The Commonwealth of Massachusetts

AUDITOR OF THE COMMONWEALTH

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Local Financial Impact Review

Massachusetts Dam Safety Law

A Report Issued Pursuant to
General Laws Chapter 11, Section 6B

January 2011

The Commonwealth of Massachusetts

AUDITOR OF THE COMMONWEALTH

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January 11, 2011

His Excellency Deval Patrick, Governor
The Honorable Therese Murray, President of the Senate
The Honorable Robert A. DeLeo, Speaker of the House
The Honorable Chairs of the Committee on Environment, Natural Resources & Agriculture
The Honorable Chairs of the Committee on Municipalities & Regional Government
Honorable Members of the General Court

I respectfully submit this review of the municipal financial impact of law and regulation governing dam safety in Massachusetts. This work was conducted pursuant to General Laws Chapter 11, Section 6B, which grants the State Auditor's Division of Local Mandates (DLM) authority to review any law or regulation that has a significant financial impact at the local level of government.

At the outset, this report provides a general overview of basic terms and data relative to the 1,547 dams subject to state law in the Commonwealth, including those owned by municipalities, the state, and private parties. Consistent with its mission, DLM focuses on municipally owned dams, specifically those that present the greatest threats to public safety.

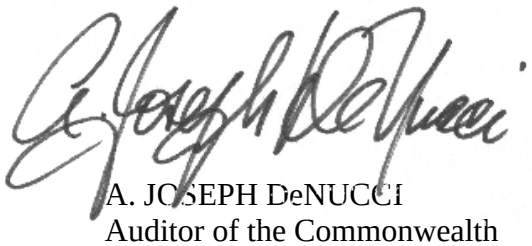
DLM identifies 62 cities and towns that own 100 relatively large dams rated in unsafe or poor condition that have the potential to cause loss of human life or significant property or infrastructure damage in the event of dam failure. The taxpayers in these communities face an estimated $60 million in remediation costs to reduce the likelihood of failure. For these 100 municipally owned critical dams, DLM presents data on the level of compliance with key statutory requirements and safety standards, including emergency action plans, inspections, maintenance, and remediation of substandard conditions. Of primary importance among these findings, owners of 75 of the 100 dams reviewed do not have an emergency action plan to ensure a reasoned approach to evacuation of neighborhoods situated in potential harm's way.

In light of these findings, DLM makes two major recommendations. In the short term, the Commonwealth should ensure that every high hazard municipally owned critical dam has an emergency action plan to warn nearby residents and to plot evacuation should dam failure become imminent due to seasonal floods or other causes. The approximate cost for the 14 municipally owned high hazard critical dams that lack this basic protection is $150,000. For longer term planning, the Commonwealth should establish a multi-year

program of incentive financing to target resources for remediation of the 100 municipal critical dams on a schedule prioritized by level of risk to public safety. Other recommendations address resource issues at the state Office of Dam Safety, and suggest a more proactive mission to provide greater guidance for and oversight of dam owners.

I hope the information in this report is useful to you in your efforts to enhance the standards of public safety for residents throughout the Commonwealth. Copies of the report are available on the OSA's website, www.mass.gov/sao, or by calling DLM at 617-727-0980. Please contact my office with questions or comments. I thank you for your support of the work of this office over many years, and I wish you the best.

Sincerely,



A. JOSEPH DeNUCCI
Auditor of the Commonwealth

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Executive Summary

Background and Objectives

Under its statutory authority, the State Auditor's Division of Local Mandates (DLM) has reviewed the financial impact of dam safety laws and regulations on municipalities which own and operate one or more dams. There are 2,892 dams located throughout Massachusetts, 1,547 of which are regulated by the state Office of Dam Safety (ODS); 627 of these regulated dams are owned by Massachusetts cities and towns. ODS has reviewed each regulated dam in terms of risk and condition.

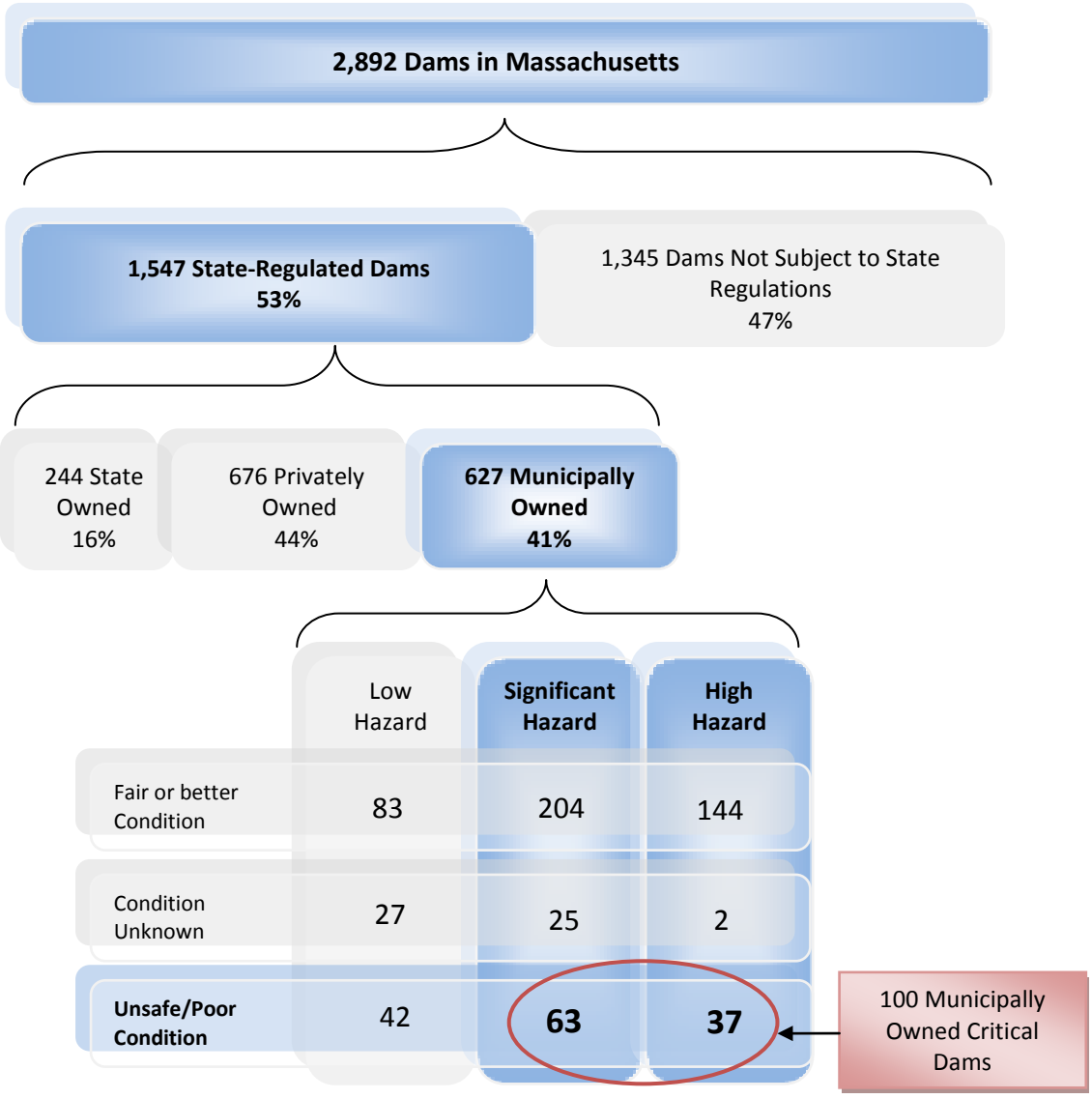
In assessing the level of risk, ODS evaluates the likelihood that a dam failure (an uncontrolled release of impounded water) would result in loss of life or substantial property damage. Dams that are "likely" to cause such damage are classified as "high hazard"; dams that "may" cause such damage are classified as "significant" hazard.

Seventy–five percent (75%) of the 627 municipally owned dams are either in the high or significant hazard category. The good news is that most of these potentially hazardous dams are in fair or better condition. The bad news is that 100 of these high or significant hazard dams owned by municipalities have substantial structural or flood routing deficiencies. The worst news is that most of these 100 high or significant hazard dams lack formal emergency action plans, the most basic level of protection for downstream populations.

ODS regulations require that the communities that own high hazard dams develop emergency action plans; the municipal owners of each of these 100 critical dams must also perform ongoing maintenance, conduct periodic engineering inspections and complete all repairs and alterations recommended in these engineering reports. Each of these requirements comes with a price tag to cities and towns and competes with a myriad of municipal responsibilities for funding. One Massachusetts mayor commented that it is very difficult to gain public support to repair a substandard dam while it is still holding; more immediate interests win the competition for limited local revenues.

This report of the Division of Local Mandates focuses on substandard municipally owned dams and the fiscal consequences of complying with dam safety law at the local level. Specifically, a review of the data indicates that there is a group of 62 communities that owns 100 relatively large dams that are in poor or unsafe condition. Because each of these 100 substandard dams has the potential to cause loss of human life or significant property damage in the event of failure, this group requires more immediate remedial action, and a priority status in the list of demands for public resources. We refer to this group as the "100 municipally owned critical dams." See Figure 1.

Figure 1: Identification of 100 Municipally Owned Critical Dams



There are several objectives of this work. Relative to the 100 municipally owned critical dams, the first is to assess the status of local compliance with selected measurable standards of safety set by state law and regulation. Second, we estimate the local financial impact of achieving compliance with these standards, and contrast this with the cost of deferred action. Overall, we hope to raise public awareness of and commitment to proper emergency planning, maintenance, and repair or removal of dangerous dams owned by cities and towns. Finally, we hope to highlight the need for additional resources at ODS, so that this office is equipped to provide greater guidance and oversight of dam owners.[1]

Findings and Recommendations

The major findings relative to the 100 municipally owned critical dams are highlighted below in conjunction with related recommendations.

Emergency Action Plans (EAPs)

High Hazard Dams: Although state regulations require EAPs for the 37 high hazard municipally owned critical dams, ODS data indicates that 14 lack this basic public safety tool. Approximate compliance cost for the 14: $150,000.

Recommendation 1

The Commonwealth should ensure that every municipality that owns a high hazard dam has a current Emergency Action Plan on file at ODS and at the Massachusetts Emergency Management Agency. In particular, the Commonwealth should focus immediately on the 14 municipally owned dams in poor condition with no written plans for an emergency. Prior to repair or removal of dangerous conditions, an EAP is a relatively low cost exercise that would at least ensure a reasoned approach to evacuation of neighborhoods situated in potential harm's way. At an estimated average price of $10,700, it would cost approximately $150,000 to provide this most basic protection at the 14 municipally owned high hazard dams in critical condition that presently do not have EAPs.

