Vermont State Auditor

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Report to the Governor, the Vermont Legislature, and the Clean Water Board

Where's the Money Flowing? Cost-Effectiveness of Lake Champlain Clean Water Efforts

7/15/2019 • Office of the Vermont State Auditor • Non-Audit Report 19-03

Mission Statement

The mission of the Vermont State Auditor's Office is to hold government accountable. This means ensuring taxpayer funds are used effectively and efficiently, and that we foster the prevention of waste, fraud, and abuse.

Principal Investigator

Geoffrey A. Battista

Non-Audit Inquiry

This is a non-audit report. A non-audit report is a tool used to inform citizens and management of issues that may need attention. It is not an audit and is not conducted under generally accepted government auditing standards. A non-audit report has a substantially smaller scope of work than an audit. Therefore, its conclusions are more limited, and it does not contain recommendations. Instead, the report includes information and possible risk-mitigation strategies relevant to the entity that is the object of the inquiry.

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Executive Summary

Vermont's waterways are among its most valuable assets. They are critical to public health, vital to sustaining Vermont's ecosystems, and they attract hundreds of millions of dollars to the economy through tourism, real estate, and business investment. However, phosphorus pollution is compromising the quality of Vermont's lakes and rivers. Not only do polluted waters pose risks to human and environmental health, but they come with a price tag. UVM researchers predict that the Lake Champlain region loses nearly $20 million for every one-meter decrease in water clarity during the summer months.

The State of Vermont's Interagency Clean Water Initiative (ICWI) strives to reduce phosphorus pollution in state waterways, which include: Lake Champlain, Lake Memphremagog, the Connecticut River (also targeted for nitrogen pollution), and smaller bodies, like Lake Carmi. Lake Champlain has been ICWI's focus since the Environmental Protection Agency (EPA) mandated the State to reduce phosphorus entering the lake from 631 to 418 metric tons per year (34%). The State responded to this mandate by allocating $66 million, two-thirds of all clean water spending between FY16 and FY18, to projects in the Lake Champlain Basin.

Since a state-mandated audit of these expenditures will not be completed until Winter 2021, the State Auditor's Office (SAO) chose to examine the cost-effectiveness of FY16-FY18 ICWI expenditures in the Lake Champlain Basin. This report begins with an overview of phosphorus sources in the Basin and then summarizes expenditures across land-use sectors and Lake Champlain watersheds. It continues by describing the types of projects in each sector and identifies their costs. Using these data, we calculate the cost-effectiveness, or "bang for the buck," of clean water projects across sectors and watersheds.

This exercise produced two main findings. First, a majority of clean water funding was allocated to low-impact infrastructure projects. Wastewater and stormwater projects received 53% of State funds, including 41% of all State grants, even though most phosphorus comes from agricultural and natural resource lands. Wastewater and stormwater projects are among the least cost-effective solutions to reduce phosphorus. Though such projects are necessary in certain locations, their comparatively poor cost-effectiveness raises important questions about the allocation of scarce clean water funds. The Legislature charged the Clean Water Board with achieving "the greatest water quality gain for the investment," and these investments do not seem to meet this charge.

Second, the analysis identified data quality problems for assessing the impact of ICWI projects. State agencies cannot yet measure phosphorus reductions for combined sewer system upgrades and several types of natural resource projects. State agencies also did not consistently measure reductions among the remaining project types. Furthermore, 95 percent of state clean water expenditures did not yield measurable phosphorus reductions. These data limitations preclude the SAO and State agencies from verifying whether the State of Vermont is meeting federally mandated phosphorus reduction targets at the lowest possible cost.

Introduction

Vermont's waterways are critical to public health and attract hundreds of millions of dollars to the economy through tourism, real estate, and business investment. This activity, in turn, supports thousands of jobs and generates revenue for Vermont's infrastructure and public services.[1] Lake Champlain, the largest lake in New England, is the end point for many of the state's longest rivers, including the Winooski, the Missisquoi, the Lamoille, and Otter Creek.[2] These waterways sustain our towns, irrigate our farms, and create boundless opportunities for outdoor recreation. Maintaining the quality of these waterways is vital to the health and prosperity of current and future residents of the Green Mountain State.

Unfortunately, phosphorus pollution is compromising the health of Vermont's lakes and rivers. Phosphorus is an element that occurs naturally in small amounts. It comes from a range of sources, such as plants, animals, and mineral deposits. In recent decades, Vermonters have added excessive levels of phosphorus to the state's soil and water from:

- Phosphorus-rich fertilizers for improved crop yields;
- Manure from livestock, which gets washed into waterways and applied to fields;
- Stormwater and wastewater pollution from developed areas and;
- Dirt roads, forest harvesting, and waterway changes that cause soil erosion.[3]

Excess phosphorus damages ecosystems. Algae and other aquatic plants grow too quickly, which in turn deprives aquatic wildlife of oxygen.[4] Cyanobacteria, also known as blue-green algae, thrive in phosphorus-rich environments. These bacteria release toxins that are poisonous to humans, causing digestive, neurological, and allergy-like symptoms.[5] In 2017, State employees and trained volunteers identified cyanobacteria in 69 of 1,350 routine inspections along Lake Champlain.[6]

Polluted water also comes with a price tag. Researchers at the UVM Gund Institute for Ecological Economics predict that every one-meter decrease in water clarity during summer

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[1] Office of the State Treasurer. "Clean Water Report, Required by Act 64 of 2015," January 17, 2017. https://dec.vermont.gov/sites/dec/files/wsm/erp/docs/_FINAL_CleanWaterReport_2017.pdf.

[2] Water also flows into Lake Champlain from New York and Québec. Twenty-three percent of all phosphorus in Lake Champlain comes from New York, while 8% comes from Québec. See p. 17 of the EPA's "Phosphorus TMDLs for Vermont Segments of Lake Champlain," June 17, 2016. https://www.epa.gov/tmdl/lake-champlain-phosphorus-tmdl-commitment-clean-water

[3] DEC Watershed Management Division. "Chapter 1. Strategic Framework for Statewide Efforts to Guide Surface Water Management." In Statewide Surface Water Management Strategy, 2017. http://dec.vermont.gov/sites/dec/files/documents/wsmd_swms_Chapter_1_Introduction.pdf.

[4] National Oceanic and Atmospheric Administration. "What is eutrophication?" June 28, 2018. https://oceanservice.noaa.gov/facts/eutrophication.html

[5] "Cyanobacteria (Blue-Green Algae)." Vermont Department of Health, July 18, 2016. http://www.healthvermont.gov/health-environment/recreational-water/cyanobacteria-blue-green-algae.

[6] Vermont Department of Health. *2017 Cyanobacteria Season Summary Data – Final*. 2017. https://apps.health.vermont.gov/gis/VTTracking/Cyanobacteria/2017Summary/2017CyanobacteriaSeasonSummaryData_Final.xlsx

results in the Lake Champlain region (including New York) losing nearly $20 million.[7] Beach closures, public health hazards, and poor fishing conditions ripple across Vermont's economy, threatening the State's reputation as a place to visit, invest, and live.

History of the Problem and Vermont's Response

Vermont has struggled for decades to reduce phosphorus pollution in Lake Champlain. In the early 1990s, Vermont, New York, and Québec agreed to collaborate to reduce phosphorus concentrations in the lake.[8] Québec focuses on the Missisquoi Bay, where it has assumed 40% of the responsibility to reduce phosphorus since 2002.[9] [10] New York and Vermont drafted strategies to reduce phosphorus according to federally mandated "total maximum daily loads" (TMDLs). TMDLs are "clean water restoration plans" that outline steps to meet pollution reduction targets from non-point and end-of-pipe sources of phosphorus.[11] New York and Vermont's TMDLs were approved by the U.S. Environmental Protection Agency (EPA) in September and November 2002, respectively.[12]

Vermont's 2002 TMDL did not stand up to outside scrutiny. The Conservation Law Foundation sued the EPA in 2008, alleging that the agency approved Vermont's TMDLs even though the TMDLs would not reliably reduce phosphorus to promised levels. The parties reached a settlement in the case in April 2010. The EPA "filed a motion with the court seeking a voluntary remand to allow the [New England EPA] Region to reconsider its approval decision" for Vermont's 2002 TMDLs.[13] The state objected to this motion, fought it in the courts, and lost in August 2010. The EPA withdrew its approval for Vermont's 2002 TMDLs in January 2011.[14]

The State of Vermont and the EPA then set out to design new TMDLs for Lake Champlain and its watersheds (Figure 1). These efforts included geospatial modelling, technical working groups, and outreach to stakeholders in industry and environmental protection, among others. Using

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7 Voigt, Brian, Julia Lees, and Jon Erickson. "An Assessment of the Economic Value of Clean Water in Lake Champlain. Technical Report #81." Grand Isle: Lake Champlain Basin Program, 2015. http://www.lcbp.org/publications/assessment-economic-value-clean-water-lake-champlain/.

8 Lake Champlain Basin Program. "Phosphorus Reduction Strategies." Lake Champlain Basin Program, 2019. http://www.lcbp.org/water-environment/water-quality/nutrients/phosphorus-reduction-strategy/.

9 Lake Champlain Basin Program. "Missisquoi Bay Agreement." Lake Champlain Basin Program, 2019. http://www.lcbp.org/water-environment/water-quality/nutrients/missisquoi-bay-agreement/.

10 Ministère de l'Environnement et de la Lutte contre les changements climatiques du Québec. "Bassin Versant de La Rivière Baie Missisquoi, plan d'action et publications," 2019. http://www.environnement.gouv.qc.ca/eau/bassinversant/bassins/missisquoi/index.htm#champlain.

11 Vermont Clean Water Initiative Agencies. "Vermont Clean Water Initiative 2018 Investment Report," January 15, 2019, 10. https://dec.vermont.gov/sites/dec/files/wsm/erp/docs/2019-01-15%20Vermont%20Clean%20Water%20Investment%20Report%20SFY2018_Revised%202019-02-01.pdf.

12 U.S. Environmental Protection Agency (EPA) and Vermont Department of Environmental Conservation (DEC). "Lake Champlain Phosphorus TMDL," September 25, 2002. https://www.dec.ny.gov/docs/water_pdf/champlain_final_tmdl.pdf

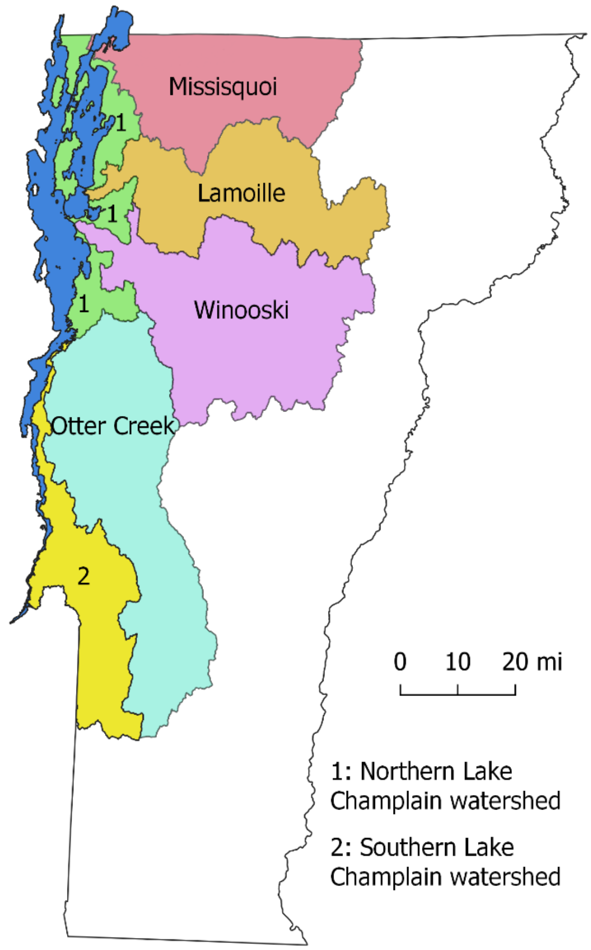
13 Ibid, 4.

14 EPA. "Phosphorus TMDLs for Vermont Segments of Lake Champlain," June 17, 2016. https://www.epa.gov/tmdl/lake-champlain-phosphorus-tmdl-commitment-clean-water

insights from these efforts, the State "developed a suite of programs to achieve the [necessary] phosphorus reductions" and gauged their support in public consultation sessions across Vermont.[16]

In May 2014, Governor Peter Shumlin submitted a draft implementation plan to the EPA. While the EPA evaluated this draft, the Vermont General Assembly passed Act 64,[17] also known as the Vermont Clean Water Act, which was signed into law in June 2015. The State of Vermont and the EPA revised the TMDLs over the following year.[18] The EPA published the latest TMDL for Vermont sections of Lake Champlain in June 2016.[19]

Figure 1. Lake Champlain Basin & Watersheds[15]



The 2016 TMDL mandates the State of Vermont to reduce phosphorus entering Lake Champlain from 631 to 418 metric tons per year (mt/y), a 34% reduction. Total reductions are broken down by phosphorus source: a 55% reduction from agriculture, 45% from stream banks, 19% from forests, and 18% from developed lands.[20] The TMDL projects a 28% *increase* in phosphorus from wastewater due to population growth and the diversion of phosphorus from other sources to wastewater systems (25 mt/y to 32 mt/y), even though it mandates phosphorus reductions from wastewater treatment facilities in certain lake segments.[21] The TMDL includes a margin of safety equal to 21 mt/y,[22] which gives the State of Vermont breathing room to meet overall phosphorus reduction targets without meeting every sector-specific target. The EPA required a margin of safety "to account

15 Created by SAO in QGIS using geodata from Vermont Open Data Portal. SAO edited watershed boundaries due to changes since the data's publication (see Appendix A).

