OFFICE OF THE PARLIAMENTARY BUDGET OFFICER
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BUREAU DU DIRECTEUR PARLEMENTAIRE DU BUDGET

Federal Contaminated Sites Cost

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The mandate of the Parliamentary Budget Officer (PBO) is to provide independent analysis to the Senate and House of Commons on the nation's finances, the economy, the estimates, and the cost of programs, legislation and policies.

The Parliamentary Budget Officer was asked, under section 79.2(d) of the Parliament of Canada Act, to estimate the financial cost to remediate Canada's contaminated sites.[1]

This report responds to that request. It estimates the costs of remediating current and future contaminated sites included in the Federal Contaminated Sites Inventory (FCSI), as well as new contaminated sites that are predicted to be added to the inventory.

The PBO modeled its analysis on historical cost data for assessing and remediating sites in the inventory.

It should be emphasized that these results are an estimate. The actual cost of remediating the sites in the inventory will depend on the degree to which past and present site assessment and remediation cost characteristics hold true going forward.

The inventory and, hence, this estimate do not cover sites controlled by private individuals or firms, enterprise Crown corporations,[2] or other levels of government;[3] shared-responsibility sites, such as the Sydney Tar Ponds;[4] sites included in the Nuclear Legacy Liabilities Program;[5] and sites remediated or sold prior to 1 April 1998[6]. In addition, this estimate does not include sites entering the inventory prior to 2006[7]; the five largest sites in the inventory (Faro mine, Colomac mine, Giant mine, Cape Dyer-DEW line, Goose Bay Air Base); and the low-level radioactive waste sites around Port Hope, Ontario. This estimate, therefore, does not provide a total estimate for remediation of all contaminated sites in Canada.

Please note that numbers may not add up due to rounding. All years referenced are fiscal years unless otherwise noted.

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[1] Parliament of Canada Act (2007); Remediation of contaminated sites for which the federal government is responsible is a matter that falls within Parliament's jurisdiction pursuant to section 79.2(d).
[2] Treasury Board of Canada Secretariat
[3] Ibid.
[4] Office of the Auditor General of Canada (2012) p. 69
[5] Ibid.
[6] Treasury Board of Canada Secretariat (2013) p. vi.
[7] There were not enough sites in FCSI prior to 2006 to provide statistical significance.

Contents

Executive Summary

Areas of land or water affected by hazardous waste or pollution are referred to as contaminated sites.[8] Such sites are typically remediated over time. Remediation refers to the process of reversing or stopping the damage to human health and the environment caused by the hazardous waste or pollution. This may involve everything from completely cleaning up the pollutant to simply risk managing the site (e.g. putting a fence around it).

The federal government is responsible for remediating a number of contaminated sites, which are contained in the Federal Contaminated Sites Inventory. The government reports the expected liability to remediate these sites to Parliament in the Public Accounts of Canada. The PBO was asked by a parliamentarian to assess the degree to which the liability reported in the public accounts reflects the cost of remediating these contaminated sites.

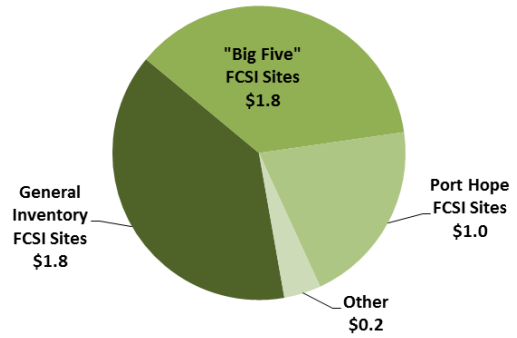
The total liability for remediating Canada's contaminated sites reported in the public accounts is $4.9 billion. As shown in Summary Figure 1 below, this can be further broken down into $1.8 billion for general inventory sites, $1.8 billion for the Big Five sites (Faro mine, Colomac mine, Giant mine, Cape Dyer-DEW line, Goose Bay Air Base), $1 billion for the low-level radiation sites around Port Hope, Ontario[9], and $200 million for other sites.[10,11]

It is the general inventory sites that are the main focus of this analysis. Whereas the public accounts report $1.8 billion associated with remediating these sites, the PBO estimates that the cost of remediation will be closer to $3.9 billion—$2.1 billion above that currently reported to Parliament in the public accounts.

The PBO estimate is higher than that reported in public accounts because it includes liabilities for sites that have not been assessed or are not fully assessed, liabilities for sites yet to be identified, and increases in liability for sites in active remediation.

Summary Figure 1 Reported contaminated sites liabilities

in billions

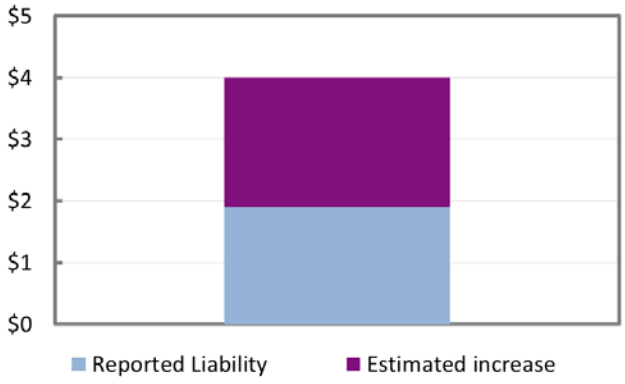


Source: Receiver General of Canada, PBO, FCSI

This additional $2.1 billion in estimated remediation cost is shown in Summary Figure 2 below.

Summary Figure 2 PBO estimated general inventory sites liabilities

billions ($)



Source: PBO and FCSI

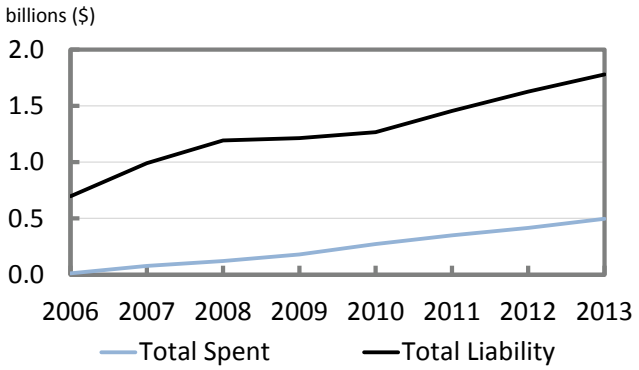
[8] Strictly speaking, a contaminated site is "a site at which substances occur at concentrations: (1) above background levels and pose or are likely to pose an immediate or long-term hazard to human health or the environment, or (2) exceeding levels specified in policies and regulations." Dillon Consulting Limited (1999) p. 2.
[9] These large sites could not be estimated because of their small number and unique characteristics.
[10] These "other" sites are not tracked in the Federal Contaminated Site Inventory (FCSI).
[11] FCSI sites add up to $4.8 billion rather than $4.9 billion due to a combination of rounding and differences between the data in FCSI and public accounts.

The fact that the PBO did not estimate the cost of the largest sites ("Big Five" and Port Hope) does not mean that they do not pose a financial risk.

As shown in Summary Figure 3 below, the liabilities reported in the public accounts (in black) for the Big Five sites have been increasing in tandem with remediation expenditures (in blue).

The year-over-year compounded increase in liability from 2006 to 2013 for these sites has been 11.4%. It is difficult to say when the liabilities will stabilize and, therefore, where the total cost to remediate will eventually settle.

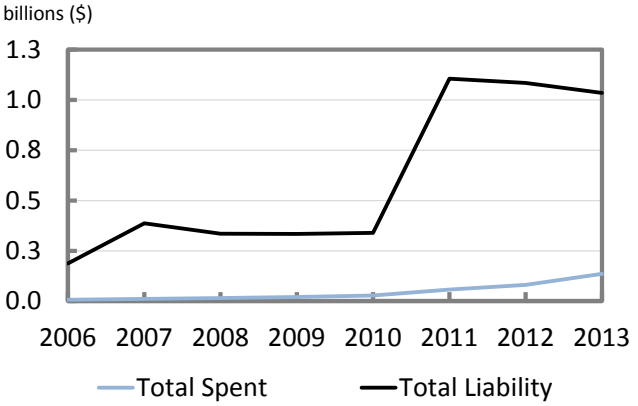
Summary Figure 3 Liability and remediation for five big sites



Source: PBO and FCSI

As shown in Summary Figure 4 below, the liabilities reported in the public accounts (in black) for the Port Hope sites have been decreasing roughly in proportion to remediation expenditures (in blue) over the past two years. This may suggest that the liability has stabilized and that the total cost to remediate will reflect, more or less, the expenditures and outstanding liabilities.

Summary Figure 4 Liability and remediation cost for Port Hope



Source: PBO and FCSI

As shown above, the likely financial costs associated with contaminated sites are significant and are not reflected in the figures reported to Parliament in the public accounts. Both the general inventory sites and the Big Five will likely see cost increases over and above those currently reported.

In addition, costs may increase as a result of yet unidentified forms of contamination. By way of example, a new contaminant, perfluorooctane sulfonate, has recently been discovered at a number of sites. This newly discovered contaminant will increase the amount the government will spend on remediation.[12]

[12] Perfluorooctane sulfonate (PFOS) is a chemical that was used in fire-fighting foams prior to 2002 for flight fuel-based fires (i.e. for airplanes at airports) (Government of Canada (2010)). Remediation plans are currently being developed to handle PFOS, but until these plans are finalized, the inventory will not include any liability estimates for this work.

1 Introduction

A contaminated site is "a site at which substances occur at concentrations: (1) above background levels and pose or are likely to pose an immediate or long-term hazard to human health or the environment, or (2) exceeding levels specified in policies and regulations."[13]

Contaminated sites have recently risen to the forefront of public debate in Canada as remediation projects have increased in number and cost.

Contaminated sites were first recognized as a major issue by the federal government in 1989 when the Canadian Council of Ministers of the Environment and the Government of Canada created a five-year National Contaminated Sites Remediation Program to begin remediating abandoned sites.

In 1995, the Contaminated Sites Management Working Group (CSMWG) was formed to develop interdepartmental strategies. In 2002, the Treasury Board launched the Federal Contaminated Sites Inventory, and in 2004, the federal government committed $3.5 billion through the Federal Contaminated Sites Action Plan (FCSAP) to clean up contaminated sites.[14] The action plan started in 2005-2006 and will run through 2019-2020[15].

The federal government has also established the Nuclear Legacy Liabilities Program (NLLP) to deal with decommissioning nuclear facilities[16] and created a program to "address historic low-level radioactive waste sites in the Port Hope, Ontario area."[17]

Furthermore, the federal government shares responsibility for remediation on special projects such as the Sydney Tar Ponds. As of March 2013, the total remaining environmental liability associated with federal sites was reported to be $10.6 billion.[18] This amount consists of:

- $4.7 billion in liabilities for the contaminated sites in the inventory;
- $0.2 billion for other contaminated sites not tracked in the inventory; and
- $5.7 billion for asset restoration, all of which, except $4 million, is for nuclear facility decommissioning (NLLP).[19]

The inventory currently lists 24,990 contaminated sites, which include open, closed, and deleted sites.[20] This total does not include sites in the NLLP or sites with shared responsibility. But it does include sites in the Port Hope program.[21]

This report uses the yearly information recorded for the contaminated sites undergoing remediation in the inventory to estimate the total cost of assessing and remediating all the remaining and future inventory sites.

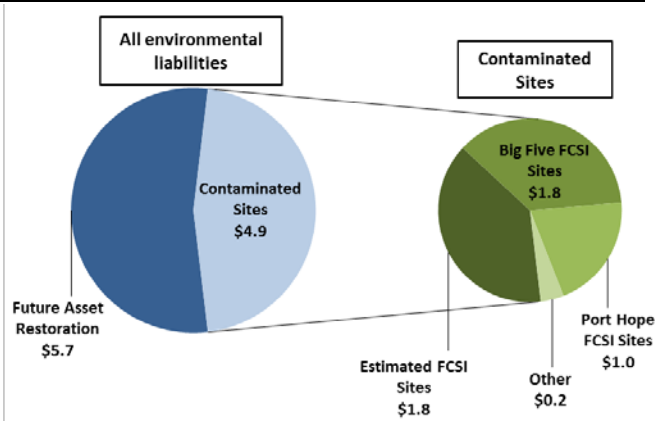
The Port Hope sites and the five largest sites (Faro mine, Colomac mine, Giant mine, Cape Dyer-DEW line, Goose Bay Air Base) were excluded from the PBO's analysis because of their unique nature.

The Port Hope sites account for $1.0 billion and the five largest sites account for $1.8 billion of the previously mentioned $4.7 billion reported environmental liabilities in the inventory; therefore, removing these sites results in a remaining, reported liability of $1.8 billion.[22] This report estimates the expected increase in this amount.

