

Citizens To Protect Berlin Pond
452 Brookfield Road
Berlin VT, 05602

January 31, 2014

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Department of Natural Conservation
1 National Life Drive, Main 2
Montpelier, VT 05602-3522

Re: Petition for Adoption of Rule Change to Prohibit Recreational Use of the Surface Water of Berlin Pond and Return Berlin Pond to Normal use as Prior to January 1, 1993.

Dear Attorney Welts:

Pursuant to 10 V.S.A. § 1424, 3 V.S.A. § 833, the Vermont Use of Public Water rule I and the *Vermont Natural Resources Board Rules of Procedure*, as applicable through the Vermont Agency of Natural Resources Department of Environmental Conservation *Interim Procedures for Evaluating Petitions to Adopt, Amend, or Repeal Surface Water and Wetlands Rules*, we hereby file this Petition to Amend Use of Public Lake-Specific Rules pertaining to Berlin Pond in the Town of Berlin to prohibit recreational use of the surface water of Berlin Pond, including use of all watercraft, with or without internal combustion motors, fishing from shore, or from the surface of ice, swimming, paddle boarding, wading or building any access on shore that could at a later time encourage such use.

Section 15 of the Vermont Natural Resources Board Rules of Procedure (2006), as adopted by the *Interim Procedure for Evaluating Petitions to Adopt, Amend or Repeal Surface Water and Wetland Rule*, signed on January 30, 2013 by David K Mears, Commissioner of the Department of Environmental Conservation, requires that petitions for rulemaking contain certain enumerated information. The following numbers and headings track Section 15 of the referenced NRB Rules of Procedure.

Detailed statement of the statutory authority under which the petition is filed

Pursuant to 10 V.S.A. § 1424, as adopted in Act No. 138 of the 2012 Legislature session and effective 14 May 2012, the Secretary of Agency of Natural Resources has the

authority to establish rules to regulate the use of public waters in the state. In making such rules, the secretary shall consider, among other factors, “the predominant use of the waters prior to regulation.” The Legislature recognized that such rule making is not necessarily a “cookie cutter” exercise, noting that subsection (c) of § 1424 provides: “The secretary shall attempt to manage the public waters so that the various uses may be enjoyed in a reasonable manner, in the best interests of all the citizens of the state. To the extent possible, the secretary shall provide for all *normal uses*. (Italics added).

It should be noted that *normal use* (“... Rules, sect. 5.2”) prior to 1993, was a pond whose surface water was protected from all human access. During this time, and up to 2012, the perimeter road was a source of peaceful, relaxing enjoyment of what has become a very rare thing in our culture: a wetland area undisturbed by human encroachment for a long period of time, where plants and wildlife were allowed to flourish and thousands of people each year could see nature that was unavailable anywhere else accessible. Also during this time, there was no shortage of nearby bodies of water easily accessible for the forms of recreation not permitted on Berlin Pond.

Chapter 11 under Title 29, § 401 provides that “lakes and ponds which are public waters and lands lying thereunder are a public trust, and it is the policy of the states that these waters and lands shall be managed to serve the public good....” Public good is defined as “that which shall be for the greatest benefit of the people of Vermont.” There are far more citizens per year who have enjoyed the peace of undisturbed nature than those per year who enjoy the newly permitted recreational access. It is the purpose of this petition to show that the greater public good lies in returning Berlin Pond to the protection it enjoyed prior to May 2012.

**Petition for Rule Change on the Surface Water
for Berlin Pond, Berlin, Vermont**

Submitted by Citizens to Protect Berlin Pond

January 31, 2014

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Petition for Rule Change on the Surface Water for Berlin Pond, Berlin, Vermont

I. Petition Request for Rule Change

Vermont Natural Resources Board Water Resources Panel / Vermont Use of Public Waters Rules that this petition seeks to change.

This petition seeks to return Berlin Pond to “normal use” (5.2 *Normal Use: Any lawful use of any specific body of public water that has occurred on a regular, frequent and consistent basis prior to January 1, 1993.*) By including in Appendix A the following:

Berlin Pond, Berlin VT

The following are prohibited on Berlin Pond:

- a. The use of all vessels and machines, regardless of how they are propelled.
- b. Swimming, wading, paddle boarding, or any activity that places humans or domestic animals in contact with the surface water or on the ice.
- c. Fishing, including fishing from boats, ice, or from shore.
- d. Hunting and shooting.
- e. The construction of any access to the pond from the shore.

Rules that encourage the above inclusion.

2.2. Rule 2.2 states that consideration will be given to, among other things, *the predominant use of the adjacent lands, as well as the predominant use of the waters prior to regulation.* In addition, *the availability of fishing, boating and bathing facilities,* (poor at Berlin Pond, easily available nearby), and *the scenic beauty and recreational uses of the area.*

2.3 Rule 2.3 states that in the evaluation of uses will *include fish and wildlife habitat, wildlife observation* (the petition will discuss Berlin Pond's myriad bird species and the numbers of birders attracted to the Pond), *the enjoyment of aesthetic values, quiet solitude of the water body....*

Definitions

Surface Water: the water in Berlin Pond in any natural form, including liquid and frozen.

Protection Prior to May 2012: any use of Berlin Pond surface water, including boating, swimming, fishing, skating, walking etc. was prohibited.

Perimeter Road: the road that surrounds the main body of water that constitutes Berlin Pond; Brookfield Road on the west, Mirror Lake Road on the south, Paine Turnpike South on the north and east. It is about 5 miles in length.

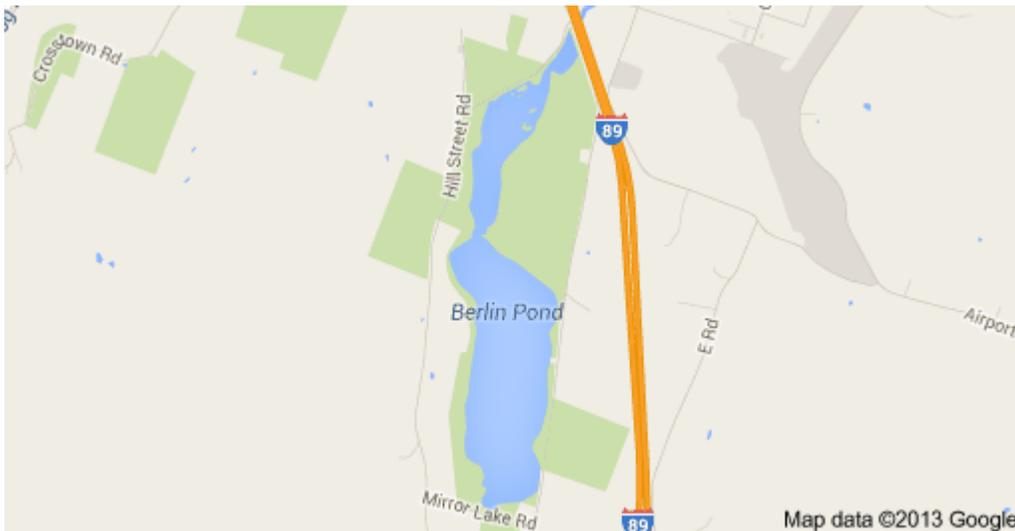
Active Recreation. Recreation that uses the shoreline and/or surface water of Berlin Pond.

Passive Recreation. Recreation that involves running, walking or cycling on the perimeter road but does not involve any activity on the shoreline or on the surface water.

II. The Pond

Geographical Description of Berlin Pond (See included maps).

The perimeter road defines a Berlin Pond residential area. This is an unpaved class 3 road which serves as an access road to the residents on it and those residents on Paine Turnpike South residing south of the pond. Approximately 4.5 miles south, it connects with Highway 64.



Historical Records of Pond Use

The purpose of the pond has been to provide drinking water to the City of Montpelier, part of the town of Berlin including the Central Vermont Medical Center, and it has been known and used for its aesthetics by walkers, runners and cyclists. In 1870 it was determined that the Winooski River, because of pollution, was no longer acceptable for

providing drinking water and the Montpelier Charter was amended by the Legislature to purchase the right to take water from Berlin Pond. On October 7, 1884, Montpelier drew the first pond water for residential and commercial use.

Conscious from the beginning of the need to insure clean drinking water, in 1894 the City of Montpelier requested the State Board of Health to examine the conditions of Berlin Pond water and concluded that the pond was “constantly in danger of pollution and could at any time bring disaster to the city. It was at that time the city was asked to protect the pond or build a filtration plant to purify the water.”

Authorities diligently protected the pond water and between 1909 and 1910 several people were arrested for either fishing or swimming. All those who challenged their arrest lost their case in court.

During this era there were a number of camps around the pond for people to enjoy the beauty of the pond and its surroundings in the summer months but this enjoyment could not include any recreation on the water.

Scientific Data for Berlin Pond

Berlin Pond, a 360 acre body of water, consists of two parts, commonly known as the upper and lower pond. Its deepest part is 57 feet, average depth 25 feet and shoreline 5 miles in circumference. Much of the immediate bottom consists of loose silt/mud which is easily disturbed (as noted by officials working on the drinking water intake) creating noticeable turbidity.

Berlin Pond as a current drinking water source

Currently Berlin Pond serves as a drinking water source for all the residents and businesses of the city of Montpelier, the Central Vermont Medical Center, and many residents of the town of Berlin. The water flows from the south end of the pond to an intake near the north end 17 feet below the surface and 10 feet above the bottom. The water entering the intake is piped to the Montpelier water filtration plant which opened in 2000. The plant serves as both a filtration mechanism and a chlorine treatment system.

Among the dangers that the plant cannot adequately process are petroleum, including gasoline and oil products introduced by boats, snowmobiles, ATVs, automobiles, ice augers etc., invasive animal species, including zebra mussels, commonly introduced by watercraft, and invasive plant species such as algae, also introduced by watercraft.

Recreational use of Berlin Pond prior to May 2012

The perimeter road circling Berlin Pond has long been a unique source of easy-access recreation for residents from Berlin, Montpelier and Barre, as well as other towns. Its

low-traffic roads have provided a place for people of all ages to safely walk, run, bicycle, push strollers, while enjoying the beauty and nature of the pond that had been undisturbed since June 24, 1903 (APTPT p.49) Unofficial but believable surveys over the past 7 years taken by several pond residents including Paul & Melissa Perley found that: on random trips (no specific day, or time of day, or time of year) on the length of Brookfield Road no fewer than 6 people would be observed recreating as described above. This is on any day, no matter the weather. On the return trip, the same observation was made. On many days there were scores more, and these observations were limited to less than half the length of the perimeter road. Based on this it is not unreasonable to assume that an average of at least 6 people per day, or over 2000 people per year use the perimeter road for this type of *Passive Recreation*.

III. Effects of Active Recreation Use of Berlin Pond as Allowed Beginning May 2012

Increased Danger to the Drinking Water Supply for the residents of the City of Montpelier and a number of residents in the Town of Berlin

These dangers are enumerated and explained in this petition.

Town of Berlin Residents

The noticeable increase in vehicle traffic from boaters, anglers, and hunters will increase the cost of road maintenance, police protection, emergency preparedness, and trash cleanup.

People seeking Passive Recreation

Increased traffic, the road being narrowed in places due to parking, and groups of anglers, boaters and hunters periodically on the road threatens the safety of all runners, walkers and cyclists, but especially small children, and people alone.

Migrating waterfowl such as Canada Geese and Snow Geese

Have already decreased in numbers as has been noted by residents and people engaged in *Passive Recreation*.

Shy bird species

Active Recreation will likely eliminate the more shy of the bird species on the pond (see Bird species list for those most likely to be affected) and decrease *Passive Recreation* people who are birders.

Berlin Pond Birds who breed here

Many of these will not be affected but some will, including but not limited to Common Loons. Signed areas can help protect Loon nesting areas, but Berlin Pond is small and

several violators of these signs were seen in both 2012 & 2013.

People seeking Active Recreation

Anglers, boaters and hunters have initially had access to a “sportsman's paradise”: a place full of undisturbed and unafraid nature. Record bass and countless perch were long taken before limits or bans were put in place. Ice anglers now report few or no perch for their efforts. It took very little time to make a large and negative impact on the small and fragile ecosystem of Berlin Pond.

IV. Reasons for this Rule Change

- A. Berlin Pond is the drinking water supply for The City of Montpelier. (p. 9)
- B. *Active Recreation* access poses Homeland Security issues for Central Vermont. (p. 16)
- C. A Protected Berlin Pond is a unique and valuable source for *Passive Recreation*. (p. 15)
- D. There are many nearby opportunities for *Active Recreation*. (p. 17)
- E. There are Significant Wetlands on the shore area of Berlin Pond. (p. 17)
- F. The unique ecosystem of Berlin Pond is sensitive and fragile. (p. 20)
- G. The Berlin Watershed Conservation of 2001 supports pond preservation. (p. 20)
- H. Changes in Berlin Pond Since May, 2012. (p. 21)
- I. Berlin Conservation Commission Environmental Evaluation (July 2012) for Berlin Pond Ecosystem supports pond preservation. (p. 22)

A. The Drinking Water Supply for City of Montpelier

Berlin Pond is the drinking water source for all of the residents of the City of Montpelier, Central Vermont Medical Center, and many citizens of Berlin. *Active Recreation* access poses a host of new issues for protecting the water supply. What follows is a study of some other water sources with the results and decisions surrounding *Active Recreation* access.



An angler leaves Berlin Pond with his gas-powered auger



Ice shanties on Berlin Pond

1. Orange Reservoir, Drinking Water Supply for Barre, Vermont

In 1994, several prominent Barre citizens, including the mayor and two councilmen, convinced Barre officials to remove the protection of the Orange Reservoir to the extent that there would be access to fishing from shore. Until that time, Orange Reservoir was protected to a similar degree that Berlin Pond had been protected until May 2012. The 1200 acres owned by the city of Barre actually include three bodies of water that collectively provide Barre City water: (in order of flow) the Dix Reservoir, Small Orange, and Orange Reservoirs.

Three areas were designated for fishing. Steven Micheli was filtration plant manager and was one of the overseers of the Barre water supply during that time, and is in a similar position today. According to Micheli, the officials who pushed through this access, promised that these three areas would be closely monitored. In fact, Micheli reports, almost immediately there was “flagrant trespassing” onto areas not designated for fishing and much trash quickly accumulated and illegal campfires were common. Volunteer trash collectors, a group put in place for that purpose, did relatively nothing after a few weeks. The Barre City police did not have the resources to do much if any patrolling of the reservoir.

After two, what Micheli described as “frustrating seasons”, the sizable bass present before 1994 were largely fished out.

Those responsible for Barre City water were, however, successful in preventing any kind of boat use or swimming. Micheli cites the invasive species, petroleum, and human bacteria as significant dangers to the water supply. Like Berlin Pond, the average depth of the water supply is shallow, averaging, in the 3 bodies of water, 13 feet. And the

treatment plant for Barre is very similar to the plant built for Montpelier, Micheli having overseen much of Montpelier's design.

As a long time water supply official, Micheli states that for the protection of Montpelier's water supply, the surface water should be left alone: no watercraft, motors or people, and cites the trespassing violations and trash, that remain a problem at the Orange Reservoir, as something to look at when shore fishing is permitted.

2. Wachusett Reservoir Watershed - Drinking Water Supply for the Massachusetts Water Resources Authority (MWRA)

In its Wachusett Reservoir Watershed 2011 Public Access Plan Update (attached pp.XX), The Division of Conservation and Recreation, Division of Water Supply Protection (DCR/DWSP) states: **“Public access to and recreational use of water supply lands are complex and sometimes controversial issues. There is an inherent conflict between water supply protection and public demand for access to these lands. Any human activity on or near water supply source waters can introduce disease causing-agents to the water supply.”** (Bold type ours.)

Items of historical interest here include a) the fact that the Wachusett Reservoir dates back to 1919, not terribly long after Berlin pond became the water source for Montpelier, and b) the governing body of the water source, MWRA, as well as all the land purchases, are funded entirely by drinking water rate payers.

According to this 2011 document, the DCR has “traditionally allowed passive recreation – recreation uses are considered passive where very minimum alteration of vegetation, topography, or other native feature is necessary for the enjoyment of the site amenities -”.... In 1996, the DCR plan “surveyed problems resulting from existing public access to watershed lands. The problems identified included dumping, poor sanitation, (evidence of people and domestic animals defecating near the reservoir and improper disposal of baby diapers), swimming, damage from motorized vehicles, and shoreline erosion.....While the Division realized that most of the visiting public complied with the existing rules and regulations, it was determined that new policies were needed to provide greater control over the minority of users who disregarded or abused the privilege of access to these water supply lands.”

For every US citizen, the events of 9/11 brought security issues to the consciousness of every citizen and encouraged the DCR to update their access plan. “The events of September 11, 2001 have heightened concerns regarding security and the need to protect public water supplies from possible terrorist action, as well as to reassure the public that security plans are in place. These ongoing issues must be considered as any policy and

public access are concerned.” The 2011 Plan goals included “To protect drinking water resources from public access impacts....To properly manage a public resource used as a supply of drinking water....To improve and protect long-term ecosystem health and biological diversity within the watershed....To assure that public access is safe and appropriate to DCR/DWSP's water quality goals.”

The DCR/DWSP identified *protection zones* which included the “Intake Protection Zone” (included are 4 miles of shoreline near the intake structure, and 680 acres of land not draining into the Wachusett Reservoir)....the “Reservoir Protection Zone” (the watershed lands around the Reservoir and main tributaries).. and the “Tributaries Headwaters Zone”. This Intake Protection Zone is considerably larger than all of the Berlin Pond Watershed Area.

The DCR/DWSP understood that “it must carefully weigh the potential for impacts to its drinking water supply before considering any uses on its properties...Recreational uses of water supply lands and any infrastructure needed to support the activity can add sources of microbial, physical and chemical contaminants to the drinking water supply... (and) “it must err on the side of caution in identifying any recreational use that might compromise water supply protection.”

Below is a list of regulated activities in the DCR/DSWP Wachusett Reservoir watershed area that apply to comparable situations in Berlin Pond. Quotation marks indicate text taken directly from the 2011 update:

A. Water Contact. “Bodily contact with the reservoir water is prohibited by regulation.....Most human activities on and near a water supply represent an added element of risk to the consumer”. The section further states that **“A single person sheds an average of 200 billion fecal bacteria in a single day. Birds and wild animals also introduce potential pathogens to the water, but pathogens from humans are more likely to ultimately be infectious to other humans than are pathogens originating from birds and animals....The link between direct water contact activities, such as swimming and wading, and the spread of water borne disease is well documented.”** (Bold type ours.)

(It is interesting to note here that the Mt. Tabor (Oregon) Reservoir was recently closed temporarily due to a man caught urinating in it.)

B. Boating. “All boating activities, both motorized and non-motorized are prohibited by current regulation in the Wachusett Reservoir watershed, except in areas specifically designated by the division.” (It should be noted here that the total Wachusett Reservoir is 117 square miles, 208 times larger than Berlin Ponds 360 acres.) “Aquatic invasive species infestations....pose another significant threat to water quality, as private boating

is one of the primary means of transport invasive species from one body of water to another. Aquatic invasive species pose a threat to native species and have the potential to alter the balance of the natural aquatic community and can have a negative impact on water quality. Once established, invasive species can be extremely difficult or impossible to remove, as a classic invasive species is aggressive, can multiply rapidly, spread quickly, and out-compete native species. These reasons make boating in the Reservoir itself an unacceptable risk.”

The DCR/DWSP does allow car-top boats (14 ft and less in length) in certain restricted areas; i.e. two ponds **outside** (bold type ours) the body of water in which the intake is installed.

C. Fishing. The DCR/DWSP feels that “Shoreline fishing, *without water contact*, (italics ours) in certain areas does not pose a significant threat to the water supply or other natural resources....Discarded fishing line and the use of lead fishing tackle, however, threatens area wildlife.” While waders are allowed in certain areas, it is noted that “Aquatic Invasive Species....pose a threat when using waders and fishing gear that has been submerged in an infested lake, pond, or stream area.

In addition: “all acts which pollute or may pollute the water supply are prohibited,....cooking and all fires are prohibited,....organized sports or activities are prohibited,....possession or drinking of alcoholic beverages is prohibited,....no person shall drive a motorized vehicle within the Watershed System except upon roads authorized for such use by the department....”

“Ice Fishing is prohibited on all DCR/DWSP owned lakes and ponds.” (Bold italics ours)

D. Off-Road Driving. “Off-Road driving using off-road vehicles (ORVs) or All-Terrain Vehicles (ATVs) has been prohibited by regulation on all DCR/DWSP lands in all of its watersheds since 1989. ORVs and ATVs have been well documented to disrupt wildlife, alter natural hydrologic patterns, and increase sediment loading into streams and wetlands, impacting water quality and aquatic plant and animal life. ATVs and ORVs on slopes, stream banks, and stream channels cause erosion, turbidity, and sedimentation, all of which are detrimental to surface waters and natural resources.”

E. Snowmobiling. “Snowmobiling has been prohibited by regulation in the Wachusett Reservoir watershed since 1996. Snowmobile use was allowed on a trial basis prior to 1996 in a small section of the Wachusett Reservoir watershed. The agency discovered considerable damage to the land and users were straying from the marked paths, thus it became a prohibited activity. In addition to damage caused to natural resources, areas where snowmobiles are allowed become compacted and any winter rain may flood

surrounding areas affecting hydrologic patterns. Hard snow is thermally convective and the underlying ground can freeze to a greater depth. Because of this, vegetation can be affected and lead to erosion of the soil in spring. This can lead to increased turbidity and sedimentation in streams and wetlands.”

F. Horseback riding. “Horseback riding is prohibited by regulation on DCR/DWSP Wachusett Reservoir watershed lands due to the threat of fecal coliform contamination and the potential of other pathogens such as *Cryptosporidium* associated with domestic animal manures as well as increased potential for erosion on access roads.”

G. Dogs and Other Pets. “Bringing any animal, other than service assistance dogs, onto the DCR Wachusett Reservoir watershed lands is prohibited by regulation. Dog and other domestic animal waste contains an enormous amount of fecal coliform bacteria (23 million fecal coliform bacterial/ gram of waste). They can also be carriers of pathogens, such as *Giardia* and *Cryptosporidium*, that can be passed on to both humans and wildlife populations.”

H. Camping. “Camping is prohibited on DCR Wachusett Reservoir watershed lands due to many factors. It is an activity that people away from regular habits for clean-up, washing, and waste disposal. Camping tends to generate more trash and litter than hiking or walking, but a lack of sanitation is a larger concern with this recreation activity. There are serious water quality concerns associated with the deposition of human fecal matter close to tributaries and reservoirs.”

J. Hiking, Nature study, Bird Watching, and Photography. “Hiking, walking (without dogs), nature study, bird watching, and photography are all considered *passive recreation* (italics ours) activities and are allowed throughout the Wachusett Reservoir watershed.....Walking on the surface of the Reservoir when frozen is strictly forbidden.”

K. Cross-Country Skiing and Snowshoeing. “Skiing is prohibited over the reservoir's frozen surface....Snowshoeing is prohibited over the reservoir's frozen surface.”

P. Paintball. “Paintball is prohibited on DCR Wachusett Reservoir lands.”

AQUATIC INVASIVE SPECIES (Wachusett) “Aquatic Invasive Species (AIS), such as the zebra mussel and hydrilla, can pose a serious threat to water supplies....AIS, once introduced, have the ability to establish a viable colony and spread rapidly within native aquatic communities, threatening the health of the waterways as they are usually impossible to eradicate....AIS are primarily spread among water bodies by human activities, especially boating and fishing.....the division controls the potential of AIS entering the Reservoir from equipment such as boats and trailers by limiting use to only

official business and requiring those vessels to be thoroughly free of AIS...”

It should again be noted here that the Wachusett Reservoir watershed area is many times the size of the Montpelier watershed area, and yet the DCR/DWSP has found it necessary to severely limit access, and prohibit it entirely near the intake facility which is itself an area much larger than Berlin Pond.

3. Other Reservoirs

Note: at this writing, no doubt due to the success of those wanting *Active Recreation* access on Berlin Pond, another water source – Stiles Pond in St Johnsbury - has been opened to *Active Recreational* access. Hugh Wescott, the town public works manager, reports large amounts of trash, serious safety issues of people accessing from an active highway, campfires, etc. It is hoped that the Agency of Natural Resources can prevent this “domino effect” degradation of our drinking water sources and natural areas

4. Other Dangers to Water Quality in Berlin Pond

Turbidity

According to Montpelier Public Works Director Todd Law, the combination of the shallowness of Berlin Pond and the soft, silty bottom makes the issue of turbidity a concern. Law notes that there are naturally caused high turbidity levels at certain times of year: spring runoff and summer rainstorms are examples. Law also speaks of high turbidity visible from the air when the boat used to transport divers and equipment for the purposes of cleaning the intake is used and notes that increased turbidity levels in Berlin Pond are unavoidable with recreational access to the surface water.

The *Oregon Department of Environmental Quality* (DEQ) considers turbidity as “a relative measurement of reduced visual clarity (scattering and absorption of light by particles of water)....Increased turbidity levels are caused by suspended particles, dissolved organic matter, and plankton organisms in the water column.” Tests done during high turbidity conditions by the DEQ note decreased ability of visually oriented fish to “detect and capture prey”. While they are still able to successfully feed, they do so at a lower rate and a higher expenditure of energy.

The DEQ, in their 2010 Turbidity Technical Review states that “As turbidity in drinking water source areas increases, the cost to meet the *Safe Drinking Water Act (Oregon)*-mandated turbidity levels similarly increases due to increased material and maintenance costs.”

Relationship of Turbidity and Coliform Bacteria Present in Drinking Water

The Montpelier Water Filtration Plant uses chlorination as the only treatment for coliform bacteria. In an article entitled Effect of Turbidity on Chlorination Efficiency and Bacterial Persistence in Drinking Water published in the journal Applied and Environmental Microbiology, July, 1981, Mark LeChevallier, T.M. Evans, and Ramon Seidler show that in a facility with chlorination as the only treatment (similar to the situation in Montpelier) “disinfection efficiency was negatively correlated with turbidity.....the incidence of coliform masking in the membrane filter technique and was found to increase as the turbidity of the chlorinated samples increased”. Coliform could pass through the water treatment process undetected during higher turbidity levels. At least in part because it was found that coliform and other bacteria could imbed themselves in the turbidity particles enabling them to escape both detection and the effects of chlorination.

Because of its shallow depth and soft bottom, boating, fishing and swimming in Berlin Pond will necessarily increase turbidity levels in Berlin Pond, which will in turn result in higher coliform counts at the tap, and a need for increased chlorination and turbidity filtration.

B. Homeland Security Issues for Central Vermont

The events of September 11, 2001, and more recently the Boston Marathon bombing in 2013, have made everyone acutely aware of possibility of terrorist threats. A vulnerable and far-reaching target is a public drinking water source. While no drinking water source can ever be completely protected from a terrorist threat, *Active Recreational* access to Berlin Pond, (with its shallow, easily reached intake) certainly increases the possibility of one. Terrorist attacks by their very nature occur unexpectedly and are designed to adversely affect as many innocent lives as possible. It seems that, for this reason alone, human access to the surface water of Berlin Pond should be eliminated.

The Homeland Security Presidential Directive-7 (attached pp. 327)

States “The Nation possesses numerous key resources, whose exploitation or destruction by terrorists could cause catastrophic health effects or mass casualties comparable to those used by a weapon of mass destruction, or could profoundly affect our national prestige and morale. In addition, there is critical infrastructure so vital that its incapacitation, exploitation, or destruction, through terrorist attack, could have a debilitating effect on security and economic well-being.” And further on includes “... State and local governments, and the private sector to protect critical infrastructure and key resources.” Drinking water and water treatment systems are the responsibility of the Environmental Protection Agency.

C. A Unique and Valuable Resource for *Passive Recreation*

The State of Vermont has a history of enabling the public lands within its jurisdiction to benefit the largest number of its citizens. Prior to May, 2012, the perimeter road of Berlin Pond provided a safe, peaceful area, with only slow residential traffic, for walking, running, cycling around the circumference of a body of water that was untouched by recreational use for over 100 years. Often present were families with small children on bicycles, and parents with strollers. *Active Recreational* access has significantly increased not only the amount of traffic, but the size and speed of the vehicles involved. *Active Recreationists* parking their vehicles have made it difficult for both resident and town service vehicles to pass.

As mentioned above, thousands of *Passive Recreationists* use Berlin Pond yearly and their numbers have dropped since *Active Recreation* was permitted especially during the more crowded times of various forms of fishing. It seems that facilities traditionally used by many are being sacrificed for uses by a few.

D. Nearby Opportunities for *Active Recreation*

Alternatives to Berlin Pond for Active Recreation

There are thirty-four lakes and ponds (ranging from 23 to 849 acres) found within a 20 mile radius of Berlin Pond that allow fishing, swimming, or boating. Twenty-two lakes or ponds found within a 20 mile radius have a state access. (See attached list) Preservation of this singular natural, not artificial, reservoir is a responsible approach that will ensure clean water into the future. A pond that can be viewed in a relatively natural state is rare and has value to many state and town residents. [Berlin Conservation Commission report July 12, 2012]

Alternatives to Berlin Pond for Passive Recreation

To date we have found no protected body of water in Vermont that has the access to the *Passive Recreation* that Berlin pond has.

E. The Wetlands of Berlin Pond

In 2012, Bradley Wheeler of Wheeler Environmental Services did a comprehensive wetland survey of the shoreline of Berlin Pond. Attached are the maps that are a result of this survey. In a statement following the survey, Mr. Wheeler wrote:

Wetlands and Natural Resources Surrounding Berlin Pond

Bradley A. Wheeler, Wheeler Environmental Services, LLC

Most of Berlin Pond is directly connected to several large Class Two wetlands. Class Two wetlands are designated as such because it has been determined by the State of Vermont that these types of wetlands are so significant that they merit specific protection under the Vermont Wetland Rules.

The large marsh and wooded wetland south of the pond are highly functioning wetlands. Some of the functions they provide include surface water quality enhancement, flood protection, and high quality wildlife habitat for a wide variety of birds, mammals, fish and insects. This area is highly regarded as an unusually valuable bird habitat, in particular.

The State of Vermont has listings in this area of rare plants and rare animals.

Near the north end of the pond, a somewhat smaller wetland, but still significant in size, extends from the pond north into a marsh/forested system, similar to the larger area at the south end of the pond. This area provides similar functions as the southern wetland. The State of Vermont lists the occurrence of a rare animal in this wetland area.

There is a large forested wetland located along the northeast approximate ½ of the pond. Most of the east side of this wetland is along Paine Turnpike. This wetland has been identified and mapped by the State of Vermont as a Significant Natural Community. It is an uncommon example of a Northern White Cedar Swamp. This wetland provides the same general functions as the other two wetlands, with expected variations due to this area being a cedar swamp and the other areas being more dominantly marsh.

There are also many smaller wetlands surrounding the pond. Each of these provides similar functions described above, except the functions are provided over a smaller geographical area. Based on the evaluation of wetland classifications in the Vermont Wetland Rules as revised in 2010, several of these wetlands may be determined to be Class Two wetlands upon further assessment.

The State of Vermont has identified numerous significant environmental reasons why specific protections of the natural resources around Berlin Pond should be a high priority. These resources in and directly adjacent to the pond include wetlands, rare plant and animal species, a significant natural community, and the pond and its surroundings are entirely within the source protection area for a public surface water supply.

With this variety of sensitive ecological habitats and species all associated with Berlin Pond, increasing human activities in and around the pond can only result in adverse impacts to these rare and possibly irreplaceable resources.

Maps of these referenced resources, produced by the State of Vermont, (attached pp. 321-326).

In October 2012, Bradley Wheeler of Wheeler Environmental Services, LLC was retained by Citizens to Protect Berlin Pond to complete an assessment of the Town of Berlin property located on Paine Turnpike South. His report follows:

Wetland Status at Town of Berlin Property

Bradley A. Wheeler, Wheeler Environmental Services, LLC

Wheeler Environmental Services, LLC has been retained by Citizens to Protect Pond to complete an assessment of the wetlands on the Town of Berlin property that is located along the east side of Paine Turnpike in Berlin, Vermont. The property is an approximately 17,000 square foot (85' x 200') parcel that is located approximately 3,400 feet north of the junction of Mirror Lake Road and Paine Turnpike. The property has 85 feet of frontage on Paine Turnpike.

Bradley Wheeler, Principal Scientist of Wheeler Environmental Services, completed a field evaluation of the site on July 13, 2012 and conducted a supplemental visit on October 15, 2012. The key information gathered during these site visits is presented below:

- Almost the entire property is a Class Two wetland. Most activities in or within 50 feet of these wetlands will require approval from the Vermont Agency of Natural Resources (VT ANR). Placement of fill in these wetlands will require approval from the U.S. Army Corps of Engineers (COE).
- Small areas of upland may be definable along the edge of Paine Turnpike (basically the road fill extension) and along the edge of Berlin Pond (where it appears some human activities dating back to the early 1900s may have occurred).
- The vegetation on most of the site is dominated by hydrophytic plant species, including: speckled alder, green ash, red maple, broad-leaved spirea, sensitive fern, cinnamon fern, royal fern, interrupted fern, tall meadow rue, and jewelweed.
- The soils on the property are hydric soils. A typical soil profile has a thick, dark fine sandy loam surface layer over a gray fine sandy loam substratum that is mottled with reduction and oxidation concentrations that indicate a long term saturation of the soils with a fluctuating groundwater table.
- A culvert under Paine Turnpike discharges surface water onto the eastern edge of the property. The surface water flows west on ground surface toward Berlin Pond. It is channelized for approximately 50 feet, after which the flow spreads out over the soil surface and ultimately seeps into the ground where it continues west as subsurface groundwater flow.
- The wetland on the property provides the functions of Surface Water and Groundwater Protection and Wildlife Habitat.

To obtain regulatory confirmation of these findings, we invited Shannon Morrison, Wetland Biologist for the VT ANR Wetland Program, Mary Abair, Senior Project Manager for the COE, to visit the site with us on October 24, 2012.

Due to scheduling issues, Ms. Morrison visited the property at 9:30 a.m. on the 24th and Ms. Abair visited the property with us at 11:30 a.m. Participants at one or both of the meetings included Shannon Morrison, VT ANR (9:30); Marty Abair, COE (11:30); Brad Wheeler wetland consultant for Citizens to Protect Berlin Pond (9:30 and 11:30); Tom Willard, Berlin Conservation Commission (9:30 and 11:30); Maggie Kerin (9:30 and 11:30), representing Citizens to Protect Berlin Pond and Jeff Schultz, Berlin Town Administrator (9:30).

The soils, vegetation and hydrology of the site were evaluated. Ms. Morrison and Ms. Abair agreed that most of the site is a wetland, with the possible exceptions of the road fill extension along Paine Turnpike and a narrow, slightly elevated ridge of soil close to the edge of Berlin Pond.

Based on the presumptions for wetland classification in the Vermont Wetland Rules (the Rules), Ms. Morrisson determined that the wetland is a Class Two wetland and would be afforded protection under the Rules. Under the Rules, virtually any proposal to conduct activities that include construction or placement of fill in or within 50 feet of the wetlands would require review and approval from the VT ANR wetlands program.

Ms. Abair indicated that any proposed activities that include placement of fill into the wetlands would require review and approval from the COE under Section 404 of the federal Clean Water Act.

Ms. Abair also indicated that any permit review process for wetland impacts would also require a review for historic resources. The initial archeological resource assessment would be completed by the Vermont Division for Historic Preservation. If it was determined that the site was sensitive for archeological resources, the further evaluation would be required before a decision on a permit application could be issued.

Neither agency can provide specific responses to the potential of permitting outcome for the site until there is a detailed proposal designed and a specific permit application submitted to them. In general, however, both Ms. Morrisson and Ms. Abair indicated that, due to the limitations imposed on the site by the wetlands, substantial construction or filling on the site would be difficult to permit under their programs.

F. The Sensitive and Fragile Ecosystem of Berlin Pond

The perimeter road hosts hundreds of birders annually as Berlin Pond has been one of the premier birding sites in Vermont due to its long period of protection. Many birds seen on the pond as well as many of those who have traditionally made their nesting sites there are in categories that tell us to be cautious about their habitat (see attached list pp. 333-341).



Heavy use by boaters on Berlin Pond results in shoreline erosion on Mirror Lake Road



Regularly discarded fishing line poses a danger to wildlife

G. The Berlin Watershed Conservation Plan, 2001

It is not insignificant in considering restoring protection to Berlin Pond that in Feb 2001, the Town of Berlin drafted the Berlin Watershed Conservation Plan (pages attached) . On the topic of *active recreation*, the document states at the outset that numerous other ponds in the nearby area are available for this type of recreation and “few, if any are as ecologically significant as Berlin Pond”.

On the subject of fishing it continues: “Fishing, whether from the waters of Berlin Pond or the shoreline, if it were to become legal, would threaten the undisturbed nature of the pond and shoreline, water quality and sensitive species. To a lesser extent, fishing might also threaten natural communities and scenic vistas. The greatest threat would be if fishing were permitted from boats....”Pond waters and shoreline have been undisturbed since the 1800's and to permit fishing, even from the shoreline, would alter this, threatening habitat of sensitive species.

“The common loon, listed as endangered in Vermont visits Berlin Pond virtually every year....Research has shown that anglers fishing from shore can have the same negative impact on wildfowl as boats...”

“..surprisingly canoes, kayaks and rowboats can potentially disturb wildlife as much as power boats.”

The document also includes the following statement. “*The Berlin Citizens Vision*, the result of (these) community meetings and questionnaires, found that Berlin residents felt very strongly about protecting natural resources. The report also emphasizedimproving recreational opportunities for residents – the highest percentage thought hiking and biking trails were the most important recreational needs.

“An issue that Berlin residents felt particularly strongly about was the need to protect Berlin Pond...”

H. Berlin Pond Changes Since May 2012

Whatever the causes, longtime residents and/or *passive recreationists* have noted the following changes in or around Berlin Pond since *active recreation* was allowed in May 2012.

* This year, for the first time, dead geese (4 goslings and one adult goose), killed by automobiles, were found on the perimeter road.

* People in kayaks were noted within the loon protection area.

* The increased number, size, and speed of vehicles were noted, particularly during heavy *active recreation* periods.



Vehicles and anglers fill Mirror Lake Road for ice fishing



Dozens of vehicles line Mirror Lake Road for ice fishing

* Fewer Canada Geese and Snow Geese were noted this year.

* Perch, which were taken by the thousands last winter (2013), had, according to ice anglers, dwindled to very few by the end of the ice fishing season.

* Higher coliform levels were noted by the water treatment personnel this past spring (2013).

I. Increased access to Berlin Pond is not supported by the Berlin Conservation Commission

The following is the Conservation Commissions report in full:

July 12, 2012

The Conservation Commission of Berlin respectfully submits the following environmental evaluation for the Berlin Pond ecosystem from a conservation perspective as Berlin considers increased access to the Pond through Berlin-owned property.

The recent Supreme Court decision overturned a century of protection from boating and fishing for the water supply of Montpelier and parts of Berlin along the Barre-Montpelier Road and the hospital plateau area. Due to Berlin Pond's historic restrictions, these environs also provide valuable habitat for birds and wildlife and offer scenic value.

We ask your consideration of the following points when evaluating Berlin Pond's unique qualities:

Berlin Pond's average depth is only 25 feet. Water stratification occurs when water masses with different properties form layers that act as barriers to water mixing. Deeper waters will stratify, separating water with different densities, buffering the deepest layers from surface pollutants.

Berlin Pond does not stratify because of its relatively shallow depth and therefore does not buffer the water intake from surface pollutants.

Berlin Pond is a natural body of water that has a long retention time compared to other community water systems that have man-made reservoirs with very short retention times. These other systems can be "flushed out" quickly. Parking lots and the resultant auto leaks, litter, and accidental spills may drain into the pond.

The introduction of invasives, such as water chestnuts and zebra mussels, all pose risks and raise the potential for increased maintenance costs and user rates. We are living in a global environment and new invasives appear regularly. Limiting boats which are transported between water bodies would curb the Pond's exposure to new species. The nexus for the introduction of invasives that threaten water supplies is often from boats.

Most other communities have alternative water supply options superior to the Berlin and Montpelier option. Montpelier and Berlin's only option should the water supply become contaminated or otherwise made unusable is the Winooski River.

Berlin Pond is designated an Important Bird Area by the Audubon Society. The Audubon Society states: *Due to the size and relatively undeveloped nature of the pond and associated uplands, Berlin Pond is home to a host of priority species. The undisturbed nature of Berlin Pond makes it unique in the state. Increased recreational use could result in higher disturbance rates.*

The Pond is thought of by many as a sanctuary for wildlife as well as for the enjoyment of the public and has had that status for nearly the last century. It is our belief that viewing natural communities in their natural state is as legitimate a use as boating and recreating on the other 850 lakes in Vermont. Berlin Pond is located in close proximity to four towns which is significant when estimating potential usage rates. Because of its scenic beauty and central location usage may be higher here than other ponds.