16 EPA. "Phosphorus TMDLs for Vermont Segments of Lake Champlain," June 17, 2016, 6.

17 See: Act 64 of 2016.

18 EPA. "Changes from Proposed to Final TMDLs," June 17, 2016. https://ofmpub.epa.gov/waters10/attains_impaired_waters.show_tmdl_document?p_tmdl_doc_blobs_id=79220/.

19 EPA. "Phosphorus TMDLs for Vermont Segments of Lake Champlain," June 17, 2016.

20 Ibid, 48.

21 Ibid, 27-32.

22 Ibid, 48.

for lack of knowledge concerning the relationship" between phosphorus flows and concentrations "in a system as complex as Lake Champlain."[23]

Funding Sources and Responsibilities

Achieving these reduction targets will require substantial investment from governments and private entities. Between July 2015 and June 2018, the State of Vermont allocated nearly $100 million to the Interagency Clean Water Initiative (ICWI).[24] [25] More than two-thirds of this funding went to projects in the Lake Champlain Basin.[26] The remaining third went to clean water projects in other parts of the state, such as: nitrogen reduction projects in the Connecticut River Basin, as part of multi-state efforts to clean Long Island Sound; phosphorus reduction projects in the Lake Memphremagog Basin and; statewide clean water initiatives.[27]

Many financial sources funded clean water projects in FY16-FY18, including the Vermont Capital Bill (38%), the Clean Water State Revolving Fund (24%), the Vermont Clean Water Fund (16%), the Federal Transportation Fund (5%), the USDA National Resource Conservation Service (5%), and other state and federal sources (12%).[28] The EPA capitalizes 80% of Clean Water State Revolving Fund loans, while the State of Vermont capitalizes the remaining 20% through loan repayment and investment earnings.[29]

The State supports clean water grants using portions or the entirety of the following sources:

- Construction bonds (Vermont Capital Bill);
- Taxes on fuel, motor vehicle purchases and fees (State Transportation Fund);
- Taxes on income, sales, meals and rooms, insurance premiums, estates and inheritances, and property transfers (General Fund);
- Conservation license plate sales (Watershed Grant Fund);
- Act 250 mitigation fees (Act 250 Mitigation Fund);
- Property transfer taxes (Housing and Conservation Trust Fund);
- Surcharges on property transfers (Clean Water Fund) and;
- Beginning October 1, unclaimed bottle deposits (Clean Water Fund).[30]

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23 EPA. "Phosphorus TMDLs for Vermont Segments of Lake Champlain," June 17, 2016, 41.
24 This amount does not include $8.2 million in federal match and $21.4 million in local match/in-kind funding throughout the State of Vermont, as seen in Figure 9 of the 2018 CWIP Investment Report.
25 Vermont Clean Water Initiative Agencies. "Vermont Clean Water Initiative 2018 Investment Report," January 15, 2019.
26 Ibid, Appendix A.
27 Vermont Clean Water Initiative Agencies. "Vermont Clean Water Initiative 2018 Investment Report," January 15, 2019, 6 and Appendix A.
28 Ibid, 14.
29 Ibid.
30 Email from Emily Bird to Geoffrey Battista, May 22, 2019.

Recent legislation, signed into law on June 19, will divert 6% of total State meals and rooms tax revenue from the General Fund to the Clean Water Fund beginning on October 1, 2019.[31]

A range of entities are responsible for implementing projects with these funds, including State agencies, regional planning offices, municipalities, and non-profits.[32] Several State agencies oversee project implementation, including the Agencies of Administration (AOA); Agriculture, Food, and Markets (AAFM); Commerce and Community Development (ACCD); Natural Resources (ANR) and; Transportation (AOT), as well as the Vermont Housing and Conservation Board (VHCB). ANR's Department of Environmental Conservation manages the Clean Water Investment Program (CWIP), which gathers data, accounts for pollution reductions, and reports clean water program data.

The secretaries of the five aforementioned State agencies and four members of the public appointed by the Governor sit on the Clean Water Board.[33] The Board recommends how to allocate funding from the Vermont Capital Bill and the Clean Water Fund—totaling 54% of all State clean water funding between July 1, 2015 and June 30, 2018 (Table 1).[34] It is also a forum for agencies to monitor revenue and coordinate expenditures from other funding sources, including agency budgets. Vermont statute notes that "all recommendations from the Board should be intended to achieve the greatest water quality gain for the investment"[35] (emphasis added).

Vermont statute requires an audit of the Clean Water Fund (CWF) by January 15, 2021.[36] However, CWF provided only 16% of all FY16-FY18 State clean water funding. As of its April 25, 2019 meeting, the Clean Water Board continues to debate the scope of the audit and whether it should include other sources of State clean water funding.[37] In the meantime, the Vermont State Auditor's Office (SAO) will periodically investigate clean water progress, regardless of funding source.

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31 See: S. 96 of 2019. Referenced June 24, 2019.
32 Vermont Clean Water Initiative Agencies. "Vermont Clean Water Initiative 2018 Investment Report," January 15, 2019, Appendix A.
33 See: Act 168 of 2018.
34 Vermont Department of Environmental Conservation. "Clean Water Fund Budget Process." Accessed April 24, 2019. https://dec.vermont.gov/watershed/cwi/cwf/budget-process.
35 See: 10 V.S.A. § 1389(d)(1).
36 See: 10 V.S.A. § 1389b.
37 Clean Water Board Meeting, April 25, 2019.

Table 1. Funding sources that account for least 5% of FY16-FY18 clean water funding[38] [39]			
Funding Source	**Decision-Making Entity**	**Financing Mechanism**	**% Funds**
Capital Bill	* Clean Water Board * State Legislature	* State bonds	38%
Clean Water Fund	* Clean Water Board * State Legislature	* Property transfer tax surcharge	16%
Clean Water State Revolving Fund	* U.S. Congress * U.S. EPA * State Legislature * VT Dept. of Environmental Conservation	* State capital construction bonds * EPA grant * Repayment funds * Investment earnings	24%
Federal Transportation Fund	* U.S. Congress * State Legislature * VT Agency of Transportation	* Federal transportation funds	5%
USDA NRCS Agricultural Conservation Easement Program	* U.S. Congress	* USDA Natural Resource Conservation Service funding	5%
		Total	**88%**

Note: This table excludes all funding sources contributing less than 5% of all FY16-FY18 State clean water funding. These funding sources include: the General Fund; the State Transportation Fund; the Transportation Alternatives Federal Fund; the Housing & Conservation Trust Fund; the Act 250 Mitigation Fund; the Watershed Grant Fund and; the Lake Champlain Basin Program. These sources altogether account for 12% of FY16-FY18 ICWI funding.

[38] Email from Emily Bird to Geoffrey Battista, May 22, 2019.

[39] Vermont Clean Water Initiative Agencies. "Vermont Clean Water Initiative 2018 Investment Report," January 15, 2019, 15.

Phosphorus Sources in Vermont

Phosphorus flows from many sources.[40] It exists naturally in soil and biomass (plants and animals), and, as soil and shorelines erode, it flows down rivers and collects in lakes and wetlands. Farmers use phosphorus-rich fertilizer to increase their crop yields, and livestock manure is rich in phosphorus. Stormwater washes phosphorus from parking lots, sidewalks, and rooftops into drainage systems, which are often released directly into waterways. Sewer and combined sewer[41] systems bring phosphorus from urban areas to wastewater treatment facilities that discharge outputs into waterways. Undermanaged dirt roads and poorly managed forest harvesting operations cause erosion that washes phosphorus into waterways.

The EPA and the Vermont Department of Environmental Conservation (DEC) took a two-step approach to estimate phosphorus sources for the 2016 TMDL. First, they input two decades of monitoring data[42] into a mathematical model[43] to determine how much phosphorus needed to be reduced among Lake Champlain's major tributaries to reach EPA-mandated levels in the lake. Since this approach does not pinpoint *how* phosphorus enters major tributaries, including land-use factors and sources along smaller rivers, the contractor Tetra Tech followed up with Soil and Water Assessment Tool (SWAT) modeling. SWAT modeling assigns phosphorus values to different types of land, like farms or forests, and uses the characteristics of the landscape to predict where the phosphorus will flow on its way to Lake Champlain.[44]

The State's Clean Water Roadmap Tool[45] provides phosphorus source estimates, excluding end-of-pipe wastewater sources and in-channel erosion sources,[46] [47] in the six watersheds that drain into Lake Champlain. Table 2 summarizes these estimates. Approximately 30% of phosphorus flows from the Otter Creek watershed, which includes most of Addison County and areas of Rutland County near Route 7. The Winooski, Missisquoi, and Southern Lake Champlain watersheds release similar amounts of phosphorus to one another (80-100 mt/y). The Lamoille and Northern Lake Champlain watersheds release less non-point phosphorus than other watersheds.

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40 DEC Watershed Management Division. "Chapter 1. Strategic Framework for Statewide Efforts to Guide Surface Water Management." In Statewide Surface Water Management Strategy, 2017. http://dec.vermont.gov/sites/dec/files/documents/wsmd_swms_Chapter_1_Introduction.pdf.

41 Combined sewer systems combine stormwater and sewage en route to treatment facilities.

42 The Lake Champlain Long-Term Monitoring Project includes 15 lake stations and 21 tributary stations in Vermont and New York. These stations measure stream flow and phosphorus content, among other variables, and are routinely checked from April to October.

43 Tetra Tech. "Lake Champlain BATHTUB Model Calibration Report," April 30, 2015. https://www.epa.gov/sites/production/files/2015-09/documents/lc-bathtub-model-calibration-report.pdf.

44 EPA. "Phosphorus TMDLs for Vermont Segments of Lake Champlain," June 17, 2016, 21.

45 State of Vermont. "Clean Water Roadmap," 2017. https://anrweb.vt.gov/DEC/CWR/CWR-tool/.

46 In-channel erosion signifies waterway erosion caused by natural or manmade phenomena.

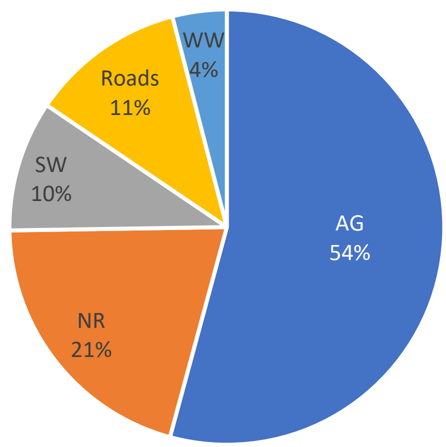
47 The SAO used Clean Water Roadmap Tool phosphorus source estimates because the Tool's land-use sector classifications and geographic units of analysis more closely correspond with ICWI expenditure data cited later in this report.

Table 2. Non-point phosphorus sources by watershed & sector, in metric tons per year[48] [49]						
Watershed	**Agriculture (AG)**	**Natural Resources (NR)**	**Stormwater (SW)**	**Roads**	**Total**	**% Basin**
Otter Creek	106.6	27.5	11.5	13.9	**159.6**	**29.6%**
Winooski	27.9	37.3	14.8	18.4	**98.4**	**18.3%**
Missisquoi	51.6	21.1	7.3	8.4	**88.4**	**16.4%**
Southern Lake	54.8	14.3	5.0	6.8	**80.8**	**15.0%**
Northern Lake	37.1	4.5	8.8	7.0	**57.4**	**10.7%**
Lamoille	26.4	10.5	7.1	10.1	**54.1**	**10.0%**
Basin-wide	**304.3**	**115.3**	**54.5**	**64.6**	**538.6**	**100.0%**

Note: All values rounded from original calculations to nearest 0.1. One metric ton = 1,000 kg, or 2205 lb.

Looking at phosphorous sources by land-use sector, the largest share of phosphorus entering the lake comes from agriculture at 54%, followed by natural resources (including forests, grasslands, shrublands, and wetlands) at 21%, roads at 11%, and stormwater at 10% (Figure 2). This pattern is relatively consistent across watersheds, though non-agricultural sources account for more than half the phosphorus in the Lamoille and Winooski watersheds (Appendix A). Wastewater (WW) is not represented in the Clean Water Roadmap Tool, but it is estimated to be the source of 4% of all phosphorus in Lake Champlain.[52] Both Table 2 and Figure 2 exclude phosphorus from in-channel erosion due to lack of data in the Clean Water Roadmap Tool.

Figure 2. Phosphorus Sources, Lake Champlain[50] [51]



The Clean Water Roadmap Tool's basin-wide total phosphorus loading (538.6 mt/y) differs from that published in the 2016 TMDL (631 mt/y) because the Clean Water Roadmap Tool does not include wastewater and in-channel erosion. The SAO used Clean Water Roadmap Tool source estimates because the Tool's land-use sector classifications and geographic units of analysis more closely correspond with State clean water expenditure data cited later in this report. The

48 State of Vermont. "Clean Water Roadmap," 2017. https://anrweb.vt.gov/DEC/CWR/CWR-tool/

49 Data were recoded using the following scheme: Agriculture from "Cropland," "Pasture/Hay," and "Farmstead" in the Clean Water Roadmap Tool. Natural resources from "Forest," "Grass/Shrubland," and "Wetlands." Stormwater from "Developed." Roads from "Roads."