[13] Dillon Consulting Limited (1999) p. 2.
[14] Government of Canada (2013b)
[15] Office of the Auditor General of Canada (2012) p. 67.
[16] Natural Resources Canada (2010)
[17] Office of the Auditor General of Canada (2012) p. 69.
[18] Receiver General for Canada (2013a) p. 5.11.
[19] Ibid.
[20] Treasury Board of Canada Secretariat
[21] Office of the Auditor General of Canada (2012) p. 69.
[22] By simple subtraction of the previous numbers one would get $1.9B but due to rounding and differences between the data in FCSI and public accounts, the actual FCSI number is $1.8B.

The breakdown of the environmental liability reported in the 2013 Public Accounts is illustrated in Figure 1-1 below ($4.9B). The focus of this report—Estimated sites in the inventory (excluding the big five and Port Hope)—is shown by the wedge in dark green.

Figure 1-1 Environmental Liabilities (billions)



Source: Receiver General of Canada, PBO, FCSI

To perform the financial analysis for this report, the PBO was provided by the Treasury Board Secretariat with an internal copy of the inventory database that contained full information for all sites. This is different than the information contained in the public version (see section 2.6.4 on page 8).

As will be explained in more detail in the body of the report, the PBO's estimate of the total cost to remediate these contaminated sites will, by definition, be higher than that of the federal government's reported liability. This is because the PBO estimate includes:

1. liabilities for sites that have not been assessed or are not fully assessed;
2. liabilities for sites yet to be identified; and
3. increases in liability for sites in active remediation.

This report has three sections. The first section provides background information regarding contaminated sites, the legal responsibility for remediation, the action plan, and the inventory. The second section presents the methodology used in the estimation. The results are outlined in the final section.

2 Background information

2.1 How do contaminated sites arise?

Contamination can arise from a number of different sources, including commercial or industrial activity, waste disposal, improper chemical storage, and spills and leaks.[23] Most contaminated sites with which the government is now dealing were contaminated by "past practices and activities whose environmental consequences were not fully understood at the time."[24]

Insofar as the federal government is concerned, the most costly projects to date have been handled by Aboriginal Affairs and Northern Development Canada (AANDC).[25] They account for about 40% of total action plan remediation expenditures.[26]

What is Federal Contaminated Sites Action Plan?

The action plan is the main federal program to address sites recorded in the inventory. It is a cost-sharing program intended to aid federal departments in managing the contaminated sites for which they are responsible. The Government of Canada is providing $3.5 billion of funding over 15 years (2005–06 to 2019–20). For more details, see section 2.7.

For AANDC, the most expensive projects have been the remediation of abandoned mines in the North.[27] Mining activity, largely unregulated in the past, created a number of environmental hazards. The financial securities obtained to restore sites have

[23] Dillon Consulting Limited (1999) p. 9; see also Office of the Auditor General of Canada (2012) p. 65.
[24] FCSAP Secretariat (2010) p. 16.
[25] AANDC was formerly known as Indian and Northern Affairs Canada (INAC). The Northern Affairs Organization (NAO), within AAND, handles the Department's contaminated sites.
[26] FCSAP Secretariat (2013)
[27] Ibid.

proven grossly inadequate and have left taxpayers responsible for remediating mine sites when mining companies have been unable to do it themselves.[28]

2.2 What does remediation mean?

Given that contaminated sites can take many forms and that contamination can arise from any number of sources, many different remedial approaches are required.

A remediation project can range from a simple surface clean-up to a prolonged and expensive monitoring project. The goal of all remediation is to allow for future land use and remove or minimize risks to the environment and human populations.

There are five broad remedial options:

(1) complete clean-up;

(2) partial clean-up of priority items;

(3) establishment of a monitoring program;

(4) risk management; and

(5) doing nothing.

A remediation plan can include removal and disposal, containment or encapsulation, or treatment.[29] Risk management is a broader option that generally involves long-term monitoring. It focuses primarily on containing and controlling the contaminant.[30]

Many factors influence the exact approach taken. They include the future land use, the medium affected, the contaminant type, the geological and ecological characteristics of the site, and the climatic conditions.[31]

However, the future use of the land is perhaps the most important factor to consider when determining which form of management is appropriate; accordingly, whether the land is intended to be used for agricultural, residential, parkland, commercial, or industrial purposes will influence, to a large degree, the appropriate approach to remediation.

Each of these categories requires a different degree of remediation, as different levels of contamination are permitted for each type of use.

In addition, the use of any neighbouring property may also influence remediation strategies.[32] Costs of remediation can vary greatly depending on the type and extent of remediation required.

2.3 Who is responsible for remediation?

Since remediation work is costly and time consuming, it is important to clearly identify the responsible party or parties.

Canadian law supports a “polluter pays” and “beneficiary pays” system.[33] That is, the party or parties responsible for causing the contamination or who profit from the contamination will be held responsible for the cost of remediation. These principles were espoused by the Canadian Council of Ministers of the Environment in their *Recommended Principles on Contaminated Sites Liability*[34] and have been adopted in most provincial laws.

There is no one level of government with complete control over environmental protection. However, while the federal government exercises some control in this area, the provincial and territorial

[28] Castrilli (2010) pp. 120-1.
[29] Canadian Council of Ministers of the Environment (1997) pp. 26-27.
[30] Dillon Consulting Limited (1999) p.4.
[31] Canadian Council of Ministers of the Environment (1997) p. 27.
[32] Environment and Natural Resources (2003) p. 9.
[33] Harbell (2002) p. 40.
[34] Canadian Council of Ministers of the Environment (2006) pp. 4-5.

governments issue the bulk of legislation regarding contaminated sites.[35]

Most provincial and territorial laws identify at least three classes of people as potentially responsible for the remediation of a contaminated site. They are:

(1) the person whose act causes the contamination;

(2) the person who owns or is in control of the contaminating substance; and

(3) the owner, occupier, or operator of the contaminated site.[36]

These parties can be held liable for remediation costs incurred by government agencies or made to undertake remediation projects.

2.4 How does the federal government become responsible?

In many cases, the federal government becomes responsible for a contaminated site because government actors caused the contamination or the government owned the contaminating substance. The government, in these cases, is the polluter and so must pay for the remediation.

In other cases, the federal government becomes responsible for a contaminated site because it is the owner of the contaminated land. The federal government can also become responsible for remediation if the contamination occurs on an Aboriginal reserve.[37]

The federal government may be left fully responsible for the remediation of an abandoned site if the polluting party no longer exists or becomes insolvent.[38] Though laws provide the government with a mechanism to recover remediation costs, these laws are ineffective in cases where the responsible party no longer exists.[39] This occurred in the Canadian North when falling mineral prices in the 1990s led to a number of mine sites being abandoned as owners went bankrupt.[40] The land reverted to the Crown, and the federal government was left to bear the costs of remediation.

Occasionally, the federal government will assume responsibility for remediation to meet obligations to protect the health of nearby populations or a delicate ecosystem–particularly fisheries. Though the government is entitled to recuperate the costs of its actions, in practice this seldom happens.[41]

2.5 What contaminated sites is the federal government responsible for?

The federal government is responsible for:

- contaminated sites in the Federal Contaminated Sites Inventory;
- Shared-Responsibility Contaminated Sites,[42] such as the Sydney Tar Ponds;[43] and
- sites included in the Nuclear Legacy Liabilities Program.[44]

2.6 What is the Federal Contaminated Sites Inventory?

The federal government created the inventory to keep track of the contaminated sites for which it is responsible.

[35] For a brief discussion of Constitutional jurisdiction, see Canadian Council of Ministers of the Environment (1997) pp. 4-5.
[36] See Appendix A.
[37] Office of the Auditor General of Canada (2012) p. 65.
[38] Castrilli (2010) pp. 120-1.
[39] Ibid. pp. 120-1.
[40] Indian and Northern Affairs Canada (2010) p. 1.
[41] MiningWatch Canada/ Mines Alerte (2000) p. 7.
[42] Under the Shared-Responsibility Contaminated Sites Policy Framework (2005), the government may provide funding for the remediation of non-federal sites if the contamination is related to federal government activities or national security. See Natural Resources Canada (2012).
[43] Office of the Auditor General of Canada (2012) p. 69.
[44] Ibid. p. 69.

Most contaminated sites for which the federal government has recognized responsibility are recorded in the inventory. The database is accessible through the website of the Treasury Board of Canada Secretariat. It is meant as a tool to inform the Government of Canada, Ministers of the Crown, parliamentarians, and the general public of the state of federal contaminated sites.[45]

2.6.1 Which contaminated sites does the inventory include?

The inventory contains information on all federal contaminated sites under the custodianship of federal departments, federal agencies or consolidated Crown corporations,[46] as well as sites for which the federal government has accepted partial or full financial responsibility.[47] This includes both known and suspected contaminated sites.[48]

The inventory does not include information on any of the following categories of contaminated site:

- sites under the control of, and polluted by, private individuals, firms, enterprise Crown corporations,[49] or other levels of government;[50]
- Shared-Responsibility Contaminated Sites,[51] such as the Sydney Tar Ponds;[52]
- sites included in the Nuclear Legacy Liabilities Program;[53] and
- sites remediated or sold prior to 1 April 1998.[54]

2.6.2 When is a liability recorded in the inventory?

Federal custodians follow Public Sector Accounting Standards (PSAS) when reporting on liabilities associated with contaminated sites. PSAS are authoritative accounting standards published by the Public Sector Accounting Board (PSAB), part of the Chartered Professional Accountants of Canada (CPA Canada).[55]

PSAS are published in the CPA Canada Public Sector Accounting Handbook and are the primary source of generally accepted accounting practices. PSAS are meant to ensure the credibility and consistency of government summary financial statements.[56]

While PSAS are not law, they are sanctioned by governments and public sector organizations, and there is a strong record of compliance in Canada.[57] Liabilities are recorded in the inventory in accordance with PSAS. For more information on PSAS, see Appendix B.

2.6.3 What information does the public version of the inventory include?

The inventory contains a large amount of information on contaminated sites. This includes, but is not limited to, the following categories:

- location and classification of the site;
- affected population;
- the reporting organization and reasons for involvement;

[45] Treasury Board of Canada Secretariat (2013) p. v.
[46] A consolidated Crown corporation is a Crown corporation that relies on Government funding as its principle source of revenue. See Receiver General for Canada (2013b) Chapter 18.1.
[47] Treasury Board of Canada Secretariat
[48] Treasury Board of Canada Secretariat (2013) p. 1.
[49] An enterprise Crown corporation is a Crown corporation that raises substantial portions of its revenue through commercial business activities and is self-sustaining. See Receiver General for Canada (2013b) Chapter 18.1.
[50] Treasury Board of Canada Secretariat
[51] Under the Shared-Responsibility Contaminated Sites Policy Framework (2005), the government may provide funding for the remediation of non-federal sites if the contamination is related to federal government activities or national security. See Natural Resources Canada (2012).
[52] Office of the Auditor General of Canada (2012) p. 69.
[53] Ibid. p. 69.
[54] Treasury Board of Canada Secretariat (2013) p. vi.
[55] Public Sector Accounting Board (2003b) p. 3.
[56] Public Sector Accounting Board (2003a) p. 14.
[57] Graham (2007) p. 29.

- details regarding the nature and severity of contamination;
- the status of the site, management strategy, and progress to date; and
- where applicable, annual and total management costs and action plan expenditures related to the site.

This information is inputted by custodians and presented in a searchable format.

What is a custodian?

The term "custodian" refers to the federal department, agency or consolidated Crown corporation responsible for the contaminated site.

The inventory also allows for the generation of annual expenditure reports showing total expenditures for all sites in the inventory. These reports can be restricted to individual reporting organizations. [58]

2.6.4 What information is missing from the public version of the inventory?

Though the inventory is meant as a tool to inform Canadians on the status of federal contaminated sites, there are gaps in the information provided in the public version. About 1,000 sites are suppressed from view for security reasons. The remaining financial liability of all sites is suppressed to preserve the integrity of the remediation bidding process by the independent contractors.[59]

The Treasury Board Secretariat provided the PBO with the restricted database. Unlike the public version of the inventory, the restricted database includes information for all sites and their financial liability.

Much of the information provided in the public version of the inventory is in summary form, with little in the way of details. The inventory does not indicate why a site was closed. Also, it does not distinguish between those sites which have been remediated and those for which federal liability has been otherwise removed.[60]

A 2009 evaluation of the inventory identified two additional omissions: (1) there is no category to identify that a site is action plan funded, and (2) there is no way of showing that a site, while not yet closed, requires no further action.[61]

2.6.5 Who pays for the remediation of federal sites in the inventory contaminated sites?

The cost of remediating a federal contaminated site is funded out of the custodian's annual budget and, often, the Federal Contaminated Sites Action Plan.

