of the methodology of backcasting.

The remainder of this thesis will be a presentation of the data and analysis drawn from the methodology. Chapter IV discusses the technology and water use involved in the pulp and paper process. This information is used to provide possible pathways for water use into the future.

CHAPTER IV: MARKET FORCES

4.1 INTRODUCTION

Financial drivers and economic factors are of the utmost importance in the Canadian pulp and paper industry. As a natural resource industry, the pulp and paper industry is subject to the trends of a boom and bust economy. Economic trends and overhead costs of production were identified in all interviews as two of the major drivers of decision-making in the industry. Market forces play a leading role in change. By understanding the forces acting on an industry, insight is gained about the structure in which decisions are made.

This chapter first discusses current economic trends in the pulp and paper industry such as the impacts of a globally competitive boom and bust industry. Given the current economic state of the Canadian pulp and paper mills and the priority of water use, an alternative opportunity is examined. The second section discusses economic instruments. The final section argues the need for pricing as well as a pricing structure framework as a key economic instrument that could provide the necessary opportunity for the water soft-path concept. This pricing scheme incorporates the imperatives of both the water soft-path concept and the natural resource industry.

4.2 CURRENT TRENDS IN THE CANADAIAN PULP AND PAPER INDUSTRY

Economic uncertainties of a boom and bust economy are realities for natural resource economies. The Canadian forest industry has been experiencing a particularly tumultuous period as examples demonstrate throughout this section. Specific factors have created what industry insiders are calling the “perfect storm” (FPAC, 2006a; CBC, 2007) and seem to have increased the impacts of this bust period of the cycle. The high value of the Canadian dollar coupled with political disputes (with the U.S over soft wood lumber.), increasing competition from international competitors (e.g., Brazil and Argentina), and increasing energy costs present unique challenges and pressures. These pressures have led to two responses from industry: a reinvention or much greater centralization.

The economic trends impacting the industry are also impacting the local economic development of small communities across Canada. It has been estimated that 40 000 direct jobs have been lost over the passed five years and 285 000 indirect jobs lost in the ripple effect on communities (CBC, 2007). It is not just the employment numbers that are important; often forest sector jobs in these communities are the best paid jobs.

Pulp and paper companies are not disappearing from the Canadian landscape. One trend developing in response to the economic difficulties is an industry reinvention. In an effort to remain competitive and combat mill closures there has been a great deal invested in product innovation. Domtar, a large paper manufacturer, announced in January 2007 the launch of the first antibacterial office paper to be sold across North America (Domtar, 2007a).   Paprican, one of Canada's leading not-for-profit research and technology institutes, is working aggressively on industry energy challenges. In response to increasing energy prices, they have developed biomass technology. Test site savings have ranged from US$1.1 million to US$7.6 million a year (Paprican, 2005).   Industry and research focus continues to be on process efficiency, product and paper quality for value added products.

In an effort to support industry, the Federal government provides subsidies. In 2007, the government introduced the EcoENERGY Efficiency Initiative, which is to provide $1.5 billion in funding to Canada's renewable energy supplies. The majority of that funding has been slated to increase supply of clean energy such as wind and biomass by funding eligible projects over four years. The initiative includes a promised $35 million in incentives to adopt clean renewable technologies (EcoENERGY, 2007).   This initiative is not a subsidy for only the pulp and paper industry and it is unknown how much direct benefit the industry will see.

In addition to industry reinvention, there has been a major trend by industry to streamline business. The trend of streamlining has been highlighted by a shift of effort towards "super mills", mill closures, and major mergers between dominating companies. Two significant mergers occurred in 2006–2007. The merger between Domtar and Weyerhaeuser, which began in 2006, was finalized in March, 2007 creating Domtar Corporation; making it the largest manufacturer of free sheet paper and a leading manufacturer of market pulp (Domtar, 2007b). In January of 2007, a merger between Abitibi Consolidated and Bowater Inc. was announced. The impending merger would rename the companies "AbitibiBowater" creating the third largest public paper and forest Product Company in North America (Abitibi, 2007).

The trend towards centralization of the industry is largely accepted as the best adaptation method by government. A major three-year research program, *Mission Possible: Sustainable Prosperity for Canada* by the Conference Board of Canada (CBOC, 2007) argued for more mill closures, concluding that uncompetitive mills should close to allow funds to be redirecting resources to research and development. The report stated,

> This is especially the case in pulp and paper, where older, smaller mills are losing ground to newer, larger global rivals. Scale matters in this industry, and to compete, Canadian companies must be able to build larger mills. Governments should change timber allocation processes and eliminate inter-provincial trade barriers to make 'super-mills' possible. (17)

Further recommendations included changing taxation policy and timber tenure systems to increase funding and provide incentives for facility expansion and biomass energy production.

By all account, interviews concurred with industry reports, media reports and the literature review the pulp and paper industry was in a tumultuous period and market considerations where a driving force behind the decision-making framework. All interviewees identified one or more aspects of market forces or another as a major challenge for the industry. The Branch Head of a Federal government department suggested that until a business case was made for water efficiency it would not be considered (personal communication July 7th, 2006). Another interviewee stated, "Economic considerations [i.e. making the right economic arguments for new action] as well as marketplace views are bigger drivers for change." (CEO Industry Association, personal communication, October 15th, 2006). The four interviews conducted with on the ground mill workers supported this sentiment by discussing the low cost of water in the overall operating budget of their respective mills. Until water becomes a higher economic burden incentive for conservation effort would continue to be a means to another gain [i.e. energy savings] (Superintendent Ontario Mill, personal communication, June 15th, 2006; Manager Ontario Mill, personal communication, October 4th, 2006; Environmental Manager Ontario, Personal Communication, June 15th, 2006; Environmental Manager Quebec, Personal Communication July 17th, 2006)

Mill closures were a trend throughout the period this research was conducted, with approximately 17 mill closures from 2004 – 2006. Eight of those were permanent closures and nine were indefinite (see Appendix D). The trend towards centralization and economic efficiency dominated the Canadian pulp and paper industry and is at the crux of management decision- making processes.

Economic implications of the market trend towards super-mills are still unknown. Within the global industry there has been major restructuring and consolidation. Until the mergers between Abitibi and Bowater and between Domtar and Weyerhaeuser, Canadian companies were never among the largest in the world. Industry argues that the greater financial advantages of larger firms include a lower cost of capital, greater scale economies in production and marketing, and better ability to integrate technological innovation and major capital projects (CEO of Industry Association, personal communication, October 15th, 2006). In terms of technical efficiencies to improve water efficiencies, capital costs may be high and centralized production may just be the most efficient way to use the resource.

Despite the economic challenges, Canada can continue to position itself well in the global economy. In 2006, The Canadian Forest Products Sector had $80 billion annual revenue, 340 000 direct jobs across the country, and contributed to three percent of the gross domestic product (FPAC, 2006a, 7). Statistics Canada (2007) listed the pulp and paper industry as the seventh top manufacturing producer in Canada.

Canada continues to be the largest exporter to the United States, India, China, and South Korea (FPAC 2006, 8). In 2006, paper manufacturing shipments reached $31 741.8 million dollars (Statistics Canada, 2007). There is expected to be a 56 per cent increase in global industrial timber demand between 1993 and 2010, and the demand for paper and pulp is expected to increase on a global scale leaving Canadian industry with the potential for increased growth (Ministry of Northern Development and Mines, 2005, 2). These economic forecasts do suggest that the Canadian industry is going to survive turbulent economic times in some form or another.

4.3 ECONOMIC INSTRUMENTS

The pulp and paper industry of Canada by all accounts, is motivated by profits and economic efficiencies and more recently public pressure for high environmental operating standards. Production costs were identified by four out of the ten interviewees as a major driver in decision-making (Superintendent Ontario Mill, personal communication, June 15th, 2006; Manager Ontario Mill, personal communication, October 4th, 2006; Environmental Manager Ontario, Personal Communication, June 15th, 2006; Environmental Manager Quebec, Personal Communication, July 17th, 2006). The crux of the water use debate in interviews always ended with the interviewee concluding that with low cost of water it would continue to be a low priority.

There are economic instruments that can be developed and used that would motivate water conservation strategies in industry practices. Economic instruments as defined by Stratos Inc. (2003) are, "market-based signals to motivate desired types of decision-making … that either provide financial rewards for desired behaviour or impose costs for undesirable behaviour". Economic instruments can include fee-based measures (explicit cost associated with environmental damage), liability and assurance regimes, and tradable permits (ibid.). Subsidies, such as the EcoEnergy program do provide capital but, as interviewees suggested, unless the target has a large operating cost [i.e., energy] it will not be considered a priority. This research focuses on pricing as one option of a suite of economic instruments that could target water use. Economic instruments have been under-used as a tool to motivate industrial behaviour. Water pricing in industrial water use was a specific gap identified in literature. Interviewees suggested water use was only a priority or a concern in operations in regards to water quality and energy use, but because of under-priced water there was a lack of motivation.

Research on water use in Canadian industry is a relatively understudied area despite the importance and role of industry (Renzetti, 2005). Studies have indicated that economic instruments could be effective and efficient policy options to change industry behaviour (Stratos Inc., 2003; Harrington and Morgenstern, 2004; Renzetti, 2005). Renzetti (2005, 22) highlights the need to address "significant information and institutional challenges" before economic instruments are to be successful in Canada. The Canadian government historically has been reluctant to use economic instruments to motivate industrial behavioural change (OECD, 2000; Stratos Inc., 2003; Renzetti, 2005)

Research of economic instruments conducted in Canada highlights some of the broad barriers and limitations to the tool. Economic instruments can be opposed politically or difficult to design establishing a "license to pollute" rather than incentive to innovate. (Chaves, 2001)

The Stratos Inc. (2003) report identified seven barriers to adoption of economic instruments in Canada:

1. Lack of Awareness: The lack of knowledge, consultation, and institutional inertia must be over come.
2. Resistance to "New Taxes": There is deep-seated opposition to any "new taxes" in Canada by government and businesses but experience overseas has overcome this resistance through various means. Overcoming resistance is possible by clearly defining and understanding environmental objective and introducing environmental taxes in stages.

3. Competitiveness Concerns: Losing a competitive edge is a major concern in Canada industry where it is in tight competition with other suppliers. In most cases it is found that the use of economic instruments will be the most efficient way of achieve an environmental goal.
4. Taxes versus Regulations: A typical concern that is closely linked to resistance is the apprehension that there will be more political opposition to taxes than regulation.
5. Lack of Experience: Lack of experience becomes a cyclical barrier because lack of experience leads to lack of adoption. To address this challenge there will have to be a major shift in political willingness to apply economic instruments.
6. Federal-Provincial Cooperation: There is a concern that economic instruments will require too much federal-provincial cooperation, but responsibility over environmental management already requires substantial cooperation.
7. Canada's Geography, Economic and Cultural Diversity: In some cases economic instruments may require site-specific tailoring because business, geography and water availability vary across the country.

With education and an understanding of the success of economic instruments in other countries these instruments are a viable opportunity (Stratos Inc, 2003). Many European countries have been quite successful at adopting economic instruments (Chaves, 2001). Pricing has a twofold importance: water in Canada is grossly under priced and undervalued; in the pulp and paper industry water is a significant resource input.

There are substantial benefits to the use of economic instruments rather than regulatory approaches. Traditional regulations and compliance are considerably more expensive for all stakeholders. Economic instruments allow industry autonomy over how goals are to be met. Ongoing incentives encourage innovation of further technology and flexibility in industry. Finally, an economic instrument can reduce the bureaucracy of enforcement by regulators and creates much needed revenue for government (Austin, 1999)

4.3.1 Barriers to Pricing

In an industry that responds to costs, a major barrier to adopting improved water conservation strategies is the low cost of water in the operating budget (Superintendent Ontario Mill, personal communication, June 15th, 2006; Manager Ontario Mill, personal communication, October 4th, 2006; Environmental Manager Ontario, Personal Communication, June 15th, 2006; Environmental Manager Quebec, Personal Communication July 17th, 2006). Under-pricing of water will continue to under-prioritize the resource. Due to the low cost of water in Canadian industrial manufacturing, water is unimportant in terms of operating costs. The operating costs (intake, treatment, discharge) for process water is rarely over one percent of total operating cost (Renzetti, 2005). Every professional interviewed from industry cited low cost as a factor in lack of priority given to water use. The lack of priority assigned to water use is disproportionate to the important role water has in production.

In Canada, 90 per cent of the industrial sector is self-supplied user and is subject to few charges for water use (Renzetti and Dupont, 1999; Renzetti, 2007) Province-wide water use charges exist in British Columbia, Manitoba, Saskatchewan, Newfoundland, and Ontario (Renzetti and Dupont, 1999), but water in Canada continues to be under-priced and economic tools are a grossly underused tool to manage water use behaviour. Charges are often akin to resource administrative costs.

