



Running Through Our Fingers

How Canada fails to capture the value of its top asset

This is the first in a series of reports prepared for Blue Economy Initiative.



Preface

It seems obvious that any important decision should take into account the costs and benefits of the different options that are available. But what about decisions we make about water? When water is allocated to a municipality, a manufacturing facility or a generating station, how do we know that the use of the water will provide an overall social and economic benefit? Would the water provide more benefit if allocated to some other use, or left where it is?

It turns out we don't actually have the information we need to know how much water contributes to the economic value of different activities. It's not a new question. When the federal government undertook an inquiry about water in 1985, economist Andrew Muller attempted to find out. He came up with an estimate of between \$7.5 and \$23 billion (equivalent to \$15 to \$44 billion in 2011 dollars). Muller noted that his "estimates are subject to important limitations in concept and coverage," but he hoped that the data put forward in his analysis would "serve as improved indicators of the importance of water and contribute to more informed public discussion."

Running Through Our Fingers is an attempt by Steven Renzetti and Diane Dupont, two of Canada's best environmental economists, and award-winning journalist Chris Wood to revisit Muller's analysis and articulate the value of water's contribution to the Canadian economy. Their conclusion? What they can quantify would suggest that water is responsible for a contribution of between \$7.8 and \$22.9 billion. The numbers are remarkably similar to Muller's 1985 estimates, but about half the value when compared to these estimates in 2011 dollars.

Has the value of water to our economy decreased? It's very unlikely. What's clear is that the amount of information available to make such an estimate has changed very little. To quote the authors of this paper, it's "disturbingly incomplete."

We simply don't have the information we need to understand how important water is, or which activities provide the most economic benefit per volume of water used. We also can't accurately account for what water is "worth" in its natural state. The authors speculate that the "unmeasured" contribution of the ecosystem services provided by water may account for a higher economic value than ever before. Indeed they predict that the value of these services may "exceed by at least an order of magnitude what water is worth in its better-measured uses."

Blue Economy Initiative aims to shed light on the connection between water and our economy. We believe that becoming a world leader in water stewardship will help Canada secure competitive advantage and support a prosperous future.

This paper is the first of a series of research papers that Blue Economy Initiative will be releasing. Over the coming months, we'll be working to advance that "informed public discussion" about water and the economy that Muller sought 25 years ago.

Nicholas Parker, Chair
Blue Economy Initiative



Summary

Canadians consistently rank water as this country's most important asset. Climate change, growing industrial use and population growth are stressing water supply and fueling international sales of water-related services. Realizing the greatest benefit from Canada's water requires a capacity to distinguish which uses generate the most value. The first estimate of water's contribution to the economy in a quarter-century suggests that while the rest of the economy has almost doubled over that period, water's measured contribution has apparently declined. The analysis clearly reveals how many "known unknowns" hold us back.

Canadians face many big-ticket decisions about what to do with water over the coming decades. Examples include:

- How much to invest in improving the water quality of the Great Lakes, Lake Winnipeg and other water bodies.
- How to replace crumbling municipal water systems and update sewage treatment, a gap estimated to be in the tens of billion of dollars.
- How much land to set aside for source water protection and flood management.
- How to allocate limited water resources among competing human uses (such as farms, municipalities and industry) and nature's ecological needs.
- How to respond to changes in precipitation and surface water flow brought on by climate change.

These challenges and questions force us to think about which course of action will best protect and derive the most value from Canada's water resources. Past experience strongly suggests that failing to understand water's value to both ecosystems and the economy contributes to poor decisions: building dams that never fill up, pricing tap water at less than its cost to supply and buying expensive technology to do the work of "free" natural wetlands.

Yet this study calls sharply into question the confidence that Canadians can place in decisions currently being made regarding water. Specifically we found that:

- The value of aquatic ecosystems is only beginning to be appreciated; their value is at least on the same scale as, and may dwarf, the value of water's market uses.
- Market uses of water contribute less value than previously thought when the cost of associated pollution is accounted for.
- Most sectors of Canada's economy are inadequately informed to make efficient, sustainable choices involving water.
- Canada's competitors are improving their decision-making by developing a better understanding of water's many values.



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1: THE ECONOMY IS BLUE

Water is an indispensable input to wealth, not only of the monetary kind. Its value to commerce and quality of life seem certain to grow. On both counts, water is a key Canadian asset.

It's often said that, "water is life." Of course that statement is true, and we fully respect and honour its implications. But one cannot escape the reality that water is also wealth.

That is, our economy runs as much on water as it does on other essential inputs of wealth: financial capital, labour, energy, technology and raw materials. Water, in fact, is the *indispensable* raw material: no economic activity, large or small, private or public, can operate without using some water directly or indirectly.

Water supports the production of goods and services. In its natural setting, it provides energy and recreational services. Water maintains ecosystems that mitigate flooding, assimilate waste and provide the solace that most people find in the presence of nature.

Equally, the many environmental impacts that prompt concern for water's quality and supply arise almost entirely from human economic activity. The future of water and the future of the economy are one.

Yet while other inputs to our prosperity are subject to regular, credible and comprehensive inventory by a range of authorities, no equivalent reporting systematically tracks Canada's freshwater account. Indeed, it has been nearly three decades since the only previous attempt to determine what this indispensable input actually contributes to Canadians' national enterprise or individual wealth.

Serving a federal inquiry in 1985, Andrew Muller estimated water's value to the Canadian economy then to be in the range of \$7.5 to \$23 billion per year — \$15.5 to \$43.7 billion in 2011 dollars.

Richer, more crowded and thirstier

The country has changed considerably since 1985. Real GDP (gross domestic product) has almost doubled, growing by 88% since 1984. The economy is increasingly dominated by services — 72% of industrial GDP in 2009, up from 60% in 1984 — as primary and secondary industries recede in relative importance. Canada's withdrawals of water have also gone up — by as much as 23%.¹

Decision-makers are growing more aware of water's economic implications. A report sponsored by Canada's biggest bank observed that failure to plan for uncertainty in water supply "can result in business instability, lost economic opportunities [and] societal impact ... in the form of water scarcity."²

Forty percent of Fortune 1000 companies surveyed in 2007 judged that a water shortage would be “catastrophic” to their operations. Two-thirds of multinational companies surveyed for the 2010 Water Disclosure Project³ put water security on the agenda of their boards or executive leadership — more than half also monitor their supply chain’s exposure to water risk.