Significant Hazard Dams: According to ODS data, owners of only two of the 63 significant hazard municipal dams in poor or unsafe condition have written EAPs, and many of these communities have "no idea of what to do in an emergency." Approximate cost for 61 EAPs: $650,000.

Recommendation 2

DCR should amend dam safety regulations to require EAPs for significant hazard potential dams, at least when they are found to be in unsafe or poor condition. Current state regulations require EAPs for all high hazard potential dams, but not for significant hazard dams. Yet, in many cases, a significant hazard potential dam may pose an equal or greater threat to human life and property in the event of dam failure, particularly when there are major structural deficiencies. At an estimated average price of $10,700, it would cost approximately $650,000 to provide this most basic protection for residents and businesses downstream of the 61 municipally owned significant hazard dams in critical condition that presently do not have EAPs.

Remediation of Substandard Dams

Every one of the 100 municipally owned critical dams requires some form of remediation, because of an unsafe or poor condition rating. Approximate cost: $60,000,000.

Recommendation 3

ODS should provide the Legislature with a listing of the 100 municipal critical dams prioritized in order of current risk to public safety. Recognizing that every substandard dam cannot be repaired at once, a program of dam remediation must be targeted first to the greatest threats to public safety: that is, the largest dams in densely populated areas with the greatest likelihood of failure. The risk-prioritized listing should be updated annually to reflect changes in dam safety ratings.

Recommendation 4

The Legislature should establish a multi-year program of incentive financing to target resources for remediation of the 100 municipal critical dams on a schedule prioritized by level of risk. The Legislature should provide for a program of revolving loans to finance remediation of the critical 100 dams on a targeted basis, as was recommended by the Senate Committee on Post Audit and Oversight[2] for privately owned dams. Offering loans at no interest would provide strong incentive to initiate repair or removal of dangerous dams sooner rather than later. As repayments accumulate, the funds should be earmarked for ongoing remedial efforts. The goal should be to initiate at least 10 remediation projects per year, because even this ambitious schedule would span 10 years to completion. Every year of deferred remediation increases the cost, due to continued deterioration of the structure and inflation in the construction industry. Not including the potential impact of inflation, DLM determined that deferring remediation for one year would add approximately $1.2 million to the cost for these 100 dams. The compounded cost of inaction over a ten year period would approach $13.5 million.

Inspections

Municipal owners have filed first round inspection reports at ODS for 87% of the 100 critical dams. However, there are ongoing state-mandated inspection compliance costs: approximately $185,000 every two years for high hazard potential dams; $315,000 every five years for significant hazard dams (at an average cost of $5,000 per dam in both classifications.)

Recommendation 5

Local chief executive officers should ensure that resources are dedicated to regular inspection of the dams owned by their communities.

The average cost of procuring periodic inspections for high and significant hazard dams is relatively minor. Although the data indicates that the majority of the municipal owners of the critical 100 dams is in compliance with the initial inspection orders, concern for public safety requires an ongoing periodic inspection rate of 100%. The pay-off can be great, where for example, a periodic inspection may uncover a minor defect that, if ignored, would multiply in terms of threat to public safety and cost of repair.

Operation and Maintenance

According to ODS data, over 80% of municipal owners of 100 critical dams have inadequate maintenance practices. Approximate cost for 84 municipal critical dams maintained at unacceptable levels: at an average of $5,000, approximately $420,000 for operation and maintenance manuals, plus an ongoing $420,000 per year to implement routine maintenance practices at these 84 locations (average $5,000 per location).

Recommendation 6

Local chief executive officers should dedicate resources to maintenance of the dams owned by their communities.

Operation and maintenance manuals and performance of annual maintenance procedures can also be procured at relatively low cost. In fact, in some cases, engineers estimate that these types of activities can be absorbed at no extra cost in the ordinary course of the duties of a public works department. As with periodic inspections, routine maintenance can uncover conditions that could lead to avoidable deterioration of the dam. Nonetheless, the data shows that too many municipal owners rate poorly in this benchmark.

Oversight of Dam Safety: Oversight and Resources

The Office of Dam Safety is not equipped to provide the oversight and guidance necessary to ensure compliance with dam safety law.

Recommendation 7

The Office of Dam Safety should be equipped to provide the oversight and guidance necessary to ensure compliance with dam safety law. Senior staff of the Department of Conservation and Recreation should reevaluate the mission and staffing level at ODS, and submit budget requests to support expansion. The Senate Committee on Post Audit and Oversight raised the issue of adequate staffing for ODS four years ago. However, since that time, agency personnel dedicated to dam safety has declined, resulting in a ratio exceeding 640 public and private sector dams per employee. The ODS mission should be expanded to provide greater guidance for and oversight of dam owners.

Recommendation 8

ODS should work directly with owners of critical dams to determine the potential availability of other public and private sector resources to offset remediation costs. The office should serve as a clearinghouse to link potential finance sources to owners of critical dams, with a specialist to guide owners through the application process. Other resources may include the Massachusetts Technology Collaborative, and the Community Preservation Act. Further, there are numerous federal and nonprofit organizations that offer support to promote protection of wetlands and wildlife habitats. Among others, examples include the Massachusetts Riverways Program, the

National Fish and Wildlife Foundation, and the Nature Conservancy. These resources and more should be explored in a systematic way for every remediation project.

Recommendation 9

ODS should also work with the state Operational Services Division to determine the feasibility of offering municipal access to Commonwealth contracts to procure emergency action plans and inspection and maintenance services.

Introduction:
Rationale, Statutory Authority, and Scope

The Town of Ashburnham petitioned the State Auditor's Division of Local Mandates (DLM) for a determination regarding the Local Mandate Law, General Laws Chapter 29, Section 27C, and orders of the state Office of Dam Safety (ODS). In general terms, the Local Mandate Law provides that post-1980 state laws and regulations that impose additional costs upon cities and towns must either be fully funded by the Commonwealth, or subject to local acceptance. The ODS orders in question were issued pursuant to post-1980 law[3] and regulations that, among other things, shifted the statutory responsibility for conducting periodic inspections of dams from ODS to owners of dams. The Town of Ashburnham owns several dams, and local officials expressed concern about the cost of conducting these inspections (ranging from $3,000 to $5,000 per dam), as well as the cost of developing emergency action plans (ranging from $5,000 to $25,000 per dam), and funding future repairs that may be deemed necessary as a result of the inspections. The cost of dam remediation may range from minor amounts to millions of dollars. Based upon court precedent, DLM concluded that the Local Mandate Law does not apply in this case, primarily because the requirements apply generally across both the public and private sectors.[4]

Important Issues of Public Safety and Local Financial Capacity

Nonetheless, Ashburnham officials raised important issues of public safety and the financial ability of cities and towns to meet their responsibilities in this regard. This concern was underscored by the results of an informal poll conducted by the Small Town Administrators Association that rated the dam safety law high among the most challenging funding obligations small communities must face. In its annual Report Card for America's Infrastructure, the American Society of Civil Engineers consistently gives the nation's dams a grade "D," noting that for every high hazard dam repaired, about two more fall deficient.[5]

Ashburnham

The Town of Ashburnham raised the issue of the cost of complying with dam safety law with DLM. Although not among the owners of the critical 100 dams featured in this work, the Town is a compelling example of the potential impact that dams can have on one small community. In an area approaching 39 square miles, Ashburnham hosts 24 dams that were built between 1846 and 1930. The Town owns nine of these, two of which are rated high hazard potential in acceptable condition.

For these reasons, DLM initiated a review of the local financial impact of dam safety law, under the authority of General Laws Chapter 11, Section 6B. This law allows DLM to review any state law that has a significant financial impact on local spending, regardless of whether it meets the more technical standards of the Local Mandate Law. An "11, 6B review" results in a report to the Legislature that quantifies the local financial impact of state law, and includes recommendations for fiscal relief.

Although an initial review of the data indicated that the financial pressures facing municipal dam owners are widespread, there is a subset of 62 communities that owns 100 relatively large dams that are in poor or unsafe condition. Because each of these 100 substandard dams has the potential to cause loss of life and substantial property damage in the event of failure, this report focuses on this group of priority dams that requires more immediate remedial action.

Background and Methodology

Nearly one-half of the world's rivers have at least one large dam.[6] Across the United States, there are over 80,000 dams,[7] and almost 3,000 of these are located in Massachusetts.[8] The predominate uses of dams in Massachusetts are for water supply, recreation, or a mixed-use combination. Dams are also built for flood control, irrigation, and the production of hydroelectricity.

Although the approximate year of construction is unknown in many cases, the data suggests that nearly one thousand dams in Massachusetts were built between 50 and 100 years ago; hundreds are between 100 and 200 years old, and a small number exceed 200 years in age. This is an important factor, as age is "a leading indicator of dam failure."[9] Many dams were built with an expected design life of 50 years, and older dams predate the more modern construction safety standards developed in the 1970s.[10]

Inherent Dangers

While dams have become an integral part of the national infrastructure, even the best maintained dam is inherently dangerous when located in, or upstream of, a residential or commercial center. Depending upon the size and nature of the dam, a sudden break or overtopping could propel a wall of tons of water and swept-up debris through an unsuspecting community. Dam failures in the 1970s in West Virginia, Idaho, and Georgia resulted in 175 deaths, over 1,000 injuries, and the destruction of over 7,000 homes. Economic damages exceeded $450 million.[11]

More recently in Massachusetts, flood events in October 2005 and May 2006 had state and local emergency officials on the alert, monitoring near-disaster conditions at numerous dam locations. The City of Taunton, for example, evacuated over 2,000 people as officials feared the collapse of the 170-year-old Whittenton Pond Dam. Human tragedy was averted, but the full economic impact for emergency response and loss to the business community was estimated to exceed $1.5 million.[12] In March 2010, a three-day storm that set precipitation records raised the Charles River to a level that threatened the Moody Street dam in Waltham, again necessitating emergency response. Waltham officials opened temporary housing to evacuees, though the dam, bolstered with sandbags and boulders, ultimately held.

Overview of Dams in Massachusetts – The Basic Terms and Data

The inventory of ODS lists 2,892 dams in Massachusetts, each owned either by private parties or local, state, or federal entities. Of these, 1,547 (53%) are under the jurisdiction of ODS, within the Executive Office of Energy and Environmental

Affairs, Department of Conservation and Recreation. Regulatory authority stems from the statutory definition of "dam" that includes:

"any artificial barrier…which impounds or diverts water…," and is at least 25 feet high or capable of impounding at least 50 acre-feet of water.[13]

By this standard, over 1,200 dams are relatively small, and therefore not subject to ODS regulations.[14] Another 77 are subject to federal regulations.[15] This overview is limited to the dams subject to state regulation, and provides a context for the more in-depth examination of the 100 municipally owned critical dams that follows. Below is an abbreviated selection of introductory data and terminology.