2.7 What is the Federal Contaminated Sites Action Plan?

The action plan is a cost-sharing program that seeks to aid custodians with the costs of both assessing and remediating contaminated sites.

There are four expert support departments[62] involved in this program and 16 custodians who are directly responsible for one or more contaminated sites.[63]

2.7.1 How much does the action plan cover?

Action plan funds can be used to cover 80% of the first $10 million of a project and 90% of any amount exceeding $10 million. The custodian is responsible

[58] Treasury Board of Canada Secretariat
[59] Office of the Auditor General of Canada (2012) p. 90.
[60] Ibid. p. 79.
[61] Goss Gilroy Inc. (2009)
[62] Treasury Board of Canada Secretariat, Environment Canada, Fisheries and Oceans Canada, and Public Works and Government Services Canada.
[63] Government of Canada (2013c)

for the remaining cost. In exceptional cases exceeding $90 million, action plan funds may be used to cover the entire cost.

Parliament has earmarked $3.5 billion in funding to the action plan over 15 years (2005–06 to 2019–20).

What has Canada done in the past to deal with contaminated sites?

The Federal Contaminated Sites Action Plan is the latest effort of the Government of Canada to address federal contaminated sites. One of the earliest efforts to address the problem was the 1989 National Contaminated Sites Remediation Program, a five-year program to clean up 45 orphaned sites.

This was followed in 1995 by creation of the Contaminated Sites Management Working Group, an interdepartmental group tasked with developing a strategy to deal with contaminated sites in general. [64]

These efforts were criticized in the 2002 Report of the Commissioner of the Environment and Sustainable Development. [65] It expressed concern that the government had not put in place the coordinated plan and long-term funding needed to effectively address the problem of contaminated sites. [66]

Along with the inventory, the action plan responds to these concerns. It provides a coordinated approach to federal contaminated sites: sites are recorded in the inventory and their remediation is funded through it.

2.7.2 What sites does the Federal Contaminated Sites Action Plan cover?

The action plan funding aids custodians with the costs of both assessment and remediation activities. For a site to qualify for funding, the following four criteria must be met:

(1) the site meets the Treasury Board definition of a contaminated site;

(2) the site was contaminated before 1 April 1998;

(3) the site is either on federal land or the government has accepted full responsibility; and

(4) a financial liability is recorded in the inventory. [67]

From 2005–06 to 2010–11, all class 1 and 2 sites (defined below) were eligible for action plan funding. [68] Since 2011–12, only class 1 sites and class 2 sites that had remediation expenditures prior to April 1, 2011 were eligible. [69]

This leaves class 3, N, and I sites as not eligible for action plan funding. Furthermore, the action plan restricts eligibility to those sites that were contaminated prior to 1998 (regardless of class), so more recently contaminated sites would also not be eligible for program funding.

How are contaminated sites in the inventory classified?

"Federal contaminated sites are classified and prioritized based on the Canadian Council of Ministers of the Environment National Classification System for Contaminated Sites (NCSCS) and the Aquatic Site Classification System (ASCS)." [70]

The NCSCS and the ASCS are objective-based scoring methodologies that allow contaminated sites to be prioritized based on "their current or potential adverse impacts to human health and/or the environment." [71] Both scoring methodologies are out of 100. The higher the score, the greater the adverse impact.

Class 1 or high risk sites have a score of 70–100. Class 2 or medium risk sites have a score of 50–69.9. Class 3 or low risk sites have a score of 37–49.9. Sites with scores less

[64] Government of Canada (2013b)
[65] Office of the Auditor General of Canada (2002)
[66] Environment Canada (2012)
[67] Government of Canada (2013a)
[68] Goss Gilroy Inc. (2009)
[69] Government of Canada (2013a)
[70] Ibid.
[71] Ibid.

than 37 are classified as class N and are not a priority for action.

Some sites are given a class I for "insufficient information" when further testing is required to determine the appropriate classification.

2.7.3 How does the Federal Contaminated Sites Action Plan work?

Sites funded through the action plan undergo the 10-step process recommended by CSMWG in *A Federal Approach to Contaminated Sites*.[72] This process begins with identifying, assessing, and classifying the site.

After a series of tests and classifications, it may be determined that no further action is necessary. Should further action be required, the custodian will develop and implement a remediation or risk management plan. Long-term monitoring is a possible final step in the process.

3 Estimation methodology

As described earlier, the scope of this report is to estimate the total cost to remediate the known, suspected, and future contaminated sites in the inventory excluding the Port Hope, Ontario sites and the five largest sites (Faro mine, Colomac mine, Giant mine, Cape Dyer-DEW line, Goose Bay Air Base).

The current reported liability remaining for these sites is $1.8 billion. The breakdown of this liability by class, status (open or closed), amount spent on remediation, anticipated liability, and amount spent on assessment is shown in Table 3-1 below.[73]

Table 3-1 2012–13 Contaminated site by class, status, and costs

Category	Spent (millions)	Liability (millions)	Assessment (millions)	# sites
Class 1				
Open	$880	$1,361	$69	813
Closed	$75	$0	$10	645
Class 2				
Open	$148	$333	$53	2,106
Closed	$58	$0	$11	763
Class 3				
Open	$22	$39	$29	1,599
Closed	$15	$0	$6	575
Class N				
Open	$9	$6	$12	780
Closed	$13	$0	$36	9,182
No Class				
Open	$8	$67	$57	5,547
Closed	$0	$0	$0	0
Total	**$1,228**	**$1,806**	**$283**	**22,010**

Source: PBO and FCSI

Only 219 of the 5,547 open and unclassified sites have had liabilities assigned to them (totalling $67 million, as shown above in Table 3-1). There remain, therefore, another 5,328 sites requiring further assessment after which they will either be:

- assigned liabilities; or
- closed without remediation.

The addition of liabilities associated with these sites will increase the total cost.

In addition, the total cost will increase as a result of:

- rising liabilities for sites undergoing remediation; and
- the addition of new sites to the inventory.[74]

The purpose of this report is to identify and implement a robust methodology to estimate the future costs associated with the anticipated increases outlined above.

[72] Dillon Consulting Limited (1999)

[73] Deleted sites are not counted since they are included in the site by which they have been subsumed. Sites included in this table had their first record in FCSI in 2005–06 or later.

[74] As observed by the Auditor General in 2011, the exact form and extent of remediation required has not yet been determined for these unassessed and partially assessed sites. Office of the Auditor General of Canada (2012) p. 81.

3.1 Prior estimations

The PBO is not the first to estimate the future costs of contaminated sites. Both the Congressional Budget Office (CBO)[75] and Resources for the Future (a U.S. think tank)[76] have performed estimations of the total cost of remediating non-federal contaminated sites in the United States.

These sites are known as Superfund sites since they were initially funded by the Hazardous Substance Superfund.[77] Superfund sites are put on the National Priority List (NPL), which is the U.S. inventory of contaminated sites eligible for remedial action.[78] NPL sites are selected from the Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS). CERCLIS contains over 43,000 sites and contains both known and suspected contaminated sites of various levels of severity.[79] At the end of 1999[80], there were 1,245 sites in the U.S. NPL inventory.[81]

The U.S. NPL inventory differs from the Canadian inventory in key ways:

- **The U.S. NPL inventory** only includes third-party sites.[82]
- **The Canadian inventory** includes both third-party sites and those contaminated by the federal government.
- **The U.S. NPL inventory** includes only what are considered to be the worst sites.
- **The Canadian inventory**, which is Canada's only tracking system, includes about 22,000 known and suspected sites of every severity, and in that way is analogous to the U.S. CERCLIS. Canada doesn't have a separate equivalent of the NPL.
- **The U.S. NPL inventory** sites follow a rigorous four-step process with specific requirements that must be satisfied for a site to advance.[83]
- **The Canadian inventory** sites follow a 10-step process, but there are few specific requirements that must be satisfied to advance.

The detailed tracking of the U.S. NPL inventory and the fact that it included fewer sites allowed Resources For the Future (RFF) to take a much more detailed approach to estimating costs than the PBO.

RFF classified each of the sites in the U.S. NPL inventory into one of 11 categories based on historic site use and contaminants.[84] RFF then averaged the time and cost of each step for sites that had completed the process, which it then used to predict the future costs of the sites that had not been through the process.[85]

Such a detailed approach was not possible for the Canadian inventory. Though the inventory follows a 10-step process, the dearth of specific requirements that must be satisfied to advance means that sites that do advance are not necessarily similar. For this reason, a different methodology had to be developed.

3.2 PBO's estimation approach

The estimation methodology involved four steps:

1. Structuring the inventory data;
2. Estimating assessment and remediation costs;

[75] Congressional Budget Office (1994)
[76] Probst and Konisky (2001). Resources for the Future was asked by Congress to do the analysis.
[77] Ibid.
[78] Congressional Budget Office (1994)
[79] Probst and Konisky (2001)
[80] For simplicity, all years are provided in financial year unless otherwise indicated.
[81] Probst and Konisky (2001)
[82] Congressional Budget Office (1994)
[83] Probst and Konisky (2001)
[84] Ibid.
[85] Ibid.

3. Estimating proportion of open and unclassified sites as class 1, 2, 3, or N; and

4. Estimating number of sites to be added in the future.

Each of these four steps is discussed in turn in the following sections.

3.2.1 Structuring the inventory data

As described earlier, the inventory is a database that contains information and fiscal year records for all known and suspected contaminated sites for which the federal government is responsible.

In the 2013 edition of the inventory, there were over 137,000 yearly entries representing 25,675 sites (including open, closed, and deleted sites). Entries start as early as 1994, but the overwhelming majority (over 136,000) are from 2006 onwards.

A record is added to the inventory for every year a site is open, including the year it closes. Each record contains the following fields:

- the class of the site (if it has one);
- its classification score (from which the class of the site is derived);
- the highest step completed (HSC) up to that point (total of 10 steps);
- planned completion years for steps seven through nine;
- the next year's budget for the site;
- liabilities (opening, contingent, and closing)[86];
- the amount the closing liabilities were adjusted in the year;
- the amount spent on the site (separate values for assessment, remediation, and care and maintenance);
- the amount remediated (in cubic metres, hectares, or tons); and
- whether the site is open or closed. [87]

Some of the data entered in these fields suffer from significant deficiencies. For example, in some cases, fields are not filled in or are not updated with a material change in circumstance (e.g. planned completion dates are outdated and remediation amounts are rarely entered).

After preliminary analysis, it was decided that the following fields would be helpful in predicting cost:

1. the class of the site;
2. liabilities (closing and opening);
3. the amount the closing liabilities were adjusted in the year;
4. the amount spent on the site (separate values for assessment, remediation, and care and maintenance); and
5. the highest step completed up to that point (total of 10 steps). [88]

While 2, 3, and 4 were generally accurate, in that they reflected the true, anticipated liability and

[86] Opening liability is the estimated remaining cost to remediate the site at the start of the year. Closing liability is the estimated remaining cost at the end of the year after taking into account any remediation performed during the year as well as any changes to the estimate. By definition, opening liability equals the previous year's closing liability. Contingent liability is explained in footnote 88.

[87] There are a few additional fields that aren't listed here for the sake of brevity.

[88] At one point during the investigation, it was thought that contingent liability (a field in a site's fiscal year record) could be used as an indicator of remediation cost variability. As it turns out, contingent liability is only used when the legal responsibility for remediating a site is in doubt. It is not used to record the difference between a higher and lower remediation estimate. Treasury Board of Canada Secretariat (2014). At one time contingent liabilities were used to record the cost difference between different outcomes, but this practice was stopped.

actual money spent, 1 and 5 required further manipulation to be used.

3.2.1.1 Classification

Custodians enter both the classification score (one to 100) and the class (1, 2 3, N or I) number manually.[89] Even though there is a defined conversion from classification score to class, there were inconsistencies between the class assigned and the classification score for some sites.[90]

These inconsistencies were dealt with by reassigning classes to each site; the classification score from the value in the last fiscal year record was used to reclassify each site.

3.2.1.2 Highest step completed

The absence of specific requirements that must be satisfied to advance in the inventory means that, generally, highest step completed (HSC) is not a good predictor of cost[91]. The exception to this is the transition from anything below HSC 4 to anything above. Sites that make this transition and stay open are more likely to require remediation. The reason is that for a site to advance to HSC 4 or higher, the custodian must specify the type of contaminants and the medium (i.e. surface, soil, water) affected. The presence of such information suggests that remediation will be necessary.

3.2.1.3 Special cases

The following bullets explain the special cases that had to be dealt with in using the inventory data and how they were handled.