Insurers are escalating their scrutiny of water-related risk as well. Of Canada’s 10 costliest natural disasters, six were droughts; the last, in 2001–2002, wrenched \$6.6 billion (in 2011 dollars) in losses from the economy. At the other extreme, flood and other water-related damages now exceed fire as the leading cause of insured loss in Canada,⁴ accounting for more than half of homeowner claims.

A key driver of twenty-first century wealth

Where risk exists, however, so does opportunity. Global population and wealth continue to grow, pushing up demand for water and its services.

Global revenues of water-related businesses reached \$522 billion in 2007.⁵ Secure access to clean fresh water is a criterion for locating many advanced industries with global options. In 2010, Ontario’s Water Opportunities and Water Conservation Act targeted this sector as a strategic opportunity for growth.

Other provinces see opportunity in feeding the world. Global food demand is expected to grow 55% by 2030. By then, half of humanity will be living under permanent water stress,⁶ reliant on food imported from other places that have more fresh water.

Canadians are also increasingly conscious that water can no more be detached from nature than it can from the economy. Indeed, water threads the two together. Not only is water essential to preserve wild habitat, landscapes deliver critical water services to the human economy. Wetlands buffer damage from extreme rainfall and assimilate wastes. Riparian (riverbank) zones safely make room for flood water.

Municipal planners and civil engineers have become more conscious of the role these landscapes play in the delivery of significant urban services, such as water supply and storm water control.

There is evidence the economic value of water’s ecological services exceeds, by orders of magnitude, the value of industrial alternatives.

There is suggestive evidence that the economic value of these ecological services exceeds, by orders of magnitude, the value of industrial alternatives. For example, researchers estimate that in three American cities with high rainfall, one dollar invested in the water-retention capacity of natural landscapes delivered the same value as \$7.50 to as much as \$200 spent on engineered flood control.⁷

Many Canadians keenly appreciate other benefits that are simply impossible to capture in an economic frame. The spiritual comfort many of us get from nature and Aboriginal peoples' relationship with the land and water are but two prominent examples. That such benefits exist even as they elude measurement implies that any estimate of water's worth expressed exclusively in economic terms — including those reported here — must inherently be incomplete.

What we mean by “value”

That water conveys intangible values does not, however, negate the importance of better quantifying those values that can in fact be measured. Not to do so, as others have observed, is to falsely imply — and often to act as though — water has no economic value.

To be clear: we are not suggesting that water's utility to the human economy constitutes its only, its primary or even its most important value. But we are asserting that the subject cannot be avoided.

Rising demand for water and its services, coinciding in some regions with declining water “income” from precipitation, will compel decision-makers to choose among competing uses of, and investments in, available water supplies. And, inevitably, they will also have to choose from among the different values that each use might provide.

The ability to distinguish between high- and low-value returns from any particular allocation of water is essential for Canadians to have confidence in their choices. As water scarcity intensifies throughout the global economy, the ability to recognize and validate potentially profitable innovations that increase water's delivered value will rely on precisely this capability.

When we speak of the “value” of water here, therefore, we use the term's standard economic meaning as “the net difference between the gross benefit received from the use of a volume of water, and the cost of that water's use.” (see glossary)

This definition has limitations, but also advantages, for the purpose of illuminating water's contribution to the economy. Building on established concepts and familiar analytic tools, it is the definition most likely, we hope, to assist other researchers.

This understanding of value also recognizes that water's economic worth is determined largely by the nature of demand for it. For some users under some circumstances, water's purity — or even its unique natural contaminants, as in the case of mineral water — may convey far greater benefit than its volume.

As well, subtracting water's cost from its benefit to reveal its net value to a user brings a crucial distinction into sharper relief. It highlights the potential for an individual user to draw great private value from water, while significant costs of its use fall on Canadian society as a whole, typically in lost eco-service benefits.

Declining returns on a national asset?

Replicating Muller's methodology, but with the most recent observations and peer-reviewed analyses from government, NGOs and economic literature, produces a measured estimate of water's net annual contribution to Canada's wealth today of between \$7.8 and \$22.9 billion (in 2011 dollars).

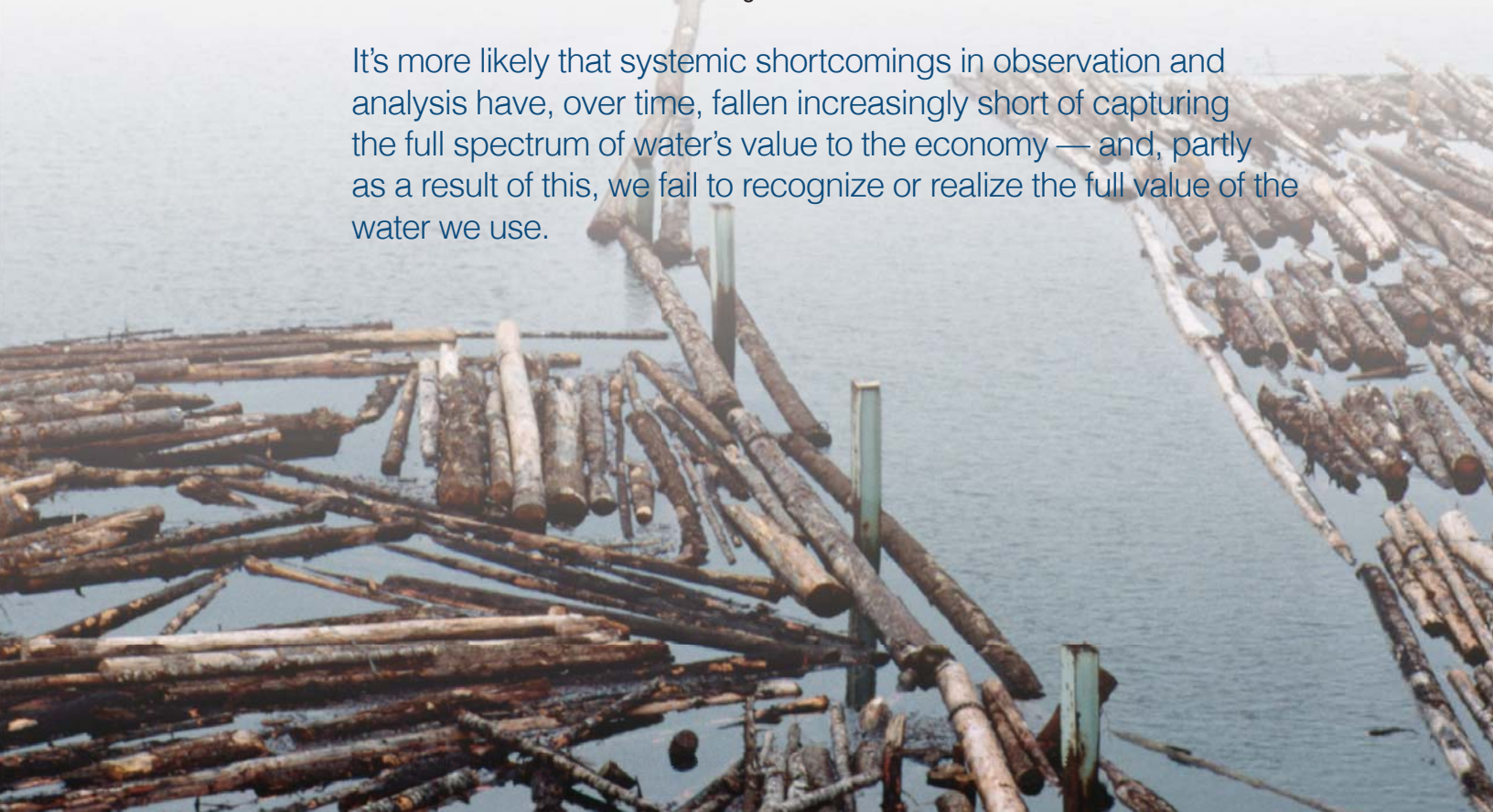
Two things are striking about this estimate. One is that in more than a quarter-century in which the rest of the economy has almost doubled, water's measured contribution has apparently declined. Our estimate of about \$7.8 to \$22.9 billion a year is about half Muller's calculation, expressed in equivalent 2011 dollars, of \$15 to \$44 billion.