When considering increasing access, collaborative planning with a state fisheries biologist will be necessary. Management may have been lacking in the Thurman Dix Reservoir in Orange which has never been open to boats and has been open to fishermen since 2008 in only two locations. Barre Public Works department remarked that the numbers of fish seem to be down and litter has increased. F &

W took a bass count at the reservoir in 2008 and have not taken one since so they were unable to confirm the fish count. The Berlin CC has contacted Fish and Wildlife and they state it's their goal to sustain quality fisheries in Berlin Pond. As an example F & W has, in response to a declining bass population in Lake Morey, initiated a more restrictive minimum length limit requirement.

The town of Berlin is considering options to open a small parcel of land owned by Berlin that would allow access for non-motorized boats and fishermen. **The Berlin Conservation Commission advises not to increase access to the pond**. Increased access could have a detrimental effect on this essential water supply and the wildlife habitat.

The Berlin property parcel which is being considered for pond access may find permitting difficult. The soil characteristics are consistent with the seepage forests, which occur along the lower stretches of the extensive slope to the east of the pond and wetlands south of the pond. Seepage forests are characterized by soils with a mix of seasonally high water table and shallow peat layers where there is gradual groundwater discharge. Water actively drains through the middle of the property resulting in a sponge-like consistency that acts as a filter for run-off from the road and hillside. It is likely that a part or all of the Town site may be a State protected Class 2 wetland. Any resurfacing of this area would create a direct path for soils and pollutants to run into the pond causing increased turbidity and pollution. **If the surface is hardened, leaks from parked cars or litter would also be washed into the pond.**

There are thirty-four lakes and ponds (ranging from 23 to 849 acres) found within a 20 mile radius of Berlin Pond that allow fishing, swimming, or boating. Twenty-two lakes or ponds found within a 20 mile radius have a state access. (See attached list) Preservation of this singular natural, not artificial, reservoir is a responsible approach that will ensure clean water into the future. A pond that can be viewed in a relatively natural state is rare and has value to many state and town residents.

V. Closing

In closing, it seems appropriate to include two essays (attached pp. 314-319), one written in 2000 by Mikhail Gorbachev entitled *The Global Water Crisis*, the other an article *Water, Water, Nowhere* by Tom Walsh written in 2013, which appeared in Vermont's *Times Argus* (a newspaper which, ironically, heavily promoted recreational use of Berlin Pond once it was opened).

The world in general, of which the United States, Vermont, and Berlin Pond are a part, stands at the threshold of a crisis far more serious than oil. It behooves every nation, every community to exercise the highest protection of its drinking water sources for now and for the future. Recreation for our citizens, including *active recreation* as defined in this petition, is important but clearly Central Vermont is blessed with an abundance of those opportunities outside Berlin Pond. And as this petition shows, human recreational access to drinking water sources gradually, and sometimes not so gradually, degrades water quality. History has continually demonstrated that the time to protect drinking water sources, as well as our sensitive wildlife habitat, is before, not after, damage is done.

Additional Documentation



Wachusett Reservoir Watershed 2011 Public Access Plan Update



June 2011

Massachusetts Department of Conservation and Recreation
Division of Water Supply Protection
Office of Watershed Management

Abstract

The Department of Conservation and Recreation Division of Water Supply Protection (DCR/DWSP or DCR-Watershed) owns 21,028 acres of land in the Wachusett Reservoir Watershed (including the reservoir). DCR/DWSP manages these watersheds primarily for water quality protection, drinking water supply, and environmental resource protection purposes. The *Wachusett Reservoir Watershed 2011 Public Access Plan Update* explains DCR/DWSP policies and outlines control measures to be used to mitigate impacts from public access on those lands. This plan includes policies for common recreational activities that occur on the land and water resources in the Wachusett Reservoir watershed. This update builds upon the information provided in previous public access plans and uses current regulations and legislation to outline policies for public access to DCR/DWSP property in Boylston, Clinton, Holden, Leominster, Princeton, Rutland, Sterling, and West Boylston. DCR/DWSP will begin implementation of the update to the *Wachusett Reservoir Watershed 2011 Public Access Plan Update* in July 2011.

Acknowledgements

This plan was prepared by staff of the Department of Conservation and Recreation, Division of Water Supply Protection. Kelley Freda, Environmental Analyst is the principal author of this report with key contributions from John Scannell, Regional Director, Derek Liimatainen, Ranger Captain, and Pat Austin, Environmental Quality Supervisor. Additionally, valuable review comments and recommendations were provided by Larry Pistrang, Environmental Analyst. Final report production support provided by Joel Zimmerman, Regional Planner. All maps were produced by DCR/DWSP GIS staff Craig Fitzgerald using DCR and MassGIS data.



Commonwealth of Massachusetts

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Timothy P. Murray, Lt. Governor

Richard K. Sullivan, Jr., Secretary, Executive Office of Energy and Environmental Affairs

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Jonathan L. Yeo, Director, Division of Water Supply Protection

Wachusett Reservoir Watershed 2011 Public Access Plan Update

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Wachusett Reservoir Watershed 2011 Public Access Plan Update

I. Introduction

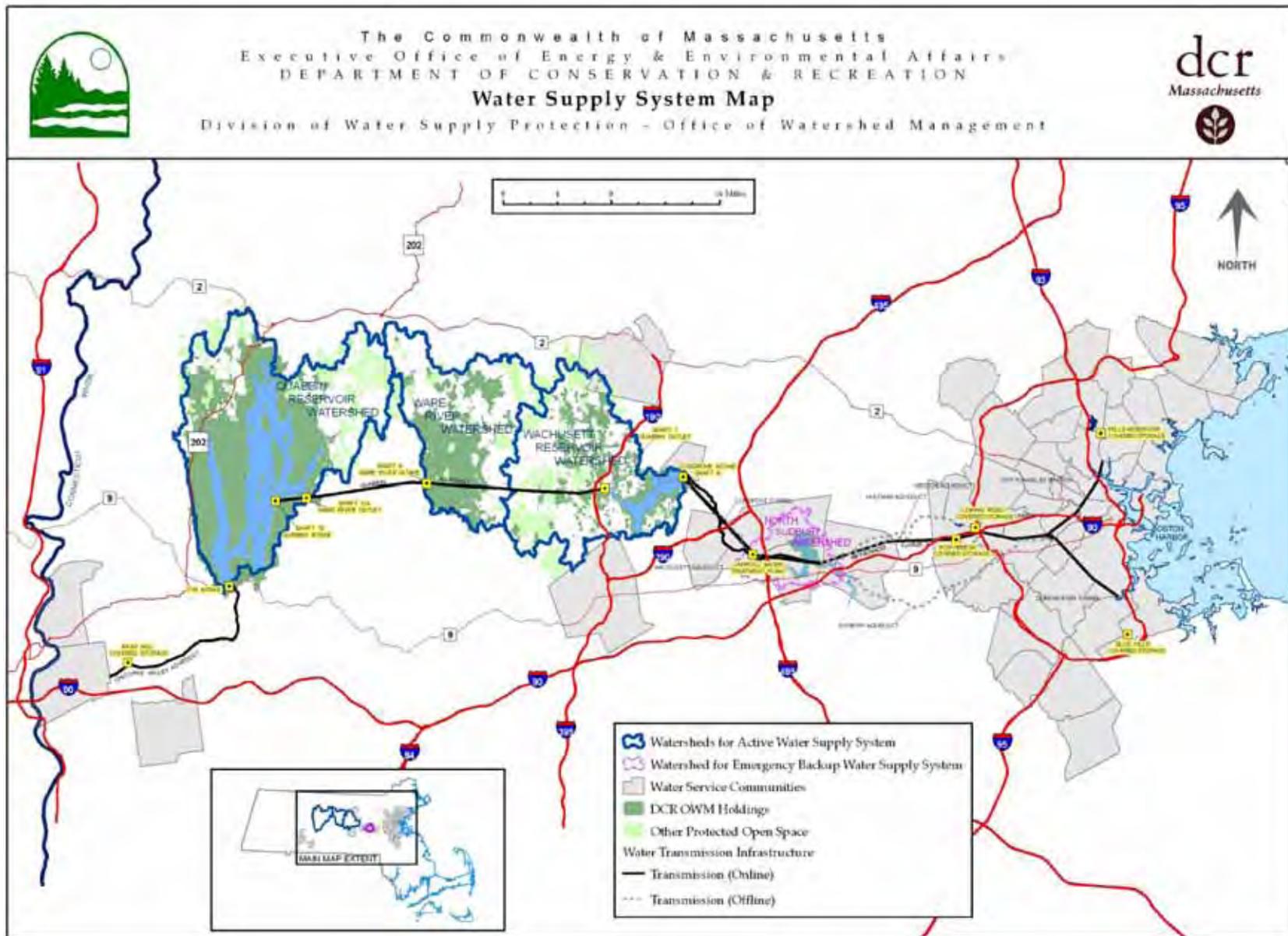
The purpose of this plan is to guide and control public access and use of lands managed by the Department of Conservation and Recreation, Division of Water Supply Protection (DCR/DWSP) within the Wachusett Reservoir watershed. The 117 square mile Wachusett Reservoir watershed includes portions of Boylston, Clinton, Holden, Hubbardston, Leominster, Paxton, Princeton, Rutland, Sterling, West Boylston, Westminster, and Worcester. The DCR Water Supply System provides source drinking water to the Massachusetts Water Resources Authority (MWRA). It is comprised of two supply reservoirs, one upstream of the other. Wachusett Reservoir, the terminal supply reservoir, receives runoff from its watershed as well as transfers from the Quabbin Reservoir through the Quabbin Aqueduct. Flow from the Ware River Watershed, located between the Quabbin and Wachusett Reservoir watersheds, can be diverted to Quabbin Reservoir by reversing flow in the Quabbin Aqueduct. Thus, Ware River flows can only be diverted to Quabbin Reservoir when the Quabbin Aqueduct is not being used to transfer flow from Quabbin to Wachusett (**Figure 1**).

Public access to and recreational use of water supply lands are complex and sometimes controversial issues. There is an inherent conflict between water supply protection and public demand for access to these lands. Any human activity on or near water supply source waters can introduce disease-causing agents to the water supply. Water supply managers must exercise caution when considering policies for public access and recreation on water supply lands. At the same time, the Division recognizes that these reservoirs and the DCR lands surrounding them are valuable environmental resources of the Commonwealth that are attractive to watershed residents and the general public. DCR/DWSP views its Public Access Plans as a blueprint for determining the levels of access that may be allowed without risking water supply safety, security, or re-directing resources of a Division whose primary responsibility is water supply protection.

The Executive Office of Energy and Environmental Affairs 2006 Statewide Comprehensive Outdoor Recreation Plan (SCORP) was reviewed for this plan; common issues and activities were integrated when appropriate for water supply protection lands. DCR/DWSP's goals and implementation priorities in the Wachusett Reservoir watershed, however, are based on its mission to protect this drinking water supply resource from public access impacts.

The policies outlined in this plan are for land owned in fee by DCR/DWSP. DCR/DWSP also controls the development rights to 2,398 acres through deeded Watershed Preservation Restrictions (WPR, synonymous to Conservation Restriction, is the term used for these types of covenants in the DCR Watershed System encompassing the Quabbin Reservoir, Ware River, and Wachusett Reservoir watersheds). The purchase of a WPR by the DCR does not give the public any rights to access the property. ***Public access on DCR Watershed Preservation Restrictions is solely at the discretion of the landowner.***

Figure 1. DCR/MWRA Water Supply System



II. Overview of the DCR/MWRA Water Supply System

A. Brief History

The Boston area drinking water supply has grown from 18th century cisterns to two source supply reservoirs that were the largest of their kinds when constructed in the first half of the 20th century. The name of the agency responsible for these invaluable resources have changed many times over the past two centuries, but the mission of stewardship has remained constant. Shortly after the construction of the Wachusett Reservoir, Chapter 350 of the Acts of 1919, Section 123 gave control of this water supply system from the Metropolitan Water and Seward Board to the Water Division of a newly created state agency, the Metropolitan District Commission (MDC).

Over fifty years later, as part of the efforts to clean up Boston Harbor, the Massachusetts legislature, under Chapter 372 of the Acts of 1984, divided the former MDC Water Division into the MDC Division of Watershed Management and the Waterworks Division of the Massachusetts Water Resources Authority (MWRA). The MDC/DWM became responsible for reservoir watershed operation and management to supply a safe and sufficient supply of water to the MWRA; the MWRA became responsible for the treatment and distribution of this water.

In July 2003, Chapter 26 of the Acts of 2003, section 290 merged the MDC with the Department of Environmental Management (DEM) to create the Department of Conservation and Recreation (DCR). The responsibilities of the former MDC Division of Watershed Management were transferred in their entirety to the Office of Watershed Management within the Division of Water Supply Protection. The mission of the Office of Watershed Management remains constant: to provide pure water through responsible land management. Together, DCR/DWSP and the MWRA provide drinking water to more than 2.2 million residents in fifty-one communities.

There is a well established working relationship between DCR and MWRA. MWRA's ratepayers entirely fund the Office of Watershed Management's annual \$30 million budget, including costs associated with land acquisition and payments in lieu of taxes. The terms of this relationship are defined in a Memorandum of Understanding (MOU) between the two agencies. The latest version of this MOU, developed soon after the creation of DCR, was signed into effect in April, 2004. Though DCR/DWSP is a department of the Commonwealth, it is not funded through the Massachusetts taxpayer. The entire budget, including land purchases, is paid for through MWRA ratepayers.

The legislature further enhanced the ability of the Office of Watershed Management to maintain this drinking water supply by establishing a Water Supply Protection Trust, created by Chapter 149 of the Acts of 2004, s. 27, and written into the general laws at MGL c. 10, § 73. The Trust provides a more efficient mechanism for MWRA's funding of the Office of Watershed Management. The Water Supply Protection Trust has a five person board of trustees responsible for approving the Office of Watershed Management's annual work plan and budget each spring for the following fiscal year beginning in July.

B. DCR Division of Water Supply Protection Mission

The land surrounding the Wachusett Reservoir is managed by the DCR Division of Water Supply Protection, Office of Watershed Management in order to protect the quality of the reservoir water, enhance the ecological integrity of the watershed, and ensure the future protection of these valuable natural resources from pollution, encroachment, and environmentally damaging public use.

The Division's mission is laid out in its enabling legislation and subsequent amendments, found at M.G.L. ch. 92A½, §2. The statute directs the DCR/DWSP to:

...construct, maintain and operate a system of watersheds, reservoirs, water rights and rights in sources of water supply [to] supply thereby a sufficient supply of pure water to the Massachusetts Water Resources Authority, and [to] utilize and conserve said water and other natural resources to protect, preserve and enhance the environment of the Commonwealth and to assure the availability of pure water for future generations.

Building on this legislatively-defined mission, DCR/DWSP's current responsibilities include:

- 9 Maintenance and operation of the source facilities (including dams) safely and efficiently.
- 9 Preservation and enhancement of the water quality of the supply sources, using education, enforcement, and cooperation to meet state and federal water quality standards and protect public health.
- 9 Watershed management activities associated with surface water protection.
- 9 Regulatory compliance with specific directives of the Legislature, such as the protection of the water supply sources, consideration of recreation opportunities, and enforcing rules and regulations for DCR/DWSP lands and water resources.
- 9 Public outreach and education to involve watershed towns, residents, and the public to increase stewardship of the water resources under the DWSP's care and control.

DCR/DWSP staff concentrates on the management, operation, and maintenance of the DCR/MWRA water supply system watersheds, reservoirs, dams, and dikes. Division staff includes professional engineers, analysts, planners, watershed rangers, foresters, aquatic biologists, natural resources specialists, geographic information specialists, wildlife biologists, and support staff with a variety of skills and training. Division staff carries out specific watershed protection programs, provide public outreach and environmental education to watershed communities and visitors, and administers and enforces specific watershed protection regulations (350 CMR 11.00). Staff activities are guided, integrated, and prioritized by the *DCR/DWSP Watershed Protection Plan Update 2008*. Public access management within land owned by or on waters controlled by the Division is an important element of the DCR/DWSP comprehensive watershed protection program.

C. Regulatory Overview

Public drinking water supplies are highly regulated in the United States to protect public health. Both federal and state laws (including the U.S. Safe Drinking Water Act along with its 1996 Amendments, the Surface Water Treatment Rule, and the Massachusetts State Surface Water Supply Regulations (310 CMR 22.00, a subset of the Massachusetts Drinking Water Regulations) require water providers to meet rigorous water quality standards for source waters. These standards change over time based on research and testing. The U.S. Environmental Protection Agency (US EPA) administers federal water quality regulations throughout the country. In Massachusetts, the Massachusetts Department of Environmental Protection (MA DEP) has been given primary responsibility for assuring compliance with state and federal drinking water regulations, and consistently monitors water quality throughout the DCR/MWRA water system to ensure compliance with these regulations.

Both the DEP and EPA conduct strict oversight of DCR operations and watershed protection activities in the Wachusett Reservoir watershed. DEP conducts annual inspections of the system because DCR is a public water supplier. DEP uses four distinct criteria in its evaluation of DCR's watershed protection efforts:

- 9 Demonstration and implementation of watershed control.
- 9 On-site inspection of the water supply system.
- 9 Documented absence of waterborne disease outbreaks.
- 9 Compliance with the existing U.S. Safe Drinking Water Act's maximum contaminant levels.

Each year that DEP has inspected DCR operations, it has found that DCR had demonstrated adequate control measure for water quality protection. The implementation of watershed plans, including the Wachusett Reservoir's Watershed Protection Plan, Public Access Plan, and Land Management Plan ensures that 2.2 million people and 5,500 industrial users continue to enjoy an abundant and high-quality water supply.

III. Plan Update

A. Watershed Protection Plans

Watershed Protection Plans were prepared in 1991 for the Wachusett Reservoir and Quabbin Reservoir/Ware River watersheds. These were the first comprehensive plans written for management of the watersheds. The Wachusett Watershed Protection Plan was updated in 1998 and 2003. The *2008 Watershed Protection Plan* updated and unified protection plan documents from the Wachusett Reservoir, Quabbin Reservoir, Ware River, and Sudbury/Foss Reservoirs Watersheds. The breadth and complexity of the Watershed System and DCR's comprehensive approach to watershed management necessitated producing this plan in five volumes. The Wachusett Watershed Protection Plan can be found in Volume IIC (www.mass.gov/dcr/watersupply/watershed/documents/2008dcrwppv2cwachusett.pdf). All plan updates reflect the shift of the water supply industry and federal drinking water regulations towards concern for microbial contaminants that can cause acute illness.

B. Purpose of a Public Access Plan

The purpose of DCR/DWSP's Public Access Plan is to guide and control public access, incorporating current information, so as to minimize the risk of impacts from recreational activities on the drinking water supply and other lands managed on a watershed basis. It is also used by DCR/DWSP to determine and set policy for low impact, passive recreation that is compatible with watershed protection on water supply lands. The federal Safe Drinking Water Act and Amendments, state drinking water regulations, and the Department of Conservation and Recreation's Watershed Protection Regulations require that public access on drinking water supply lands must be managed to minimize the risk of waterborne disease and to control other impacts such as erosion and sedimentation. The primary function of these water supply lands is to protect the DCR's ability to provide high-quality drinking water for current and future generations. The DCR/DWSP's access plans detail the Division's management rationale and explain which programs and activities are used to limit and control access to these lands and waters.

Public access, in the Division's management context, is a wide-ranging concept. It includes: the physical ability to enter and use land for recreational activities; the legal restrictions or prohibitions related to access or specific land or water-based recreational activities; sign placement; mapping; user education; and inter-governmental coordination and public safety.

C. Wachusett Public Access Plans

1. 1996 Plan

DCR watershed management policy has traditionally allowed passive recreation — recreation uses are considered passive where very minimum alteration of vegetation, topography or other native feature is necessary for the enjoyment of the site amenities — in the Wachusett Reservoir watershed. The 1996 *Wachusett Watershed MDC Public Access Plan* (the 1996 Plan) was the

first written Public Access Plan for the Wachusett Reservoir watershed. The goal of this plan was to reduce the existing level of threats to water quality from public use of DCR/DWSP watershed lands and to provide management programs that afford long term protection of Wachusett Reservoir. The 1996 Plan surveyed problems resulting from existing public access to watershed lands. The problems identified included dumping, poor sanitation (evidence of people and domestic animals defecating near the reservoir and improper disposal of dirty diapers), swimming, domestic animals, damage from motorized vehicles, and shoreline erosion.

While the Division realized that most of the visiting public complied with the existing rules and regulations, it was determined that new policies were needed to provide greater control over the minority of users who disregarded or abused the privilege of access to these water supply lands. In addition, it was clear that some activities, such as snowmobiling and bicycling, that were allowed in certain areas needed to be limited or curtailed.

2. 2003 Plan Update

The Wachusett Watershed Public Access Plan was updated and modified in 2003 based upon new information and staff observations while in the field. Minor policy changes made in this plan update included: integrating the Off-Watershed Zone into the Intake Protection Zone; expanding access for hiking, cross-country skiing and snowshoeing to lands east of Gates 1 and 2 on Route 70; and the removal of the permit requirement for bicycling in designated areas. Clarification of the bicycling policy included allowing bicycling from Gate 39 to 42 (the roadway alongside of the spillway to below the dam).

Chapter VI contains a status review of the recommendations made in the 2003 plan.

D. Why Update the Access Plan?

It is important to periodically review the Access Plan to identify changes in existing conditions, evaluate the policies that have been implemented, and assess additional needs to meet the mandate of water quality and resource protection. In addition, the desire to increase recreational opportunities on DCR property, and all other Commonwealth lands, has steadily grown due to the region's population growth and the current economic downturn. The Plan Update revises implementation priorities, re-assesses the public's recreational desires, and develops a response to evaluate these demands with the Division's primary goals of water supply and resource protection. The policy review and recommendations made in this Plan Update build upon the original 1996 Plan and 2003 Plan Update.

The events of September 11, 2001 have heightened concerns regarding security and the need to protect public water supplies from possible terrorist action, as well as to reassure the public that security plans are in place. These ongoing issues must be considered as any policy and public access are addressed.

It is important that current policies and visitor impacts be assessed and modified on a regular basis, since any recreational use of watershed lands and waters is a potential cause of water supply

contamination. Since 2003, there have been several changes in recreation patterns noted by staff in the field. There has also been an increase in the range of activities that are now available (i.e., geocaching and letterboxing) and the pressure for these activities to occur on DCR/DWSP lands. Plan updates allow for new activities taking place on DCR/DWSP lands not addressed in previous reports to be reviewed and current policy to be reassessed. This update takes into account research, studies, and information that is available on each recreational activity.

E. Public Input

DCR/DWSP has found public access management on public drinking water supply lands and waters to be a complex and sometimes controversial issue. In addition, private landowners living next to water supply lands may be positively or negatively affected by public access management decisions (Bureau of Land Management, 1991, 1993, 1998). Therefore, DCR/DWSP compiled a survey in order to gain insight into the public's knowledge of DCR rules, regulations, and outreach efforts. The survey was designed to determine the most effective way to distribute information (land closures, educational, announcements, rules, etc.) to the public. A public kick-off meeting was held at DCR/DWSP Headquarters in West Boylston on October 28, 2010 where the survey was announced and the plan update process explained. The survey was made available through SurveyMonkey on the internet (www.mass.gov/dcr/watersupply.htm) from October until January 15, 2011. The survey website and link was advertised through many different outlets and printed copies were also made available. Another public meeting was held at the same location on May 3, 2011 after the draft of the plan update was complete; comments were accepted until May 20, 2011. A specific listing of survey availability and results can be found in Chapter VIII and Appendix D.

F. Public Access Plan Goals

The Division's public access management goals are used to develop the policies outlined in the Plan. These goals are:

- 9 To protect drinking water resources from public access impacts.
- 9 To properly manage a public resource used as a source supply of drinking water.
- 9 To protect historic and prehistoric sites within the watershed.
- 9 To improve and protect long-term ecosystem health and biological diversity within the watershed.
- 9 To assure that public access is safe and appropriate to DCR/DWSP's water quality goals.

IV. Existing Conditions

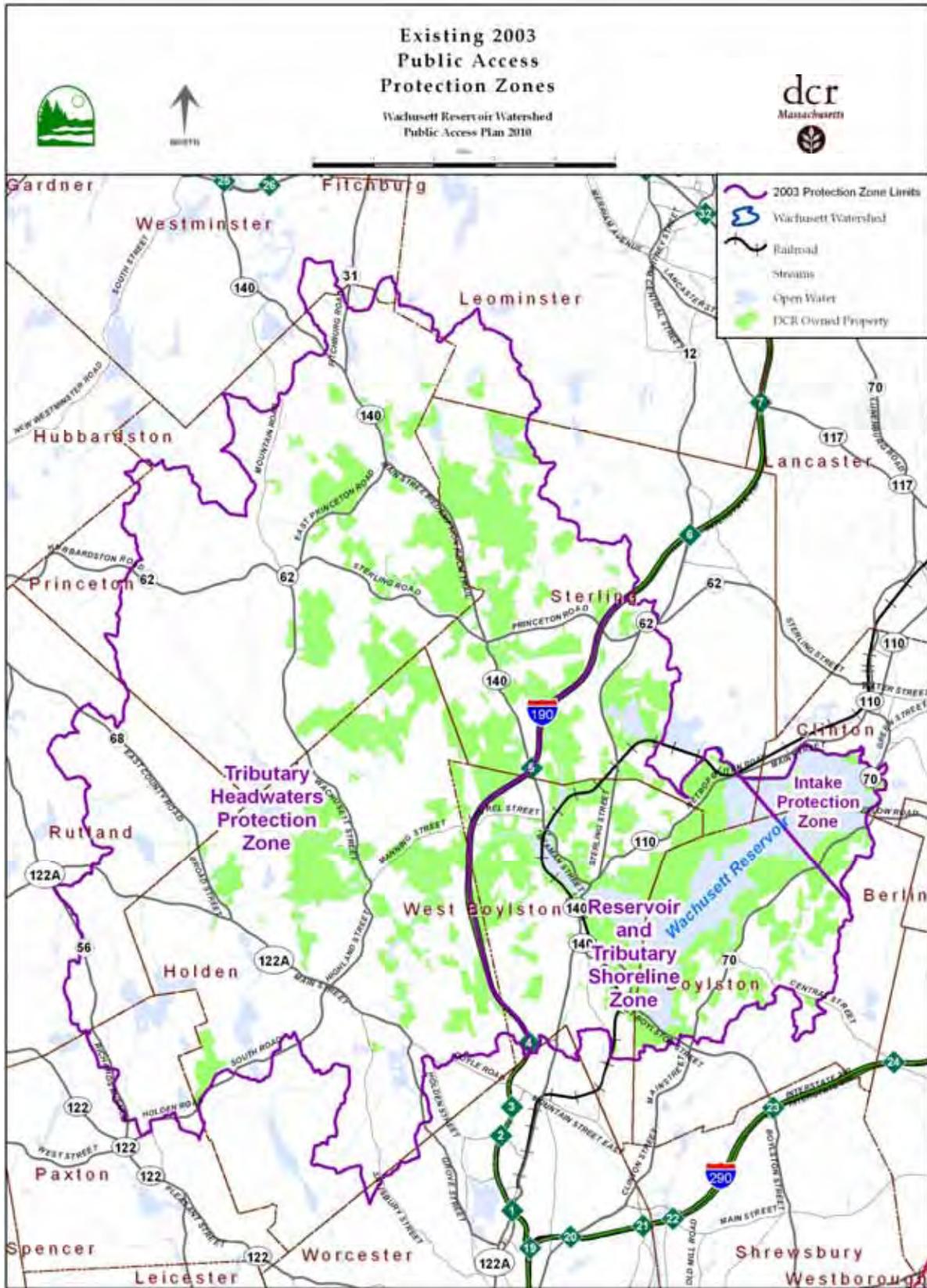
The Wachusett Reservoir watershed is located in east-central Massachusetts and includes approximately 117 square miles (74,919 acres) of land and water resources. Boundaries of the Wachusett Reservoir watershed lie within 12 municipalities of Worcester County; it encompasses the towns of Boylston, Clinton, Holden, Hubbardston, Paxton, Princeton, Rutland, Sterling, West Boylston, Westminster, and the cities of Worcester and Leominster. The Wachusett Reservoir watershed makes up the headwaters of the Nashua River watershed. For a more detailed description of the existing natural resources of the Wachusett Reservoir Watershed, please refer to the *2001-2010 DCR Wachusett Land Management Plan* or the *2008 Wachusett Reservoir Watershed Protection Plan Update*.

A. Public Access Protection Zones

In order for the Public Access Plan and all subsequent updates to be as easy to understand as possible, the watershed has been divided into three management zones: the Intake Protection Zone, the Reservoir Protection Zone and the Tributary Headwaters Zone (**Figure 2**).

- 9 *The Intake Protection Zone* provides primary protection of the water supply by prohibiting public access near reservoir intake structures. The Intake Protection Zone includes four miles of reservoir shoreline, at both the North (near Gate #36 to the dam) and South Dikes, and the Reservoir's South Shore, from Hastings Cove (Gate #5) to the Cosgrove Intake on Route 70. This zone also includes approximately 680 acres of DCR/DWSP land that does not drain to the Wachusett Reservoir. Signage on DCR property within this zone consists of: North Dike Protection Zone and Intake Protection Zone.
- 9 *The Reservoir Protection Zone (referred to in previous plans as the Reservoir and Tributary Shoreline and West Waushacum Pond Protection Zone)* includes the watershed lands around the Reservoir and main tributaries (Quinapoxet and Stillwater Rivers) and the West Waushacum Pond. Signage on DCR property within this zone consists of: Reservoir Shoreline Zone, Quinapoxet Zone, Stillwater Zone and Waushacum Ponds Zone.
- 9 *The Tributary Headwaters Zone* is made up of DCR/DWSP lands located outside of the Route I-190 and Route 62 corridor. Signage on DCR property within this zone includes Tributary Headwaters Zone.

Figure 2. Wachusett Reservoir Watershed Existing 2003 Public Access Protection Zones





Aerial photo of Wachusett Reservoir in 1930 at historic low-water level.

B. DCR Land Ownership

The Wachusett Reservoir watershed consists of 74,835 acres (**Figure 3**). DCR/DWSP owns 21,028 acres of this area; another 2,400 acres are protected by DCR under Watershed Preservation Restrictions where the land remains in private ownership (**Table 1**). DCR allows some form of access on 80% of its Wachusett Reservoir watershed property. Public access is not allowed on 149 acres of land (0.7% of total area) within the watershed. Public access is also not allowed on the 4,151 acre Wachusett Reservoir. These no public access lands are located within the Intake Protection Zone (**Table 2**).

Table 1. DCR/DWSP Protected Lands in the Wachusett Reservoir Watershed

	Acres	% of Watershed
Wachusett Reservoir Watershed	74,835	100
DCR/DWSP owned (in fee)	21,028*	28
Watershed Preservation Restrictions	2,398	3.2

Source: DCR/DWSP, January 2011

* Acreage includes the Reservoir. Deviation from other written sources is due to updated 2011 parcel information.

Figure 3: DCR Open Space

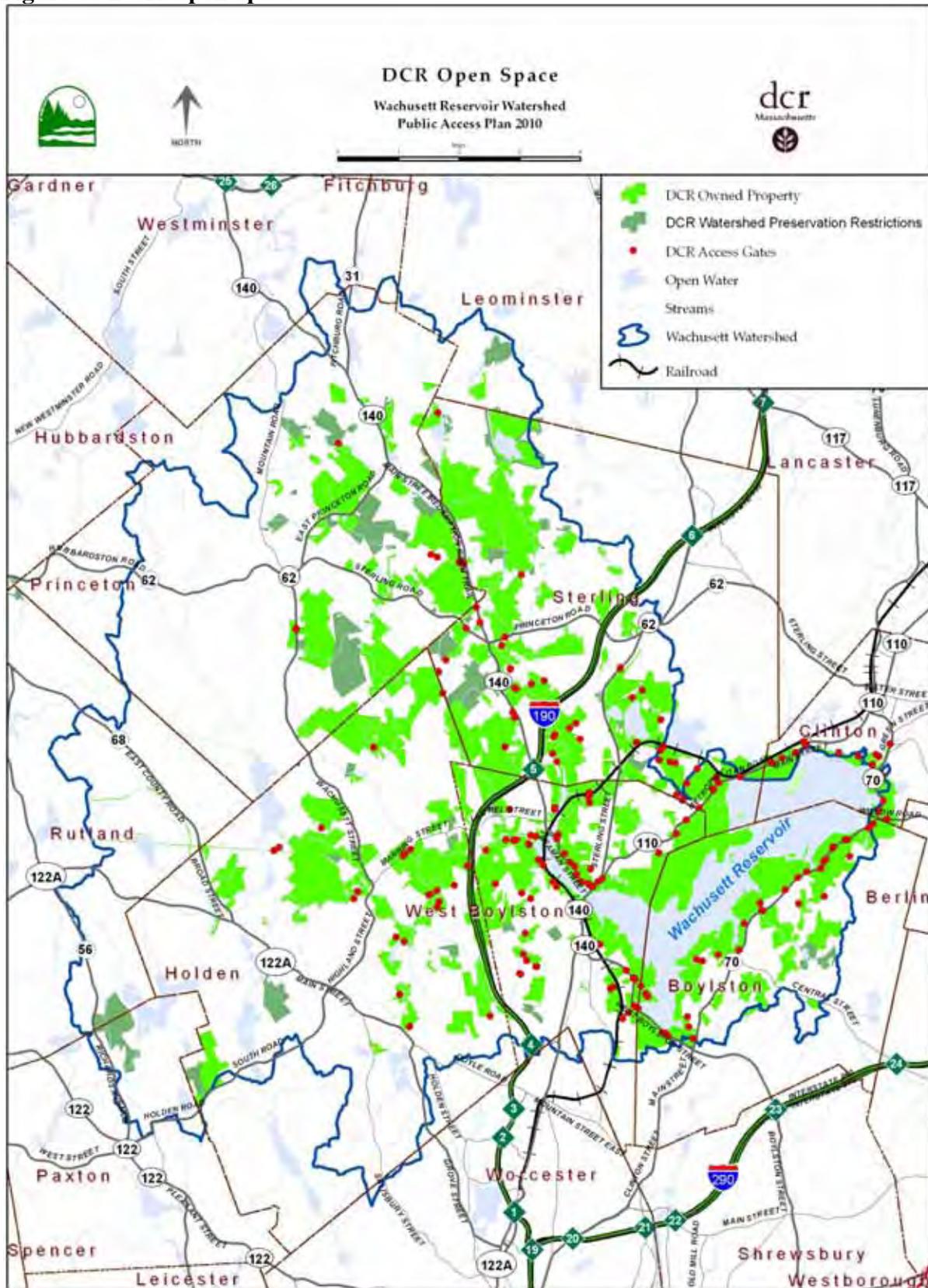


Table 2. DCR Lands Accessibility

	Acres	% of Total
DCR/DWSP Ownership	21,028	100
Wachusett Reservoir	4,151	19.7
DCR No Trespassing	149	0.7
DCR Public Access	16,728	79.6

Source: DCR/DWSP, January 2011

Table 3. DCR Owned Land by Municipality

Municipality	Acres
Boylston	4,899.5
Clinton	1,007.8
Holden	3,715.6
Leominster	44.6
Paxton	0.0
Princeton	2,681.6
Rutland	40.6
Sterling	5,213.6
West Boylston	3,424.8
Worcester	0.2
TOTAL	21,028.5*

Source: DCR/DWSP, January 2011

* Total acreage includes the Reservoir. Figure based upon 2011 parcel data.

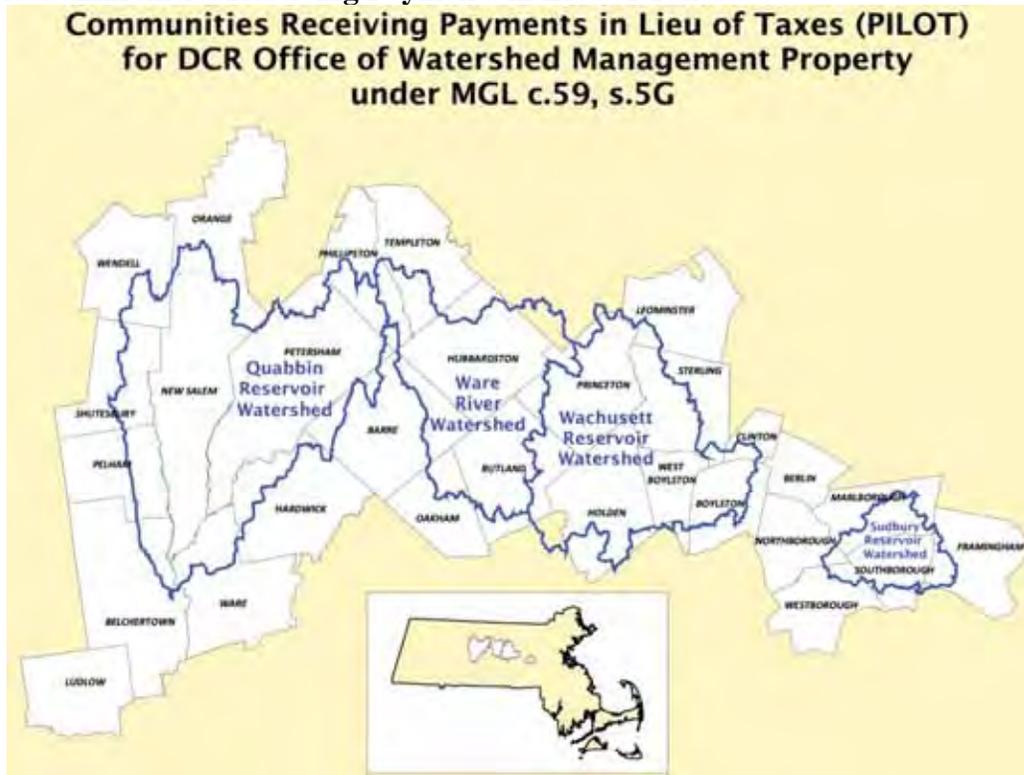
C. *Payments in Lieu of Taxes Program*

The DCR-Watershed Payments in lieu of Taxes (PILOT) program is the method that DCR-Watershed compensates communities which contain the land and water bodies that comprise one of the nation's largest unfiltered water supply systems (**Figure 4**). The PILOT program guarantees regular and stable payment to the 29 communities shown below. More than \$2,945,000 was paid in Fiscal Year 2011 to Wachusett Reservoir Watershed towns (**Table 4**).

Massachusetts General Laws c.59, §5G mandates that DCR's Division of Water Supply Protection make Payments in Lieu of Taxes on the Commonwealth property managed by the Office of Watershed Management. The current law was ratified in 1984 for the Quabbin Reservoir and Ware River Watersheds and was amended in 1987 to include communities in the Wachusett and Sudbury Reservoir Watersheds.

The base information used for determining DCR PILOT, as with all other State Owned Land PILOT, is the valuation performed every four years by the Department of Revenue (DOR); the latest revaluation was completed in 2009 and was the basis of the FY2010 PILOT. It is strictly DOR's responsibility to set the value for this land.

Figure 4. Communities Receiving Payments in Lieu of Taxes



There are, however, several differences between the DCR PILOT and other State Owned Land reimbursements that are made by the Commonwealth under MGL c.58, §§13-17:

- **MWRA ratepayers pay the bill.** Funds for the DCR PILOT payments come from MWRA rate payers who use the reservoir waters; MWRA provides funding to DCR to make PILOT payments to the watershed towns. Unlike other PILOT programs for state-owned lands, which are disbursed through state aid to communities (“Cherry Sheets”) and are subject to legislative appropriation, the DCR program is paid in full directly to each community. The DCR payment does not appear on the Cherry Sheet.
- **DCR PILOT utilizes the local commercial tax rate.** The PILOT which is distributed through the “Cherry Sheet” is based on a statewide average of residential tax rates calculated by DOR. DCR PILOT is required to utilize each community’s commercial tax rate in calculating the PILOT obligation.
- **The payment can never be less than the previous year.** MGL c. 59, §5G states that DCR PILOT can never be less than the previous year’s payment. This “hold harmless” clause provides the watershed communities the security of level funding even if a drop in valuation or tax rate combines to lower the calculated PILOT. This requirement provided watershed communities close to \$1 million in FY08.

Since 1985, more than \$90 million has been distributed in DCR-Watershed PILOT payments. Fiscal Year 2011 PILOT calculated for all 29 eligible communities in the DCR/MWRA water supply system was \$7 million. For a complete listing for each watershed community, go to www.mass.gov/dcr/watersupply/watershed/pilot.htm.