Pricing schemes vary little across the country and are usually similar to water withdrawal permits. Seven of 13 provinces and territories have some sort of permit fee or levy to regulate water use but the fees are consistently low, from $0.01to $1.43/1000 cubic meters (Nowlan, 2005, 79). The percentage of operating costs to the pulp and paper industry would be dependent on the process of operation. The Ontario government in 2004 amended the Water Taking and Transfer Regulation, which introduced an increase in fee for administrative cost recovery (O. Reg. 387/04). For the most part, fees are low, few provinces state the intention of the fees (water conservation efforts) or administration costs, and there seems to be no correlation between low prices and efficient water withdrawal by self-supplied water users (Renzetti and Dupont, 1999; Renzetti, 2007).

By implementing a pricing structure for the pulp and paper industry there would be motivation for companies to adopt water conservation strategies. Hypothetically, if government increased the charge for water, production costs would increase in the operation. Higher production cost would persuade users to adopt the water soft-path concept, which promotes reduced water use. A company would thereby decrease the quantity of water used and also therefore the water costs in the operations budget. This pricing scheme would provide incentive to adopt water management tools that would use less water as well as promote economically efficient business practices. Many argue that water users do in fact respond to price and demand patterns fluctuate in response to price changes, although more research is needed to fully understand the implications of pricing in industrial water use (Baumann et al., 1998; Renzetti and Dupont, 1999; Tate, 1985).

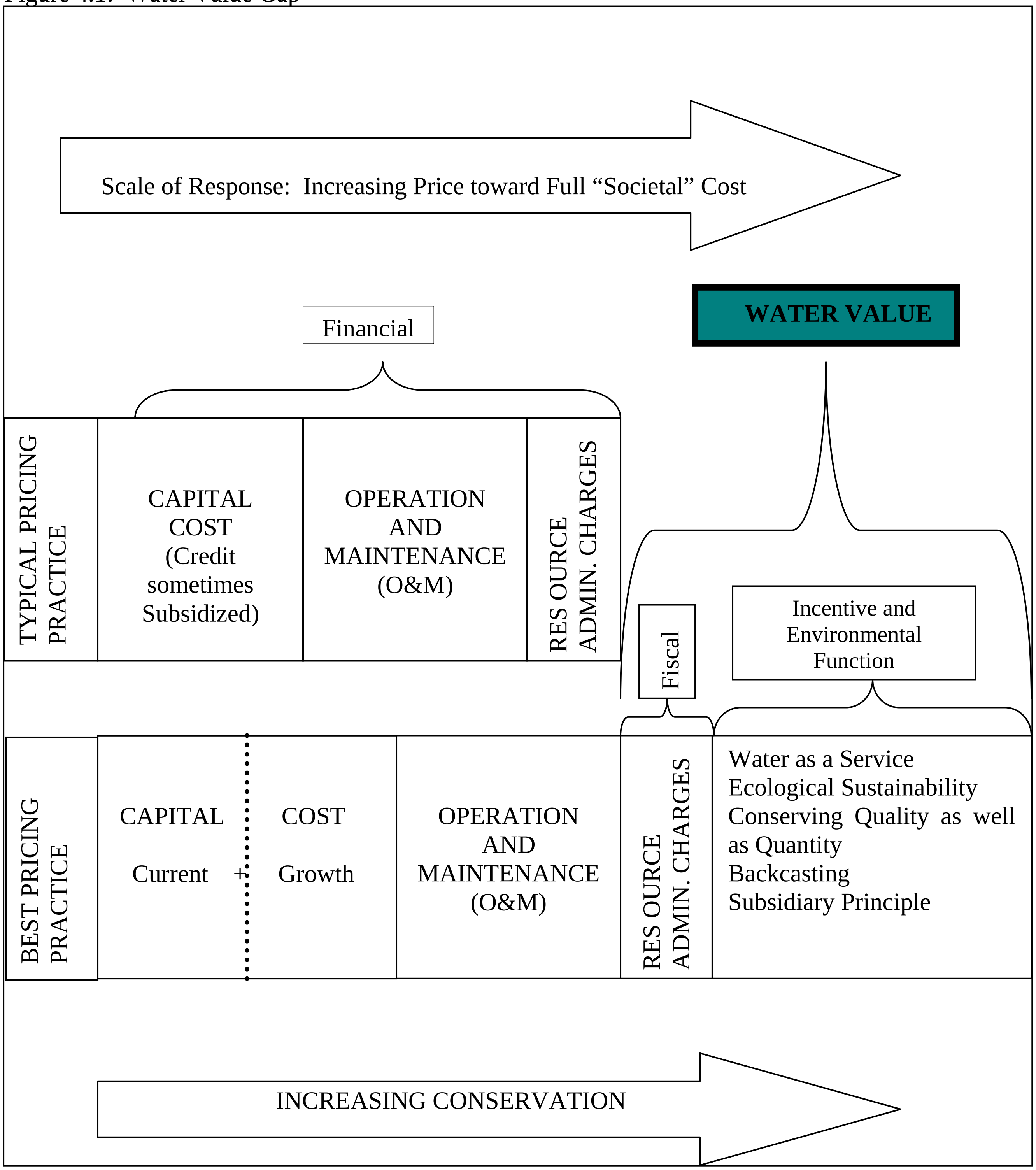
There is an ingrained misconception that water conservation will have negative economic impact. The belief that water efficiency and reduction will lead to economic decline both in industry and in water supply agencies has been disproved first with the decoupling of energy use and economic growth and later with other natural resources such as water (Baumann, 1998; Lovins, 1977; Gleick, 2000). Economic instruments but specifically pricing structures could provide great opportunity to motivate behavioural change to encourage water conservation.

4.3.2 A Pricing Structure

Figure 5.1 represents the “Water Value Gap” between typical and best-practice pricing. This figure, adopted from Renzetti and Marbek Resource Consultants (2005), illustrates where there are opportunities for the soft-path concept using economic tools. There are four important functions – financial, fiscal, incentive, and environmental. Financial function is to encourage and finance water efficiency and conservation investment. The fiscal function is to increase water resource budgets or recover administration costs. The incentive function is to change water user behaviour, and the environmental function is to motivate behaviour in a socially desirable direction (Renzetti and Marbek Resource Consultants, 2005, 19)

In applying the soft-path concept, the scope would include the entire range of functions because the scale of the challenge is to include the soft-path criteria within the pricing structure. The best pricing practices are those that provide opportunity for water soft-path concept implementation in the pulp and paper industry. These pricing practices are what would be expected for a water soft-path concept implementation by 2030. The top row, “Typical Pricing Practices”, illustrates current, basic pricing of infrastructure. In typical pricing practice externalities or management issues are not addressed. In the “Best Pricing Practice” components of full value of water and how it could be priced to reflect environmental and social values would be included in the pricing framework. The “Value Gap” highlighted in bold type and blue is the gap between current practices and full cost of pricing (includes environmental and social values).

Figure 4.1: Water Value Gap



Note: Adopted from Renzetti and Marbek Resource Consultants (2005)

It is important to understand what is assumed under each cost section. The “Typical Pricing Practice” breaks down costs by capital cost, operation and maintenance (O&M) costs, and resource administration charges. These costs are all identified as having a “financial function”, meaning the costs are meant to encourage and finance water efficiency investment. If applied to the pulp and paper industry the capital costs refer to overhead costs such as start up fees and energy costs. “O&M” costs refer to maintaining mill infrastructure at current capacity. “Resource administrative” charges refer to fees charged by the government for such things as the Permit to Take Water in Ontario.

In the “Best Pricing Practice Scenario” Renzetti and Marbek Resource Consultants (2005) break the costs down further. “Capital costs” are divided into current and growth. Growth is an additional cost and includes such things as upgrading mills. “Resource Administrative Charges” becomes a fiscal function, meaning it is not just to encourage water efficiency but increase water resource budgets at the municipal or provincial level. The final step in charging for water includes charges for water as a service, environmental costs and soft-path ideas. These fall under an “Incentive Function” or “Environmental Function” meant to either change water user behaviour or incent behaviour in a desirable direction. It is in the last two steps in charging (resource administration charges and external costs) that the water value gap is found. The water value determines where the pricing structure places the value on water. By increasing conservation or increasing pricing toward full societal costs there is a high water value placed on the resource by the pricing structure.

Economic instruments such as pricing provide opportunity to close the gap between typical practices and full cost or value of water as would be required for water soft-path concept implementation. Countries within the European Union and Australia have adopted pricing structures quite successfully. In Portugal this concept is implemented through a tax calculated in proportion to the amount used and economic value for a sector. This charge structure also takes into account water availability (Chaves, 2001, 191). The revenue is then allocated to improvement in the river basin. Similarly in the pulp and paper industry those monies could be allocated to further research on pollutants or river basin maintenance.

4.3.3 Implications

Across the country there is wide geographical variance with some mills encountering water shortages more than others. To accommodate geographical variation across the country fees could be tailored to local water supply-demand balances. In Canada, 69 mills are located on rivers and seven are located on lakes (Appendix C). Pricing could vary by volume used to account for regional ecosystems or particularly vulnerable ecosystems (Renzetti, 2007). Besides accommodating geographical variation, these fees could be part of not just motivation for economical efficiency but also a larger government strategy to promote water efficiency and environmental protection (Renzetti, 2007).

Dupont and Renzetti (1999) argue that with the supply of under-priced water the government is providing a hidden subsidy. None of the provinces include economic value of water removal on permit fees such as they might do for other resources such as forests (Renzetti, 2007). Therefore, industry is receiving a subsidy of water by ignoring the “economic value created by the application of water in production processes" (Dupont and Renzetti, 1999, 363). It seems reasonable to pay a fee to secure a resource that allows the company to profit. Also, provinces do provide infrastructure and services to provide resources (Renzetti, 2007). Even self-supplied users use infrastructure, such as roads, provided by governments. A reasonable pricing structure would accommodate cost of infrastructure and hidden subsidies such as for water.

A valid concern and argument of implementing a pricing structure is the increase of operational costs. Research conducted in the U.S. suggests that overall compliance costs of command and control approach could be reduced by one-quarter. By implementing economic instruments improvement and innovation is more likely to be encouraged (Stratos Inc., 2001; Anderson, 1991).

4.4 CONCLUSION

The market forces in the pulp and paper industry play a major role in the decision-making process of mills. The current tumultuous state of the Canadian industry provides a complex back drop in application of new concepts such as the water soft-path concept. The lack of pricing of water is a disincentive to adopt conservation strategies. There are economic instruments, such as pricing, that can provide motivation to industry to adopt such ideas. Historically, Canadian governments have been reluctant to use economic tools to motivate industrial behaviour. This tool is a lost opportunity and should be considered as a valid and excellent tool that supports and complements traditional regulatory and policy practices.

While pricing is not the only viable economic instrument, it was the most suitable instrument to examine given the scope of this research. A pricing structure such as The Water Value Gap illustrates the gap between current and best practices and the necessary steps needed to incorporate not just financial functions but incentive and environmental functions into a pricing structure. Pricing structures are implemented through regulation and policy. The following chapter discusses Canada's regulatory and policy framework as well as the gaps and opportunities for incorporation of innovative changes such as pricing structures.

CHAPTER V: REGULATION AND POLICY

5.1 INTRODUCTION

This chapter examines the second system of influence, policy and regulation, as it pertains to water management in the pulp and paper industry. Growing water quality and quantity concerns coupled with a greater demand for forest products in a global economy requires that Canada reconcile environmental and economic imperatives. As of yet, there are no comprehensive strategies in place to govern industrial water use. There is no framework in place for practitioners, industrial planners or bureaucrats to develop a sustainable water management system. Federal water law and policy currently provide a broad but weak framework for industrial water management. Provincial water laws such as allocation do not provide the structure or motivation needed to manage water resources in a sustainable manner. The absence of industrial water policy downplays the importance of the management of Canadian freshwater and the important role it plays in industrial processes today and into the future.

This research found an absence of industrial water policy and regulation, but in absence there is important opportunity. An adoption and shift towards innovative strategies governing industrial water use is the key recommendation to enhance a management system that could encourage the water soft-path concept.

5.3 BASELINE

There are three important documents that are meant to guide freshwater management in Canada. The Canada Water Act (1970) and the Federal Water Policy (1987) govern water use under federal jurisdiction. The third important document for the pulp and paper industry identified by the literature is the Environmental Effects Monitoring Strategy

(1996), governing water quality of discharged water. The following discussion of the documents identifies the opportunities provided for the soft-path concept.