Over the quarter-century in which the economy doubled, demand for water rose by a quarter and uncertainty about water's supply and security escalated globally, water's measured contribution to the economy of Canada has apparently declined.

The second noteworthy feature of water's measured contribution to Canada's wealth is that it seems so minor — less than 2% of a \$1.195 trillion economy. By comparison, Industry Canada reports that manufacturing alone contributed \$151 billion to GDP in 2009; farming, forestry, fishing and hunting combined were worth \$25 billion.

Technical deficiencies in both the data available in 1985 and today's data may account for some of the apparent decline.⁸ But in the context of a growing national economy, rising demand for water-dependent goods and services, and increasing uncertainty about supply both at home and abroad, we do not believe this decline can be read as evidence that water's fundamental economic value to Canada is diminishing.

It's more likely that systemic shortcomings in observation and analysis have, over time, fallen increasingly short of capturing the full spectrum of water's value to the economy — and, partly as a result of this, we fail to recognize or realize the full value of the water we use.



2: VALUES MATTER

Assets must be managed. Good management is impossible without the ability to make valid comparisons among competing choices. Current reporting systematically understates eco-service values.

Choice compels us to consider value. Without a clear sense of what value to expect from each of two alternatives, humans either cannot make up their minds or toss a mental coin.

When we flip a coin, the success rate of our decisions cannot rise much above random chance and may even be expensively wrong.

Over more than a decade beginning in 1966, the US Army Corps of Engineers spent \$46 million building a dam on the Canadian River in Oklahoma's semi-arid panhandle. It anticipated \$922,000 in annual benefits from water supplied to eight communities, flood control and recreation. Neither the planned reservoir, ironically to be named Lake Optima, nor its benefits ever materialized.⁹ As subsequent investigation revealed, upstream farmers were instead capturing the water to irrigate cotton and other crops made profitable, in a further irony, by federal crop subsidies.

The Corp recently spent another \$1.2 million to replace a guardrail around the empty "lake," bringing its total loss to more than one-third of a billion 2011 dollars — funds that might have more beneficially supported demand-management or other strategies for local water supply.

The need to have a sense of the stakes on either side of a choice causes us to rely heavily on any information before us, tempting us to impute positive value to the mere existence of data about one option, and discount the significance of what we don't know about others — the "known unknowns."

This is often the case with water, where the economic benefit of extracting it from nature to make a product, say beer, is clear and well-supported, while the cost of aquatic "dead zones," where brewery effluent microbes consume all oxygen, is diffuse and poorly documented.

Yet water's dynamic nature obliges us to make decisions about it on a daily basis. Indeed, the consequences of a decision not to act may be larger than a choice to act.

Erosion at a bend in a river, for instance, will continue indefinitely if left unchecked, potentially endangering infrastructure. Commuters heading back to work in Vancouver after a recent long weekend encountered the potential consequences: high water in the Fraser River washed away the footings of an electricity transmission tower, bringing it down across a key highway.

At the same time, of course, any action to stabilize a receding riverbank carries its own consequences — such as reducing riparian areas available to safely accommodate flood waters.

Epic stakes

Some decisions about water carry relatively limited implications (Water the lawn, or let it go another day?). Others are on an epic scale.

Water is a prerequisite for investments in heavy oil extraction forecast to top \$20 billion over the next decade. The Federation of Canadian Municipalities estimates its members face \$31 billion in costs over the same period to maintain and upgrade existing water, wastewater and stormwater systems, and a further \$56.6 billion for expansion.^{10,11}

Substantial as they are, those sums pale by global comparison. Trade in water-related services and technologies that reduce the volumes needed in industrial processes or lower the cost of refurbishing water mains is now worth more than \$522 billion a year. Analysts predict that will double before the end of the decade.¹²

Global trade in farm products is already worth more than \$1 trillion a year.¹³ Fresh water is indispensable to agriculture, and, as drought-stressed regions rely increasingly on imported food, Canadian agribusiness stands to benefit.

Global trade in water-related technology, services and farm products is worth more than \$1.5 trillion a year.

Water is an investment too

Decisions about how to invest limited water resources are equally consequential.

In some Canadian river basins, water has been allocated to existing users in volumes that equal or even exceed what is actually present for much of the year. This locks in historical uses and leaves nothing to support tomorrow's growth enterprises or to realize potential added value under new climate circumstances. Nor does it consider the survival of ecosystems.

Such dilemmas are pressing. Longer, warmer summers with more extreme heat waves challenge water supply in the season of highest demand. Contrary to Canadians' self-image as a nation richly endowed with water, many regions already face periodic water scarcity.¹⁴

Climate change is sharpening this disparity. Between 1971 and 2004, annual water "yield" (roughly a measure of the water available in any given watershed over a period of time) in Canada's populated south fell by 8.5% — the equivalent of losing 3.5 cubic kilometres of water every year for the last third of a century.¹⁵

In the face of such constraints Alberta, British Columbia and Ontario are exploring ways to redeploy their water investments more nimbly. But expediting the flow of water to higher-value uses requires first that decision-makers accurately understand not only the additional benefits to be gained under proposed alternative uses, but also what benefits may be lost.