Table 4. Annual Payments in Lieu of Taxes to Wachusett Reservoir Watershed Towns

Community	PILOT FY2009	PILOT FY2010	PILOT FY2011
Boylston	\$541,958	\$541,958	\$541,958
Clinton	\$128,815	\$155,959	\$174,023
Holden	\$767,553	\$767,553	\$811,635
Leominster	\$7,970	\$7,970	\$7,970
Princeton	\$172,113	\$233,179	\$240,153
Sterling	\$513,666	\$567,021	\$567,021
West Boylston	\$602,756	\$602,756	\$602,756
Total Wachusett Reservoir Watershed	\$2,734,830	\$2,876,397	\$2,945,518
Total PILOT	\$6,107,378	\$6,741,130	\$7,000,366
% of Total PILOT	45%	43%	42%

Source: DCR/DWSP

V. Recreational Activities, Water Supply Compatibility, and Current Policy

The Department of Conservation and Recreation Division of Water Supply Protection must carefully weigh the potential for impacts to the drinking water supply and other environmental resources before considering any uses on its properties. In general, any human use will cause impacts to the drinking water supply. Recreational uses of water supply lands and any infrastructure needed to support the activity can add sources of microbial, physical, and chemical contaminants to the drinking water supply. The responsibility of DCR/DWSP is to determine what uses may be allowed in certain areas while limiting the potential of water quality impacts to acceptable levels. Because the Division purchases and maintains its land for water supply protection, it must err on the side of caution in identifying any recreational use that might compromise water supply protection.

The American Water Works Association (AWWA), in its *Statement of Policy on Recreational Use of Domestic Water Supply Reservoirs* (revised January 25, 2009; Appendix C) states,

Protection of public health and drinking water quality should be the highest priority in operational decisions for reservoirs used jointly for water supply and recreation. Decisions regarding recreational use of domestic water supply reservoirs should be consistent with the intent of the source water protection program developed and implemented by the utilities and other responsible parties.

The following issues must be considered when determining whether a proposed activity has the potential to compromise water quality:

- The type and intensity of proposed public access use.
- The physical features of the area being considered for public activities.
- The potential for impacts to water quality from all visitors.
- The resource needs to properly manage any particular use on its properties, always keeping water supply protection the primary focus.

The criteria to determine whether an activity is compatible with the Division's water supply mission identifies whether the activity has the potential to degrade the quality of water in the watershed or degrade any natural resources within the watershed. DCR/DWSP must also consider the following information in making such a determination:

- Division of Water Supply Protection goals, guiding legislation, and regulations.
- Environmental impacts to water quality and land resources.
- Potential for impacts to watershed resources and waterworks infrastructure.
- Potential impacts to staffing and other resources.
- The safety of users, abutters, staff, and the general public.

The DCR Division of Water Supply Protection has general regulations (350 CMR 11.00) relating to public access promulgated to protect the metropolitan water supply. Some of the restrictions include:

- Entrance on and exit from the land of the Watershed System shall be made through gates or other designated areas.
- No person is allowed within any land of the Watershed System, except from one hour before sunrise to one hour after sunset, unless authorized by a written permit from the Department or its designee.
- Powered boats are prohibited within the waters of the Watershed System except in areas designated by the Department or its designee.
- All acts which pollute or may pollute the water supply are prohibited. No litter or any refuse of any sort may be thrown or left in or on any land or water within any Watershed System.
- Cooking and all fires are prohibited within the Watershed System.
- No person shall wade or swim in any Tributary or Surface Waters on or within the property of the Commonwealth except at areas designated by the Department or its designee.
- Organized sports or activities are prohibited within the Watershed System except by written permit from the Department or its designee.
- Possession or drinking of alcoholic beverages is prohibited on DCR properties.
- No person shall drive a motorized vehicle within the Watershed System except upon roads authorized for such use by the Department or its designee.

The following recreational activities (listed below as A-P) are the most common outdoor pursuits and/or those that may present the most serious harm to water quality. Any activity not identified should be presumed to be prohibited on DCR Wachusett Reservoir watershed property.



Sunset over the Wachusett Reservoir

A. Water Contact

Bodily contact with the reservoir water is prohibited by regulation. Any types of contact with a drinking water source is a possible pathway for bacteria and other diseases to compromise drinking water quality. Most human activities on and near a water supply represent an added element of risk to the consumers. The only way to guarantee that pathogens do not reach the Intake is to not allow them to be introduced into a water body in the first place. According to the 2008 Maine Water Utilities Association Position Paper “Proposed Siting Criteria for State-Financed Public Boat Launches On Public Water Supplies”:

- A single person sheds an average of 200 billion fecal bacteria in a single day.
- Birds and wild animals also introduce potential pathogens to the water, but pathogens from humans are more likely to ultimately be infectious to other humans than are pathogens originating from birds or animals.

The link between direct water contact activities, such as swimming and wading, and the spread of water borne disease is well documented. Human body contact recreation adds fecal bacteria and disease causing organisms to water and these pathogens can be carried by wind and currents away from their point of introduction.

B. Boating (Motorized and Non-motorized)

All boating activities, both motorized and non-motorized, are prohibited by current regulation in the Wachusett Reservoir watershed, except in areas specifically designated by the Division. Although boating poses less of a risk to the water supply than swimming, it is still considered an unnecessary threat to the water supply due to the likelihood of water contact during boating activity.

The recent discovery and documentation of aquatic invasive species infestations, such as the zebra mussel in Laurel Lake in Lee and Lenox, MA and *Hydrilla* in Clinton, MA pose another significant threat to water quality, as private boating is one of the primary means of transport of invasive species from one body of water to another. Aquatic invasive species pose a threat to native species and have the potential to alter the balance of the natural aquatic community and can have a negative impact on water quality. Once established, invasive species can be extremely difficult or impossible to remove, as a classic invasive species is aggressive, can multiply rapidly, spread quickly, and out-compete native species. These reasons make boating in the Reservoir itself an unacceptable risk.

Car top boats (up to 14 feet in length), canoes, kayaks and electric outboard motors are, however, permitted at both West Waushacum Pond and Muddy Pond. Canoes and kayaks are also allowed on portions of both the Quinapoxet and Stillwater Rivers. All regulations related to boating must be followed, including the wearing of appropriate Personal Flotation Devices (PFDs) from September 15 through May 15 and year round for children under twelve years of age. It is also a requirement to have a wearable personal flotation device for each person that is on the boat.

C. Fishing

Shoreline fishing, without water contact, in certain areas and for a limited period of time does not pose a significant threat to the water supply or other natural resources. Shoreline fishing, with a valid Massachusetts fishing license, is allowed in the Wachusett Reservoir watershed from the first Saturday in April until November 30 of each year. Depending on ice conditions of the surface waters, the shoreline fishing season could start later or end earlier at the discretion of the Division in order to protect public safety. Around the Wachusett Reservoir proper, shoreline fishing is allowed from Gate 6 on Route 70 to Gate 36 on Route 110.

Discarded fishing line and the use of lead fishing tackle, however, threatens area wildlife. Fishing line does not readily break down and persists in the environment for many years. Birds, animals, and turtles often get tangled in this line, are unable to free themselves and die because of exposure, starvation, or predation. DCR/DWSP launched a fishing line recycling program in 2007, asking fisherman to discard old and unusable fishing line in specially made canisters located at several heavily used fishing areas. In addition to protecting wildlife, this line is kept out of landfills by recycling into other products. To date over twenty four miles of fishing line has been removed and recycled from watershed lands.

Lead sinkers can harm waterfowl. In an effort to protect the Common Loon, an endangered species, the MA Fisheries and Wildlife Board prohibited the use of all lead sinkers (not including artificial lures, jigs, lead core line or weighted flies) in 2001 for the taking of fish in Quabbin and Wachusett Reservoirs, the loons' primary habitat in the state. The Fisheries and Wildlife Board expanded this ban in 2009 when they unanimously voted to prohibit the use of lead sinkers, lead weights, and lead fishing jigs with a mass of less than 1 ounce in all inland waters of Massachusetts. This regulatory change will take effect January 1, 2012.

Fishing with waders is allowed along streams in areas of the Wachusett Reservoir watershed where appropriate access can be gained and there are limited public safety concerns. These areas are currently located on the Quinapoxet River upstream of the accretion dam on River Road and on the Stillwater River upstream of the confluence of the Stillwater River and Waushacum Brook at Thomas Basin. Year round fishing is allowed on the Quinapoxet River upstream of the accretion dam and on the Stillwater River upstream of the rail road trestle near Waushacum Street in Sterling. It is against the law to fish from or trespass on any railroad tracks or bridge. Massachusetts law (M.G.L ch. 160, §218) specifically prohibits a person from being present, standing, walking or riding a bicycle, snow vehicle, recreational or other vehicle on the right-of-way of a railroad or other property used or controlled by that railroad except at a highway or other authorized grade crossing. Violation brings a fine and any person who violates this section can be arrested without a warrant by law enforcement authorities.

Aquatic Invasive Species (see Section B – Boating above and/or Chapter X under Public Education/Interpretive Services/Public Outreach) pose a threat when using waders and fishing gear that has been submerged in an infested lake, pond, or stream area. Therefore, while fishing is allowed in many areas around the Wachusett Reservoir, it is important that users be vigilant about cleaning any fishing equipment (including waders). Any visible mud, plants, fish or animals should be removed before transporting equipment, and any fishing equipment that comes into contact with the water should be thoroughly cleaned and dried before using at the Wachusett Reservoir or any of its tributaries.

Ice fishing is prohibited on all DCR DWSP owned lakes and ponds.

D. Off-Road Driving

Off-Road driving using Off-Road Vehicles (ORVs) or All-Terrain Vehicles (ATVs) has been prohibited by regulation on all DCR/DWSP lands in all of its watersheds since 1989. ORVs and ATVs have been well documented to disrupt wildlife, alter natural hydrologic patterns, and increase sediment loading into streams and wetlands, impacting water quality and aquatic plant and animal life. ATVs can also open up areas that are currently inaccessible, subjecting them to increased use. ATVs and ORVs on slopes, streambanks, and stream channels cause erosion, turbidity, and sedimentation, all of which are detrimental to surface waters and natural resources.

E. Snowmobiling

Snowmobiling has been prohibited by regulation in the Wachusett Reservoir watershed since 1996. Snowmobile use was allowed on a trial basis prior to 1996 in a small section of the Wachusett Reservoir watershed. The agency discovered considerable damage to the land and users were straying from the marked paths, thus it became a prohibited activity. In addition to damage caused to natural resources, areas where snowmobiles are allowed become compacted and any winter rain may flood surrounding areas, affecting hydrologic patterns. Hard snow is more thermally conductive and the underlying ground can freeze to a greater depth. Because of this, vegetation can be affected and lead to erosion of the soil in the spring. This can lead to increased turbidity and sedimentation in streams and wetlands.

F. Horseback Riding

Horseback riding is prohibited by regulation on DCR/DWSP Wachusett Reservoir watershed lands due to the threat of fecal coliform contamination and the potential of other pathogens such as *Cryptosporidium* associated with domestic animal manures as well as increased potential for erosion on access roads. The Massachusetts Drinking Water Regulations 310 CMR 22.00 cite strict prohibitions on animals within 100 feet of a public drinking water reservoir and its tributaries.

Although horse wastes are organic, biodegradable materials, many of their biological and chemical properties can be detrimental to fish, insects, and other aquatic life if the waste gets into water bodies. Jane Frankenberger from Purdue University, in a 2006 webcast entitled “Pathogens in Animal Manure, Should We Be Concerned?” stresses the point of pathogen survivability of weeks to months in cool streams and river waters. She further states that when horses are allowed near streams, the amount of manure deposited may be small, but the pathway of contaminants to water is usually unimpeded.

Since all of the lands in the Wachusett Reservoir watershed are purchased for water supply protection, they are in close proximity to tributaries and surface waters that flow into the drinking water supply and do not allow adequate buffers between horse trails and water

resources. Additional road maintenance required to repair erosion impacts would also compromise the limited resources available to the Division for watershed protection.

Horseback riding is allowed over an extensive trail system on DCR/DWSP property in the Ware River watershed because these areas are sufficiently hydrologically distant from the Quabbin and Wachusett Reservoirs (see www.mass.gov/dcr/watersupply/watershed/maps/wrachorse.pdf).

G. Dogs and Other Pets

Bringing any animal, other than service assistance dogs, onto DCR Wachusett Reservoir watershed lands is prohibited by regulation. Dog and other domestic animal wastes contain an enormous amount of fecal coliform bacteria (23 million fecal coliform bacteria/gram of waste). They can also be carriers of pathogens, such as *Giardia* and *Cryptosporidium*, that can be passed on to both human and wildlife populations. Parasites found in domestic animal feces can be introduced into wildlife populations and ultimately into the water supply. Waste from domestic animals can directly enter into the reservoir or tributaries that flow into the reservoir. When pet waste is left on the ground, the bacteria and parasites can survive for long periods of time. During rainfall, it can get washed into the drinking water supply via overland flow and streams. In addition to bacterial contamination, pet waste also contains Nitrogen and Phosphorus. These nutrients, when deposited in large amounts, can disrupt water chemistry and quality.

Significant outreach has been conducted by DCR/DWSP staff to educate watershed residents and watershed visitors on the dangers of pet waste. Neighborhood letters, posters, brochures, and palm cards for use by the Watershed Ranger staff have been designed and used in this effort.



There are two exceptions to the domestic pet rules. Dog walking is allowed on DCR/DWSP land below the Wachusett Dam to the top of the spillway at posted signage because this is an area that does not drain into the Wachusett Reservoir. Dogs are also allowed for active hunting purposes with the appropriate permit and during a valid hunting season on DCR/DWSP lands in the Wachusett Reservoir watershed (in authorized hunting areas only). There is historic precedent for use of hunting dogs on large tracts of land owned by the DCR. The current minor use of hunting dogs, combined with the relatively short time frame of hunting season and the ability to track users through the DCR hunting permit process, poses a limited threat to water quality. The DCR hunting permit program should be modified to require sportsmen to pick up after their dogs while on DCR Wachusett Reservoir watershed lands.

People seeking to walk their dogs have other options in the watershed, including Leominster State Forest and Wachusett Mountain State Reservation. Regulations state that dogs must be on a leash of less than ten feet at these DCR State Park sites. Dog waste pick up bags are provided at Leominster State Forest in three areas.

H. Camping

Camping is prohibited on DCR Wachusett Reservoir watershed lands due to many factors. It is an activity that takes people away from regular habits for clean-up, washing, and waste disposal. Camping tends to generate more trash and litter than hiking or walking, but a lack of sanitation is a larger concern with this recreation activity. There are serious water quality concerns associated with the deposition of human fecal matter close to tributaries and reservoirs.

Impacts to soil and vegetation are environmental effects of camping that been extensively examined. It is estimated that in the United States that one quarter of the population hikes and camps as a recreational activity (Cordell and Super, 2000). Recent studies have shown that environmental effects from camping are not limited to the actual campsite, but also impact surrounding trails and vegetation. Camping areas soils can become compacted over time and ground vegetation can become void, allowing for a greater erosion and sedimentation potential. Studies have also shown that trampling of vegetation occurs as campers define new pathways and trees are removed or damaged for use as firewood (open fires are also prohibited on DCR Wachusett Reservoir watershed lands).

Given the environmental impacts, lack of sanitary facilities and the resources that would be needed to properly monitor, administer, and enforce this activity, DCR considers camping inappropriate for the Wachusett Reservoir watershed. There are many alternatives for this activity in the region, including several DCR state parks (www.mass.gov/dcr/recreate/camping.htm).

I. Hunting and Trapping

DCR/DWSP regulations prohibit hunting and trapping, except at times and in areas designated by the DCR. Currently, hunting is allowed on designated DCR Wachusett Reservoir Watershed Lands in the Tributary Headwaters Zone by special permit and possession of a valid

Massachusetts hunting license. Existing hunting season dates are set by MassWildlife. Hunters are required to follow all applicable state laws related to hunting and follow proper hunter ethics. No significant impacts have been noted since this activity has been allowed and continuation of the activity in these areas does not pose a significant threat to water quality. Licensed trappers can trap on DCR property with a special permit available through the Regional Director's office.

J. Hiking, Nature Study, Bird Watching, and Photography

Hiking, walking (without dogs - see G above), nature study, bird watching, and photography are all considered passive recreation activities and are allowed throughout the Wachusett Reservoir watershed with the exception of the areas within the Intake Protection Zone that are designated as “No Public Access.” Passive recreation encompasses the less intensive range of outdoor activities compatible with preserving natural resource functions such as floodplain protection. All of these activities have relatively minor impact to water quality. Walking on the surface of the Reservoir when frozen is strictly forbidden.

K. Cross-Country Skiing and Snowshoeing

DCR policy allows cross-country skiing in all areas where hiking is allowed in the Wachusett Reservoir watershed except along the Promenade at the top of the dam. Skiing is prohibited over the reservoir's frozen surface.

Snowshoeing is also allowed throughout the Wachusett Reservoir watershed except in those areas surrounding the Intake Protection Zone where public access is prohibited. Snowshoeing is prohibited over the reservoir's frozen surface.

L. Bicycle Riding

Regulations restrict off-road bicycle riding to designated areas of DCR/DWSP property. Currently these areas are limited to portions of the Mass Central Rail Trail that cross DCR land in Holden, Sterling and Rutland. Marked bicycle trails exist in a loop off of the trail on River Street in Holden. Bicycling is also allowed from DCR Gate 39 to the road below the dam on the lower road (old rail bed) of the North Dike only. The paved road below the dam is considered off watershed because it drains to the Nashua River and not the reservoir.

The City of Baltimore, Maryland has historically allowed bicycling on access roads within watershed lands that serve over 1 million people with their drinking water. Mountain bikes had created their own set of problems, and as a result, a Mountain Bike Plan was agreed upon and adopted by both the mountain biking community and the City of Baltimore in 1998. The plan had laid out clear guidelines and responsibilities for all of the parties to follow so that mountain biking could occur without negative impacts on their water supply. In a Press Release dated December 10, 2009 related to bicycling on watershed properties, the Department of Public Works states, “the approved trails were not sufficient for many, and single tracks now

honeycomb the reservoir. Vegetation has been destroyed, trees damaged, ramps built and the resulting erosion is threatening our drinking water supply. Our watershed lands are not parks and have never been parks. They are buffers to protect our most precious natural resource.” As of the writing of this plan, the debate over mountain biking in Baltimore drinking water reservoir watersheds is ongoing.

The recent issues with the City of Baltimore bicycling policy heighten DCR’s concern with this type of activity negatively affecting the Wachusett Reservoir by allowing pollutants to enter into the water system.

As stated in the previous case, bicycle riding has the potential to cause severe erosion when trails are not properly sited or maintained on a regular basis, and therefore bicycling is limited within the Wachusett Reservoir watershed. Bicycling is allowed at several nearby Central Massachusetts State Parks, including Leominster State Forest and on paved roadways at Wachusett Mountain State Reservation (www.mass.gov/dcr/recreate/mtnbike.htm).

M. Picnicking

DCR regulations do not prohibit picnicking on Wachusett Reservoir watershed lands. Picnic, in this context, is defined as a meal eaten outdoors. Picnickers are responsible for removing all trash from the property.

It is important to note that DCR prohibits groups of 25 or more without a special permit. Special permits are issued through the Wachusett/Sudbury Regional Director. Permit applications are currently available upon request directly to the Regional Director’s office; permit applications, similar to those for Ware River and Quabbin Reservoir watersheds, should be made available online. DCR regulations also prohibit any fires, any cooking activity, and all alcoholic beverages on watershed lands under the care and control of DCR/DWSP.

N. Geocaching and Letterboxing

Geocaching and letterboxing are relatively new outdoor recreation activities. Geocaching is an outdoor activity in which participants use a Global Positioning System (GPS) to hide and seek containers, called “geocaches” or “caches”, anywhere in the world. A typical cache is a container (tupperware or similar) that contains items for trading, usually toys or trinkets of little value. Geocaching is also described as a game of high-tech hide and seek. Letterboxing is a similar activity but does not normally use the aid of GPS. Letterboxing is an outdoor hobby that combines elements of orienteering, art, and puzzle solving. Letterboxers hide small, weatherproof boxes in publicly-accessible places and distribute clues to finding the box in printed catalogs, on one of several web sites, or by word of mouth. Individual letterboxes usually contain a notebook and a rubber stamp. Finders make an imprint of the letterbox’s stamp, either on their personal notebook or on a postcard, and leave an impression of their personal stamp on the letterbox’s “visitors’ book” or “logbook” — as proof of having found the box and letting subsequent letterboxers see who have visited.

There are approximately 28 registered geocaches and 17 registered letterboxes currently placed on DCR Wachusett Reservoir watershed property as listed on www.geocaching.com and www.letterboxing.org. Many of these listings remind participants that the hidden sites on DCR Wachusett Reservoir watershed property have rules and regulations that must be followed, that dogs are not allowed, and a few even describe the water system. At this time, there are over 1,500 geocaches placed within a twenty mile radius of the DCR headquarters building in West Boylston, and over 400 letterboxes in Worcester County, a testament to the growing popularity of this outdoor activity.

Geocaching and letterboxing are allowed on DCR Wachusett Reservoir watershed lands, however, there are several rules for this type of activity to ensure minimal impact on the natural and cultural resources. DCR drafted a statewide policy in 2007 for Geocaching and Letterboxing on all DCR lands, including the watersheds. At this time, current DCR Wachusett Reservoir watershed geocaching/letterboxing guidelines (Appendix B) encompass portions of the draft statewide policy, including:

- 9 All caches to be placed on DCR Wachusett Reservoir watershed property must be registered on www.geocaching.com or www.letterboxing.org, noting that DCR Wachusett Reservoir watershed rules must be adhered to when on the property. Each cache must contain contact information of the owner. In the event a cache has to be removed by DCR staff, effort will be made to notify the owner.
- 9 Caches placed in no trespassing areas or areas deemed to be inappropriate by the DCR Wachusett Watershed Rangers will be removed immediately and kept at the Watershed Ranger office for thirty days. Effort will be made to notify the owner of the cache.
- 9 Caches CANNOT be placed in the following locations:
 - Areas that would encourage disturbance or dismantling of historic structures, historic buildings, rock walls or cellar hole foundations.
 - Wetland resources protected under the 310 CMR 10.00.
 - Areas that could potentially cause danger to visitors trying to locate the cache.
 - Underwater or in streams.
 - Wildlife dens.
 - Restricted access areas of the DCR Wachusett Reservoir watershed.
- 9 Caches must be in transparent containers, e.g., Tupperware or Rubbermaid. Metal (ammo boxes), PVC pipes, or other non-transparent containers are prohibited.
- 9 No digging or excavation is permitted at any time in the placement or retrieval of a cache.
- 9 No defacement or alteration to DCR Wachusett Reservoir watershed property, including but not limited to signs, benches, buildings, or natural features is allowed.
- 9 No removal or significant disturbance of vegetation, plant growth, or other flora is permitted at any time in the placement or operation of a cache.
- 9 Caches will not contain food, alcohol, firearms, drugs, dangerous items (e.g., fireworks or matches), or sexually explicit material. No natural materials from DCR Wachusett Reservoir watershed lands shall be placed into the cache.
- 9 No monies or profits can be derived from the placement of a cache by the owner or an affiliated business or organization.
- 9 Any questions regarding geocaching or letterboxing can be directed to the DCR Wachusett Reservoir Watershed Rangers at 978-365-3800.

The geocaching guidelines should be made available through the DCR website and placed on kiosks and bulletin boards. These guidelines are subject to change based on future statewide DCR policy and/or problems with current implementation.

O. Paintball

Paintball is prohibited on DCR Wachusett Reservoir watershed lands. Paintball is another relatively new outdoor recreational activity in which players compete, in teams or individually, to eliminate opponents by hitting them with capsules containing paint. Although an air gun is not considered a weapon in Massachusetts, many paintball guns are made to look like authentic weapons. Serious security concerns arise with having this type of activity near sensitive areas such as a drinking water supply. There are other factors to consider with this activity including: paintball debris and paint left behind destroys the aesthetics of natural areas; remains of paint on trees, signs, historic structures, can be considered defacing state property; and paintball markings left on trees can conflict with official DCR Wachusett Reservoir watershed markings such as boundary or forestry work. The likelihood of vegetation being trampled, new trails being blazed, vegetation being cut, and litter left behind are all very high with this activity. Paintball can also be perceived as an organized activity, which is against DCR watershed regulations. Paintball activity is not compatible with other passive recreational activities and uses of the watershed lands.

P. All Other Activities

As previously stated, any activity not identified should be presumed to be prohibited on DCR Wachusett Reservoir watershed property. Questions concerning an activity not cited in this plan should be directed to the Wachusett/Sudbury Watershed Rangers at 978-365-3800.

VI. Discussion and Recommendations by Management Zone

This section provides a status report and policy assessment for each of the management zones described in Chapter IV. The DCR has implemented numbered gates to access roads within the watershed. This allows a useful reference for describing access entry points for both monitoring and public safety purposes. The gates are numbered sequentially, in a clockwise order, around the Reservoir beginning at the Wachusett Dam on Rte 70. Gates 1 – 16 are located along Route 70, Gates 17-26 along Route 140, and Gates 27-42 along Route 110. Most other gates in the watershed have been numbered beginning with the letter of the town the gate is located in.

A. Intake Protection Zone

In the 2003 Public Access Plan Update, the “Off-Watershed Lands Zone” became a part of the Intake Protection Zone, although drainage from these areas flows off of the watershed to other water bodies, not the Wachusett Reservoir. These off watershed lands include the portion of the North Dike from Gate 36 to 40 away from the shoreline that is not fenced, the roadway below the Dam, including the fountain and river area, a majority of the Promenade at the top of the Route 70 side of the dam, land across from Gates 1-5 on the West Side of Route 70, a few parcels in Boylston, and a small area around Old Campground Road in Sterling. DCR is still required to protect the natural resources under its care and control but the rules differ in these specific areas (see below for specific areas and allowed activities) as recreation is not a threat to the drinking water supply.

Most of the boundary of the Intake Protection Zone is fenced and posted with DCR/DWSP signs. New “No Trespassing” signs are posted at DCR/DWSP Gates 1-5, which are north of the Fishing Limit. A four foot fence lines a majority (from the spillway to Gate 38) of the North Dike to prevent shoreline access and no public access is allowed on any rip rap of the North Dike beginning at Gate 36. The remaining portion of the North Dike is open to the public and was previously managed as Off-Watershed Lands. The North Dike is a very popular area and receives heavy use during all seasons. The most frequently used access points are Gates 36 and 39. Any public access to any of the Reservoir islands is strictly forbidden.

The “No Public Access” policy works well, greatly reducing the concerns of improper access in this zone. Nevertheless, trespassing is an ongoing problem, with the most frequent violations on the Route 70 side of the reservoir, and often shoreline fishing around Gate 5, the boundary of the “no access zone.” “No fishing beyond this point” signage on the shoreline has been replaced several times, and in an attempt to make the no trespassing area more clear, a wire fence has been placed perpendicular to the water from the hillside and is posted with a No Trespassing sign. Trespassing in the area between the Promenade of the dam and Gate 1 has been observed to be an issue as many visitors utilize this area to watch the sunset near the shoreline. Additional signage at the shoreline and/or the addition of a fence or barrier would curb any potential activity and make the limits of public access clear.

Figure 5. Wachusett Reservoir Protection Zones

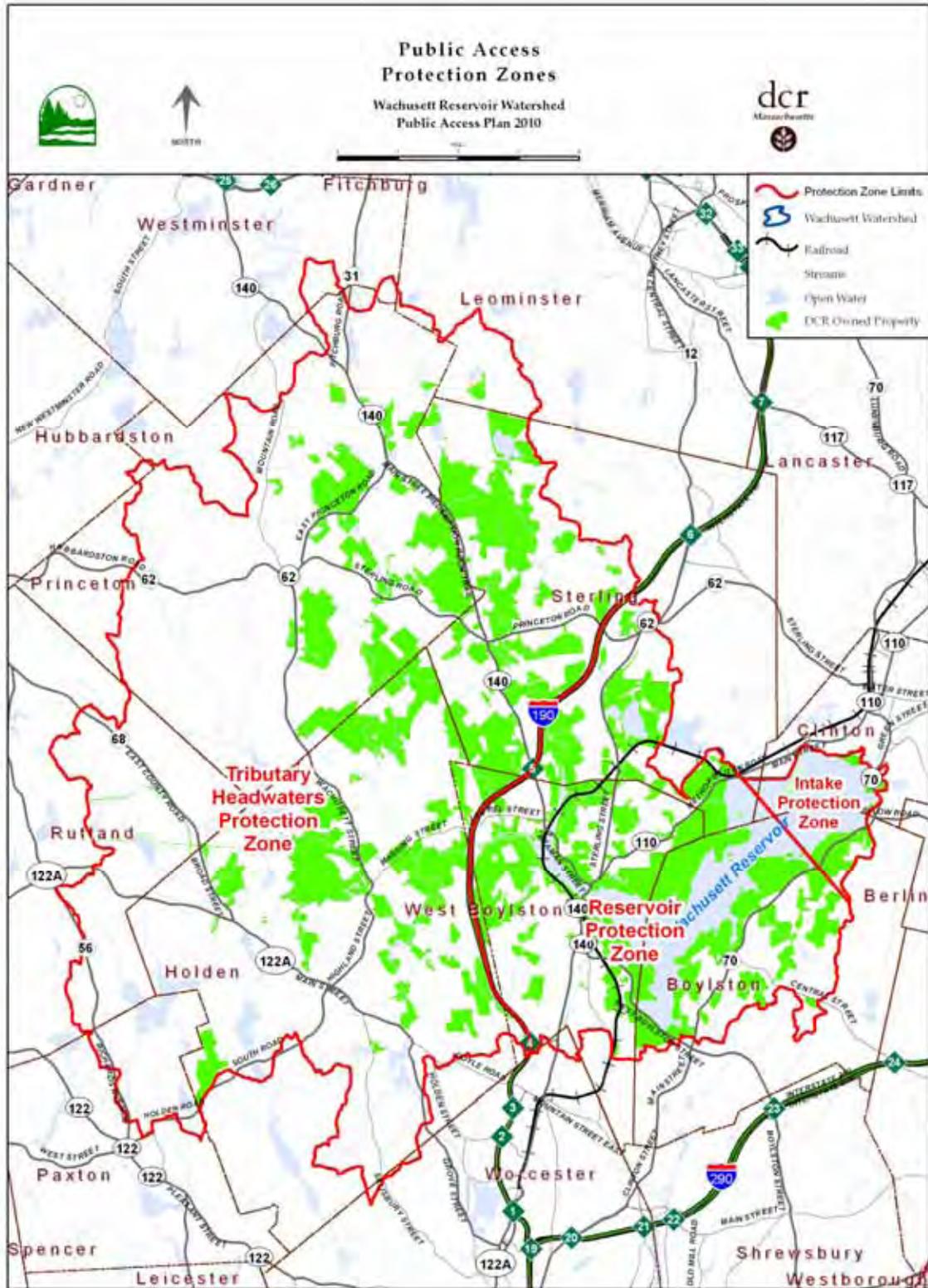
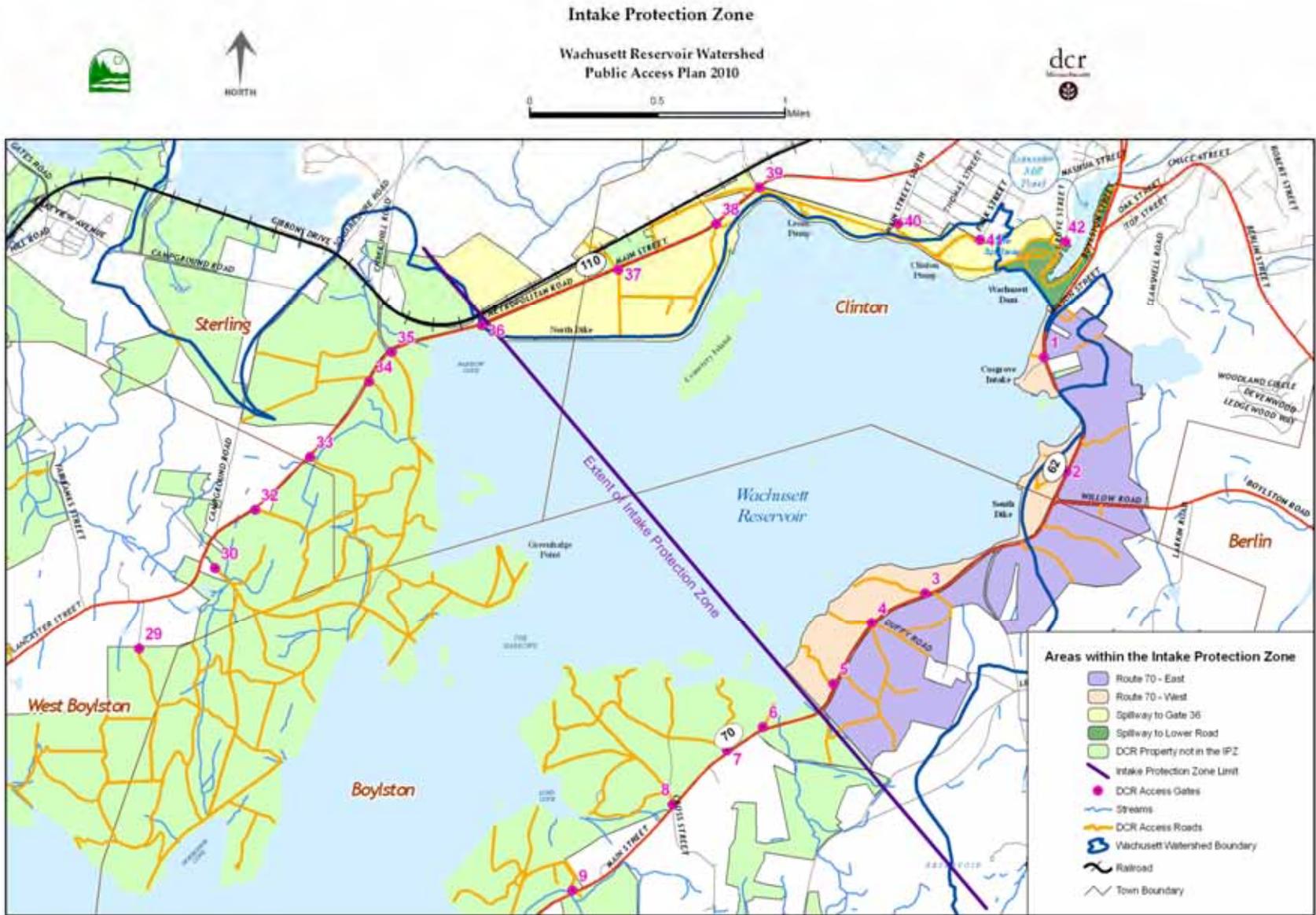


Figure 6. Wachusett Reservoir Intake Protection Zone and Gate Numbers



DCR Watershed Rangers have increased patrols and monitoring in this area since the events of September 11, 2001 and general awareness has been heightened by DCR/DWSP staff. State Police routinely patrol the watershed and pay special attention in this area.

The Intake Protection Zone has been divided into five areas to provide simplicity for discussion, enforcement and mapping purposes:

1. Spillway to Lower Road (including the spillway, fountain area, and river).
2. Promenade of the Dam Route 70.
3. Spillway to Gate 36.
4. Route 70 East (Non-reservoir side of Route 70).
5. Route 70 West (Reservoir side of Route 70).
6. Off watershed lands

1. Spillway to Lower Road

One major area where the “No Public Access” rules differ from the all other parts of the Intake Protection Zone is the area below the Wachusett Dam, including the fountain and mill pond. All drainage from this area flows into the Nashua River, not the Reservoir. Nearby residents use this area frequently for daily walks, jogging, etc. Dog walking (leashed) is allowed on the paved roadway and along the spillway. Signage has been posted at the limit of dog walking. Dog walkers are required to pick up after their pets and must have pick up bags with them while in this area. Bicycling and fishing are allowed. Fishing season begins the first Saturday in April until November 30 (both dates provided no ice is present).

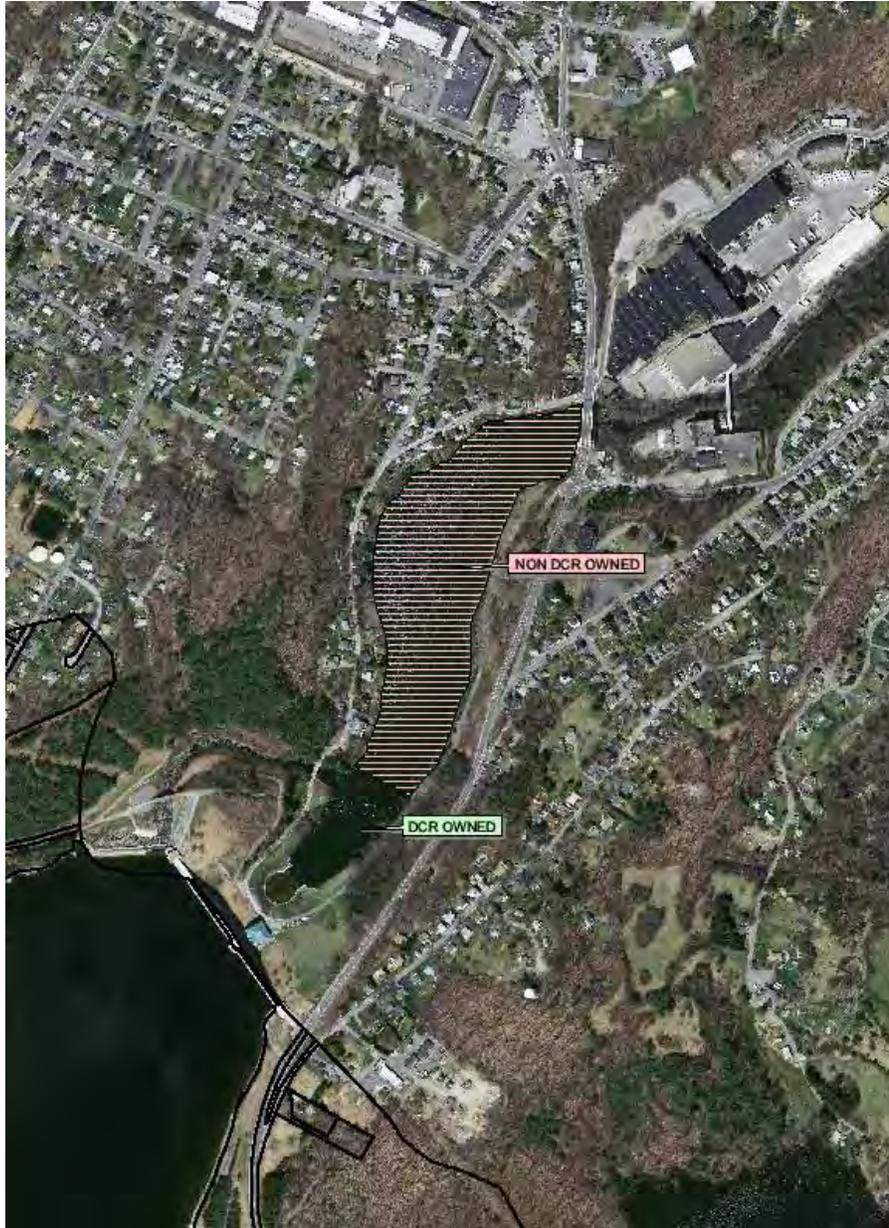
Currently, public access is limited at this location as the road leading to the Dam from Route 70 is indefinitely closed due to a road wash out. This location is posted “No Trespassing,” even for foot traffic due to the wash out and public safety risks associated with the rough surface of the roadway as well as having no guardrails or fencing in place to the river. Rangers have reported that even with proper signage, trespassing here is still an issue. Public can access the open portion of the areas below the dam from Gate 42 on Grove Street although parking is very limited.

In the past, there has been much confusion when dealing with water recreation public access issues on the Lancaster Mill Pond. With the renovation of a mill building on Green Street into over 120 condominiums, it is important that these public access issues be explained and proper signage be posted, as the use in this vicinity will most likely increase. The area once served to impound water for industrial use by mills that are no longer in operation. Much of the confusion stems from the fact that DCR does not own the pond in its entirety; in fact, only a small portion is DCR-owned, from the fountain to approximately 275 feet downstream of the remaining concrete railroad bridge abutments. It is privately owned from this point to the Route 70 Bridge (**Figure 7**).

From historical records, it appears that this pond parcel transfers with a portion of the old Lancaster Mills, most recently sold in 2008. DCR cannot grant recreation opportunities or public

access to areas that it does not own; conversely, the agency does not automatically allow its properties to be utilized in obtaining recreation access to privately owned areas.

Figure 7. Lancaster Mill Pond Ownership



Shoreline fishing is allowed downstream of the fountain impoundment to the DCR property line (just beyond the concrete blocks). Any access to the fountain or spillway is strictly prohibited. Because DCR owns such a small amount of the pond, boating and canoeing is not allowed. Swimming and ice fishing are prohibited as well on the DCR portion. This area should be considered a priority when placing additional kiosks or bulletin boards on DCR property, and should include a map of property ownership.

The Division reserves the right to limit public access in this area due to emergency situations, public safety issues, or security risks when conditions warrant. Proper signage will be posted in the event that closure is necessary.