5.2.1 The Canada Water Act

The Canada Water Act was proclaimed in September 1970. Catalyzed by pollution issues and water resource problems, it was heralded as the newest weapon against environmental pollution (Lenoski, 1972, 25). It was an act to "provide for the management of the water resources of Canada including research and the planning and implementation of programs relating to the conservation, development and utilisation of water resources" (Canada Water Act, 1970). The Act covered four main issues:

- A commitment to research and facilities including an inventory of federal waters, data and management plans (RS, c5(1st Supp),s4).
- Water quality management with the recognition that pollution is an increasing threat to the health of Canadians and their environment (RS,c5(1st Supp), s8)
- A commitment to co-operation between the Government of Canada and the Provincial Governments (RS,c5(1st Supp), s8)
- Requirements to ensure the legislation is followed (RS,c5(1st Supp), s8)

The Canada Water Act was placed into an area of overlapping jurisdiction because, at the time, the anti-pollution awareness was a national issue. The public awareness drove national initiative and support, as well as an attempt at federal-provincial cohesion (Lenoski, 1972). During the 1970s there was a proliferation of government initiatives due to public awareness. These initiatives underwent major financial cut backs during the 1980s, during a period of national economic recession (Averill and Whelan, 2000).

The Canada Water Act (1970) could potentially facilitate characteristics of the water soft-path concept. Within the Act (1970) there is a stated commitment to research and understanding of federal waters. The Technical Chapter of this thesis discussed the lack of data on industrial water use. The ignorance of water use in industry at the federal and provincial levels is a major barrier to understanding and facilitating sustainable water use.

An increased commitment to the water quality of this Act, a commitment to research and facilities, would increase knowledge satisfying the need for understanding of Canadian water and also facilitate better opportunities for the soft-path concept.

The second commitment addressed by the Act, water quality management, also holds promise for the soft-path concept. The literature review of this thesis discussed the tenets of the soft-path concept, including matching water quality with need. The purpose would be increasing grey water use or recycled water and reducing total freshwater intake in water processes. Addressing water quality management would provide a better understanding of water quality needs and discharge in industrial processes. Both water quality and quantity are important factors in product quality in the pulp and paper industry.

The third commitment addressed by the Act, greater cooperation between the Federal and Provincial governments, should be expanded to include municipal or watershed jurisdictions. The soft-path concept promotes a decentralized management system and control at the lowest appropriate unit requiring cooperation at many levels of government.

Finally, the fourth commitment, addressed enforcement of legislation, which is a necessary prerequisite to success of the water soft-path concept. Any new initiative requires, among many things, a strong legislative framework supporting the values and ideas within the soft-path concept. The successful implementation of any concept requires supporting strategies.

5.2.2 The Federal Water Policy

The Federal Water Policy of 1987 was progressive and included themes for sustainability, polluter pay, and water pricing. The ideas embodied in the document are highlighted in this statement, “We must now start viewing water both as a key to environmental health and as a commodity that has real value, and begin to manage it accordingly” (Federal Water Policy, 1987). It was a statement of the federal government’s philosophy and goals for Canada’s freshwater resources.

The policy recognized that water was one of Canada's most undervalued and neglected natural resources (Federal Water Policy, 1987). An emerging theme was the wise and efficient use of water through the idea of a fair value for water concept that respected provincial jurisdiction and international obligation. The policy was meant to recognize the dependence of a productive economy upon a healthy environment. The two goals of the policy were to protect and enhance the quality of the water resource, and to promote the wise and efficient management and use of water. The five strategies to implement the goals were: water pricing, scientific leadership, integrated planning, legislation, and public awareness.

The Federal Water Policy (1987) was very progressive in terms of moving towards sustainability in managing resources. As such, it provided the groundwork for what could be a significant leadership document for the implementation of the soft-path concept. Preventing achievement on this policy was the reluctance of government, at all levels, to follow through with strategies (Boyd, 2003). The reluctance on the part of the government to act creates a deadlock on environmental action, further influenced by serious financial cuts to the policy program.

The two leading Federal documents did not directly impact actions on water use by the Canadian pulp and paper industry. The Federal Water Policy (1987) and the Canada Water Act (1970) also lacks the ability to integrate and coordinate at the federal, provincial, territorial levels (de Loë and Kreutzwiser, 2007). The Environmental Effects Monitoring (1996) strategy was a Federal initiative to address water quality concerns in industry.

5.2.3 Environmental Effects Monitoring

The most significant federal strategy addressing industrial water management is the Environmental Effect Monitoring (EEM) strategy (1996). The EEM is a science-based tool that measures and monitors aquatic ecosystems for impacts from human activity. The objective of the pulp and paper EEM is to evaluate pulp and paper effluent on aquatic ecosystems. The information is meant to be used with social, economic and technical information to improve and enhance aquatic ecosystem protection (EC, 2005a).

This strategy is an important step towards fulfilling the soft-path concept. The soft-path concept considers ecosystem needs and health as an important value of water management. The EEM is considered to lay the groundwork to understanding the effects of pulp and paper effluent on the surrounding natural environment. The regulation still remains a process to understand effluent impact, an assessment tool, and not a remediation tool. The provincial and territories responsibility could address this further.

The three federal documents seem to be full of good intentions but fall short of targeting key challenges in water management. The Act and Policy fall short of acting like an integrated framework for a variety of water issues at all levels of government (de Loë and Kreutzwiser, 2007).

5.3 PROVINCIAL JURISDICITON

The division of power for the federal government, as was previously outlined, was quite distinct. The provincial and territorial responsibility of water is water as a natural resource. In Canada, various law doctrines are used such as riparian rights, prior allocation, civil code, and the authority management approach (Nowlan, 2005). In Ontario and the Maritimes water law was primarily based on riparian rights, where landowners whose property is adjacent to water had the right to reasonable use of it (Hughes, 1998; Nowlan, 2005). Prior appropriation, used in the West, assigned rights to water based on “first in, first right”. “First in, first right” means that subsequent users could use remaining water so long as it did not encroach on prior users rights. Civil code was used in Quebec, and the authority management approach used in the Territories (Nowlan, 2005). These law doctrines were important because they were the framework upon which all subsequent policy and regulatory provincial strategies are determined

The provinces had a diverse policy and regulatory framework across the country dictating water issues. These frameworks reflected the diverse issues the provinces and territories face (and continue to face) in water management. In British Columbia and Ontario, there were serious quality concerns such the Walkerton crisis (2000) and the Vancouver boil water advisories (fall of 2006). In Alberta and Saskatchewan, there were serious quantity concerns with major droughts, such as the three -year drought between 2001 and 2004. In Manitoba, there were also quantity concerns with major floods such as the 1997 Red River Flood. The regulations and policies that manage water use and allocation in provinces vary across the country (Table 6.1). The general trend found was weak allocation frameworks and ineffective water policy.

Without strong policy, the majority of provincial acts and regulations attempted to manage allocation and use based on prior allocation systems that fail to consider the complexity of water use. Provinces across the country had similar challenges that were, in some places, being addressed. Enforcement of existing legislation seemed to be a challenge and accompanied by unregulated industry and agriculture. Allocation systems were flawed providing inadequate knowledge of water use and needs. For example, in Ontario, provincial regulation, Renzetti (2005) argued, is fragmented due to the provincial division of authority between allocation (Ministry of Natural Resources) and protection (Ministry of Environment) of water. These two ministries have very different foci, promotion of resource exploitation and resource protection respectively. Source water protection was increasingly at the forefront of the agenda but geographical variation within provinces made strategies difficult to streamline. Table 5.1 highlights water policy framework, strategies and challenges of some provinces. The failure to recognize, by the Government of Canada, the complexity of water use and fragmented nature of regulation provided little incentive for industrial water efficiency.

Table 5.1: Outline of Provincial Water Policy Framework, Strategies and Challenges

Province	Policy Framework	Strategies	Challenges
British Columbia	BC Water Act, BC Water Act; Groundwater Protection Regulation, 2004; Drinking Water Protection Act, 2003	Water Conservation Strategy, 2001; currently a cohesive policy is being developed	Enforcement of licenses is suspect Policy initiatives from "Stewardship of the Water" (1990) discussion paper from government remain unimplemented. BC has highest number of 'boil water' orders in the country. Agricultural practices are relatively unregulated Major reduction in staffing and resources for MOE Weak methodology for address in-stream flow
Alberta	Water Act, 1996	Water for Life, 2003	Increasing water stresses from population, agricultural and industrial growth Extended droughts and concern over long term flow reductions due to impacts of climatic change
Saskatchewan		Long Term Safe Drinking Water Strategy, 2002; Green Strategy currently being developed	Significant geographic variation in water supply across the province No legislated requirement for source water protection
Manitoba	Water Protection Act, 2006	The Manitoba Water Strategy, 2003	Rivers experiencing record high flow levels but also with prairie droughts US/Provincial conflict over Devils Lake outlet
Ontario	Clean Water Act, 2005; Permit to Take Water Program; Ontario Water Resource Act, 1961	Currently no provincial policy or strategy	The Walkerton Inquiry (2002) has resulted in a major awareness of water issues in the province. Policy developments in quality but not quantity seem to be on the political agenda.
Newfoundland/ Labrador	Water Resources Act, 2002;		NF has one of the most comprehensive systems for permitting water use. Although there is no threshold quantity there is strict reporting requirements and fees for water withdrawals

Source: Adapted from the Walter and Duncan Gordon Foundation (WDGF, 2006)

For water soft-path adoption in industrial water use, the complex institutional barriers and challenges in provincial governments ought to be addressed. There was a complete neglect in provincial institutional bodies to address self-supplied or municipally supplied water. The major gap in industrial water policy found at the provincial level demonstrated complex challenges that were present at all levels of government. There was also no policy or regulation at the provincial level that addressed pulp and paper water use directly. There is regulation to address water quality of pulp and paper effluent at the federal level.

5.4 DRIVERS

To understand the challenges one must understand the drivers behind policy. The World Business Council on Sustainable Development (WBCSD, 2006) reported on the need for a wider framework citing five drivers for this change. People, planet, policy, past legacies and politics were major categories of drivers that contributed to the complex relationship of water management in business. The drivers should be considered by government officials. The success of any business is based on availability, cost and quality of water. There are five drivers: people, planet, policy, politics, and past legacy. All five drivers include complex factors within each shown in Table 5.2.

Table 5.2: Wider framework for dealing with the complex nature of water in industry

People	Planet	Policy	Politics	Past Legacy
• Population • Population growth • Urbanization • Trends in lifestyle	• Climate change • Biodiversity	• Need and willingness and capacity to govern	• Political leverage • Inadequacy to cooperate • Conflict between users	• Failing infrastructure • Poor pricing systems • Culture and attitudes of society

WBCSD (2006)

These drivers create the complex framework of policy. These drivers are what are required to base planning tools around. It is the drivers presented by the WBCSD (2006) that must be encapsulated into a long term industrial water use policy. The drivers identified in

Table 5.2 provide the framework in which all successful regulation and policy need to consider.

5.5 CHALLENGES

In a review of the literature and interviews with key experts in industry, government and non-governmental agencies, there was a distinct, almost irreconcilable divide between water management practices in industry and water regulation and policy in government. This divide was highlighted by the absence of water strategy for industry within all levels of government.

There was uncertainty of how to address water management challenged by an economically stressed industry. From an industry perspective, "Society views (from ENGOs, and others), economic considerations (i.e., making the right economic arguments for new action) as well as marketplace views, are bigger drivers for change" (CEO of Industrial Association, personal interview, October 2006). It was social and economic considerations and not government regulation and policy that drove change. A workshop led by a partnership of a Canadian environmental non-governmental organization and a national forest association in October 2006 highlighted the challenges to better understanding industrial water use Forest Sustainability Sector (FPAC workshop, 2006). These challenges were financial, coordination and lack of leadership. It also highlighted the result of lack of leadership from government. There was clear understanding and concern that something needed to be done but no one stakeholder had financial capability to take that role.

The historical backdrop to the Canadian pulp and paper industry is as old as the country. Canada's forests are a public resource and for the most part leased to industry. Only seven percent of Canada's forest are privately owned (May, 2005, 16). In theory, the leases should allow the Provincial governments to charge high premiums on Canadian forests or requiring strict cutting practices. Instead, in an attempt to "lure" foreign investment governments have made profitable arrangements for forest companies (May, 2006, 16).

Government arrangements have included: Long-term leases of over nearly 9 million hectares to Japanese companies; Newfoundland offers 99 year leases with no stumpage fees; New Brunswick leased timber rights for fifty years in 1913 with annual payments of three cents per hectare for the first year, and 1.5 cents per hectare for every year afterwards (May, 2006, 17). The high profit leases do not stop companies from pressuring government for better tenure agreements. The argument is that longer, more favourable tenure agreements make it more likely industry will be able to reinvest (May, 2006). Industry has management to push governments into these deals for fear of mill closures. The historical relationship between industry and government plays into policy formation not just economically but environmentally.