As shown in Figure 2, dams have been constructed throughout the state, with the exception of Nantucket Island. The greatest numbers are in Worcester and Middlesex counties, while Berkshire, Bristol, Essex, Hampden, and Norfolk counties each have 100 or more. Note that location is simply where the dam sits; it does not indicate public ownership. Each of the dams listed in Figure 2 may be owned by a municipality, the Commonwealth, or a private sector entity.

Figure 2: Locations of State-Regulated Dams by County

County	# Dams	%
Barnstable	27	2
Berkshire	133	9
Bristol	100	6
Dukes	6	<1
Essex	137	9
Franklin	65	4
Hampden	109	7
Hampshire	73	5
Middlesex	174	11
Nantucket	0	0
Norfolk	117	8
Plymouth	132	9
Suffolk	4	<1
Worcester	470	30

Hazard Classification and Condition Ratings

Like most state dam safety programs, Massachusetts classifies dams by the potential hazard to life and property in the event of dam failure, defined as an uncontrolled release of the impounded water.[16] The regulations provide for three hazard classes: high, significant, and low. It is important to understand that the system of dam classifications and ratings reflects a given point in time. As noted in a recent dam safety inspection report:

It is critical to note that the condition of the dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the reported condition of the dam will continue to represent the condition of the dam at some point in the future.[17]

Dams are also rated by the condition of the structure: good, satisfactory, fair, poor, or unsafe. Clearly, dams in poor or unsafe condition should be of great concern.

High hazard dams are those located "where failure will likely cause loss of life and serious damage to home(s), industrial or commercial facilities, important utilities, main highway(s) or railroad(s)."

Significant hazard dams are defined as being located "where failure may cause loss of life and damage to home(s), industrial or commercial facilities, secondary highway(s) or railroad(s), or cause interruption of use or service of relatively important facilities."

Low hazard dams are "located where failure may cause minimal property damage to others. Loss of life is not expected."

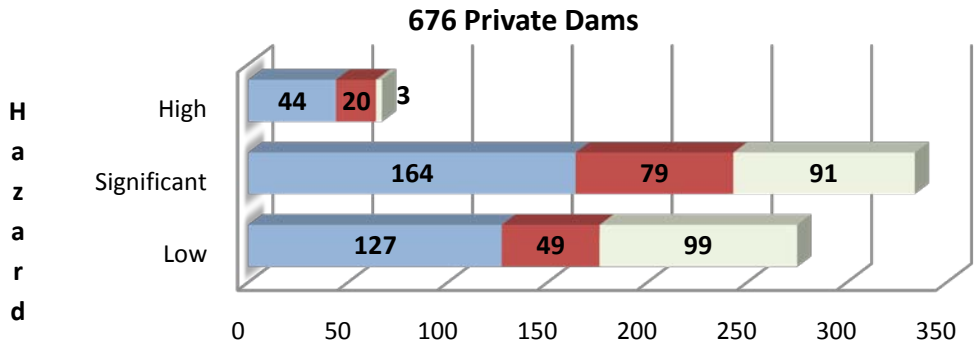
Poor Condition – dams with major structural, operational, maintenance, and flood routing capability deficiencies.

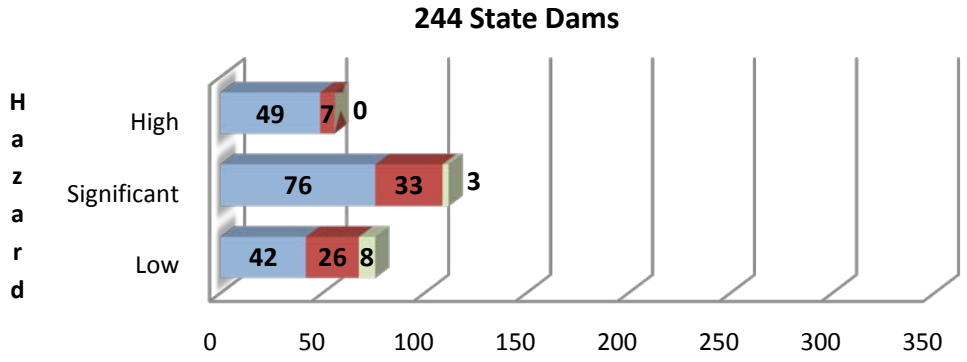
Unsafe Condition - dams are at a high risk of failure.

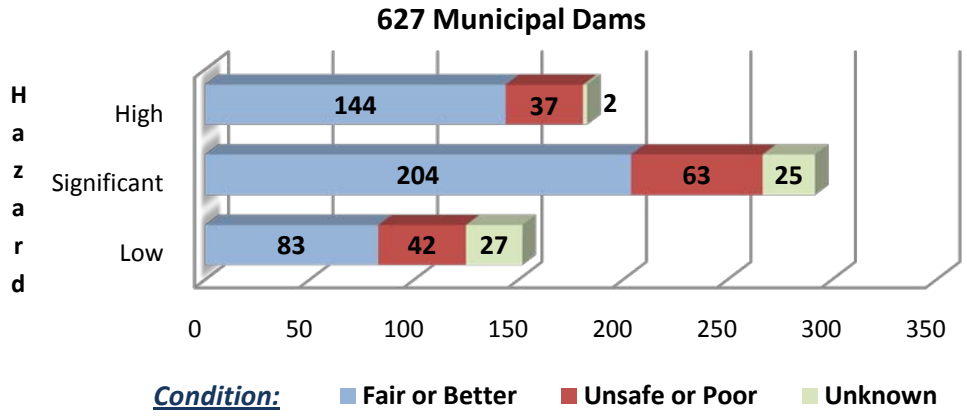
ODS data indicates that approximately 44% of state-regulated dams are privately owned, 16% are state-owned, and 40% are municipally owned. While almost one-third (503) are rated low hazard potential, over two-thirds (1,044) are high or significant hazard dams with the potential to cause loss of life or significant property damage. Among these potentially more dangerous structures, approximately one in three is listed in unsafe, poor, or unknown condition. See Figure 3.

Figure 3: 1,547 State-Regulated Dams

Ownership, Hazard, & Condition







As noted earlier, the focus of this report is dams owned by municipalities. There are 213 cities and towns that own 627 dams, and nearly 40% of these communities own more than five dams. See Figure 4.

Figure 4: 24 Municipalities Responsible for More than Five Dams

City	#
Worcester	28
Fitchburg	20
Springfield	18
Gloucester	14
Lynn	14
Attleboro	12
Brockton	11
Leominster	10
Dudley	9
Haverhill	9
Peabody	9
Pittsfield	9
Plymouth	9
Amherst	8
Fall River	8
Mansfield	8
Northampton	8
Orange	8
Westfield	8
Foxborough	7
Gardner	7
Holyoke	7
Danvers	6
Winchester	6

Cities and towns throughout the state feel the financial impact of dam ownership. However, the majority do not own the more hazardous dams that are in the poorest stages of structural deterioration. This report focuses on the 62 localities that own 100 dams that are in critical condition and therefore more likely to cause loss of life and/or substantial destruction of property.

Objectives and Methodology

There are several objectives of this work. The first is to identify the subset of locally owned dams that pose the greatest potential threat to public safety in Massachusetts. There are 100 dams that fit these criteria, and we refer to them as the "100 municipally owned critical dams." Relative to these 100, the second objective is to assess the status of local compliance with selected measurable standards of safety set by state law and regulation. Finally, we will estimate the local financial impact of achieving compliance with these standards, and contrast this with the cost of deferred action. Overall, we hope to raise public awareness of the importance of properly maintaining, repairing, or removing potentially hazardous dams owned by cities and towns, and to join others in promoting discussion on the most effective means to this end. Additionally, we hope to encourage ODS to take a more aggressive stance with regard to compliance with its regulations and a more pro-active role in devising strategies to address the needs identified in this report.

Our methods included: review of relevant federal and state laws, regulations, guidelines, models, and reports; compilation and analysis of relevant data from the Office of Dam Safety inventory of Massachusetts dams, and from the U. S. Army Corps of Engineers National Inventory of Dams; review of over 100 dam inspection reports with accompanying recommendations filed at ODS by certified civil engineers; site visits, and personal and telephone interviews of selected state and local personnel working in dam safety.

Unless attributed otherwise, the primary source of data discussed in this report is DCR, ODS. (Appendix 1 provides a brief overview of the legal and administrative framework for dam safety in Massachusetts.)

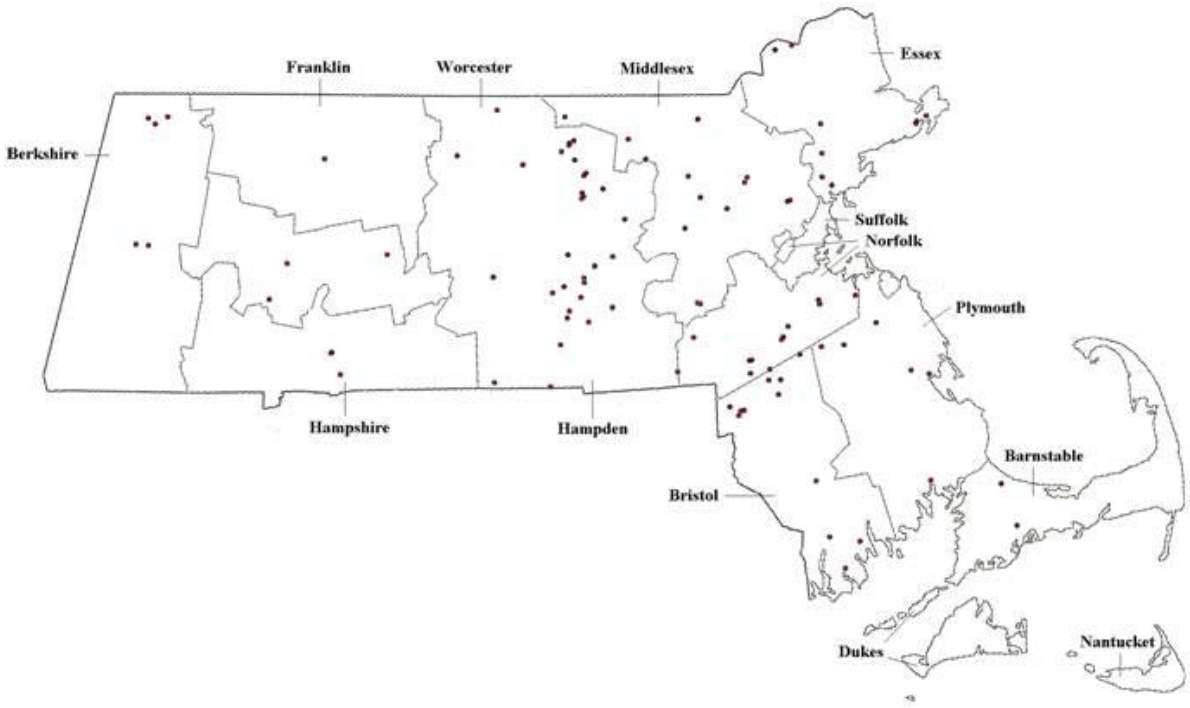
100 Municipally Owned Critical Dams

From the 627 locally owned dams listed in the ODS inventory, DLM identified 100 dams that are classified as high and significant hazard potential and are in poor or unsafe condition. These 100 dams represent 16% of municipally owned dams. Each of these could potentially cause loss of life and significant property damage in the event of failure, *and* each of these has major deficiencies that increase the likelihood of failure. Engineers' inspections indicate that 94 of these 100 are in poor condition, and six are rated as unsafe, posing a high risk of failure. As noted earlier, factors such as age, outmoded design standards, poor maintenance, earthquakes, and flood events exacerbate the likelihood of dam failure.