50 State of Vermont. "Clean Water Roadmap," 2017. https://anrweb.vt.gov/DEC/CWR/CWR-tool/.

51 Data were recoded using the following scheme: Agriculture from "Cropland," "Pasture/Hay," and "Farmstead" in the Clean Water Roadmap Tool. Natural resources from "Forest," "Grass/Shrubland," and "Wetlands." Stormwater from "Developed." Roads from "Roads." Wastewater was added as 4% of the total phosphorus loading, based on 2016 TMDL estimates.

52 EPA. "Phosphorus TMDLs for Vermont Segments of Lake Champlain," June 17, 2016, 48.

DEC is currently considering whether to align watershed-scale expenditure and phosphorus reduction accounting with TMDL mandates at the lake segment scale—a considerable challenge given the complex relationship between watershed baseloads and lake segment phosphorus concentrations.[53]

[53] Email from Emily Boedecker to Doug Hoffer, June 24, 2019.

Phosphorus Reduction Expenditures in Vermont

The State of Vermont must reduce phosphorus pollution from many sources to successfully meet EPA-mandated targets. Strategies vary across land-use sectors (Appendix B). Farmers can adopt new practices and technologies. Waterway restoration projects can capture phosphorus in wetlands and along shorelines. Stormwater drainage and culvert investments can reduce pollution from paved surfaces and prevent erosion on dirt roads. Sewer and treatment facilities upgrades can capture phosphorus in wastewater and stormwater before being released into waterways.

Clean water projects in the Lake Champlain Basin received more than $66 million between FY16-FY18 (Table 3). The Winooski and Northern Lake Champlain watersheds received around $20 million each, and about 50% of their awards went to wastewater projects.[54] The Otter Creek watershed received about $9 million, with the largest share going to agriculture and 25% going to wastewater projects in the Rutland area. The Missisquoi watershed received more than $8 million, with a majority going to agriculture projects. The Southern Lake Champlain and Lamoille watersheds received the least amount of funding, focusing on agriculture while supporting projects in other land-use sectors.

Table 3. Interagency Clean Water Initiative Expenditures, FY16-FY18 (millions of dollars)[55]

Watershed	AG	NR	SW	Roads	WW	Multi	Total
Winooski	1.826	1.917	4.766	2.102	10.645	0.480	$21.736
North Lake	2.808	0.656	4.087	0.655	9.291	0.721	$18.219
Otter Creek	3.373	1.023	0.968	0.765	2.270	0.578	$8.977
Missisquoi	4.732	0.684	0.770	1.318	0.000	0.659	$8.162
South Lake	1.939	0.493	0.823	0.524	0.616	0.624	$5.019
Lamoille	1.064	0.836	0.965	0.649	0.068	0.537	$4.119
Basin-wide	$15.742	$5.610	$12.380	$6.012	$22.889	$3.599	$66.232

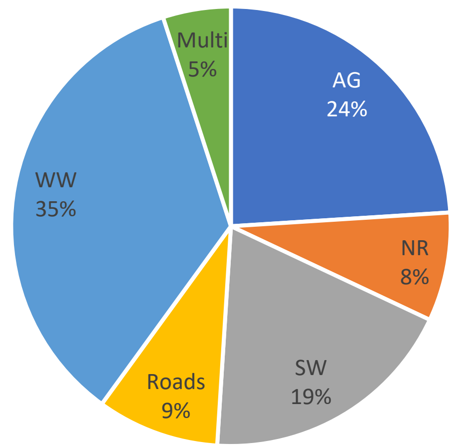
Note: Expenditures are classified by project type: "AG" is Agriculture; "NR" is Natural Resources; "SW" is Stormwater; "Roads" is Roads; "WW" is Wastewater and; "Multi" is Multi-sector. All values rounded to nearest 0.001 by DEC at SAO's request.

[54] "The Northern Lake Champlain and Winooski [watersheds] are outliers with investments at $18.2 and $21.7 million respectively. Significant investments in these basins are largely driven by municipal wastewater treatment and CSO abatement requirements, as well as municipal stormwater treatment requirements for Vermont's most populous municipalities" (2018 Clean Water Initiative Investment Report, 19).

[55] Email from Emily Boedecker to Doug Hoffer, June 24, 2019.

Multi-sector project expenditures varied by watershed. These expenditures went to the following project types: outreach & education; organizational capacity & development; mapping and analytical support and; water quality sampling.[56] [57] Expenditure data by watershed are available in Appendix A.

Figure 3. State Clean Water Expenditures, Lake Champlain (FY16-FY18)[58]



Combining these expenditures (Figure 3), we see that wastewater projects received the largest share of State clean water funding in the Basin even though the share of phosphorous pollution from this source is the lowest by far. Wastewater accounts for 4% of phosphorus pollution, but wastewater projects accounted for 35% of expenditures. The State of Vermont awarded two-thirds of wastewater funding as no- and low-interest loans from the Clean Water State Revolving Fund (CWSRF).[59] [60] [61] The remaining third came from Pollution Control Grants (Vermont Capital Fund),[62] which are provided to help municipalities pay back CWSRF loans.[63]

Smaller amounts of clean water funding went to other land-use sectors: agriculture is responsible for the largest share of phosphorus pollution (54%), but the State spent only 24% of total expenditures on agriculture projects. Stormwater received 19% of the funding, roads got 9%, and natural resources got 8%. Five percent of clean water spending went to multi-sector initiatives to build local partners' capabilities, provide technical assistance to farmers, and conduct public outreach.

56 Vermont Clean Water Initiative Agencies. "Vermont Clean Water Initiative 2018 Investment Report," January 15, 2019, Appendix A.
57 Email from Emily Boedecker to Doug Hoffer, June 7, 2019.
58 Vermont Clean Water Initiative Agencies. "Vermont Clean Water Initiative 2018 Investment Report," January 15, 2019, Appendix A.
59 Ibid, 18.
60 EPA. "Clean Water State Revolving Fund," February 20, 2019. https://dec.vermont.gov/facilities-engineering/water-financing/cwsrf/.
61 The Clean Water State Revolving Fund is a national program. The EPA capitalizes 80% of loans. The State of Vermont capitalizes 20% of loans and allocates awards.
62 VT Department of Environmental Conservation. "VT Pollution Control Grants," 2019. https://dec.vermont.gov/facilities-engineering/water-financing/vt-pollution-control-grants.
63 Response provided by Amy Polaczyk in: Email from Emily Bird to Geoffrey Battista, May 1, 2019.

Cost-Effectiveness of Phosphorus Reduction Practices

The State of Vermont plans to invest hundreds of millions of dollars over the next couple decades to meet phosphorus reduction targets. Vermont statute emphasizes that Clean Water Board recommendations "should be intended to achieve the greatest water quality gain for the investment."[64]

But which projects give taxpayers the best bang for their buck? Evidence suggests it is cheaper to reduce phosphorus from agriculture and natural resources than from stormwater, roads, and wastewater.[65] [66] At the same time, expensive stormwater and wastewater projects are necessary to reduce phosphorus in certain places. These include shallow and sheltered bodies of water, such as: St. Albans Bay, the southern tip of Lake Champlain, and rivers passing through large towns.

Wastewater projects are costly capital investments with benefits beyond phosphorus reduction. These benefits include solid waste processing, sewer service extensions to existing properties, and laying the groundwork for future development. The 2016 TMDL specifically targets wastewater investments in lake segments where: 1) the "currently permitted wastewater load represents a significant proportion of the total phosphorus load from all Vermont sources" and 2) wastewater upgrades would "meaningfully reduce the phosphorus reduction burden placed on non-wastewater sources," such as stormwater flowing into municipal water systems.[67] These criteria generally prioritize wastewater investments in two watersheds: Northern Lake Champlain (including St. Albans and metro Burlington) and Winooski (including Waterbury and Barre-Montpelier).[68]

This section of the report shows the cost-effectiveness of projects throughout the Lake Champlain Basin by land-use sector to determine whether taxpayers are getting the greatest value for their investments. The SAO defines cost-effectiveness in this analysis as the kilograms of phosphorus reduced annually for every $100,000 in State clean water spending. Readers should consider the following data limitations when interpreting the cost-effectiveness calculations in this section and those presented in Appendix C:

1. ICWI has only released three years of data. ICWI expects phosphorus reductions to increase as agencies gain expertise, measurement improves, and early investments bear fruit.

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64 See: 10 V.S.A. § 1389(d)(1).

65 EPA. "A Compilation of Cost Data Associated with the Impacts and Control of Nutrient Pollution," May 2015. https://www.epa.gov/sites/production/files/2015-04/documents/nutrient-economics-report-2015.pdf.

66 USDA Agricultural Research Service. "Best Management Practices to Minimize Agricultural Phosphorus Impacts on Water Quality," July 2006. https://www.ars.usda.gov/is/np/BestMgmtPractices/Best%20Management%20Practices.pdf.

67 EPA. "Phosphorus TMDLs for Vermont Segments of Lake Champlain," June 17, 2016, 28.

68 Ibid, 30-32.

2. The cost-effectiveness of projects in the natural resource and stormwater sectors may calculate lower than actual cost-effectiveness. This is because State agencies cannot yet measure phosphorus reductions for the following types of projects: river and floodplain restoration, lakeshore restoration, wetland restoration, forest erosion control, and combined sewer overflow abatement.[69] It is difficult to quantify phosphorus reductions from these project types because they are complex and context-sensitive. However, State agencies contributing to ICWI have reviewed neither the data required to quantify phosphorus reductions nor the average impact of these projects as of the latest CWIP Investment Report.[70]
3. Cost-effectiveness calculations in all land-use sectors may calculate lower than actual cost-effectiveness because phosphorus reductions are not systematically estimated among measurable project types.[71] ICWI has estimated phosphorus reductions for the following project types between FY16 and FY17:
    - 100% of total acres for crop rotation and associated practices;
    - 69% of total acres for forested agricultural buffers;
    - 53% of total acres for annual conservation practices (FY17);
    - 41% of total acres for stormwater treatment practices;
    - 27% of total acres for non-agricultural forested riparian buffers and;
    - An unknown percent of total miles for road erosion control practices.[72]

   ICWI and its partner agencies have not yet calculated the proportion of projects quantified for FY18, which ended on June 30, 2018.[73] [74]

Figure 4 shows that the cost-effectiveness of phosphorus reduction projects varies by land-use sector. Agricultural projects are the most cost-effective, capturing an estimated 8.3 kg phosphorus annually per $100,000 spent (8.3 kg/$100k).[75] This is more than twice as cost-effective as natural resource projects (3.1 kg/100k) and five times as cost-effective as road projects (1.3 kg/100k).

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69 Vermont Clean Water Initiative Agencies. “Vermont Clean Water Initiative 2018 Investment Report,” January 15, 2019, 93.

70 Ibid, Appendix C.

71 Vermont Clean Water Initiative Agencies. “Vermont Clean Water Initiative 2017 Investment Report,” January 15, 2018. https://dec.vermont.gov/sites/dec/files/wsm/erp/docs/2017CleanWaterInitiativeInvestmentReport_5MB.pdf.

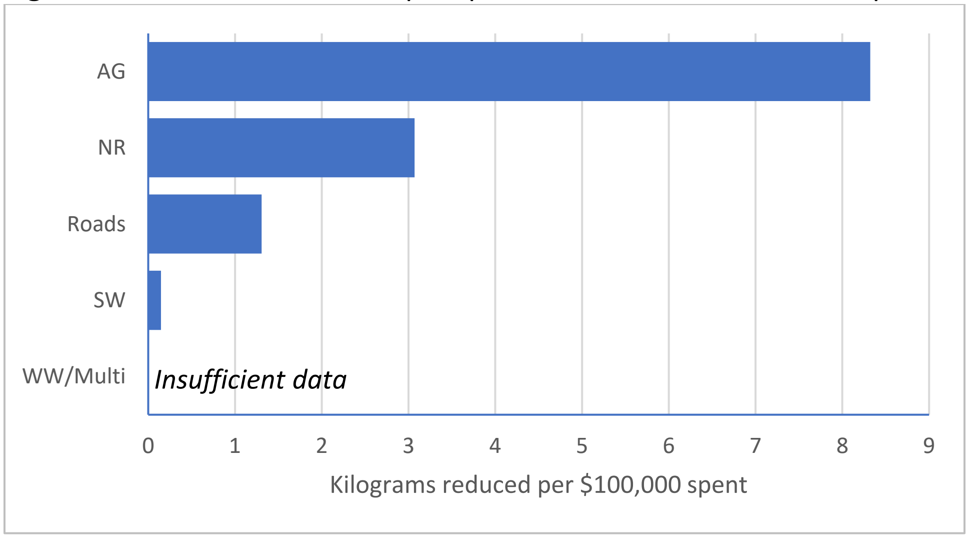
72 Vermont Clean Water Initiative Agencies. “Vermont Clean Water Initiative 2017 Investment Report,” January 15, 2018.

73 Email from Emily Bird to Geoffrey Battista, April 23, 2019.

74 CWIP notes the FY18 Investment Report omitted summaries of the proportion of projects quantified by land-use sector “for the purposes of streamlining/simplifying the report.” CWIP offered to calculate and provide data to the SAO within “a couple weeks” of April 23, 2019. Rather than wait for the data, which had been available by mid-April in previous years, the SAO continued with publication.