Vereijken (2006) pinpointed the failure of countries to put water concerns on mainstream political agenda, which is a prevalent oversight in Canadian politics. The lack of communication to the public and between levels of government resulted in a lack of a cohesive strategy for industrial water users. Contributing to the disconnection of the levels of government was the disengagement between scientists, social scientists, public servants, and politicians. This barrier was illustrated often in both federal and provincial legislation that failed to consider hydrological data and all users. In Ontario, allocation policy based on prior appropriation continually failed to consider all users and had no inability to accommodate changing users and needs (Kreutzwiser and De Loë, 2002).

The problem of disconnection between stakeholders explained the lack of current and available data on water, such as availability of groundwater and the status of aquifers. If decision makers in government did not understand the problems at hand, the problem was not given adequate funding. The last industrial federal water survey was conducted in 1996, was voluntary and relied on non-standardized reporting from industries across the country. Municipal data, while reported more frequently, were inconsistent in how water use was reported (total water use versus consumptive water use). Underlying these barriers was the way scientists and policy makers communicated such as vocabulary, culture differences, values, and ideologies in the science and policy silos (Taylor, 2006)

A consistent criticism, across the country, of policy development, both in the academic literature and the non-governmental sphere, was the continued enforcement of supply-side management rather than alternative management approaches. The entrenchment of paradigms and dogma was inhibiting an evolution in a water paradigm shift (Gleick, 2000; Brandes, 2005). For example, Canadian water reuse regulation entrenches supply-side paradigms. Canadian law mandates that wastewater must be treated as a serious substance requiring disposal, yet wastewater can be considered a valuable resource for recycled water or source of grey water (Boyd, 2003). This narrow range of legal tools that government relies on ensures reactive and not proactive policy (Boyd, 2003). As a CEO of an Industry Association (Interview, October 2006) commented, "without cohesive federal water policy federal initiatives are small and ineffective in addressing the problems at large". The lack of policy and leadership is very much a result of an attitudinal barrier. There is a perception of an abundance of water in Canada. There is also a misconception that the economy will address management but without a true pricing structure water is unaccounted for the business of the pulp and paper industry.

Without government leadership action has been driven by public concern. The rise of the environmental movement has had a major impact on all industries. In the pulp and paper industry, concerns really came to the forefront with water quality issues of the discharge of dioxins in the 1980s (Sonnenfield, 2002). The public attention encouraged industry to make operational changes yet concern continues regarding industry discharge and water use despite the effluent regulation from 1996. Christie and McEachern (2002) found that the pulp and paper industry are still the biggest users and polluters of water and suffer few penalties. The federal government still has no water policy regarding industrial water use and there is still a major institutional gap in incorporating environmental problems from the pulp and paper industry into policy.

As discussed previously, current policy and regulations serve to increase barriers to innovation enforcing the status quo of water use with under pricing, subsidies and barriers to reuse technologies. Twenty years since the Federal Water Policy was made public there is still no comprehensive way of managing allocation use in the larger system of a boom and bust economy.

5.6 OPPORTUNITIES

A shift away from reliance on new water supply and entrenched ideas and tools need to motivate policy change (Gleick, 2005; Brandes, 2005; WBCSD, 2006). As Brandes (2005, 5) stated, "Water is the strategic resource of the 21^{st} century". Literature suggests key elements to addressing the complexity of water management include: market mechanisms such as pricing (refer to Chapter V); capacity to collect data; and enhanced government capacity such as integrated water management and leadership (WBCSD, 2006; Renzetti, 2005; Averill and Whelan, 2000). These three broad elements are key preliminary steps for government to address in creating opportunity for the water soft-path concept.

5.6.1 Market Mechanisms

Market mechanisms such as water pricing are tools under-utilized by governments and could play an important role in managing industrial water use (Tate et al., 1992). Further discussion of under-pricing is in Chapter IV on market forces. Research suggests, despite the under-studied area, that Canadian industrial water management would be sensitive to market mechanisms (Renzetti, 2005). Government need to capitalize on this and lead initiatives to regulate and apply market mechanisms to self-supplied water user.

5.6.2 Data

A major barrier to water soft-path implementation is the lack of data on water availability and water use. Ninety percent of industrial water use is self-supplied (PRI, 2006a). Due to the self-supplied nature water use efficiency practices for industry have not been targeted by provincial conservation initiatives and therefore, little is known. The last national Industrial Water Survey was conducted in 1996 by Environment Canada. Between 1976 and 1996 these surveys were conducted every five years (Scharf et al., 2002). Capacity for data collection and understanding of water has been undermined by financial and staffing cutbacks such as the downsizing in the 1990s of Environment Canada, the disbanding of the Inland Water Directorate, and funding for cooperative agreements declined to zero by 2000 (Averill and Whelan, 2000). Yet, the *Pulp and Paper Journal of Canada* has been publishing an annual directory of mills across the country including information such as water consumption, use operating status, product capacity, and environmental certification since approximately 1875.

5.7.3 Holistic Water Management

The need to overcome institutional barriers and create a more holistic management approach is well understood by the federal government. In 2000, the proceedings of the government's roundtable on water held by the Public Policy Forum (PRI, 2006b) repeatedly made reference to the fragmented nature of water interests at the federal level. In the spring of 2006, experts at the Policy Research Initiative's “Freshwater for the Future” Conference reiterated the fragmented nature and lack of federal leadership (PRI, 2006b). Again, in 2006, a National Workshop Series on water policy in Canada was held by Pollution Probe and a key definition of the problem was made, “addressing the incredibly complex institutional mechanisms governing water is thus a significant challenge in achieving sustainable water policy” (Pollution Probe, 2006, 14). There is a continued need to overcome institutional barriers.

A more holistic approach would seek to integrate all water users (municipal, industrial, and commercial, self-supplied, municipal) under one management umbrella. This umbrella would encompass reconciling ecosystem needs and industrial needs. A holistic approach would also, as Broadley and Kinkhead (2006) suggested, include water conservation and water use efficiency as a goal within broader sustainable development goals and commitments of all jurisdictions (horizontally and vertically). The holistic approach could provide an opportunity to institutionalize the water soft-path concept in all management practices.

Two characteristics of this holistic approach would include the subsidiary principle and integration of users. The subsidiary principle matches authority over water to the appropriate jurisdiction. The subsidiary principle, in a nested governance structure, recognizes that in certain situations local people and institutions are the best jurisdictional authority to deal with local issues. To integrate users, the subsidiary principle in a nested governance structure would provide a framework for the necessary engagement of municipal, industry, business and other stakeholders. Boardley and Kinkhead (2006) suggested ensuring target setting, identifying alternative measures, formalizing commitments, finding innovating resource approaches and assessing progress for successful engagement. These characteristics, if adopted, provide a framework conducive to flexible, innovative concepts such as the soft-path.

5.8 CONCLUSIONS

As previously discussed, the pulp and paper industry is in a turbulent period. There is a need to satisfy a depressed industry as well as create an economically and environmentally sustainable industry. An analysis of the Canadian government's regulatory and policy framework reveals three important observations. There is a growing complexity of governing water. There is an increasing need to bridge the priorities of economic prosperity and environmentally healthy environment. Most important, the absence of industrial policy governing water management needs to be addressed. A primary recommendation of this research is an adoption and shift in strategies governing industrial water use toward governing strategies that included holistic water management, capacity for data collection and market mechanisms.

This shift would require deep changes to be made to policies that reject entrenched paradigms. An inclusive management approach that considers all users and all water challenges will provide a greater opportunity for a successful water soft-path approach.

This chapter discussed the framework of water policy and jurisdictional division to understand where the barriers lie and opportunities can be found for a shift towards a soft-path concept in industrial water management. The division of power and the competing interests of water users and environment, economics and industry create barriers to an effective regulatory government. The entrenchment of outdated methods has been compounded by few attempts to create a shift in water policy frameworks that promote conservation, innovation, water reuse, reduction and holistic water management. Vital to this shift is matching authority over water to the appropriate jurisdiction. A major bridging exercise needs to occur to reconcilable the divide between industry, water policy and water paradigms. Using an integrated water management approach for the pulp and paper industry requires each level of government to play a role but roles should be to support the management on the ground, in the watershed.

As a starting point for integrating the soft-path and over coming barriers unique to Canada market mechanisms need to be identified and utilized. There needs to be a shift away from entrenched ideas seen in water management. The subsidiary principle could be utilized with an upgrade in efficient industrial technology and data collection and dissemination needs to be upgraded and accountable.

Market force and policy and regulation are important factors in providing opportunity for adopting the water soft-path but ultimately there needs to be the technical capability for that advancement. Market forces, policy and regulation, and technology are tightly intertwined systems of influence that are dependent upon each other. The following chapter discusses the technological opportunities in the pulp and paper industry for water use conservation.

CHAPTER VI: TECHNOLOGY

6.1 INTRODUCTION

This thesis does not propose that technical solutions are the only solution to all resource problems, but technical advances need to occur for efficiencies in industrial process to be economically and environmentally effective. An analysis of current technology and advanced technologies shows that technology is not an obstacle to implementing conservation or soft-path strategies. There are technical advancements that allow appropriate quality process water and high recycling efforts.

Industry has made and continues to make great strides in technical improvements. Advanced technologies available at the time of this research included: integrated pulp and paper process; zero liquid; advanced membrane technology; and reuse technology. These technologies all reduced the quantity of water needed for the pulp and paper process. Despite reductions, water continues to be intrinsically linked to the pulp and paper process. This chapter discusses the role water plays in the pulp and paper processes and the technology used and available to reduce that role. The relationship between water quantity, water quality, and energy is discussed as these relationships are intrinsically linked to technical advances and water efficiencies. The next section is an analysis of the available water use data. Finally, new technology and scenario building is done with different rates of technical implementation providing different success for future goals.

It is important to understand the three relationships of water use plays in the industry. It provides services, particularly cooling. It is intrinsically linked to energy use because it requires energy to move any water brought into the industrial system. Water use is also intrinsically linked to water quality of the effluent being discharged at the end of the industrial process

6.2 WATER USE IN THE PULP AND PAPER INDUSTRY

6.2.1 Services

There are four main services provided by water in pulp and paper. Water is used in chemical make up, transport and management of material flows, material separation, and cooling (Boardley and Kinkhead, 2006; Browne et al., 2001; Scharf et. al, 2002). While water is used for the same purposes, it is important to recognize that there is not one uniform process used in the pulp and paper industry. The three pulping processes—chemical pulping, mechanical processing, and thermo-mechanical—all use water for the same functions but to varying degrees and efficiencies. Within these three pulping processes there are innumerable factors that affect water use such as the age of the mill, product being produced, climatic variability, water availability, and technological availability. A key factor that affects water use is energy use and energy efficiency in mill processes.

6.2.2 Water and Energy

Water reduction efforts are most often an effort to improve energy efficiency around the mill and operation costs. Much of the energy use in a typical pulp mill is for treating, heating and pumping water, so when water is conserved, reused or reclaimed, there are significant energy savings. Hellebust (2006, 11) explained the significant relationship of energy use and water: "Water is like hydrogen fuel in that it is not a source of energy but rather a carrier of energy…When assessing the efficiency of a service that water provides, the energy it took to put the water in that useful form must be stated". The same concept applies to the relationship of energy use and water consumption in pulp and paper mills. When done correctly, reducing water in a specific process increases the productivity of water and the efficiency of that process is increased and reduces the energy required to provide the specific service. Reducing energy costs is a major driving forcing in reducing water use (CEO of Industrial Association, October, 2006). Ultimately, a reduction of demand will reduce resource use and allow for important cost savings (Boardley and Kinkhead, 2006). Water recycling is one of the most effective efficiency measures in the industry (Vickers, 2001).

6.2.3 Water Quantity and Water Quality

Besides the linkage between water and energy, there is that between water quantity and quality. The relationship between water quantity and water quality is very complex. Pulp and paper mills produce more water pollution than almost any other industry (Christie and McEachern, 2000; Delphi Group, 2004). Water inputted into the industrial system needs to be accounted for at the end of the production, in the form of effluent. The Canadian government enacted in 1992 the *Pulp and Paper Effluent Regulations (PPER*), which implemented an environmental effects monitoring program as well as increased reporting requirements. This regulation attempts to control suspended solids, oxygen consuming waste and fish toxic substances. Currently, there is at least some type of primary treatment at mills across the country. Secondary treatment is prevalent but not universal and less likely to be found are tertiary treatment systems (Browne et al., 2001). As regulations on effluent discharge increase there will be more motivation for mills to move towards system closures and efficient technologies because those efforts are more economical than secondary treatment plants (Mill Manager, June, 2006). Pulp and paper mills' dependency on large volumes of water only increases a company's responsibility and concern for process quality of resource input and output (CEO of Industrial Association, October, 2006). This responsibility becomes a driver to reduce dependency on large quantities of water. The relationship between quality of water discharged and quantity of water used in processes is tightly entwined. If a mill successfully reduces effluent volume, it can face increased concentration of effluent toxicity that requires more costs for treatment.