Location

The 100 dams under review are located in 62 communities throughout 11 counties; the counties with ten or more critical dams are Worcester (32), Middlesex (14), Norfolk (13), Bristol (11), and Essex (10). None of the municipally owned, critical dams are in Dukes, Nantucket, or Suffolk counties. Figure 5 shows the disbursement of the critical 100 across the state. (Appendix 2 lists the cities and towns that own critical dams, and provides basic data from the ODS inventory on each of these substandard structures.)

Figure 5: 100 Municipally Owned Critical Dams



Potential for Harm: Picture This

Below is an image from Google Earth, showing one of the critical 100 municipal dams that is located in a densely populated area. Originally constructed in 1914, this high hazard structure is 60 feet high and normally impounds 5,200 acre-feet of water, primarily for the purpose of water supply. Although the data indicates that the municipal owner has performed adequate levels of maintenance, despite those efforts, this dam has major structural deficiencies, and is rated in poor condition. Remarkably, the dam sits at an elevation of 100 feet above sea level, over a neighborhood of homes, schools, and businesses situated at elevations descending to 23 feet above sea level; that is, 77 feet below the dam. See Figure 6.

Figure 6: A Municipally Owned Critical Dam Positioned within a Densely Populated Neighborhood

Size, Purpose, and Age: The Oldest Was Erected Nearly 200 Years Ago

As may be expected from the high and significant hazard classifications, the vast majority of the critical 100 municipal dams are relatively large, at least 15 feet in height, or impounding at least 50 acre-feet of water. While most serve recreation or water supply purposes, 16 aid in flood control for the surrounding areas.

Although the ODS database does not indicate the approximate age of construction for 12 of the critical 100, the newest was built in 1977 for recreational purposes. Ten are less than 60 years old, built in the 1960s and 1950s, and 77 exceed 60 years in age. Among the 77 older dams, 35 were erected between the years 1900 and 1910, exceeding 100 years of age; 22 were built in the 1800s. The oldest in this group of critical dams was constructed in 1819; it is 191 years old and, not surprisingly, in unsafe condition, presenting a high risk of failure. As noted earlier, age is "a leading indicator of dam failure," because older dams predate the more modern construction standards developed in the 1970s.[18]

Findings and Financial Impact

State law and regulations set the standards of public safety for the construction, operation, and repair or removal of dams. Among these requirements, we have selected four key elements for further review in relation to the 100 municipally owned critical dams: emergency action plans, inspections, maintenance, and remediation of substandard conditions. We have also prepared estimates of the cost of achieving full compliance with these standards.

Emergency Action Plans (EAPs)

High Hazard Dams: Although state regulations require EAPs for the 37 high hazard municipally owned critical dams, ODS data indicates that 14 lack this basic public safety tool.

Significant Hazard Dams: According to ODS data, 61 owners of the 63 significant hazard municipal dams in poor or unsafe condition have no written EAP, and many of these communities have "no idea of what to do in an emergency."

According to the Federal Emergency Management Agency, "An Emergency Action Plan (EAP) is one of the primary safeguards against the loss of life and property damage that can result from the failure of a high-hazard potential dam."[19] Noncompliance with this threshold requirement leaves downstream communities without even a minimal level of emergency preparedness. State regulations require EAPs for all high hazard dams, including those that are in good condition. Regulators have deferred requiring EAPs across-the-board for significant hazard dams, until greater compliance is achieved for the high hazard structures.

ODS collects data to monitor compliance with this requirement, and categorizes a dam owner's level of compliance along a scale ranging from "a detailed written plan filed with the agency" to "owner has no idea of what to do in an emergency." Figure 7 shows the ranges of emergency preparedness indicated by the ODS data for the 100 locally owned critical dams. Even though owners of significant hazard dams are not required to prepare and file EAPs with the state, ODS includes this subset in its monitoring efforts.

302 Code of Massachusetts Regulations 10.11, Minimum Elements of an EAP

(a) the identification of equipment, manpower and material available for implementation of the plan;

(b) a notification procedure for informing the local emergency agencies;

(c) a dam failure inundation map for high hazard potential dams…;

(d) a procedure for warning nearby local residents if failure of the dam is imminent and a listing of addresses and telephone numbers of downstream residents who may be affected by the failure of the dam.

Figure 7: Level of Emergency Preparedness for 100 Municipally Owned Critical Dams

ODS Defined Level of Preparedness	# Out of the 37 High Hazard Dams	# Out of the 63 Significant Hazard Dams
Detailed, updated, written plan available and filed with DCR	**8**	**–**
Available written plan that needs updating	**15**	**2**
No formal plan, but well thought out	**5**	**5**
Some idea of what to do in an emergency, but no written plan	**7**	**32**
No plan or idea of what to do in an emergency	**2**	**23**
Blank field in database	**_**	**1**

Seventy-five of the 100 municipally owned critical dams have no formal, written EAP. Current state regulations require only the 37 high hazard potential dams in this group to have such plans. However, only eight of these 37 dams had written EAPs on file at ODS. Another 15 had met partial compliance, but were not up-to-date. Owners of 14 high hazard dams in poor condition had no written plan of how to proceed in an emergency, and two of these had no idea of what to do. These conditions persist despite the fact that ODS issued orders in June of 2006 to all owners of high hazard dams to develop and submit EAPs by December of that year.

Although not required to file a written plan with ODS, owners of only seven of the 63 locally owned critical dams rated significant hazard potential have at least a "well thought out" plan of emergency action. Thirty-two have "some idea," while 23 have "no idea of what to do in an emergency." The data indicates that one dam in this latter category, "no idea of what to do," has a structural height of 25 feet and normally impounds 1,775 acre-feet of water.

Cost to Achieve Compliance

The average engineers' cost estimate for developing an EAP is approximately $10,700.[20] At this average rate, DLM projects that it would cost approximately $150,000 to procure EAPs with inundation maps for the 14 high hazard municipally owned critical dams that have no written plan. It would require approximately $650,000 to provide similar protection at the 61 significant hazard dams that lack this basic public safety tool.

Inspections

Municipal owners of critical dams have filed first round routine inspection reports at ODS for 87% of the 100 critical dams. However, owners of 13 of the high hazard dams have not kept up with the inspection schedule.

As noted in the introduction to this report, the responsibility for obtaining and paying for inspections of dams was shifted from DCR to individual dam owners in 2002.[21] The schedule for routine formal inspections (known as Phase I inspections) varies by hazard classification of the dam:

High Hazard, every two years

Significant Hazard, every five years[22]

The inspection report contents are determined by DCR and must be completed and filed by a registered professional civil engineer. Phase I inspections include a review of any historical records and emergency action plans, a visual evaluation of the structure to determine the present condition of the dam, and recommendations for further analyses and remedial actions as necessary. The reports also include site sketches and photographs.

As a rule, the owners of the critical 100 dams have been responsive to Phase I inspection orders. These first-round high hazard dam inspections were due to be filed with DCR in September 2006. According to the ODS database, every one of the 37 municipal owners of critical high hazard dams has obtained a Phase I inspection since 2006. However, 13 of this group do not show updated inspections to comply with the ongoing biennial schedule set by regulation.

First-round inspections of significant hazard dams were due in December 2006. For the 63 municipal owners of critical significant hazard dams, the data shows that 52 are in compliance with the five-year inspection schedule, with Phase 1 reports on file dated no further back in time than 2006. Nine of this group show older reports that predate the five-year regulatory cycle, with five of the nine over 10 years behind the compliance schedule.[23]

Cost to Achieve Compliance

For every owner of the critical 100 to obtain and maintain compliance, the periodic cost of conducting Phase I inspections may be estimated using the $5,000 average cost per inspection.[24] For the 37 high hazard dams, the result is $185,000 every two years. For the 63 rated as significant hazard, the result is $315,000 every five years.[25]

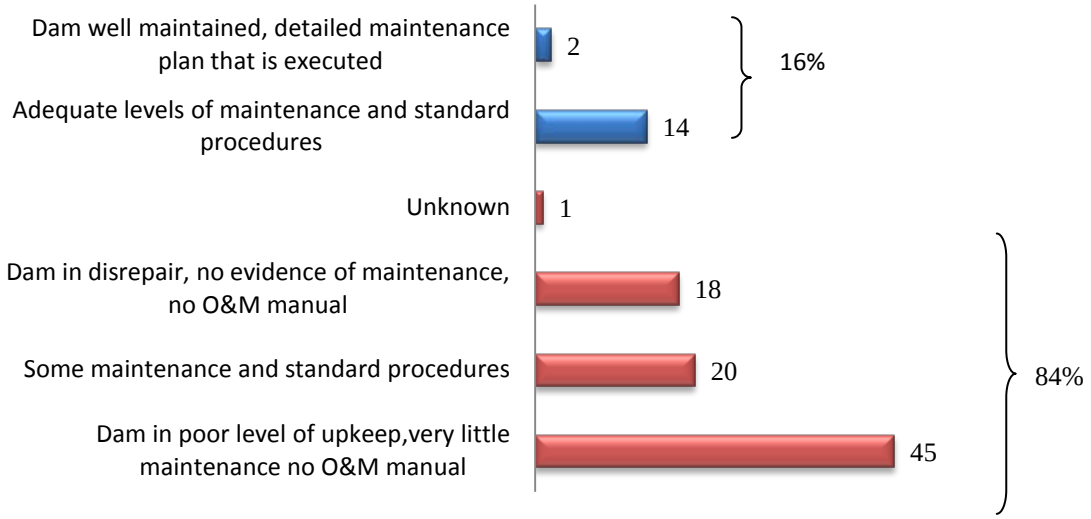
Operation and Maintenance

Over 80% of municipal owners of 100 critical dams have inadequate maintenance practices.

State regulations require that the final design report for dam construction or remediation must include a plan for Operation and Maintenance (O & M).[26] An O & M Manual delineates "…routine maintenance and operational procedures under routine and storm conditions." Among other things, these procedures might include regularly scheduled maintenance activities such as exercising and lubricating gates and valves, monitoring for seepage and other abnormalities, repointing masonry, vegetation control, removal of debris, and detection and repair of animal burrows.

