Journal of Great Lakes Research 38 (2012) 183–192

Contents lists available at SciVerse ScienceDirect

Journal of Great Lakes Research

journal homepage: www.elsevier.com/locate/jglr

Water quality trading in the Lake Winnipeg Basin: A multilevel architecture

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ARTICLE INFO

Article history:
Received 11 October 2010
Accepted 8 August 2011
Available online 21 January 2012

Communicated by Leonard Wassenaar

Index words:
Lake Winnipeg
Multi-jurisdictional
Water quality
Markets
Nutrients
Agriculture

ABSTRACT

Excess nutrients or eutrophication are degrading freshwater bodies worldwide which is undermining human wellbeing. Some of the world's large lakes, such as Lake Victoria, Lake Tai and Lake Winnipeg, have become eutrophic due to excess nutrients from point and non-point sources. Novel approaches that can prevent excess nutrients from over fertilizing surface water bodies are required. Water quality trading (WQT) is a market mechanism that could cost-effectively provide a means to remediate eutrophication by reducing nutrient loads from point and non-point sources. This paper provides WQT design considerations to remediate water quality within large multi-jurisdictional basins by examining Lake Winnipeg which has become the most eutrophied large lake in the world due to excessive phosphorus loads. The multilevel architecture proposed is designed to simultaneously remediate water quality and encourage integrated water resource management. Inter-sub-basin trading allows for meeting a phosphorus load target for the lake while intra-sub-basin trading allows for meeting phosphorus load targets at the sub-basin outflows. The paper also provides regulatory frameworks (Boundary Waters Treaty, United States Clean Water Act, the Canadian Environmental Protection and the Canada Water Acts) and institutional support (International Joint Commission, United States Environmental Protection Agency and Environment Canada) required to manage an international WQT system within the Lake Winnipeg Basin. To reduce transaction costs a composite market with clearing house and exchange characteristics is likely best suited. By providing design considerations in the form of a multilevel WQT system, this paper makes a contribution towards WQT research within large multi-jurisdictional basins.

Introduction

Nutrient emissions into water bodies from point and non-point sources are expected to increase worldwide with rising populations, agricultural production, energy consumption and loss of natural environments (Selman and Greenhalgh, 2009). Large lakes in many parts of the world, such as Lake Victoria, Lake Tai, Lake Balaton and Lake Winnipeg, have been degraded due to excess nutrients from point and non-point sources (Selman and Greenhalgh, 2009). To maintain and improve human wellbeing, this continued rise in the eutrophication of the world's freshwater bodies will have to be reversed.

Lake Winnipeg has become the most eutrophied large lake in the world as indicated by its summer chlorophyll levels (Lake Winnipeg Stewardship Board, 2006). Toxic blue-green algal blooms affecting the lake are primarily driven by phosphorus loads originating from industrial and municipal wastewater point sources and diffuse non-point sources from agricultural lands and natural background sources. The Lake Winnipeg Basin (LWB) drains water from approximately 1 million km^2 that serves over six million people, passes through 55 million ha of agricultural land and supports 17 million livestock, sustaining a multi-billion dollar agricultural industry (Roy et al., 2007; Voora and Venema, 2008) (see Fig. 1). The lake supports a commercial fishery (worth CAD$20 million per year), hydroelectricity production and aboriginal livelihoods, and its shores are home to over 23,000 people (Lake Winnipeg Stewardship Board, 2006). Effectively remediating the lake's water quality will require novel approaches that lower water pollution from point and non-point sources.

Water quality trading (WQT) is an economic instrument for managing water quality. A pollution-control authority sets an overall limit and allocations are made to polluting entities that trade among themselves to meet the limit. A key argument for WQT has been its cost and ecological effectiveness when compared to conventional regulatory approaches, which can be costly when all point sources must meet a standard regardless of abatement costs (Heberling, 2011; Nguyen et al., 2006; Pharino, 2007). Pharino (2007) reports that 470 large point source emitters in the United States could save between US$611 million and US$5.6 billion if they could purchase nutrient reductions from non-point sources. Non-point sources cannot be easily regulated, as they often cannot be linked to a particular party, are difficult to monitor and can dramatically increase due to random events. WQT can support conservation practices that improve

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doi:10.1016/j.jglr.2011.09.009