Valuation is not destiny

Our language here may discomfort some readers. They fear that speaking of “investing” water for its highest “return” to the economy must lead inexorably to Canada’s lakes, rivers, wetlands and aquifers being turned over to unrestrained market bidding and corporate monopoly.

This is unrealistic. Much legislation, common law and a decisive weight of public opinion stand in the way of that happening. Moreover, information is not action. Water’s economic contribution demands a role in choices about its use for human purposes, but should not be the only factor taken into consideration — especially when those uses affect nature.

Yet economic decisions that impact aquatic ecosystems will continue to be made. And it bears repeating that when explicit monetary benefits are set against unspecified impairment to the service of an aquatic resource, the latter’s value is easily assumed to be zero.

Refusing to challenge that assumed valuation, no less than the assumption itself, places disproportionate weight on other arguments to defend intact ecosystems. Some of these, like the existence value of biodiversity, are appealing in principle but difficult in particular cases: If trout remain in other lakes, is biodiversity hurt by their loss in this one? Pleas that appeal to the value of aesthetics, culture or the sacred are even more elusive.

We have no quarrel with any of these dimensions of value, but on their own they rarely influence development decisions. This is especially unfortunate when the choice to pursue an easily estimated economic return entails significant loss of ecosystem benefits that currently go unmeasured, but are far from intangible or negligible.

It is well-established that resources not clearly owned by some party — including public commons such as lakes and rivers — tend to be undervalued. It is not an argument for privatizing these to observe that a failure to accurately establish their value cheats both nature and Canada’s citizens.

Material omissions

The precise extent of these missing values is among the known unknowns that render much decision-making about water in Canada a matter of guesswork. But orders of magnitude can be inferred from a growing number of investigations.

The Council of Canadian Ministers of the Environment, for instance, examined the pros and cons of upgrading all the sewage treatment plants in Newfoundland and New Brunswick. It found that economic benefits from improved health, more productive ecosystems and attractive scenery over the 25-year life of the upgrades would exceed their cost by \$204 million in Newfoundland and \$450 million in New Brunswick.¹⁶

If better sewage treatment returned a similar value across the country, it would mean that, by “saving” the cost of upgrades, Canadians would be in fact choosing to forgo net benefits — over and above the cost of their investment — of \$500 million to \$1 billion a year.

US analysts conducted a similar study of the costs and benefits of scores of proposals to improve water quality in the Great Lakes. Completing all the projects would cost US\$26 billion over several decades. The net present value of the benefits expected to flow from them were calculated to be US\$50 billion — a return on the contemplated investment of nearly two to one.

Canadians will invest tens of billions of dollars in the coming decade on infrastructure and industrial capital to manage or exploit water. Other decisions will commit resources: water or what now are functioning ecosystem assets.

Canadians cannot make these decisions in confidence without current, accurate, specific and inclusive information about water's relative value under both its present and its proposed uses.



3: WHAT WE KNOW

The measured portion of water's contribution to the economy declined over the last 25 years. The hitherto “unmeasured” contribution from water's provision of eco-services may be far larger.

Just as a glass of ice water is more refreshing than a lukewarm one on a hot day, water's value depends on its condition and context as much as its volume.

Water contributes directly to financial prosperity when it is withdrawn from nature and put to use making goods or providing services that consumers pay for. Canadians also profit economically from water in its natural setting when they exploit rivers for hydroelectric power or lakes for transportation. Most easily overlooked are the benefits Canadians receive from water's essential role in the provision of eco-services, from rain retention to waste assimilation.

We searched databases kept by various branches of the federal government, the American Economics Association, think tanks and NGOs (see sources for a partial list) for current evaluations of all these different contributions.

Before we share what we found, it is important to note that water “use” and its synonyms can have different meanings that invite misleading, apples-to-oranges comparisons. We distinguish below between water “withdrawn” (removed from its natural setting) and water “consumed” (withdrawn but not returned). A third category of “in-stream” use benefits from water without withdrawing or consuming it. For more on this subject, please refer to the glossary.

Who's using Canada's water

The main sectors of the Canadian economy that withdraw water (and in some cases, do not return it) from nature are:



Municipalities. Public utilities withdraw, treat and deliver water for most of what people do within their service areas, from household needs to fighting fires. Along with landscape irrigation and supplying water to businesses, institutions like schools and hospitals, and industries connected to city mains, these activities account for about 10% of water withdrawals in Canada — 11% if rural use is included.

Most of this water eventually returns to its watershed. In older cities, 30% to 40% leaks out of decaying pipes before it ever reaches a tap.



Agriculture: Farms withdraw less water from nature than cities do, but return so little that the sector is actually responsible for two-thirds of the country's water consumption. Nine-tenths of that irrigates crops, mainly in Alberta, Saskatchewan and British Columbia. The remainder goes to livestock.

Unlike cities, however, little of that water returns to its local source. And what does is often heavily laced with agricultural chemicals. (The same is true of runoff from rain-fed fields.)



Electrical generation: Gas, coal and nuclear generators all use water for heat transport and cooling. The volumes are large: one kilowatt-hour of electricity takes 140 litres of water to produce electricity in a conventional thermal power plant — 205 in a nuclear plant. For illustration, the six reactors at Ontario's Pickering generating stations¹⁷ require roughly five and a half cubic kilometres of water a year to produce 27 billion kilowatt-hours of electricity.

Almost all that water returns to the environment a few degrees warmer than when it was removed; only a little is released as vapour. But relying on water for cooling makes such facilities highly sensitive to temperature. In both France and the United States, power generation has curtailed when river water has become too warm for process cooling.



Manufacturing: Major industries collectively withdraw slightly more water from nature than either farms or cities — 15% by volume. Papermaking accounts for one-third of that. Primary metals take another fifth, as does food and beverage production. Chemical makers account for about 8%, and mineral and oil refining 5%.

Most water is used for moving process material — pulp slurry on its way to becoming paper, for example — or for cleaning, cooling or creating steam. Relatively little winds up directly in a product like a can of pears or keg of beer.

While recycling and process innovation have reduced the intensity of industrial water use (the volume required to produce a given value of output), rising production has more than offset such efficiency gains, with the result that total water withdrawals continue to rise.