- **Problem**: sites open for several years, close, and then reopen again either the next year or some year in the future, sometimes multiple times.
- **Solution**: remove the intervening close records.
- **Problem**: sites closed multiple times in a row.[92]
- **Solution**: keep first close and delete subsequent ones.
- **Problem**: sites subsumed into other sites don't carry over previous expenditures (remediation and assessment).
- **Solution**: add previous expenditures to subsuming site.
- **Problem**: some sites' first liability is entered via the opening liability field instead of via a liability adjustment.[93]
- **Solution**: add amount entered in opening liability to liability adjustment.
- **Problem**: in some cases, the estimated cost of remediation increases and this is reflected by the outstanding liability being reduced by less than the amount of remediation dollars spent.[94]
- **Solution**: adjust the total spent and outstanding liability to reflect full cost of remediation.

Taking each of the special cases above into account, a new database table was created that modified fiscal year records for each site. This table removed:

[89] This has changed for 2013 where the custodian can only enter the classification score and the class is automatically assigned.

[90] In addition, sometimes the number "1" and the letter "I" would be interchanged. To add to the confusion, the classification score and/or class of a site could also change over time.

[91] As an interesting side note, 20% of new sites start life at HSC4 or higher and are 5 times more expensive than sites that start life at HSC3 or less.

[92] When a site is closed it should have its last fiscal year record in the year in which it is closed, indicating that the site is closed. No further fiscal year records should be added for the site unless it reopens.

[93] When a site has its first liability entered, it is supposed to be added via a liability adjustment not open liability. The open liability field is only meant to indicate the liabilities carried forward from the previous year.

[94] In general, this should not occur, as when remediation dollars are spent on a site, the outstanding liability should be reduced by the amount spent. In the extreme case, the amount spent on remediation doesn't reduce the liability at all and the liability can even increase through a positive liability adjustment.

- all deleted sites;
- sites with fiscal year records starting prior to 2006[95];
- the big five sites and Port Hope[96]; and
- the extra close records for those sites having more than one.

The following new fields were added:

- the previously described reclassification;
- running total for assessment costs; and
- running total for remediation costs.

Doing this made the amount spent and outstanding liability for each year readily available; summing the fields for outstanding liability and the total amount spent on remediation for a particular year gives the total predicted cost of remediating the site at the point in time.

As will be explained in the following sections, this information was then used to track the changes in predicted site remediation by class.

3.2.2 Estimating assessment and remediation costs

To estimate the future cost of remediating sites that have not started remediation or have started but have not completed remediation, it is necessary to determine the average cost to remediate a contaminated site.[97]

Clearly, every site is unique and if there were a limited number of sites, the concept of an average remediation cost would not be valid. But since there are a very large number of sites (over 22,000), using average remediation cost is a valid methodology even with large variance.

Using the results from Table 3-1 above, the average cost of remediation for the sites separated by class and open/closed status are shown in Table 3-2.[98]

Table 3-2 Average remediation costs

Category	Average Remediation Cost (thousands)
Class 1	
Open	$2,756
Closed	$116
Class 2	
Open	$228
Closed	$76
Class 3	
Open	$38
Closed	$26
Class N	
Open	$19
Closed	$2

Source: PBO and FCSI

This table shows there is a substantial difference in remediation costs based on class of site (more so for open sites).

The remediation costs were estimated using a weighted average cost based on class and year in which the site started remediation (transitioned to HSC 4 or higher and remained open)[99]. The cost was estimated for each cohort of sites separated by class and by the fiscal year that they started remediation.

[95] Sites with records prior to 2006 were too few to be statistically significant (only 421 sites with $14 million spent on remediation)

[96] In addition to these six sites, one other site was removed which was an outlier since it came into the system with $36 million in liability one year and the following year had all its liability removed (without remediation) and was closed.

[97] Often when making estimates a sensitivity analysis is performed using two standard deviations from the average as a minimum and maximum value. Given the high variability of the liability values, the standard deviation is greater than the average making sensitivity analysis impractical.

[98] Averages for open sites were calculated by summing spent and liability and then dividing by number of sites.

[99] Three different methodologies were investigated to determine an estimate of remediation costs: linear regression; average cost based on class of site and number of years in remediation; and weighted average cost based on class and year in which the site started remediation (transitioned to HSC 4 or higher and remained open). For reasons discussed in Appendix C, option three was chosen.

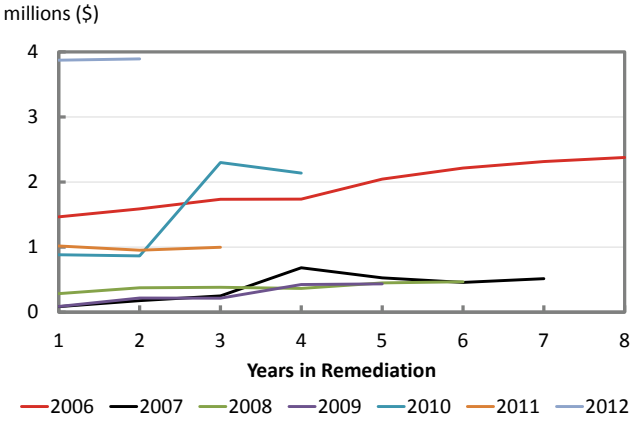
What is a cohort?

A cohort is a group of sites all of the same class which all started remediation in the same year.

The overall average remediation cost for each class was obtained by weighting the average remediation cost of each cohort by the number of sites in the cohort.

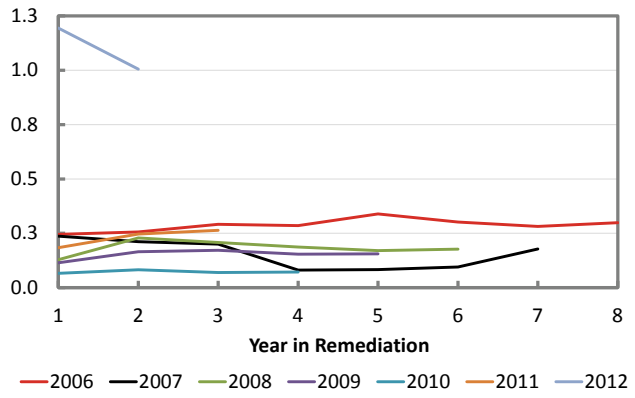
For this methodology to be valid, there has to be consistency within each cohort, such that they approximately reach a constant average price over time. This appears to be the case for each of the classes, as shown in Figure 3-1, Figure 3-2, and Figure 3-3.

Figure 3-1 Average remediation cost class 1 sites by cohort



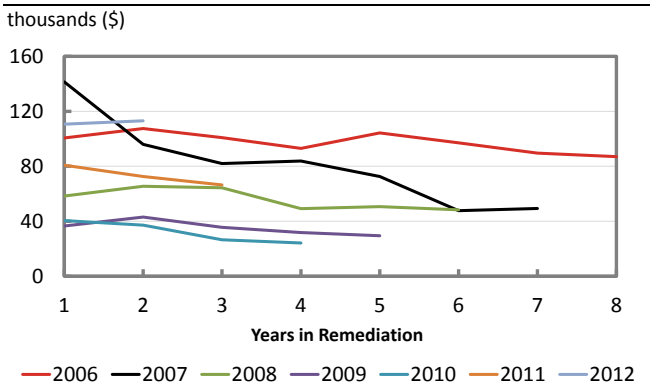
Source: PBO and FCSI

Figure 3-2 Average remediation cost class 2 sites by cohort



Source: PBO and FCSI

Figure 3-3 Average remediation cost class 3 sites by cohort



Source: PBO and FCSI

As seen in Figure 3-1 above, the average remediation costs for each class 1 cohort generally increase during the first few years of remediation, after which they taper off and approach a constant value.

However, cohorts that started in 2011 onwards have not been in existence long enough to reach a constant value. To account for this, the weighted average increase from the first year to 2013 for the cohorts from 2006 to 2010 was calculated.

This value was then used to multiply the first year remediation cost of cohorts 2011, 2012, and 2013 to obtain their final average remediation costs. The same method was applied to the class 2 and class 3 sites.

While class 1 sites increase substantially over time, from the above graphs, it can be seen that class 2 sites increase only marginally and class 3 sites decrease. The full results for the estimated average remediation cost of class 1, 2, and 3 sites are presented in Section 4.1.

3.2.3 Estimating proportion of open and unclassified sites as class 1, 2, 3, or N

At the end of 2013, there were 5,547 open sites in the inventory that did not have a contamination score or class assigned. It was necessary to determine a method to estimate the proportion of these sites that would be classified as class 1, 2, 3, or N.

Two methods were investigated as possible solutions. The first used trend analysis based on the conversion ratio of previous years. The second used probability analysis (ordered logistic regression) with assessment costs as the independent variable and the probability of being a class 1, 2, 3, or N as the dependent variable. For various reasons outlined in Appendix D, the second approach was used.

Given that the class of sites forms an ordered list from 1 through N and many of the sites in the unclassified pool have assessment costs, it is possible to use ordered logistic regression (also known as a proportional odds model) to estimate the number of sites requiring remediation. For the purpose of this estimation, all class N sites and sites that were closed without a class were assigned a class of 4.

Ordered logistic regression uses an independent variable (assessment dollars spent on the site) to determine the likelihood of a value for the dependent variable being assigned. The dependent variable in this case is the site being assigned a class (i.e. 1, 2, 3, or 4).

Ordered logistic regression is well suited to using a site's assessment costs to determine its class due to the linear relationship between the two: the lower the class, the higher the assessment cost.

The ordered logistic regression equation needs to be estimated using existing sites. All open sites that have been classified (i.e. assigned a class of 1, 2, 3, or N) and all closed sites were used in the estimation for a total of 16,870 sites. Closed sites that didn't have a class assigned were set to N (which, for estimation purposes, were set to 4).

Once the regression equation was estimated, it was then used to predict the likelihood of each of the 5,547 open unclassified sites being classified as a class 1, 2, 3, or 4.

For the amount of assessment dollars spent on each site, the ordered logistic regression equation estimates the probability of that site being a class 1, 2, 3, or 4. The four probabilities add up to one, by definition. The higher the assessment dollars spent on a site, the more likely it will be a class 1 site than any other class.

The results of the ordered logistic regression equation estimation are shown in Figure 3-4 below. The horizontal axis is the dollar amount spent on assessment and the vertical axis is the probability it will be a class 1, 2, 3, or 4.

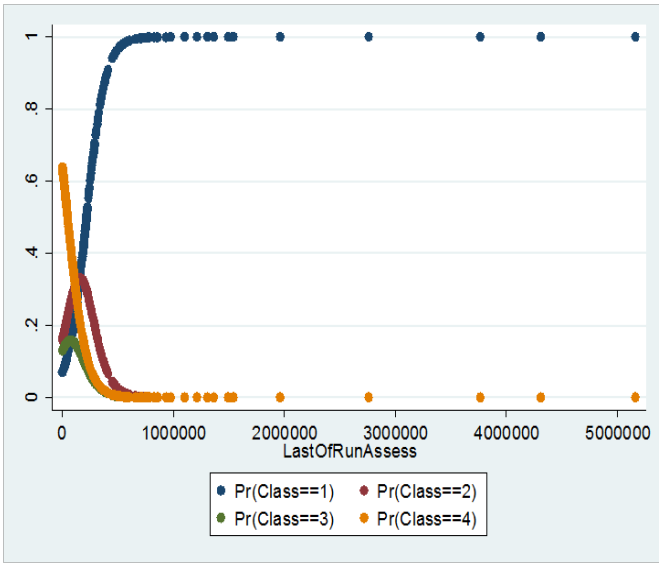
If a vertical line is drawn upwards from the dollar amount, the point where it intersects each of the four coloured curves is the probability it will be assigned the class represented by that curve.

For example, the peak of the red curve (class 2 sites) appears to be about $200,000. At this point, a site has a:

- 39% chance of being class 1;
- 37% chance of being class 2;
- 10% chance of being class 3; and
- 14% chance of being class 4.

Figure 3-4 Results of ordered logistic regression

```
Ordered logistic regression                     Number of obs   =      16870
                                                LR chi2(1)      =     867.97
                                                Prob > chi2     =     0.0000
Log likelihood = -17875.963                     Pseudo R2       =     0.0237
------------------------------------------------------------------------------
       Class |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
LastOfRunAs~s |  -.0000119   5.20e-07   -22.82   0.000    -.0000129   -.0000109
-------------+----------------------------------------------------------------
       /cut1 |  -2.582896   .0298132                      -2.641328   -2.524463
       /cut2 |  -1.208804   .0190669                      -1.246174   -1.171433
       /cut3 |  -.5718825   .016851                       -.6049098   -.5388552
```



Source: PBO and FCSI

As the cost of assessment increases or decreases, the probabilities of the site being assigned each of the four classes change accordingly.

In looking at the graph of the regression estimation results, it is apparent that having zero assessment dollars spent does not guarantee a site will be classified as not needing remediation. In fact, there is only a 63% chance of such a site being a class 4. A site with zero assessment dollars spent has a:

- 17% chance of being class 2;
- 15% chance of being class 3; and
- 5% chance of being class 1.