Nonetheless, ODS collects data to monitor the extent of maintenance activities and categorizes levels of maintenance from "dam well maintained, detailed maintenance plan that is executed" to "dam in disrepair with no evidence of maintenance." See Figure 8.

Figure 8: Level of Maintenance for 100 Municipally Owned Critical Dams



The data shows that approximately one in six of the owners of the critical 100 dams practice adequate or better maintenance procedures, a level of performance that may be considered acceptable. The vast majority, over 80%, are rated as having less than adequate levels of maintenance, a situation that can only be considered unacceptable.

Cost to Achieve Compliance

In many cases, engineers' dam safety inspection reports include recommendations that owners develop operation and maintenance manuals and undertake routine maintenance practices on a regular basis. In this context, engineers' estimates for developing operation and maintenance manuals average approximately $5,000.[27] At an estimated average of

$5,000, there would be a one-time cost of approximately $420,000 to procure operation and maintenance manuals for the 84 dams maintained at unacceptable levels.

In addition, engineers provide cost estimates for carrying out the practices prescribed in the operation and maintenance manuals. From the inspection reports available for the critical 100 that include estimates for performing routine maintenance on a yearly basis, the average estimated cost is approximately $5,000.[28] At an average allotment of $5,000, it would cost approximately $420,000 per year to implement routine maintenance activities for these critical local dams.

Remediation

The current projected cost of remediation for the 100 municipally owned critical dams is approximately $60 million, an average of $600,000 per dam. Deferring remediation would lead to further increased costs. Deferring remediation by ten years would add approximately $13.4 million, not including the effects of inflation.

Because of an unsafe or poor condition rating, every one of the 100 municipally owned critical dams requires some form of remediation. Remediation may include repairs, alterations, or removal/decommissioning of the structure.

Cost to Achieve Compliance

To estimate these costs, DLM referenced several sources obtained from ODS and found baseline estimates for 96 of the 100. The sources were professional civil engineers' inspection reports; data for dams in the remediation permit process; and databases obtained from ODS in April 2008 and August 2010. When there was more than one source for a given dam, we used the most current amount. To this baseline cost data, we applied the Civil Works Construction Cost Index system for dams published by the U. S. Army Corps of Engineers.[29] Because the date of the baseline source data differs for most of these dams,[30] the values were indexed quarterly and compounded across a custom time span for each dam, from the record date of the baseline data to the present. The resulting amount is the 2010 projected cost. For the 96, these projections total to $55,022,762, with an average cost of $573,154.[31]

To project estimates for the four dams with no cost data, we adapted the methodology developed by the Association of State Dam Safety Officials.[32] In summary, this approach looks to the experience with dams that have known remediation costs, and uses the average per foot cost to make estimates for dams with unknown remediation costs.[33] The resulting projected estimate for the group of four is $4,732,423. [34] This amount, combined with the 2010 projected amounts for the 96 dams, brings the total estimated cost of remediation for the 100 municipally owned critical dams to approximately $60 million, averaging about $600,000 per dam.[35] As shown in Figure 9, cost projections for 86 of the 100 dams are under $1 million. Projections for the remaining 14 range between $1 million and $3 million.

Figure 9: 62 Municipal Owners of 100 Critical Dams Ranges of Projected Cost of Remediation

	Under $500K	$500K- $1M	$1M - $1.5M	$1.5M - $2M	$2M - $2.5M	$2.5M - $3M	Over $3M	Total # of Dams
Abington		1						1
Athol	1							1
Attleboro	3	1						4
Auburn	1	1						2
Ayer		1						1
Bedford	1		1					2
Bellingham		1						1
Blackstone	1							1
Bolton		1						1
Brockton		1						1
Canton			1					1
Chelmsford		1						1
Clinton	3							3
Concord	1	1						2
Danvers						1		1
Dartmouth	1							1
Dudley	1							1
Duxbury	1							1
Easton	1							1
Fall River	1	1						2
Fitchburg		6						6
Foxborough	3	1		1				5
Gardner		1						1
Gloucester	3	1						4
Grafton	1							1
Greenfield	1							1
Groton	1							1
Hanover	1							1
Haverhill	1	1						2
Holden	1							1
Holliston	2							2
Holyoke		1						1
Lancaster			1					1
Leicester	1							1
Leominster		2						2
Lincoln	1							1
Lynn	2							2
Mansfield	1	1						2
Mashpee	1							1
Millbury		1						1
New Bedford	1							1
North Adams		1		2				3
North Brookfield		1						1
Northampton		1						1

	Under $500K	$500K- $1M	$1M - $1.5M	$1.5M - $2M	$2M - $2.5M	$2.5M - $3M	Over $3M	Total # of Dams
Northborough		1						1
Norton	1							1
Oxford	1							1
Peabody		1						1
Pembroke	1							1
Pittsfield		1					1	2
Sandwich		1						1
Sharon	2							2
Shrewsbury	1							1
Southbridge		1						1
Springfield	3		1					4
Sudbury	1							1
Tri-Town Water Board			2					2
Wareham					1			1
Weymouth			1					1
Winchendon				1				1
Winchester	2							2
Worcester	2	2						4
Total	**51**	**35**	**7**	**4**	**1**	**1**	**1**	**100**

Noting that recommendations offered by the Senate Committee on Post Audit and Oversight in 2006 had not as yet been implemented, DLM investigated the impact on remediation costs over time due to inaction. As indicated earlier, failure to properly maintain these dams and undertake necessary repairs will lead to further deterioration of these structures that are already rated as unsafe or poor in condition. Using data from engineering reports and the Army Corps of Engineers, DLM was able to measure the impact of neglect and continued structural deterioration on remediation costs for the 100 municipally owned critical dams. The cost of inflation, which has been relatively flat over the past two years, but will likely increase at some point, would be additional.

From separate databases obtained in 2008 and in 2010, DLM estimated a two-year cost of inaction to be approximately $2.4 million. When compounded over longer periods, the cost increases become even more significant, approximately $6.3 million for five years and $13.4 million for ten years of inaction, not including the potential impact of inflation. Clearly, the cost of maintenance is recovered many times over by reduced costs for remediation.

Recommendations

Emergency Action Plans (EAPs)

Recommendation 1

High Hazard Dams: The Commonwealth should ensure that every municipality that owns a high hazard dam has a current Emergency Action Plan on file at ODS and at the Massachusetts Emergency Management Agency. In particular, the Commonwealth should focus immediately on the 14 municipally owned dams in poor condition with no written plans for an emergency. Prior to repair or removal of dangerous conditions, an EAP is a relatively low cost exercise that would at least ensure a reasoned approach to evacuation of neighborhoods situated in potential harm's way. At an estimated average price of $10,700, it would cost approximately $150,000 to provide this most basic protection at the 14 municipally owned high hazard dams in critical condition that presently do not have EAPs.

Recommendation 2

Significant Hazard Dams: DCR should amend dam safety regulations to require EAPs for significant hazard potential dams, at least when they are found to be in unsafe or poor condition. Current state regulations require EAPs for all high hazard potential dams, but not for significant hazard dams. Yet, in many cases, a significant hazard potential dam may pose an equal or greater threat to human life and property in the event of dam failure, particularly when there are major structural deficiencies. At an estimated average price of $10,700, it would cost approximately $650,000 to provide this most basic protection for residents and businesses downstream of the 61 municipally owned significant hazard dams in critical condition that presently do not have EAPs.

Remediation

Recommendation 3

ODS should provide the Legislature with a listing of the 100 municipal critical dams prioritized in order of current risk to public safety. Recognizing that every substandard dam cannot be repaired at once, a program of dam remediation must be targeted first to the greatest threats to public safety: that is, the largest dams in densely populated areas with the greatest likelihood of failure. The risk-prioritized listing should be updated annually to reflect changes in dam safety ratings.

Recommendation 4

The Legislature should establish a multi-year program of incentive financing to target resources for remediation of the 100 municipal critical dams on a schedule prioritized by level of risk. The Legislature should provide for a program of revolving loans to finance remediation of the critical 100 dams on a targeted basis, as was recommended by the Senate Committee on Post Audit and Oversight[36] for privately owned dams. to provide a program of revolving loans to finance the projected $60 million cost for remediation of

the critical 100 dams on a targeted basis. Offering loans at no interest would provide strong incentive to initiate repair or removal of dangerous dams sooner rather than later. The goal should be to initiate at least 10 remediation projects per year, because even this ambitious schedule would span 10 years to completion. As explained earlier, every year of deferred remediation increases the cost, due to continued deterioration of the structure and inflation in the construction industry. As repayments accumulate, the funds should be earmarked for ongoing remedial efforts.

Inspections

Recommendation 5

Local chief executive officers should ensure that resources are dedicated to regular inspection of the dams owned by their communities.

The average cost of procuring periodic inspections for high and significant hazard dams is relatively minor. Although the data indicates that the majority of the municipal owners of the critical 100 dams are in compliance with the initial inspection orders, concern for public safety requires an ongoing periodic inspection rate of 100%. The pay-off can be great, where for example, a periodic inspection may uncover a minor defect that, if ignored, would multiply in terms of threat to public safety and cost of repair.

Inspections for the 100 municipal critical dams would cost approximately $185,000 every two years for high hazard potential dams and $315,000 every five years for significant hazard dams (at an average cost of $5,000 per dam in both classifications).

Operations and Maintenance

Recommendation 6

Local chief executive officers should dedicate resources to maintenance of the dams owned by their communities.

Operation and maintenance manuals and performance of annual maintenance procedures can also be procured at relatively low cost. In fact, in some cases, engineers estimate that these types of activities can be absorbed at no extra cost in the ordinary course of the duties of a public works department. As with periodic inspections, routine maintenance can uncover conditions that could lead to avoidable deterioration of the dam. Nonetheless, the data shows that too many municipal owners rate poorly in this benchmark.

At an average of $5,000, the cost to procure operation and maintenance manuals for the 84 municipal critical dams maintained at unacceptable levels would be approximately $420,000. Additionally, an ongoing $420,000 per year would be required to carry out routine maintenance practices at these 84 locations.

Oversight of Dam Safety: Oversight and Resources

Recommendation 7

The Office of Dam Safety should be equipped to provide the oversight and guidance necessary to ensure compliance with dam safety law. In addition to the 100 municipally owned dams that are the focus of this report, ODS is responsible for 40 state-owned and 148 privately owned dams, which are classified as "high" or "significant" hazard and are in "poor" or "unsafe" condition. See Figure 3.