And while industry returns much of the water it uses to nature, its quality is often significantly degraded.



Oil and gas: This sector's relationship to water is exceptional in several ways. Its water withdrawals are not comprehensively tracked or publicly disclosed¹⁸, although they may be large: between 1.4 and four litres of water are used to extract each litre of synthetic crude from bitumen (Canada produces roughly 1.5 million barrels or 240 million litres of bitumen crude a day); 4 million litres of water is needed to bring a typical new natural gas well into production. This use is also expected to grow substantially, with at least one forecast doubling the production of oil sand and tripling that of natural gas in the decade ahead.

Much of this water is consumed, in that it is left behind in geological formations or recovered in such a state that it must be sequestered from the hydrological cycle.



Mining: Mining for metals, non-metallic minerals and coal uses water for cleaning ore, cooling drills and sometimes blasting ore loose from rock. As a sector, its share of Canadian water withdrawals is tiny — only 1% — in part because the industry reuses and recycles much of that. But the impact of its practices on water-based ecosystem services may be large.

The major economic in-stream users of water are:



Hydroelectric producers: Synonymous with electricity in much of Canada, hydro provides more than half (59%¹⁹) of Canada's electrical energy and earns export revenue for several provinces. Although it neither consumes nor contaminates the water it uses, hydro generation disrupts ecosystems and natural flows in significantly damaging ways. These include not only land flooded behind dams, but also altered timing of river flows, water temperature and velocities.



Recreation: A day "on the water" epitomizes the Canadian holiday, be it summer swimming or winter snowboarding. Water also supports wetlands that provide waterfowl for hunting and other bird species for watching. If a unique study conducted in 1996 remains accurate,²⁰ slightly more than one Canadian in four participates in outdoor recreation involving water.

Their activities neither withdraw nor consume much water, but can cause significant seasonal pollution in smaller waterways and beaches.



Navigation: Water provided Canada's first highways. It remains a key transportation provider for heavy goods in the south and everyday communication in the north. Log tows on the Fraser River, ocean freighters loading grain at Thunder Bay and the many northern communities that rely on winter "ice roads," all derive transportation benefits from water.

Neither shipping nor ice roads withdraw or consume water directly. But they can affect it. Cargo vessels introduced zebra mussels to the Great Lakes in ballast water; controlling the species now costs other users of the lakes as much as \$400 million a year.²¹ Relatively small changes in water's flow or condition may also have outsized impacts on its value to transportation. It's been estimated that a mere one metre drop in water level in some seaway channels would force freighters to reduce their loads to avoid grounding — at a net loss in revenue of up to \$2.5 million a year for the average vessel.²² For northern communities, one or two degrees of temperature make the difference between a sturdy winter road and a treacherous trip across crumbling ice.

Elusive eco-service values

Water is also embedded in terrestrial and aquatic ecosystems that provide numerous services to humanity, from global climate regulation to field-specific supply of soil moisture. The calculation of economic value derived from these services is in its infancy, but a start has been made on assessing their contribution to specific regions, for instance:



British Columbia's Lower Fraser Valley: Research in 2004 identified the beneficial goods and services provided by 40,000 hectares of wetland in southwestern BC, among these were water supply, coastal storm protection, flood control, rearing habitat for commercial fish and shellfish, and habitat important to other wildlife. The economic contribution of these services was estimated to be \$277.6 million a year (in 2011 dollars) — and up to \$29,400 per hectare for some particularly high-value plots.²³



Mackenzie Watershed: The Mackenzie River drains one-fifth of Canada; it is one of earth's last unbroken ecosystems and is the size of Western Europe. Its influences are significant on a continental and even global scale. Some, like carbon sequestration, are well-known if not well-quantified. Others, like the influence of boreal land cover on precipitation in central Canada, are only suspected. Nonetheless, researchers making an initial assessment of various landscapes estimated the services flowing annually from boreal wetlands alone to be worth \$370.5 billion a year (\$418.8 billion in 2011 dollars).²⁴

Measures, estimates and guesses

Such valuations of eco-services remain contentious in expert circles — both for their methods and their conclusions. In scouring the research literature²⁵, however, we observed that available estimates of water's conventional economic value to private commercial and public interests were often no better. Either these were based on highly partial or out-of-date data, had simply not been calculated or were otherwise of dubious quality. We discuss these shortcomings in more detail on page 15.

Drawing on such credible data as were available, and for the sake of easier comparison employing as closely as possible Muller's methodology from 1985, we nonetheless established a range of current measured values for some of water's most important contributions to Canada's economy.

Table 1: Estimated Economic Value of Water to Canada in 2011 (millions)

Discrepancies in totals are due to rounding of figures in the original study.

Sector	Low estimate	High estimate
Withdrawal uses:		
Municipal	\$ 927.2	\$ 985.1
Irrigation	\$ 65.6	\$ 2,786.7
Thermal power	\$ 10.4	\$ 43.2
Manufacturing	\$ 410.6	\$ 2,450.0
Resource extraction	\$ 19.8	\$ 251.8
Measured value from withdrawal uses	\$ 1,431.0	\$ 6,516.9

In-stream uses:		
Hydroelectricity	\$ 5,519.4	\$ 11,827.2
Waste assimilation	\$ 863.1	\$ 2,325.1
Fishing	\$ 81.1	\$ 722.3
Measured value from in-stream uses	\$ 6,469.1	\$ 14,875.4
Measured value of water to Canada's economy	\$ 7,900.5	\$ 21,392.3

Eco-service uses: (examples for illustration; estimated values)		
Lower BC Mainland ²⁶	\$ 277.6	
Ontario Greenbelt ²⁷	\$ 1,456.0	
Mackenzie River Basin ²⁸	\$ 418,815.4	
Estimated value of select regional eco-services	\$ 420,549.0	

These results beg several comments.

First, they are disturbingly incomplete. They represent only economic sectors for which both water-use data and at least somewhat valid estimates of water's contribution to the sector exist. Even some sectors that are closely documented in other respects, such as water-borne shipping, have not been studied to reveal the unique value conveyed, literally in that case, by water in contrast to other means of transport.

This imbalance of data is most striking in the relatively well-articulated estimates of water's benefit to private users (the measured value of water to Canada's economy highlighted in Table 1), in contrast to the pervasive and glaring deficiencies in recording water's many non-market social benefits.

Nonetheless — and further underscoring the potential significance of these known unknowns — initial efforts to determine the economic benefits that non-market eco-services provide to Canadians find values that exceed by at least an order of magnitude what water is worth in its better-measured uses in industry, agriculture or municipal sanitation.