6.3 WATER USE DATA

It is important to note that "product water" at different stages of the pulping process varies considerably. Generally, 30 - 40% of the pre-processed logs, wood, and chips are composed of water. During the pulping process water content of the pulp is about 50% water, which rises to 99% on the wet end of the paper machine. When the product is ready for shipping it has about 9% water (Environmental Manager of Canadian Mill, personal communication, June, 2006). Water consumed in a product is a key loss that should be considered in water conservation strategies.

Quantity of water used in the pulp and paper industry is highly variable and based upon many factors. Water is used in every process from chipping to paper making. Factors that influence the quantity of water include: the type of the process (i.e., chemical or mechanical); the climate; and the geography of the mill. Water-saving technologies also vary with respect to pulping type, processes, and age of technology, physical geography and weather. For example, water used for cooling processes is considerably reduced in the winter from the summer.

Throughout the literature there is a large range of data reported on water use, water consumption and gross water use. There were three explanations for the range: the variety of processes that impact resource use; inconsistent data collection methods; and terminology differences. Data varied by how it was measured (mcm/year; air dried tonne (adt) by tonne of paper or by tonne of pulp), and by what was measured such as water consumed, water productivity, and gross water use. Because there is no standardized reporting scheme in Canada what was measured by mills was sometimes unclear.

There is inconsistency in terminology used by sources to describe water data. "Water use" and "water consumption" are often used interchangeably in industry. The terms are used interchangeably because of difficulties of measuring water consumed (water intake minus discharge) (Key Paprican Research Expert personal communication, April, 2007). According to a key Paprican Research expert, water use reported by industry does not include recycled water. Inclusion of recycled water would give an enormous number due to the multiple cycles that occur with water before it’s discharged. For example, paper machines recycle water many times over before it is discharged. Despite the synonymous use of the terms "consumption", "use", and "intake", some industry-reported data were an order of magnitude larger than other reported intake data, such as was the case for water intake reported in 1996 for Rolland (21 900m^3/t) compared to intake reported by Skeena in 1996 (112.51 m^3/t) (Refer to Appendix B). By understanding the pulping process and the recycling of water, this datum was more likely to be gross water use rather than intake. More examples include, in 1996 St Anne-Nackawic reported consumption at 168.3 m^3/t and Kenogami reported 142.1 m^3/t for consumption (refer to Appendix C).

Data were gathered from the following eight key sources.

1. *The NALCO Water Handbook* (Kemmer, 1988, 30.3) presents data as "net water use" (also known as gross water use) measured in gal/ton (the conversion factor is gal/ton x 0.0042 for m^3/t). The range of net water use was 126 – 288 m^3/t mechanical pulping; 126 – 210 m^3/t chemical pulping; and 126 -188 m^3/t. Kemmer (1988) produced this second edition handbook for North American industries using data from through the 1980s.

2. Kroesa (1990, 7) reported water consumption (not total use) range as 42 – 63 m^3/t mechanical pulping; and 147 -189 m^3/t chemical pulping. This report was produced by Green Peace intended to educate society on the impacts and processes of paper production and draws largely on data from the late 1980's.

3. Friends of the Earth (FOE, 1996), which cited the Kroesa (1990) data, used the term water use and gave a range of 45 – 68 m^3/t mechanical pulping and 160 -205 m^3/t chemical pulping. It is unknown why FOE reported different numbers than Kroesa, but provides generalized global data for the 1990s.

4. Christie and McEachern (2000, 11) reported a chemical pulping process range of 60 – 100 m^3/t for water use. The report produced by Christie and McEachern (2000) pertains specifically to Canadian mills and refers to data from 1996.

5. A report for the Canadian Council of Ministers of the Environment (CCME) by Kinkhead and Boardley (2006) differentiated terminologies. It uses "water conservation" and "water efficiency" interchangeably to describe actions for reduction in water loss,

waste or minimizing water used. Water use productivity is another term used in the report, defined as “water used to produce one unit of any good or service, e.g. m^3/tonne or m^3/$1,000 of shipment value. The lower the water input required, the higher the productivity" (Kinkhead and Boardley, 2006, 153). Water use of a Kraft mill (chemical pulping) with once-through cooling ranges from 55-90 m^3 per air dried tonne (adt) of product (Kinkhead and Boardley, 2006, 109). Mechanical pulping water use ranges from 6-20 m^3/adt (Kinkhead and Boardley, 2006, 109).

6. *The Pulp and Paper Journal of Canada* had the most data. The directory has been published for 133 years (Personal Communication, Pulp and Paper Journal manager April, 2007). It included data of mill, contact information, water use, source, production capacity, and environmental certification. Data were collected by surveys sent to mills. Four directories were selected to gain a range of water use: 1980, 1982, 1996, and 2007. The older volumes were selected based on availability, 1996 was selected because it could be cross-referenced with the Industrial Water Survey (2002), and 2007 was the most recent directory available. Data were reported in a variety of volume units including US gallons, litres, and metric tonnes, and time units of minute, day and years. All data were converted into cubic meters per tonne of product. In these directories "water consumption" and "water use" are used interchangeably (Paprican Researcher, personal communication, 2007). Response rate for the 2007 directory was approximately 75%. Of the 111 applicable mills to this research only 36 reported both water use and production capacity.

7. Data for two mills were received from interviews. One tissue production mill withdrew only $15m^3$/t and was one of two world-wide to withdraw so little for that product. The average identified in the research for tissue production is 40 – 150 m^3/t. The second mill reported 6.6 m^3/t water uses for a semi-chemical pulping process. Both mills cited best business case as motivation for water efficiency (Superintendent Ontario Mill, personal communication, June 15th, 2006). Both these mills provide examples of what is possible if the systems of influence play into water conservation.

8. FPAC (Forest Products Association of Canada) provided data collected from members (20 companies across Canada). There was a 90% response rate to the water use survey that was completed annually until 2001. Water consumption was reduced 34% from 1989 to 2001 FPAC (2004, 1). It is believed that reductions were being achieved through adoption of new technologies and manufacturing processes that permit recovery and reuse of process waters, and through tighter process controls and improved maintenance (CEO of Industrial Association, October, 2006).

Figures 6.1 to 6.3 show the water intake and consumption range of the three pulping processes, plotted against the years for which the data were reported. Due to the irregularity of the data reported over the years there is not consistent number of data point for either years reported or consumption versus intake. The data for these figures are provided in Appendices B and C.

Figure 6.1: Water Intake and Consumption for Mechanical Pulping Process

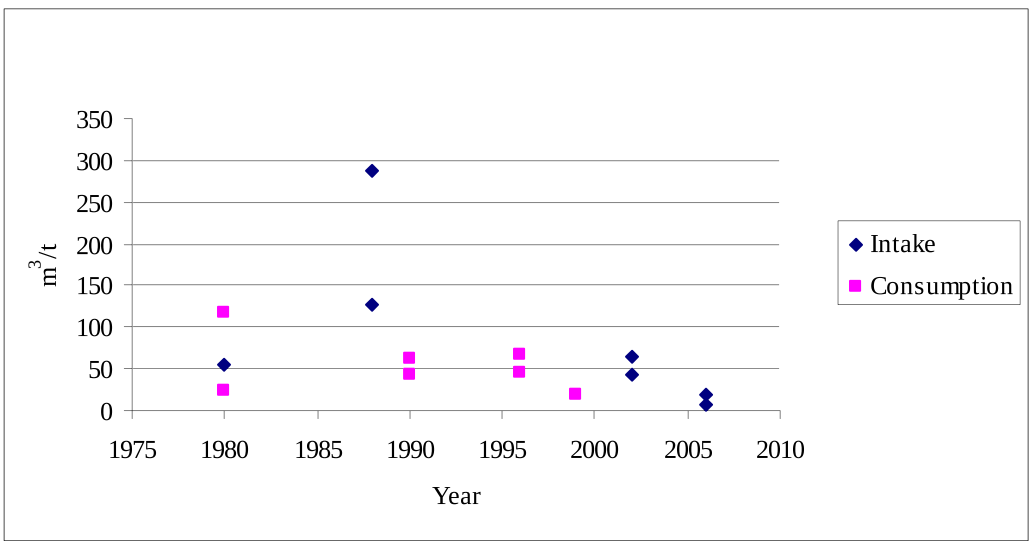
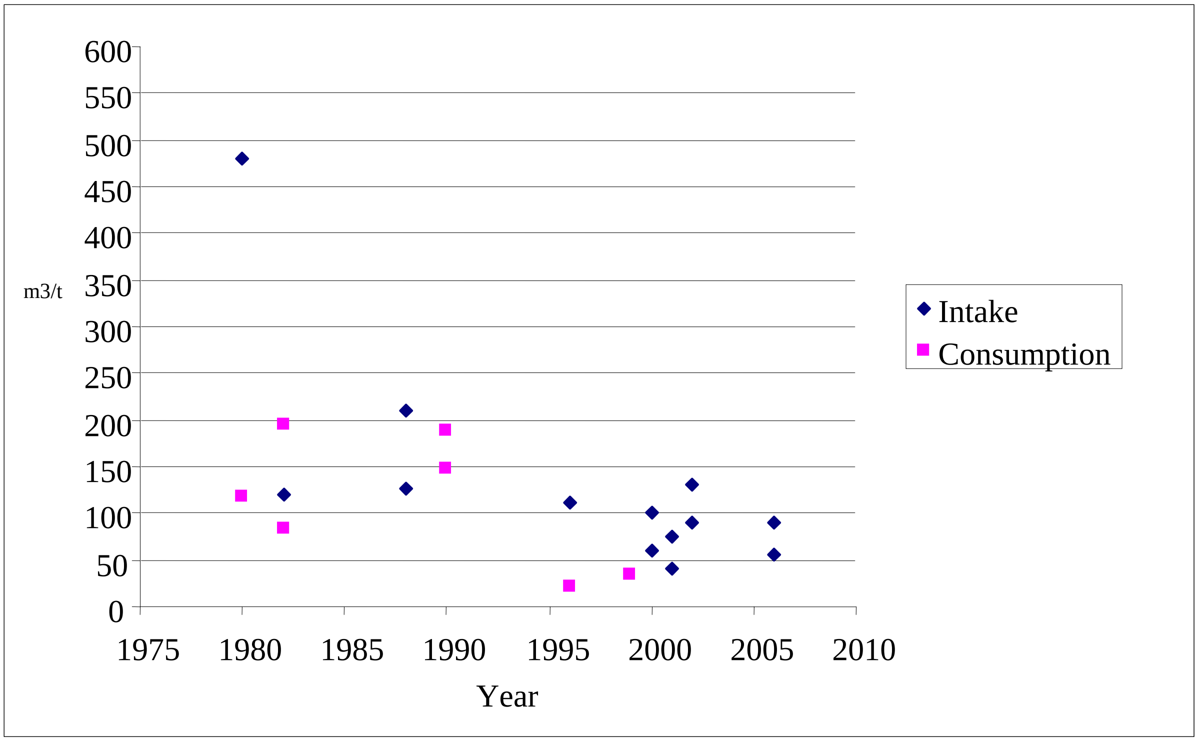


Figure 6.1 shows a slow but steady decline in both water intake and water consumption in the mechanical pulping process.

Figure 6.2: Water Intake and Consumption for Chemical Pulping



In Figure 6.2 a similar decline in water intake and consumption as in the mechanical pulping can be observed. The decline is not steady but the overall trend is towards less water use over time.