Senior staff of the Department of Conservation and Recreation should reevaluate the mission and staffing level at ODS, and submit budget requests to support expansion. The Senate Committee on Post Audit and Oversight raised the issue of adequate staffing for ODS four years ago. However, since that time, agency personnel dedicated to dam safety has declined. The most recent data[37] from the Association of State Dam Safety Officials listed Massachusetts with 306 regulated dams per employee, a factor more than 1.5 times greater than the national average. Recent recession-driven budget cuts have left ODS with 4.5 full-time equivalent positions, resulting in a ratio exceeding 640 regulated dams per employee. The ODS mission should be expanded to provide greater guidance for and oversight of dam owners that have historically shown that they cannot or will not comply with even basic standards of safety.

Recommendation 8

ODS should work directly with owners of critical dams to determine the potential availability of other public and private sector resources to offset remediation costs. The office should serve as a clearinghouse to link potential finance sources to owners of critical dams, with a specialist to guide owners to resources and through the application process. Other public and private sector resources may include the Massachusetts Technology Collaborative and the Massachusetts Renewable Energy Trust at dam locations with the potential to generate hydroelectric power. The Community Preservation Act and the MassWorks infrastructure program are other potential avenues. Further, there are numerous federal and nonprofit organizations that offer support for projects that promote conservation or restoration of wetlands and wildlife habitats. Among others, examples include the Massachusetts Riverways Program, the National Fish and Wildlife Foundation, the National Resources Conservation Service, and the Nature Conservancy. These resources and more should be explored in a systematic way for every remediation project.

Recommendation 9

ODS should also work with the state Operational Services Division to determine the feasibility and benefits of offering municipal access to Commonwealth contracts to procure emergency action plans and inspection and maintenance services. The Department of Conservation and Recreation presently procures these services for state-owned dams, and should determine whether there would be a cost benefit to making state contracts available to the municipal dam owners.

Appendix 1

Overview of Legal and Administrative Framework

While the federal government sets the standards for federally owned and regulated dams, states develop their own rules for the state, local, and privately held dams within their boundaries. In Massachusetts, the Office of Dam Safety (ODS) within the Executive Office of Energy and Environmental Affairs, Department of Conservation of Recreation (DCR) is the primary regulatory authority, responsible for enforcement of the standards for public safety set by General Laws Chapter 253, Sections 44–50, and annual state budget provisions.[38] DCR regulations governing dam safety are at 302 Code of Massachusetts Regulations 10.00. These standards apply to dams that fall within the statutory thresholds relative to height and impoundment capacity, the relatively larger dams.[39] The DCR ODS website[40] displays the following mission statement that summarizes agency obligations: "[ODS] maintains records of dams located throughout the Commonwealth, ensures compliance with acceptable practices pertaining to dam inspection, maintenance, operation and repair of dams."

Responsibilities of Dam Owners

Whether the owner is a private party, state agency, or municipality, the law and regulations assign full financial and management responsibility to the entity that holds legal title to the dam. Moreover, the law explicitly provides that the owner is liable for personal injury or property damage "resulting from the operation, failure of or misoperation of a dam.[41]"

The duties of owners relevant to this review include the following compliance actions:

- For high hazard and newly constructed significant hazard dams, owners must devise emergency action plans, including procedures to notify emergency agencies and local residents in the event dam failure appears to be imminent. Copies must be filed at DCR and the Massachusetts Emergency Management Agency. Regulations also call for an annual review and update of emergency action plans.
- Owners must obtain a registered, professional civil engineer to conduct routine inspections certifying safety and adequacy of the dam, submit relevant reports to DCR, and comply with any DCR order for subsequent more thorough or follow-up inspections.
- Although not explicitly required by state law or regulation, a prudent owner must perform routine maintenance at the site.
- Owners must comply with any DCR orders to undertake remedial actions at any deficient dam, and obtain requisite permits to repair, alter, or remove the structure, along with plans and specifications that conform to agency's safety, design, and construction criteria. Permits must be filed at the local registry of deeds.

- Finally, owners must pay for all of the above, as well as applicable fees[42] and any noncompliance fines[43] assessed; by regulation, state and municipal owners are exempt from paying fees, but not from paying fines.

Appendix 2

62 Municipalities Own 100 Critical Dams

Selected ODS Data

Promary Owner/ Dam Name	Location	Hazard	Overall Physical Condition	Size*	Year Completed	ODS Level of Maintenance	ODS EAP Status
1. Abington – 1 Dam							
Hunts Pond Dam	Brockton	Significant	POOR	3	1920	Dam in poor level of upkeep, very little maintenance, no O&M manual	No plan of idea of what to do in the event of an emergency.
2. Athol – 1 Dam							
Phillipston Reservoir Dam	Phillipston	Significant	UNSAFE	2	1895	Dam in poor level of upkeep, very little maintenance, no O&M manual	Some idea of what to do in an emergency but no written plan.
3. Attleboro – 4 Dams							
Hoppin Hill Reservoir Dam	No. Attleborough	High	POOR	1	1940	Adequate levels of maintenance and standard procedures	Available written plan that needs updating.
Manchester Pond South Dike	Attleboro	High	POOR	1	1963	Dam in poor level of upkeep, very little maintenance, no O&M manual	Available written plan that needs updating.
Manchester Res. E. Dike Embankments	Attleboro	High	POOR	1	1963	Dam in poor level of upkeep, very little maintenance, no O&M manual	Available written plan that needs updating.
Farmers Pond Dam	Attleboro	Significant	POOR		0	Dam in disrepair, no evidence of maintenance, no O&M manual	No plan of idea of what to do in the event of an emergency.
4. Auburn – 2 Dams							
Eddy Pond Dam	Auburn	High	POOR	1	1920	Some maintenance and standard procedures	Available written plan that needs updating.
Auburn Pond Dam	Auburn	High	POOR	2	1900	Some maintenance and standard procedures	Available written plan that needs updating.
5. Ayer – 1 Dam							
Balch Pond Dam	Ayer	Significant	POOR	2	1900	Dam in poor level of upkeep, very little maintenance, no O&M manual	Some idea of what to do in an emergency but no written plan.

***Size**

1. Large: ≥1,000 acre feet & ≥40 height (feet)
2. Intermediate: ≥50 and <1,000 acre feet & ≥15 and <40 height (feet)
3. Small: ≥15 and <50 acre feet & ≥6 and <15 height (feet)

Promary Owner/ Dam Name	Location	Hazard	Overall Physical Condition	Size*	Year Completed	ODS Level of Maintenance	ODS EAP Status
6. Bedford – 2 Dams							
Wilson Corne Mill Dam	Bedford	Significant	POOR	2	1900	Dam in poor level of upkeep, very little maintenance, no O&M manual	Some idea of what to do in an emergency but no written plan.
Old Water Supply Dam	Bedford	Significant	POOR	3	1900	Dam in poor level of upkeep, very little maintenance, no O&M manual	Some idea of what to do in an emergency but no written plan.
7. Bellingham – 1 Dam							
Old Mill Dam	Bellingham	Significant	POOR		1900	Dam in poor level of upkeep, very little maintenance, no O&M manual	Some idea of what to do in an emergency but no written plan.
8. Blackstone – 1 Dam							
Lake Hiawatha Dam	Blackstone	Significant	POOR	2	1900	Some maintenance and standard procedures	Some idea of what to do in an emergency but no written plan.
9. Bolton – 1 Dam							
Fyfeshire Pond Dam	Bolton	Significant	UNSAFE		0	Dam in poor level of upkeep, very little maintenance, no O&M manual	Some idea of what to do in an emergency but no written plan.
10. Brockton – 1 Dam							
Thirty Acre Pond Dam	Brockton	High	POOR	2	1900	Dam in poor level of upkeep, very little maintenance, no O&M manual	Detailed, updated written plan available and filled with MADCR.
11. Canton – 1 Dam							
Shepard Pond Dam	Canton	Significant	POOR	2	1880	Adequate levels of maintenance and standard procedures	Some idea of what to do in an emergency but no written plan.
12. Chelmsford – 1 Dam							
Swains Pond Dam	Chelmsford	Significant	POOR	3	0	Dam in disrepair, no evidence of maintenance, no O&M manual	Some idea of what to do in an emergency but no written plan.
13. Clinton – 3 Dams							
Heywood Reservoir Dam	Sterling	Significant	POOR	1	1926	Dam in poor level of upkeep, very little maintenance, no O&M manual	No plan of idea of what to do in the event of an emergency.
Fitch Basin Dam	Sterling	Significant	POOR	1	1928	Dam in disrepair, no evidence of maintenance, no O&M manual	No plan of idea of what to do in the event of an emergency.
Upper Lynde Basin Dam	Sterling	Significant	POOR	1	1924	Dam in disrepair, no evidence of maintenance, no O&M manual	No plan of idea of what to do in the event of an emergency.

Promary Owner/ Dam Name	Location	Hazard	Overall Physical Condition	Size*	Year Completed	ODS Level of Maintenance	ODS EAP Status
14. Concord – 2 Dams							
Nagog Pond Dam	Acton	Significant	POOR	1	1909	Dam in poor level of upkeep, very little maintenance, no O&M manual	No formal plan but well thought out.
Warners Pond Dam	Concord	Significant	POOR	2	1900	Dam in poor level of upkeep, very little maintenance, no O&M manual	Some idea of what to do in an emergency but no written plan.
15. Danvers – 1 Dam							
Curtis Pond Dam	Middleton	Significant	UNSAFE	2	1920	Dam in disrepair, no evidence of maintenance, no O&M manual	Some idea of what to do in an emergency but no written plan.
16. Dartmouth – 1 Dam							
Russells Mill Pond Dam	Dartmouth	Significant	POOR	3	0	Some maintenance and standard procedures	Some idea of what to do in an emergency but no written plan.
17. Dudley – 1 Dam							
Carpenter Road Pond Dam	Dudley	Significant	UNSAFE		1900	Dam in disrepair, no evidence of maintenance, no O&M manual	No plan of idea of what to do in the event of an emergency.
18. Duxbury – 1 Dam							
Mill Pond Dam	Duxbury	Significant	POOR	2	1900	Dam in disrepair, no evidence of maintenance, no O&M manual	No plan of idea of what to do in the event of an emergency.
19. Easton – 1 Dam							
Long Pond Dam	Easton	Significant	POOR		1850	Dam in poor level of upkeep, very little maintenance, no O&M manual	Some idea of what to do in an emergency but no written plan.
20. Fall River – 2 Dams							
Terry Brook Reservoir Dam	Freetown	High	POOR	1	1900	Dam in poor level of upkeep, very little maintenance, no O&M manual	Available written plan that needs updating.
Lake Noquochoke Upper Dam	Dartmouth	Significant	POOR	1	1942	Dam in disrepair, no evidence of maintenance, no O&M manual	No plan of idea of what to do in the event of an emergency.