The mystery of missing value

What should perhaps strike us most forcefully about this updated estimate of water's contribution to the Canadian economy, however, is that its value, when it is measured at all, appears to have declined over the last quarter-century.

Either Canadians have failed to realize any additional value from their use of water over the course of a quarter-century — and may even be getting less value from it now than in 1985 — or the data fail to tell the full story.



4: WHAT WE DON'T KNOW

Gaps in data imperil decision-making in every sector. Economic benefits from water eco-services, and corresponding losses from their impairment, are significantly understated.

Is it possible that Canada's water contributes less to our prosperity today than it did a quarter-century ago? In view of the country's growing population and economy, its increasing use of water and water's tightening supply both globally and domestically, we think it unlikely.

As noted earlier, some of this anomaly may arise from methodological issues in the data available both to Muller and the present authors. More may be accounted for by the economy's shift away from manufacturing and extractive industries, which are relatively heavy water users, to services.

It is also possible that the data both then and now failed to capture many known and suspected benefits derived from water, and that these unquantified values have increased over time. Water's value remains largely "off the books" of economic reporting in Canada. In the course of our research, we were repeatedly surprised by the limited extent, depth, currency and resolution of data about who uses how much water in Canada and to what benefit.

National databases of Industrial Water Use, Municipal Waste and Wastewater and the National Pollutant Release Inventory all provide some information — but much of it is relatively old and coverage is incomplete.

Statistics Canada conducted a voluntary pilot survey of agricultural water use in 2007, but many farmers were unable to report the volumes they actually used for irrigation; a follow-up study in 2010 remains unreleased. The national municipal inventory omits many smaller communities, and there is little information at all about recreational water use.

A particular oversight is the very partial coverage of water used in or affected by oil and gas recovery. Although terrestrial producers in the two provinces where the industry is most active — Alberta and British Columbia — must obtain licences to remove fresh water from rivers or lakes, in neither case are the volumes actually withdrawn reported to the public or even, often, to government.

One estimate, now several years old, indicated that heavy oil production in Alberta would require 200 million cubic metres of water a year by 2010 — enough to supply all the households in Ottawa over the same time. The requirement was anticipated to double along with production by 2020. (The study did not address water used in gas recovery.)

The industry has reported its pollutant emissions to the National Pollutant Release Inventory at least since 2009, but the accuracy of those reports is questioned. They are unaudited, and at least one analysis by independent researchers measured the industry's actual releases of benzene, to name only one pollutant, to be more than twice its reported estimates.²⁹

No less troubling is our lack of knowledge about groundwater. Industry draws groundwater for 14% of its needs, the farm sector for 43%. Nine million Canadians rely on it. Yet it remains almost entirely unmeasured. A federal initiative to map the location of major aquifers will not be complete until 2030. Important features like aquifer volume, drawdown rates and linkages to surface water are generally unstudied.

*“There is a critical lack of data on groundwater allocations...
on actual withdrawals... and on volumes discharged or reused.
Groundwater cannot be managed effectively, at any scale.”
Council of Canadian Academies’ Expert Panel on Groundwater*

Overall, what is most lacking is precisely the kind of information most germane to good management decisions: timely data about water use by specific watersheds or among firms in a particular industry.

Curious lack of curiosity about value

Likewise, a diligent search in academic literature, government and non-governmental organization reports for recent peer-reviewed estimates of water’s economic value in Canadian contexts reveals remarkably little.

In some fields of significant activity, only a single peer-reviewed study supports an estimate of water’s value to a sector. Despite the outsized strategic importance of hydroelectric power to Canada’s economy, only a handful of studies estimate this value.

Also remarkable is the wide range of estimates supported by the data that do exist. In the case of water’s contribution to food and beverage production, for example, assessments ran from under \$67 million to \$2.8 billion — a more than 40-fold difference. This cannot support much confidence at either end of the estimated range.

Once again a striking blind spot surrounds the petroleum sector. Its significant water consumption, central importance to the Canadian economy and the vast investments being contemplated to expand its activity notwithstanding, we were unable to locate even one peer-reviewed, published estimate of water’s value to oil and gas recovery.

Costs hint at “hidden” values

Likewise, only a spare handful of studies estimate the value that eco-services provide or the corresponding cost when these are impaired by development or pollution. Those studies suggest, however, that the missing values are likely large.

One sector, where current reporting almost certainly undervalues eco-services supported by water, also consumes more of it than any other: farming.

Many farms treat fields with pesticides, herbicides, fertilizers and almost half the nation's daily output of human waste (dried and treated). Such applications are rising: Canadian farms applied herbicide to nearly three times more acreage in 2005 than in 1970. Livestock husbandry has become reliant on pharmaceutical supplements in feed, which are often passed through to the environment in animal waste.

There is strongly suggestive evidence that these practices, while they benefit individual farmers, impair eco-services and thereby incur significant costs to society at large that are not currently captured in economic reporting.

Plowed fields, for example, release silt that clogs infrastructure and phosphorus that pollutes waterways. Research in Manitoba revealed that each plowed hectare caused an average \$143 worth of damage per year. At that rate, switching all Manitoba farms to no-till practices could in theory save nearly \$400 million a year.

Another way to infer the magnitude of unmeasured eco-system values is to consider what it costs to restore³⁰ them once they are lost. Canada's 10,000 worked-out mines have left behind close to a trillion tons of tailings rock and other waste prone to acid leakage. The cost of stabilizing the environment at these sites is estimated to be \$2 to \$5 billion.³¹

Suggestive comparisons

It is also instructive to see what researchers elsewhere have concluded.

Nitrogen and phosphorus-laden field runoff contributes to eutrophication of American waterways as well. The resulting cost to biological and economic productivity was estimated in 2009 to be \$2.2 billion annually.

British researchers traced \$357 million a year in costs to remediating poor water quality and repairing damaged infrastructure to upstream agricultural practices.³² Were Canadian farms doing equivalent damage (unlikely, given our much lower population density), off-field pollution and sedimentation would cost Canadians \$3.5 billion a year.

Other studies have concluded that wetlands contribute \$2.4 billion worth of coastal protection and water quality improvements to the British economy a year, as well as flood protection worth another \$577 million.

It must be stressed that none of these studies give reliable insight into the value Canadians receive in eco-services, or the costs incurred when these are impaired. All extrapolate from limited local experience to national scale, or from distant jurisdictions with different geographies and practices. Yet it is telling that no better indicators exist of the full value that Canadians may be failing to record — or capture — from their use of water.