2. Promenade of the Wachusett Dam Route 70

This is one of the busiest areas for visitors and residents as the views are spectacular, especially during sunset. This area has been posted “No Trespassing” for much of the past nine years. Initially closed due to the events of September 11, 2001, it was re-opened in 2005. It was closed again in 2007 upon the discovery of Polychlorinated Biphenyls (PCBs) in the 1950s’ era caulking in the upper walkway of the dam. Remediation was overseen by MWRA. The area was able to be re-opened to the public in December 2010.

Dogs and bicycling are not allowed in this area and sledding (of all types) is prohibited on the hillside. Access to the shoreline of the Reservoir is strictly forbidden.

3. Spillway to Gate 36

A portion of this area is managed as “No Shoreline Access” and a portion was formerly managed as Off-watershed. There is no shoreline access from the dam to approximately two miles along the North Dike (fencing or rip rap). A majority of this section is fenced with signage, and a sign is posted at the No Shoreline Access limit, near Gate 36. Public access on any rip rap along the North Dike is prohibited. Signage is needed at this location. The limit of fishing is also near this location close to Gate 36 and is also posted. The North Dike is open for walking, jogging, cross-country skiing and snowshoeing. These same activities are also allowed on Division owned property on the North side of Route 110 (across Route 110 from the reservoir) within this protection zone. All other activities are prohibited.

An old rail bed remains from Gate 39 to the dam. Bicycles are allowed at this location of the North Dike only and a “no bicycles beyond this point” sign has been placed at the intersection of the rail bed and the North Dike. Bicyclists can enter at Gate 39 and follow the rail bed to the spillway of the dam. From the spillway, bicycles are allowed down to the paved lower roadway only. Signage is needed near Gate 40 alerting bicyclists that they are not allowed on the top of the dike.

4. Route 70-East (Non-reservoir side of Route 70 from Gate 5 Area to the Promenade)

These lands lie primarily along the east side of Route 70 across from Gates 1-5. Foot access only is allowed (hiking, walking, snowshoeing, cross-country skiing) in these areas, with the exception of the property between Willow Road (Route 62) to Mile Hill Road due to public safety risks. This area is posted “No Trespassing.” Dog walking and bicycling is prohibited.

5. Route 70-West (Reservoir side of Route 70 from Gate 5 Area to the Promenade)

This area is no public access and is posted accordingly.

6. Off-watershed Lands

These lands include Old Campground Road in Sterling and the area primarily around South Meadow Road in Clinton. Walking, hiking, cross-country skiing, and snow shoeing are the only activities allowed on these properties.

General Recommendations

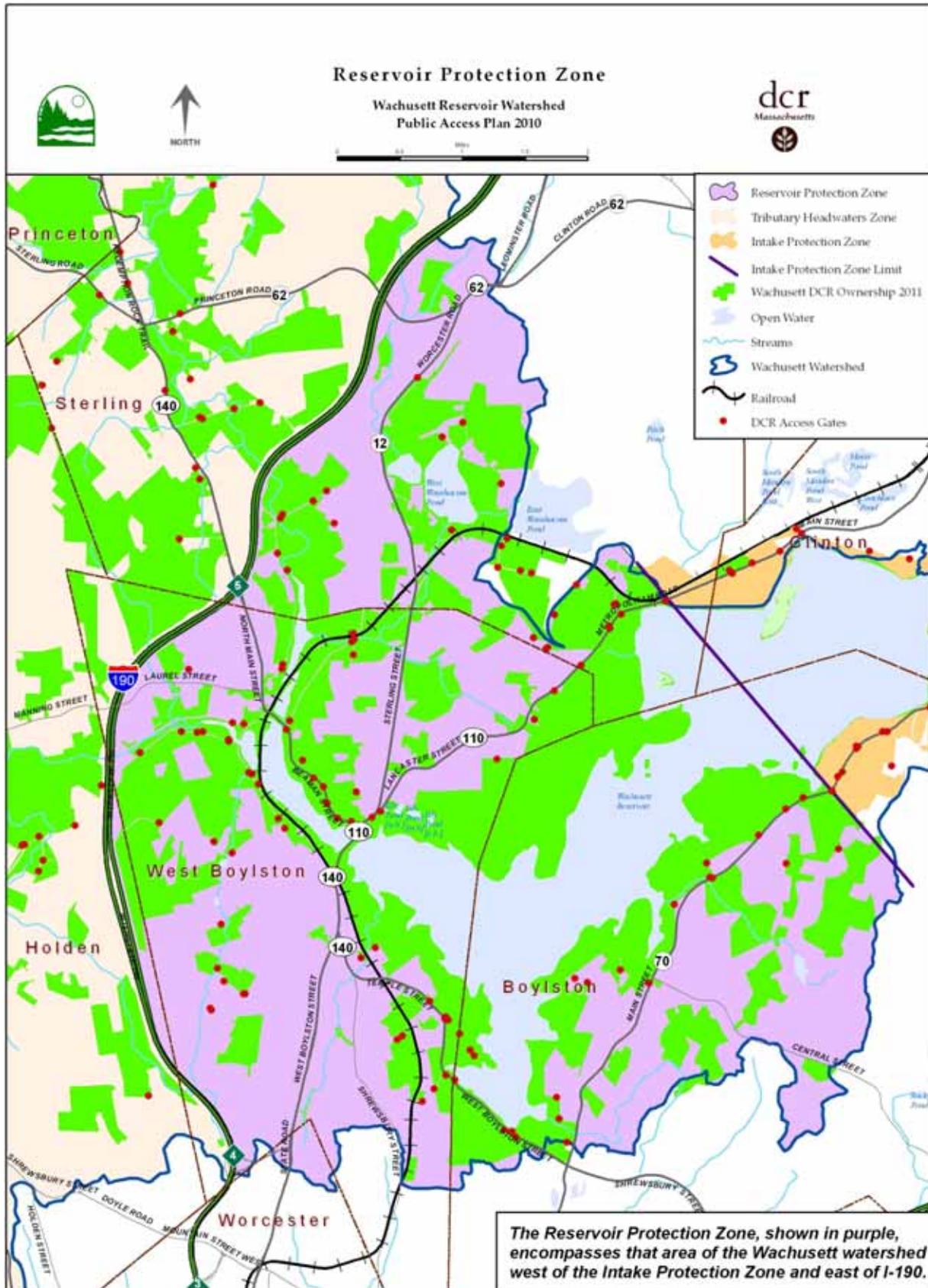
- Have Watershed Rangers continue to enforce regulations and maintain cooperative efforts with local and state police on all enforcement issues with the priority on the security of the intake structures.
- Update kiosk information with rules and regulations stressed at the promenade as this area has been off limits for an extended period of time.
- Consider installing a kiosk or bulletin board with DCR ownership maps of the mill pond at the road below Wachusett Dam.
- Add “No Trespassing After Dark” signage in the area of the Promenade.
- Verify rules signage on the east side of Route 70 in Boylston for accuracy.
- Ensure that No Trespassing boundaries are clearly marked in the area of Route 62 (Willow Road) to Mile Hill Road.
- Post “No Access On Rip Rap” signage near Gate 36.
- Post signage near Gate 40 alerting bicyclists that they are not allowed on the top of the dike.

B. Reservoir Protection Zone

The Reservoir Protection Zone includes all DCR land around the reservoir that lies beyond the four-mile Intake Protection Zone, and other DCR land adjacent to the Thomas Basin and West Waushacum Pond (**Figure 8**). Allowed uses include walking, hiking, seasonal shoreline fishing, cross-country skiing, and snowshoeing.

Year-round shoreline fishing is authorized on the Quinapoxet River upstream of the accretion dam, and on the Stillwater River upstream of the railroad tracks (it is against federal law to trespass on railroad property). Fishing with waders is allowed upstream of the accretion dam on the Quinapoxet River, and upstream of the confluence with Waushacum Brook on the Stillwater River. Non-motorized boating and fishing are authorized at West Waushacum Pond from the first Saturday in April (providing no ice is present) until November 30. Canoeing is allowed on the Stillwater River upstream of the bridge on Muddy Pond Road and on the Quinapoxet River upstream of the accretion dam.

Figure 8. Reservoir Protection Zone



No bodily contact with water (i.e., swimming and wading) is allowed in this zone except for fishing with waders in the above mentioned areas. Access is from one hour before sunrise until one hour after sunset only.

General watershed regulations state that access and exit from DCR Watershed property must be through DCR gates or other DCR designated entrances. Steel closure gates and fencing restrict access to much of the DCR/DWSP lands in this management zone. These gates are important to maintain, not only for public access but also to eliminate illegal dumping and vehicular access on DCR property.

There are many heavily used sites in this management zone, including the Old Stone Church, Stillwater Farm, Thomas Basin, Mass Central Rail Trail, Bob's Hot Dog Truck, Mass Wildlife Headquarters and West Waushacum Pond. Previously, parking was a problem at several areas, causing erosion and parking along main roadways. Several new parking areas have been constructed, including Thomas Street, Gate 25, Gate 8, Mass Wildlife, and near the Mass Central Rail Trail on Gates Road. New rules signs now include universal symbols for authorized and prohibited activity. The rules signs are posted at all gates. Kiosks and bulletin boards have been added at several heavily used locations and information is updated on a regular basis by the Ranger staff.

Despite regulations being well posted, trespassing at night is an issue at several areas within this zone, most noticeably at the Old Stone Church and Rail Trail. Dog walking has also been a problem in this management zone, despite posted signage. DCR has done an extensive amount of outreach through many avenues regarding dogs on watershed property, and Rangers have been given cards to be used in the field when a dog walking violation is encountered in an attempt to curb this activity (see Appendix F).

In season, occasional swimming and wading is prevalent at many areas in this management zone. Rangers continue to patrol with emphasis on these activities during the summer. In the past, bicycling had been an issue inside Gates 25- 23 and 35-28 because of the many access roads. Bicycling has not been as much of a problem since the rail trail was constructed and trails made available further away from the reservoir.

While ATV/Snowmobile use is not allowed, there has historically been trespassing issues. While this activity has decreased around the reservoir itself, trespassing is still prevalent across from South Bay on Route 140 along the power line and railroad rights of way.

The West Boylston portion of River Road, from the Oakdale Power Station to the Route I-190 overpass is currently blocked off to vehicular access due to deteriorated road conditions. Because of the road closure, canoeing and kayaking along this section of the river has been limited as there is no vehicular access to the take out point. This road closure is currently serving as a protection for water quality in the Quinapoxet River, but has the potential to allow for illegal uses on DCR property that did not exist previously, both during the day and at night. As DCR/DWSP owns property on both sides of this currently closed portion, DCR must be more vigilant in patrolling for illegal uses and working with law enforcement to eliminate any rules violations observed. Contact is needed with the Town of West Boylston to install an access gate at either end of this road to provide emergency access for DCR as well as West Boylston Police and Fire Departments.

Changes have been made at the Oakdale softball field on Route 140 since the last Wachusett Public Access Plan update. In accordance with DEP regulations, a water supplier must be in control of activities that occur within 400 feet of a water supply. Since the lease of the fields had expired in 1992, DCR has allowed the area to return to its natural vegetated state and access is limited.

General Recommendations

- Coordinate with railroad and utility companies to limit public access by ATVs and snowmobiles on their rights-of-way.
- Continue to monitor for illegal dumping and add barriers when needed.
- Continue to monitor use of sani-cans and relocate to different areas if needed.
- Monitor use of property along closed River Road for illegal activity and work with law enforcement to curb any observed activity.
- Post additional signage listing emergency phone numbers and a reference gate number at key areas of the shoreline, where the reservoir is a long distance from the gate.
- Post the link to the Public Access Plan on kiosks and bulletin boards.
- Verify all management zone rules signage correspond with Public Access Plan management zones; replace and/or update as necessary.
- Work with appropriate authority to re-paint “No Fishing/Standing From Bridge” on Thomas Street at the Quinapoxet River.
- Maintain access trail from River Road to the handicapped platform on the Quinapoxet River.
- Consider advances in technology when making decisions related to public safety in this management zone. For example, a February 2010 study estimated that 75% of teens and 93% of adults owned a cell phone, and a majority of these owners used cell phones to access the internet on a regular basis (<http://pewresearch.org/pubs/1484/social-media-mobile-internet-use-teens-millennials-fewer-blog>). Explore the addition of emergency contact numbers in several key areas of the shoreline where the gate is a long distance from the reservoir. Gates 8, 23, 25, 30, 35, and 37 should have these postings for emergencies, such as a health related incident where a phone number is needed immediately. The sign should also reference a gate number for the fastest access that can be relayed to responders during the call.
- Place a link to the Public Access Plan on all kiosks and bulletin boards.
- Maintain the access trail leading from River Road to the handicapped fishing platform constructed in 2004 as an Eagle Scout Project near MWRA Shaft #1 on the Quinapoxet River.
- Work with the Town of West Boylston to install an access gate at either end of River Road to provide emergency access for DCR as well as West Boylston Police and Fire Departments.
- Develop monitoring program to evaluate sani-can usage.
- Post limit of fishing with waders signage at confluence of Waushacum Brook and Stillwater River.
- Post information on control of Aquatic Invasive Species.

Site Specific Recommendations

1. Old Stone Church

This area is heavily used, mainly during the warmer months. It is a priority for Ranger patrols in order to continue educating visitors about rules and regulations. This is a very popular area for wedding photography in the summer and fall, with some parties unaware of the special permit requirement for groups over 25 people. Dogs, wading, and swimming are also occasional issues at this site. Night trespassing has become a problem over the past few years.

The lack of parking at the Old Stone Church also creates significant public safety concerns. There is no dedicated parking lot at this site; cars are limited to parking alongside the public roadway. DCR does not have the ability to provide adequate parking facilities in this area for large gatherings. Groups of 25 or less people can continue to utilize this walk-in only area for wedding photographs or ceremonies on a first-come, first-served basis with no permit or pre-arrangement with DCR. DCR regulations (350 CMR 11.09(2)(a)18) require a permit from the Regional Director for any gathering of more than 25 people. Due to the array of public safety issues involving inadequate parking, staff resources and water quality impacts, DCR will no longer issue group use permits for this site.

- Add no trespassing after dark signage to both gates to allow local and state police greater enforcement ability.
- Continue dog waste education by staff and information on kiosks.



Old Stone Church

2. Bob's Hot Dogs

This area at the junction of Routes 140 and 12 was previously thought to be under the control of the MA Department of Transportation. DCR/DWSP, however, has since been found to be the owner of this parcel; therefore, DCR rules and regulations now apply in this area. The kiosk installed at this location gets very good visibility and should continue to be utilized as much as possible. Parking, especially during the summer months, continues to be a problem in this area. The road shoulder along the reservoir side of the triangle is a common place for visitors to park. DCR should discuss improving this area with the Town of West Boylston, as there is approximately an 8" drop from the edge of pavement. Improvements would eliminate the threat of a water quality issue as well as improve public safety.

It is important to note that Bob's Hot Dog truck parks on a public way with a permit from the town, and not on Division property. Visitors who purchase items from this truck utilize Division property for picnicking. Trash in this area has not been a problem, as the truck also provides a trash barrel.

- Prioritize maintenance of the brochure box and kiosk, as this area is very busy during all seasons.
- Discuss improving the road shoulder along the reservoir side of the triangle with the Town of West Boylston.

3. Stillwater Farm Interpretive Site

The Stillwater Farm Interpretive Site in Sterling is an environmental education facility managed by the Division of Water Supply Protection. This 55 acre site on the Stillwater River hosts an 18th century farmhouse and a self-guided interpretive trail. The facility provides individuals and groups an opportunity to better understand the connections between land use and community character, and between natural resource protection and land management. Stillwater Farm, through scheduled programs and events, demonstrates both past and present interactions between the working landscape and resource stewardship. Particular emphasis is given to watershed related issues and dynamics. The site is staffed regularly by Interpretive Services from Memorial Day to Labor Day, and the interpretive shed contains brochures and educational materials year round.

- Utilize kiosk for timely watershed related information.
- Consider developing a permanent multi geocache trail using relevant watershed and water quality facts.

4. Rail Trails

There are currently three rail trails on DCR/DWSP property. One begins off of River Road in Holden and extends to land owned by the Town of West Boylston. The second is the Sterling section off of Gates Road. The third is a trail off of Route 68 in Rutland. Dogs continue to be a problem in Holden and Sterling as the trails are partly owned by other entities. "No Dogs Allowed" signs have been placed at paths that lead to the Quinapoxet River off of the Oakdale

section. Rangers continue to enforce this regulation and educate the public with the use of informative palm cards (see Appendix F). Night trespassing has also become an issue, particularly at the Oakdale section. Illegal posting of inappropriate materials and stickers had been an issue along the Sterling section, but has been curbed by Ranger and law enforcement involvement. Due to the expansive size of the trail, a map is not included within this plan, but can be found online through the Wachusett Greenways website at: www.wachusettgreenways.org/Trail%20map.html.

- Continue dog education when violators cross onto DCR/DWSP property.
- Coordinate with local and state police to enforce no trespassing after dark regulations. Place signs as needed and perform occasional night patrols.
- Coordinate with Wachusett Greenways and the Town of West Boylston to place a dog waste station and odorless collection system near the beginning of the trail.
- Talk with the Town of West Boylston about posting “No Trespassing After Dark” signs on their section of the trail.
- Continue to partner with Wachusett Greenways and others, such as the Clinton Greenway Conservation Trust, regarding appropriate extensions of the rail trail and other connections on DCR land.

5. West Waushacum Pond

There are no major issues in this area, but litter and trash is an ongoing problem. Outreach, education, and modified signage should be used to address this issue. New signs have been placed that include correction of the spelling of Waushacum and also list the authorized fishing season. Electric motor boats, canoes, and kayaks are allowed on West Waushacum Pond provided that all regulations related to boating be followed, including the wearing of appropriate Personal Flotation Devices (PFDs) from September 15 through May 15 and year round for children under twelve years of age. It is also a requirement to have a wearable personal flotation device for each person that is on the boat. The purchase of kayaks for Ranger staff has allowed patrol of the waters and island. Prior ATV and snowmobile use has declined due to the upgrade of the old rail line to a bicycle trail (Sterling section of Mass Central Rail Trail) and barriers that have been put in place. DCR owns a significant portion of this rail trail, allowing cross-country skiing, walking, jogging, bicycling, and snowshoeing. Dogs are not allowed, but have been observed despite signage.

- Utilize outreach, education, and modified signage to address ongoing litter and trash problems.
- Continue on-going Ranger patrols and coordination with local and state police.

C. Tributary Headwaters Zone

The Tributary Headwaters Zone is comprised of watershed lands that are most distant from the Wachusett Reservoir and its nearby tributaries, extending from Route I-190 west to the watershed boundary (**Figure 9**). All activities that are allowed in the Reservoir and Tributary Shorelines Zone are allowed in this zone - walking, hiking, cross-country skiing, and fishing. Due to the distance from the reservoir, additional activities are authorized in this zone, including hunting, bicycling and canoeing at areas designated by the Division.

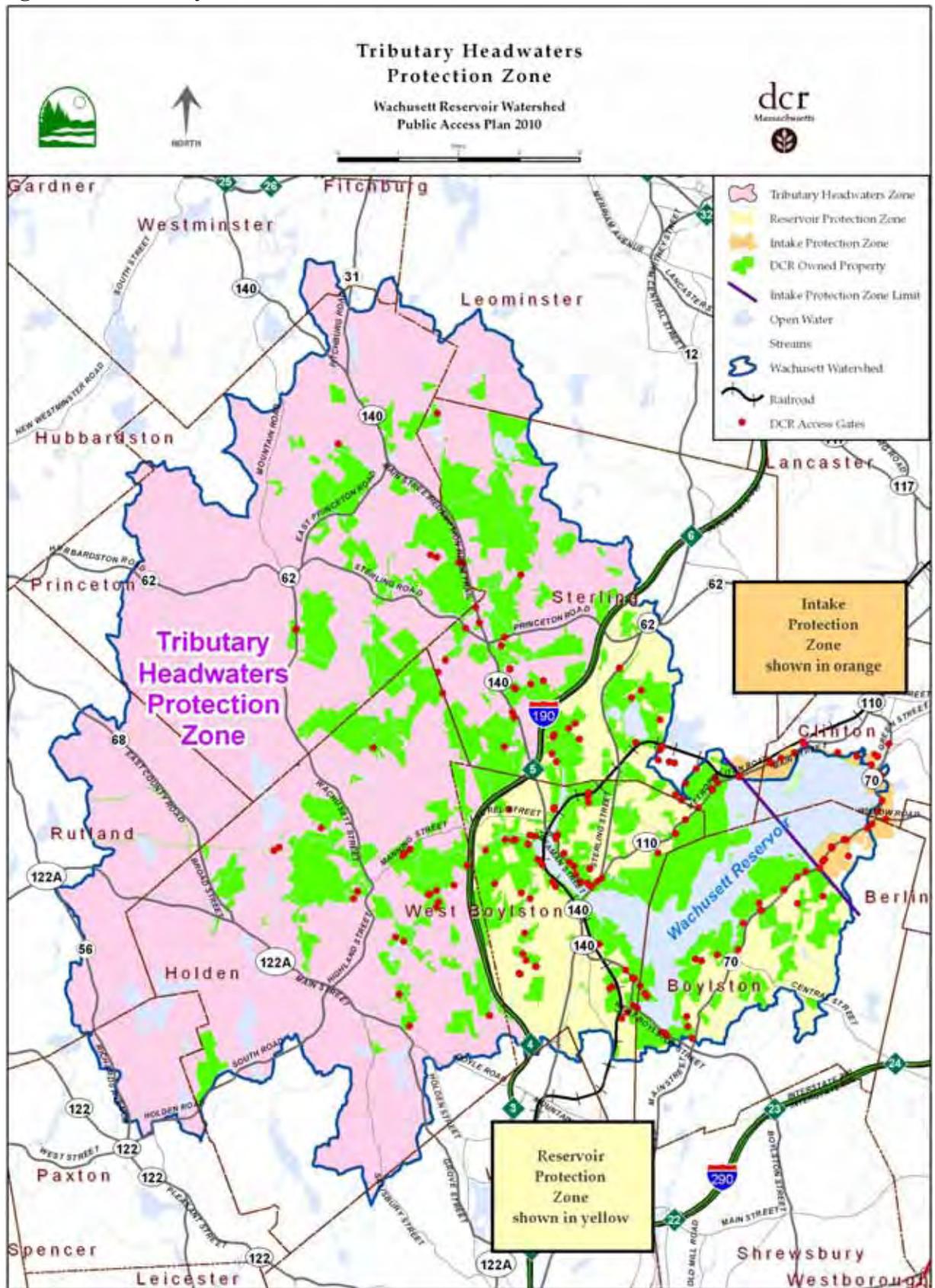
Hunting is allowed in this zone on DCR/DWSP lands west of Route I-190 and North of Route 62. All state, federal and local hunting laws apply and a free DCR Watershed Hunting Permit must be in possession at all times. The permit application is available for download from the DCR website at www.mass.gov/dcr/watersupply/watershed/documents/wachhunt.pdf, as well as at the DCR headquarters and Wachusett Reservoir Watershed Ranger Station. A map of designated hunting areas is distributed with each hunting permit. Designated hunting areas are based on state hunting regulations within the Tributary Headwaters Zone. MassWildlife regulations prohibit the “discharge of a firearm or release of an arrow upon or across any state or hard surfaced highway, within 150 feet of any such highway, or possession of a loaded firearm, discharge of a firearm or hunting on the land of another within 500 feet of any dwelling or building in use, except as authorized by the owner or occupant thereof.” This regulation limits hunting on the smaller parcels of DCR/DWSP lands in the Tributary Headwaters Zone and maps are prepared accordingly. During hunting season, notices are placed at all parcels where visitor use is high, reminding hunters that it is a multi-use area, and other users that hunting is allowed and that they should wear bright colors, such as hunter orange, while in the woods.

The Division’s designated off-road bicycling area is also in this zone. This area is on the DCR-owned section of the Mass Central Rail Trail and a few marked trails that spur off in two distinct areas in Holden (Mill Street and Manning Street to Route 31).

Hunting and bicycling were originally an allowed use in these areas on a trial basis. After finding that no impacts to the water supply or resource degradation occurred as a result of these activities, they are now both authorized by the Division.

Canoeing and kayaks are allowed on the Quinapoxet and Stillwater Rivers upstream of Thomas Basin. Canoes must be taken out of the Quinapoxet River just before the accretion dam and from the Stillwater River at the bridge located on Muddy Pond Road. Both lower limits of canoeing and kayaking fall within the Reservoir and Tributary Shoreline Zone. No special permit is required, as this is a fairly low use activity and the season is short. All state regulations related to boating must be followed, including the wearing of appropriate Personal Flotation Devices (PFDs) from September 15 through May 15 and year-round for children under twelve years of age. When conditions are deemed dangerous (i.e., after intense rainfall), Ranger staff reserves the right to limit this activity and post notices accordingly. Division staff continues to monitor this activity, but no significant adverse impacts to water quality or DCR/DWSP lands have been found. As stated previously in this report, at this time, the West Boylston section of River Road has been closed to vehicular access, limiting the canoeing and kayaking along the Quinapoxet River.

Figure 9. Tributary Headwaters Protection Zone



Old signage is still observed on occasion at properties in this zone, which state that picnicking is prohibited on watershed lands. These signs should be replaced when located. Additional signage should be placed along the Quinapoxet River for canoeists and kayakers, including a warning sign leading up to the accretion dam and a permanent warning sign at Canada Mills stating that conditions can become dangerous during times of high water levels and that users are at their own risk as well as information about Aquatic Invasive Species.

General Recommendations

- Continue to monitor for illegal activities.
- Continue to monitor for illegal dumping and add barriers when needed.
- Verify all management zone rules signage correspond with Public Access Plan management zones; replace and/or update as necessary.
- Place additional signage along the Quinapoxet River for canoeists and kayakers.

Site Specific Recommendations

1. Poutwater Pond

Poutwater Pond is a designated Nature Preserve Area within the Tributary Headwaters Zone. Nature Preserves are intended to serve in perpetuity as examples of the state's natural heritage. They are dedicated for the conservation of natural communities and species of plants and animals and for scientific research and education. Nature Preserves are recognized by statute as areas to be monitored and maintained in a natural condition and should be used and managed in a manner consistent with protecting and perpetuating that condition.



Poutwater Pond

DCR (203 acres), MassWildlife (11 acres), and the Town of Holden protect an extensive area around the pond and bog; different regulations apply under each landowner. Most of the regulations on the DCR-owned portion of the preserve are the same as in the rest of the DCR lands in the Tributary Headwaters Zone. The Nature Preserve designation also brings with it general regulations on administration and general access rules, but defer to the administering agency if these rules differ. One of these differences is the group access permit. DCR requires a special permit for groups of 25 people or more on all other DCR Watershed lands, but it is required for groups of 10 or more people for Poutwater Pond lands. Access on the DCR portion of the preserve is from one hour before sunrise until one hour after sunset, and access is allowed 24 hours/day on MassWildlife property.

Main impacts to this site are from group visits to the bog and seemingly cyclical ATV and snowmobile use on trails. Rules signs have been placed at DCR gates on Holden Road and Pikes Hill Road. Several areas have been blocked by downed large trees, which have helped curb ATV activity. A boardwalk has been placed on the floating mat to protect this unique vegetation and allow safer access for educational and research purposes. DCR Wachusett Rangers continue to monitor this area for illegal activities and work with State Police to enforce DCR regulations.

- Continue to monitor for illegal activities and work with State Police to enforce DCR regulations.
- Investigate maintenance needs of bog boardwalk and repair if needed and funding allows.
- Coordinate with DCR Land Management Plan for ongoing maintenance needs of this area.

D. Public Access and Security

The events of September 11, 2001 highlighted the need for increased security throughout the watershed, particularly in the area around the Intake Zone. Since water utilities are in the forefront of ensuring that our nation's water systems are protected against terrorist threats, DCR and the MWRA have already developed several additional safeguards. For security purposes, the following access improvements are left vague.

Video surveillance has been added at multiple areas, and several gates have been replaced with more secure entrances. Guardrail along Route 70 in the area of the dam has been replaced with a higher fence to discourage any climbing over or trespassing. An additional gated entrance has been established for staff to access the boat cove without the need to enter the Cosgrove Intake Facility. Watershed Rangers, as well as all other DCR and MWRA staff, remain vigilant and observant of any activity taking place in priority areas such those as around the dam and structures.

The Department of Homeland Security has established a five-tiered Homeland Security Advisory System to provide a national framework for notification about the nature and degree of terrorist threats. In response, the Environmental Protection Agency developed a guide and recommendation document for drinking water suppliers and wastewater utilities to guard against

terrorist and security threats based upon the five-tiered system. The public access sections of this document have been reviewed for this plan.

Public access to any DCR land may be limited at any time due to potential security issues. In the event that any closure is necessary, the public will be notified through signage, the media, and any other available outlets deemed necessary.



National Guard on patrol during a temporary closure of the Wachusett Dam Promenade in 2001.

E. Status of 2003 Access Plan Objectives

The following table present the implementation objectives stated in the 2003 Plan. The right hand column provides the status of these objectives as of January 2011.

Table 5. 2003 Access Plan Objectives Status

Issue	Implementation Objectives	2011 Status
Structural and Access Controls	<ol style="list-style-type: none"> 1. Replace gates and other barriers where vehicular access can be gained illegally. 2. Install a new lock system on gates. 3. Institute a numbering system for all gates outside the main Reservoir basin. 4. Improve entry points (gates and/or parking): <ol style="list-style-type: none"> a. Route 110 near Campground Road (Gate 30 area). b. Route 12/140 near the Railroad Bridge (Gate 25). c. Route 140 near MA Dept. of Fish & Wildlife (Gate 19). d. Route 70 near Cross Street. 	<ol style="list-style-type: none"> 1. Ongoing. 2. Will be reevaluated and occur when funding permits if needed. 3. Completed. 4a. In process. 4b. Completed. 4c. Completed. 4d. Completed.
Signs	<ol style="list-style-type: none"> 1. Install new signs where needed with updated policies, universal symbols, and encourage use of sani-cans. 2. Install kiosks or bulletin boards at major entry points. 3. Install additional kiosks at other parking areas, as resources permit. 	<ol style="list-style-type: none"> 1. Ongoing. 2. Completed and ongoing. 3. As needed basis.
Mapping	<ol style="list-style-type: none"> 1. Develop and distribute Public Access Map(s) that show locations for hiking, bicycling, hunting, and parking. 2. Work with outside interests to produce and distribute a fishing map. 	<ol style="list-style-type: none"> 1. Not Completed. 2. Completed.
Enforcement	<ol style="list-style-type: none"> 1. Utilize Wachusett Reservoir Watershed Ranger Staff for patrols. 2. Meet regularly with State Police, Environmental Police, and local Police to ensure and enhance coordination on enforcement issues. 3. Ensure that contact numbers of DCR and the State Police are printed on signs and brochures. 	<ol style="list-style-type: none"> 1. Ongoing 2. Ongoing, as needed. 3. Ongoing.
Sanitation	<ol style="list-style-type: none"> 1. Evaluate moving existing toilets or providing additional toilets at sites that might receive more use. 2. Prepare feasibility study of the potential use of permanent facilities in selected areas. 	<ol style="list-style-type: none"> 1. Additional toilets added 2. Ongoing. Continue to evaluate need.
Encroachments	<ol style="list-style-type: none"> 1. Monitor DCR property for encroachments. 2. Coordinate with Natural Resources Section for encroachment resolution. 	<ol style="list-style-type: none"> 1. Ongoing by all staff. Detailed property line surveys completed. 2. Ongoing, as needed.
Specific Site Recommendations	<ol style="list-style-type: none"> 1. Old Stone Church: <ol style="list-style-type: none"> a. Continue presence of Rangers. b. Continue to provide Trash Barrels. c. Continue to provide Sani-can. d. Consider providing more permanent toilet facilities. 2. Bob's Hot Dogs: Request MHD to evaluate safety issues at the site and make any needed pedestrian or traffic safety improvements. 3. Rail Trail: <ol style="list-style-type: none"> a. Continue to support the work of Wachusett Greenways where appropriate. b. Continue participation on the Mass Central Rail Trail Task Force. c. Enter into working relationships with similar trail groups where the mission supports DCR/DWSP's overall goals. 	<ol style="list-style-type: none"> 1a. Ongoing. 1b. Ongoing. 1c. Ongoing. 1d. Determined not an appropriate option. 2. Town of West Boylston added stop and yield signs. 3a. Ongoing. 3b. Ongoing. 3c. Ongoing.

Issue	Implementation Objectives	2011 Status
	4. Waushacum Ponds <ul style="list-style-type: none"> a. Educate users on proper trash disposal and allowed boating uses through Signs and informational materials. b. Support Wachusett Greenways in improving the trail along the old rail bed from Gates Road to the Sterling Millworks, including restoration of pedestrian bridge shoreline erosion. 5. Poutwater Pond: Limit the illegal ATV and snowmobile activity through increased enforcement and barrier placement. 6. Quinapoxet River: Erect signs to clearly define boat take-out at River Rd. turn-off.	4a. Signage added. 4b. Completed. 5. Ongoing, additional barriers placed. 6. Not completed.
Public Education/ Interpretive Services	1. Provide indirect contact with public via: <ul style="list-style-type: none"> a. Signs. b. Kiosks/Bulletin Boards. c. Pamphlets. d. Maps (see Mapping). e. Website. 2. Provide direct contact with public via: <ul style="list-style-type: none"> a. Watershed Ranger Patrols. b. Guided Hikes and Tours. c. School Programs. d. Public Events. 	1. Ongoing. 2. Programs and events expanded.
Partnerships	1. Foster partnerships with local entities to develop and maintain facilities on DCR/DWSP policies and regulations. <ul style="list-style-type: none"> a. Wachusett Greenways – Rail Trail. b. Stewardship programs. 	1. Ongoing.
Open Space Coordination	1. Maintain communication and coordinate when possible with other owners of open space in the watershed, including: DEM, DFWELE, Non-profit and other private landowners, and watershed communities. 2. Continue to integrate common issues raised in the Statewide Comprehensive Outdoor Recreation Plan.	1. Ongoing. DEM now DCR Division of State Parks. 2. Ongoing.
Monitoring/ Program Evaluation	1. Maintain a regular monitoring program for DCR/DWSP forest roads, access points and reservoir shorelines. 2. Revive the Wachusett Advisory Committee as a forum to review and provide input to the DCR on all of its water protection programs in the watershed. 3. Provide a yearly review of the plan and, if necessary, a public meeting to gather input on implementation of the plan.	1. Ongoing. 2. Ongoing due to previous attempts being unsuccessful. 3. Complete.



Thomas Basin Parking Area

F. Summary of Current Recommendations

The following summarizes the recommendations produced by DCR staff in the development of updating the Wachusett Reservoir Watershed Access Plan.

1. Signage

- Add a kiosk or bulletin board with DCR ownership maps of the Mill Pond at the road below the dam.
- Add “No Trespassing After Dark” signage in the area of the Promenade.
- Verify rules signage east of Route 70 (gates 1-5) for accuracy.
- Utilize Stillwater Farm kiosk for timely watershed related information.
- Place signs as needed and talk with the Town of West Boylston to add signage along their portion of the Rail Trail.
- Replace any old rules sign with updated DCR universal symbol rules sign.
- Post EPA Drinking Water Security posters on kiosks and bulletin boards; especially at Bobs Hot Dog triangle, the Promenade and Old Stone Church.
- Provide a link to the DCR Watershed website and Public Access Plan on bulletin boards and kiosks.
- Work with watershed towns to add a link to the Public Access Plan and maps on all town websites.
- Post emergency phone numbers and gate reference number at the shoreline of the reservoir where there is a significant distance from the gate.
- Verify all management zone rules signage correspond to public access plan management zones.
- Work with appropriate parties to re-paint “No Fishing From Bridge” and add “No Standing On Bridge” at Thomas Street/Quinapoxet River.
- Update kiosk and bulletin board information more frequently and look into fade-resistant paper.
- Add screening or other way to keep bees from nesting inside kiosks.
- Explore the addition of emergency contact numbers in several key areas of the shoreline where the gate is a long distance from the reservoir.
- Place additional signage along the Quinapoxet River for canoeists and kayakers, including a warning sign leading up to the accretion dam and a permanent warning sign at Canada Mills stating that conditions can become dangerous during times of high water levels and that users are at their own risk.
- Post “No Access on Rip Rap” signage near Gate 36.
- Post signage near Gate 40 alerting bicyclists that they are not allowed on the top of the dike.
- Post limit of fishing with waders signage at confluence of Waushacum Brook and Stillwater River.

2. Monitoring and Enforcement

- Continue to monitor for illegal dumping and add barriers as needed.
- Continue to monitor use of sani-cans and relocate if needed. Create pilot program for this task.
- Coordinate with utilities to limit activities by ATVs and snowmobiles on utility corridors.
- Monitor use of property along closed portion of River Road for illegal activity and work with law enforcement to curb any activity noted.
- Continue dog waste education when violators cross onto DCR/DWSP property on the Holden section of the Mass Central Rail Trail.
- Coordinate with local and state police to enforce trespassing after dark violators.
- Ensure that “No Trespassing” boundaries are clearly marked in the area of Route 62 (Willow Road) to Mile Hill Road.
- Implement 2010 Aquatic Invasive Species Assessment and Management Plan Public Education and Outreach recommendations.

3. Access

- Consider developing a permanent geocache on existing trail on Stillwater Farm parcel, using relevant watershed and water quality facts and information.
- Coordinate with the Town of West Boylston and Wachusett Greenways to place a dog waste station and odorless collection system at the beginning of the Oakdale Section of the Mass Central Rail Trail.
- Revise hunting map, replacing stars with gate numbers and show updated DCR/DWSP ownership.
- Make group permit or request form available online at www.mass.gov/dcr/watersupply/watershed/dwmpmtrts.htm
- Explore possibility with MWRA of opening the top of the dam to the public on special occasions.
- Maintain access trail from River Road to handicapped platform on the Quinapoxet River.
- Work with IT to improve website to make it easier to navigate and find information on the watersheds.
- Compose general public access map and visitor guide.
- Re-mark and re-establish designated bicycling trails in Holden (Mill Street and Upper Loop trail on Mass Central Rail Trail). Re-blaze, re-establish, and place new DCR bicycling trail placards along trails. Create new placards.
- Explore creating a DCR Wachusett Watershed facebook page and/or Twitter account.
- Work with the Town of West Boylston to install an access gate at either end of River Road to provide emergency access for DCR as well as West Boylston Police and Fire Departments.

- Have geocaching guidelines available on the internet through the DCR website, and post on kiosks and bulletin boards.
- Curb potential trespassing and make the limits of public access clear by adding signage at the shoreline and/or a fence or barrier between the dam Promenade and Gate 1.
- Discuss improving the road shoulder along the reservoir side of the triangle at Rtes. 12/140 West Boylston (near Bob's Hot Dog Truck) with the Town of West Boylston.
- Explore options for reducing the size of hunting permits.
- Place benches near Gate 36 and Gate 39 along the North Dike.
- Look towards funding for capital improvements needed below the dam and perform regular maintenance.
- Investigate maintenance needs of Poutwater Pond bog boardwalk and repair as needed and if funding allows.
- Coordinate with Wachusett Reservoir Watershed Land Management Plan for ongoing maintenance needs of Poutwater Pond property.

VII. Public Survey and Comments

DCR/DWSP compiled a survey in order to gain insight into the public’s knowledge of DCR rules, regulations and outreach efforts. The survey was designed to determine the most effective way to distribute information (land closures, educational, announcements, rules, etc.) to the public. A public kick-off meeting was advertised and held at DCR/DWSP Headquarters in West Boylston on October 28, 2010 where the survey was announced and the plan update process explained. The survey was made available through SurveyMonkey on the internet (www.mass.gov/dcr/watersupply.htm) from October 2010 through January 2011. The survey website and link was advertised through many different outlets and printed copies were also made available to the public (**Table 6**). Another public meeting was held at the same location on May 3, 2011 after the draft of the plan update was complete.

Table 6. Public Access Survey Distribution

The survey website link was available through:	Paper copies of the survey were available at:
<ul style="list-style-type: none"> • Watershed Town Websites • DCR/DWSP <i>Downstream</i> Newsletter • Local media- Worcester Telegram & Gazette, Clinton Item, West Boylston Banner, Holden Landmark • DCR/DWSP Bulletin Board and Kiosk Notice • Ranger Hand Out 	<ul style="list-style-type: none"> • All Watershed Town Halls • All Watershed Town Libraries • DCR Headquarters • Local Bait Shop • DCR Brochure Boxes • MassWildlife Central District Office

DCR/DWSP would like to thank the public for taking the time to complete the survey and for submitting valuable input during this Public Access Plan update process. DCR would also like to thank the municipalities for making copies of the survey available at town halls and libraries and for providing a link to the online survey from their municipal websites.

A total of 320 online surveys were completed and seven paper copies were returned directly to DCR. While this survey was designed to gather information and visitor knowledge and not to be a scientific analysis, percentages will be shown where appropriate, as will graphs, charts and/or tables.

This section summarizes the responses to the survey and comments submitted directly to DCR. Complete survey results can be found in Appendix D.