Figure 6.3: Water Intake and Consumption for TMP Pulping

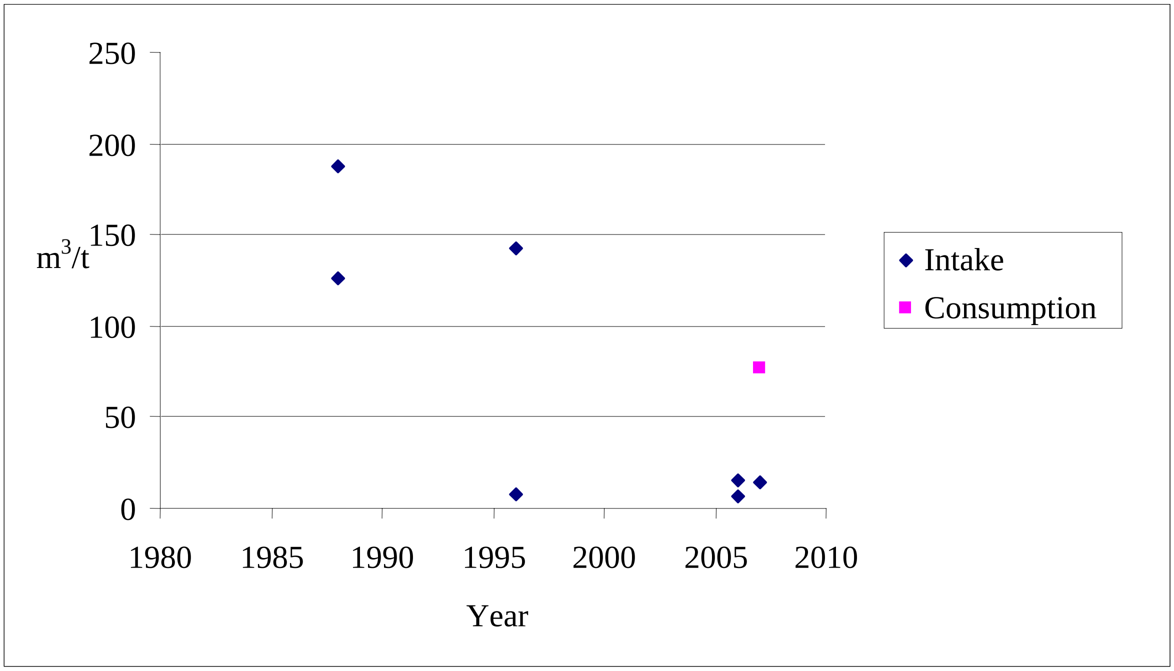


Figure 6.3 has fewer years reported because TMP is a newer pulping process that is replacing mechanical mills. The large range found in 2007 is the first year where a large number of TMP mills reported water intake or consumption data. Overall, the trend is decreased water consumption and intake as was the case in the mechanical and chemical pulping processes

6.4 BEST PRACTICES

As discussed, there are external factors influencing conservation efforts beyond technology. Technical changes in processes occur as a means of reducing capital or operating costs for water supply or effluent treatment, improving energy efficiency, or expanding production (Browne et al., 2001. The nature of these pulping processes does require more water than the mechanical process. Serious considerations of the implementation of water efficient technological advances are motivated by reducing energy costs and resolving the water quality and quantity issues (Stratton and Gleadow, 2003).

Best practices are important to reducing total use and improving quality of discharged water but vital to these processes are water quality of process water. It is important that any process has “good kidneys” for quality of product (Environmental Manager, May, 2006). Both reverse osmosis and advanced membrane technology work as highly evolved water purifiers to maintain quality levels of process water. Another major thrust towards improving efficiencies was the improvement of the total chlorine free (TCF) bleaching sequence (Environmental Manager, May, 2006).

6.4.1 Closed Loop System

Closed looped systems are closed because of the recycled wastewater and the opportunity to reduce systems input. The history of closed loop systems dates back to 1934 with the development of a recovery furnace. In 1967 the Rapson-Reeve process aided the evolution. It is a collection of technologies used to integrate the chemical input and recovery processes. It was to be “a cost-effective alternative to biological wastewater treatment facilities" (Stratton and Gleadow, 2003), 7). This process was implemented in Thunder Bay for several years but due to the infancy of the technology it still had process problems so the closed loop was reopened. The technical advancement did facilitate an opportunity for further improvements. Closed loop systems required superior process water control to maintain quality of available water (Browne, 2001). Often, companies invest in close loop systems to avoid effluent charges, allow for higher water temperatures while avoiding water loss from evaporation, and reduce dependency on fresh water supply (Browne, 2001). Some water will always be lost to evaporation but it can be as low as 2 cubic metres per tonne of pulp (Christie and McEachern, 2000)

Domtar’s Trenton mill in Trenton Ontario is one of the first closed loop processes in North America. The process was based on evaporation technology but also includes a paper machine and chemical pulping process. Research began in 1990 on the process of closing the system. The process water containing unrecovered wood solids is evaporated and the condensate is returned into the process while the water is recovered and used again (Rodenn, 1997). The company found a used evaporator body that would allow for the system to be closed in a relatively easy manner. The mill continues to draw from the Trent River for cooling systems, steam boilers and a slight amount to make up for evaporation losses. From surveys conducted, it was found that with the closed loop system the mill can use municipal water, is not required to have a secondary water treatment facility, and water intake is as little as 6.6 m^3/tonne of pulp (Mill Superintendent, personal communication, June 15th, 2006) double check interview notes

6.4.2 Zero Liquid Effluent

In an effort to reduce dependency on freshwater supply and reduce water quality concerns, significant research has occurred in the area of zero liquid effluent (ZLE) process. It is essentially a modified thermo-mechanical process with a highly technical bleaching system (Boardley and Kinkhead, 2006). The world's first successful ZLE mill was reported to be the Millar Western Meadow Lake mill in Saskatchewan developed in 1992.

This technology has both economic and environmental benefits .The major drivers for the system's closure and use of advanced technologies were to increase wood-fibre recovery and to conserve energy, which in turn would reduce water use. This mill, in a globally, economically competitive industry made choices that were both environmentally and economically sound. While reducing production costs the ZLE process uses ten times and forty times less water than thermo-mechanical and chemical pulping respectively. The process produces 60% more pulp per tree than the chemical pulping process (EC, 2005b).

6.4.3 The Ideal Mill

De Choudens and Lachenal (1999) identified the following characteristics in the ideal mill: zero effluent; no impact on the environment; low exploitation costs; high capacity; low investment per tonne of pulp; and high quality of product. Most importantly, this futuristic mill would produce electrical energy, and the only water entering the mill would be for cooling water and not for process. Ideally, the process water would be reduced to water from the wood, and would leave the mill in clean steam and condensates (De Choudens and Lachenal, 1999).

> "A bleached Kraft pulp mill, located in a paper complex, at the beginning of the next century can be described e.g. in the following way. Seen from the outside, a thin steam gets loose of the caustification with a light typical sulphuric odour. Without this imperceptible odour, it is impossible to affirm that we are in a pulp mill. However, 4000 tonnes of bleached Kraft pulp is produced each day from three wet laps." (De Choudens and Lachenal, 1999, 18)

This picture painted by De Choudens and Lachenal is available with today's technology and best available technologies. Some basic process improvements would include:

- dry debarking
- segregation and counter-current reuse of paper mill process waters
- use of thickeners or presses prior to pulp drying
- cooling water collection and reuse
- enhanced liquid storage to balance process water requirements and prevent intermittent overflows of process waters
- installation of more efficient pulp-washing equipment

Further improvements to chemical pulping are:

- high efficiency brown-stock washing and screening
- improved spill controls
- steam stripping and reuse of all pulping condensates
- cooling water collection and reuse
- digester-extended and/or oxygen delignification process to bleaching
- elemental chlorine free or total chlorine free bleaching with alkaline filtrate recycle

With these basic process improvements the following productivity targets could be made:

Integrated mills - 12-20m^3/adt

Mechanical or Chemi-mechanical - 15 – 20 m^3/adt

Zero Effluent mills - 2 m^3/adt

Bleached Chemical - 30-50m^3/adt

Unbleached Chemical – 14 -25 m^3/adt

(Boardley and Kinkhead, 2006, 110)

6.5 CONCLUSION

This chapter discussed the intrinsic linkage between water quality and water quantity and energy in the pulp and paper industry. Water is an integral part in the pulp and paper industry. Water plays a role in transport, cooling, and material separation. Water is also very much linked to energy consumption in the industrial processes.

The pulp and paper industry is the largest industrial user of water but seeks to reduce water use to reduce capital costs of infrastructure, energy costs, or because there is a strain on availability (Paprican Researcher, 2007). Over the past 27 years gross water use, intake and consumption have all declined. These declines have happened for a variety of reasons: the type of the process (i.e., chemical or mechanical); the climate; the geography of the mill; water saving technologies; and age of technology.

Review of process and technology shows the decline in water intake, gross water use and consumption has been occurring, but the inconsistencies in reporting and data make truly understanding water use in the industry difficult. The difficulties in the data, as well as the poor reporting mechanism have greater implications for policy, regulation and long term industry planning. Without a thorough understanding of water use within a watershed makes larger water planning difficult and unreliable.

Industry is and will continue to develop new water conservation technologies that will ideally seek to continually reduce water need in the industry. The success of these improvements will be uncertain as long as reporting and inconsistencies continue.

CHAPTER VII: CONCLUSIONS

7.1 INTRODUCTION

Industrial water use is very much an understudied area in Canada. Given the role of pulp and paper mills in water use and quality concerns there is a surprising gap in knowledge. To examine the application of the water soft-path concept in industrial water systems two research questions were asked:

1. What are the prevailing conditions in market forces, policy and regulation, and technology that influence the Canadian pulp and paper industry decision-making framework?
2. What are the barriers to, and opportunities for, introducing a soft-path approach to water management in pulp and paper mills?

This research was conducted in two parts. First, to understand opportunities and barriers of a new concept one must first understand the prevailing conditions that influence the decision-making framework of the subject. The prevailing conditions of technology, market forces, and policy and regulation were studied to answer the second research question about barriers and opportunities. Ultimately, this research provides a necessary understanding of influences on the broader decision-making framework in the pulp and paper that impact water management decisions and opportunities.

This chapter has been divided into three main sections: results, further research and recommendations, and the concluding remarks.

7.2 RESULTS

There are major themes that can be drawn out of all three systems of influence that overlap each other. Technology, market forces, and policy and regulation do not operate in isolation but together impact the broader decision-making framework. Market approaches can complement regulatory frameworks, while similarly regulation has to go beyond technology because there is not a "one size fits all" approach for example, technology is available for a highly water efficient mill but the economics of water do not make it that cost effective nor is there a policy or regulatory framework to require it. There are many factors affecting the decision-making framework of water use in mills. These many factors create the complex environment in which decisions are made and industry and communities exist.

This research has:

- built on and expanded the literature on water soft-path and water management paradigms;
- built on industrial water pricing literature; and,
- striven to understand the interdisciplinary nature of systems working alone and simultaneously together to understand how the broader world operates.

7.2.1 Inter-System Findings

There are two key barriers found in the market system for the water soft-path concept. First, the market is a complex system within which the pulp and paper industry finds itself. In the midst of a bust period for mills across the country economic efficiency is at the crux of the decision-making framework. Secondly, the current regulatory and policy environment does not place a high value on water and therefore water is not a major operating cost for industry. As long as water is not a major operating cost and the decision-making process is still based on market efficiencies, there is little incentive for mill operators to seek out and adopt conservation methods such as the water soft-path concept.

There is a hidden subsidy provided by governments in access to free or little cost for water. Pricing water and a regulatory regime to accompany it would provide incentive for mills to reduce water use, account for the non-monetary value of water, and increase initiatives toward energy and pollution reduction. Energy and quality are intrinsically linked to water use and initiatives would have secondary benefits to these factors. Under the current economic regime, pricing should consider, as a first step towards linking the importances of water in the industrial process.

The freshwater resources in Canada are increasingly degraded and scarce in many regions. The market system must evolve to increase incentives and include environmental costs in business. Economic instruments continue to be an underused tool to initiate behavioural change by industry. To initiate desired behaviour, pricing of externalities has been proposed as a method to bridge the environmental and economic imperatives in the decision-making framework. The misconception that water conservation will have negative economic impact may be one of the most important impediments to moving towards a more comprehensive understanding of water systems. The belief that water efficiency and reduction of quantity used will lead to economic decline both in industry and in water supply agencies has been disproved first with the decoupling of energy use and economic growth and later with other natural resources such as water (Baumann et al., 1998; Lovins, 1977; Gleick, 2000).

The pricing structure referred to in this research was developed by Renzetti (2005) and incorporates a water value cost. By incorporating a value cost one can motivate adoption of conservation efforts such as the soft-path concept. Economic instruments and pricing structures are opportunities available to be used but adoption must take place at the regulatory and policy level. Many researchers have argued that water users do in fact respond to price, and demand patterns fluctuate in response to price changes (Baumann et al., 1998; Renzetti, 1999; Tate, 1985). As discussed in Chapter VI technology is available to allow companies to reduce water use in response to a pricing structure. Industry has also supported the trend towards super-mills citing an increase in capital for upgrades and technical upgrades as a key feature in the trend (FPAC, 2006a; Conference Board of

Canada, 2007). If mergers of large companies would in fact result in larger capital stocks, technical upgrades to reduce costs of water pricing could be implemented.

Table 7.1 provides a summary of the barriers and opportunities for market forces in applying the water soft-path concept.