In fact, few sectors of the Canadian economy, if any, have enough information about the value of water to their activities, or in support of ecosystem services, to make efficient, sustainable decisions about its management.



5: WEALTH TO DRAW ON

Water can contribute more than it does to Canada's wealth. Water-related goods and services are a global growth sector. Healthy ecosystems support both measured and immeasurable wealth.

We run a number of risks when we fail to account for the many values of water.

One is simply that we may invest public or private resources in developments that produce negative returns, either to shareholders or the public.

A second, and equally significant, risk is that Canadians may fail to detect potentially profitable investment opportunities where water is contributing less value than it might. That may already be happening in some semi-arid regions where irrigation is used to grow relatively low-value hay for animal fodder.

Such an opportunity appeared when the International Joint Commission on Boundary Waters asked experts³³ to model the expected impacts, including upon wetlands, of three alternative plans for managing Lake Ontario's highly controlled water level. A plan that allowed lake levels to fluctuate more widely competed favourably with other proposals. It produced a sharp increase in the productivity of lake-adjacent wetlands at a small cost to shipping and with a slight increase in shoreline erosion.

The inability to distinguish higher- from lower-value water uses also handicaps efforts to turn Canada's theoretical advantage in water into a larger share of the more than \$500 billion dollars the world spends every year to improve access to, clean up or reduce the cost of its water.

Like racers who don't own a stopwatch, innovators who lack a metric to demonstrate their accomplishment in realizing additional value from water will find it hard to compete.

The opportunities being put at risk are growing. The world market for water-related goods and services is forecast to hit \$1 trillion within a decade. Other countries are out in front. Germany's 19% share of global sales of sustainable water technology supports nearly a third of a million jobs.³⁴ Israel expected its exports of desalination, recycling and high-efficiency irrigation equipment to hit \$2.5 billion in 2010.

Other developed economies are preparing themselves with the kinds of information that Canada is neglecting. Coca-Cola and half a dozen other US corporations with international exposure have partnered with the Washington-based World Resources Institute to develop "a global database of water risk information," aiming at "an unprecedented level of detail and resolution." Britain and New Zealand have conducted detailed assessments of national eco-service assets.

In the European Union, prices set for water must by law cover the *full cost* of its supply, including a calculation of any loss of eco-services.

Disconnect

A third category of risk arises when the private benefit derived from a particular water use (the mine owner's profit for example) is decoupled from its full cost to society (the dispersed losses from any resulting impairment to ecosystem functions). When this happens, water itself need not become private property for its value to be effectively privatized, while the public bears the costs.

Another example is water diverted from a river for irrigation. This benefits farmers, whose profit appears on the economic record. The costs of impaired eco-services — dried-out creeks, closed beaches, aquatic dead zones — are diffuse and only rarely recorded. Nonetheless, as we have seen, they can be very large.

Alberta currently faces this risk in an undertaking with ominous echoes of Oklahoma's phantom Lake Optima. Despite a documented century-long decline in virtually all its major rivers, the province is considering spending more than \$250 million to convey water by canal and pipeline from the Red Deer River to the aptly dubbed "Dry Belt" 120 kilometres further south.

Proponents of the plan assert this will benefit the Dry Belt economy, and that the environmental impact of the water diversion will be assessed. But such a review will give reliable guidance to Alberta's decision only if it fully weighs the private benefit of the delivered water against the economic loss of impaired eco-services resulting from the diversion. Of course any such plan should also fully assess alternative solutions, especially local or regional ones, that may have a higher net value.

Failure to fully correlate costs to anticipated benefits in such cases leads to disjunction between an individual user's perception of water's value, and how it looks from society's point of view. Unaware of the full cost of their activity, a miner (or Dry Belt farmer) for instance easily overestimates water's real value: its benefit less its cost. Public stewards of the affected watershed may see only a long list of costs — from lost recreation to extra water treatment — and no benefit.

Threshold risk

A fourth risk of failing to account for water's in situ value is that ecosystems will become increasingly impaired but society, failing to observe their decline, will notice nothing until, as one scientist put it, "we see the canary die" — at worst courting ecosystem collapse.

"Due to limited, dated information... on regional and national scales, the sustainability of the country's water use becomes a question."

National Round Table on the Environment and the Economy

A fifth, global factor adds further uncertainty to all the foregoing dimensions of risk. Climate change is redistributing rain and snowfall around the map and calendar.³⁵ Two global trends are unmistakable: an increase in extreme storms and multi-day downpours, and more volatile weather changes from one extreme to the other, often straying beyond seasonal norms of the last century. Southern Canada, where most Canadians reside and agriculture occurs, is becoming drier.

These changes have profound implications for water's availability to the economy, its quality and security of supply, the location and specifications of water infrastructure, and the resilience of key eco-systems.

The values at risk are far from trivial. Canadian businesses and governments will commit billions of dollars and trillions of litres of the country's top asset to water-related and water-dependent activities in the years ahead. A positive return on those investments relies on their being made in the light of the fullest possible information.

Even when we account for as many of water's values as possible, of course, information by itself does not and cannot make decisions. Nor does it eliminate all risk. But it can better illuminate our choices.

What Canadians do not know about the value they receive from water compromises the quality of their choices, and puts at risk the highest return on this natural resource and financial assets alike.



6. CATCHING THE CURRENT

Improving performance requires first that we measure performance. Canadians would benefit in multiple ways from more timely and refined reporting on the values water contributes to the economy.

One antidote to risk is information. That is old news to financial markets. Investors, regulators and analysts can all refer to reliable and regularly refreshed core data like consumer prices or regional hiring rates. The unprecedented stakes now riding on choices about water accentuate the need for similarly refined and robust reporting on its flow through the economy.

“Managing Canada’s environment without scientifically sound environmental information is akin to trying to steer the country’s economy without using indicators such as the gross domestic product.”

Environment Commissioner Scott Vaughan

Due diligence before a significant financial investment means considering multiple factors — a target firm’s reputation, the remaining term of key contracts, liens on assets. Likewise, achieving positive return on investments related to water (or of water itself) is more likely after a diligent review of water’s supply, quality, cost and benefit — that is, its value — in both current and proposed uses.

Timely high-resolution reporting on water’s current economic value, watershed by watershed, would do more than support such due diligence. Just as so-called “value” investors pore through financial reports for underappreciated companies, they might be expected to scrutinize such a detailed information resource for overlooked opportunities.