Link to survey: www.mass.gov/dcr/watersupply.htm
 Click on "2011 Wachusett Public Access Plan and Survey" on left sidebar

**2011 WACHUSETT RESERVOIR
 WATERSHED PUBLIC ACCESS PLAN UPDATE**

DCR/DWSP has begun the process of updating the Wachusett Reservoir Watershed Public Access Plan and we welcome your input! Please take a few minutes to complete our online visitor use survey (link above).

SURVEY CLOSSES JANUARY 15, 2011

For more information contact:
 Kelley Freda, Environmental Analyst at
 508-792-7806 ext 205
 (Kelley.freda@state.ma.us)



Public Access Survey Handout

A. Survey Result Summary

1. Demographics

A majority of users (57.6%) who completed the survey were between the ages of 40-59 who learned of the survey mainly through the local newspaper and municipalities. 69.8% of respondents consisted of watershed residents, 18.6% Non-watershed residents, 22.3% abutters to DCR lands, and 2.8% were municipal officials.

Table 7. Survey Response Affiliation

Please tell us what describes your affiliation with DCR Wachusett Watershed lands (please check all that apply):		
Answer Options	Response Percent	Response Count
Watershed resident	69.8	222
Non-watershed resident	18.6	59
Abutter to DCR Wachusett watershed lands	22.3	71
Municipal official	2.8	9
	<i>answered question</i>	318
	<i>skipped question</i>	2

Table 8. Survey Response Age

What age group do you belong to?		
Answer Options	Response Percent	Response Count
19 or under	0.0%	0
20-29	7.9%	25
30-39	18.6%	59
40-49	30.2%	96
50-59	27.4%	87
60 or over	16.0%	51
<i>answered question</i>		318
<i>skipped question</i>		2

Table 9. Survey Response Frequency of Use

On an average, how many days per season do you utilize DCR Wachusett Watershed lands?					
Answer Options	Less than 7	7 - 14	15 - 30	over 30	Response Count
Spring	72	107	73	64	316
Summer	64	76	90	80	310
Fall	65	99	86	61	311
Winter	141	80	44	35	300
<i>answered question</i>					318
<i>skipped question</i>					2

Table 10. Survey Response Time of Use

When do you mostly use DCR Wachusett Watershed lands?				
Answer Options	day	evening	both	Response Count
Weekday	116	54	76	244
Weekend	189	8	113	301
<i>answered question</i>				314
<i>skipped question</i>				6

2. Recreation Types

When asked which type of passive recreation activities were engaged in on DCR Wachusett Watershed lands, a majority of respondents listed more than one activity. Hiking and walking were the most popular activities (93.3%), while bird hunting (3.2%) was the least popular.

Table 11. Survey Response Recreation Activities

What passive recreation activities do you engage in on DCR Wachusett Watershed lands? (check all that apply)		
Answer Options	Response Percent	Response Count
Fishing	36.2%	114
Hunting	8.6%	27
Bird hunting with a dog	3.2%	10
Hiking/walking	93.3%	294
Bicycle riding	39.4%	124
Cross-country skiing/snowshoeing	44.4%	140
Picnicking/relaxing	41.9%	132
Geocaching/letterboxing	7.6%	24
Photography/nature study/birdwatching	47.3%	149
Other	12.4%	39
	<i>answered question</i>	315
	<i>skipped question</i>	5

3. Rules and Emergency Information

While most people were aware of what activities are allowed and those that are prohibited while on DCR Wachusett Watershed lands, a large number were not aware of whom to contact in the case of an emergency, even though this contact is also listed on the rules signage. Results show that DCR needs to modify or change the way that this emergency information is presented to the public. For example, the color on signage could be changed to differentiate it from other text, and the phone numbers could be placed in more areas around the watershed. Other options include developing a card with emergency contact numbers and bulleted rules to be handed out and placed in brochure boxes. Stickers with emergency phone numbers could be purchased for fishermen to place inside of their tackle boxes. A little more than half of the respondents have not observed a violation of DCR/DWSP rules and regulations while on our property, but of the respondents who have observed a violation of DCR rules and regulations, dog walking was the most noted.

4. Fishing and Aquatic Invasive Species

Most fishermen who returned the survey purchased their fishing licenses through town or city clerk’s offices, WalMart, or online through MassWildlife. Only a few purchased their licenses at the MassWildlife Regional Office. Approximately three quarters of the respondents are aware of the types and impacts of Aquatic Invasive Species, showing that the Commonwealth, DCR, and Sportsmen’s Clubs outreach and education on the dangers of AIS have been well received by the public. Less than twenty percent of respondents who fish at the Reservoir said that they belong to a sportsmen’s association. While it is important to include these associations when performing outreach or getting notices out to users of DCR property, it is crucial to continue to place this type of information on kiosks and bulletin boards. DCR will work with MassWildlife to include more reservoir information, rules and regulation in their annual fishing abstracts.

5. Ranger Staff and Education

While over 90% of respondents are aware that Watershed Rangers patrol DCR Wachusett Watershed lands, about half have not had the opportunity to talk with a Ranger. A large majority (86.5%) of respondents have read the information on bulletin boards and kiosks that are maintained by DCR Watershed Rangers. Some comments noted the professionalism and friendliness of the Ranger staff and the fact that the visitors look forward to talking with them while enjoying DCR property. Responses to the types of information people would like to see on kiosks and bulletin boards varied, but recurring themes included: historical information, trail maps and emergency contact information, rules and regulations, upcoming events, and clearly advertising the DCR Watershed website.

Some replies also focused on keeping current information posted as well as the physical conditions of kiosks and bulletin boards. DCR will look into fade resistant paper options, updating information on a more frequent basis, and yearly painting.

A majority of the responses demonstrate that people are still not aware that DCR Wachusett Watershed staff conduct free public outreach and education programs, even though advertisements are placed in local newspapers and signs placed on kiosks and bulletin boards. Most respondents have not attended a program. Answers varied when asked what types of free program that they would attend, including: guided hikes, history walks and talks (most responses), plant and wildlife identification programs, general animal/nature topics, eagles, and programs geared towards children. Most program ideas could be modified through the Ranger and Interpretive staff to include the DCR/DWSP mission.

6. General

Responses were very similar in nature to the question “please tell us about one aspect of the DCR Wachusett Watershed that you would change if given the chance.” The most prevalent answers were dog walking, more areas for bicycling, and allowing boating. Although DCR recognizes the public’s desire for these activities, as discussed in previous chapters, they are not compatible with the mission of DCR’s Division of Water Supply Protection. Lands acquired for the protection of the drinking water supply within the Wachusett Reservoir watershed are purchased with MWRA ratepayer funds and not taxpayer dollars. Any expansion of current access policies or additional activity poses an unnecessary threat to water quality and the water supply. In addition, the water supply regulators believe that the current policies in place for public access provide sufficient passive recreational opportunities without any unnecessary risk to the drinking water.

Other topics mentioned included: access to the top of the dam on special occasions; ice fishing; more programs and activities at Stillwater Farm; better marked trails; the addition of a few benches along the North Dike; and horseback riding. DCR will explore several of these issues in implementing the Access Plan. Ice fishing and horseback riding, however, are not allowed by regulation and will not be considered.

There were several comments requesting the expansion of the hunting zone east of Route I-190; however, there were just as many responses that were opposed to expanding the hunting zone.

There were also a few suggestions that hunting be prohibited altogether on DCR lands. DCR Natural Resources staff has found no evidence to suggest that deer are impacting tree regeneration in these areas, and no reasons to believe that the deer herd itself is suffering. Accordingly, since there is no management reason to expand or change the hunting zone, it will remain in its current configuration.

Answers about one aspect of the DCR Wachusett Watershed that was really liked generally voiced a similar theme: the close proximity; peaceful setting; availability of trails for hiking, running and walking; the view; quietness; solitude; and wildlife. Most responses to this question highlighted the protected open space and natural setting, and the amount of land open to the public for passive recreation.

Public comments to the question, “Is there anything else you would like to tell us?” were varied, sometimes overlapping both previous questions, “What is one aspect of the DCR Wachusett Watershed really liked?” and “What is one aspect that would be changed if given the chance?” Several comments stated that dog walking should be allowed and, alternatively, some respondents did not like dogs on the property and did not feel safe while walking where owners let their dogs run unleashed. Rangers will continue to monitor and enforce and educate the no dogs rule. Other comments once again addressed hunting, ice fishing, and litter.

Finally, several people were appreciative of DCR’s willingness to allow passive recreation and hoped to maintain this privilege. Appreciation of DCR’s efforts in keeping the lands clean, property purchases for water protection, and general statements thanking DCR for good work were also mentioned.

B. Other Comments

Most comments received from the public are responded to within the context of other sections of this plan. The following are responses to issues not referred to or answered elsewhere within this document.

1. If preservation of the water is the highest priority, then the use of airplanes above the water supply should be prohibited. On most nice days in the warmer months a private airplane can be seen flying over the Clinton portion of the water in the Wachusett Reservoir. The plane is both a visual and audible nuisance. The pilot also performs stunts, such as purposely stalling the engine, and practicing aeronautical daredevil techniques. These activities should not be allowed as they pose a danger of the aircraft crashing into the water supply. The airspace above the reservoir should be restricted in some manner. The height at which the plane is flown is also very low.

The FAA regulation currently states that planes cannot fly within 500 feet of manmade structures (the dam, Cosgrove Intake, other buildings) and people (this does not include the water). DCR has worked with the proper authorities to enforce this regulation. If there is a plane that you think is operating unsafely, contact the DCR Wachusett Rangers at 978-365-3800 or State Police at 508-829-8410.

2. I would like to know where the best resource of information is located.

The best source when looking for information on rules and regulations, public access, water quality or plans for the Wachusett Reservoir Watershed can be found online at www.mass.gov/dcr/watersupply/watershed/water.htm.

3. Get rid of the paper permit to hunt in allowed areas. It gets ruined in the rain and gets lost. Regular hunting licenses should suffice.

The DCR hunting permit program allows DCR to track the users of our property for this activity. It also allows us to provide a copy of rules to permittees and to contact all of these users if needed through regular mail. DCR will look into other options such as a business card sized permit.

4. I would like to hear an explanation as to why no human can touch the water. Isn't the water treated before consumed? Isn't Quinsigamond a "secondary reservoir?" If so, why is there unrestricted use of it?

As stated in Chapter IV, any bodily contact with the water is a possible pathway for bacteria and other diseases to contaminate a drinking water supply and compromise water quality. Yes, the Wachusett Reservoir water is disinfected before it is consumed, but it is also UNFILTERED; thus removing the "multi-barrier" approach for pollutant removal. DCR and MWRA continue to meet the EPA filtration waiver requirement due to (in part) exemplary watershed management and restrictions on public access, such as bodily contact with the water.

Lake Quinsigamond in Worcester is not a surface water source used as a drinking water supply. It is a "Great Pond", and as such, restrictions on recreation are not as strict. This surface water is managed by the DCR Division of State Parks and Recreation.

5. You may wish to reduce the 1-mile fishing set back. I don't understand why that is a rule. I don't think people should fish from the dam, but they certainly should be able to fish along the dike and/or just past the pumping station on Rte 70.

The fishing limits are based upon the Public Access Protection Zones. The area around the dam, etc. falls within the Intake Protection Zone where public access is most limited due to safety and security reasons.

6. I enjoy visiting the Reservoir very much. Lately, this past summer, I have been seeing a lot more trash/littering along the paths of the Clinton portion of the Reservoir and wonder if there is anyone that is assigned the responsibility of picking up the trash. The grounds are maintained so well throughout the year, I find that it makes me pretty annoyed that some

people are so thoughtless to just leave there trash behind when visiting the Reservoir. FYI...I take a grocery size bag with me, occasionally, and have no trouble filing it by the end of my walk/run.

Thank you for your personal efforts to keep this area clean. DCR does not have anyone specifically tasked with the responsibility of picking up trash. DCR asks that what is brought in is taken out and it is against DCR rules to leave any trash on our property. Each year, the DCR Rangers host a cleanup day, usually around Earth Day in April. The public is invited to attend and help pick up litter around the Reservoir on this day. In addition, DCR will look at other possible alternatives and public education to improve sanitation by means of a pilot and monitoring program.

7. Several comments were related to the dam and lower road area, including when the flags will be put back up on the Promenade and when parking will be available again for photography.

The Promenade was reopened in December 2010 after the completion of PCB remediation and additional construction activities. Flags are now flying; DCR has also installed a light which allows the flags to fly at night. The road below the dam has never been closed, with the exception of the small area of washed out roadway beginning at the Lower Road gate across from Cumberland Farms (currently posted “No Trespassing”). This area will be reopened when and if funding allows for repair of the roadway. Access can be obtained through Gate #42 on Grove Street.

8. Allow ice skating. I was told it was a liability issue, but when I pointed out that DCR allows skating on other bodies of water under its oversight, I was told it’s a water quality issue.

Ice skating and ice fishing are both safety and resource risks. As the reservoir is a drinking water supply, water levels can fluctuate year round and render the ice unsafe during the winter. In addition there are the added resources for monitoring as well as resources for emergency response should someone get injured. This also is true for other lakes and ponds in the Wachusett Watershed owned by DCR/DWSP. Added monitoring by water supply staff and the potential need for emergency response is an unnecessary drain on water supply staff resources.

The DCR Division of State Parks (a separate branch of DCR whose mission is recreation) provides ice skating opportunities at five designated ponds and lakes in state parks and forests when conditions permit (Blackstone River and Canal Heritage State Park, Uxbridge; D.A.R. State Forest, Goshen; Dunn Pond State Park, Gardner; Mt. Tom State Reservation, Holyoke; and Wendell State Forest, Wendell). Conditions at the five facilities are monitored daily. As stated in Chapter V, the Mill Pond below the Wachusett Dam is not owned in its entirety by DCR and DCR does not give permission for recreational activity on water that is not controlled by the Division.

9. A few benches along the spine of the dike at the Wachusett Reservoir would be great!

DCR is not opposed to this suggestion and will look into placing benches near Gate 36 and Gate 39 along the North Dike.

10. You are custodians of an important and historic landscape at the dam site- please do a better job!

DCR is aware that the level of maintenance below the dam has not been at the previous level due to years of construction. Because of the age of the entire area, capital improvements are needed. DCR will look towards funding these improvements and will once again perform regular maintenance.

11. Allow horse-back riding around the reservoir, as it will not impact water quality, especially compared to the wildlife and fishing.

DCR does not allow horse-back riding on Wachusett Reservoir watershed lands for several reasons. All domestic animals pose a very serious threat to the drinking water supply, as they have the potential to contaminate the resource with an array of pollutants, such as fecal coliform, giardia, and cryptosporidium. Therefore these domestic animals create a risk to the water supply that can be controlled by restrictions. In comparison, wildlife can also be an impact to water quality, however DCR has less ability to control the presence of wildlife on the watershed. However, DCR does work to mitigate the effects of gulls, beavers, muskrat, and any other wildlife that are present in high numbers close to the Cosgrove Intake. Finally, as mentioned in Section V, DCR's regulations do not allow horses on DCR Watershed property except in designated areas of the Ware River watershed which are the most hydrologically remote portions of the water supply watershed system.

12. Allow weddings at the Old Stone Church.

DCR recognizes the appeal of the Old Stone Church as the back-drop for a wide range of functions; however neither the grounds, the building itself, or staff resources are capable of expanding the use of this historic site. Drinking water regulations will not allow this type of expanded, intensive use of land on the banks of a source water supply. In addition, there is no dedicated parking lot at this site; cars are limited to parking alongside the public roadway and DCR does not have the ability to provide adequate parking facilities in this area for large gatherings. DCR regulations (350 CMR 11.09(2)(a)18) require a permit from the Regional Director for any gathering of more than 25 people. Due to the array of public safety issues involving inadequate parking, staff resources and water quality impacts, DCR will no longer issue group use permits for this site.

VIII. 2011 Public Access Policies

Based on research conducted and staff observations while in the field since the last update, the only minor change proposed to the public access policy is the addition of geocaching and letterboxing as allowed activities in all areas that are open to the public, and the prohibition of paintball. Bicycling and dog walking have been clarified, and the former Reservoir and Tributary Shoreline and West Waushacum Pond Protection Zone has been renamed the Reservoir Protection Zone.

Table 12. 2011 Public Access Policies

Activity	2003 Policy	2011 Policy
Shoreline Fishing	Integrate Off-Watershed Zone into Intake Protection Zone; no fishing allowed in Intake Protection Zone.	No Change
Hiking	Expand to allow access to lands east of Gates 1 and 2 Rte 70	No Change
Cross-Country Skiing	Expand to Allow access to lands east of Gates 1 and 2 Rte 70	No Change
Boating	Non-motorized boats allowed on Quinapoxet and Stillwater Rivers in the Tributary Headwaters Zone; non-motorized boats allowed on West Waushacum Pond.	No Change
Swimming	PROHIBITED	No Change
Bicycling	No permit requirement for off-road biking in designated area; clarify policy to allow biking from Gate 39 to 42 (formerly Off-Watershed Zone).	Clarified: Bicycling allowed in designated areas, rail trails, and from gate 39 to road below the dam on the old rail line bed only.
Horseback Riding	PROHIBITED	No Change
Camping	PROHIBITED	No Change
Motorized Vehicles (ATVs, ORVs, Snowmobiles)	PROHIBITED	No Change
Hunting	Hunting allowed with DCR permit. Hunting area is entire Tributary Headwaters Zone (locations must still meet DWFELE regulations).	No Change
Dog Walking	Allowed below Wachusett Dam with leash or while hunting in Tributary Headwaters Zone.	Clarified: Dogs (leashed) allowed from below the dam to posted signage at the top of the spillway or while actively hunting in Tributary Headwaters Zone.
Geocaching/ Letterboxing	None	New: Geocaching/letterboxing authorized in all areas where public is allowed. Guidelines must be followed.
Paintball	None	New: Paintball prohibited on all DCR/DWSP property.

Table 13. DCR/DWSP 2011 Public Access Policy Summary- Intake Protection Zone

Activity	Intake Protection Zone				
	East Side (Non-reservoir) Route 70 from Gate 5 to Promenade	West Side (Reservoir) Route 70 from Gate 5 to Promenade	Promenade	Road Below Dam and Spillway to Top of Dam	North Dike from Spillway to Area just before Gate 36
Off-Road Driving (ORVs, ATVs)	⊘	⊘	⊘	⊘	⊘
Snowmobiling	⊘	⊘	⊘	⊘	⊘
Bicycling	⊘	⊘	⊘	✓	✓ ₁
Walking/Hiking	✓ ₇	⊘	✓	✓	✓
Dog Walking	⊘	⊘	⊘	✓ ₂	⊘
Cross-Country Skiing	✓ ₇	⊘	⊘	✓	✓
Shoreline Fishing	⊘	⊘	⊘	✓ ₃	⊘
Fishing with Waders	⊘	⊘	⊘	⊘	⊘
Horseback Riding	⊘	⊘	⊘	⊘	⊘
Hunting	⊘	⊘	⊘	⊘	⊘
Boating – non-motorized	⊘	⊘	⊘	⊘	⊘
Boating – motorized (including “jet skis”)	⊘	⊘	⊘	⊘	⊘
Swimming	⊘	⊘	⊘	⊘	⊘
Ice Skating/Ice Fishing	⊘	⊘	⊘	⊘	⊘
Camping	⊘	⊘	⊘	⊘	⊘
Picnicking	✓ _{4,7}	⊘	⊘	✓ ₄	✓ ₄
Fires & Cooking	⊘	⊘	⊘	⊘	⊘
Programs/Assemblies	✓ _{5,7}	⊘	✓ ₅	✓ ₅	✓ ₅
Trail Clearing/Trail Marking/Advertising	⊘	⊘	⊘	⊘	⊘
Collecting/Metal Detecting	⊘	⊘	⊘	⊘	⊘
Geocaching/Letterboxing	✓ _{6,7}	⊘	⊘	✓ ₆	✓ ₆

✓ - Public access is allowed in designated areas only

⊘ - Activity prohibited

1. Allowed on rail bed from gate 39 to spillway only. 2. Dogs only allowed to top of spillway and must stop at sign. Dog waste must be picked up and disposed of properly. 3. Fishing allowed from fountain impoundment to approximately 275 feet after concrete abutments of old railroad bridge. 4. Trash must be carried off of DCR property. 5. DCR Special permit required. 6. Geocaching Guidelines must be adhered to and all DCR rules apply. 7. Except for property between Rte 62(Willow Rd) and Mile Hill Roads.

Public access is allowed in designated areas only from one hour before sunrise until one hour after sunset. Any activity that injures or defaces the property of the Commonwealth is strictly prohibited. All alcoholic beverages are prohibited. Night access is prohibited. See 350 CMR 11.09(2) for a complete list of regulations. For additional information contact the Wachusett/Sudbury Rangers at 978-365-3800. In an emergency, contact the Watershed Rangers or the Massachusetts State Police at 508-829-8410 or 911.

Table 14. DCR/DWSP 2011 Public Access Policy Summary Reservoir and Tributary Protection Zones

Activity	Reservoir Protection Zone	Tributary Headwaters Zone
Off-Road Driving (ORVs, ATVs)	⊘	⊘
Snowmobiling	⊘	⊘
Bicycling	⊘	✓
Walking/Hiking	✓	✓
Dog Walking	⊘	⊘ ¹
Cross-Country Skiing	✓	✓
Shoreline Fishing	✓	✓
Fishing with Waders	✓ ²	✓
Horseback Riding	⊘	⊘
Hunting	⊘	✓ ³
Boating – non-motorized	✓ ⁴	✓
Boating – motorized (including “jet skis”)	⊘	⊘
Swimming	⊘	⊘
Ice Skating/Ice Fishing	⊘	⊘
Camping	⊘	⊘
Picnicking	✓	✓
Fires & Cooking	⊘	⊘
Programs/Assemblies	✓ ³	✓ ³
Trail Clearing/Trail Marking/Advertising	⊘	⊘
Collecting/Metal Detecting	⊘	⊘
Geocaching/Letterboxing	✓ ⁵	✓ ⁵

✓ - Public access is allowed in designated areas only ⊘- Activity prohibited

1. Dogs allowed with hunting permit only. 2. Upstream of DCR dam at Oakdale Power Station on Quinapoxet River and upstream of the Stillwater River confluence with Waushacum Brook. 3. DCR Special permit required. 4. Canoes/kayaks allowed at :West Waushacum Pond; on the Stillwater River upstream of Muddy Pond Road bridge; on the Quinapoxet River upstream of dam at Oakdale Power Station. 5. Geocaching Guidelines must be adhered to and all DCR rules apply.

Public access is allowed in designated areas only from one hour before sunrise until one hour after sunset. Any activity that injures or defaces the property of the Commonwealth is strictly prohibited. All alcoholic beverages are prohibited. Night access is prohibited. See 350 CMR 11.09(2) for a complete list of regulations. For additional information contact the Wachusett/Sudbury Rangers at 978-365-3800. In an emergency, contact the Watershed Rangers or the Massachusetts State Police at 508-829-8410 or 911.

Table 15. DCR/DWSP 2011 Public Access Policy - High Use Visitor Areas

ACTIVITY	Old Stone Church	West Waushacum Pond	Oakdale Rail Trail	Sterling Rail Trail	Road Below Dam
Off-Road Driving (ORVs, ATVs)	⊘	⊘	⊘	⊘	⊘
Snowmobiling	⊘	⊘	⊘	⊘	⊘
Bicycling	⊘	⊘	✓	✓	✓
Walking/Hiking	✓	✓	✓	✓	✓
Dog Walking	⊘	⊘	⊘ ¹	⊘	✓
Cross-Country Skiing	✓	✓	✓	✓	✓
Shoreline Fishing	✓	✓	✓	✓	✓ ²
Fishing with Waders	⊘	⊘	✓ ⁵	⊘	⊘
Horseback Riding	⊘	⊘	⊘	⊘	⊘
Hunting	⊘	⊘	⊘	⊘	⊘
Boating – non-motorized	⊘	✓	⊘	⊘	⊘
Boating – motorized (including “jet skis”)	⊘	⊘	⊘	⊘	⊘
Swimming	⊘	⊘	⊘	⊘	⊘
Ice Skating/Ice Fishing	⊘	⊘	⊘	⊘	⊘
Camping	⊘	⊘	⊘	⊘	⊘
Picnicking	✓	✓	✓	✓	✓
Fires & Cooking	⊘	⊘	⊘	⊘	⊘
Programs/Assemblies	✓ ³	✓ ³	✓ ³	✓ ³	✓ ³
Trail Clearing/Trail Marking/Advertising	⊘	⊘	⊘	⊘	⊘
Collecting/Metal Detecting	⊘	⊘	⊘	⊘	⊘
Geocaching/Letterboxing	✓ ⁴	✓ ⁴	✓ ⁴	✓ ⁴	✓ ⁴

✓ - Public access is allowed in designated areas only

⊘ - Activity prohibited

1. Dogs only allowed on West Boylston owned portion from Oakdale to Route I-190 overpass as posted. 2. From fountain impoundment to approximately 275 feet downstream of concrete railroad abutments 3. DCR Special Permit required 4. Geocaching guidelines must be followed 5. Upstream of accretion dam.

Public access is allowed in designated areas only from one hour before sunrise until one hour after sunset. Any activity that injures or defaces the property of the Commonwealth is strictly prohibited. All alcoholic beverages are prohibited. Night access is prohibited. See 350 CMR 11.09(2) for a complete list of regulations. For additional information contact the Wachusett/Sudbury Rangers at 978-365-3800. In an emergency, contact the Watershed Rangers or the Massachusetts State Police at 508-829-8410 or 911.

IX. Plan Implementation

The DCR/DWSP staff will implement the policies, control measures, activities and programs cited in this plan beginning in July 2011. Staffing levels and funding will control the implementation of several of the current recommendations. In general, plan implementation will include the following steps:

- 9 Maintaining, improving, and adding structural access controls and signs, as needed.
- 9 Monitoring, enforcement, and corrective actions.
- 9 Providing educational programs and opportunities to promote watershed protection.
- 9 Partnering initiatives with local groups, town entities, State Police, state agencies, and others.
- 9 Conducting Plan evaluation and modification at regular intervals and as necessary.

The *Wachusett Reservoir Watershed 2011 Public Access Plan Update* implementation focuses on the continuation of the same access policies as 2003. The implementation strategy is mindful of the extremely limited funding for activities beyond routine maintenance and patrols. The plan, however, leaves open opportunities, when appropriate, to partner with other groups and organizations. This plan continues programs that provide passive education to visitors and enforces DCR regulations and policies through Ranger patrols and police coordination.

A. Structural and Access Controls

Structural and access controls are in place on much of the DCR/DWSP lands in the Wachusett Reservoir watershed. Gates and barriers control the access to sensitive locations and provide controlled points for public access (350 CMR 11.09 (2)(a)1 states, “entrance on and exit from land of the Watershed System shall be made through gates or other designated areas.”). Many gates around the reservoir perimeter have been replaced with more secure structures to provide greater protection of the water supply from unauthorized vehicular access. Old cable gates have been replaced with “farm style” gates for safety. Several parking areas have been constructed to allow for signage and educational materials, bulletin boards and kiosks to be in one common access point and to provide better public safety. These entry points are intentionally located near public roadways so they can be easily monitored by Watershed Rangers and police. A focused entry point also allows staff to control public access and monitor uses at each location.

Controlling public access around railroad and power lines rights of ways is difficult due to private property ownership and easements. However, some form of barrier is needed in several areas around the watershed to limit motorized vehicle use, most notably ATVs. DCR will work with utility companies to attempt to limit access to DCR lands through utility corridors.

Controlling access on DCR/DWSP lands in the Tributary Headwaters Zone is more challenging than in the other protection zones because the main type of visitor use is different. In this zone, illegal access takes place mostly by motorized vehicles, including ATVs and snowmobiles. Downed trees and large boulders work well in these locations, as they still allow for foot access.

The addition of structural controls and boulders is a continuing ongoing process through the Watershed Rangers. When it is observed that access controls are needed, Rangers ensure that this work is completed. The plan update will continue the existing protocol of maintaining existing barriers and identifying additional locations as needed.

In addition to the previous recommendations, a large parking lot was also relocated near the Oakdale Rail Trail at Thomas Basin to assist the West Boylston Water District in complying with a Department of Environmental Protection directive to improve controls adjacent to their Oakdale well. Boulders have recently been placed to limit parking on the grassed area, which had become a problem. Some concern has been raised about the need for additional parking in this area; DCR will continue to review the situation and seek resolution if this becomes a problem area.

Table 16. Structural Access Control Status

Site	Recommendation	Status
Route 110 near Campground Road (gate 30 area)	Construct small parking area and realign Gate 30 roadway.	In process. Plans for new parking area and access road not across private property complete. Likely construction 2011.
Route 12/140 near the Railroad Bridge (Gate 25)	Construct small parking area at gate and move gate.	Completed at Gate 25.
Route 140 near MassWildlife (Gate 19)	Construct small parking area at gate and move gate.	Completed at Gate 19.
Route 70 near Cross Street	Construct small parking area at gate and move gate.	Completed at Gate 8.
River Rd. and Mill St.	Construct access barriers.	Guardrail and boulders have been placed on Mill Street to control illegal dumping and ATV use. All cable gates on River Road have been replaced where necessary for fire control or blocked with boulders if access no longer needed.
Newell Hill Rd. Extension	Construct access barriers.	Gate and boulders have been placed at beginning of road.



Mill Street boulder barrier



Typical DCR/DWSP gate

Implementation Recommendations

- Continue existing protocol for maintaining gates and other structural controls.
- Continue to review the need for additional parking as needed.

B. Signs

Watershed Rangers are continuously observing and addressing sign issues within the Wachusett Reservoir watershed when an activity or issue arises that needs attention. All rules signs have been replaced with new DCR universal symbol signs. Old signage is replaced when found on more remote properties. “No Trespassing After Dark” signs have been placed at the Old Stone Church gate at the request of the Watershed Rangers and West Boylston Police to curb a growing trend in nighttime trespassing at this location.

Limit of bicycling near Gate 39 and dog walking along the spillway area of the Intake Protection Zone have been posted with signage since the last plan. “No Dogs Allowed” signs have been placed along the Mass Central Rail Trail at all paths leading to the Quinapoxet River, and also at both ends of DCR property on the Sterling section of the rail trail. Other signs that have been placed at problem areas include “No Dumping,” “No Trespassing,” and “No Fishing.”

In addition to rules signs, bulletin boards and kiosks have been placed at entry points at many areas around the watershed. Bulletin boards and kiosks have generally been placed in high use areas typically near DCR parking areas.

Large bulletin boards are located at: Manning Street Rail Trail parking lot, Oakdale Rail Trail at Route I-190, River Road parking area, and the Sterling Rail Trail. Smaller bulletin boards are at Gate 8, Gate 19, Gate 25 and Gate 35. Bulletin boards allow DCR to place upcoming interpretive programs, rules and regulations, emergency contact information, historical information, watershed maps, and general information on current water quality and/or watershed outreach topics. All bulletin board information is updated on a regular basis by the Watershed Ranger staff.

Four-sided kiosks have been placed at the Promenade of the Wachusett Dam, the Old Stone Church, Gate 36/North Dike, Bob’s Hot Dogs triangle (Junction of Rtes 12 and 140), and at the Stillwater Farm. Information on kiosks also includes emergency contact information, historical information, water quality/watershed education and outreach, watershed maps and current issues. These are also updated on a regular basis by the Ranger staff.

Several brochure boxes were placed at key kiosk locations around the watershed in 2010 to distribute take home information on water quality and public access issues. They have become an integral part of the DCR’s outreach program and are monitored and filled by Ranger staff.

Both the bulletin boards and kiosks contain a lot of information for visitors; many people have been observed reading them and referring to them when asking questions of staff. Other locations for both bulletin boards and kiosks will be evaluated on an as need basis. Recommendations include investigating the use of alternative fade resistant paper or printing as

well as information should be updated on a more frequent basis. In addition, screening or other avenues to keep bees from nesting inside kiosks should be implemented.

Implementation Recommendations

- Add a kiosk or bulletin board in the vicinity of the road below the dam when access to the entire area is reopened.
- Purchase fade resistant paper for kiosk information.
- Update kiosk/bulletin board information on a more frequent basis.
- Add screening or another way to keep bees from nesting inside kiosks. Talk with State Parks to see how they deal with this problem.



Kiosk and brochure box



Typical DCR Wachusett Reservoir watershed signage, kiosks and bulletin boards

C. Mapping

The DCR/DWSP reservoir fishing map has been updated to include all DCR/DWSP gate numbers for access points, fire roads, and the fishing limit. The reverse of the map has a listing of the most relevant regulations for this activity and emergency contact information. Recommendations for the next revision and reprinting include adding No Public Access Zone and parking lots to the map and information on Aquatic Invasive Species prevention in the narrative.

Wachusett Greenways has produced a Wachusett Greenways Guide that is available on-line (www.wachusettgreenways.org/wgg.html) and in print, and is also posted on Wachusett Greenways bulletin boards at both sections of the Mass Central Rail Trail. DCR/DWSP's mission, to ensure clean water, is listed, and DCR property ownership is demarcated.

DCR's Wachusett Reservoir watershed hunting map was revised in 2004. The map shows allowed hunting areas north of Route I-190 on one side, and west of Route I-190 on the reverse. Parcel data for these areas was from 2003 and 2004. Since hunting on designated areas of DCR/DWSP lands is by permit only, a hunting map is mailed with each permit issued. Allowable hunting properties are an extensive portion of the Tributary Headwaters Zone, therefore any map made to include the entire area should show the parcels as large as possible, although signage is physically present. DCR watershed property has been acquired since the last revision of the map, and gates have been numbered. A new map will be designed, replacing the stars (previously gates) with a gate number, and showing updated Wachusett DCR/DWSP ownership. A few relevant regulations can also be added to the bottom of the map.

Implementation Recommendations

- Revise fishing map, adding No Public Access Zone and parking lots to the map, and information on Aquatic Invasive Species prevention in the narrative.
- Revise hunting map, replacing stars with gate numbers and show updated Wachusett DCR/DWSP ownership.
- Compose general access map and visitor guide.

D. Enforcement

Watershed Rangers are trained educators who work to identify violations and educate the public on watershed regulations. Once a violation is observed, the Rangers will talk with the violator to explain why the rule or regulation is in effect and how it relates to water quality. For situations where additional help is needed, the Rangers rely on the State Police, the primary enforcement officials on the Division's properties, who can summons violators to court since all DCR/DWSP offenses are criminal in nature. This cooperative system of education and police enforcement has worked very effectively in the Wachusett Reservoir watershed and it is important to continue this partnership, especially with the potential security risks now faced by the agency.

Environmental Police Officers who work in the inland regions are responsible for enforcing a wide variety of environmental laws and regulations. Enforcement of the statutes regarding

hunting, fishing, trapping, boating, and ATVs are a part of these officers' job duties. They also provide invaluable assistance when dealing with these types of violations on DCR/DWSP property or when investigation is needed. Local police have also worked well with DCR/DWSP on issues of mutual concern in the watershed communities, especially when illegal activity occurs after dark. All of these relationships are critical to the enforcement of DCR/DWSP rules and regulations and security of the drinking water supply. DCR meets with all above entities as needed to enhance coordination on enforcement issues.

The public and visitors to the Wachusett Reservoir watershed are an effective tool in identifying and reporting improper, illegal and suspicious activity on DCR/DWSP property. It is important that everyone remains vigilant in ensuring that the drinking water supply remains safe. DCR encourages the public to notify the appropriate authorities when observing an illegal or suspicious activity, and to not try to intervene on their own. All contact information is available on all DCR signage, bulletin boards, kiosks, and brochures for reporting these activities. Water security of the reservoir and all infrastructures should be a priority on DCR/DWSP lands for the public to be observant. The Environmental Protection Agency has designed several drinking water security posters for use by the water supply community. Thought should be given to place these with appropriate contact phone numbers on all bulletin boards and kiosks or on gates at priority areas.

Implementation Recommendations

- Continue education and enforcement efforts of the Watershed Rangers.
- Maintain working relationships with State Police, Environmental Police, and local police.
- Place security related signs in appropriate locations.



EPA Water Security Poster

E. Public Education/Interpretive Services/Public Outreach

Watershed protection is most effective when public access management is complemented by public education. Providing information about watershed protection and water quality is a critical protection tool because so much human activity is not governed by federal or state laws related to water quality. It is important, when talking with visitors, that they be given correct information, and when dealing with rules infractions they are given a background and reasons for the regulation and why it is needed for resource protection. Rangers, who have been trained in interpretive techniques, are the front line educators when dealing with the public and public access issues on our property.

Public education can be broken down into two major categories: direct and indirect contact. Printed information, usually through signs, bulletin boards and brochures are the main avenues for indirect contact. Several brochures on water quality issues have been developed by DCR staff and have been distributed to topic relevant places within the watershed. Town halls, libraries, veterinarian offices, medical facilities and police departments have been utilized for this effort.

Direct contact information can happen in many ways. Watershed Rangers speak informally with thousands of annual visitors to the watershed lands. This is one of the most effective means of public education. Direct interactions allow staff to answer questions, identify improper activities, and immediately inform the visitor the reason why a particular use is restricted.



DCR staff lead an education program on water quality related issues.

School programs allow staff to teach students within the watershed about how their activities affect the water supply resources. School programs also provide an opportunity to distribute printed information to students and their families. DCR staff has constructed displays on drinking water and watershed protection which have been displayed at each public library during National Drinking Water Week, and also participate in other town fairs and events as time and staff allows. Printed information is also made available at the display locations. Other public

programs offered by DCR, all with a resource protection theme, include: guided hikes and tours on DCR property; watershed protection lectures; Old Stone Church historical talk; watershed geocaching event; and a learn to fish program. All events help to reinforce the need for proper resource protection and are a part of DCR's overall education strategy.

DCR has conducted a considerable amount of public outreach in regards to specific topics identified by staff as critical to water quality protection. Three of these issues are dog waste, aquatic invasive species, and fishing line recycling.

Implementation Recommendations

- Continue to conduct public education programs, including programs for schools in the watershed communities.
- Maintain information kiosks and bulletin boards.
- Utilize media as necessary for watershed events, programs, and public access advisories.

1. Dogs and Pet Waste

Dogs are prohibited on DCR Watershed lands, but there are over 5,500 dogs licensed within the five watershed towns. Storm drain systems can carry bacteria from pet waste to nearby wetlands, streams, and surface water bodies, negatively impacting water quality.

Public education and outreach conducted to date includes:

- Watershed Rangers have been provided with small reminder cards that can be handed out to dog owners who are observed walking their dogs on watershed lands. The cards include an explanation as to why the no dog rule is in effect for water quality protection.
- DCR has designed a brochure reminding residents to please pick up after their dogs which has been made available at all watershed town clerk offices and veterinarian offices. Holden Veterinary Clinic has also used these brochures in their “puppy packets” distributed to all new puppy owners (see Appendix F).



Dog-related public education materials.

- Information has been posted on bulletin boards and kiosks.
- A letter has been sent out to neighborhoods where dog waste is the suspected cause of higher bacteria levels in tributaries.
- An article has been published in DCR's *Downstream* newsletter.
- Information has been posted at the new Town of Sterling Greenery Park, adjacent to DCR property.
- Dog waste pick up dispensers were donated to both the Sterling Greenery Park and West Boylston Cemetery Department, where drainage flows into main tributaries and dog waste had become a problem.
- DCR also acted as an advisor to a local elementary school class that chose to find a solution to the community problem of pet waste. The students' outreach included: public service announcements; presentations to the entire student body, school committee and conservation commission; posters; brochures; and a video broadcast on community access television.

DCR will continue to conduct outreach on dog waste and identify innovative ways to educate the public on this topic.

2. Aquatic Invasive Species

Aquatic Invasive Species (AIS), such as the zebra mussel and hydrilla, can pose a serious threat to water supplies. AIS, very simply, are not supposed to be here. They are transported from distant regions of North America ("native transplants") as well as from other continents ("exotics"). AIS, once introduced, have the ability to establish a viable colony and spread rapidly within native aquatic communities, threatening the health of waterways as they usually are impossible to eradicate.



DCR/DWSP Aquatic Biologist Jamie Carr investigating the presence of *Hydrilla* at South Meadow Pond in Clinton (off watershed).

AIS can have a significant impact on game fish populations, including a reduction in juvenile fish food sources resulting in less fish for sport. AIS are primarily spread among water bodies by human activities, especially boating and fishing.

While the Division controls the potential of AIS entering the Reservoir from equipment such as boats and trailers by limiting use to only official business and requiring those vessels to be thoroughly free of AIS, a greater challenge to DCR is preventing introduction of AIS to Wachusett Reservoir from anglers fishing from shore. The approach to providing public outreach on the threats from AIS must be multi-faceted to reach the general public as well as user groups. DCR has begun conducting outreach on AIS and will continue to do so through the implementation of the Aquatic Invasive Species Assessment and Management Plan (DCR 2010). DCR will utilize additional means, including the media if conditions warrant.

AIS outreach has included:

- Fact cards for the Rangers to distribute to fishermen while in the field.
- Notices placed at local bait and tackle shops and Wal-Mart sporting section.
- Advisories posted at South Meadow Pond and DCR bulletin boards and kiosks.
- Articles in the DCR *Downstream* newsletter, and through e-mail with all watershed sportsmen's clubs.