This occurs because there are numerous occasions in the inventory of sites being assigned a class of 1, 2, or 3 with no assessment money being recorded.

The estimated ordered logistic regression equation predicted that 2,100 of the 5,547 open and unclassified sites would be assigned a class of 1, 2, or 3 (38% conversion rate).

This value of 2,100 is much closer to the predicted low, rough estimate of 1,705 using average assessment cost than the 417 estimate using trend analysis.[100] The predicted number of class 1, 2, and 3 sites was 436, 926, and 738 respectively (a ratio of 21%, 44%, and 35%).

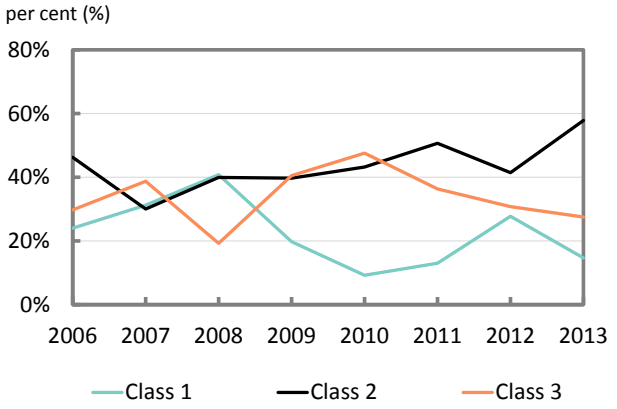
To confirm that the proportion of class 1, 2, and 3 sites predicted by the ordered logistic regression was reasonable, an analysis of the ratio was performed.

Figure 3-5 shows the relative percentage for each class that transitioned into remediation each year from 2006 to 2013. The graph illustrates that there does not appear to be a clear trend. Given this, it was decided to perform a weighted average instead, with the results shown in Table 3-3 below.

The weighted percentages for class 1, 2, and 3 sites of 22%, 44%, and 33%, respectively, from Table 3-3, are almost identical to the ratio of 21%, 44%, and 35% predicted by the ordered logistic regression.

[100] The alternative estimation methods using average assessment cost and trend analysis are presented in Appendix D.

Figure 3-5 % of class 1, 2 and 3 sites transitioning to remediation each year



Source: PBO and FCSI

Table 3-3 Weighted ratio of class 1, 2 and 3 sites entering remediation[101]

Fiscal Year	Total		
	Class 1	Class 2	Class 3
2006	810	1560	1002
2007	129	124	160
2008	148	145	70
2009	149	299	305
2010	66	308	339
2011	67	261	187
2012	73	109	81
2013	16	63	30
Weighted	**22%**	**44%**	**33%**

Source: PBO and FCSI

There are two known biases that could affect the above ordered logistic regression results: one negative (reducing the estimate) and one positive (increasing the estimate).

The negative bias is that the 5,547 open and unclassified sites have not completed assessment and some of them have not even started to be assessed. As these sites incur further assessment costs, the proportion of the sites predicted to require remediation will increase.

In addition, it is possible that the proportion of sites classified as class 1 and/or class 2 will increase. If sites that currently have assessment costs that make them more likely to be class 2 or 3 incur further costs, they are then at some point more likely to be class 1 or 2 sites.

The positive bias is that the estimating equation included both open and closed classified sites. As shown in Table D-1 and Table D-2 in Appendix D, the average assessment value for all classes of closed sites is much lower than that of the current open sites.

Given that there are over twice as many closed sites as open classified sites (11,218 to 5,298), the lower assessment costs for the closed sites could possibly bias the estimation equation such that there are in fact fewer class 1, 2, and 3 sites than the equation is predicting.

This would occur if the average assessment costs of the sites in the open and unclassified pool are closer in characteristic to the open classified site versus the already closed sites. The opposite would be true, though unlikely, if the open and unclassified sites were more similar to the already closed sites.

A priori, it is not possible to determine if the two biases will cancel each other or if one or the other will dominate. However, for the purposes of this report and ease of analysis, it was assumed that the effects of the two biases would more or less cancel each other.

3.2.4 Estimating number of sites to be added in the future

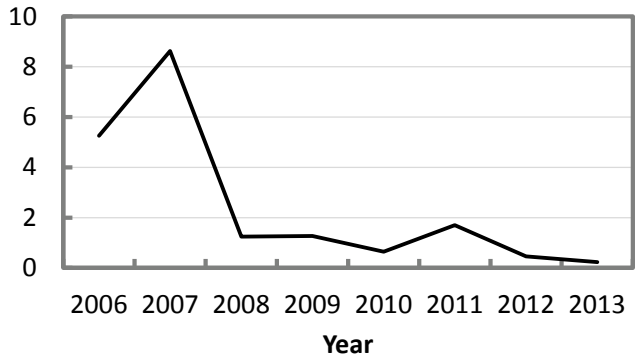
Finally, to predict the number of new sites that would be added to FSCI in the future, geometric trend analysis was used[102].

[101] The weighted total does not add up to 100% due to rounding.

[102] There are two simple methods for predicting the future number of new sites: linear estimation and geometric estimation. Since the number of new sites each year has been more or less steadily declining for the past seven years, linear estimation predicts that no new sites would be

Figure 3-6 and Table 3-4 below illustrate and list the number of new sites that have been added to the inventory during each of the past eight years. The calendar year in which a site's tombstone data were added to the inventory was used.

Figure 3-6 Number of new sites added to the inventory each year



Source: PBO and FCSI

Table 3-4 Number of new sites added to the inventory each year

Fiscal Year	# New Sites
2006	5,252
2007	8,622
2008	1,242
2009	1,274
2010	642
2011	1,703
2012	461
2013	229

Source: PBO and FCSI

Since the purpose of this method is to predict the total number of future sites that would be added, using a fiscal or calendar year did not matter. The calendar year was used since it was easier to implement.

Except for the large increase in 2011 and a negligible increase in 2009, the number of new sites added to the inventory has been steadily declining since 2007.

The geometric approach looks at the decline by half from 2009 to 2010 and the decline by half again from 2012 to 2013. A series of numbers that decline by half from each number to the next, adds up to the initial number (when not including the initial number). It was felt that the large increase in the number of sites added in 2011 was due to the extra assessment funding from the economic action plan. It, in a sense, "shook the tree" to shake out any "waiting in the wings" contaminated sites and was therefore not indicative of the future rate for the addition of new sites.[103]

So assuming the number of new sites added in 2014 is half of the number of new sites in 2013 and so on, the total number of new sites that would be added in future years would be 229.

These new sites were assumed to be added to the existing pool of 5,547 open and unclassified sites. As a test of reasonableness that these new sites have the same transitioning rate to remediation and proportions of class 1, 2, and 3s as the existing sites, an analysis of recently added sites was performed.

New sites added from 2009 through 2013 have moved into remediation at a rate of 24%. More recently, sites from 2011 through 2013 have moved into remediation at a rate of 42%. So the average is currently increasing, which indicates that the 38% conversion used for the 5,547 open and unclassified sites is not unreasonable for the 229 future sites.

Also, the proportion of the class 1, 2, and 3 sites from 2011 through 2013 has been 28%, 47%, and 25%,

added in 2014. This result seems unrealistic and, as such, a linear estimation approach was not adopted. A moving average estimate was attempted but since there were only six data points (2008-2013) it didn't converge. Survival analysis was unsuccessfully tried as well.

[103] Even if this assumption is incorrect and the actual number of new sites should be 1000 instead, the difference is not material ($166M). Using numbers that are presented later in the report, the average cost of a new site is $215K (.38*(.21*2,000K+.44*280K+.35*64K)). 771*215K = $166M.

respectively, which, again, is not dramatically different than the 21%, 44%, and 35% (class 1, 2, 3) used for the 5,547 sites.

4 Estimation results

This section presents the results for the estimated total cost to remediate the contaminated sites in the inventory, not including the big five sites and Port Hope. The estimation uses the methodologies that were detailed in the previous section.

Section 4.1 presents the results for the estimation of the average remediation costs for class 1, 2, and 3 sites.

Section 4.2 reviews the estimation results for the number and makeup (proportion of class 1, 2, and 3) of sites predicted to require remediation from the pool of open and unclassified sites.

Section 4.3 reviews the results for the predicted number of sites to be added in the future.

Section 4.4 presents the rollup and full estimation using the results of the first three sections.

For completeness, section 4.5 presents graphs illustrating the historical remediation cost estimate for the big five and Port Hope sites.

Section 4.6 concludes with a brief look at a contaminant that is currently being investigated by custodians but for which determining estimated remediation costs is still ongoing.

4.1 Average remediation cost

As discussed above[104], the average remediation costs for class 1, 2, and 3 sites were estimated by using a weighted average cost for each cohort.

The average cost for each cohort includes all costs and estimated liabilities, up to and including 2013.

What's the relationship between liability, expenditure, and cost?

Remediation cost includes both expenditures made so far and any estimated liabilities. The estimated liability for a site reflects how much the custodian expects to spend on remediating it in the future.

In theory, the liability for a site should decrease exactly in proportion to expenditures on remediation. Over time, therefore, liability should decrease and expenditures should increase until all liabilities are discharged.

Many contaminated sites do not, however, exhibit this tendency. In many cases, expenditures and liabilities increase in tandem. This suggests that the initial assessment of liability was sanguine and that the site will end up costing more than had been originally thought.

The sites included in each cohort average are:

- all closed sites with and without remediation expenditures (closed sites no longer have liabilities since they are fully remediated); and
- only those open sites that have liabilities and/or remediation expenditures.

Open sites, with a class assigned but without liabilities and/or expenditures, were not included.

Including closed sites that do not incur remediation costs lowers the average[105] but implicitly accounts for the case of the sites closing without remediation expenditures.[106]

[104] Section 3.2.2 on page 13.

[105] If the average only included sites with expenses, it would necessarily be higher.

[106] As discussed in Appendix C, some sites can be assigned a class and can close without ever incurring remediation costs. Implementing the average remediation cost calculation excluding open sites that have a class yet are without liabilities and/or remediation expenditures involves an implicit assumption: the ratio of open sites without liabilities and expenditures that will or will not incur remediation expenses before closing in the future will be the same as the current ratio. Current ratio refers to the 2013 ratio of closed sites without remediation expenses to

Remediation costs for a cohort change over time: class 1 and class 2 sites increase, while class 3 sites decrease (see Figure 3-1, Figure 3-2, and Figure 3-3). As such, the most recent fiscal year cohorts (i.e. 2011, 2012, and 2013) needed to be scaled. This was done by multiplying their first-year average estimated cost of remediation (liability plus amount spent) by the weighted average increase from the first year to 2013 for each of the cohorts from 2006 to 2010.[107]

The average weighted cost change:

- for class 1 sites increased by 73%;
- for class 2 sites increased by 20%; and
- for class 3 sites decreased by 65%.

These weighted average cost change calculations are shown in Appendix E.

The average estimated remediation cost for each class and the number of sites used to calculate them are shown in Table 4-1, Table 4-2, and Table 4-3 below.

The average weighted cost changes outlined above indicate that the initial cost estimates are generally too low for class 1 and 2 sites and too high for class 3 sites.[108]

Table 4-1 Average cost for class 1 sites

Fiscal Year	# sites	Average Cost (thousands)	Total Cost (thousands)
2006	716	$2,376	$1,701,326
2007	121	$515	$62,324
2008	146	$468	$68,302
2009	100	$435	$43,549
2010	57	$2,137	$121,822
2011	61	$1,758	$107,236
2012	62	$6,691	$414,833
2013	13	$2,139	$27,803
Total	**1,276**		**$2,547,194**
(total cost) /(total # sites)		**$1,996**	

Source: PBO and FCSI

Table 4-2 Average cost for class 2 sites

Fiscal Year	# sites	Average Cost (thousands)	Total Cost (thousands)
2006	1,155	$298	$344,764
2007	100	$178	$17,803
2008	120	$177	$21,261
2009	161	$156	$25,070
2010	231	$72	$16,616
2011	152	$221	$33,583
2012	64	$1,437	$91,948
2013	29	$371	$10,771
Total	**2,012**		**$561,816**
(total cost) /(total # sites)		**$279**	

Source: PBO and FCSI

Table 4-3 Average cost for class 3 sites

Fiscal Year	# sites	Average Cost (thousands)	Total Cost (thousands)
2006	595	$87	$51,784
2007	67	$49	$3,307
2008	34	$48	$1,647
2009	129	$30	$3,813
2010	202	$24	$4,911
2011	103	$61	$6,318
2012	31	$84	$2,606
2013	11	$25	$277
Total	**1,172**		**$74,663**
(total cost) /(total # sites)		**$64**	

Source: PBO and FCSI

The estimated average remediation cost is:

- $2 million for class 1 sites;
- $279,000 for class 2 sites; and
- $64,000 for class 3 sites.

closed sites with remediation expenses and open sites with liabilities and/or expenditures.