75 Please note that agricultural investments depreciate more quickly than those in other land-use sectors. Certain conservation practices have one-year lifespans, for example. Farm capital investments and agricultural forest buffers have longer lifespans.

Figure 4. Cost-effectiveness of phosphorus reduction in Lake Champlain Basin, by sector.[76]



The cost-effectiveness of stormwater projects is unclear because some expensive projects lack phosphorus reduction data. Four million dollars in stormwater spending in the Northern Lake Champlain watershed, for example, only yielded a 0.3 kg reduction in phosphorus from 0.2 acres of treated impervious surfaces across three locations: Lake Iroquois in Williston (erosion control); Burlington (installation of better-draining sidewalks) and; Shelburne (green stormwater management on a residential street).[77] In other watersheds, the cost-effectiveness of stormwater projects does not exceed 0.5 kg/$100k.

It is difficult to determine the cost-effectiveness of wastewater projects because investments may not directly relate to phosphorus discharges.[78] Seven of eight wastewater projects involved sewer extensions and refurbishments.[79] Phosphorus reductions cannot be calculated for extensions and refurbishments. ICWI justifies these investments because they are "important to maintain and improve aging infrastructure and provide sewer service to more areas."[80] While these investments may be important for these purposes, it is unclear how they relate to State phosphorus reduction objectives.

At the same time, a $6.3 million wastewater treatment facility upgrade in Waterbury was very cost-effective (12.1 kg/$100k).[81] [82] This result should not be generalized to other treatment

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76 Calculated from SAO using data from Vermont Clean Water Initiative Agencies. "Vermont Clean Water Initiative 2018 Investment Report," January 15, 2019, Appendix A.

77 Vermont Clean Water Initiative Agencies. "Vermont Clean Water Initiative 2018 Investment Report," January 15, 2019, 63.

78 Ibid., 39.

79 Email from Emily Bird to Geoffrey Battista, April 23, 2019.

80 Ibid.

81 Vermont Clean Water Initiative Agencies. "Vermont Clean Water Initiative 2016 Investment Report," December 30, 2016, 25. http://dec.vermont.gov/sites/dec/files/wsm/erp/docs/2016CleanWaterInitiativeInvestmentReport.pdf.

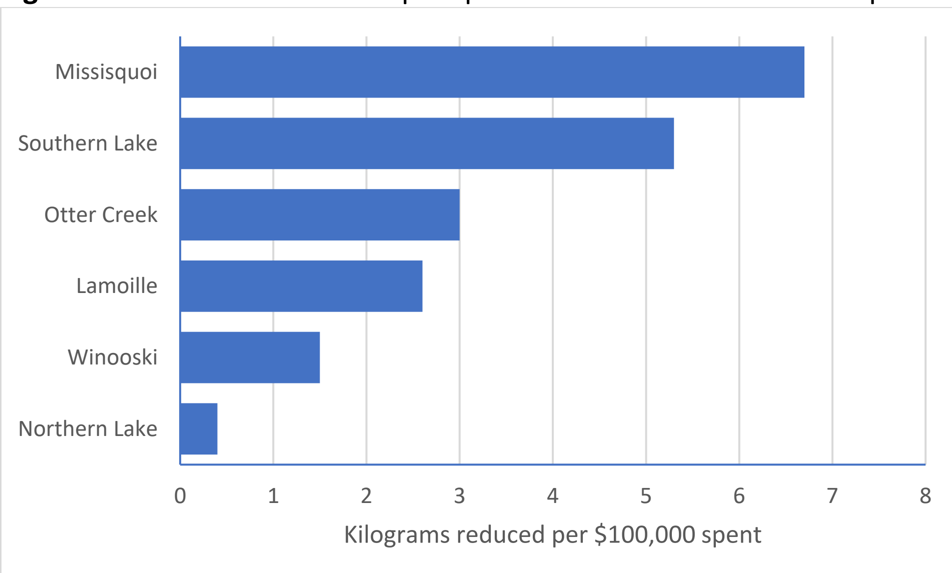
82 Email from Emily Bird to Geoffrey Battista, April 23, 2019.

facility upgrades, however, because their cost-effectiveness varies widely by facility type, size, volume, and upgrade measures.[83]

It is unclear what impact multi-sector expenditures have on phosphorus reduction, though other metrics related to the efficiency of agency operations may be more appropriate. The Vermont Department of Environmental Conservation plans to classify multi-sector projects by land-use sector, where appropriate, in future reporting years.[84]

Overall, every $100,000 spent on State clean water projects in the Lake Champlain Basin captured 2.4 kg of phosphorus per year. But cost-effectiveness varied by watershed (Figure 5). The most cost-effective watersheds were those whose projects had measurable phosphorus reductions: Missisquoi (6.7 kg/$100k), Southern Lake Champlain (5.3 kg/$100k); Otter Creek (3.0 kg/$100k) and; Lamoille (2.6 kg/100k). The Winooski watershed (1.5 kg/$100k) and Northern Lake Champlain watershed (0.4 kg/$100k) were less cost-effective because their wastewater and stormwater projects yielded little measurable reduction in phosphorus.[85]

Figure 5. Cost-effectiveness of phosphorus reduction in Lake Champlain Basin, by watershed[86]



[83] Tetra Tech. "Lake Champlain Phosphorus Removal: Technologies and Cost for Point Source Phosphorus Removal," January 13, 2014.

[84] Email from Emily Boedecker to Doug Hoffer, June 7, 2019.

[85] The $6.3 million wastewater treatment facility upgrade in Waterbury was not included in these calculations because it is not officially acknowledged in the 2018 Clean Water Initiative 2018 Investment Report. See Appendix C for source data.

[86] Calculated from SAO using data from Vermont Clean Water Initiative Agencies. "Vermont Clean Water Initiative 2018 Investment Report," January 15, 2019, Appendix A.

Upon reviewing the cost-effectiveness calculations above, DEC presented three critiques:

1. The calculations included the cost of incomplete projects, even though phosphorus reductions are not reported until projects are complete;
2. The calculations included the cost of project types whose phosphorus reductions are not yet quantifiable, such as combined sewer overflow abatement and;
3. The calculations did not consider project lifespan, meaning that expensive but long-lasting investments could calculate as less cost-effective than inexpensive, short-term investments.[87]

The SAO requested higher-resolution data to address these critiques. DEC furnished a spreadsheet of all clean water projects funded and completed between FY16 and FY18, inclusive, with pairwise project lifespan and phosphorus reduction data.[88] This sample of projects overlaps (though does not precisely align) with that presented in the 2018 CWIP Investment Report—whose data are subject to the limitations above.

This new spreadsheet listed 1,423 projects within the Lake Champlain Basin, including statewide projects, at a total cost of nearly $77 million in state funds. These projects were collectively forecast to capture an average of 2,962 kg phosphorus annually during their lifespans. These numbers yield a lifespan-adjusted cost-effectiveness of 3.9 kg/$100k for clean water projects in the Lake Champlain Basin.

However, these new data also revealed that 95% of all state clean water expenditures did not yield any measurable reduction in phosphorus.[89] Most projects in all land-use sectors, including all wastewater projects, did not yield measurable phosphorus reductions. By failing to register project impacts, State agencies cannot demonstrate that they are meeting phosphorus reduction targets, let alone at the lowest cost to taxpayers.

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87 Email from Emily Boedecker to Doug Hoffer, June 7, 2019.

88 Email from Emily Boedecker to Doug Hoffer, June 24, 2019.

89 $3.44 million of $76.73 million in clean water project expenditures yielded measurable phosphorus reductions.

Conclusion

Vermont statute emphasizes that Clean Water Board recommendations "should be intended to achieve the greatest water quality gain for the investment."[90] The State has allocated more than $66 million to Lake Champlain Basin projects from FY16 to FY18. Wastewater and stormwater projects received 53% of these funds, including 41% of all State grants,[91] even though most phosphorus doesn't come from these sources; the majority of phosphorous comes from the agricultural and natural resource sectors. Wastewater and stormwater projects were among the least cost-effective solutions to reduce phosphorus. These projects are not cost-effective because they are expensive and, apart from one wastewater facility upgrade, have little to no measurable impact on phosphorus.

This finding raises an important question: why were projects with low cost-effectiveness prioritized in the early years of the Interagency Clean Water Initiative? Stormwater and wastewater projects provide many benefits to municipalities, from public sanitation to economic development. Because these projects are expensive, it is in the interest of municipalities to leverage State funds whenever possible. But, considering the immense resources required to meet EPA-mandated phosphorus reduction targets, does it make sense for the State to invest dollars aimed at this tangential goal on projects with little impact on phosphorus?

The State of Vermont has recently taken steps to clarify its clean water priorities.[92] Regional clean water service providers (CWSPs) will be established and "required to identify, prioritize, develop, construct, verify, inspect, operate, and maintain clean water projects" as they disperse state funds. CWSPs will consider projects' phosphorus reduction impacts among other criteria, including those unrelated to phosphorus pollution, as they weigh which projects to fund in their respective regions. The Secretary of Natural Resources will oversee CWSPs' progress and hold them accountable to meeting pollution reduction targets. DEC asserts these measures will improve the targeting of funds based on anticipated phosphorus reductions.[93]

In addition to matters of cost-inefficiency, this inquiry found issues concerning the quality of project impact data used by State agencies. Four years after the passage of Act 64, State agencies cannot measure phosphorus reductions for combined sewer system upgrades and several types of natural resource projects.[94] The State tracks wastewater treatment discharges using self-reported data from facility operators,[95] but phosphorus reductions from wastewater projects have neither been quantified nor published in CWIP Investment Reports. ICWI staff

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90 See: 10 V.S.A. § 1389(d)(1).

91 (Stormwater grants + Wastewater grants) divided by (Total funds – Wastewater loans) in Lake Champlain Basin.

92 See: S.96 of 2019.

93 Email from Emily Boedecker to Doug Hoffer, June 24, 2019.

94 Vermont Clean Water Initiative Agencies. "Vermont Clean Water Initiative 2018 Investment Report," January 15, 2019, 93.

95 Email from Emily Bird to Geoffrey Battista, April 23, 2019.

note that the impact of wastewater projects will feature in annual reports beginning with FY19.[96]

However, State agencies also did not consistently estimate phosphorus reductions among measurable project types. The percentage of project acres that were quantified varied by project type in FY16 and FY17 (see section "Cost-Effectiveness of Phosphorus Reduction Practices").[97] ICWI and its State agency partners also have not yet calculated the percentage of project acres that were quantified for FY18.[98] Additional project data provided by DEC show the vast majority of projects in all land-use sectors have not yielded any measurable reduction in phosphorus.[99] These omissions make it difficult to accurately assess the efficiency and effectiveness of the State's clean water investments.

State agencies are making progress in estimating phosphorus reductions: developing new methods and tools, investing in employees' capabilities, and registering phosphorus reductions in more areas, such Lake Memphremagog. Continuing this progress is necessary to maximize the value that taxpayers receive for their investments. We encourage state agencies to continue improving how they estimate, monitor, and publish phosphorus reduction data. As data quality improves, the State of Vermont can provide Vermonters and the EPA with a more robust and transparent accounting of its progress toward a cleaner Lake Champlain.

[96] Email from Emily Bird to Geoffrey Battista, April 23, 2019.
[97] Vermont Clean Water Initiative Agencies. "Vermont Clean Water Initiative 2017 Investment Report," January 15, 2018.
[98] Email from Emily Bird to Geoffrey Battista, April 23, 2019.
[99] Email from Emily Boedecker to Doug Hoffer, June 24, 2019.

Appendix A: Watershed Summaries

This section summarizes four variables by watershed:

1. Phosphorus sources by land-use sector, excluding wastewater (at the watershed scale) and in-channel erosion;
2. ICWI project expenditures by land-use sector;
3. ICWI phosphorus reduction estimates by land-use sector and;
4. ICWI cost-effectiveness.

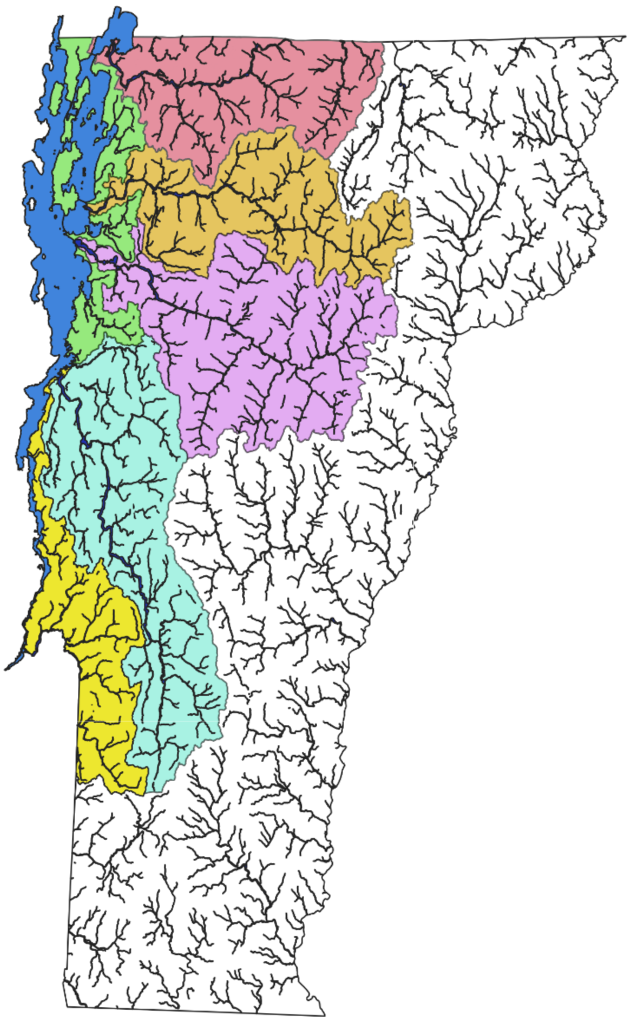
Each watershed features a map of rivers and their relationship to Lake Champlain. Maps are not to scale and have been enlarged to maximize detail.