3. Fishing Line Recycling

Fishing line, when left on the ground, poses a hazard to wildlife as well as anyone who tries to pull it from tangled branches and brush. Fishing line can entangle waterfowl, such as cormorants and loons, as well as beaver and muskrat. These animals cannot break free and are left to die in the drinking water supply. In an effort to address the amount of fishing line left on the Wachusett Reservoir shoreline, DCR has placed fishing line recycling canisters and associated signs at many popular fishing gates around the reservoir and its tributaries. Several articles on this topic have been published in the DCR *Downstream* newsletter. Canisters are emptied on a regular basis and the line is sent to a company in Florida that recycles it into other items. As of December 2010, over 24 miles of line has been kept out of the reservoir and recycled. DCR will continue to promote this program that benefits water quality, public safety, and wildlife health.



Fishing line recycling canister.

F. Sanitation

DCR does not have any public restroom facilities in the watershed. Human sanitation can be an issue in all management zones, but most importantly, in the Reservoir Protection Zone as sections of shoreline are a significant distance from roadways, gates and parking areas, and fishermen spend many hours at their locations. Sani-cans are provided at the Old Stone Church, Oakdale Rail Trail, Gate 36, and Gate 23 from April until November. Ranger staff has noted that the location at Gate 23 (near the MassWildlife Central District office) has been used extensively by road bicyclists and passers-by, and not DCR visitors. DCR will develop a monitoring program to determine usage at the current locations and recommend alternative/additional locations, or relocating to different areas depending on season and/or visitor usage of the lands. The number of sani cans, identifying proper areas to locate them in, and the ability for them to be emptied must be taken into consideration and alternative options may be explored.

Implementation Recommendations

- Continue to provide sani-cans at key locations. Develop a pilot program to monitor sani-can usage within the Reservoir Protection Zone.
- Encourage and coordinate with Wachusett Greenways and the Town of West Boylston to place an odorless dog waste collection station at the Mass Central Rail Trail in Oakdale.

G. Monitoring/Public Evaluation

This Public Access Plan Update outlines any policy changes in public access management on DCR/DWSP lands and waters in the Wachusett Reservoir watershed. It is important that the Division monitor and evaluate these policies. Legislation requires the Division to update its watershed protection plans on a regular basis (5 year cycles). However, on-going monitoring and evaluation of DCR/DWSP access policies will occur in order to ensure a successful watershed protection program.

DCR will maintain a regular monitoring program for its forest roads, access points, and reservoir shorelines. This is accomplished primarily through Watershed Ranger patrols and environmental assessment activities performed by DCR/DWSP Environmental Quality staff. These programs will help identify impacts from public access, particularly illegal dumping and erosion from overuse.

Implementation Recommendations

- Maintain a regular monitoring program for forest roads, access points, and reservoir shorelines.
- Provide review of public access issues in annual work plans and other reports.

**Table 17. Wachusett Reservoir Watershed 2011 Public Access Plan Update
Implementation Summary**

Issue	Implementation Objectives
Structural Controls	<ol style="list-style-type: none"> 1. Work with railroad and Power Company to add barriers or signage on ROWs to stop ORVs from entering onto DCR property. 2. Continue to monitor for illegal dumping and install barriers where needed. 3. Work with the Town of West Boylston to install an access gate at either end of River Road to provide emergency access for DCR as well as West Boylston Police and Fire Departments. 4. Explore the addition of a fence or barrier between the dam Promenade and Gate 1 to curb any potential trespassing and make the limits of public access clear.
Signs	<ol style="list-style-type: none"> 1. Continue to remove old signage as observed in the field. 2. Ensure that correct contact numbers of DCR and the State Police are printed on signs. 3. Install additional signage where public access problems arise. 4. Post emergency contact phone numbers and gate reference number at key locations along the shoreline where there is a significant distance from the gate to the reservoir. 5. Add “No Trespassing After Dark” signage to the Old Stone Church and Dam Promenade. 6. Talk with the Town of West Boylston about access after dark on their portion of the Mass Central Rail Trail. 7. Verify rules signage east of Route 70 for accuracy. 8. Confirm Public Access Management Zone signage in the field corresponds to the wording in the Public Access Plan. 9. Work with the responsible party to repaint “No Fishing/Standing From Bridge” at the Thomas Street/Quinapoxet River Bridge. 10. Ensure adequate “No Trespassing” signage is in place to delineate the area between Route 62 (Willow Road) and Mile Hill Road. 11. Change color of emergency contact information on signs or consider adding separate signs at gates for this information. 12. Create new bicycle trail placards and place along trails. Re-blaze and re-establish existing trails. 13. Place signage along the Quinapoxet River for canoeists and kayakers, including a warning sign leading up to the accretion dam and a permanent warning sign at Canada Mills stating that conditions can become dangerous during times of high water levels and that users are at their own risk. 14. Post “No Access on Rip Rap” signage near Gate 36. 15. Post signage near Gate 40 alerting bicyclists that they are not allowed on the top of the dike. 16. Post “Limit of Fishing With Waders” signage at confluence of Waushacum Brook and Stillwater River. 17. Add signage between the dam Promenade and Gate 1 to curb any potential trespassing and make the limits of public access clear.

Issue	Implementation Objectives
Mapping	<ol style="list-style-type: none"> 1. Develop and distribute Public Access Map(s) that show locations for hiking, bicycling, and parking. 2. Develop, if resources allow, Wachusett Reservoir watershed guide incorporating all maps. 3. Modify hunting map, replacing stars with gate numbers and show updated DCR/DWSP ownership. 4. Revise fishing map, adding No Public Access Zone and parking lots to the map, and information on Aquatic Invasive Species prevention in the narrative.
Enforcement	<ol style="list-style-type: none"> 1. Continue to conduct regular patrols of the Wachusett Watershed. 2. Work with local and state law enforcement on night trespassing issues. 3. Work with local and state law enforcement on ATV/snowmobile activity. 4. Monitor use of property along closed section of River Road for illegal activity and work with law enforcement to curb any activity observed.
Public Education/ Interpretive Services	<ol style="list-style-type: none"> 1. Continue to use media as necessary for watershed events, programs, and public access advisories. 2. Conduct environmental programs for schools in the watershed communities. 3. Conduct public education programs. 4. Maintain information kiosks and bulletin boards. 5. Install kiosk or bulletin board at the road below the dam. 6. Continue dog waste education by staff in the field and kiosk postings. 7. Post link to Public Access Plan on all boards and kiosks. 8. Post geocaching guidelines on all kiosks and bulletin boards. 9. Consider developing a permanent, water quality/watershed themed multi-use letterbox or geocache at Stillwater Farm. 10. Post EPA Drinking Water Security Posters on kiosks and bulletin boards at the Old Stone Church, Bobs Hot Dog Triangle, the Dam Promenade, and below the Dam. 11. Change kiosk and bulletin board information more frequently and look into fade resistant paper or printing. 12. Add screening or other avenue to keep bees from nesting inside kiosks. 13. Work with the Open Space Committees in each watershed town to ensure that their plan updates are compatible with DCR's mission. 14. Work with MassWildlife to include better DCR Reservoir information, rules and regulations in annual fishing abstracts.
Sanitation	<ol style="list-style-type: none"> 1. Coordinate with Wachusett Greenways and the Town of West Boylston to place an odorless dog waste collection station at the Mass Central Rail Trail in Oakdale. 2. Develop a pilot program to monitor sani-can usage within the Reservoir Protection Zone.

Issue	Implementation Objectives
Technology	<ol style="list-style-type: none"> 1. Explore possibility of creating an official Facebook Page or Twitter for timely announcements, general information, or emergency information such as closures. 2. Provide DCR Group Permit or request form on DCR Public Access website 3. Work with watershed towns to provide a link to the Public Access Plan and maps on their town websites. 4. Work with IT to make DCR website easier to navigate for information on the watershed. 5. Have geocaching guidelines available online through the DCR website. 6. Provide bicycling map online through DCR website.
Maintenance	<ol style="list-style-type: none"> 1. Maintain access trail to handicapped platform from River Road to Quinapoxet River. 2. Discuss improving the road shoulder along the reservoir side of the triangle at Rtes 12/140 West Boylston (near Bob's Hot Dog Truck) with local and state road agencies. 3. Perform regular maintenance below the Dam. 4. Coordinate with DCR Land Management Plan for ongoing maintenance needs at Poutwater Pond. 5. Investigate maintenance needs at Poutwater Pond bog boardwalk and repair as needed and if funding allows.

X. Other Open Space and Public Access

Although recreational activities are limited on DCR Wachusett Reservoir watershed lands, there are many alternatives when looking to engage in a specific activity. This section lists some of these locations. It is important that the public check with each management agency before participating in their chosen activity because all property owners have different rules and regulations, which sometimes change.

A. DCR Division of State Parks and Recreation

There are 32 DCR State Parks in Central Massachusetts. Two of the closest to Wachusett Reservoir are Leominster State Forest and Wachusett Mountain State Reservation.

Wachusett Mountain State Reservation is 3,000 acres; it contains a wealth of natural resources. The mountain access road is currently closed to motorists, bicyclists, and pedestrians during the Wachusett Mountain Parkway Road System Rehabilitation. The project, which began in spring of 2010 and is expected to be completed in the summer of 2011, will repair the deteriorated roadway infrastructure and bring the roadway into compliance with current safety and functional standards. Wachusett Mountain offers many miles of hiking and walking trails, some of which lead to spectacular scenery. Dogs (on leashes) are allowed at the Reservation and bicycles are limited to the paved roadway.

Leominster State Forest is a 4,300 acre parcel of forested land that offers recreational opportunities year round, ranging from mountain biking (on multi-use trails) and swimming in the summer to cross-country skiing and snowmobiling in the winter. Dogs (on leashes) are allowed.

Some of the local options for camping include Willard Brook State Forest, Otter River State Forest, Pearl Hill, and Lake Dennison. Several properties offer swimming in the summer, including Dunn State Park and Quinsigamond State Park. There are also swimming pools operated or leased by DCR in Clinton, Leominster, Fitchburg, and Worcester.

The State Park system also offers the public several locations to ride ATVs (www.mass.gov/dcr/recreate/orv.htm), snowmobiles (www.mass.gov/dcr/recreate/snowmobile.htm), and horses (www.mass.gov/dcr/recreate/horse.htm). More information on the DCR State Park System and regulations for central Massachusetts can be found at www.mass.gov/dcr/central.htm.

B. MassWildlife

The Department of Fisheries, Wildlife and Law Enforcement (DFWELE) is the state agency responsible for managing and conserving the state's fisheries and wildlife, including rare and endangered species. The Division of Fisheries and Wildlife (MassWildlife) works to conserve and manage the Commonwealth's wildlife heritage by offering expertise and assistance, addressing issues involving wildlife and habitat, and ensuring that people understand and comply

with laws designed to protect our populations of wild plants and animals. MassWildlife controls 102 Wildlife Management Areas (WMA) and 13 wildlife sanctuaries across the state, encompassing over 160,000 acres of land and water. All WMAs are open to hunting, fishing, trapping, and other outdoor recreation activities; sanctuaries are more restrictive.

There are two significant MassWildlife properties in the Wachusett Reservoir Watershed, Poutwater Pond WMA and Minn's Wildlife Sanctuary. There is a description of Poutwater Pond Nature Preserve (comprised of DCR and MassWildlife lands) in Section III. The 138 acre Minn's Wildlife Sanctuary in Princeton does not allow hunting; it does contain a trail that climbs to the top of Little Wachusett Mt. and connects to the MA Audubon Wachusett Meadow Sanctuary.

Additional information can be found on-line at www.mass.gov/dfwele/dfw.

C. *Massachusetts Audubon Society*

Massachusetts Audubon Society is the largest conservation organization in New England, protecting more than 29,000 acres of conservation land, conducting educational programs for children and adults, and advocating for sound environmental policies at the local, state, and federal levels. Mass Audubon maintains 41 wildlife sanctuaries that are open to the public. The Wachusett Meadow Wildlife Sanctuary provides eleven miles of trails over more than 1,000 acres at the base of Wachusett Mountain in Princeton. Pets, leashed or unleashed, are not allowed on this site. Motorized vehicles, bicycles, hunting, fishing, and trapping are also not permitted in the wildlife sanctuaries.

Additional information can be found on-line at www.massaudubon.org.

D. *Land Trusts*

Land Trusts are local, independent nonprofit organizations that work with landowners who want to protect open land for conservation, recreation, and other public benefit. Land trusts may acquire land through donation or purchase, or hold conservation restrictions on private property. There are several active Land Trusts in the Wachusett Reservoir watershed, including: White Oak Land Conservation Society, North County Land Trust, Princeton Land Trust, Sterling Land Trust, and West Boylston Land Trust. Some already own land, such as White Oak's 600 acres in Holden and Rutland, while others are still organizing their resources. Each Land Trust has its own access rules.

E. *Other Open Space*

Other protected open space within the watershed includes: golf courses, lands in Chapter 61 (61, 61A and 61B), DCR Watershed Preservation Restrictions, and local community ownership. It is important that DCR forms partnerships with each open space owner to preserve and protect the

natural resources and to adequately and effectively promote the mission of the DCR/ DWSP. Open Space and Recreation Plan Updates and Master Plans for the towns of West Boylston, Sterling, Clinton, Boylston, Holden, Paxton, and Princeton were reviewed for this Public Access Plan Update. Each community had similar goals listed for the future and each plan highlighted DCR/DWSP as a valuable open space owner. The towns also recognized the purpose and need of these lands for water supply protection. The watershed towns, understandably, would like a broader range of active recreation activities on DCR/DWSP lands, including bicycling and boating, activities which DCR deems inappropriate uses of watersheds lands. DCR will work with the Open Space Committees in each town to ensure that their plan updates are compatible with DCR's mission.

REFERENCES

Massachusetts Acts and Resolves

Acts of 1919, Chapter 350, Section 123 (Creation of MDC)
Acts of 1984, Chapter 372 (Creation of MWRA and MDC Division of Watershed Management)
Acts of 1992, Chapter 36 (Watershed Protection Act)
Acts of 2003, Chapter 41 (Creation of the Department of Conservation and Recreation)
Acts of 2004, Chapter 149, Section 27 (Creation of the Water Supply Protection Trust)

Massachusetts General Laws (MGL)

MGL Chapter 59, Section 5G (Watershed Payments in Lieu of Taxes)
MGL Chapter 92A½ (DCR Watershed Management)

Code of Massachusetts Regulations (CMR)

310 CMR 22.00 Drinking Water
350 CMR 11.00 Watershed Protection

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Appendix A. Watershed Regulations

Official Disclaimer: These regulations are provided to you for your convenience. Official versions of all Massachusetts State statutes are available through the State Bookstore. When downloading from the web please be aware that the copy you receive may differ from the official version. If you need the statutes for work that may have any legal implications, make sure to get the official version from the State bookstore.

350 CMR 11.09: General Rules and Regulations for the Protection of Watersheds and the Watershed System

In order to facilitate review of all regulations promulgated by the Commission and the Division relating to Watersheds and the Watershed System, this Section includes regulations of general applicability to Waters of the Watershed System. The regulations in 350 CMR 11.09 are intended to supersede the regulations in 310 CMR 23.00, 350 CMR 8.01, 350 CMR 9.00, and 350 CMR 10.00.

(1) Waters of the Watershed System.

(a) No Person shall take or divert any Waters of the Watershed System of the Commission and no Person shall corrupt, render impure, waste or improperly use any such water.

(b) No Person shall:

1. engage in any construction activity involving filling, dredging, grubbing or altering land without adequate provisions to prevent erosion resulting in clay, silt or other turbidity laden waters from entering the Waters of the Watershed System;

2. construct, establish or maintain any agricultural facility or place where animal manure may be deposited or accumulated without adequate provision to prevent any manure or other Pollutant from flowing or being washed into the Waters of the Watershed System;

3. engage in any other activity which could degrade the quality of Waters of the Watershed System or interfere with their use as a source of water supply.

(c) No Person shall allow a condition to exist on such Person's property which could result in the direct or ultimate discharge of any Pollutant into the Waters of the Watershed System.

(d) Any records of any board of health or health agent concerning matters within the Watershed shall be open to inspection by the employees and agents of the Commission and the Department.

(e) Whenever an incident occurs, is likely to occur, or a situation exists that threatens to add Pollutants to the Waters of the Watershed System, the Person causing or contributing to the pollution or potential pollution shall notify the Commission and the Department immediately.

(2) Watershed System.

(a) General Regulations.

1. Entrance on and exit from land of the Watershed System shall be made through gates or other designated areas.
2. No Person is allowed within any land of the Watershed System, except from one hour before sunrise to one hour after sunset, unless authorized by a written permit from the Commission or its designee.
3. Powered boats are prohibited within the Waters of the Watershed System except in areas designated by the Commission or its designee.
4. All acts which pollute or may pollute the water supply are prohibited. No litter or refuse of any sort may be thrown or left in or on any land or water within any Watershed System. All Persons within said System shall use the sanitary facilities provided for public use.
5. All acts which injure the property of the Commonwealth are prohibited. No Person shall injure, deface, destroy, remove or carry off any property, real or personal, under the care and control of the Commission, including but not limited to, all historic artifacts and natural materials. The removal of gravel, topsoil, stones, boulders, or other earthen material is prohibited from the Watershed System except for removal for official use for land management purposes by Commission staff. No Person shall build or construct any object or structure of the property of the Commonwealth except with the written permission of the Commission or its designee.
6. Cooking and all fires are prohibited within the Watershed System.
7. No Person shall wade or swim in any reservoir except wading while using boots for the purpose of launching boats at designated boat launch areas.
8. No Person shall wade or swim in any Tributary or Surface Waters on or within the property of the Commonwealth except at areas designated by the Commission or its designee.
9. Organized sports activities, including but not limited to orienteering and baseball, are prohibited in the Watershed System except by written permit from the Commission or its designee.
10. Any violation of 350 CMR 11.09 will be deemed sufficient cause for revocation of fishing privileges for a period of time not less than one year from the time of violation. The Commission and its employees are not responsible for any damage to or loss of property sustained by fishermen, or for any injury or loss of life which may be incurred in connection with public use of the reservoirs and Watershed System.

11. Breach of peace, profanity or other disorderly conduct offensive to the general public is strictly prohibited within the Watershed system. Possession of and drinking of alcoholic beverages is prohibited within said System.
12. No Person shall drive a motorized vehicle within the Watershed System except upon roads authorized for such use by the Commission or its designee. Recreational vehicles are prohibited on all Watershed System property except the use of snowmobiles in areas designated by the Commission or its designee. Motor vehicles shall be parked only in areas designated by the Commission or its designee. Operators of motor vehicles shall obey all regulatory signs unless otherwise directed by a police officer or person in charge. No Person shall willfully obstruct the free passage of vehicles or Persons within the Watershed System. Vehicle access for official use may be granted by the Commission or its designee.
13. No Person shall bring any animal within any Watershed System property except for horses and dogs at the Ware River Watershed at areas designated by the Commission or its designee.
14. The use of bicycles, skis and other means of non-motorized transportation within the Watershed system shall be permitted only in areas designated by the Commission or its designee.
15. No Person, except in an emergency, shall bring, land or cause to descend within any Watershed System property any aircraft except with a written permit from the Commission or its designee.
16. Parades, games, fairs, carnivals, fishing derbies, bazaars, gifts or solicitations for raising or collecting funds shall not be permitted within the Watershed System without written approval of the Commission or its designee.
17. Lotteries, raffles, gambling and games of chance are prohibited; and no Person shall have possession of machinery, instruments or equipment of any kind for use of same in the Watershed System.
18. Public assemblies of more than 25 persons shall not be allowed within the Watershed System without a written permit from the Commission or its designee.
19. No Person shall engage in any business, sale or display of goods or wares within the Watershed System without a written permit from the Commission or its designee.
20. Commercial signs and advertising are prohibited in the Watershed System.
21. No Person shall have possession of or discharge any weapon, firearm, fireworks, or other explosive on or within the Watershed System except at times and areas designated by the Commission or its designee. All forms of target shooting are prohibited on or within the Watershed System.
22. No Person may hunt, shoot or trap animals on or within any Watershed System property except at times and in areas designated by the Commission or its designee.

23. All Persons within the Watershed System shall obey the lawful directions of regulatory signs, police officers or persons in charge, or of Federal or Commonwealth wardens or enforcement officers.

24. The Watershed System or parts thereof may be closed for public access at the discretion of the Commission or its designee when necessary to protect the lands and waters under the care and control of the Commission.

25. The possession of all types of metal detectors or similar devices is prohibited on all of the Watershed System property.

(b) Special Regulations for Quabbin Reservoir.

1. Persons in compliance with Commonwealth Fish and Game Laws and Regulations, will be allowed to fish from shore in areas designated by the Commission or its designee. A valid state fishing or sporting license is required by any Person renting or launching a boat at any Commission facilities subject to 350 CMR 11.09. Reasonable fees for the use of boats, for rental of outboard motors for fishing purposes, or use of Commission facilities including parking and boat ramps, may be charged by the Commission.

2. Persons permitted to fish from boats shall, at all times, be responsible for the sanitary condition of the boats. Persons under 16 years of age must be accompanied by a Person possessing a valid fishing license in order to boat on Quabbin Reservoir.

3. Only boats of a minimum length of 12 feet, and of a type considered safe by the Commission representative in charge, shall be used. No inboard motors, collapsible boats, sailboats, pontoon boats, square sterned canoes, or other similar craft will be permitted in the water, and no boats will be permitted in the water except in areas designated for boating by the Commission or its designee. Outboard motors shall have a rating of not more than one-half the BIA or OBC rated horsepower for the boat and shall not exceed 20 horsepower, except that outboard motors for Commission boats less than fourteen 14 feet six inches in length shall not exceed ten horsepower. Boats less than 14 feet six inches in length will be limited to three occupants, and boats of that length and in excess thereof may be licensed to carry four occupants. No boats shall carry more than four occupants. Canoes and jon boats of a minimum length of 12 feet, and of a type considered safe by the Commission representative in charge, shall be used and only in areas designated for boating by the Commission on Pottapaug Pond above the regulating dam and at Gate 31 above the regulating dam. Canoes less than 16 feet and jon boats less than 14 feet six inches in length will be limited to two occupants, and canoes and jon boats in excess thereof may be licensed to carry three occupants. All boats must be in compliance with current Commonwealth Boating Laws. All boats must be clean and contain no refuse of any kind. Commission personnel shall have the right to inspect all private boats launched at Commonwealth facilities and may deny access in order to protect water quality or the safety of occupants. Chock blocks must be used on vehicles when removing boats from the Reservoir.

4. No Person shall operate a motor boat at a speed other than reasonable and proper or in such a manner as to annoy or endanger the occupants of other boats.

5. Fishing from the shorelines of the Quabbin Reservoir and its Tributaries within the Watershed System or from boats shall be allowed only during a season designated by the Commission or its designee. All privately-owned boats, motors and other equipment must be removed from the property of the Commission each day.

6. Boats shall not leave the mooring areas before dawn, and must return at the time posted at each mooring area. The beaching of boats at any point except at the designated mooring and landing areas is strictly prohibited, except in cases of extreme emergency.

(c) Special Regulations for Ware River.

1. Persons in compliance with Commonwealth Fish and Game Laws and Regulations will be allowed to fish in the Ware River in areas designated by the Commission or its designee.

2. Powered boats and powered canoes are prohibited within the Ware River Watershed Reservation.

(d) Special Regulations for Wachusett Reservoir.

1. Persons in compliance with Commonwealth Fish and Game Laws and Regulations will be allowed to fish from the shore of Wachusett Reservoir in areas designated by the Commission or its designee.

2. Boating is prohibited in Wachusett Reservoir.

3. Fishing from the shoreline of the Reservoir shall be allowed only during a season designated by the Commission or its designee.

(e) Special Regulations for Sudbury Reservoir.

1. Persons in compliance with Commonwealth Fish and Game Laws and Regulations will be allowed to fish from the shore of Sudbury Reservoir in areas designated by the Commission or its designee.

2. Boating is prohibited on Sudbury Reservoir except in areas designated by the Commission or its designee.

11.10: Enforcement

Any Person who, without lawful authority, takes or diverts any Waters of the Watershed System or corrupts or defiles any such Waters or any source of such Waters or who violates and refuses to comply with any rule, regulation or order of the Commission shall be subject to the fines set forth in M.G.L. c. 92, ' 111. The provisions of 350 CMR 11.00 shall be enforced upon petition of the Commission or of any town or Person interested by the Supreme Judicial Court or Superior Court or any justice of either court as provided in M.G.L. c. 92, ' 112. In addition, upon written request by the Division, the Department shall have the authority to enforce the provisions of St.

1992 c. 36 and 350 CMR 11.00 by all legally permitted enforcement mechanisms including, but not limited to: issuing notices of noncompliance; convening pre-enforcement conferences; issuing water supply orders pursuant to M.G.L. c. 111, ‘ 160; and imposing administrative penalties pursuant to M.G.L. c. 21A, ‘ 16 and 310 CMR 5.00. Such written request by the Division to the Department may seek enforcement for a specified type of violation or area, for a designated group of cases or for an individual matter.

REGULATORY AUTHORITY

350 CMR 11.00: St. 1992, c. 36.

Appendix B. Geocaching Guidelines

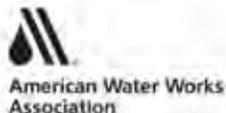
Wachusett Reservoir Watershed Geocaching/Letterboxing Guidelines



Geocaching and letterboxing are allowed on DCR Wachusett Reservoir watershed lands. There are, however, several rules for this type of activity to ensure minimal impact on the natural and cultural resources.

- 9 All caches to be placed on DCR Wachusett Reservoir watershed property must be registered on www.geocaching.com or www.letterboxing.org , noting that DCR Wachusett Reservoir watershed rules must be adhered to when on the property. Each cache must contain contact information of the owner. In the event a cache has to be removed by DCR staff, effort will be made to notify the owner.
- 9 Caches placed in no trespassing areas or areas deemed to be inappropriate by the DCR Wachusett Watershed Rangers will be removed immediately and kept at the Watershed Ranger office for thirty days. Effort will be made to notify the owner of the cache removal.
- 9 Caches CANNOT be placed in the following locations:
 - o Areas that would encourage disturbance or dismantling of historic structures, historic buildings, rock walls or cellar hole foundations
 - o Wetland resources protected under the Code of Massachusetts Regulations (310 CMR 10)
 - o Areas that could potentially cause danger to visitors trying to locate the cache
 - o Underwater or in streams
 - o Wildlife dens
 - o Restricted access areas of the DCR Wachusett Reservoir watershed
- 9 Caches must be in transparent containers, e.g., Tupperware or Rubbermaid. Metal (ammo boxes), PVC pipes, or other non-transparent containers are prohibited.
- 9 No digging or excavation is permitted at any time in the placement or retrieval of a cache.
- 9 No defacement or alteration to DCR Wachusett Reservoir watershed property, including but not limited to signs, benches, buildings, or natural features is allowed.
- 9 No removal or significant disturbance of vegetation, plant growth, or other flora is permitted at any time in the placement or operation of a cache.
- 9 Caches will not contain food, alcohol, firearms, drugs, dangerous items (e.g., fireworks or matches), or sexually explicit material. No natural materials from DCR Wachusett Reservoir watershed lands shall be placed into the cache.
- 9 No monies or profits can be derived from the placement of a cache by the owner or an affiliated business or organization.
- 9 Any questions regarding geocaching or letterboxing can be directed to the DCR Wachusett Reservoir Watershed Rangers at 978-365-3800.

Appendix C. AWWA Policy on Recreational Use of Domestic Water Supply Reservoirs



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Statement of Policy on Public Water Supply Matters

Recreational Use of Domestic Water Supply Reservoirs

The American Water Works Association (AWWA) supports the principle that water of the highest quality should be used as the source of supply for public water systems. Accordingly, the risks and potential mitigation requirements of any recreational activity on water supply reservoirs should be identified and publicly evaluated. In the evaluation, utility- and customer-determined acceptable levels of risk should be given the highest consideration. No recreation should be permitted on finished-water reservoirs under any circumstances.

Protection of public health and drinking water quality should be the highest priority in operational decisions for reservoirs used jointly for water supply and recreation. Decisions regarding recreational use of domestic water supply reservoirs should be consistent with the intent of the source water protection program developed and implemented by the utilities and other responsible parties.

Recreational uses of domestic water supply reservoirs and the land-based infrastructure necessary to support such uses can add sources of microbial, physical, and chemical contaminants to the drinking water produced from the reservoirs. Water utility decisions on permitting recreational uses of water supply reservoirs should consider the following issues: (1) the potential for water quality degradation, (2) the public health risk, (3) the acceptance of such health risk by the customers, (4) the current required level of treatment, and (5) additional treatment requirements, uncertainties, and costs that may be incurred. Recreational uses should be prohibited in those instances where a scientifically-based risk assessment, or, in the absence of a risk assessment, the best available scientific data demonstrates a probable or imminent degradation of water quality or hazard to public health that cannot be controlled or mitigated in a cost effective manner.

Continued . . .

Adopted by the Board of Directors June 13, 1971, reaffirmed Jan. 28, 1979, and Jan. 25, 1987, revised June 23, 1996, June 13, 2004, and January 25, 2009.

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When considering proposals for recreational use of domestic water supply reservoirs, the water utility should work with stakeholders to develop an integrated reservoir management plan, including appropriate water quality monitoring, to evaluate and, if necessary, mitigate water quality impacts, and to minimize increased risks. Body-contact recreation (e.g., swimming, water skiing, wind surfing) and use of two-cycle gasoline engines on boats should be discouraged or prohibited. In addition, boat inspection/washing stations and restrictive use of live bait should be considered to prevent the introduction of foreign and invasive species (such as zebra mussels or non-native algal species) that could potentially destabilize a reservoir's ecology and water quality. Where feasible, costs for monitoring, evaluations, and mitigation should be borne by those proposing or benefiting from the recreational activity, not by the utility or its customers.

If recreation already exists on a reservoir, the water utility should work or continue to work with stakeholders to develop an integrated reservoir management plan and associated implementation actions to mitigate water quality impacts and to minimize increased risks.

Recreational Use of Domestic Water Supply Reservoirs

Adopted by the Board of Directors June 13, 1971, reaffirmed Jan. 28, 1979, and Jan. 25, 1987, revised June 23, 1996, June 13, 2004, and January 25, 2009

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Appendix D. Public Access Survey and Results

Water Supply Protection Wachusett Watershed Public Access Survey

1. Please tell us where you live:

2. Please tell us what describes your affiliation with DCR Wachusett Watershed lands (please check all that apply):

- Watershed resident
- Non-watershed resident
- Abutter to DCR Wachusett watershed lands
- Municipal official

3. What age group do you belong to?

- 19 or under
- 20-29
- 30-39
- 40-49
- 50-59
- 60 or over

4. How did you learn about this survey?

- DCR website
- DCR Kiosk/bulletin board
- Direct mailing
- DCR Watershed Downstream newsletter
- Local Newspaper
- DCR Watershed Rangers/Staff
- DCR press release
- Town Hall

Other (please specify)

5. On a average, how many days per season do you utilize DCR Wachusett Watershed lands?

	Less than 7	7 - 14	15 - 30	over 30
Spring	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Summer	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Fall	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Winter	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

6. When do you mostly use DCR Wachusett Watershed lands?

	day	evening	both
Weekday	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Weekend	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

7. What passive recreation activities do you engage in on DCR Wachusett Watershed lands? (check all that apply)

- | | |
|--|--|
| <input type="checkbox"/> Fishing | <input type="checkbox"/> Cross-country skiing/snowshoeing |
| <input type="checkbox"/> Hunting | <input type="checkbox"/> Picnicking/relaxing |
| <input type="checkbox"/> Bird hunting with a dog | <input type="checkbox"/> Geocaching/letterboxing |
| <input type="checkbox"/> Hiking/walking | <input type="checkbox"/> Photography/nature study/birdwatching |
| <input type="checkbox"/> Bicycle riding | <input type="checkbox"/> Other |

8. Of the above, what is the PRIMARY type of passive recreation you engage in on DCR Wachusett Watershed lands?

9. While on DCR Wachusett Watershed lands, would you know who to contact in case of an emergency or water/environmental issue?

- Yes
- No

If yes, who is this contact?

10. While on DCR Wachusett Watershed lands, is it clear to you what activities are allowed and those that are prohibited?

- Yes
- No

11. When looking for information on DCR Wachusett Watershed rules, regulations, or general reservoir information, where do you try to find the answers?

12. Have you observed a violation of DCR Wachusett Watershed rules and regulations while on our property?

- Yes
- No

13. While on DCR Wachusett Watershed lands, how often have you encountered the following:

	often	occasionally	rarely	never
Dog walking:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Swimming or wading:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Feeding ducks and geese:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Horseback riding:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Snowmobiling/ATVs:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Visitor consuming alcohol/drugs:	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

14. Do you fish at the Wachusett Reservoir?

- Yes
- No

15. If yes, do you belong to a sportsmen's association?

- Yes
- No

16. How do you usually purchase your fishing license?

- City/town clerk
- MassWildlife office
- WalMart
- Online through MassWildlife
- Other

17. As a fisherman, are you aware of the types and impacts of Aquatic Invasive Species?

- Yes
- No

18. Are you aware that DCR Watershed Rangers patrol DCR Wachusett Watershed lands?

- Yes
- No

19. If yes, have you had the opportunity to talk with a ranger?

- Yes
- No

20. Have you read the information provided on DCR Wachusett Watershed kiosks and bulletin boards?

- Yes
- No

Please suggest information you would like available on kiosks and bulletin boards



21. Are you aware that DCR Wachusett Watershed staff offer free education programs?

- Yes
- No

22. If yes, have you attended a program?

- Yes
- No

Type of free program that you would attend

23. Once through DCR Wachusett gates, is our trail system easy to follow?

- Yes
- No

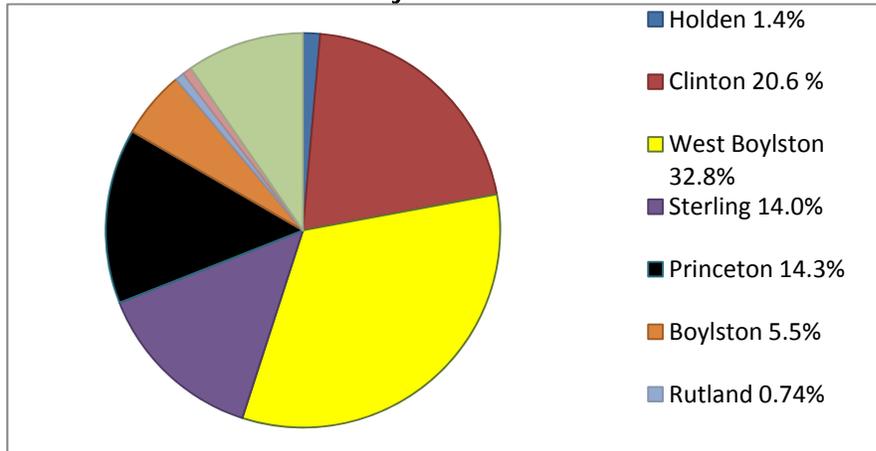
24. Please tell us about one aspect of the DCR Wachusett Watershed that you really like.

25. Please tell us about one aspect of the DCR Wachusett Watershed that you would change if given the chance.

26. Is there anything else you would like to tell us?

DCR/DWSP Wachusett Watershed 2011 Public Access Survey Results

Question 1: Please tell us where you are from:



Question 2: Please tell us what describes your affiliation with DCR Wachusett Watershed lands (please check all that apply):

Answer Options	Response Percent	Response Count
Watershed resident	69.8%	222
Non-watershed resident	18.6%	59
Abutter to DCR Wachusett watershed lands	22.3%	71
Municipal official	2.8%	9
<i>answered question</i>		318
<i>skipped question</i>		2

Question 3: What age group do you belong to?

Answer Options	Response Percent	Response Count
19 or under	0.0%	0
20-29	7.9%	25
30-39	18.6%	59
40-49	30.2%	96
50-59	27.4%	87
60 or over	16.0%	51
<i>answered question</i>		318
<i>skipped question</i>		2

Question 4: How did you learn about this survey?

Answer Options	Response Percent	Response Count
DCR website	5.0%	10
DCR Kiosk/bulletin board	3.5%	7
Direct mailing	3.5%	7
DCR Watershed Downstream newsletter	0.0%	0
Local Newspaper	44.6%	90
DCR Watershed Rangers/Staff	4.5%	9
DCR press release	5.0%	10
Town Hall	34.2%	69
Other (please specify)		135
	<i>answered question</i>	202
	<i>skipped question</i>	118

Responses to "other":

- Email from DCR representative
- Clinton Mass web site
- www.ClintonMass.com
- Local website
- ClintonMass.com
- www.clintonmass.com discussion forum
- Clintonmass.com discussion forum
- Web site
- Clintonmass.com
- Clintonmass.com discussion site
- Eight Point Sportsmen's Club Web Site
- Clinton online discussion
- Clintonmass.com
- Town of Sterling email notices
- Sterling News & Notices Email
- Sterling News & Notices email
- Clinton, MA. web site
- Email from town
- Town of Sterling email
- Town email updates
- Direct email through town
- Sterling Town News Email
- Sterling town email notification
- Town email notification
- Sportsmen's club 8pt
- 8 Point
- Sportsmen's club
- Town of Sterling News and Notices Email
- Family member
- Clinton blog
- Clintonmass.com
- Clinton mass web site
- Email from resident at Ridgefield Condo
- E-mail from town
- Clintonmass.com
- Clintonmass.com
- Brother in law
- Co-worker
- Newspaper
- Forwarded by a friend
-

- Town email
- Town Hall email list serve sent it to residents :)
- Town Website Notices
- Town hall blog
- Email
- Clintonmass.com/forum
- Email from town of West Boylston
- Town of Princeton Email
- Princeton town Web mail
- Email
- Princeton town hall email to residents on email lists
- E-mail from Town of West Boylston
- Town email
- Town E-Mail message
- Town of West Boylston email
- E-mail from town administrator
- Town West Boylston website
- Princeton internet email
- Town Administrator Email
- Town administrator
- Press release forwarded to my email by the town
- Local E-mail
- Resident
- Friend
- From a neighbor
- Friend
- Email
- Town News email
- Princeton news emailing
- Town website
- Friend
- Sent e-mail
- Friend forwarded it
- Town email
- E-mail from town
- Nonprofit meeting discussing access
- Town email
- <http://www.clintonmass.com/forum/>
- Town News email
- West Boylston town events email
- Email
- Town email system
- www.clintonmass.com
- Clinton Fish & Game
- Received from Clinton Fish and Game Sportsmen's Club (Kelley)
- Town email
- Clinton Fish & Game Protective Assoc.
- Eight Point Sportsman's Club meeting
- Town of WB email
- Other concerned parties
- A friend informed me
- West Boylston Town Manager E-mail Blog
- Administrator's blog - e-mail
- Email sent from town administrator
- The Banner - West Boylston news
- 8pt. Sportsman's club website
- Town e mail
- Club
- Princeton mass email
- Forwarded from an individual
- Notified by other watershed abutters
- Friend
- Town email
- Clintonmass.com
- Word of mouth

- 8pt sportsmen club
- Neighbors
- Local website
- 8 point sportsman club
- Referred by friend
- Email from Town of Sterling Town government
- Clintonmass.com
- www.clintonmass.com
- More than one above.
- Various committees
- Town Website
- Email
- Family
- West Boylston town website
- Also town website
- Town Website

- Clintonmass.com
- Sportsmen's club
- Officer left on car
- Monthly Town Newsletter
- Little postcard on my vehicle
- West Boylston town website
- www.clintonmass.com
- Eight Point Sportsman's Club
- Rail Trail
- Cable Channel Notice
- Holden Library
- DCR Rangers/Staff
- Newspaper
- DCR Website/ Fish and Game Office
- Library

Question 5: On average, how many days do you utilize DCR Wachusett Watershed lands?

Answer options	<7	7-14	15-30	>30	Response Count
Spring	72	107	73	64	316
Summer	64	76	90	80	310
Fall	65	99	86	61	311
Winter	141	80	44	35	300
<i>answered question</i>					318
<i>skipped question</i>					2

Question 6: When do you mostly use DCR Wachusett Watershed lands?

Answer Options	day	evening	both	Response Count
Weekday	116	54	76	244
Weekend	189	8	113	301
<i>answered question</i>				314
<i>skipped question</i>				6

Question 7: What passive recreation activities do you engage in on DCR Wachusett Watershed lands? (check all that apply)

Answer Options	Response Percent	Response Count
Fishing	36.2%	114
Hunting	8.6%	27
Bird hunting with a dog	3.2%	10
Hiking/walking	93.3%	294
Bicycle riding	39.4%	124
Cross-country skiing/snowshoeing	44.4%	140
Picnicking/relaxing	41.9%	132
Geocaching/letterboxing	7.6%	24
Photography/nature study/birdwatching	47.3%	149
Other	12.4%	39
<i>answered question</i>		315
<i>skipped question</i>		5

Question 8: Of the above, what is the PRIMARY type of passive recreation you engage in on DCR Wachusett Watershed lands?