[107] The possibility of modeling the rate at which sites close with no remediation costs was investigated, but there was no discernable trend. With no discernable trend, there was no advantage in separately modeling sites closing with and without remediation expenses.

[108] That said, some of the increase for class 1 and 2 sites is due to sites being assigned liabilities for the first time, and these liabilities are higher (on average) than those assigned to the earlier sites.

These figures are show on the last line in Table 4-1, Table 4-2, and Table 4-3, respectively.[109]

The average assessment cost is:

- $54,000 for class 1 sites;
- $23,000 for class 2 sites;
- $16,000 for class 3 sites; and
- $5,000 for class N sites.[110]

4.2 Classification of open and unclassified sites

Section 3.2.3 above discussed in detail the probabilistic method (ordered logistic regression) that was used to determine how many of the open and unclassified sites would be classified as class 1, 2, 3, or N.

The likelihood of open, unclassified sites being assigned a class is 38%. That is, 38% or 2,100 of the 5,547 current open and unclassified sites will be classified as class 1, 2, or 3[111].

The likelihood of these sites being assigned as a:

- class 1 is 21% (i.e. 441 sites);
- class 2 is 44% (i.e. 924 sites); and
- class 3 is 35% (i.e. 735 sites).

4.3 Number and classification of future sites

229 more sites are predicted to be added to the inventory in the future[112]. These sites are expected to have the same likelihood as the existing pool of open, unclassified sites above of being assigned class 1, 2, and 3 (i.e. 38%) and in the same proportion:

- class 1 is 21% (i.e. 18 sites);
- class 2 is 44% (i.e. 38 sites); and
- class 3 is 35% (i.e. 30 sites).

4.4 Rollup of the total estimated remediation cost

To recap, the estimations presented in the previous sections include:

- the average remediation and assessment costs for class 1, 2, 3, and N sites.
- the percentage of open unclassified sites that will be assigned a class of 1, 2, 3, or N; and
- the number and classification of new sites that will be added to the inventory in the future.

Using these estimations, it is possible to calculate the total expected cost of remediating and assessing the contaminated sites in the inventory. As noted earlier, this estimation does not include the big five sites or the Port Hope sites. The next section presents the historical cost graphs for these excluded sites.

For ease of reading, all the values that were derived in the previous section are presented in Table 4-4 below. The only values in this table that are not presented previously are the current number of class 1, 2, 3, and N sites (open and closed combined).

[109] Even class N sites, which are not supposed to require remediation expenditures, do on occasion incur costs. Since these amounts are generally very low, a formal model was not developed. Instead, a simple average of all the class N sites (including closed sites that never had a class assigned) was used. This amount was $3,000. Since assessment costs are immaterial when compared to remediation costs, they were calculated using a simple average as well.

[110] Class N sites generally have some assessment expenses to determine that they do not require remediation.

[111] As detailed in section 3.2.4.

[112] As detailed in section 3.2.4.

Table 4-4 Values used in estimating total remediation cost

Category	Conversion Rate (per cent)	Average Assessment cost (thousands)	Average Remediation cost (thousands)	Current Total (open/closed)
Class 1	0.21%	$54	$2,000	1,458
Class 2	0.44%	$23	$280	2,869
Class 3	0.35%	$16	$64	2,174
Class N		$5	$3	9,962
Future Sites				229
Unclassified Sites				5,547
class 1, 2 or 3	0.38%			

Source: PBO and FC

The number of sites were obtained via a simple query of the inventory. These values are all higher than those presented in Table 4-1, Table 4-2, Table 4-3 above, since the values include the open sites of each class that have zero liabilities.

The total estimated remediation and assessment cost for the inventory sites is obtained by summing the result of a simple equation for each class type. This total remediation cost includes previous expenditures that have been made on the sites.

The format of the general equation is:

Cost = average cost for site class × (conversion rate × (unclassified sites + future sites) × % converted for class + current number of sites for class)

Using class 1 remediation costs as an example, the above equation would be thus:

Cost = $2 million × (0.38 × (5,547 + 229) × .21 + 1,458)

= $3,831 million

After repeating this process for both remediation and assessment for all classes, the final results are shown in Table 4-5 below.

Table 4-5 Total estimated remediation and assessment cost for sites by class

Category	Total Cost (millions)
Class 1	
Assessment	$104
Remediation	$3,831
Class 2	
Assessment	$88
Remediation	$1,071
Class 3	
Assessment	$47
Remediation	$187
Class N	
Assessment	$68
Remediation	$41

Source: PBO

Similarly, to determine the difference between the PBO estimated liabilities and those already recorded in the inventory, the liabilities recorded in the inventory need to be subtracted. The end result is the estimated PBO incremental liabilities to that which is currently recorded in the inventory.

The totals that are currently recorded in the inventory for both liabilities and previous amount spent on remediation for each class of site were previously presented in Table 3-1 on page 10. The total previously spent on assessment can be calculated from Table D-1 and Table D-2 in Appendix D. The difference between these values and the PBO totals of Table 4-5 are presented in Table 4-6 below.

Table 4-6 PBO Estimated incremental liabilities

Category	Incremental Liability (millions)
Class 1	
Assessment	$25
Liability	$1,515
Class 2	
Assessment	$24
Liability	$532
Class 3	
Assessment	$12
Liability	$111
Class N	
Assessment	$20
Liability	$13
Less: Open unclassified assessment	-$57
Less: Open unclassified liability	-$75
Total incremental liability	$2,095
Total incremental assessment	$24

Source: PBO

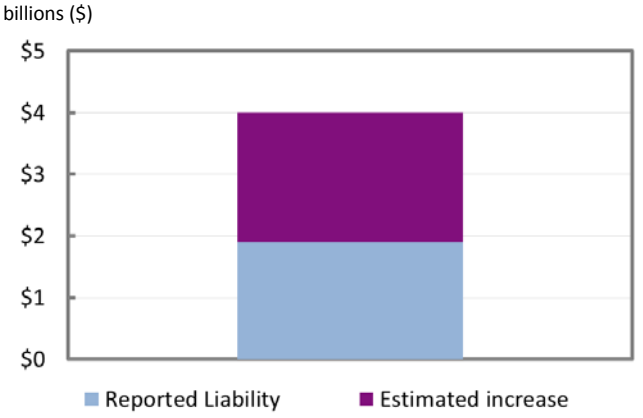
4.4.1 Main findings

The results indicate that the current liability of $1.8 billion in the public accounts for the contaminated sites in the inventory (minus the big five and Port Hope) underestimates the total remediation costs by $2.1 billion. Therefore the total future cost is estimated to be $3.9 billion.

In addition, it is estimated that another $24 million is required for assessment.[113]

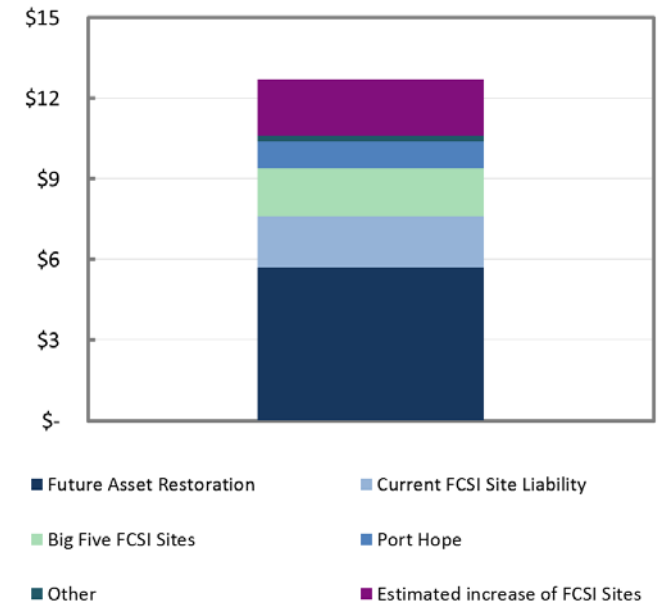
The increase in the estimated inventory liabilities over the current reported liabilities for the inventory is shown in magenta in Figure 4-1. Figure 4-2 shows the increase, in magenta, for the current reported environmental liabilities.

Figure 4-1 Estimated increase in total inventory liabilities



Source: PBO and FCSI

Figure 4-2 Estimated increase in total environmental liabilities due to inventory increase



Source: PBO and FCSI

4.5 Historical cost increases for big five and Port Hope Sites

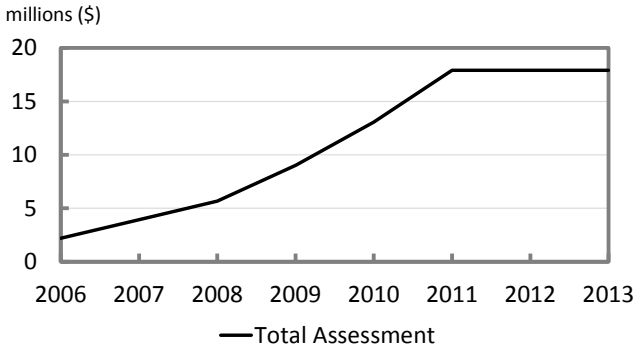
Though the unique nature of these expensive-to-remediate sites precluded them from the PBO

[113] Note that amounts required for site assessment are not considered a liability and are, therefore, not reported in Public Accounts.

estimation, it is still informative to graph their historical costs to determine if their costs have stabilized or have continued to increase year-over-year. This is to understand if the liability trends of these sites indicate that they will likely incur further liabilities going forward.

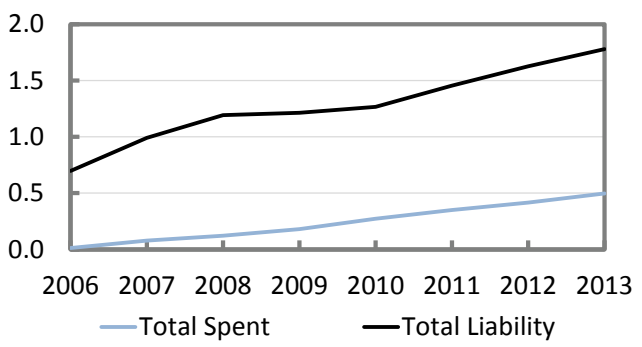
Historical graphs of the sites' liability, remediation and assessment costs are shown in Figure 4-3, Figure 4-4, Figure 4-5, and Figure 4-6 below. The big five sites will be discussed first, followed by the Port Hope sites.

Figure 4-3 Total Assessment cost for big five sites



Source: PBO and FCSI

Figure 4-4 Liability and remediation cost for big five sites



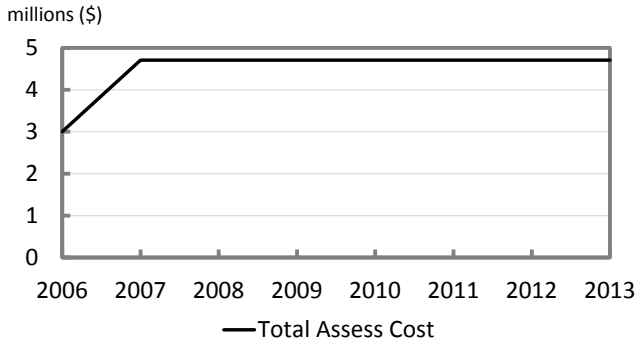
Source: PBO and FCSI

The big five sites include Faro mine, Colomac mine, Giant mine, Cape Dyer-DEW line, and Goose Bay Air Base. As seen in Figure 4-3, the total assessment costs have been $18 million and no further assessment costs have been incurred since 2011.

As for remediation and liability, both have been continuously increasing since 2006. Ideally, one would expect the liability to decrease as remediation is performed.[114] Unfortunately, the liability continues to increase for these sites even while they are being remediated.

Currently, the combined outstanding liability for these sites is $1.8 billion. So far, $500 million has been spent on remediating them. The year-over-year compounded increase in liability from 2006 to 2013 has been 11.4%. At this point, it is not possible to estimate what the total liability will eventually be.

Figure 4-5 Assessment cost for Port Hope



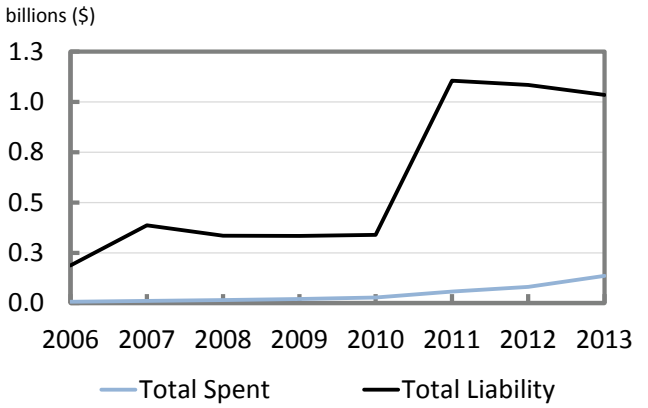
Source: PBO and FCSI

The expenditure and liability graphs for the Port Hope sites tell a different story than those of the big five sites.