Promary Owner/ Dam Name	Location	Hazard	Overall Physical Condition	Size*	Year Completed	ODS Level of Maintenance	ODS EAP Status
21. Fitchburg – 6 Dams							
Overlook Reservoir Dam	Fitchburg	High	POOR	1	1872	Adequate levels of maintenance and standard procedures	No formal plan but well thought out.
Greenes Pond Dam	Fitchburg	High	POOR	1	1925	Some maintenance and standard procedures	Detailed, updated written plan available and filled with MADCR.
Mctaggarts Pond Dam	Fitchburg	High	POOR	1	1928	Dam in poor level of upkeep, very little maintenance, no O&M manual	No formal plan but well thought out.
Overlook Reservoir Dike	Fitchburg	High	POOR	1	1872	Adequate levels of maintenance and standard procedures	No formal plan but well thought out.
Ashby Reservoir Dam	Ashby	High	POOR		1900	Dam in poor level of upkeep, very little maintenance, no O&M manual	Some idea of what to do in an emergency but no written plan.
Mirror Lake Dam	Fitchburg	Significant	POOR	1	1922	Adequate levels of maintenance and standard procedures	No formal plan but well thought out.
22. Foxborough – 5 Dams							
Carpenter Pond Dam	Foxborough	Significant	POOR	2	1886	Dam in poor level of upkeep, very little maintenance, no O&M manual	Some idea of what to do in an emergency but no written plan.
Glue Factory Pond West Dam	Foxborough	Significant	POOR	3	1910	Some maintenance and standard procedures	Some idea of what to do in an emergency but no written plan.
West Street Dam	Foxborough	Significant	POOR	3	1977	Dam in poor level of upkeep, very little maintenance, no O&M manual	No formal plan but well thought out.
Carpenter Upper Pond Dike	Foxborough	Significant	UNSAFE	1	1900	Dam in poor level of upkeep, very little maintenance, no O&M manual	Some idea of what to do in an emergency but no written plan.
Carpenter Upper Pond Dam	Foxborough	Significant	UNSAFE	1	1819	Dam in poor level of upkeep, very little maintenance, no O&M manual	Some idea of what to do in an emergency but no written plan.
23. Gardner – 1 Dam							
Wayside Pond Dam	Gardner	Significant	POOR	2	1965	Adequate levels of maintenance and standard procedures	Some idea of what to do in an emergency but no written plan.

Promary Owner/ Dam Name	Location	Hazard	Overall Physical Condition	Size*	Year Completed	ODS Level of Maintenance	ODS EAP Status
24. Gloucester – 4 Dams							
Fernwood Lake North Dam	Gloucester	High	POOR	1	1877	Dam in poor level of upkeep, very little maintenance, no O&M manual	Some idea of what to do in an emergency but no written plan.
Fernwood Lake West Dam	Gloucester	High	POOR	1	1877	Dam in poor level of upkeep, very little maintenance, no O&M manual	Some idea of what to do in an emergency but no written plan.
Babson Reservoir Dam	Gloucester	High	POOR	2	1930	Adequate levels of maintenance and standard procedures	Some idea of what to do in an emergency but no written plan.
Fernwood Lake South Dike	Gloucester	Significant	POOR	1	1900	Dam in poor level of upkeep, very little maintenance, no O&M manual	Some idea of what to do in an emergency but no written plan.
25. Grafton – 1 Dam							
Lake Ripple Dam	Grafton	Significant	POOR	2	1982	Adequate levels of maintenance and standard procedures	No plan of idea of what to do in the event of an emergency.
26. Greenfield – 1 Dam							
Wiley & Russell Dam	Greenfield	Significant	POOR	2	1936	Dam in disrepair, no evidence of maintenance, no O&M manual	Some idea of what to do in an emergency but no written plan.
27. Groton – 1 Dam							
Squannacook River Dam	Groton	Significant	POOR	2	1936	Dam in poor level of upkeep, very little maintenance, no O&M manual	Some idea of what to do in an emergency but no written plan.
28. Hanover – 1 Dam							
Hackett Pond Dam	Hanover	Significant	POOR		1960	Dam in disrepair, no evidence of maintenance, no O&M manual	No plan of idea of what to do in the event of an emergency.
29. Haverhill – 2 Dams							
Frye Pond Dam	Haverhill	Significant	POOR	3		Dam in poor level of upkeep, very little maintenance, no O&M manual	No plan of idea of what to do in the event of an emergency.
Crystal Lake Dam	Haverhill	Significant	POOR		1930	Adequate levels of maintenance and standard procedures	Some idea of what to do in an emergency but no written plan.
30. Holden – 1 Dam							
Old Grist Mill Pond Dam	Holden	Significant	POOR	2	0	Dam in poor level of upkeep, very little maintenance, no O&M manual	No plan of idea of what to do in the event of an emergency.

Promary Owner/ Dam Name	Location	Hazard	Overall Physical Condition	Size*	Year Completed	ODS Level of Maintenance	ODS EAP Status
31. Holliston – 2 Dams							
Houghton Pond Dam	Holliston	High	POOR	2	1898	Some maintenance and standard procedures	Some idea of what to do in an emergency but no written plan.
Factory Pond Dam	Holliston	Significant	POOR	2	1873	Some maintenance and standard procedures	Some idea of what to do in an emergency but no written plan.
32. Holyoke – 1 Dam							
White Reservoir Dam	Southampton	Significant	POOR	1	1912	Dam in poor level of upkeep, very little maintenance, no O&M manual	Some idea of what to do in an emergency but no written plan.
33. Lancaster – 1 Dam							
Bartlett Pond Dam	Lancaster	Significant	POOR	3	0	Dam in poor level of upkeep, very little maintenance, no O&M manual	No plan of idea of what to do in the event of an emergency.
34. Leicester – 1 Dam							
Waite Pond Dam	Leicester	Significant	POOR	2	1920	Dam in disrepair, no evidence of maintenance, no O&M manual	No plan of idea of what to do in the event of an emergency.
35. Leominster – 2 Dams							
Rockwell Pond Dam	Leominster	High	POOR	2	1900	Dam in poor level of upkeep, very little maintenance, no O&M manual	Available written plan that needs updating.
Barrett Park Pond Dam	Leominster	Significant	POOR	1	1900	Dam in poor level of upkeep, very little maintenance, no O&M manual	No formal plan but well thought out.
36. Lincoln – 1 Dam							
Sandy Pond Dam	Lincoln	Significant	POOR		1900	Dam in poor level of upkeep, very little maintenance, no O&M manual	No plan of idea of what to do in the event of an emergency.
37. Lynn – 2 Dams							
Walden Pond Outlet Dam	Saugus	High	POOR	1	1905	Adequate levels of maintenance and standard procedures	No formal plan but well thought out.
Breeds Pond Outlet Dam #5	Lynn	High	POOR	1	1914	Adequate levels of maintenance and standard procedures	Detailed, updated written plan available and filled with MADCR.
38. Mansfield – 2 Dams							
Canoe River Campground Dam	Mansfield	Significant	POOR	2	1900	Dam in disrepair, no evidence of maintenance, no O&M manual	No plan of idea of what to do in the event of an emergency.
Kingman Pond Dam	Mansfield	Significant	POOR	2		Dam in poor level of upkeep, very little maintenance, no O&M manual	No plan of idea of what to do in the event of an emergency.

Promary Owner/ Dam Name	Location	Hazard	Overall Physical Condition	Size*	Year Completed	ODS Level of Maintenance	ODS EAP Status
39. Mashpee – 1 Dam							
Santuit Pond	Mashpee	Significant	POOR		0	Dam in disrepair, no evidence of maintenance, no O&M manual	No plan of idea of what to do in the event of an emergency.
40. Millbury – 1 Dam							
Brierly Pond Dam	Millbury	Significant	POOR	2	1880	Information not provided	Information not provided
41. New Bedford – 1 Dam							
Buttonwood Park Pond Dam	New Bedford	Significant	POOR	2	1960	Adequate levels of maintenance and standard procedures	Some idea of what to do in an emergency but no written plan.
42. North Adams – 3 Dams							
Notch Reservoir Dam	North Adams	High	POOR	1	1897	Adequate levels of maintenance and standard procedures	Available written plan that needs updating.
Mount Williams Reservoir Dam	North Adams	High	POOR	1	1914	Some maintenance and standard procedures	Available written plan that needs updating.
Windsor Lake Dam	North Adams	High	POOR	2	1883	Dam in poor level of upkeep, very little maintenance, no O&M manual	Available written plan that needs updating.
43. North Brookfield – 1 Dam							
Horse Pond Dam	North Brookfield	Significant	POOR	2	1950	Some maintenance and standard procedures	Some idea of what to do in an emergency but no written plan.
44. Northampton – 1 Dam							
Roberts Meadow Upper Reservoir Dam	Northampton	High	POOR	2	1883	Dam in poor level of upkeep, very little maintenance, no O&M manual	Detailed, updated written plan available and filled with MADCR.
45. Northborough – 1 Dam							
Northborough Reservoir Dam	Shrewsbury	Significant	POOR	1	1900	Some maintenance and standard procedures	Some idea of what to do in an emergency but no written plan.
46. Norton – 1 Dam							
Norton Reservoir Dam	Norton	High	POOR	2	1900	Adequate levels of maintenance and standard procedures	Available written plan that needs updating.
47. Oxford – 1 Dam							
Mckinstry's Pond Dam	Oxford	Significant	POOR		0	Dam in disrepair, no evidence of maintenance, no O&M manual	No plan of idea of what to do in the event of an emergency.
48. Peabody – 1 Dam							
Elginwood Pond Dam	Peabody	Significant	POOR	2	1960	Dam in poor level of upkeep, very little maintenance, no O&M manual	No plan of idea of what to do in the event of an emergency.