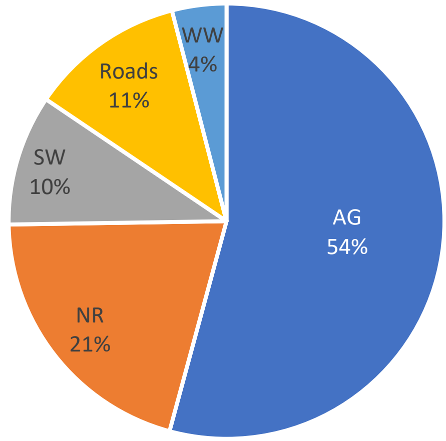
Data and their sources are listed below.

Data	Source
Watershed Phosphorus	Clean Water Roadmap Tool
ICWI Expenditures	2018 CWIP Investment Report
ICWI Phosphorus Reductions Estimates	2018 CWIP Investment Report
ICWI Cost-Effectiveness	Calculated by SAO
Geospatial - Watersheds	Vermont Open Data Portal
Geospatial - Rivers	Vermont Open Data Portal
Geospatial - Lake Champlain	Vermont Open Data Portal

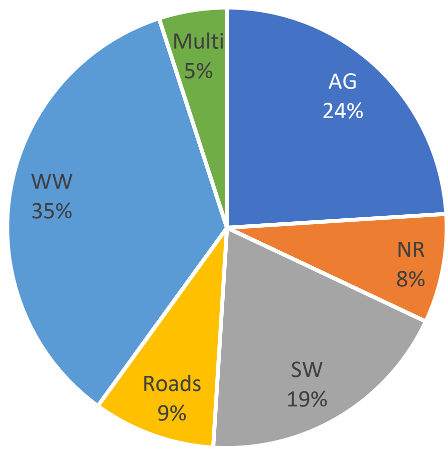
Note: SAO edited "Geospatial – Watersheds" due to boundary adjustments between 2008 and 2019.

Lake Champlain Basin





Phosphorus Sources, by sector*



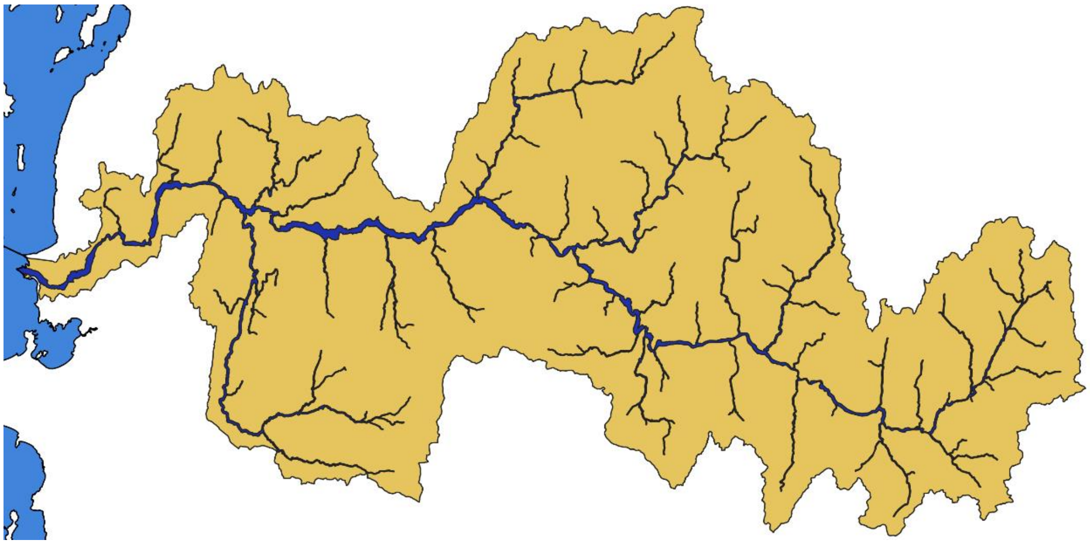
ICWI Expenditures, by sector

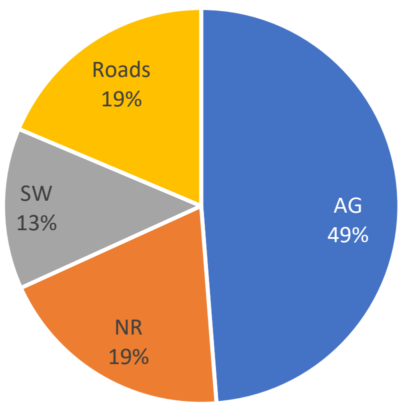
ICWI Performance (FY16-FY18)	
Basin Phosphorus	538,590 kg/y**
ICWI Expenditures	$66,232,457
ICWI Phosphorus Reduction Est.	1,575 kg/y
ICWI Cost-Effectiveness	**2.4 kg/$100k**

* "Phosphorus Sources, by sector" includes wastewater amount equal to 4% of 2016 TMDL total, added onto the "Basin Phosphorus" amount total derived from the Clean Water Roadmap Tool (CWRT) and proportioned as a percentage of the total. The CWRT data was used wherever possible because its land-use sector classifications and geographic units of analysis correspond with ICWI expenditure data.

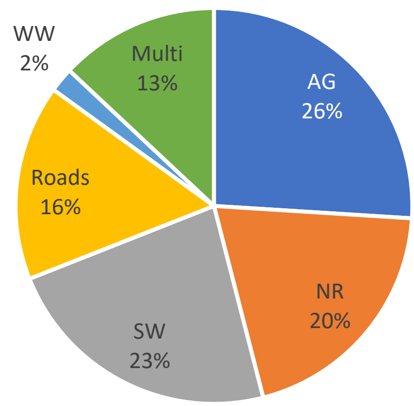
** The "Basin Phosphorus" total does not include wastewater or in-channel erosion.

Lamoille Watershed





Phosphorus Sources, by sector*

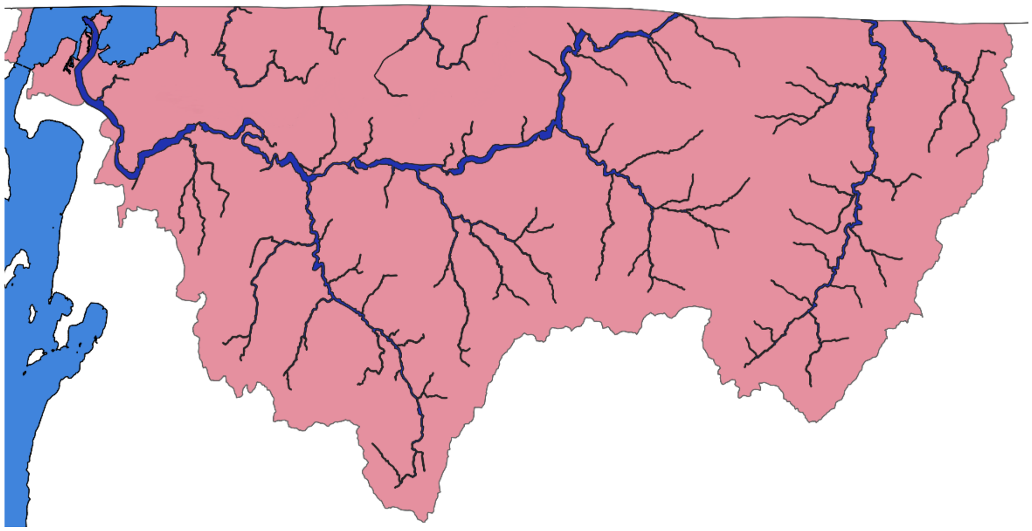


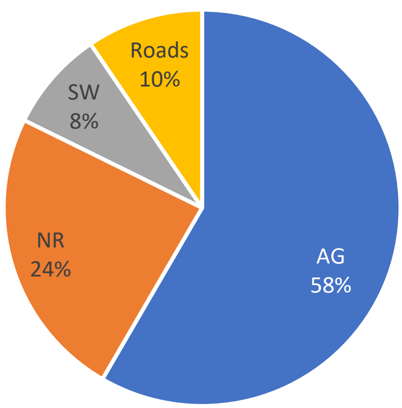
ICWI Expenditures, by sector

ICWI Performance (FY16-FY18)	
Watershed Phosphorus*	54,050 kg/y
ICWI Expenditures	$4,118,564
ICWI Phosphorus Reduction Est.	108 kg/y
ICWI Cost-Effectiveness	**2.6 kg/$100k**

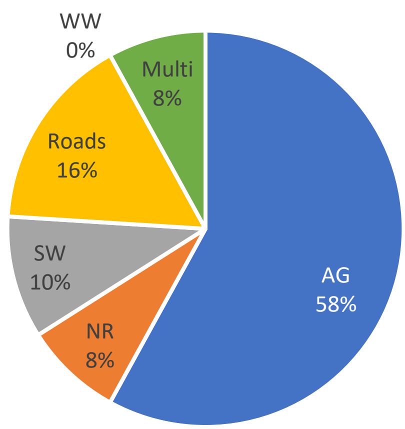
* Excludes wastewater and in-channel erosion sources.

Missisquoi Watershed





Phosphorus Sources, by sector*

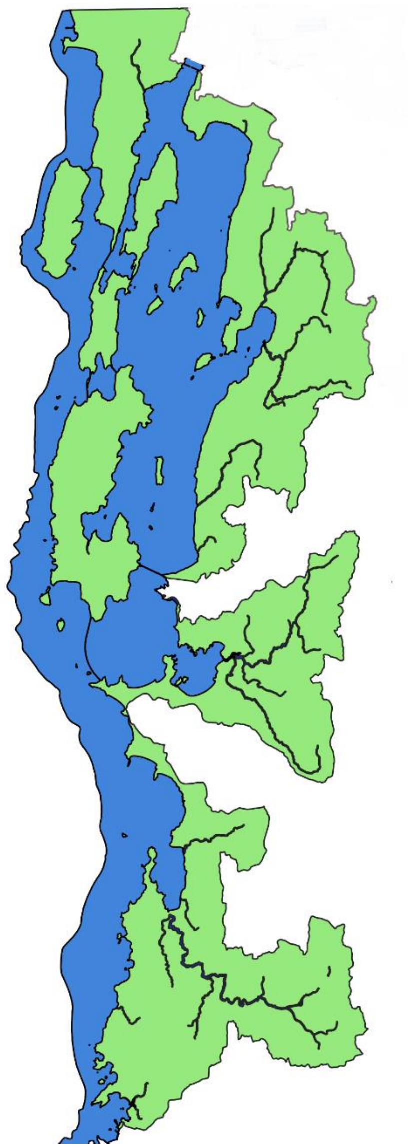


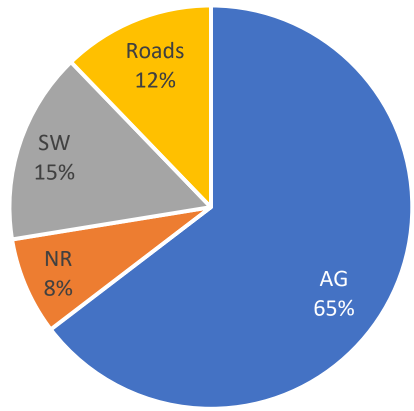
ICWI Expenditures, by sector

ICWI Performance (FY16-FY18)	
Watershed Phosphorus*	88,398 kg/y
ICWI Expenditures	$8,162,429
ICWI Phosphorus Reduction Est.	547 kg/y
ICWI Cost-Effectiveness	**6.7 kg/$100k**

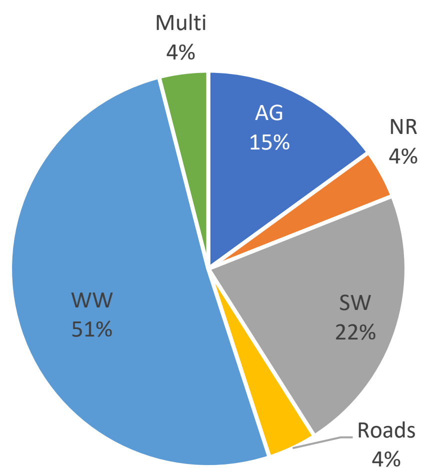
* Excludes wastewater and in-channel erosion sources.