Figure 4-5 shows that assessment was finished in 2007 with a total cost of $4.7 million. For remediation, Figure 4-6 shows that the liability peaked in 2011 at $1.11 billion. Since that time, as remediation has been performed, the liability has decreased by close to the same amount.

[114] See, for example, the grey box in section 4.1.

Figure 4-6 Liability and remediation cost for Port Hope



Source: PBO and FCSI

This is as expected. In 2013, the liability of the Port Hope sites is $1.03 billion. So far, $136 million has been spent on remediation.

4.6 Potential costs going forward

A new contaminant that has been identified over the past several years is a chemical that was used in fire-fighting foams prior to 2002 for flight fuel-based fires (i.e. for airplanes at airports).[115]

The chemical is perfluorooctane sulfonate (PFOS) and has been found in the ground water at some airports.

Remediation plans are currently being developed to handle PFOS, but until these plans are finalized, the inventory will not include any liability estimates for this work.

As a result, these costs are not included in the PBO's cost estimate. The addition of the remediation liabilities for PFOS will increase the overall remediation estimate.

[115] Government of Canada (2010)

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Appendix A Legislation and regulation dealing with contaminated sites

Canadian Environmental Protection Act, 1999, SC 1999, c 33.
Clean Environment Act, RSNB 1973, c C-6.
Clean Water Act, SNB 1989, c C-6.1.
Consolidation of Environmental Protection Act, RSNWT 1988, c E-7 (Nunavut).
Consolidation of Environmental Rights Act, RSNWT 1988, c 83(supp) (Nunavut).
Contaminated Sites Registry Regulation, PEI Reg EC656-06.
Contaminated Sites Regulation, YOIC 2002/171.
Contaminated Sites Regulation, BC Reg 375/96.
Contaminated Sites Regulation, NS Reg. 64/2012 (coming into force July 6, 2013).
The Contaminated Sites Remediation Act, CCSM, c C205.
The Environment Act, CCSM, c E125.
Environment Act, RSY 2002, c 76.
Environment Act, SNS, 1994-5, c 1.
Environment Quality Act, RSQ c Q-2.
Environmental Bill of Rights, 1993, SO 1993, c 28.
Environmental Management Act, SBC 2003, c 53.
The Environmental Management and Protection Act, 2002, SS 2002, c E-10.21.
Environmental Protection Act, RSO 1990, c E19.
Environmental Protection Act, RSNWT 1988, c E-7.
Environmental Protection Act, RSPEI 1988, c E-9.
Environmental Protection Act, SNL 2002, c E-14.2.
Environmental Protection and Enhancement Act, RSA 2000, c E-12.
Environmental Rights Act, RSNWT 1988, c 83(supp).
Petroleum Hydrocarboon Remediation Regulations, PEI Reg EC655-06.

Appendix B Public Sector Accounting Standards

Federal custodians follow Public Sector Accounting Standards (PSAS) when reporting on liabilities associated with contaminated sites.

PSAS are authoritative accounting standards published by the Public Sector Accounting Board (PSAB), part of the Chartered Professional Accountants of Canada (CPA Canada).[116]

PSAS are published in the *CPA Canada Public Sector Accounting Handbook* and are the primary source of generally accepted accounting practices (GAAP). PSAS are meant to ensure the credibility and consistency of government summary financial statements.[117]

While PSAS are not law, they are sanctioned by governments and public sector organizations and there is a strong record of compliance in Canada.[118]

B.1 Which Public Sector Accounting Standards relate to contaminated sites?

Contaminated sites present a number of complex accounting issues, and in the early 2000s, there was uncertainty surrounding the liabilities they generated.

In 2006, PSAB was asked to clarify accounting practices for contaminated sites. Of particular concern was how contaminated sites interacted with existing standards, most importantly PS 3200 – Liabilities and PS 3300 – Contingent Liabilities.[119]

PSAB released PS 3260 – Liability for Contaminated Sites to address these concerns. This standard sets out the accounting practices that should be followed when dealing with contaminated sites. It explains when a government entity should record a liability for a contaminated site, what information should be recorded, and how the existing accounting standards should be applied to these sites.

This standard also identifies situations in which PS 2130 – Measurement Uncertainty, and PS 2400 – Subsequent Events may apply to contaminated sites.

Finally, PS 3260 differentiates between contaminated sites and solid waste landfills: liabilities for landfills are dealt with in PS 3270.[120]

B.2 What relevance do Public Sector Accounting Standards have to determining federal liability?

Under PS 3260, the federal government should recognize a liability for a contaminated site when:

(1) environmental standards exists;

(2) contamination exceeds the environmental standards;

(3) the government is directly responsible or accepts responsibility;

(4) it is expected that future economic benefits will be given up; and

(5) a reasonable estimate of the amount can be made.[121]

This standard also explains how the federal government may become responsible for a site. Responsibility can arise through legal obligation if the government is directly responsible for the contamination or for the contaminated land. PS 3260 suggests that responsibility may also arise through a moral obligation.

[116] Public Sector Accounting Board (2003b) p. 3.
[117] Public Sector Accounting Board (2003a) p. 14.
[118] Graham (2007) p. 29.
[119] Financial Reporting & Assurance Standards Canada (2013)
[120] Pubic Sector Accounting Board (2013) PS 3260.
[121] Ibid. PS 3260.08.

One example of this is that the government may become responsible for remediation if an appropriate representative publicly commits to a remediation plan for a specific site.[122]

PS 3260 states that financial liabilities associated with contaminated sites should be treated like any other financial liability. If a liability is recognized, then the estimated costs associated with remediation should be recorded in financial statements and reflected in the Public Accounts.

If no liability is recognized, a note is placed in the financial statement and Public Accounts detailing the nature of the liability and the reason that no estimate can be made.[123]

Though the government cannot be forced to comply with PSAS, these standards do form the generally accepted accounting principles and are widely adhered to.[124]

They provide government officials from a variety of departments, agencies, and corporations with a consistent set of standards and definitions with which to evaluate their potential liability. This encourages a uniform approach to accounting for contaminated sites.

[122] Ibid. PS 3260.28.
[123] Ibid. PS 3200.30.
[124] Public Sector Accounting Board (2003a) p. 12.

Appendix C Methods to estimate assessment and remediation costs

Three different methodologies were investigated to determine an estimate of remediation costs:

1. linear regression;
2. average cost based on class of site and number of years in remediation; and
3. weighted average cost based on class and year in which the site started remediation (transitioned to HSC 4 or higher and remained open).

For reasons discussed below, option three was chosen.

C.1 Average cost by linear regression

Linear regression uses a set of independent variables (also known as predictor variables) to estimate a dependent variable, in this case remediation cost.

Linear regression uses the information from sites that have completed remediation to predict the costs of the sites that are in the process of being remediated (HSC 4 or higher and therefore have a class assigned). The closed sites are used to estimate the regression equation, which is then used to estimate the remediation costs of the sites that have entered remediation.

When a site enters remediation, at a minimum, it has a class assigned, a classification score, the types of contaminants involved, the medium(s) in which the contaminants are found, the location of the site (longitude and latitude), and the responsible department.

In the vast majority of cases, sites entering remediation also have a liability estimate (predicted cost of remediating the site), a management strategy, and an estimate of the amount of contamination (in cubic metres, hectares, or tons).

This site information was used to create a regression equation for the cost of remediation. Dummy variables were used for each class, responsible department, contaminant, management strategy, and medium. Longitude and latitude were used with only their integer component. Also, with the hypothesis that sites located north of 60 degrees would be more expensive due to remoteness, a dummy variable set to one was added for these sites.

In the regression, the following independent variables were significant at $p > 0.10$:

- initial liability;
- most department dummies;
- the class 1 dummy;
- the decile rank of amount of contamination;
- two contaminant types;
- one management strategy; and
- one medium.

The R-squared for the regression was 0.25 with a 0.21 R-squared when only initial liability is in the equation. Of note, the coefficient of initial liability is 0.75 when initial liability is the only independent variable indicating that for these closed sites, the initial liability is on average an overestimation of the final total cost of remediation. That is, the final cost was 75% of the initial estimate, all else equal.

When the results of the regression were used to estimate the final remediation costs of the sites that were currently under remediation, the estimate was 37% less than the current estimated liabilities for the sites.

These regression results, though disappointing, do make sense. The problem is that the in-sample closed sites are radically different than the out-of-sample open sites. When looking at the average

remediation costs for the sites (see Table 3-2 above), the costs for the open sites are consistently higher than those of the closed sites.

In the case of the class 1 sites, the open sites are 24 times more expensive than the closed class 1 sites. The point here is that the simpler, less complicated and, therefore, less expensive sites get closed sooner.

Also, the sites which have closed have a total cost less than their initial estimate, while the current estimated remediation costs of the open sites (total spent so far plus estimated liability) are considerably higher than their initial estimates. Given the difference between the two groups, regression is not an accurate predictor of remediation costs.

C.2 Average cost by class and years in remediation

The second method that was investigated to determine an average cost for remediating sites was analysing the sites based on number of years in remediation.

This entailed putting all the sites that had entered remediation (HSC 4 or higher with an assigned class) in three groups separated by class and tracking the average estimated remediation cost (amount spent plus remaining liability) based on the number of years the sites had been in remediation.

This method does not consider which calendar year a site enters remediation. Rather, it groups sites based on the number of years in remediation. So, the first-year average is the average for all sites of a particular class in their first year of remediation. The second-year average is the average for all sites of a particular class in their second year of remediation, and so forth.

Therefore, the first-year average would contain the first-year data for all the sites that entered remediation in 2006 through 2013. The second-year average would use the second-year data for each site that had at least two years' worth of data.

This would, therefore, only include sites entering in 2006 through 2012, since those sites that entered in 2013 do not have second-year data yet.

Thus, the average for each additional year involves dropping one more year's worth of data working backwards in time to the point where the only sites that have an eighth year of data are the sites that entered remediation in 2006.

It is important to note that a site entering remediation is not a guarantee that it will be assigned a liability and accrue remediation expenses. It is a common occurrence in the database for sites in remediation to be closed without ever having a liability assigned or incurring remediation expenses.

So the average for each year in which the group of sites has been in remediation includes both open and closed (current and previous) sites as well as sites with and without liabilities and/or remediation expenses.

The idea behind using average yearly estimated cost of remediation is that as a site's remediation progresses, the estimated cost will become increasingly accurate. Note that as a site progresses through remediation, more money will be spent on remediation. The liability is reduced accordingly to the point where remediation is finished and the cost is no longer an estimate.

In the first few years of remediation, one would expect the estimated cost to fluctuate as more accurate information is obtained via the ongoing remediation process. But one would expect that after several years, the average cost should stabilize.

For average yearly estimated cost to work as a method, there has to be consistency in the average

cost of sites entering remediation each year; if the average costs of sites are significantly different based on the year that they start remediation, this method does not work.

As it turns out, there is considerable fluctuation in the average cost of sites depending on which year they entered remediation, such that this method could not be used.

As an example, the average cost of remediating class 1 sites varies from a high of about $4 million per site for sites starting remediation in 2012 to a low of about $500,000 for sites starting remediation in 2007, 2008 and 2009 (see Figure 3-1 on page 15).

In Figure C-1 below, a graph of the results based number of years in remediation is shown for class 1 sites. Each of the lines represents a different scenario.

As described in the body of the report, it is common for sites to enter remediation without liabilities and at a later date close without ever incurring liabilities or remediation expenses. Each of the scenarios in the figure represents a different assumption of what happens with the open sites that have zero liabilities.

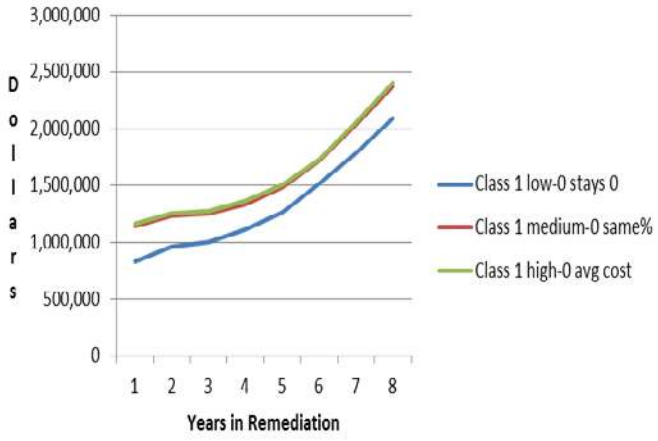
The blue line (low-0 stays 0) is the lowest valued case where it is assumed that all the open sites with zero liability close with zero liability. The red line (medium-0 same %) is the average case where it is assumed that the open zero liability sites get assigned the average liability in the same proportion as the closed sites with zero liabilities and the closed and open sites with liabilities.