Promary Owner/ Dam Name	Location	Hazard	Overall Physical Condition	Size*	Year Completed	ODS Level of Maintenance	ODS EAP Status
49. Pembroke – 1 Dam							
Lower Chandler Pond Dam	Pembroke	Significant	POOR	2	1920	Some maintenance and standard procedures	No formal plan but well thought out.
50. Pittsfield – 2 Dams							
Ashley Lake Dam	Washington	High	POOR	1	1901	Some maintenance and standard procedures	Available written plan that needs updating.
Farnham Reservoir Dam	Washington	High	POOR	1	1910	Some maintenance and standard procedures	Available written plan that needs updating.
51. Sandwich – 1 Dam							
Upper Shawme Lake Dam	Sandwich	Significant	POOR	2	1900	Dam in disrepair, no evidence of maintenance, no O&M manual	Some idea of what to do in an emergency but no written plan.
52. Sharon – 2 Dams							
Manns Pond Dam	Sharon	Significant	POOR	2	1860	Some maintenance and standard procedures	Available written plan that needs updating.
Hammershop Pond Dam	Sharon	Significant	POOR		0	Dam in poor level of upkeep, very little maintenance, no O&M manual	Some idea of what to do in an emergency but no written plan.
53. Shrewsbury – 1 Dam							
Newton Pond Dam	Shrewsbury	Significant	POOR	1	1949	Some maintenance and standard procedures	Some idea of what to do in an emergency but no written plan.
54. Southbridge – 1 Dam							
Southbridge Reservoir #5 Dam	Southbridge	Significant	POOR	1	1938	Dam well maintained, detailed maintenance plan that is executed	Available written plan that needs updating.
55. Springfield – 4 Dams							
Van Horn Park Lower Dam	Springfield	High	POOR	1	1957	Dam in poor level of upkeep, very little maintenance, no O&M manual	Detailed, updated written plan available and filled with MADCR.
Forest Park Upper Pond Dam	Springfield	Significant	POOR	2	1919	Dam in poor level of upkeep, very little maintenance, no O&M manual	Some idea of what to do in an emergency but no written plan.
Van Horn Park Upper Dam	Springfield	Significant	POOR	2	1957	Dam in poor level of upkeep, very little maintenance, no O&M manual	Some idea of what to do in an emergency but no written plan.
Knights Pond Dam and Dike	Belchertown	Significant	POOR	2	1900	Dam well maintained, detailed maintenance plan that is executed	No plan of idea of what to do in the event of an emergency.
56. Sudbury – 1 Dam							
Stearns Millpond Dam	Sudbury	Significant	POOR	2	1900	Dam in poor level of upkeep, very little maintenance, no O&M manual	No plan of idea of what to do in the event of an emergency.

Promary Owner/ Dam Name	Location	Hazard	Overall Physical Condition	Size*	Year Completed	ODS Level of Maintenance	ODS EAP Status
57. Tri-Town Water Board – 2 Dams							
Great Pond Upper Reservoir Dam	Braintree	High	POOR	1	1940	Some maintenance and standard procedures	Available written plan that needs updating.
Great Pond Dam	Braintree	High	POOR	1	1945	Dam in poor level of upkeep,very little maintenance no O&M manual	Available written plan that needs updating.
58. Wareham – 1 Dam							
Parker Mills Pond Dam	Wareham	High	POOR	1	1900	Some maintenance and standard procedures	Detailed, updated written plan available and filled with MADCR.
59. Weymouth – 1 Dam							
Iron Hill Dam	Weymouth	High	POOR	2	0	Dam in poor level of upkeep, very little maintenance, no O&M manual	No formal plan but well thought out.
60. Winchendon – 1 Dam							
Whitney Pond Dam	Winchendon	High	POOR		1880	Dam in disrepair, no evidence of maintenance, no O&M manual	Detailed, updated written plan available and filled with MADCR.
61. Winchester – 2 Dams							
South Reservoir East Dike	Medford	High	POOR	1	1890	Some maintenance and standard procedures	Detailed, updated written plan available and filled with MADCR.
South Reservoir West Dike	Medford	High	POOR	2	1882	Dam in poor level of upkeep, very little maintenance, no O&M manual	No plan of idea of what to do in the event of an emergency.
62. Worcester – 4 Dams							
Patch Pond Dam	Worcester	High	POOR	3	1900	Dam in disrepair, no evidence of maintenance, no O&M manual	No plan of idea of what to do in the event of an emergency.
Quinsigamond Pond Dam	Worcester		POOR		1891	Dam in disrepair, no evidence of maintenance, no O&M manual	Some idea of what to do in an emergency but no written plan.
Green Hill Pond Dam	Worcester	High	POOR		1881	Some maintenance and standard procedures	Some idea of what to do in an emergency but no written plan.
Bell Pond Dam	Worcester	Significant	POOR	2	1840	Dam in poor level of upkeep, very little maintenance, no O&M manual	No plan of idea of what to do in the event of an emergency.

Source: Office of Dam Safety, New Application Inventory of Dams (August 10. 2010)

***Size**

1. Large: ≥1,000 acre feet & ≥40 height (feet)
2. Intermediate: ≥50 and <1,000 acre feet & ≥15 and <40 height (feet)
3. Small: ≥15 and <50 acre feet & ≥6 and <15 height (feet)

End Notes

[1] In addition to the 100 municipally owned dams, 40 state-owned and 148 privately owned dams fall in the category of "high" or "significant" hazard and are in "poor" or "unsafe" condition.

[2] *Decades of Neglect/Recommendations to Improve Dam Safety and Maintenance in Massachusetts*, A Report of the Senate Committee on Post Audit and Oversight, Senate Bill No. 2549 May 2006. Note that the loan program recommended in this report was targeted to privately owned dams.

[3] Chapter 330 of the Acts of 2002.

[4] See reply to Town of Ashburnham at www.mass.gov/sao/mandatepage.htm.

[5] *2009 Report Card for America's Infrastructure*, American Society of Civil Engineers, March 2009.

[6] Report of the World Commission on Dams, November 2000, Introduction.

[7] National Inventory of Dams, Army Corps of Engineers.

[8] MA Department of Conservation and Recreation, Office of Dam Safety Database, August 10, 2010.

[9] *Aging Infrastructure: Dam Safety*, p. 5, Congressional Research Service Report for Congress, Sept. 2005.

[10] Ibid.

[11] April 2004 *Federal Guidelines for Dam Safety*, U.S. Dept of Homeland Security, Federal Emergency Management Agency and NPDP database.

[12] Telephone interview, Taunton Emergency Management Director, Feb. 2009.

[13] G. L. c. 253, § 44. Per 302 CMR 10.03(2), an acre-foot of water would cover "one acre to a depth of one foot…One million U.S. gallons = 3.068 acre-foot."

[14] The regulatory status is listed as "unknown" for 4 of the 1,268.

[15] Of these, 16 are owned by the federal government, and 61 are owned by private parties, regulated by the Federal Energy Regulatory Commission.

[16] 302 CMR 10.03(2).

[17] October 8, 2008 Phase I Inspection Report, Lower Van Horn Reservoir Dam, Springfield, MA; most inspection reports we reviewed contain similar clarifications.

[18] *Aging Infrastructure: Dam Safety*, p. 5, Congressional Research Service Report for Congress, Sept. 2005.

[19] Emergency Action Planning for State-Regulated High Hazard Potential Dams, FEMA 608, August 2007.

[20] Estimates derived from Phase I Inspection Reports for 84 of the 100 critical local dams provided by ODS. In the reports that recommend development of an EAP, cost estimates run as high as $40,000, but in most cases, range from $7,500 to $15,000.

[21] Chapter 330 of the Acts of 2002.

[22] Although the scope of this work excludes low hazard dams, the regulations call for inspections for these structures on a 10-year cycle.

[23] The relevant field was blank in the database for 2 of this group.

[24] Although a few of the local dam managers we interviewed reported Phase I inspection costs from $7,500 to as much as $10,000 per dam, the costs generally ranged from $2,500 to $6,000.

[25] Note that these amounts do not include additional studies and analyses that DCR may deem necessary as a result of findings from the routine inspections. These will vary depending upon specific site conditions, and may include such tests as hydrologic/hydraulic assessments, structural stability analyses, and subsurface investigations. As may be expected considering the poor or unsafe condition of the critical 100 dams, 90% of the Phase I reports on file for the group called for further investigations.

[26] 302 CMR 10.09.

[27] The estimate ranges as high as $16,000 in one instance, and as low as $1,000 in another. However, most often these estimates fall in the $3,000 to $6,000 range.

[28] Estimates range as high as $18,000 in a few cases, while some suggest that these activities could be absorbed at no extra cost in the ordinary course of the duties of a public works department.

[29] http://140.194.76.129/publications/eng-manuals/em1110-2-1304/entire.pdf.

[30] Although the baseline sources for 2 dams date back to 1998 and 1999, most of the older sources were developed in 2006. Several are from records filed at ODS in 2010.

[31] The median is $466,039.

[32] *The Cost of Rehabilitating Our Nation's Dams/A Methodology, Estimate & Proposed Funding Mechanisms*, December 2002 (Revised October 2003).

[33] More specifically, the methodology of the Association of State Dam Safety Officials uses average costs of remedial action for dams with known costs, and calculates separate averages for categories based upon the height of the dam. The assumption is that substandard dams that fall within certain ranges of height could be expected to require similar levels of investment. Applying this theory, DLM calculated average costs based upon ODS size categories.

Size 1**:** the largest dams, impounding at least 1,000 acre feet of water or spanning at least 40 feet in height: approximate average cost $685,000; average cost/foot $30,000.

Size 2: the dams that store less than 1,000 but more than 50 acre feet of water, or span from 15 up to 40 feet in height: approximate average cost $520,000; average cost per foot $35,000.

Size 3**:** the relatively smaller dams, impounding between 15 and 50 acre feet of water, or ranging from 6 up to 15 feet in height: approximate average cost $450,000; average cost/ foot $41,000.

[34] The projected average cost for the small group of four (approximately $1.2 million) is skewed by the high estimate for one very large dam, that exceeds 100 feet in height with a maximum impoundment of 1,900 acre-feet: just over $3 million. The median projected amount for the group is approximately $625,000.

[35] To test this result, we ran the raw data for each of the critical 100 through the Association of State Dam Safety Officials methodology, and obtained a similar projected cost of remediation: $59 million for the group.

[36] *Decades of Neglect/Recommendations to Improve Dam Safety and Maintenance in Massachusetts*, A Report of the Senate Committee on Post Audit and Oversight, Senate Bill No. 2549 May 2006. Note that the loan program recommended in this report was targeted to privately owned dams.

[37] *2008 Statistics on State Dam Safety Regulation*, August 2009, www.damsafety.org.

[38] Also within the Executive Office of Energy and Environmental Affairs, the Departments of Environmental Protection and Fish and Game may have jurisdiction over dams in support of water quality and water management objectives. The Executive Office of Public Safety, Massachusetts Emergency Management Agency may become involved in disaster management at any dam location. Local Conservation Commissions may play a role in dam management through their permitting authority.

[39] G. L. c. 253, § 44 defines "dams" as barriers that are at least 25 feet high or capable of impounding at least 50 acre-feet of water. According to 302 CMR 10.03(2), an acre-foot of water would cover "one acre to a depth of one foot…One million U.S. gallons = 3.068 acre-foot." The Commissioner may take jurisdiction of certain smaller dams that may endanger public safety.

[40] http://www.mass.gov/dcr/pe/damSafety/

[41] G. L. c. 253 § 48B.

[42] The fee for dam registration is $75; for transfer of ownership $50; to apply for a construction, alteration or removal permit, $50; fees for review and issuance of construction, alteration, or removal permit range from $250 to $1,000, depending upon the estimated cost of the project. 302 CMR 10.15 (1) – (3).

[43] Fines for noncompliance with any of the major requirements of dam safety law and regulations are $500 for each day in violation. 302 CMR 10.15 (4).