Northern Lake Champlain Watershed





Phosphorus Sources, by sector*

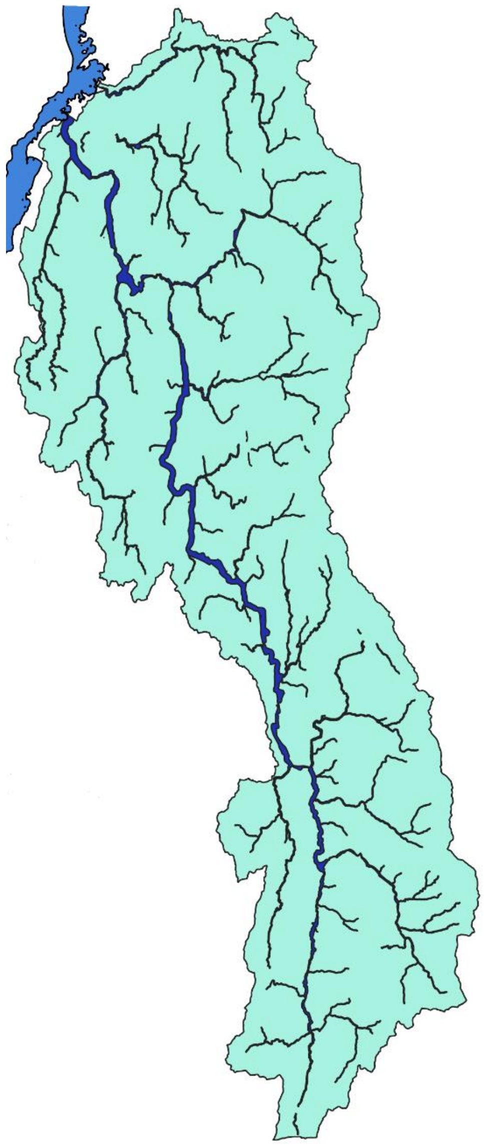


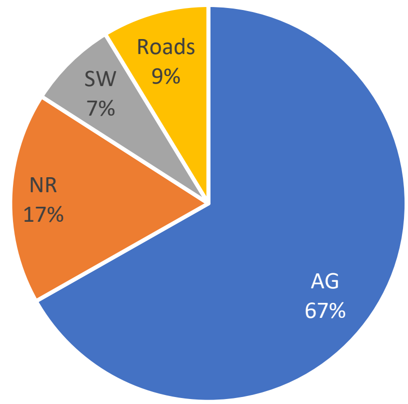
ICWI Expenditures, by sector

ICWI Performance (FY16-FY18)	
Watershed Phosphorus*	57,363 kg/y
ICWI Expenditures	$18,219,111
ICWI Phosphorus Reduction Est.	67 kg/y
ICWI Cost-Effectiveness	**0.4 kg/$100k**

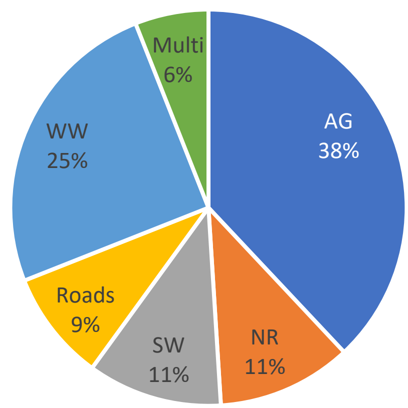
* Excludes wastewater and in-channel erosion sources.

Otter Creek Watershed





Phosphorus Sources, by sector*

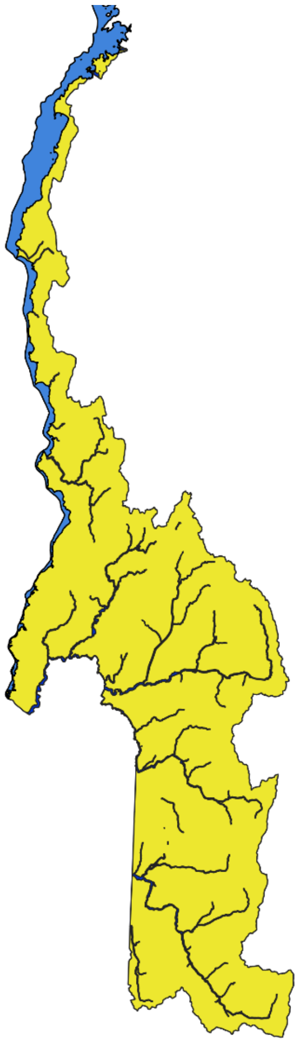


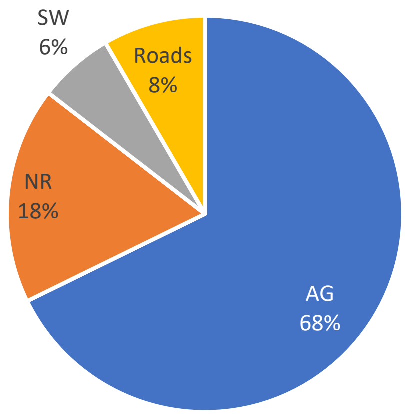
ICWI Expenditures, by sector

ICWI Performance (FY16-FY18)	
Watershed Phosphorus*	159,590 kg/y
ICWI Expenditures	$8,976,930
ICWI Phosphorus Reduction Est.	270 kg/y
ICWI Cost-Effectiveness	**3.0 kg/$100k**

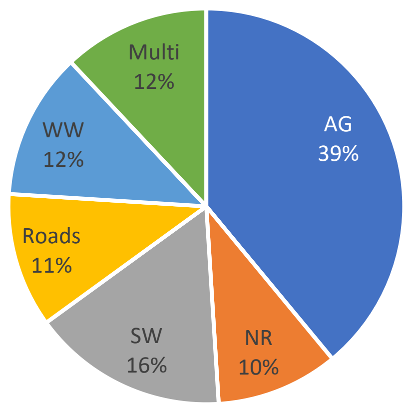
* Excludes wastewater and in-channel erosion sources.

Southern Lake Champlain Watershed





Phosphorus Sources, by sector*

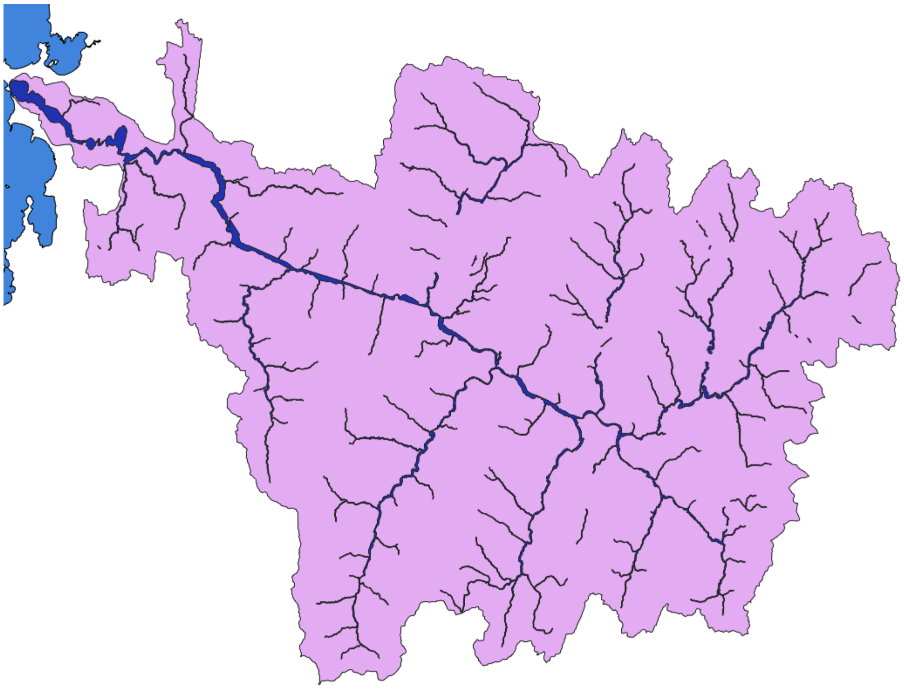


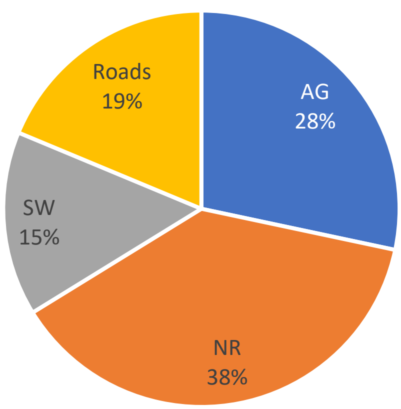
ICWI Expenditures, by sector

ICWI Performance (FY16-FY18)	
Watershed Phosphorus*	80,817 kg/y
ICWI Expenditures	$5,019,022
ICWI Phosphorus Reduction Est.	266 kg/y
ICWI Cost-Effectiveness	**5.3 kg/$100k**

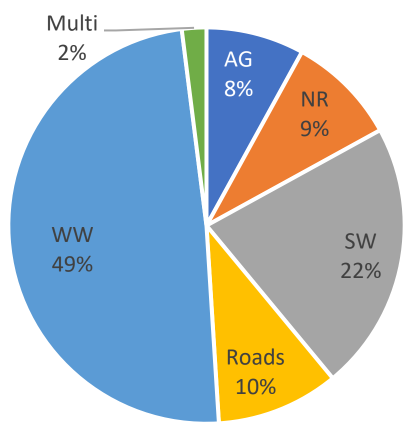
* Excludes wastewater and in-channel erosion sources.

Winooski Watershed





Phosphorus Sources, by sector*



ICWI Expenditures, by sector

ICWI Performance (FY16-FY18)	
Watershed Phosphorus*	98,372 kg/y
ICWI Expenditures	$21,736,401
ICWI Phosphorus Reduction Est.	318 kg/y
ICWI Cost-Effectiveness	**1.5 kg/$100k**

* Excludes wastewater and in-channel erosion sources.

Appendix B: Phosphorus Reduction Practices

Phosphorus Reduction Practices: Example Best Practices and Sample Projects (FY 2016-2018)				
Sector	**Example Best Practices**	**Sample Projects (FY18)**		
		Title	**Cost**	**Agency**
Agriculture	Fertilizing differently Managing livestock Storing waste Restoring forest buffers Using innovative technology and practices	Ridgeview Farm (Fairfield) – Alternative Manure Incorporation Vermont Land Trust – Agricultural Easement Farm #1 (Richford) Wastewater Storage Structure	$350, grant $264,000, grant $50,000. grant	AAFM VHCB AAFM
Natural Resources	Assessing waterways Buying and restoring easements Restoring riparian buffers Clearing waterways Restoring wetlands	Bouchard Farm Ditch Improvement Project – Rock River Town Garage Beecher Hill Brook – Floodplain restoration	$47,913, grant $43,398, grant	ANR ANR
Stormwater	Designing master plans Stemming illicit discharges Repairing and replacing infrastructure	Barre Town School Parking Lot Bioretention Lake Saint Catherine Watershed Master Planning	$6,520, grant $27,753, grant	ANR ANR
Roads	Remediating road erosion Investing in culverts and drainage Purchasing equipment	Essex - Vacuum Flusher / Pipeline Truck Central Vermont - Class 4 Road Erosion Remediation	$283,000, grant $113,000, grant	VTrans ANR
Wastewater	Extending sewer systems Phasing out combined sewer systems Upgrading or constructing treatment facilities	South Burlington – Wastewater Collection System Refurbishment, Final Design Waterbury – Wastewater Treatment Facility Upgrade, Construction	$306,720, 0% loan $6.4 million, grant	ANR ANR

Source: 2018 Clean Water Initiative Investment Report. Among agencies: “AAFM” is Agency of Agriculture, Food, and Markets; “ANR” is Agency of Natural Resources; “VTrans” is Agency of Transportation and; “VHCB” is Vermont Housing and Conservation Board.

Appendix C: Cost-Effectiveness Data

Row values were calculated in the following manner:

- "Cost" — State clean water expenditures divided by $100,000;
- "Impact" — Kilograms of phosphorus reduced per year by State programs and;
- "Cost-eff." — "Impact" / "Cost."

ND denotes "No Data." ID denotes "Insufficient Data."

Cost-Effectiveness Source Data (FY 2016-2018)								
		Missisquoi	**Lamoille**	**North Lake**	**Otter Creek**	**South Lake**	**Winooski**	**LC Basin**
AG	Cost	47.3	10.7	27.3	34.1	19.6	17.4	**156.5**
	Impact	519.0	86.0	52.0	216.0	215.0	214.0	**1,302.0**
	Cost-eff.	**11.0**	**8.0**	**1.9**	**6.3**	**11.0**	**12.3**	**8.3**
NR	Cost	6.5	8.2	7.3	9.9	5.0	19.6	**56.5**
	Impact	13.0	3.5	13.0	37.0	34.0	73.0	**173.5**
	Cost-eff.	**2.0**	**0.4**	**1.8**	**3.7**	**6.8**	**3.7**	**3.1**
SW	Cost	8.2	9.5	40.1	9.9	8.0	47.8	**123.4**
	Impact	3.4	4.4	0.3	2.5	ND	7.6	**18.2**
	Cost-eff.	**0.4**	**0.5**	**0.0**	**0.3**	**ND**	**0.2**	**0.1**
Roads	Cost	13.1	6.6	7.3	8.1	5.5	21.7	**62.3**
	Impact	12.0	14.0	1.4	14.0	17.0	23.0	**81.4**
	Cost-eff.	**0.9**	**2.1**	**0.2**	**1.7**	**3.1**	**1.1**	**1.3**
WW	Cost	0.0	0.8	92.9	22.4	6.0	106.5	**228.7**
	Impact	ND	ND	ND	ND	ND	776	**ID**
	Cost-eff.	**ND**	**ND**	**ND**	**ND**	**ND**	**7.3**	**ID**
Multi	Cost	6.5	5.4	7.3	5.4	6.0	4.4	**34.9**
	Impact	ND	ND	ND	ND	ND	ND	**ND**
	Cost-eff.	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**	**ND**
All	Cost	81.6	41.2	182.2	89.8	50.2	217.4	**662.3**
	Impact	547.4	107.9	66.7	269.5	266.0	317.6	**1,575.1**
	Cost-eff.	**6.7**	**2.6**	**0.4**	**3.0**	**5.3**	**1.5**	**2.4**

Source: Vermont Clean Water Initiative Agencies. "Vermont Clean Water Initiative 2018 Investment Report," January 15, 2019. All values rounded from original calculations to nearest 0.1.