Answer Options	Response Percent	Response Count
Hiking/walking	64%	192
Fishing	15%	44
Bicycle riding	8%	23
Photography/nature study/birdwatching	5%	15
Hunting	5%	14
Cross-country skiing/snowshoeing	2%	7
Picnicking/relaxing	2%	5
Geocaching/letterboxing	0%	1
<i>answered question</i>		301

Additional comments*:

- Hiking and walking. I was also under the impression that some of West Boylston's roads are technically DCR watershed property, and I use those on a daily basis. We only fished for the first year we were here in West Boylston. We stopped picnicking after someone called the State Police, accusing my wife of letting my son swim in the reservoir (he was just playing barefoot near the bank, and at three, hadn't even learned to swim yet). We still use the rail trail, but we haven't been back for a picnic since.
- Bike Riding - Even though it is prohibited. This exclusion needs to be removed.
- Physically unable to access DCR Land

* While the majority of comments are listed, comments that were irrelevant and/or did not relate to public access on DCR property were eliminated.

Question 9: While on DCR Wachusett Watershed land, would you know who to contact in case of an emergency or water/environmental issue?

Answer Options	Response Percent	Response Count
Yes	35.8%	112
No	64.2%	201
<i>answered question</i>		313
<i>skipped question</i>		7

Question 10: While on DCR Wachusett Watershed lands, is it clear to you what activities are allowed and those that are prohibited?

Answer Options	Response Percent	Response Count
Yes	89.5%	280
No	10.5%	33
<i>answered question</i>		313
<i>skipped question</i>		7

Question 11: When looking for information on DCR Wachusett Watershed rules, regulations or general reservoir information, where do you try to find the answers?

Answer Options	Response Percent	Response Count
Internet	53%	145
Signage, bulletin boards, and kiosks	47%	128
Contact DCR or MassWildlife	4%	11
	<i>answered question</i>	272
	<i>skipped question</i>	48

Other responses: Local newspaper, bait shop, fishing regulations handout, pamphlets, and watershed plan. Responses could choose more than one answer option.

Question 12: Have you observed a violation of DCR Wachusett Watershed rules and regulations while on our property?

Answer Options	Response Percent	Response Count
Yes	39.0%	119
No	61.0%	186
	<i>answered question</i>	305
	<i>skipped question</i>	15

Question 13: While on DCR Wachusett Watershed lands, how often have you encountered the following:

Answer Options	often	occasionally	rarely	never	Response Count
Dog walking:	76	129	67	37	309
Swimming or wading:	6	23	73	202	304
Feeding ducks and geese:	6	34	56	203	299
Horseback riding:	2	30	39	228	299
Snowmobiling/ATVs:	6	42	55	198	301
Visitor consuming alcohol/drugs	4	26	44	229	303
				<i>answered question</i>	313
				<i>skipped question</i>	7

Question 14: Do you fish at the Wachusett Reservoir?

Answer Options	Response Percent	Response Count
Yes	36.8%	116
No	63.2%	199
	<i>answered question</i>	315
	<i>skipped question</i>	5

Question 15: If yes, do you belong to a sportsmen's association?

Answer Options	Response Percent	Response Count
Yes	18.9%	38
No	81.1%	163
	<i>answered question</i>	201
	<i>skipped question</i>	119

Question 16: How do you usually purchase your fishing license?

Answer Options	Response Percent	Response Count
City/town clerk	23.9%	38
MassWildlife office	5.7%	9
WalMart	27.7%	44
Online through MassWildlife	27.7%	44
Other	15.1%	24
<i>answered question</i>		159
<i>skipped question</i>		161

Question 17: As a fisherman, are you aware of the types and impacts of Aquatic Invasive Species?

Answer Options	Response Percent	Response Count
Yes	76.7%	122
No	23.3%	37
<i>answered question</i>		159
<i>skipped question</i>		161

Question 18: Are you aware that DCR Watershed Rangers patrol DCR Wachusett Watershed lands?

Answer Options	Response Percent	Response Count
Yes	92.0%	286
No	8.0%	25
<i>answered question</i>		311
<i>skipped question</i>		9

Question 19: If yes, have you had the opportunity to talk with a ranger?

Answer Options	Response Percent	Response Count
Yes	49.8%	147
No	50.2%	148
<i>answered question</i>		295
<i>skipped question</i>		25

Question 20: Have you read the information provided on DCR Wachusett Watershed kiosks and bulletin boards?

Answer Options	Response Percent	Response Count
Yes	86.5%	270
No	13.5%	42
<i>answered question</i>		312
<i>skipped question</i>		8

Please suggest types of information you would like available on kiosks and bulletin boards:

- Daily water temperatures
- More relevant information about the locations within the watershed- history, natural history, etc. The current information is generally pretty arbitrary and vague, if there is any at all. For example, at the dam, it would be nice to know about the dam. At other gates, it would be nice to know what makes that place important and what you might expect to see on the trail.
- Volunteer/friends group opportunities. Trail Maps
- I think the kiosks need to be freshened up a bit, they are looking a little weathered.
- Reasons why dogs aren't permitted if the owners are responsible and clean up after them.
- What is in season.
- Local education about the areas such as native species.
- I would like the amount of kiosks and bulletins strictly limited so that it does not detract from the beautiful nature.
- We believe more signs against dog walking should be put up. Whenever we have told someone they shouldn't walk their dog we have been called names.
- Info on ticks and lyme disease
- Info on ALB
- Hunting schedules for type of arms.
- Marked trail guides
- The kiosks themselves look old and tired, need some tlc. No suggestions though on additional info that should be posted.
- Where you can go to do what
- How about the effect of fishing lead on loons and other water birds
- Brief rules and scope
- Trail maps for cross-country skiing, hiking, etc.
- information on what activities are permitted, when access is allowed, whether mountain biking / snowshoeing / cross country skiing is allowed)
- A sign directing show shoers to keep off cross country ski trails
- Summer/winter usage trail maps
- Trail maps, rules (abbreviated), emergency contact
- I would like to see that the penalties for breaking the law be posted. I would like to see a range around the kiosk because there is never dcr around when I'm near the stone church or near the rail trails.
- Separate trails for bicycles. They are a pain.
- Maps, regulations
- Upcoming events ways to help ensure safety of watershed and surrounding lands
- Bicycling, geography
- 1. Reporting of issues
- 2. Invasive species to watch out for (with photos in various seasons)
- 3. List w/photos of local flora/fauna identification guide
- 4. Wachusett Dam construction/engineering details/schematic of structure
- 5. Comprehensive watershed map w/labels of rivers, brooks, ponds, islands, buildings, power stations (former and current), bridges, streets, location of Cosgrove intake, Quabbin Aqueduct, points of interest, bike trails, etc.
- Rules & Regs; short/general information such as history, statistics, etc.
- Trail maps would be nice. Maybe a sign warning us that police will threaten to arrest small children for being too close to the water would be nice, too.
- Wildlife identification
- Same as now. Rules & Regs, statistics & information, history
- Advertise the website more clearly. As a board member of a sportsmen's club many people didn't know it.
- Website information
- Information about local species
- Information about new DCR areas open to hiking, nature observation, and/or hunting.
- What you have, I like history, flora and fauna to look for, trails, rules, regulations and upcoming events. Change them more often to keep it interesting.
- Simple summary of do's and don'ts.
- I enjoy historical information as well as info about native plants and wildlife.
- Rules and contact info
- They're fine as is
- Emergency info and upcoming events
- Trail maps / weather forecast / heads up on poison ivy etc.
- Trail info, programs
- Information on protecting wildlife and the watershed
- Make aware to others that hunting is allowed and safety oranges should be worn.
- More notification about drinking alcohol and smashing your bottles (at least take your trash out!)"
- fines for littering
- I would like information about the history of the dam and the reservoir and about the free programs you mention
- Where the hunting is
- Fishing Permit Required for all ages 15 and up
- Historical information and natural history
- Information about programs and use of the property. Information on the Mass Central Rail Trail.
- More hiking maps
- I'd like a more detailed map with miles/distance, so I know how many miles I am walking on the trails
- The info provided is ample. maybe some more "please don't litter" signs, but sadly that probably won't keep the jerks from doing it.
- Emphasis on prohibitions(dogs,bikes,picnics,etc)as well as points of interest
- Seasons, Fishing info, Ranger Interaction opportunities
- Post that all dogs must be leashed.
- Please increase the fines for littering. There are a few visitors that tend to have a large trash footprint (usually the fishermen) making it difficult for all sportsmen.
- That during the hunting season all persons and animals (dogs & horses) should wear hunter orange.
- Descriptive maps.
- Better/more detailed trail maps.
- Historical, wildlife and native species. Current information on drinking water (water in general) current issues or threats/issues

Question 21: Are you aware that DCR Wachusett Watershed staff offer free education programs?

Answer Options	Response Percent	Response Count
Yes	39.1%	122
No	60.9%	190
<i>answered question</i>		312
<i>skipped question</i>		8

Question 22: If yes, have you attended a program?

Answer Options	Response Percent	Response Count
Yes	14.4%	31
No	85.6%	184
<i>answered question</i>		215
<i>skipped question</i>		105

Type of free program you would attend:

- Weather program
- History of watershed & surrounding area
- History walks, nature walks, programs for young kids
- Old stone church talk
- Identification programs: birds/trees/flowers,
- overview of trail interconnectivity networks, history of the area
- Bird watching, history, invasive species, fish/water species
- Bald eagle observation, fishing instruction - especially fly fishing.
- Informational hike to learn the history behind the Reservoir.
- Historic
- History and tours
- Hiking
- Ranger Hike
- Most any.
- Historical and engineering information on the creation of the water space, spillway, and dam.
- History of the reservoir
- I missed the last one, Oct. 2010, which offered a walk/hike along the Reservoir that provided some history of the Reservoir. I prefer outdoor, informational hikes.
- Wildlife talks
- Animal-related programs
- I like the nature presentations
- Bird identification
- Children's programs at Mount Wachusett
- Wildlife
- Wildlife identification
- Bird watching
- Just became aware of them through the website
- Informational
- Bird talks
- Plant ID
- History of reservoir, towns before res, rare wildlife, geology/geography, water supply (aqueducts, early equipment, plans etc),
- History tours; nature walks.
- More education about the local flora and fauna.
- There is a nice program at Quabbin. Kiosks are sufficient at Wachusett watershed.
- I would like to see more history programs and if there is a DVD of how the reservoir was built.
- History /function of the dam & tour
- Environmental
- Wildlife
- Wildlife Information
- Rail trail days
- All of the programs already offered appeared interesting to me but I was not available to attend on the days they were planned.
- History of the mills, anything about fishing especially if you can tell me about some of those secret places no one is willing to tell me about
- Town history.
- We have attended walks at Quabbin. Hoping to attend Wachusett Watershed programs when we retire.
- Very interested in programs related to the eagles that have been living at the reservoir.
- Nothing comes to mind now
- Information about the building of the reservoir
- Any nature watch or instructional fishing
- Educational programs for kids (nature walks) in conjunction with local elementary schools,
- Historical; education about native species
- History of res
- Children's Fishing Program
- I would attend any free programs that interested me or my kids.
- Environmental protection topics, land conservation topics, topics that support the
- Goals and objectives of local Open Space and Recreation Plans, topics that affect local land owners.
- Historical
- Advanced Fishing Techniques/ Tips
- Hiking tours with historical and nature
- I don't fish, but the fishing programs seemed very appealing.
- Invasive plant species
- Fishing
- Bird identification
- Habitat that call the Reservoir their home. I see deer regularly, sometimes a fox or coyote. would enjoy learning more of wildlife at the Reservoir.
- Creation of the Wachusett Reservoir
- Eagle nesting on the reservoir

- The history of the reservoir and the history of the fish species that live there [i.e. how/when did the lake trout get in there?]
- Bird watching.
- Program with a birder's format
- Ecology/environmental/wildlife watching/hikes/snowshoeing/
- Wildlife
- Watershed ecology
- I want your resources built into the Clinton Public School Curriculum
- Touring facilities like Dam, water testing process, etc.
- Historical documentary and timeline of watershed creation.
- Resource protection and security.
- Local ecology, issues with watershed protection and development, what homeowners can do to
- Protect the watershed (avoid using pesticides, etc.)
- Anything on hiking.
- How to protect of our natural resources
- The Rangers have presented to my class at Major Edwards School on a number of occasions, I have also taken Project Wild and Project Wet courses.
- Bird watching, fishing, hunter safety, bald eagle, deer, history, wildlife,

Question 23: Once through DCR Wachusett gates, is our trail system easy to follow?

Answer Options	Response Percent	Response Count
Yes	85.6%	255
No	14.4%	43
<i>answered question</i>		298
<i>skipped question</i>		22

Question 24: Please tell us about one aspect of the DCR Wachusett Watershed that you really like*.

- Proximity and easy access
- Water
- Good brush clearing
- That you allow bicycling on the Rail Trail
- The land is beautiful.
- The availability of hunting lands
- I really enjoy my days fishing on the property and anticipate many more years of fishing.
- I like the aspect that these lands are open to the public.
- We like it that no boats or motorized vehicles are allowed in these areas.
- It's sheer beauty, all year round.
- The secluded atmosphere
- I enjoy walking and enjoying the beauty of the reservoir.
- So close to towns but allows an escape
- It is a very relaxing place to walk & enjoy as a family for free.
- Very close to my home.
- Quiet!
- Hunting opportunities in certain areas (would like to see expanded)
- My family loves the West Boylston rail trail
- The Trails
- Trails
- Like it all
- Quiet, solitude, wildlife.
- Trails.
- Safe, clean
- The vastness of the trail system.
- The serenity it has to offer. Walking the trails is a great stress reliever.
- Kept clear of storm debris
- Gateway into nature
- It's protected natural space
- The quiet and clean lands
- Natural beauty.
- Fishing
- It is not overly congested with visitors.
- Availability of trout
- The fact that we can use the property for recreational activities.
- So well maintained - always clean and beautiful to look at!
- We enjoy the opportunity to take a nice, quiet country walk.
- Cleanliness of trails and upkeep
- Clean
- Open space/conservation of forests.
- Quiet and trails
- Privacy and isolation
- Ability to use the area for exercise
- Access to non city like area
- The observation of wildlife while snowshoeing.
- Excellent fishing opportunities
- I enjoy walking down paths around the reservoir that you have maintained.
- Unspoiled area
- The great amount of areas to explore.
- Hiking trails and pathways
- Peaceful place to be
- Clean and peaceful
- Land conservation and limited use.
- The beauty and ability to get out and enjoy nature
- Stillwater Farm
- it's nearby
- Not a lot of people there
- Peace
- The water!
- Protection from development
- Beautiful and well kept trails
- Large area of open & forested space to hike - good trails.
- Beauty and retained land
- Its accessibility
- Trails
- Rail trails, fishing access, opportunity to observe wildlife.
- Rail trail and river
- Open multi-use access
- Rail trail
- Large tracts of open space
- That the Watershed is patrolled.
- Protected land that will never be developed
- Accessibility
- The upkeep of the trails.
- Rail trail
- Trails
- Chance to connect with nature.
- Quiet
- The availability of public land in general
- Variety of terrain, access
- Lots of trails
- The trails are kept wide and groomed. There is a wide variety of walking trails to take advantage of.
- Easy access / parking / upkeep
- I like the stairs by the dam. I wish the route 62 side of the stairs would open soon.
- Wildlife
- Love the open trails.
- The good trail system.
- It's beautiful, relaxing, nature close to home
- Walking trails
- Well maintained open trails
- Accessibility for children
- Rail trails
- Wild state.
- Rarely crowded
- Hiking trails

- Rail trail
- Peacefulness
- Quiet and spare
- Do not utilize the land
- The bike trail!
- I like the access available to me.
- Beauty. Engineering. Quiet and peaceful.
- Utilization of previously unusable land
- It's a beautiful spot to take long walks with the camera.
- It's quiet.
- The rail trail.
- Beautiful, clean trails
- Fishing
- Hiking and snowshoeing and it is a great place to do that
- Trails
- It's a great area to hike/snowshoe/bird watch and unwind.
- Peaceful /serene
- Trails
- Natural beauty
- It's beauty
- Walking
- Love having the Rail Trail available in our town
- The scenery
- The open space close to home
- The bike trail is great.
- The beauty of the scenery
- The preservation of open space.
- Walking trails
- The rail trail
- It's free
- Access to the trails
- Quiet
- The land is generally very clean and free of litter.
- The wildlife!!! oh, & the peace & quiet
- clean
- I like the amount of access available and the well defined trails.
- Access
- Appears well maintained
- DCR classes
- The views and peacefulness
- Clean and preserved nature!
- It's down the road from my house
- Not much, the rail trail is pleasant, but boring.
- I like the trails for walking and cross country skiing
- Peaceful setting.
- Availability of trails to run on
- The openness
- Scenic value.
- The land will not be built on.
- Tranquility
- Enjoy close access to nature and recreation
- Local access
- Lack of motorized vehicles.
- The view
- Local convenience
- Beauty and cleanliness
- Generally uncrowded.
- Scenery
- Greenways partnership
- Hiking
- Having close access to nature; the people that are mostly there are there to enjoy it
- Quiet environment
- The natural setting
- Hunting, fishing
- I particularly appreciate that things are left in as close to a natural state as is feasible
- Not too many restrictions
- The quiet!
- I really like that it is so clean and natural
- Scenic beauty
- The scenery and quiet.
- I like that I can just walk to some of the trails
- The accessibility
- Fairly Clean
- Easy walking trails
- I love the peace and quiet
- Central Mass Rail Trail
- Land is protected from development
- Peaceful, fresh air, relaxing
- Access to the public.
- Cleanliness of property.
- Access to toilet facilities
- Unspoiled large bodies of water
- The way things are run
- Well maintained trails!
- Accessibility to hike, walk, and x-c ski in the woods and along the water edge
- It's beautiful, clean, safe and a fun place to walk for exercise
- Being out in the environment and seeing people enjoying it.
- Peaceful
- It's readily accessible and it's free
- Fishing access and informative/ friendly rangers on patrol.
- The tranquility and pristine beauty
- Most of the areas that I fish are clean of most trash.
- Wildlife and environmental management and protection
- Trail system
- I enjoy being able to hunt the land.
- That its available to everyone to enjoy
- It attracts wildlife that are easily viewed (eagles)
- Very well managed and maintained
- That leashed dogs are allowed on the trail in West Boylston.
- Gates 8 and 9
- The ability to walk dogs on leash.
- Walking in the Spillway area of the Wachusett Reservoir
- That it's there.
- Open space with natural looking landscapes.
- Large tracts of land accessible from the Worcester urban area
- That it is open and available to use.
- The fact there is so much protected property from development
- That it is open to the public.....
- It is clean and comfortable to walk
- There is nothing better than running along the Wachusett Reservoir.
- Great trail system.
- The tranquility and beauty.
- That it's always clean and organized.
- The trails are pretty extensive, but not well maintained.
- Quietness, limited recreation available to preserve the resources
- The isolation from urban surroundings.
- Rail trails- great spots for young families, senior citizen walking groups, plenty of shade in summer and benches for rest spots
- Wide open space DCR has provided by trimming and cutting brush along reservoir walking trails and grass along shore, etc.
- Safe and secure, parking lot at gate 8
- No houses, no boats

- The main aspect that I Appreciate Very Much is the fact that the public is allowed as much access to the Reservoir that we currently have. I would be very upset if public access becomes limited in the future, or worse yet, non-existent.. That would be a tragedy in my opinion
- I enjoy the peaceful tranquility that is found along the paths of the Reservoir. I enjoy the Reservoir almost daily, except in the winter months, and am always surprised that more people do not utilize such a beautiful part of our town, and bordering towns.
- Offers many areas to walk-around and/or fish at. Very beautiful lands and waters to enjoy and relax at.
- Fishing and hiking is easily accessible and the nature is so beautiful just moments from my home
- Thank you for putting up some signs about bicycling being allowed from dam to Rte 110, but few people know that.
- I like talking with DCR rangers and showing them the pictures of all the giant small mouth bass and lake trout that my brother and I have caught!
- The fact that the water is kept pure - that is no boats, motorized or otherwise.
- Rangers are helpful. trails are mowed.
- Wonderful place for walking, hiking, and biking. as a consumer, I really appreciate the clean water.
- Once you are past the gates at any entrance, the cleanliness of the trail system and the shorelines.
- DCR presence has been exponentially stepped up in recent years which is good to see. I think more immediate person to person contact between the rangers and the public are required for education/implementation of rules etc.
- How open the trails are, and well kept up the trails are. Down Scar Hill Road we like to sit in the sand and watch the sunset/sunrise.
- The solitude, the ability to follow the seasons, the cyclic nature of the flora and fauna, bird watching, esp. eagle watch
- I love being able to hike the trails and water's edge of the reservoir, viewing and hiking near the dam and spillway areas.

* While the majority of comments are listed, comments that were irrelevant and/or did not relate to public access on DCR property were eliminated.

Question 25: Please tell us about one aspect of the DCR Wachusett Watershed that you would change if given the chance*.

- Allow bicycles
- Bike riding
- The South end of the basin between Malden Brook and the railroad track is heavily silted in with mud, brush, debris, weeds, rubbish, and dead animals (fish, birds, amphibians, etc.). It needs to be dredged out from shore using a large excavator each year because the water currents bring all that debris into the shore area repeatedly.
- More bicycling allowed on trails round Wachusett Reservoir, North Dike, etc.
- Better information on trails around Wachusett Reservoir
- I would like the story of the reservoir told better, including more and better access to the Dam. The reservoir, its infrastructure, and its watershed are incredible resources and people around here are generally ignorant about them. I think public engagement either personally (rangers) or through better signs/kiosks would help a lot.
- Allowing more sportsman opportunities.
- My best friend and fishing buddy is severely handicapped (Hip and both knees replaced). I know some gates can be opened but there are several (35 and the one to Andrews point) that he likes to fish and can't because of the long walk. Please reconsider which gates can be opened so he and others like him have access to these and similar places.
- I would like to have more access to the Watershed lands.
- I'd like to see trails blazed or otherwise clearly indicated with directions and destinations.
- The trails need to be cleaned and the invasive species of plants need to be better controlled
- Please allow access to the Wachusett dam. It is beautiful and walking it offers a very unique perspective of the reservoir and the town of Clinton. I used to walk it as a child and would be eternally grateful if it were opened again!!!!
- I'd love to see the Dam reopened for the public. Such a beautiful part of town that no one can enjoy.
- Allow access to the stairs and the lower road in Clinton. allow parking near the reservoir
- Opening the dam to foot traffic. I used to love walking on the dam and taking in the view as a kid/young adult.
- Allowing non-motorized boats on the water.
- Better shoreline access at the reservoir, because much vegetation has taken hold on old shoreline trails.
- More access from Clinton
- Expanded Hunting and possible use of kayak/canoeing
- Better access to the Wachusett reservoir area.
- Dogs not allowed in some areas (Wachusett Res) and Rail trail. Totally unfair.
- You need to allow people to walk their dogs there - I use it infrequently because you do not.
- No snowmobiles!
- I can't think of anything off the top of my head. In the past couple of years 2007 - 2009 there was a lot of construction going on in the Clinton part of the Reservoir.. I was very unhappy that such large portions of the Reservoir were off limits to the public during construction. If anything, I think trying to find a way to allow the public to visit all of the Reservoir during these times of construction would be my thought. There were large portions of the walking paths closed off to the public but in my opinion there could have been a better way to keep the public safe while getting the job at the same time.
- Removing the bicycling exclusion. There a beautiful trails for bikes and I feel the public would enjoy riding there.
- Allow mountain biking in wooded areas. We are avid bikers who follow regulations. We are often thrown into the ATV category which is not a correct comparison. Many mountain bikers are interested preserving the area we ride in and many trails become impossible to ride once riding by ATV and dirt bikes. Please consider allowing mountain biking as part of a healthy activity.
- A clearly communicated website whereby one could get one or more maps of all the trails.
- Better Trail guides - get rid of the litter bugs
- Better trail maintenance. The trails I walk are being taken over by weeds.
- Dogs (with responsible owners)
- I would open the fishing at Wachusett to boating , permit dogs for hunting, be able to swim/wade in water
- More accessible to hunters, fishermen, swimming, biking.

- Access to cross over the dam. This is a marvelous man made dam that a generation of young people is not getting the chance to appreciate.
- Being able to fish from a boat on Wachusett Reservoir
- Allow ice skating.
- I'd like to be able to walk a dog as long as I remove waste. I'd like to prohibit planes from flying over the watershed. I'd love to be able to walk over the dam again, and also kayak on the water.
- We would like more patrolling to insure rules are complied with. Also all rangers should enforce the rules.
- More availability to bike through the trails
- Dogs allowed
- Prohibit access to the public to all areas..
- Add more fish and allow canoes!
- Allow dogs
- Ugly fences
- Access to the reservoir with canoes for fishing
- Allow dogs
- Allow bicycles on the fire roads
- Allow picnicking
- Allow access on and near the dam like the good old days
- Tours of the dam
- Allow people to collect firewood
- Allow access after dark for star gazing
- Increased Hunting and connection of bike trails into Clinton
- Would like a limited ice fishing season
- Add bicycle use in certain areas.
- Mountain biking in more areas would be nice.
- I would like to be able to walk my dog on the properties.
- Separate areas for different types of recreational activities. Biking only, dogs only, hiking only, etc.
- Better care/upkeep taken @ promenade area/lower road.
- Would love to swim
- Ticks
- Abolish any and all hunting that is currently allowed on the DCR Wachusett Watershed.
- I would revisit some of the areas where hunting is allowed. The population has grown in the area and with more people and houses there is a greater chance of accidents. Hunting and hiking don't seem to be a good mix. While I do continue to hike during hunting season I do not feel comfortable doing so and find that I limit my activity.
- I would like to see more programming and activities at Stillwater Farm- I see that the local garden club has been doing more there..that is great but more can be done with that site. School buses bring students there at times as well- there should be more of that if possible.
- Dogs. I like to walk with my dog on a leash. I don't care for owners that don't leash their pet
- A few benches along the spine of the dike at Wachusett Reservoir would be great!
- Publicity about active partnerships with other like-minded entities: land trust, Audubon, scouts, other state agencies, TTR, etc
- Allow mountain biking
- Would allow dogs.
- Portapotties at parking lots. I only know of 2.
- limited access points (unclear which gates are ok for parking, not ok for any access, ok for walk-in-access)
- Would love to be able to sail, kayak or canoe!
- Trail improvements
- Allow ice fishing
- Allow dog walking
- Better marked trails other than the rail trail and trail map
- Resume more activities. e.g., pre 9/11 access to space; dogs permitted on land (on leash), etc....
- Non-motorized boating in reservoir
- Horseback riding
- I would allow people to walk with their pets as long as they pick up after them. I would allow people to snowmobile around the fire roads. I would allow non motorized row boats and sailboat to access the water for fishing and leisure
- I would allow swimming
- Restricting dogs altogether.
- Less signs that begin with the word no
- More areas for dogs, and separate areas for bicycles. Many bikers travel too fast and are a hazard.
- Beavers are becoming invasive and destroying a lot of treed land
- Allow canoeing on the Wachusett Reservoir
- More boating
- I would like to see more rangers/security on some of the major trails. I don't like to take my children on walks without another adult with me.
- Open the top of the dam once a year for a special town day.
- Trash
- I would allow non-motorized boating on the reservoir as is allowed on the Quabbin Reservoir.
- It would be nice to have more access to the water - swimming/wading or motorless boats.
- I would love to see kayaking and canoeing allowed.
- Allow dogs -- after all there are deer, coyotes, fishers and all manner of animals.
- More info about not littering....like if you bring it with you take back with you. Respecting the area so everyone can enjoy it with little or no impact on the wildlife.
- I would permit the local schools to row/crew on the water.
- More information on programs
- Access to water with non motorized boats like canoes
- Less litter along rte 140/70 access areas
- Allow sailing on Quabbin
- Absurd levels of regs.
- More recreational use of land, reservoir
- Continue to clear the woods from the ice storm damage
- Dog walking
- Allow dog walking - we have loads of lands and it is a shame dogs are prohibited - we don't use the land as much as we would and go elsewhere since we cannot bring our dog
- Trail maps
- Would love to be able to swim, but I know that since it's a drinking water source, that's not possible
- I would love to be able to put a canoe on the Wachusett Reservoir --.
- Bicycling around lower road should be allowed (intake area B2).
- Limitations on dog walking along the rail trails
- I would like a place to park - there's only a few parking spots here and there.
- You have signs disallowing dogs outside the watershed (old RR grade & road behind Clinton Reservoir Cemetery) and upstream of reservoir (Wachusett Greenways trails and nearby land) even though 1) dogs are allowed on land on/next to reservoir itself (towns, roads, WG trail), 2) you don't chase birds from that far up reservoir (e coli breaks down before intakes); 3) there are towns, roads, and RRs on the edge of the reservoir and running right over it with all sorts of pollutants much closer to the intakes than dogs well upstream of the reservoir; 4) you allow motorboats in the Quabbin which spew toxins that break down far, far slower than e coli and will soon bring invasive species into the Quabbin, then the aqueducts, and then the Wachusett.

- Access to top of dam. That is a one-of-a-kind view. I was told by a ranger that the dam is no longer closed due to security issues (safety of structure and/or water supply), but a safety issue with the fence. Please replace fence as part of standard maintenance. Historical or not...it needs to be maintained/improved and brought up to code. Can sell pieces of it as a fundraiser and the Clinton/Boylston/W Boylston Historical Societies, etc. would probably love to display a section (possibly even the Museum of Russian Icons).
- Allow dogs, kayaking, canoeing, camping, and ATV's.
- You should allow swimming and non-powered boating (canoes, paddleboats, rowboats) on the reservoir. This type of activity has a low impact on the potability of the water and is allowed in plenty of other reservoirs in this state and in other states and would have a tremendous positive economic impact on the watershed communities in the summer months. Furthermore, that water is treated before it comes out of a tap in Boston, isn't it? What difference would a canoe make, anyway?
- More trails would also be nice. .
- It may be a little too restrictive
- Less restricted fishing.
- Allowing dogs. I know all the places around that allow dogs and it would be a great safe env. to walk a pet. Most pet owners are very responsible and clean up after their dogs.
- Reopen the walk across the dam in Clinton.
- I would like to see an area for canoes. This could be run by the state so that people would have to rent canoes and then they could go fishing on the water. The Quabbin has that and so should the Wachusett.
- No fishing. The litter that I've seen has been bait containers left on shoreline
- Allow access with dogs
- Open the spillway / fountain area
- Allow dogs on leash
- More maintained trails
- Non motorized boating. It would be great to Kayak
- Allow more hunting areas
- Non-motorized small boats for fishing and pleasure, small sail boats, kayaking. a program for kids/adults in boat safety,
- Expanding fishing boundaries at Wachusett Reservoir! Allow mountain biking!!!!!!
- Possibility of designated camping areas?
- Provide maps of trails and a system to know where you are out in the woods. Allow mountain bike access.
- Update identification of where DCR property overlaps private property.
- Passive boating
- Allow kayaking/canoeing on the reservoir. I come from Maine and the water supply for Portland is Sebago Lake where all water sports are allowed.
- Public access to the water. I would like to be able to take my kayak out on the reservoir.
- I am a quadriplegic, confined to a wheelchair and have found no access point to the watershed wide enough for my wheelchair to pass through.
- Make the Quinapoxet and the Stillwater catch & release in the streams - clear more trails to fishing locations, picnic tables, do more with the Springdale Mills - more parking - a covered pavilion
- Reevaluate limited controlled water access. California allows canoes and kayaks on their primary reservoirs. Why can't Massachusetts?
- Would like to have light boating (no engines). I think this would be a huge boon to the local economy if we could do this. I personally would get a kayak immediately.
- Allow canoeing
- More bicycle access, particularly on the DCR trails in West Boylston that run along the reservoir east of 140, as well as the trails east of 110 leading up towards the dam.
- Become dog friendlier. Not all dog owners are irresponsible.
- Access for non-motorized boating
- More Public access, Hunting, Horseback riding
- Allow non powered boating, canoes, kayaks
- I wish that hunting access would be allowed on more of the watershed. Specifically, land abutting the reservoir. Even if on a limited basis such as archery only.
- Expand access
- Allow non-motorized boating on Wachusett
- Remove the shooting range on the West Boylston trail
- Access to water with nonmotorized boats!!!!
- Keeping dogs on their leashes
- Non motor boating and a monitored swimming area for residents only.
- I would like to see non motorized boats allowed on the reservoir
- Better parking
- Probably out of your control but lack of respect for regulations a/b leashing dogs and keeping them out of areas they shouldn't be.
- I would like t see non-motorized vehicles on the reservoir
- Open the water access to boating.
- Allowed to ice fish West Waushacum pond
- Allow dogs (on leash) up to 50 ft from shore
- It would be nice to have canoe/kayak usage nearer the dam. Basically allow non-motorized access all but within 1000 ft of dam.
- I would love to canoe on the reservoir. I can't see how that would have a negative impact on water quality. (I own a canoe but have to go out of town to use it.)
- Allow ice fishing
- Wading, swimming and motorless boating should be allowed to towns abutting the Watershed.
- It would be nice to have non-motorized access to the upper Wachusett Reservoir near the Old Stone Church. Kayaking/ Canoeing would be a great activity to have access to.
- Allow snowmobiles at the Wachusett reservoir again. Allow public access to the entire Wachusett Dam area (including opening the gates to the top of the dam) again.
- None - I believe increased access will not benefit the town, only cause additional issues that will require monitoring.
- I would like to be able to use man-powered watercraft on the water. i would like to be able to have a dog on a leash while hiking there. i would like to see signage identifying natural landmarks and species.
- More information on where hunting is allowed and where it is ok to enter.
- Non-motorized access to the water
- I would like to see non-motorized boats able to use the reservoir for fishing
- Motorless boating, canoeing
- I would definitely allow horseback riding to at least abutters - its too beautiful back there to not allow this.
- I would like you to try allowing snowmobiling in certain areas again
- Open some of the trails up to mountain biking
- Would like to see the Clinton Dam open for weekends and holidays again
- Allowing non-motorizes boats.
- Expanded hunting opportunities. Areas in the past we once could hunt for over 50 years are now closed to us, for example the West Boylston power lines.
- I would love to see non motorized boating. It would bring attention to the area and would make the town more attractive to possible new homeowners.

- More trash containers for fishermen
- Boating Regulations
- I would make it more accessible to the public by repairing the access road near the dam in Clinton
- Create an upland area where you permit people to walk their dogs, complete with resources for managing their pet waste
- Please allow public access to the promenade at the top of the dam. This is probably Clinton's most valuable scenic asset.
- Allow dogs & biking on more of the trails.
- The grass should be mowed around the walking paths.
- Allow Mountain Bikes w/ Permit (\$125 - 250)
- No access in some areas
- Clearer signage to get to the parking area for the Sterling rail trail entrance in town. Also, may not be environmentally feasible, but a porta-potty on the WB/Holden rail trail would be nice.
- Bicycling on the North Dike.
- I would expand the fishing access areas to where they were pre 1980.
- Allow dogs and picnicking...provide access to trash/dog waste bins or barrels
- More toilet facilities. I am aware of facilities at Comet Pond and Oakdale Rail Trail. Please add one in Rutland somewhere along the rail trail.
- I would like to have the "Main Trails" have Gate numbering on the trees, so people would have a better understanding on what trails they came in on. A lot of people get turned around in some areas where there are numerous feeder trails.
- Relax usage and access rules, to pre 9/11, e.g. for dogs to be with an owner.
- As quality land for outdoor recreation becomes scarcer, more demand for multi-use is placed on large tracts of state owned land. the Army Corp of Engineer managed lands are not ideal due to their questionable water quality for certain tracts, as alternative outdoor recreational use areas...plus the use of atvs and skimbiles on some tracts detracts from the natural state of tract.
- Allow kayaks in the Wachusett!
- Leave fishing open until the end of the year
- Dog walking. I would love to walk my leashed dogs in the watershed area.
- Passive recreation should include ice fishing, ice skating, sail boating and canoeing
- More k9 access and boat access
- Boating or kayaking
- Ice fishing on the DCR ponds, access for canoes and non internal combustion powered small boats on the reservoir. snowmobile access on DCR lands, increased hunting areas
- Abusive use of lands ex: trash dumping, drinking, fires, usage of land after hours, by the public whether intentional or not. Recommend charging for usage/ obtaining license to utilize some of the rail trails or areas of the watershed for recreation to offset costs/ fix infrastructure and eliminate unsavory characters. Some type of security at rail trails or emergency call boxes.
- The opportunity to use a metal detector on the beaches. Perhaps by permit and DCR regulation.
- Keeping the reservoir open to fishing for the first 2 weeks of December.
- Allow dogs and horses. Most dog owners would pooper scoop if asked to.
- I think all the land should be open to hunting.
- More land opened to hunting, if there's concern about too many people on certain properties, make it a lottery.
- More frequent rounds by rangers to enforce rules re:dogs,bikes,picnics on North Dike
- Allow kayaking
- Litter near shoreline
- Allow deer hunting on all public watershed lands.
- Inclusion of dog walking on DCR trails...as a blanket rule it doesn't make sense...perhaps an exclusion from the water or within 100 feet of shore would make more sense and garner more support and use of the DCR trails.
- Allow leashed dogs on more trails.
- Open the dam and lower area to the public
- Reduce restrictions on dog walking at some locations. Particularly, Sterling. Enforce waste pick-up. Most dogs owners are more responsible than littering kids or adults.
- Open the gates to the Clinton Dam more frequently
- Activities on reservation land within Clinton are entirely too restricted-no bikes?
- Water open to swimming and/or non-motorized boating.
- Forestry management--don't let non-science be the major factor guiding forest policy decisions for the lands.
- Open up more lands to hunting, the land directly attached to the Wachusett, rt. 70 and rt. 110
- Trash containers
- Open up more land for hunting.
- I'd open the dam area up again and the road along the Nashua River for walkers & runners.
- An earlier trees and branches cleanup.
- Better maintain the trails.
- Nothing. DCR is doing a great job
- More parking near the spillway/dam area.
- Access to photos/negatives of the History of the Wachusett Reservoir where my family has lived in West Boylston for generations, prior to the reservoir being built.
- I think that some supervised/controlled use of ATV's &/or snowmobiles could be introduced in select locations with either permitting or user fees which could subsidize education/enforcement efforts.
- Open up the reservoir to non motorized activity
- More dog walking access, more mountain bike access, more passive water access
- Swimming should be allowed in certain areas
- Ice often doesn't form until late January, please extend fishing season to December 20 or until Christmas
- Fishing through December or close reservoir second or third week in December
- Hunting of nasty geese- limited season, hunting on all DCR property, nonmotorized boating on reservoir

* While the majority of comments are listed, comments that were irrelevant and/or did not relate to public access on DCR property were eliminated.

Question 26: Is there anything else you would like to tell us*?

- You need to improve the mowing along the fences and remove the poison ivy that is getting out into the walking paths/access openings.
- The dam should be reopened to pedestrian traffic and fishing.
- I wish we could walk dogs (and clean up), but understand that will never happen!
- I know public access is secondary to protecting the water, but I think many more uses are compatible than are allowed in some areas. It's hard to understand what policies are what they are without better information.