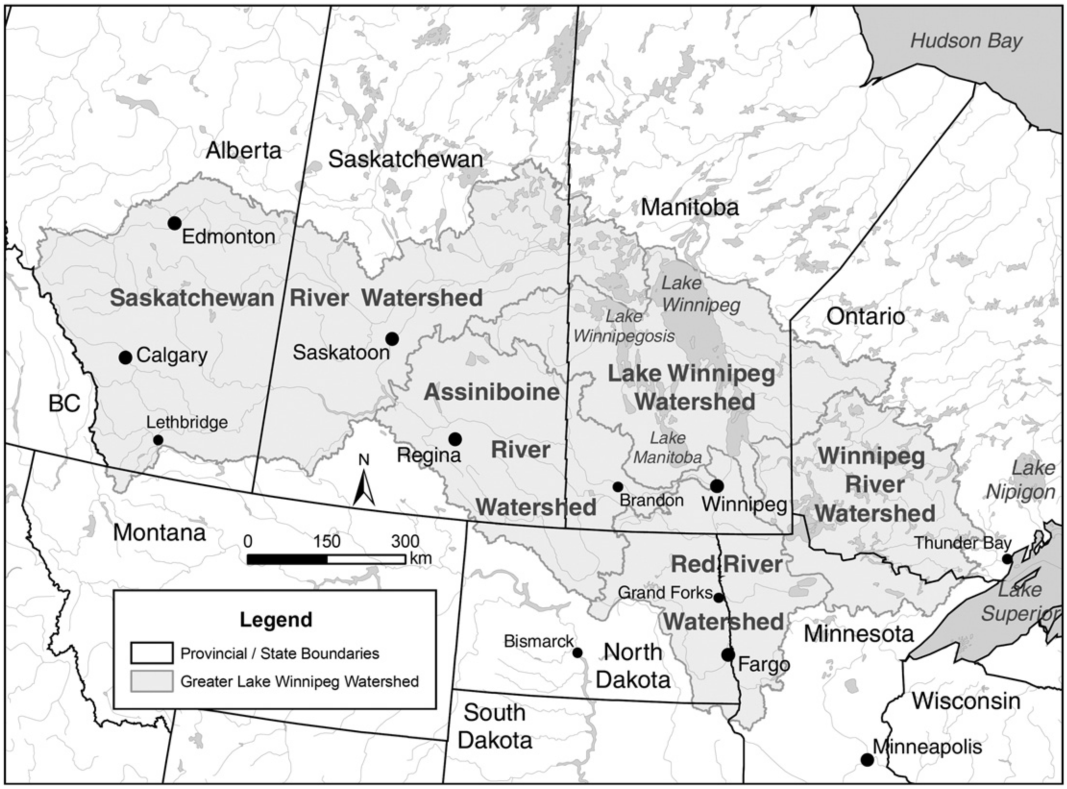

Fig. 1. The Lake Winnipeg Basin (Western Canada Wilderness Committee, 2008).

soil, water and air, as well as raise land values and farm incomes, thus leading to multiple environmental and socioeconomic benefits. Although WQT offers some advantages, it can be difficult to implement. For instance, monitoring and verifying non-point source reductions from agricultural best management practices (BMPs) can be costly and challenging (Pharino, 2007; Shortle and Horan, 2004). Although limiting WQT between point sources may lower transaction costs, including non-point sources increases the range of marginal abatement costs, which stimulates trading (Selman et al., 2009).

WQT may involve: agricultural producers; industrial and municipal wastewater and stormwater facilities; government agencies at the federal, provincial and local levels; nongovernmental organizations; and relevant community and civil society groups. The roles of these stakeholders will depend largely on the market structure (see Table 1).

There are two distinct types of trading systems: closed systems (cap and trade) and open systems (credit or offset) (Sauvé et al., 2006). Closed trading systems achieve an environmental objective through tradable discharge allocations given to participating sources such that they do not exceed a regulated cap. In open systems, tradable credits are provided to facilities that reduce their emissions below a regulated baseline, which can then be sold to facilities facing difficulties in meeting their regulatory requirements. These trading systems can also be combined to take advantage of desired elements in both market types. Non-point sources can be incorporated by integrating them within an allowance cap or by establishing non-point source credits outside the cap that can be purchased by dischargers to meet their limit (Selman et al., 2009; Shabman and Stephenson, 2007).

WQT can occur in different ways. Individuals or institutions can interact directly to buy and sell credits, use intermediaries as brokers or agents, or use established markets with predetermined rules and structures. A market structure may evolve over time through improved information sharing and/or lowered transaction costs. Four market structures are described in Table 2.

This research provides physical, regulatory, institutional and market design considerations for the application of WQT to remediate water quality and enable integrated water resource management within large multi-jurisdictional basins. The proposed design consists of a multilevel basin trading system with provisions for point to non-point source trading at the sub-basin scale. This paper sets the stage for further research to thoroughly explore WQT as a potential solution to remediate large multi-jurisdictional basins such as the LWB.

Table 1
Entities that could participate in WQT.

Trading entity	Role
Buyers and sellers	Point and non-point sources that buy and sell credits of offsets under a WQT system.
Policy makers and/or regulators	Establish trading regulations, guidance documents and tools to assist trading entities.
Credit Exchanges	Third parties (brokers, aggregators and central exchanges) that facilitate the exchange of credits between buyers and sellers.
Financial and technical service providers	Provide financing and technical expertise to establish and operate a WQT system (access to financing and adoption of conservation practices).
Verification and monitoring officials	Ensure that water quality outcomes are met through the WQT system (water quality monitoring, verification of conservation actions, trade conditions and transactions).

Design considerations

Recommendations for designing and implementing WQT in the LWB were developed by examining the essential building blocks of WQT programs and by generating lessons learned from its