Appendix D: Management Correspondence

This section summarizes report-related correspondence between the State Auditor and Emily Boedecker, Commissioner of Department of Environmental Conservation, including:

1. Email from Emily Boedecker to Doug Hoffer, June 7, 2019;
2. Email from Doug Hoffer to Emily Boedecker, June 13, 2019 and;
3. Email from Emily Boedecker to Doug Hoffer, June 24, 2019.

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Email from Emily Boedecker to Doug Hoffer, June 7, 2019

Thank you for sharing a copy of your Office's "non-audit" inquiry into the cost-effectiveness of expenditures on water quality projects by Vermont's Interagency Clean Water Initiative. Your focus on ensuring Vermont's clean water dollars are invested in the most cost-effective and impactful projects is one the Clean Water Initiative Program shares. In fact, the Agency of Natural Resources also identified barriers in both the current delivery system and the current funding sources that resulted in the recently passed S. 96, An Act Relating to the Provision of Water Quality Services, and the state budget that provides an ongoing source of general fund revenue to the clean water fund.

S. 96 focuses on the vast majority of Vermont's clean water work – which is to address diffuse, non-point sources of pollution – by establishing robust estimates of the efficacy and cost-effectiveness of individual practices. Over the next two years S. 96 requires the Agency of Natural Resources to evaluate, and then periodically re-evaluate, the magnitude of the investment required to implement discretionary projects that address diffuse sources of pollution and in consideration of the projected phosphorus reductions achieved by Vermont's regulatory programs. When fully implemented, S. 96 will prioritize Vermont's investments in discretionary clean water projects based on the anticipated phosphorus reduction. Discretionary clean water projects, such as natural resources restoration, are necessary to achieve the required phosphorus reductions for Lake Champlain but are not driven by regulation. Your report spotlights the challenges and areas for improvement that led the Administration and General Assembly to pass S. 96 in the first year of the 2019-2020 biennium.

While you did not request a management response to your conclusions, it is critical to note that the Report fails to acknowledge the broader statutory and regulatory framework that governs the work of the Clean Water Initiative Program. The failure to consider this context offers readers a false choice – suggesting that some of the less cost-effective investments are optional and could and should be reprogrammed. There are three important concepts that we believe should be included in your final report to provide context for stakeholders and decision-makers.

First, the report does not consider the statutory limitations of specific grants and funding sources administered by state agencies. Decisions about how to allocate available funds are often constrained by statutory and appropriations overlays. For example, the report is critical of the cost-effectiveness of investments made in municipal wastewater improvements. However, the report fails to consider the statutory requirement to direct the Clean Water State Revolving Fund (24 V.S.A. Chapter 120) and matched state appropriations to municipal wastewater improvements. As acknowledged in your report, the Clean Water State Revolving Fund investments are in the form of loans that are bonded by municipalities, which leverage local investment, and ultimately are paid back.

Second, both the federal Clean Water Act and the Vermont Clean Water Act (Act 64) require that many of these regulatory activities that you conclude are not as cost-effective as others must be completed regardless of their cost-effectiveness. Further, the Lake Champlain TMDL requires phosphorus reductions by specific sector, including wastewater, developed lands, agriculture, forests, and river systems. In order to meet our clean water goals, it is not an "either or" proposition, but an "all of the above" approach.

Finally, clean water work in Vermont cannot, legally or practically, be myopic in focusing on phosphorus pollution. While some investments may yield modest benefits in terms of phosphorus reduction, they are often mandated by law because they yield other important environmental and public health outcomes. The complex statutory and permit requirements that must be balanced when considering how to prioritize clean water investments cannot be ignored or oversimplified. For example, an upgrade at a wastewater treatment facility may yield modest reductions in phosphorous but result in significant reductions in an acute pollutant of concern, such as E. coli bacteria, or ammonia.

We hope that this additional context is helpful to you and your team in thinking about how you present the work of the Interagency Clean Water Initiative and the Agency's Clean Water Initiative Program. In addition to these general comments, we have identified a number of important factual inaccuracies and technical issues that we believe warrant correction and encourage you to consider in preparing your final report. These are described in the attached Appendix A.

In closing, we appreciate your interest in the important investments that Vermont is making in clean water. This work is significant, complex and essential not only to the Agency, but to all Vermonters. The additional context provided above, coupled with the factual corrections attached, will present a more complete and accurate review.

Sincerely,

Emily Boedecker

Email from Doug Hoffer to Emily Boedecker, June 13, 2019

Commissioner Boedecker,

Thank you again for your management response and appendix. It provided context in many areas, but we have some remaining questions (attached). We would appreciate responses to our questions, including available data, by EOB Wednesday, June 19.

Thank you,

Doug

Email from Emily Boedecker to Doug Hoffer, June 24, 2019

This memo provides additional information in response to questions received from your Office on June 13, 2019. Certain of your follow-up questions touch on the dynamic and evolving nature of this work. Our technical and financial staff continue to build upon the accounting and tracking tools necessary to implement the full suite of clean water requirements imposed by the Vermont State Law and the Lake Champlain TMDL (and other TMDLs). Like yours, our staff are also operating at full capacity on this work, which can be noted from the depth of responsiveness on your questions, and scope of technical tools your staff have reviewed, few of which were even in existence even three years ago.

I note your intention to conduct future similar non-Audit inquiry, and DEC welcomes this to ensure transparency and accountability to the processes we oversee on behalf of Vermonters. As appropriate to the manner in which non-audit inquiries are conducted, DEC requests advance notification and engagement in future inquiries. DEC can most effectively respond to your office's needs when the scope of inquiry and individual questions posed are mutually understood, and staff are provided sufficient advance warning to weave the necessary work into their workplans. Our staff have worked hard to establish the granting, accounting, and tracking systems discussed in your report, and welcomes future constructive feedback and recommendations.

Appendix E: Abridged DEC Technical Comments and SAO Responses

The DEC provided initial comments to the SAO's report draft on June 7, 2019 (plain text). The SAO submitted its comment responses on June 13 (marked in red and underlined). The DEC sent its final comments and supplementary data on June 24 (double-underlined). Actions taken in lieu of responses are written in brackets, e.g., [Data provided by DEC on June 24.] Minor changes have been made to the comments for clarity.

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Technical Corrections

DEC Comment #1: Page 7, second full paragraph. The accurate total reduction percentages, based on the Phosphorus TMDLs for Vermont Segment of Lake Champlain (the TMDL), are: 80% from agricultural production areas; 54% from agricultural fields and pastures and; 21% from developed lands. See Table 8 of the TMDL.

SAO Response #1: Thank you for directing us to Table 8. We drew from Figure 7 for our work. Table 8's phosphorus reductions roughly correspond with those in Figure 7 in the following categories: agricultural nonpoint, streams, forest, developed land, and total. However, Table 8 shows a decrease in wastewater phosphorus while Figure 7 shows an increase. Table 8 also does not account for the TMDL's margin of safety. Please clarify and justify which source is more appropriate to describe mandated phosphorus reductions for the purposes of this report.

DEC Response #1: Table 7 provides the lake segment-level requirements that DEC and USEPA consider the mandated phosphorus allocations. Regarding wastewater, Table 8 reports a percent wastewater reduction calculated by considering the pre-TMDL permitted load vs. the post-TMDL permitted load. In other words, there is an overall 42.1% reduction in the permitted load. However, even with that reduction in the permitted load, there is still an allowable wastewater load increase from what is being discharged currently, up to the new, post-TMDL allocation. Regarding the Margin of Safety in Table 8, we have confirmed that this is incorporated into the reductions in Table 8. We confirmed our understanding with Region 1 of the US Environmental Protection Agency. Please find confirmatory email correspondence in the attached email document #1.

DEC Comment #2: Page 10, Table 1. The Transportation Alternatives Fund (TA) is one component of the Federal Transportation Fund identified in the fourth row of the table. TA funds may be included in the Federal Transportation Funds row, which would elevate the percentage from 5% to 9% of total funds, to bring the total accounted funding to 92%. [SAO chose to maintain status quo.]

DEC Comment #3: Page 11, last paragraph, and Table 2. These numbers do not accurately reflect the TMDL, and DEC cautions against the use of the Clean Water Roadmap (CWR) to summarize baseloads to Lake Champlain for the purpose of the Report. The purpose of the

CWR is to downscale the load and wasteload allocations of the TMDL to as fine a geographic scale as practicable, to support tactical basin planning. While this is very useful from a planning perspective (see Tactical Basin Plans published since 2016), to be accurate the baseloads associated with lake segments must be taken from the TMDL. Documentation of the CWR acknowledges that the errors by-segment are +/- ~15%; however, the errors seem substantially larger in the case of agricultural land use in the Otter Creek basin, something that DEC will investigate. Figure 4, and Table 3 from the TMDL provide the most accurate information, broken down by land use sector. DEC recognizes the benefit of using the CWR in that basins are computed separately from lake segments, and roads are broken out as a sector separate from developed lands. Nonetheless, the TMDL presents the most accurate statement of baseloads to Lake Champlain. 4) Likewise, the data underlying Figure 2 of the Report would be more accurately reflected by reliance on the data in Table 3 of the TMDL.

SAO Response #3: Thank you for discussing baseloads. We have debated how to register baseloads since the earliest stages of this inquiry. Though the TMDL offers precise modelling data of baseloads, it is insufficient for the purposes of identifying the cost efficiency of investments for the following reasons:

1. Lake segments are the geographic unit of analysis in the TMDL, while the Interagency Clean Water Initiative (ICWI) publishes expenditure and phosphorus reduction data by watershed. We have not come across a replicable method to convert lake segment phosphorus loads into watershed loads.

2. CWR land-use sector classifications more closely match those used by ICWI when publishing expenditure and phosphorus reduction data. We understand that ICWI's classifications have evolved over time away from those in the TMDL, e.g., adding roads and folding CSO into wastewater. These changes make it difficult to measure ICWI progress against TMDL baseloads.

We acknowledge the limitations of our approach throughout the report and appendices. We are rewriting key paragraphs to more clearly convey these limitations. That being said, we welcome additional data should it address our above reservations with the TMDL data. Please provide these data if they are available.

DEC Response #3: The baseload attribution from lake segment to planning basin is one of the most technically complex components of planning and accounting for implementation of the TMDL, and an area of active engagement for DEC. The Clean Water Roadmap (CWR) does a great job of "downscaling" the original SWAT estimates for planning purposes, however, as noted in our prior response, there is error associated with modeling to develop the fine catchment-scale CWR estimates. There is another tool available that the Auditor may not be aware of, called the "HUC 12" tool, which is a spreadsheet model that expresses baseloads, reported directly by the SWAT model, at the "Hydrologic Unit Code – level 12" scale (the Dog River watershed would be a good example of a "HUC12" watershed). The HUC 12 tool was developed as a data visualization tool for output from the SWAT model. This tool is available from USEPA, and a copy of it is provided in as an attachment. DEC is in the process of considering whether to pivot Tactical Basin Planning watershed scale that Clean Water Initiative accounting occurs to align with the Lake Champlain TMDL segments. The content of the HUC12 tool is likely to assist this effort, but DEC cautions that doing so accurately will require careful cross-referencing to the original TMDL and underlying native SWAT data; a substantial analytical task.

DEC Comment #4: Page 14 and Figure 3. Wastewater accounts for 4% of the total load (see Table 3 of the TMDL), and 35% of spending in the Lake Champlain basin (see Vermont Clean Water Initiative 2018 Investment Report, Page 6). [Corrected by SAO from original values of 5% and 34%, respectively.]

DEC Comment #5: Page 14 last paragraph, agriculture comprises 41% of phosphorus loading (see Table 3 of the TMDL). [See *Technical Corrections,* SAO Response #3]

Minor Technical Points

DEC Comment #1: Introduction, page 4, uses the term “hazardous” to describe the levels of phosphorus in certain surface waters. Phosphorus in surface waters in and of itself is not hazardous. Certain impacts from high levels of phosphorus, specifically cyanobacteria blooms, may be hazardous. [Rewritten by SAO.]

DEC Comment #2: Page 8, first full paragraph. Lake Carmi is part and parcel of the Lake Champlain basin. [Rewritten by SAO.]

DEC Comment #3: Page 11, first full paragraph, concludes that dirt roads and forest harvesting cause erosion (…). More accurately, stormwater from undermanaged dirt roads, and poorly managed harvesting operations results in erosion. This is the reason that Act 64 required promulgation of the Municipal Roads General Permit and the revised Acceptable Management Practices for Maintaining Water Quality on Logging Jobs in Vermont. [Rewritten by SAO.]

DEC Comment #4: Table 3 presents sums computed based on percentages of total expenses from the Vermont Clean Water Initiative 2018 Investment Report, resulting in some rounding inaccuracies.

SAO Response #4: Please provide the expenditure data for each watershed in the Lake Champlain Basin, per the rows and columns in Table 3. Thank you. [Data provided by DEC on June 24.]