Credible metrics

Explicit estimates of water’s eco-service values would not entirely prevent the disconnection of private gain from social cost, but would reduce that risk. Regulators could more easily hold water users to account for impairment to socially valued eco-services. Sound metrics would empower claims for compensation when eco-services are lost, and deter frivolous claims when they are not.

The question of when to call a halt to activities that destroy natural landscapes will remain contentious. Views differ about the “rights of nature” and as to what is “acceptable” disruption to ecosystems. Whatever approach is taken, the better we know how our habitat and human economy interact, the more likely we are to anticipate critical thresholds — to see the canary shiver before it expires — and respond in time.

Adapt to change, respond to opportunity

Climate change may increase our national water balance even while some regions experience water losses. These changes are likely to reduce the positive margin of benefit over cost in some water uses and locations. Canadians need to be able to recognize when that margin turns negative — as well as spot the emerging opportunities when climate shifts deliver a potential net increase in water's value.

To a degree, global regions that “lose” water as a result of climate change will create “winners” among better-provided regions. Canada can be among the latter.

To seize the opportunities the century presents and mitigate its emerging risks, however, our society and economy require more actionable, precise and current information about water's use and economic contribution than is presently reported.

Other countries are filling this gap in their intelligence. Britain's recent “first of its kind” national inventory of the economic, health and social benefits of ecosystems catalogued more than a dozen such services from ecosystems across the entire country. The goal of the “UK National Ecosystem Assessment” was not to establish a single “pounds and pence” price tag for British nature, but instead to improve the return on public and private investment by better predicting whether a particular choice (such as to sacrifice urban green space for development) will yield a net benefit or loss to the UK economy.

Canada could do likewise. We see several immediate opportunities.

While the size of Canada's geography challenges a thorough assessment of all the economic services received from water in its natural setting, such an inventory would improve decision-making on a national scale. Statistics Canada, which has conducted at least initial inventories of other natural capital assets, such as oil and gas, could lead such an effort.

More manageable might be to extend regional studies. The watershed centered on Lake Winnipeg is a leading candidate for such an evaluation of the net benefit or loss to Manitobans of water uses that deliver documented financial returns, but also incur large losses by nourishing algae blooms that reduce the value of eco-services like recreation or its freshwater fishery.

Natural resources, including water, fall under provincial jurisdiction. The federal government could play an effective role, however, in coordinating the collection of data about water use on a consistent, comparable and timely basis. At the very least, we urge that the petroleum industry be required to report its audited water withdrawals and pollutant releases to the relevant public inventories.

The unprecedented challenge of resource limits wears many faces: climate change, peak oil, fragile food reserves. Addressing these will escalate competition for secure, clean, fresh water. In that competition, Canada has strong cards to play, but little ability at present to read them.

Canada's security and prosperity in the twenty-first century depend on filling the gaps in our water-intelligence gathering capability.

CREDITS

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Economic research for this report was completed by Diane Dupont, Ph.D., and Steven Renzetti, Ph.D., members of the economics faculty at Brock University, St. Catharines, Ontario. The report was drafted and supplemented with additional material by Chris Wood, a British Columbia-based journalist and the author of *Dry Spring: The Coming Water Crisis of North America*.

KEY SOURCES

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- [The Municipal Water and Wastewater Survey](#)
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GLOSSARY

Eco-services

Known more formally as “ecological goods and services,” these are benefits that humanity derives from the functioning of living ecosystems. They are generally considered to fall into four categories:

- Provisioning:** the supply of physical goods such as food, fibre and timber, as well as of fresh water.
- Regulating:** the service of providing natural checks and balances such as climate control, water storage or the absorption of floodwaters.
- Supporting:** natural services like pollination or nutrient cycling that support other functions directly useful to humans, such as fruit or fish production.
- Cultural:** experiential services, such as outdoor recreation, aesthetic enjoyment or spiritual sustenance.

Hydrological cycle

Water is dynamic, always on the move, even, as ice. While much of the earth’s water is stably contained in oceans, underground aquifers or icecaps, humans rely mostly on the small portion that follows the “hydrological cycle”: escaping from surface water into the atmosphere as vapour; condensing there and falling back to earth as liquid rain or frozen snow; finally, following the pull of gravity to collect in rivers or glaciers and flow eventually back to the ocean.

Value

What any individual finds “valuable” or “beneficial” is a matter of preference. We use the words here in the narrower sense employed by economics.

A “benefit” is the increase in profit derived by a business or the improvement in a household’s well being from their use of something. Economists determine this benefit from users’ “willingness to pay” to enjoy it; in the case of water, it is influenced by factors like water’s quality and reliability.

“Economic value” is the difference between the increase in profit or well being derived from something’s use and the cost to enjoy that benefit. To establish the economic value of water to a particular user, therefore, requires subtracting what they paid for the water from the benefit they enjoyed by using it.

In theory, the sum of all Canadian users’ willingness to pay for water and its services determines its total economic benefit to Canada. Subtracting from this the total cost to society of providing that water (including the cost of impaired eco-services) would then reveal water’s total economic value.

Water consumption

Water withdrawn from its natural setting within a watershed but not returned is considered “consumed.” In fact, comparatively little water is ever consumed in a physical sense by chemical transformation in the process of making other products. Most eventually returns to the hydrological cycle. But that does not mean it becomes available for use again by Canadians or even by the global community.

Little water used to irrigate farmland, for example, returns to its source. Much is transpired into the air by plants and falls elsewhere as rain or snow. The rest often leaves its original watershed embedded in agricultural products; it is released back to nature in human or livestock waste, but often far from its origin.

Water used in oil and gas production is not physically consumed, but is typically so contaminated after use that it must be sequestered in outdoor settling ponds or underground for periods of years to near perpetuity, or it must be treated as toxic waste.

Water withdrawal

Water is “withdrawn” whenever it is removed from its natural setting, whether that is a river, lake or underground aquifer. In Canada, relatively few of these withdrawals are metered.

Water yield

Calculated for any given area and time period, the water “yield” is the amount of water that is received in precipitation less what is “evapo-transpired” back into the atmosphere from plants and water surfaces. It includes both surface runoff and what flows through groundwater channels.

ENDNOTES

- 1 Like much else in the water data, this figure can be debated, but is drawn from Environment Canada's Industrial Water Use Survey. Not all water withdrawn from nature is retained. Much returns to its source watershed, although often degraded; more is returned through waste to remote watersheds. Water derived from aquifers may add to the surface inventory and may not return to the source, while surface water elsewhere is pumped into the ground beyond recovery.
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