Table 7.1: Summary of Market Forces Barriers and Opportunities

Barriers • Industry is in major economic upheaval • Distinct lack of economic value placed on water Opportunities • Trend of major mergers • Pricing structures available

7.2.2 Regulation and Policy System Findings

To bridge economic and environmental imperatives one must also bridge regulation and policy with market forces. As discussed in the results of Chapter V, in Canada there has been a historical resistance by government to use market tools to change behaviour of industry. The absence of market tools is matched by an absence of industrial water policy or framework to guide water use. Various regulations at the provincial level are slowly trying to implement changes that will cause a better awareness of water use.

The lack of regulation and policy for practitioners, industrial planners or bureaucrats also leaves a requirement for a framework to develop a sustainable water management system and guide the decision-making process for water use. Most alarming, the absence of industrial water policy downplays the importance of the management of Canadian freshwater. The inaction demonstrates a lack of concern of the important role water plays in industrial processes.

Competing interests in public policy fields, the division of power in government, and the nature of water are all barriers identified to the creation of water policy. The jurisdictional division also creates fiction. The division of power and jurisdictional divide creates barriers in implementing important regulation such as pricing. While pricing structures, such as suggested in this thesis, provide great benefits will not be implemented until the problems of jurisdictional power are resolved. These barriers also contribute to the inability to implement concepts such as the water soft-path.

There are strategies that would encourage water soft-path adoption. A shift away from reliance on new water supply and entrenched ideas and tools needs to motivate policy change, for example a shift from supply-side to demand-side management and water soft-path concepts. Part of this shift needs to incorporate a systems approach versus the historical silos approach that compartmentalizes a complex issue. Five key drivers to consider as a precursor to policy change (people, planet, policy, politics and past legacy) were discussed in Chapter V. Table 7.2 provides a summary of the barriers and opportunities for the water soft-path in policy and regulation.

Table 7.2: Summary of Policy and Regulation Barriers and Opportunities

Barriers • Lack of industrial water policy framework (self supplied or municipal supplied) • Water issues not on the political agenda • Disconnect between science and policy • Under use of economic instruments • Lack of leadership
Opportunities • Innovative strategies (water resources challenges, social acceptance, interconnectivity) • Market mechanisms • Data reporting, collection and dissemination • Holistic water management

7.2.3 *Technology*

This thesis does not propose technical solutions as the one approach to all resource problems, but technical advances need to occur for efficiencies in industrial process to be economically and environmentally effective. An analysis of current processes as well as advanced technologies shows that technology is not an impediment to implementing a water soft-path management framework in the pulp and paper industry.

The technological system looked at where and how water was used as well as infrastructure and efficiencies in infrastructure. Water is used as a service, such as to transport material, and to clean and wash. Water is intrinsically linked to energy use, which is a major operating cost. Water use is also intrinsically linked to water quality. Effluent discharge potency is linked to the amount of water discharged with effluent.

Water use within the mill process is affected by many factors such as climate, water availability, season, and technology. All these factors affect how much water is used and creates the range of water use seen across Canadian pulp and paper mills. Despite the range and factors impacting water use there continues to be a downward trend in water use, in part due to technological advances. The downward trend in water use clearly indicates opportunity for a conservation ethic scenario and application of the water soft-path concept using advanced technologies.

The review of technologies in the pulping process show great advances in efficiencies. If technological implementation was the only factor in water efficiency a conservation ethic scenario could be reached with a retrofit program and regulation for new mill buildings. Technology, however, is not the only factor driving water use. A barrier to addressing water use beyond a technical level is the lack of data on water use in mills.

Knowledge of Canadian industrial water use is incomplete. There is a lack of understanding of self-supplied users. There are few data reported on water use in the pulp and paper industry and little government action to govern water use of industrial users. This gap in knowledge hinders the impetus for technical development.

The Government of Canada requires no reporting of water use, self-supplied or otherwise. The last industrial survey was conducted in 1996 and provided a broad picture of water use for the manufacturing group “paper and allied products”, which includes lumber, recycled forest material, as well as pulp and paper. As such, neither the Canadian Government nor the provincial governments have consistent data on water use, withdrawal, consumption or discharge in pulp and paper mills across the country.

Data that are reported have no standardized method. Data, if reported, can be in a variety of units such as imperial gallons, American gallons, litres per tonne, cubic metric tones and so on. There also seems to be no consideration when reporting water use to differentiate between water use, total water use, water consumption and recycled water. This lack of consistency makes it extremely difficult to make substantial claims about current water use in pulp and paper mills and forecasting of mill use.

Neither the Government of Canada nor the Provincial Governments collected water use data and what data were collected were published infrequently, with great secrecy until published. The *Pulp and Paper Journal of Canada*, on the other hand, publishes an annual directory of pulp and paper mills from across the country. This directory includes production capacity, water use, source and other pulping information. There is an apparent disconnect between industries ability to collect and publish data and governments seemingly inability to uptake, use or disseminate this information.

Key recommendations to consider for improving knowledge of water use in the pulp and paper industry include the development of standardized reporting methods. The Government of Canada should begin a reporting program for self-supplied and municipal water users, with standardized definitions and standards for frequency and consistency of reports.

Table 7.3 provides the key barriers and opportunities to applying the water soft path in the pulp and paper industry.

Table 7.3: Summary of Technology Barriers and Opportunities

Barriers

- Gap in knowledge of Canadian industrial water use
- Lack of understanding of self-supplied users
- Little data reported on water use in the pulp and paper industry
- Little government action to govern water use of industrial users.
- No standardized reporting method

Opportunities

- Opportunity through energy reduction and climate change adaptation strategies.
- An overall downward trend in water use and water consumption in all pulping methods
- Technologies are available to greatly reduce water use and consumption
- Technologies being implemented and are both environmentally and economically successful.

7.3 FURTHER RESEARCH AND RECOMMENDATIONS

This research addresses the important drivers for change in the water management of pulp and paper mills. This work addresses the systems of influence as they relate to the opportunities and barriers to implementing the water soft-path concept. While it provides to a small body of literature on Canadian industrial water use much more is needed to understand the complex problems.

7.3.1 Research

The literature suggested that corporate culture comprises considerations of technology, market forces, regulation and policy. Corporate culture is a thread through all the systems of influence and greatly impacts the decision-making framework of industry. Further research in the pulp and paper industry is needed to completely understand the complex role corporate culture has on the decision-making framework as well as its role with systems of influence identified in this research.

Further research on economic modelling for industrial water pricing specific to the pulp and paper industry would be beneficial for understanding the implications for consumers and industry. As well, water pricing must be accompanied by a policy and regulatory regime to support well documented and holistic water management

Finally, further research into a comprehensive understanding of the water withdrawals by mills across the country would contribute to a better understanding of industrial water use, self-supplied users, and could contribute to a better understanding of watershed water systems.

7.3.2 Government

Water issues are increasingly coming to the forefront of Canadian consciousness. An integrated attempt to understand how all sectors of Canadian society use water and impact other sectors is needed. Governments at all levels need to show leadership by putting water use and other water issues on the political agenda. There is a growing body of literature on Canadian water policy but, without government leadership the move from literature to action will be slow and cumbersome.

Government leadership could be provided to ensure better reporting capacity for industrial water-use data. Water use data of both self-supplied users and municipal users needs to be understood to approach water management with all the information. The capacity to collect data as well as disseminate them needs to be greatly improved. Standardized reporting mechanisms are needed specifically for the industry.

Finally, Canada is in desperate need of an industrial water policy and framework in which to put water issues on the political agenda, connect science and policy and report data. Without a framework there are no operating rules in which to manage water resources. Backcasting could provide that framework. Backcasting provides a goal and coupled with the soft-path concepts is a framework to structure efforts within.

7.4.3 Industry

Business must look beyond the next quarter, to the 20 – 30 year future endpoint suggested by the water soft-path approach. A 20 – 30 year business plan is a difficult shift from current short-term business plans that are used.

To aid data collection, reporting and dissemination, industry needs to have standards for reporting including definitions for water use categories and standard reporting units.

Industry needs to engage communities on water issues and promote and develop clear goals and targets for water use. Calculation of water budgets is one way of helping to develop goals. Industry, government and communities can develop audit programs to help implement the soft-path approach. Alternatively, water soft-path goals can be written into pre-existing industry environmental targets such as ISO 14000. By including water use goals in accepted environmental standards it will ensure community trust and legitimize the industries efforts.

7.5 CONCLUSION

The purpose of this study was two fold. First, this research was meant to gain a better understanding of influences within which the Canadian pulp and paper industry works and how those influences impact the decision-making framework. Secondly, the thesis explored how the decision-making framework formed barriers and opportunities to the water soft-path concept.

Environmental, economic and social imperatives can no longer be seen in isolation from each other. Canada has a long history of dependency on natural resources. Hundreds of communities across the country are dependent on the forest industry. It is fundamental that we examine ways in which to accommodate all imperatives to ensure a healthy Canada for all.

Canadian water concerns and industrial water concerns have challenges that need to be addressed. This research contributes to those challenges and attempts to inform a broader management strategy for Canadian water use. By examining broader systems of influence on decision making frameworks it allows more informed analysis on the application of opportunities in water conservation, for everything is interconnected.

APPENDIX A: SURVEY ON WATER USE

SURVEY ON WATER USE

Company Name:

Respondents name:____________ Respondents position: ____________

Respondents Contact information:

Date:

1. What pulp and paper manufacturing processes are used in the company's operations?
2. What products does the mill produce?
3. How long has the mill been in operation?
4. How much water is withdrawn yearly for mill processes? Is there seasonal variation and if so, why?
5. How much water is returned, consumed and recycled in the mill processes (approximations are fine)?
6. Is mill water self-supplied or from a municipal source?
7. Is the company charged for water withdrawal, treatment or discharge?
8. Does the company have ISO 14000 certification or any other environmental management certification?
9. What level of water treatment system is in place at the mill?
10. Is the mill or will it in the future be required to request a Permit to Take Water?
11. What other environmental regulatory requirements are required of you by the Ontario or Federal government that monitors water use?
12. Additional Comments:

APPENDIX B: PULP AND PAPER JOURNAL ANNUAL DIRECTORY: WATER INTAKE AND CONSUMPTION DATA

Company	Pulp process	Production Capacity	Water	Consumption/Gross Use		m3/t
		tonnes/year	AS REPORTED	Intake	M3/YEAR	
1980						
Mississauga Mil	Mechanical	92710	1.5 millgpd	consumption	2299500	24.8
Wayagamack Division	Chemical	95685	30 000MgD	intake or gross?	45990000000	480.6
Tahsis Co	Kraft Bleached	230000	112500m3/d	consumption	41062500	178.5
Trenton Mill	semi-chemcial	73000	700musgpd	consumption or gross use	970900000	13300.0
Esponola Division	chemical	37885	30Mgpd	consumption	45990000	1213.9
QNS Paper Compang	mechanical	510970	39 mill gpd	consumption	59787000	117.0
Rayonier Quebec	chemical	260000	30000mgpd	gross use	45990000000	176884.6
St jerome Mill	mechanical	111325	4000000gpd	intake	6132000	55.1
Total Mills:	8	Mech. Consumption: 24.8 - 117.0				
Chemical:	5	Mech. Use: 55.1				
Mechanical:	3	Chem. Consumption: 117.0 - 1213.9				
TMP:		Chem. Use: 480.6				
1982						
Belgo Divisin	mech.	343797	18 mgpd	consumption	27594000	80.3
Wayagamack Divisin	Chem.	381425	30 mgpd	intake	45990000	120.57
East Angus	Chem.	144377	15 mgpd	consumption	22995000	159.27
Trenton Mill	TMP	143080	800M usgpd	gross use	1109600000	7755.10
Espanola Divisino	Chem.	545675	30 Mgpd	consumption	45990000	84.28
Manitoba Forestry	chem	137423	10000mgpd	use	15330000000	111553.01