The green line (high-0 avg cost) is the highest valued case where it is assumed that all the open zero liability sites have the average liability. The highest value scenario (green line) and medium value scenario (red line) are so close since the percentage of class 1 sites closing with zero remediation expenses is consistently around 10%. Throughout this report, the average or medium case was used in the reported values.

Taking Figure C-1 at face value, one would assume that the average cost of remediating a class 1 site increases year-over-year unbounded. As it turns this would not be an accurate interpretation, a fact which becomes clear after examining Figure 3-1 on page 15.

Figure 3-1 separates out each of the entry year groups that were aggregated in Figure C-1. Notice the great disparity in average remediation costs between the different years.[125]

Figure C-1 Aggregated average cost based on years in remediation



Source: PBO and FCSI

The aveage cost for the sites that entered remediation in 2006 (also known as the 2006 cohort) appears to be tapering off at approximately $2.3 milllion while the three cohorts just before it (2007, 2008, and 2009) are all around $500,000.

Therefore, the steep increase in the curve of Figure C-1 in the final three years is being driven by the much less expensive sites of 2007 through 2009 no longer being included in the average. The increase

[125] Since sites that entered in 2013 only have one data point, it is not on the graph. 2013's average value is $1.2 million.

was not due to a penchant for remediation costs to continuously increase.

Appendix D Methods to estimate open and unclassified sites as class 1, 2, 3, or N

As mentioned in the body of the report, two methods were investigated as possible solutions to estimate the proportion of the 5,547 open, unclassified sites in the inventory that would be classified as class 1, 2, 3, or N. The first used trend analysis based on the conversion ratio of previous years. The second used probability analysis (ordered logistic regression) with assessment costs as the independent variable and the probability of being a class 1, 2, 3, or N as the dependent variable. The second approach was used. The following contains the analysis conducted under the first approach and the reasons why it was rejected.

D.1 Site classification using trend analysis

As the title suggests, this estimation method predicts the future percentage of class 1, 2, 3, and N sites based on extrapolating the historical trend.

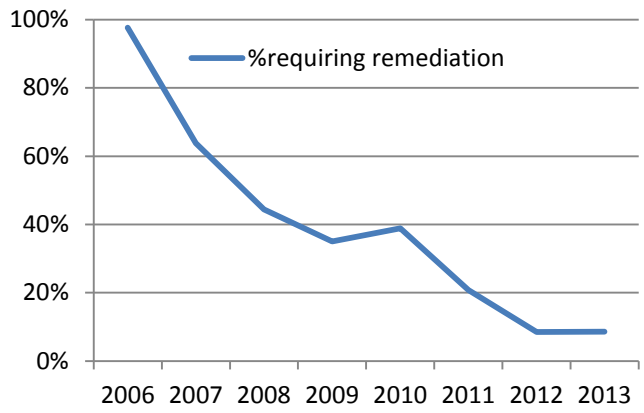
At any given time, the inventory has a pool of open sites that are waiting on initial assessment so that a decision can be made on whether they need remediation or not. Each year a number of sites from this pool complete their initial assessment and get either closed or transition to HSC 4 or higher and have a class assigned (1, 2, or 3).

Since class N indicates that a site does not require remediation, it is the equivalent of a site getting closed without having a class assigned.

This trend analysis can be divided into two separate analyses. The first analysis estimates the percentage of sites from the pool of unassessed sites that need remediation (i.e. get a class assigned) versus those not requiring remediation (i.e. get closed). The second analysis estimates the proportion of class 1, 2, and 3 sites that need remediation.

To determine the trend for the percentage of sites moving to remediation each year, the sites were graphed in Figure D-1 below.

Figure D-1 % of Sites transitioning to remediation



Source: PBO and FCSI

The percentage of sites moving into remediation versus closing without requiring remediation declined steadily from 2006 to 2012 except for a small increase in 2010.[126] For 2012 and 2013, the percentage moving into remediation appears to have stabilized at 8.5%.

Without further information, a conversion rate of 8.5% of the 5,547 open and unclassified sites in the database seems reasonable. This means that 471 of these 5,547 sites will require remediation.

One way by which this 8.5% conversion rate can be substantiated is to investigate the amount of assessment dollars that have been spent on these 5,547 sites in comparison to the already closed sites and those sites that are open and have been classified. Table D-1 and Table D-2 below provide the average assessment cost for open and closed sites, respectively.

[126] The small increase in 2010 is likely due to the additional money allocated to assessment and remediation from Canada's Economic Action Plan.

These two tables raise a couple of interesting points. First, consistent with the average costs of remediation in Table 3-2 on page 14, the average assessment costs for open sites are much higher than for the closed sites.

Second, given that the open unclassified sites have an average assessment cost of $10,000 versus $3,000 for the closed unclassified sites, it seems fair to conclude there are a substantial number of sites in this pool of unclassified sites that will require remediation.

This is based on the assumption that as the cost of assessment increases, the likelihood of requiring remediation increases. That is, there is a positive correlation between assessment costs and the amount of remediation required.

Table D-1 Average assessment cost by class for open sites

Class	# of open sites	Average Assessment Cost
1	813	$85,000
2	2,106	$25,000
3	1,598	$18,000
1, 2, 3 combined	4,517	$33,000
N	781	$15,000
unclassified	5,547	$10,000

Source: PBO and FCSI

Table D-2 Average assessment cost by class for closed sites

Class	# of closed sites	Average Assessment Cost
1	657	$15,000
2	785	$15,000
3	594	$10,000
1, 2, 3 combined	2,036	$13,000
N	1,618	$9,000
unclassified	7,564	$3,000

Source: PBO and FCSI

From Table D-1, the average assessment cost for all open class 1, 2, and 3 sites is $33,000. A rough estimate of the number of sites in the open and unclassified group (i.e. the 5,547 sites) that would likely need remediation can be determined by ordering the sites in this group from highest to lowest assessment costs to date and then determining where to draw a line so that the sites above the line would also have an average assessment cost of $33,000.

The number of sites from the pool of open and unclassified sites required to achieve an average assessment cost of $33,000 is 1,705.[127] This number of sites is considerably greater than the earlier trend analysis prediction of only 471 sites.

In addition, the number 1,705 is likely to be too low since it separates the group above and below with an assessment cost of $1,300 where, in actual fact, the assessment costs of both groups would contain a mixture of values above and below $1,300.

There is a possible explanation for why the trend analysis option would be misleading: the proportional makeup of the sites (i.e. the percentage of class 1, 2, 3, or N) that were finishing assessment over the past several years was not representative of the overall proportional makeup of sites in the open and unclassified group.

Over the past several years, the amount of money available for assessment activities has been reduced. In 2010, $56 million was spent on assessment. In 2011, this fell to $55 million.[128]

For 2012 and 2013, assessment dollars have been limited to an average of $34 million per year.[129] In addition, only those class 1 and 2 sites that have

[127] The 1705 number was arrived at by performing iterative queries on the PBO modified FCSI database.
[128] FCSAP Secretariat (2013)
[129] Environment Canada (2012)

received remediation funding in 2011 or earlier can receive action plan remediation funds.[130]

It is possible that, in the face of reduced assessment funding and no funds available to initiate new remediation of class 1 and 2 sites, custodians are focusing their efforts on assessing and closing those sites unlikely to need remediation. This would then leave a disproportionate amount of sites requiring remediation in the pool of open and unclassified sites.

Given these findings, trend analysis is likely not an accurate method for estimating the proportion of sites requiring remediation in the pool of open and unclassified sites.

[130] Government of Canada (2013a)

Appendix E Average remediation cost increase calculations

Table E-1 Class 1 Remediation Cost Increase Calculation

year since start of remed.	cohort avg. remed. cost	% increase since 1st year	cohort avg. remed. cost	% increase since 1st year	cohort avg. remed. cost	% increase since 1st year	cohort avg. remed. cost	% increase since 1st year	cohort avg. remed. cost	% increase since 1st year	cohort avg. remed. cost	% increase since 1st year	cohort avg. remed. cost	% increase since 1st year	cohort avg. remed. cost	
	2006		2007		2008		2009		2010		2011		2012		2013	
1	1465878.63		84664.2991		283760.464		87473.967		881106.765		1017370.77		3872125.87		1237700.85	
2	1586724.99	8%	177170.636	109%	373554.625	32%	216601.932	148%	865468.661	-2%	951923.914	-6%	3893090.1	1%		
3	1735315.55	18%	248446.636	193%	381936.07	35%	214164.087	145%	2299807.04	161%	996806.016	-2%				
4	1737108.89	19%	683213.342	707%	365233.792	29%	425283.418	386%	2137225.89	143%						
5	2044653.62	39%	527123.95	523%	450683.712	59%	435486.98	398%								
6	2214434.73	51%	458245.521	441%	467823.096	65%										
7	2314013.59	58%	515071.058	508%												
8	2376153.52	62%														
number of sites	811		129		148		149		66		67		73		16	

total $ initial value 2006 through 2010 (1st avg cost*# of sites) =	1,312,932,484
straight average 2006 through 2010 =	235%
# of sites weighted average 2006 through 2010 =	149%
total $ weighted average 2006 through 2010 =	73%
Smallest cohort increase =	508%
Largest cohort increase =	62%

Source: PBO and FCSI

Table E-2 Class 2 Remediation cost increase calculation

year since start of remed.	cohort avg. remed. cost	% increase since 1st year	cohort avg. remed. cost	% increase since 1st year	cohort avg. remed. cost	% increase since 1st year	cohort avg. remed. cost	% increase since 1st year	cohort avg. remed. cost	% increase since 1st year	cohort avg. remed. cost	% increase since 1st year	cohort avg. remed. cost	% increase since 1st year	cohort avg. remed. cost	
	2006		**2007**		**2008**		**2009**		**2010**		**2011**		**2012**		**2013**	
1	244732.677		236925.464		128492.294		114703.302		65980.5157		183683.844		1194426.54		308795.483	
2	255913.041	5%	211642.341	-11%	228325.733	78%	164797.623	44%	82257.3791	25%	246567.589	34%	1005433.39	-16%		
3	290971.394	19%	200038.703	-16%	207587.473	62%	171901.007	50%	69371.1101	5%	263690.454	44%				
4	285039.457	16%	80867.6154	-66%	186651.175	45%	153650.179	34%	71930.0909	9%						
5	339027.232	39%	82714.4063	-65%	170469.817	33%	155716.242	36%								
6	301718.191	23%	95088.2526	-60%	177175.083	38%										
7	281934.888	15%	178031.38	-25%												
8	298496.755	22%														
number of sites	1558		119		145		299		308		261		109		63	
														total $ initial value =		482,737,310
												straight average 2006 through 2010 =				16%
											# of sites weighted average 2006 through 2010 =					21%
											total $ weighted average 2006 through 2010 =					20%
												Smallest cohort increase =				-25%
												Largest cohort increase =				38%

Source: PBO and FCSI

Table E-3 Class 3 Remediation cost increase calculation

year since start of remed.	cohort avg. remed. cost	% increase since 1st year	cohort avg. remed. cost	% increase since 1st year	cohort avg. remed. cost	% increase since 1st year	cohort avg. remed. cost	% increase since 1st year	cohort avg. remed. cost	% increase since 1st year	cohort avg. remed. cost	% increase since 1st year	cohort avg. remed. cost	% increase since 1st year	cohort avg. remed. cost	
year	2006		2007		2008		2009		2010		2011		2012		2013	
1	100567.939		141304.718		58360.2581		36583.2		40525.0238		80738.3165		110651.444		33158.6364	
2	107443.321	7%	95986.6078	-32%	65483.2414	12%	43121.6825	18%	37196.58	-8%	72601.5269	-10%	113093.194	2%		
3	100858.036	0%	82025.5088	-42%	64429.5	10%	35635.3267	-3%	26646.8802	-34%	66477.3204	-18%				
4	92992.1742	-8%	83884.7755	-41%	49182.9286	-16%	31900.4783	-13%	24313.5545	-40%						
5	104270.328	4%	72548.2813	-49%	50732.9375	-13%	29559.4806	-19%								
6	97113.0661	-3%	47708.5873	-66%	48427.4706	-17%										
7	89626.7936	-11%	49363.9104	-65%												
8	87031.605	-13%														
number of sites	1002		160		70		305		339		187		81		30	
															total $ initial value =	152,358,907
														straight average 2006 through 2010 =		-31%
													# of sites weighted average 2006 through 2010 =			-24%
												total $ weighted average 2006 through 2010 =			-24%
														Smallest cohort increase =		-65%
														Largest cohort increase =		-13%

Source: PBO and FCSI