DEC Comment #5: Page 14 last full paragraph, multi-sector investments were not made in support of state employees. Rather, these investments benefitted the capacity and development of local partner organizations. [Rewritten by SAO.]

DEC Comment #6: In Footnote 74, regarding the depreciation of agricultural investments, please note that this applies to annual agricultural conservation practices only, which are accounted only for one year, based on the availability of record of payment for that year. However, farmers may implement for longer timeframes (see legend of Figure 17 page 28 of the Vermont Clean Water Initiative 2018 Investment Report for agricultural projects' anticipated lifespan). [SAO chose to maintain status quo, as some of these points were already noted elsewhere in the draft report.]

Clarifications of Policy and Narrative

DEC Comment #1: The Report is presented as an evaluation of the Clean Water Initiative Program (CWIP). DEC's Clean Water Initiative Program (CWIP) coordinates and manages: (1) gathering data, (2) accounting for pollutant reductions, and (3) reporting for the State of Vermont clean water funding programs shown in Table 1 on page 13 of the Vermont Clean Water Initiative 2018 Investment Report. DEC's CWIP does not influence or determine all clean water funding decisions across state government, including cost effectiveness of these investments. DEC's CWIP also relies on state funding programs to track, manage, and QA/QC check datasets. Since this Report evaluates data quality and cost effectiveness of funding decisions, which is the responsibility of all State of Vermont clean water funding programs and not just DEC's CWIP, this report would best be presented as an evaluation of the Interagency Clean Water Initiative. [Rewritten by SAO.]

DEC Comment #2: The executive summary highlights the high proportion of funds awarded to the stormwater and wastewater sectors and questions the allocation of scarce clean water funds to these sectors. As noted in our letter above, the Lake Champlain, Memphremagog, and other TMDLs establish sector allocations that are binding under the Federal Clean Water Act. While actions are required in all sectors, the State aims to direct funding to the most cost-effective projects within each sector. The State's policy is to supplement municipal costs of compliance with clean water regulations to minimize additional costs passed on to rate payers.

SAO Response #2: Please provide us with this policy, including source or authorization information, broken down by funding source as necessary.

DEC Response #2: Authority is conferred to the State to assist with municipal costs of compliance with clean water regulations by Act 64 of 2015 and modified in Act 154 (2016) and Act 168 (2018). More specifically see §10 V.S.A. 1389(e)(1)(A-D). For DEC, the Clean Water Initiative Granting Policy is updated annually, and the most recent copy may be found online, **here**. A comprehensive discussion on grant matching rates for municipalities (from multiple Agency funding sources) may be found in the 2017 "Act 73" report prepared by Treasurer Pearce. Please see specifically pages 25 and 26. Finally, S. 96 of 2019 amends priorities for Clean Water Fund usage in a manner that continues to support municipal stormwater mitigation, in §4(e)(2)(C) of that legislation, which amends §10 V.S.A 1389(e).

DEC Comment #3: Page 6, first full paragraph, describes the reasons for which EPA remanded the 2002 TMDL. A more accurate description is that the TMDL did not account for climate change and there were inadequate reasonable assurances that the nonpoint source load allocations were achieve. [SAO made minor revisions, weighing both 2016 TMDL language and the DEC comment.]

DEC Comment #4: Page 9, second paragraph, should also recognize the Vermont Housing and Conservation Board as an agency responsible for implementing clean water improvements. [Rewritten by SAO.]

DEC Comment #5: Page 13. Last paragraph. The complete list of multi-sector project types includes: Education & Outreach; Organizational Capacity & Development; Research; Technical Assistance; Mapping and Analytical Support and; Water Quality Sampling. During the next year of reporting, DEC plans to create sector-specific project categories for multi-sector project types, where appropriate, which will allow those projects to be grouped into land-use sectors (e.g., agricultural education and outreach). [Rewritten by SAO.]

DEC Comment #6: Page 15, second paragraph, summarizes requirements for wastewater treatment in certain segments of the Lake. While Rutland is called out in the report, the TMDL does not require this or any other facility in the Otter Creek segment to reduce loading relative to prior permitted loads. Section 6 of the TMDL details the specific segments and facilities where advanced wastewater treatment is necessary. These reductions are assigned based on proportion of wastewater contribution to the segment and facility size. Generally speaking, WWTFs discharging more than 200,000 gallons per day in critical lake segments (Missisquoi, St. Albans, and South Lake A and B) are required to reduce loads to a concentration equivalent of 0.2 mg/l, as are those facilities discharging to the Main Lake, Shelburne Bay, Burlington Bay, Missisquoi Bay, and South Lake Champlain segments. [Rewritten by SAO.]

Opportunities for Improved Cost-Efficiency

DEC Introduction: DEC appreciates the concluding paragraph of the Report which emphasizes the need for agencies to continue improving how they estimate and report phosphorus reductions. These improved methodologies may also inform agencies' abilities to make investments considering cost effectiveness of treatment of phosphorus, other nutrients, and sediment pollution. DEC and other agencies continue to dedicate staff time and resources to advance this work. We take this charge seriously. DEC offers the following observations to contextualize the intricacies in calculating cost effectiveness for the reader.

DEC Comment #1: The methodology used by the Report incorporated the costs of projects not yet complete (i.e., funded and in progress/ongoing) in its cost effectiveness calculation. However, phosphorus reductions and other project outputs are not reported until a project is fully constructed/implemented. For example:

a. State agencies funded 2,169 projects SFY 2016-2018, of which 1,428 were complete and 741 were ongoing at the close of the SFY 2018 reporting period.

b. The Report states, "Four million dollars in stormwater spending in the Northern Lake Champlain watershed, for example, only yielded a 0.3 kg reduction in phosphorus…" Forty-two stormwater projects in various project stages (e.g., project identification, design, and construction) have been funded in Northern Lake Champlain watershed in SFY 2016-2018; at the close of SFY 2018 reporting period, only 10 were complete, only 4 of which were categorized as construction/implementation.

SAO Response #1: Thank you for acknowledging this issue. To account for project completion, we would need pairwise project expenditure and phosphorus reduction data for all projects funded and completed between FY 2016 and FY 2018, broken down by land-use sector and watershed. These data must include completed projects with no measurable phosphorus reductions. These data must also include "projects constructed/implemented for which pollutant reductions are not yet quantifiable" (Opportunities for Improved Cost-Efficiency Information #2), such as the AAFM Best Management Practice Program, as these are included in expenditure data alongside phosphorus-reduction projects in CWIP investment reports. Are these data readily available?

DEC Response #1: The attached Excel workbook contains all projects funded and/or completed SFY 2016-2018 in the Lake Champlain basin. The first worksheet contains completed projects with quantified phosphorus reductions. The second worksheet contains projects without quantified phosphorus reductions. Projects in the Lake Champlain basin may lack quantified phosphorus for the following reasons: a. the project is not yet constructed/implemented; b. the project step is not construction/implementation; c. insufficient data were available to quantify phosphorus reductions and; d. the methodology is not yet in place to quantify phosphorus reductions. This workbook includes statewide and multi-basin projects that overlap the Lake Champlain basin. State funds awarded to statewide and multi-basin projects were split equally across the applicable watersheds when presenting dollars awarded per watershed/basin in the Investment Report. Database fields shown as column headers in the Excel workbook are defined in Appendix A, along with important considerations for interpreting the dataset.

SAO Response #1: Additionally, we request clarification on three points:

SAO Response #1a: We understand that phosphorus reductions and other project outputs are not reported until a project is fully constructed/implemented. However, do any clean water funding sources use predicted phosphorus reduction as a criterion for approval? If so, is this criterion validated ex-ante, post-hoc?

DEC Response #1a: The DEC Clean Water Initiative Program review committees rank projects for funding based on scoring criteria defined in the request for proposals (RFP). Review committees consider projects' anticipated nutrient and sediment pollution reduction where information is available. Pollution reduction estimates may be available through: 1. sector-based assessments (e.g., Stormwater Master Plan) that identify and prioritize projects based on anticipated nutrient and sediment pollution reduction and 2. prior completed design estimates of nutrient and sediment pollution reduction.

It is important to note that anticipated pollution reductions are not always available at the grant application stage, especially for proposed design projects, since the design itself informs the anticipated pollution reduction. Additionally, DEC CWIP continues to work on developing accounting methodologies, where these are not yet available (please see further additional information regarding S. 96, below). Where pollution reduction estimates are not available to inform funding decisions, the review committee may consider anticipated project outputs (e.g., acres of floodplain restored) relative to cost.

DEC CWIP is developing tools to evaluate anticipated pollution reductions in its funding decisions, starting with the online Stormwater Treatment Practice Calculator. Applicants must complete the Stormwater Treatment Practice Calculator and attach to stormwater construction grant applications to demonstrate the project's anticipated phosphorus reduction to the review committee.

The review committee considers other important factors in its decision making, such as: 1. project readiness to proceed (e.g., design complete and permits in place); 2. local support (e.g., landowner agreement) and; 3. technical review by DEC programs to ensure projects are permittable and do not cause negative impacts to natural resources. Other state agency funding programs may incorporate other criteria and should be contacted to determine how they prioritize funding decisions awards.

The state acknowledges the need to target funds based to the most cost-effective projects for phosphorus treatment within each sector. Note that S. 96 "An act relating to the provision of water quality services" will require dispersal of funds to regional Clean Water Service Providers based on phosphorus reduction targets and the cost per unit of phosphorus reduction beginning November 1, 2021. This requirement will help improve targeting of funds based on anticipated phosphorus reductions.

SAO Response #1b: Subsection (1b) notes that among 42 stormwater projects in the Northern Lake Champlain watershed, "only 4 of which were categorized as construction/ implementation." This finding differs from the three projects cited in our report, as gleaned directly from correspondence with ICWI/CWIP (Email from Emily Bird to Geoffrey Battista, May 22). Please explain this difference.

DEC Response #1b: Four "Stormwater – Implementation" projects were completed in SFY 2016-2018 in the Northern Lake Champlain watershed. Three had quantified phosphorus reductions, as noted in the email from Emily Bird to Geoffrey Battista on 5/22 and listed below. Insufficient data were available to quantify phosphorus reductions for the fourth project, titled "Reducing Residential Stormwater Runoff in the City of Burlington" as the project was funded in SFY 2012 before reporting requirements were in place to support quantifying pollutant reductions.

SAO Response #1c: The above email also notes that CWIP(?) calculated partial phosphorus reductions for incomplete projects:

Since the Munroe Brook/Brook Lane, Shelburne Stormwater Treatment project was installed part-way through SFY 2018 (11/6/2017), a portion (approximately 0.1 kg/yr) of the 0.2 kg/yr total phosphorus load reduction is reported in SFY 2018, which is how the 0.3 kg/yr total phosphorus load reduction for Northern Lake Champlain in SFY 2016-2018 was calculated. In next year's report, this value will be 0.4 kg/yr, plus reductions from additional state-funded stormwater treatment practices implemented in SFY 2019 (to be determined). (Email from Emily Bird to Geoffrey Battista, May 22)

Please clarify your phosphorus accounting approach on this issue.

DEC Response #1c: The email referenced did not intend to imply that the CWI calculates partial phosphorus reductions for incomplete projects. To clarify, total phosphorus load reductions are estimated as an annual average. If a project is active for a fraction of a reporting period, a fraction of the annual average load reduction may be attributed to the reporting period. For example, the Munroe Brook/Brook Lake project was completed November 6, 2017 and active for 65% of the SFY 2018 reporting period (July 1, 2017-June 30, 2018). The project's estimated annual average total phosphorus load reduction is 0.2 kilograms per year. Therefore 65% of the estimated annual average total phosphorus load reduction (0.13 kilograms) was attributed to SFY 2018.

DEC Comment #2: The methodology presented in the Report incorporated costs of projects constructed/implemented for which pollutant reductions are not yet quantifiable, but assigned these costs to other programs and practice types. For example: Over $19 million was awarded to agricultural clean water projects in SFY 2016-2018, of which over $6 million is through Agency of Agriculture, Food and Market's (AAFM) Best Management Practice Program to implement clean water projects on farm production areas/barnyards. Pollutant reductions on these sites will be assessed at the site-compliance status scale through AAFM inspections. Compliance status data were not available for SFY 2016-2018 reporting purposes; therefore, pollutant reductions were not assigned to projects implemented through AAFM's Best Management Practice Program. The method in the Report assigns the $6 million investment through AAFM's Best Management Practice Program to phosphorus reductions achieved by other programs and practice types, skewing the resulting cost effectiveness determination. This same issue applies to methods used to calculate cost effectiveness in other sectors. [SAO chose to maintain status quo, as it is investigating the cost-effectiveness of ICWI, not just projects that yield measurable phosphorus reductions.]

DEC Comment #3: The methodology employed by the Report does not consider project lifespan in cost effectiveness. Stormwater treatment practices and wastewater treatment projects may be relatively more expensive, but these investments, when properly maintained, will provide phosphorus reductions over a greater lifespan than, for example, an annual agricultural conservation practice. Grey infrastructure such as wastewater and stormwater is expected to have a lifespan of 20 to 30 years.

SAO Response #3: Thank you for bringing up this issue. To control for project lifespan, we would need expenditures and phosphorus reductions by project type, rather than land-use sector, and the lifecycles of these project types. We would further need these data disaggregated by watershed and year of funding and completion, subject to the parameters in the previous point (Opportunities for Improved Cost-Efficiency #1).

DEC Response #3: The attached Excel workbook contain projects' approximate lifespan and should address this request. [Workbook provided on June 24]