QNS Paper	chem	498979	39 mgpd	consumption	59787000	119.82
Nackawic	chem	212000	27mgpd	consumption	41391000	195.24
Tahsis Co	chem	230000	112500m3/day	consumption	112500	178.53
Total Mills:	9	Mech. Consumption: 80.3				
Chemical:	7	Chem. Consumption: 84.3 - 195.2				
Mechanical:	1	Chem. Use: 120.5 - 111553.0				
TMP:	1	TMP Consumption: 7755.1				
1996						
Papetierie Alma	mech.	278158	16000 mgpd	gross use	24528000000	88180
Kenogami	TMP	219000	20.3mgpg	consumption	31119900	142.1
Alberta-Pacific Forest	chem.	500000	90000m3/d	consumption	32850000	65.7
Trenton	TMP	237250	1.4 musgpd	consumption	1941800	8.2
Espanola	Chem.	438000	32mgpd	consumption	49056000	112
Edmunston	chem	546405	11 mgpd	consumption	16863000	30.9
Irving	chem	310000	29 mgpd	intake	44457000	143.41
Newsprint Div.	chem	200000	40000m3/d	consumption		73
			14600000			
Meadow Lake	chem.	292000	1400L/min	gross use		2520
			735840000			
Whitecourt	chem	210000	12000m3/d	consumption		20.85714286
			4380000			
Pulp Operatins	chem	547500	150000m3/d	consumption		100
			54750000			
provincial papers	chem	160000	17200usMgpd	intake		149.1025
			23856400			
Baie	chem	555000	31mmgal/d	consumption		85.63
			47523000000			
Rolland	chem	140000	2000000gpd	use		21900
			3066000000			
Skeena	chem	492750	40000000USdal/d	use		.112.59
			55480000000			

Soucy	TMP	456250	3.1Mgpd	consumption		10.46
			4752300000			
St Anne-Nackawic	chem	245900	27Mgpd	consumption		168.3
			41391000000			
Belgo	TMP	329540	18milgpd	consumption		83.8
			27594000000			
Wayagamack	TMP	174200	80000m3/d	Intake		167.6234214
			29200000			
Stora Forest	chem	183698	100000m3/day	consumption		198.6956853
			36500000			
Total Mills:	20	Mech. Use: 88180				
Chemical:	14	Chem. Consumption: 20.9 - 2520				
Mechanical:	1	Chem. Use: 112.6 - 21900				
TMP:	5	TMP Consumption: 8.2 - 142.1				
Data from the 1996 Pulp and Paper Annual Directory Pulp and Paper Journal of Canada special edition						
	WATER USE = WATER INTAKE					

APPENDIX C: WATER INTAKE AND CONSUMPTION DATA CONTINUED

Source, Date	Mechanical (m3/t)		Chemical (bleached, kraft)(m3/t)		TMP (m3/t)			
Kemmer, 1988	126	288	126	210	126	188	net water use m3/t	
Kroesa, 1990	42	63	147	189			water consumption	
FOE, 1996*	45	68	159	204			water consumption m3/t	
1999		20	35				water consumption m3/adt	
Christie and McEachern, 2000			60	100			water use m3/t	
Paprican, 2001			40	75			total water use m3/adt	
Tembec, 2002	43	55	90	130			m3/t average water-use productivity	
Kinkhead, Boardley, 2006	6	20	55	90			water use m3/t	
Corrugated Medium, Surveyed mill, 2006					6.6		water use m3/t	
Tissue Production, Surveyed mill, 2006					15		water use m3/t	
							lowest use in world. Avg 30 -150 m3/t	
Pulp and Paper Annual Directory, 2007					43.9		water consumption	
					91		water consumption	
					62.97		water consumption	
					224 000		water use m3/t	
					76.39		water consumption	
			80.57				water consumption	
					45.42		water consumption	
					26.49		water consumption	
					43.1		water consumption	
					76.12		water consumption	
					15.75		water use	
	33.32						water use	
	516.38						water use	
					28.34		water consumption	
			139.3					
			91.52					
					489.32		water use	

					2.24		water consumption	
					14.6		water consumption	
			7.78				water consumption	
			53.14				water consumption	
			97.8				water consumption	
			27.65				water consumption	
					40.66		water consumption	
			84.24				water consumption	
			61320				water use	
					52.14		water consumption	
			100				water consumption	
European Union IPPC Directives	12	20	40	65			m3/adt water-use productivity	
enhanced efficiency	12	20	30	50	15	20	water productivity m3/adt	
conservation commitment		ZLE BCT MP mills	2m3/adt					
*1996 data based on 1990 data BUT 1996 data calls it gross water use and 1990 labels it water consumption								
		WATER USE = WATER INTAKE						

APPENDIX D: 2007 MILLS OPENED, CLOSED AND REOPENED
(Pulp and Paper Annual Directory, 2007)

Mills	Closed Permanetly	Closed Indef.	Reopened		
ALMA DIVISION	KENORA DIVISION '05	FJORDCELL INC. '06	NACKAWIC	closed '05	reopening '06
AMOS DIVISION	PORT-ALFRED DIVISION '04	THUNDER BAY DIVISION '6	TERRACE BAY PULP	reopened '06	
BAIE COMEAU DIVISION	STEPHENVILLE DIVISION '5	ALBERNI SPECIALTIES '06	PORT HAWKESBURY	resumed production after 10	
BELGO DIVISION	POWELL RIVER DIV. 01	LEBEL-SUR-QUEVILLON '05	MIRAMACHI	restarted May '06	
CLERMONT DIVISION	CORNWALL '05	VANCOUVER MILL -	4 mills		
FORT FRANCES DIVISION	BATHURST MILL '05	SKEENA PULP OPERATIONS '01			
FORT WILLIAM DIVISION	SMOOTH ROCK FALLS '06	RED ROCK DIVISION '06			
GRAND FALLS DIVISION	SQUAMISH OPERATION '06	ST MARYS PAPER LTD '06			
IROQOIS FALLS DIVISION	8 but 7 in time of research	SASKATCHEWANT PRINCE '05			
KENORA DIVISION		9 but 8 in time of research			
LAURENTIDE DIVISION					
MacKENZIE DIVISION					
PORT-ALFRED DIVISION					
STEPHENVILLE DIVISION					
THOROLD DIVISION					
BEAUPRÉ DIVISION					
KENOGAMI DIVISION					
WHITECOURT					
BOYLE					
SCARBOROUGH MILL					
WHITBY MILL					
ATHOLVILLE					
NACKAWIC					
DOLBEAU MILL					
DONNACONA MILL					
GATINEAU MILL					
THUNDER BAY					

OPERATION					
DALHOUSIE					
BROOKLYN					
TERRACE BAY PULP					
PRINCE GEORGE PULP					
Mills opened con't					
PAPER MILL	SAINT JOHN MILL	WINDSOR MILL			
INTERCONTINENTAL MILL	TORONTO MILL	EDMUNDSTON PULP DIVISION			
NORTHWOOD PULP MILL	PORT CARTIER, QC	THURSO PULP DIVISION			
TAYLOR PULP	HUNTSVILLE MILL	PORT MELLON			
QUESNEL	BROMPTONVILLE MILL	INTERLAKE INC.			
PAPIER KINGSEY FALLS	CORNER BROOK PULP AND PAPER	SAINT JOHN			
CASCADES EAST ANGUS INC.	TROIS-RIVIÉRES MILL	SAINT JOHN			
EAST ANGUS MILL	TROIS-RIVIÉRES MILL	WINDSOR MILL			
JONQUIERE MILL	MARATHON	ALBERTA MILL			
TORONTO MILL	DRUMMONDVILLE	DRYDEN MILL			
FJORDCELL INC.	MEADOW LAKE MILL	KAMLOOPS			
ROLLAND DIVISION	WHITECOURT	SASKATCHEWAN PRINCE			
THUNDER BAY DIVISION	PICTOU	ALBERT PULP AND PAPER			
BREAKEY FIBRES DIVISION	SKEENA PULP OPERATIONS	F.F. SOUCY DIVISION			
CALGARY	RED ROCK DIVISION	MASSON MILL			
CANDAIC	TRENTON DIVISION	109 mills			
KINGSEY FALLS DIVISION	HARMAC PULP OPERATIONS				
LACHUTE	BATHURST MILL				
LAVAL	PONTIAC MILL				
ALBERNI SPECIALTIES	ST MARYS PAPER LTD				
CROFTON PULP & PAPER	PORT HAWKESBURY				
ELK FALLS PULP AND PAPER	TÉMISCAMING				
POWELL RIVER DIV.	SKOOKUMCHUCK PULP				
CFK	SMOOTH ROCK FALLS				

PEACE RIVER PULP DIV.	SPRUCE FALLS OPERATIONS				
CORNWALL	PINE FALLS DIVISION				
ESPANOLA MILL	TOLKO MANITOBA KRAFT				
HULL/OTTAWA	MIRAMACHI				
LEBEL-SUR-QUEVILLON	HINTON PULP				
VANCOUVER MILL -	SLAVE LAKE PULP				

APPENDIX E: MILLS BASED ON LOCATION AND WATER SOURCE

ALMA DIVISION	Source: River	CFK	Source: River	
AMOS DIVISION	Source: River	PEACE RIVER PULP DIV.	Source: River	
BAIE COMEAU DIVISION	Source: River;Lake		ESPANOLA MILL	Source: river
BELGO DIVISION	Source: River	HULL/OTTAWA	Source: Ottawa River	
CLERMONT DIVISION	Source: 98% river; 2% municipal		LEBEL-SUR-QUEVILLON	Source: Lake
FORT FRANCES DIVISION	Source: River	VANCOUVER MILL -		
FORT WILLIAM DIVISION	Source: lake; river		KITIMAT	
GRAND FALLS DIVISION	Source: River	WINDSOR MILL		
IROQOIS FALLS DIVISION	Source: River	EDMUNDSTON PULP DIVISION	Water Source: Madawaska River	
LAURENTIDE DIVISION	Source: River	THURSO PULP DIVISION	Source: River	
MacKENZIE DIVISION		PORT MELLON	Source: River	
THOROLD DIVISION		INTERLAKE INC.		
BEAUPRÉ DIVISION	Source: River	SAINT JOHN	Source: River	
KENOGAMI DIVISION	Source: River	SAINT JOHN	Source: Spruce Lake and Lock Lomond reservoirs	
WHITECOURT	Source: Athabasca River		SAINT JOHN MILL	Source: River
BOYLE	Source: Lake	TORONTO MILL		
SCARBOROUGH MILL		PORT CARTIER, QC	Source: River	
WHITBY MILL		HUNTSVILLE MILL		
ATHOLVILLE	Source: River	BROMPTONVILLE MILL	Source: River	
NACKAWIC	Water Source: St John River		CORNER BROOK PULP AND PAPER	Source: River
DOLBEAU MILL	Source: Mistassini River		TROIS-RIVIÉRES MILL	Source: River
DONNACONA MILL	Source: Jacques Cartier River		TROIS-RIVIÉRES MILL	Source: River
GATINEAU MILL	Source: River	MARATHON	Source: Lake	
THUNDER BAY OPERATION	river; lake	DRUMMONDVILLE	Source: River	

DALHOUSIE	Water Source: Charlo River		MEADOW LAKE MILL	Source: Lake
BROOKLYN	Source: River	WHITECOURT	Source: River water	
TERRACE BAY PULP	Water source: Lake Superior		PICTOU	Source: River
PRINCE GEORGE PULP	Source: River	SKEENA PULP OPERATIONS	Source: lake system	
INTERCONTINENTAL MILL	Source: River	RED ROCK DIVISION		
NORTHWOOD PULP MILL	Source: River	TRENTON DIVISION	Source: River	
TAYLOR PULP	Source: River	HARMAC PULP OPERATIONS	Source: Rivers & wells	
QUESNEL		QUESNEL RIVER PULP CO.	Source: three "deep" wells	
PAPIER KINGSEY FALLS	Source: River	ST-FELICIEN	Source: River	
CASCADES EAST ANGUS INC.	Source: River	PONTIAC MILL	Source: River	
EAST ANGUS MILL		PORT HAWKESBURY	Source: River	
JONQUIERE MILL		TÉMISCAMING	source: local river	
TORONTO MILL		SKOOKUMCHUCK PULP	source: Skookumchuk	
FJORDCELL INC.		SPRUCE FALLS OPERATIONS	Source: River	
ROLLAND DIVISION	Source: North River		PINE FALLS DIVISION	Source: River
THUNDER BAY DIVISION	Source: Lake Superior		TOLKO MANITOBA KRAFT	Source: Saskatchewan River
BREAKEY FIBRES DIVISION	Source: River	MIRAMACHI	Source: Miramichi River	
CALGARY		HINTON PULP	Source: River and Lake	
CANDAIC	Source: River	SLAVE LAKE PULP	Source: River	
KINGSEY FALLS DIVISION		ALBERTA MILL		
LACHUTE		DRYDEN MILL	Source: Wabigoon River	
LAVAL	Source: River	KAMLOOPS	Source: River	
ALBERNI SPECIALTIES	Source: Sproat Lake		SASKATCHEWANT PRINCE	Source: River
CROFTON PULP & PAPER	Source: River	ALBERT PULP AND PAPER	Source: 99% river; 1% city	
ELK FALLS PULP AND PAPER	Source: River	F.F. SOUCY DIVISION	Source: river	
MASSON MILL	Source: River			
CASTLEGAR	Source: Arrow Lake			

100 mills total				

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