- Please consider opening up the access gates to bike riding and opening up more areas to hunting and fishing
- Your Ranger staff is well trained and is professional yet very friendly in their approach to the gents fishing. Also, I read that you were considering the parking situation (particularly on 110). If you restrict parking on the highway, then you need to accommodate the users, particularly where the reservoir nears the road at the beginning of the dike on the 110 shore.
- I don't like it when people take their dogs on the lands and let them run free.
- You may wish to reduce the 1 mile fishing set back. I don't understand why that is a rule. I don't think people should fish from the dam, but they certainly should be able to fish along the dyke and or just past the pumping station on Rte 70.
- Signage is sometimes removed from areas and it is unclear if access is allowed or not
- Open the reservoir top for walking across.
- Wish you had more programs, more often, and publicized them better.
- When women specifically walk and don't have a partner they need to be able to walk their dogs!
- I enjoy visiting the Reservoir very much. Lately, this past summer, I have been seeing a lot more trash/littering along the paths of the Clinton portion of the Reservoir and wonder if there is anyone that is assigned the responsibility of picking up the trash. The grounds are maintained so well throughout the year, I find that it makes pretty annoyed that some people are so thoughtless to just leave their trash behind when visiting the Reservoir. FYI... I take a grocery size bag with me, occasionally, and have no trouble filing it by the end of my walk/run..
- Keep up the good work!
- I love that this resource is available to me and enjoy it's beauty and well kept trails
- It would be nice if you could designate some of the land to off-road riding.
- You should open up the reservoirs for ice fishing.
- Allow mt. bikes on trails
- If preservation of the water is the highest priority, then the use of airplanes above the water supply should be prohibited. On most nice days in the warmer months a private airplane can be seen flying over the Clinton portion of the water in the Wachusett Reservoir. The plane is both a visual and audible nuisance. The pilot also performs stunts, such as purposely stalling the engine, and practicing aeronautical daredevil techniques. These activities should not be allowed as they pose a danger of the aircraft crashing into the water supply. The airspace above the reservoir should be restricted in some manner. The height at which the plane is flown is also very low.
- It would be nice to utilize non power boats in the water. And also walk dogs in the area as long as the waste is removed from the watershed area.
- Thank you for keeping it so beautiful.
- We love walking here, but at times have felt very unsafe due to loose dogs and irate owners
- I always walk my dog it is unfair to not allow it
- Access to the Dam area should be allowed. People that go there are not terrorist and pose no threat.
- More fish and Access to different locations and parking
- I think that tree cutting is an important part of watershed management
- Stand-by for ALB clear cuts.
- I think your usage policies are too restrictive.
- Mountain bikes, not motorbikes. would be a great way to explore more.
- Would like to know where the best resource of information is located.
- I have heard/read that there is a possibility that the allowed areas of hunting would be expanded in the near future. I am very much against this idea. No hunting!!!!
- Keep buying up land to protect the water supply!
- Thank you!
- It would be great if there were an online location that I could go to find out all information and that URL was posted on signs at the reservoir.
- Would like less logging
- I appreciate the access to the lands for walking and fishing!
- I have written to DCR in the past but got no response.
- Would like to see minor alterations in the RTs140/110/12 intersection to facilitate increase passive recreation and parking
- as more and more rules are applied, and other open space becomes private/no longer available for use, the remaining public space needs to serve a wider range of uses; DCR land needs to evolve to too.
- Some, not many, people fishing leave trash behind.
- If you are so worried about pollution and silt how come you never seem to trim all the trees along the edge of the water? The river basin near river road used to be deep and a wonderful play to fish now you're lucky if its 5 feet deep. It's all full or silt. How come you don't dredge it out?
- Thank you!
- Please open the top entrance to the dam that leads to the stairs that go down into the park
- A better trail map of the trails/fire roads.
- Allow more access especially on the land opposite the water supply on Rt. 70 in Boylston/Clinton. I don't see why the land on the other side of the street cannot be used by the hiking public.
- Very much enjoy taking hikes with the family to enjoy the fresh air and nature
- I support more access, including use of non-motorized boats on the water and motorized vehicles such as ATV's and snowmobiles on the trails.
- Thank you
- Yes...every time I fish or hike I bring a bag and collect trash...I bet if you asked folks to do the same thing and maybe provide bags like some places do with doggy waste the litter would be a lot less
- Kayaking/canoeing would be awesome
- I'd love to see tours of the aqueducts and intakes, and trails on aqueduct land.
- Please open River St. to dam for pedestrians and bikes, and the open area between the top of the dam and Rte 70 for pedestrians.
- I've heard locals with environmental and terror concerns; we drink that water and live just below the dam and north dike. Because of the EPA lawsuit, the state bought lots of watershed land; mostly way upstream. Meanwhile, we have towns, fertilizers and commerce right on/next to the reservoir. The north dike collapsed when built; it might again. You keep e coli 1 1/2 miles from the intakes, but some could drive tractor trailers into the reservoir or tributaries, or cut locks and drive tractors or truck bombs to the north dike. Even if diluted, if there was contamination from

environment or terror, would 2 1/2 million people still drink that water? We need to start moving roads and vehicle access away from the reservoirs.

- Would be lovely to have some groomed x-country ski trails.
- Can't wait for the flags to start flying again at the top of the dam!
- I have missed being able to take sunset photos from Rt. 70 at the top of the dam because parking has been eliminated.
- Seriously, giving the people in our communities the same kind of recreational options that people living around other reservoirs have would have a big impact on our towns. Please consider it
- Please don't make it any more restrictive than it already is!
- Don't harass photographers.
- Maybe have a couple of rental shops for mountain biking through the trails. I would also like to see the DCR release some of the land for renewable energy. It doesn't have to be right at the water edge but there is so much land that could be utilized for either housing wind farm solar farm something. The town doesn't receive much from the state so if a wind farm or solar farm was built maybe the town could get a cheaper rate on electricity from the farm.
- I do not access the property thru a gated area. Therefore, I don't have chance to read info/rules posted from DCR. Now I will definitely stop/read your bulletins for further information/sessions regarding your possible access changes.
- As a young child my family used to swim there. I had my wedding photos taken there. As a young adult I use to jog the stairs both sides As a middle age adult -- none of that is available
- Please don't close it down :(
- Allow non-motorized boats
- Get rid of the paper permit to hunt in allowed areas. It gets ruined in the rain and gets lost. Regular hunting license should suffice.
- Leave the dog issue alone; people need a place to walk pets. they're no more messy than the wildlife & birds in the surrounding woods
- During prime time spring and early summer fishing I go fishing from gate 6-11 (lots of walking) every day. I think it would be great if the DCR would allow mountain biking, the trails are awesome, and you guys drive your trucks down there all the time, so how would a mountain bike damage the land any more than the trucks do? The long walk to the rook would be shortened to 10 minutes on a mountain bike! :-) (think, more state records!)
- Please keep this open to the public :)
- Allow rental/limited boat use on the reservoir.
- It's nice to have the expanded areas of use. Opening additional areas seldom used by people to hunting would be nice if it also protects the environment, but it's also nice to have some areas reserved for no hunting and hiking without concern of hunters. Thank you.
- I wish we could take kayaks & canoes out into the reservoir.
- I believe that the recreational restrictions could be eased to make the property more "human" friendly. It never made sense to me that you can't walk your dog on the property yet wild animals are everywhere. What am I missing?
- I have been on many of the watershed rail trails and think that they all have different feels and are well maintained. The section in West Boylston is my favorite and is consistently the cleanest.
- We are residents that greatly appreciate the efforts made by DCR.
- Please keep up the good work.
- Many of us are interested in seeing recreational boating here, much like the Quabbin.
- Please keep motorized vehicles banned
- It would greatly increase quality of life and community to allow non motorized boating on water. At least a trial of use would not hurt.
- We moved here believing there was public access to our lovely environs. Instead the hostility we have encountered from DCR personally and as a municipality has severely limited our desire to interact. We go to Mass Audubon trails instead.
- I would love to see limited access for bicycles.
- Just today, I passed two women with a dog off leash on the West Boylston section. When I turned around to run back towards Holden, I finally passed them again on the Holden section. Felt like saying, "Are you going to let your dog go in the water too?? You've disregarded the other rules"
- Support passive water use
- As a Clinton resident, I like to see as few restrictions on town resident usage of the watershed as possible. I feel it is in the spirit of the original agreement
- I feel that people from West Boylston should be allowed to more widely use the land by walking dogs (and picking up after them) on the land, kayaking, and snowmobiling, particularly if your land abuts DCR land and you are responsible regarding the use. We could simply carry our licenses so that we can identify ourselves as residents. Definitely not enough perks for West Boylston residents.
- Would like information as to when the dam will reopen. It appears to me all the construction has been completed for many months
- I recently heard a story of a boater urinating 10' from a loon's nest on Quabbin. I'd hate to increase the chances of such behavior at occurring at Wachusett. Boating and drinking are often related activities.
- I would like to hear an explanation as to why no human can touch the water. isn't the water treated before consumed? Isn't Quinsigamond a "secondary reservoir?" if so, why is there unrestricted use of it?
- Please allow dogs on leashes and require owners to clean up after them; I find it hard to believe that dogs cause more damage to the watershed than the non biodegradable rubbish and detritus that fishermen leave behind (old, tangled line, Dunkin Donuts cups, food and fishing equipment plastic wrapping, empty cans and bottles)
- I think people would truly appreciate it if the baseball field that was closed could be re-opened at a different location. Everyone understands why it was closed, but it seems that there must be land somewhere else that could be used for that purpose
- Horses would have much less impact on DCR Land than Fisherman with all of their trash. Please consider limited passes during specific times of the year for horseback riding!
- I think allowing certain privileges to watershed residents should be considered i.e. kayaking, snowmobiling, resident only fishing.
- Open the waters to non-motorized boats from the causeway to the railroad bridge - I would gladly pay a small fee for a permit which would generate revenue. As in Quabbin, a maximum boat count could be maintained.
- Great job- keep up the good work!!!!

- Wachusett is a untapped resource that could be better utilized. Citizens from the sponsoring communities deserve to have more access to this amazing area!
- DCR does a good job of posting its trail access rules and defining its lands for the casual visitor. Wish that local communities had the resources to do so on their conservation lands.
- There are so many trails where dogs wouldn't affect the quality of the water. I'm sure that not all hunters police their brass & how many fishermen lose their lead based tackle in the water. I also really don't understand why so many trails are closed to biking as well.
- I've seen more bikers than dogs around.
- Allow Canoes w/ Permit (\$500 - 750)
- We love being able to walk thru the areas and take photographs! It's beautiful. It's nice to know this is available to us.
- Thank you for providing and maintaining these recreational areas
- Continuation of the Mass Central Rail trail through the DCR property. Allowing cycling on the north Dike is a logical and safe path. It keeps the bicycles off of the road and puts additional eyes on the reservoir to protect it.
- Thank you for this valuable resource.
- Please have more clean up days at gate entrances and some parking areas. They collect to much trash for one person to consistently clean up after other inconsiderate people.
- I have a lot of very good pre 9/11 memories, that cannot be repeated due to the restrictions. One can question our news and public scare tactics for the sake of water purity, while at the same time, there is unmanaged ever-growing wildlife populations that foul the same body of water worse than humans can.
- This was the year I fished there and I loved it
- I feel that a system could be set up to allow responsible dog walking, with "doggy do-do" bags and disposal cans available. Tufts Farm Field does this very well. I also feel that a little dog urine is insignificant compared to what other animals are depositing in the watershed. We walk at the W. Boylston Rail Trail and would love to be able to walk the whole trail. Thanks!
- The #1 reason I enjoy living in West Boylston is my close access to the Wachusett Reservoir and its surrounding watershed woods and network of roads.
- I think you've done a great job on allowing bike and hiking but, need to open more areas for a wider range of activities.
- I think the present direction of DCR plan for utilization of lands to be of great quality but I worry that not enough monies will be give to the DCR for further personnel and or improvements of the valued land. An even greater presence of the DCR in high use times will hopefully eliminate/educate the public so further issues described above do not continue to happen. Unfortunately I think some type of fines/ticketing is going to be needed to eliminate many of the issues.
- Responsible metal detector use on the beach areas could help remove pounds of old lead sinkers. Lead is easily detectable along with coins, lures, cans and metal trash. Good clean fun.
- The place is truly a treasure and must be cherished, and while there are some people who don't properly respect the privilege by breaking the rules [littering especially] they are far overshadowed by the ones who leave nothing but footprints. please keep public access open!
- Having licensed sportsmen obtain an additional permit to utilize public land is redundant and unnecessary.
- Good job to DCR!
- Never, never allow snowmobiles, ATVs skateboards on the North Dike in spite of pressure from various interests
- Non motorized watercraft would also be reasonable use of the Wachusett Reservoir...watercraft are allowed on the Quabbin but not the Wachusett.
- Please continue to have a dog friendly walking trail, there are very few places to walk dogs safely and there are no dog parks in central MA.
- Please open the dam area in Clinton to the public. I grew up with this opportunity and would like to share it with my kids.
- Allow more on leash dog walking at more DCR locations. There are limited local choices which are clogged with walkers, strollers and bikers which become to o congested. And unsafe for walking dogs.
- You are custodians of an important and historic landscape at the dam site-please do a better job!
- Need to fix the access road to the Clinton Dam off of Rte. 70. Don't forget to fight for funding it. Rte. 70 is starting to erode and sag down towards Lancaster Mill Pond. Need to bite the bullet on that.
- Is it really necessary to provide permits for hunters? Didn't this occur with fishing years ago and finally it was given up? I suggest that you be more customer friendly to hunters applying for permits--to do this only by postal mail seems a bit much in this day and age.
- I run the dike area and believe all of us runners serve as eyes and ears for the DCR, helping keep the area as the stewards we intend to be of this treasure.
- Keep up the good work and please do not consider limiting or expanding recreation as it exists now- I think you do a great job of balancing open space, protecting the water supply and recreational opportunities as is
- I sincerely hope that people will be able to continue to enjoy the beauty and nature that surrounds the Wachusett Watershed Area and to be able to access more of its history.
- Keep in mind that true sportsmen preserve the environment- just like the true recyclers who use your facility rather than illegally dumping in the watershed.
- Beavers in the watershed are not good, especially on Quinapoxet and Stillwater Rivers. Too many dams that hold back water which seems to kill a lot of trees, creating a swamp like atmosphere which inhabits mosquitoes especially on Stillwater River
- Fishing season should be ice out to ice in (mid/late March through December)
- Please put trash barrels at each gate. This would cut down the amount of trash I see around the reservoir.
- We really enjoy the reservoir rail/bike trail and hiking paths
- Open the reservoir area to reasonable human activity such as non motorized craft, ice skating/boating
- Stop wasting money ie: fence building in areas that should be open to the public
- Have rangers pick up trash at gates
- The erection of fences making it difficult to access the bluffs above the railway cut just beyond the dam. There was no problem before the fence was installed.

* While the majority of comments are listed, comments that were irrelevant and/or did not relate to public access on DCR property were eliminated.

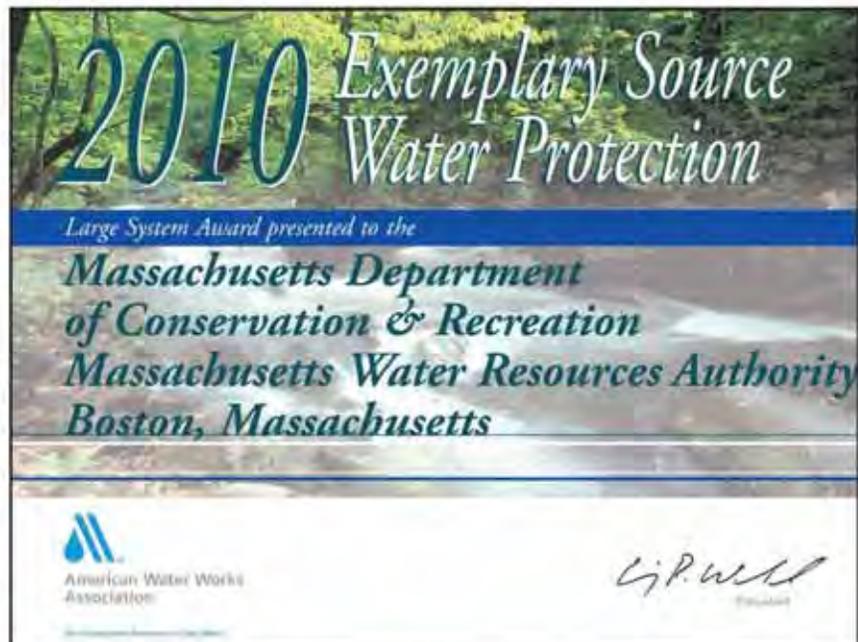
Appendix E. AWWA Award Newsletter

DCR Wins National Clean Drinking Water Award

The Massachusetts Department of Conservation and Recreation's Division of Water Supply Protection (DCR/DWSP) has received the American Water Works Association (AWWA) 2010 Exemplary Source Water Protection Award for Large Systems. The Division's Office of Watershed Management has a long-standing reputation for successfully providing pure water to the Massachusetts Water Resources Authority (MWRA) for treatment and distribution to more than 2 million people. This award certifies DCR as an international role model for drinking water quality protection.

AWWA, an international nonprofit and educational society, is the largest and oldest organization of water professionals in the world, with membership of more than 60,000 people and 4,600 utilities that supply water to roughly 180 million people in North America. Members represent treatment plant operators and managers, scientists, environmentalists, manufacturers, academicians, regulators, and others who hold genuine interest in water supply and public health. AWWA is the authoritative resource on safe water.

The significance of this award is magnified by the fact that DCR's advocate was its regulating agency, the MA Department of Environmental Protection (DEP). DEP's detailed nomination to the award committee was based on its intimate knowledge of DCR's work, derived from DEP's annual inspections and on-going program review, which are required for DCR's source water to maintain MWRA's federal filtration waiver. DEP's recommendation was supported by the New England chapter of the AWWA, which subsequently submitted the nomination material to be considered with other applicants from around the country.



The water at Quabbin Reservoir is crystal clear.



A tranquil day on the Ware River.

The nominations were judged on how well a water system meets six components of AWWA's Source Water Protection Standard: 1) program vision; 2) source water characterization; 3) explicit protection goals; 4) development of an Action Plan; 5) implementation of the Action Plan; and 6) periodic evaluation and revision of the entire program. The award was also based on three additional factors: the 1) documented effectiveness of the program; 2) innovativeness of the approach; and 3) the difficulties overcome by the organization.



Quabbin Reservoir, frozen over in winter.

DCR's watershed management programs excel in all of these areas. DEP explicitly noted DCR's extensive planning processes, water quality monitoring, natural and cultural resource stewardship activities, and community outreach through advisory committees, interpretive services, technical assistance, ranger patrols, and publications. All of these elements are unified into an annual Work Plan and corresponding budget that is reviewed and approved by the Water Supply Protection Trust. The following are factors that contributed to AWWA's recognition of DCR's efforts.

Effective. The source water provided by DCR to MWRA continuously meets the federal standard for unfiltered source water fecal coliform. Components to this success include:

- A bird harassment program at both reservoirs that is a major element in DCR's ability to meet critical water quality parameters.
- A strong understanding of water quality issues throughout the watersheds and reservoirs.
- An excellent track record of planning, entailing periodic updates to the Watershed Protection Plans, Public Access Plans, and Land Management Plans, with appropriate public involvement integrated into the process.
- The ability to control harmful land uses across the watershed system provided by the targeted expenditures of the Land Acquisition Program and implementation of the Watershed Protection Act regulations.
- A team of scientists, labor and craftsmen, planners, engineers, rangers, foresters, educators, and managers who work together to accomplish the 100+ programs and projects identified in each annual Work Plan.

Innovative. DCR's professional staff draws upon the resources of experts and academic institutions to bring the most advanced strategies into its watershed protection programs, such as:

- Research tracking the migratory habits of gulls that will advise components of the bird harassment program.
- Microbial tracking on tributaries to the Wachusett Reservoir that identified the need for educational programs focusing on dog waste.
- Multi-jurisdictional emergency planning, training, and equipment deployment, performed in association with MWRA, state, and local officials.





- ◆ Ongoing water quality related education programs at the Quabbin Visitors Center, in watershed community classrooms, out in the field, and on-line.
- ◆ Community infrastructure developments that address long-term waste issues, such as the Wachusett Earthday recycling site.
- ◆ The Quabbin boat decontamination program, rapidly developed and implemented, which minimizes the threat from invasive aquatic species while allowing private fishing boats on the reservoir.

Perseverance. DCR has a long history of addressing myriad political and logistical challenges.

- ◆ Creating a source water protection program that encompasses four watersheds and close to 500 square miles, coordinating with dozens of individual community governments, legislators, and stakeholder groups.
- ◆ Working with the citizens of the watersheds, who do not consume the water from either the Quabbin or Wachusett Reservoirs. DCR identifies projects that promote protection of both the locally utilized natural resources as well as the drinking supply for people close to 100 miles away.
- ◆ Respecting and honoring the sacrifices made by previous generations that had their communities transformed into a drinking water supply.

At a ceremony in the Division's field headquarters in West Boylston, DCR Commissioner Rick Sullivan heralded the daily efforts of the 150 staff dedicated to Watershed Protection. Division Director Jonathan Yeo recognized the men and women who have worked for the agency as it has evolved over the past century. The Director also praised the support and team efforts of the MWRA, whose ratepayers provide the money for operations, land acquisition, payments in lieu of taxes, and long-term capital

investments. The Water Supply Protection Trust's five trustees – MWRA Executive Director Fred Laskey, Katherine Haynes Dunphy, Judith Eisman, William Meehan, and Kathy Baskin (EEA Secretary Ian Bowles' representative) – were also acknowledged for their effective oversight and support of the Division.



DCR Director Jonathan Yeo proudly displays the AWWA Clean Drinking Water Award with DCR Commissioner Rick Sullivan.

The AWWA award would not have been possible without the commitment and expertise of the Division of Water Supply Protection staff. Commissioner Sullivan and Director Yeo thanked the current employees in the Office of Watershed Management for all of their contributions that help protect some of the best drinking water in the world.

For more information:

www.mass.gov/dcr/watersupply.htm

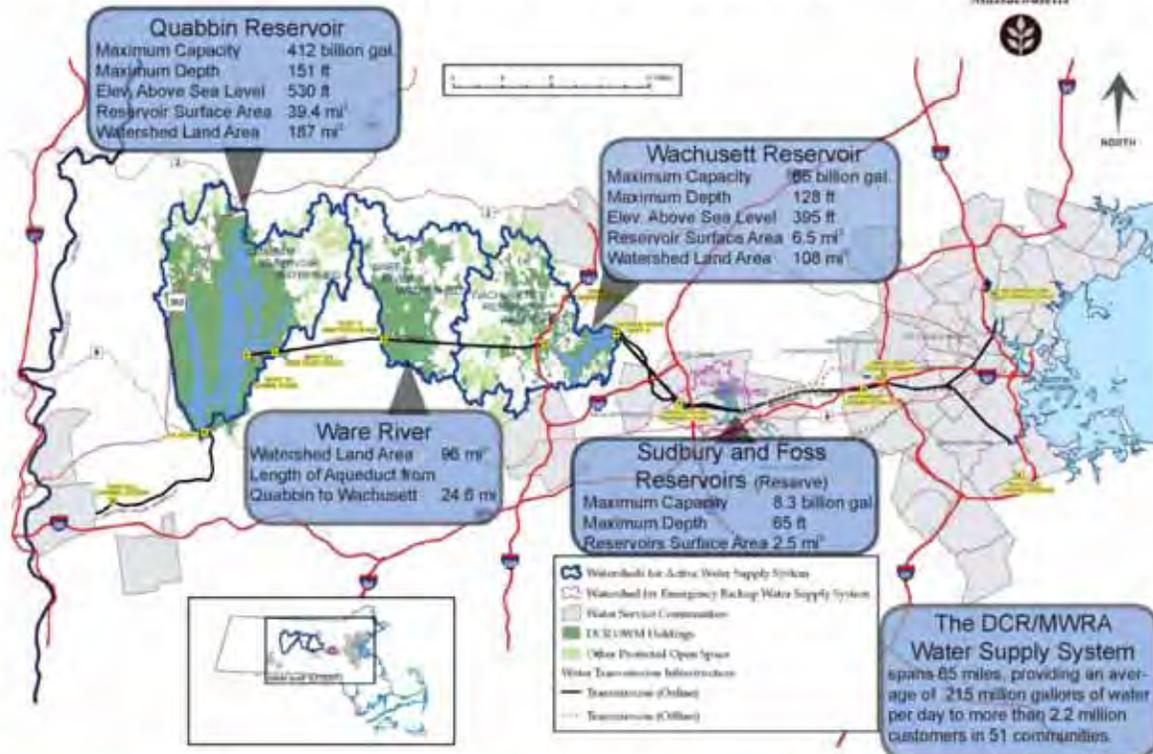


Department of Conservation and Recreation
 Division of Water Supply Protection
 Office of Watershed Management
 251 Causeway Street
 Boston, MA 02114
 (617) 626-1250

Wachusett Reservoir on a crisp fall morning.

The DCR Watershed System at a Glance

dcr
Massachusetts



Congratulations and Special Thanks to the DCR Division of Water Supply Protection, Office of Watershed Management 2010 Staff!

Director: Jonathan Yeo **Regional Directors:** Quabbin – Bill Pala, Wachusett – John Scannell
Assistant Regional Directors: Quabbin – Dave Small, Wachusett – Scott Murphy
Natural Resource Director: Dan Clark **Budget Manager:** Eileen Honen
Environmental Quality: Quabbin – Bob Bishop, Rebecca Budaj, Peter Deslauriers, Lisa Gustavaen, Yuehlin Lee, Paul Reyes, Bernadetta Susianti-Kubik, Wachusett – Pat Austin, Kelley Freda, David Getman, Tristan Lundgren, Paula Packard, Larry Pistrang, Steve Sulprizio, Vincent Vignaly, Dave Worden
Natural Resources: Steve Anderson, Jim French, Kiana Koenen, Thom Kyker-Snowman, Ken MacKenzie, Jillian Pereira, Caroline Rausler, Jim Taylor
Forestry: Quabbin – Herm Eck, Derek Beard, Dennis Morin, Randall Stone, Steven Ward, Steve Wood, Wachusett – Greg Buzzell, Brian Keegan
Watershed Protection Act: Quabbin – Jeff Lacy, Wachusett – Nancy McGrath, Allan Rantala; Boston – Joel Zimmerman
Watershed Engineering: Quabbin – Scott Campbell, Peter Jzyk, Douglas Williams, Steve Mansfield, Wachusett – Bill Moulton, Ed Connor, Paula Davison, Ross Goodale
Administrative and Technical Support: Quabbin – Paul Lyons, Linda Boulette, Sandra Conkey, Philip Lamothe, Kimberly Turek, Jennifer Peterkin, Wachusett – Marybeth Bonin, Craig Fitzgerald, Christine Muir, Christy Power; Boston – Ashley Chan, Joanne Driggs-Williams, Flora Martinez, Paul Penner, Mulunesh Sisay, Cynthia Smith
Watershed Rangers: Quabbin – Dave Zaganiacz, Peter Baldracchi, Gerard Houle, Jamie Hogan, Tiffany Leclair, John Maslon, Sean McQuard; Wachusett – Rick Mathews, Derek Liimatamen, Rebecca Baronoski, Bruce Fant, Thomas Gonzales, Tim O'Connor, Benjamin Pollini, Nathan Tobey, Keith Vicari, Dave Wright
Interpretive Services: Quabbin – Cliff Read, Maria Beiter-Tucker, Dale Monette, Wachusett – Jim Lafley, Roger Clifford
Watershed Maintenance & Operations: Quabbin – Al Walsh, Jeffrey Adams, Bruce Andrew, Steven Baran, Michael Barnes, Ray Cusson, Al Detour, Camille Domina, Randall Florence; Gary Gaines, Laurie Gauvin, Jason Holden, Gordon Humphrey, Allyn Hurlbut, Stephen Jarvis Jr, David Kenyon, John Krasnecky, Chet Krol, Paul Lapierre, Lars Larson, Conrad Letourneau, Thomas Peloquin, Ronald Peters, Frederick Provost, Andrew Ohlson, Donald Sorrenho, Craig Stoddard, Michael Strzemieniski, Michael Wisnoski; Wachusett – Mike Tomaiolo, Ronald Anderson, John Buckley, Albert Bull, Robert Carlson, Glenn Cheries, Wayne Chestna, Zack Costa, Brian Dziokonski, Terry Fellowes, Paul Gosselin, Francis Guy, Terance Kearney, Sean Lovejoy, Fred Mellor, George Nelson, Tim O'Connor, Robert Parker, Vincent Pasquale, Ray Pelletier, John Pingeton, Michael Ponyta, Ed Power, Pete Rarnig, Paul Silvestri, Dave Simmons, Chris Tuff, Dan Valerio, John Vento, Dan Wolski, Ted Zdonczyk

Appendix F. Pet Waste Outreach

What's the Problem With Pet Waste?

Pet waste left in our yards and communities can have many adverse effects on the environment, as it is full of harmful bacteria and excess nutrients. Besides the fact pet waste is a neighborhood nuisance, it can make people sick, especially children who are more likely to come into contact with it while playing. Pet waste left on lawns can also kill or damage grass and other plants.



When pet waste is washed into lakes or streams, the waste decays, uses up oxygen and sometimes releases ammonia. This can kill fish!

Pet waste also contains nutrients that encourage weed and algae growth. Overly fertile water becomes cloudy and green...imagine this in your backyard pond or stream!

Managing pet waste properly is something easy that everyone can do to make a difference in the quality of our surface waters.



Individual actions can result in a significant water quality improvement when carried out by a majority of people. Unlike some forms of stormwater pollutants, individuals in our watershed can easily and economically manage pet waste and help to keep your waters safe and aesthetically pleasing.

WACHUSETT WATERSHED
department of Conservation and Recreation
 180 Beaman Street
 West Boylston, MA. 01583
 508-792-7806
www.mass.gov/dcr

dcr
Massachusetts



**DOG WASTE
 AND
 SURFACE
 WATER
 QUALITY**

DID YOU KNOW?

There are over 5,500 licensed dogs in the Wachusett Reservoir Watershed?



Each one of these dogs produces about $\frac{3}{4}$ lbs of solid waste and 7.8 billion bacteria per day!



Rainfall and snowmelt in the Wachusett Watershed goes directly into our streams, rivers and lakes untreated. Along its way it picks up contaminants in its path. That's why it is important to insure that pollutants such as pet waste do not end up in our storm drains.

WHY AREN'T DOGS ALLOWED ON DCR WATERSHED LANDS?*

DCR's Watershed lands serve as protection for a sensitive drinking water supply for 2.2 million Massachusetts residents, the Wachusett Reservoir.

Waste from dogs can enter directly into the reservoir or into the tributaries that then flow into the reservoir.

Bacteria and other parasites, such as Giardia and Cryptosporidium can survive for long periods when left on the ground. During the next rainfall, these can get washed into the drinking water supply, compromising water quality which is regulated by state and federal laws.

*** Dogs are ONLY ALLOWED on the portion of the Oakdale Rail Trail not owned by DCR (Thomas Street to the I190 overpass). Please pick up after your pet.**

How you can help



- BRING IT- Always bring a plastic bag when you walk your dog.
- BAG IT-Use the bag as a glove to pick up the pet waste. Scoop up the waste and turn the bag inside out around the waste.
- DISPOSE IT- Properly dispose the waste by placing it in a trash can or flushing it unbagged down the toilet. **NEVER THROW WASTE DOWN A STORM DRAIN!**
- Pick up after your pet in your yard.

Side 1

Dog Waste and the Wachusett Watershed

In the Wachusett Watershed, there are over 5,500 licensed dogs, and they are estimated to produce about 2,750 pounds of dog waste and 5.2 million fecal coliform PER DAY!

Scientists from the U.S. Geological Survey estimate that pet waste contributes between 20 to 30 percent of the water pollution in America.



It is important that dogs be kept away from the reservoir and more importantly, that their fecal material, or waste, is not allowed to enter the water.

Side 2

Rainfall and snowmelt in the Wachusett Watershed flows directly into our streams, rivers, lakes and reservoirs, picking up contaminants along the way.

Pet waste left on the ground can have many adverse effects on the environment, as it is full of harmful bacteria and excess nutrients.

When pet waste is washed into surface waters, such as the streams flowing into the Wachusett Reservoir (and the reservoir itself) the waste decays, using up oxygen and sometimes releasing ammonia. This can kill fish. Pet waste also contains nutrients that encourage weed and algae growth.

Waste from mammals also has the potential to carry disease-causing organisms, which can contaminate a drinking water supply.

Watershed Ranger Dog Waste Card Hand-out

Appendix G. AIS Outreach



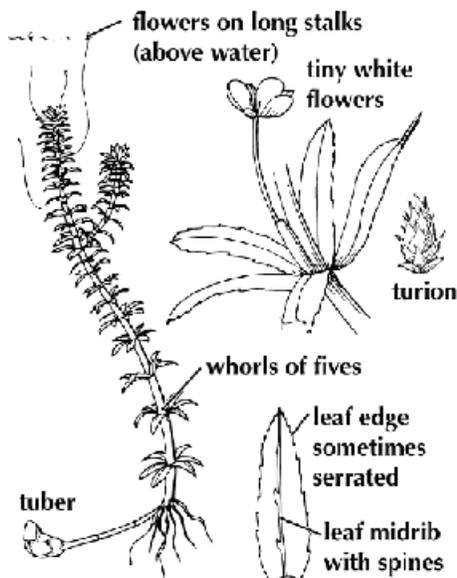
ATTENTION FISHERMEN:

HYDRILLA, an invasive aquatic plant
has been found in nearby South Meadow Pond in Clinton.

WE DO NOT WANT IT TO SPREAD TO OTHER WATERS!

Small pieces of this plant can resprout and grow into new plants. Once established, it can replace native vegetation and **AFFECT FISH POPULATIONS!**

Please use extra caution by inspecting and cleaning all fishing equipment, including bait buckets and any other means of transport **BEFORE** fishing here.



If you think you have seen this plant, please contact:
Jamie Carr, DCR Aquatic Biologist at 508-792-7806 ext. 241

Side 1

ALERT!

We need your help keeping Aquatic Invasive Species out of DCR waters!

Aquatic Invasive Species (AIS) are a group of plants and animals that are not native to Massachusetts and don't belong here. Those threatening DCR waters have been transported from distant regions of North America as well as from other continents. Once introduced, they have the ability to become established and spread rapidly within native aquatic communities. Invasions by these species threaten the health of our waters and are usually **IMPOSSIBLE TO GET RID OF!**

Many AIS are harmful to game fish populations. Negative impacts to game fish include loss of spawning habitat and disruption of the food chain that supports adult fish.

The spread of AIS among water bodies is mainly caused by human activities; especially boating and fishing. Many AIS have life-cycle stages that are small to microscopic in size and can survive out of water for some time. Please guard against moving plant fragments, mud, or debris from one water body to another by making sure your boat, trailer, and fishing gear are **CLEAN** and **DRY** after visiting **ANY** water body. More specific recommendations are given on the back of this card.

Side 2

Complete this checklist after visiting any water body:

- **Inspect** – boat, trailer, and fishing gear
- **Remove** – plant fragments, mud, debris (hot wash or pressure wash boat/trailer if possible; clean fishing gear)
- **Drain** – any standing water (bilge, etc.)
- **Dry** – allow at least 5 days of complete dryness (longer if possible) before visiting a different water body

Avoid using felt-soled waders in rivers and streams because they can harbor the invasive alga known as Didymo or “rock snot.”

Never dump aquarium organisms or release exotic pets (turtles, frogs, etc.) into natural waters.

Use of bait sold commercially is permissible in DCR waters, but do not transfer privately harvested bait organisms between water bodies.

More information on AIS is available at <http://www.mass.gov/dcr/watersupply.htm>

Watershed Ranger AIS Card Hand-out

Appendix H. Public Meeting Minutes and Comments

DCR Public Meeting Minutes
Wachusett Public Access Plan Update
Tuesday, May 3, 2011 7:00
DCR Water Supply Headquarters
180 Beaman Street, West Boylston

Regional Director John Scannell opened the public meeting at 7:05 p.m. with 9 people in attendance.

The meeting began with introductions and an explanation of the purpose of the public meeting; to present the draft of the updated Wachusett Public Access Plan. RD Scannell explained that the meeting would consist of a short powerpoint presentation and then public comments on the plan would be accepted.

The powerpoint presentation included a brief overview of the agency, public access planning, the timeline of the update process, survey results, and minor changes proposed for the plan.

JS then opened the meeting for public comment. He explained that there would be no debating of the issues but comments would be recorded and reviewed.

Public Comments:

JS first asked Susan Templeton (representing Representative Naughton's office) if she had any comments. She had none at this time.

- Winthrop Handy, 53 Central Street, West Boylston. Resident who has lived in West Boylston since 1973. WB has an industrial area, chemicals in the ground along the Quinapoxet River, landfills, and hazardous waste cleanup sites and does not understand how dog waste can contaminate the river (in relation to no dogs allowed on the DCR portion of the Mass Central Rail Trail). DCR has decimated the tax base. He had always hoped to use a boat on the reservoir. West Boylston has the DCR, the jail and private entities consuming the tax base and the town deserves a little more than what it is getting in return. The town cannot afford to pay DPW workers or fix the town hall. A meeting was scheduled with Representative McGovern to discuss these issues at a time when the town was suing DCR over the recycling center. The town needs more money from DCR and MWRA.
- Cheryl Lekstrom. Representing the Mass Farm Bureau Federation (consisting of 6500 farm families in the Commonwealth), and liaison to the equine committee. Has been a West Boylston resident since 1981 and has offered public comment at many past DCR meetings. The federation believes that horses should be allowed in areas not as prone to erosion issues and does not agree with DCR reasoning on not allowing domestic

animals and horses. Feels DCR has taken on a draconian approach to horseback riders who provide eyes and ears for water quality and security. Feels that horses could be allowed in specific areas.

- Thomas Berube, Barre. Quabbin Watershed Advisory Council and Mass. Sportsmen's Council. Does not understand the rationale of the dog issue on the rail trail beyond West Boylston. Some of the trail is owned by private entities and Mass Wildlife but is posted no dogs allowed.
- Barbara Wyatt, Sterling Street, West Boylston. West Boylston Open Space Committee and Economic Development Committee. Would like DCR to consider the addition of "scenic overlooks" or pull off parking areas, especially in the area of the Old Stone Church as she always sees photographers in this area. She would like to see a pull off area with interpretive signage or a plaque. She would also like DCR to consider additional parking areas around the watershed and parking spaces at gates, and new maps showing DCRs trails on them. She also feels that a visitor's center is needed.
- Tom Burke, Clinton. Concerned with the downstream flooding of the Nashua River and who is responsible for cleaning up the mess left behind after the floods last year. (JS addressed this comment as it was not specifically related to the public access update. He stated that he had met with Representative Naughton and Susan Templeton from his office last week and that together they will work to find a solution to improving the situation and solving the problem. Significant effort will be needed as there are many blockages that are causing the river to rise and this is not only causing downstream problems but it is also limiting our availability to control the reservoir levels.)

There were no other public comments.

JS reminded all in attendance that written comments on the plan would be accepted until May 20, 2011 by e-mail and regular mail. The mailing and e-mail addresses were displayed.

The meeting ended at 7:50 p.m.

Comments Received on the 2011 Wachusett Reservoir Access Plan Update

From: Diana Engelbart [<mailto:engelbrt@rcn.com>]
Sent: Friday, May 20, 2011 5:38 PM
To: Updates, DCR (DCR)
Subject: Wachusett Reservoir access plan

To my understanding, people who commented on the access plan had these priorities:

- public access for dog walking,
- bicycle riding,
- geocaching (GPS hide & seek)
- parking.
- establishing a visitors center,
- scenic overlook parking,
- maps of trails and access gates,
- weddings at the Old Stone Church
- hunting

I'd like to add my support for the above items. I'd also like to work with the DCR to provide downloadable trail maps to the West Boylston website. I would also like to explore the idea of the rangers taking elementary school children on nature/plant identification walks.

Sincerely,

Diana Engelbart
West Boylston Open Space Committee
West Boylston Town Wide Planning

From: Fallavollita, Lynn [<mailto:Lynn.Fallavollita@umassmemorial.org>]
Sent: Wednesday, May 18, 2011 10:07 AM
To: Updates, DCR (DCR)
Cc: Erin Palumbo; Pat Pepi; Sighle Philbin; Fallavollita, Lynn; Frank Perla; Margaret Rotti
Subject: DCR PUBLIC ACCESS PLAN

The West Boylston Agriculture Commission would like to offer the following response to the DCR Public Access Plan:

- We support open access for all equine recreational activity.
- We believe equine activity would have no impact to the watershed.
- There would not be an overabundance of equine activity in this area due to lack of available parking for horse trailers.
- So much of West Boylston is DCR Land yet the residence of the town have very limited use of this land.
- The best way to protect the watershed is with education. We should not keep people away but rather allow them to use, enjoy and learn to care for it. Lets teach our children to respect and protect their environment.

The West Boylston Agricultural Commission wishes to thank you to reconsidering equine activity on DCR Land.

Respectfully submitted,

West Boylston Agricultural Commission
Pat Pepi
Sighle Philbin
Erin Palumbo
Frank Perla
Peggy Rotti
Lynn Fallavollita

From: Kevin O'Loughlin [<mailto:oloughlink@clinton.k12.ma.us>]
Sent: Tuesday, May 17, 2011 10:55 AM
To: Updates, DCR (DCR)
Subject: "Wachusett Reservoir Access Plan"

The Wachsett Dam is a beautiful site. Built by immigrants, hard working people. Each shovel full of dirt that was removed from the site was an act of pride. The building of roads, dikes, removal of bodies from a cemetery was a testament to the strength of our country. Many towns like Clinton, Boylston West Boylston and Sterling had to give up part of their land. There were homes and businesses abandoned for this cause to give water to Boston. I feel that the people affected by this act would want their heirs to be able to appreciate the beauty of the area. I propose that the citizens be allowed to have access to the Wachsett Dam area. To be able to walk across, down and around the dam structure. It would foster an appreciation for the esthetic beauty of the grounds, teach the young about the sacrifices our fore fathers made, become a learning tool for the students of Clinton to learn about the importance of water and water conservation and for all to appreciate how we are intertwined with our ecology of our watershed. Thank you very much for your consideration,
Kevin O'Loughlin
May 17, 2011

From: Philip Philbin [<mailto:tiseyes@gmail.com>]
Sent: Thursday, May 12, 2011 10:59 AM
To: Updates, DCR (DCR)
Subject: Access by horse

To whom it may concern,

I believe it is very wrong to restrict the use of access by horse to lands of the taxpayers of mass. By the mass D C R.

Responsible use of these lands should be reinstated first to all abutters of these properties The very people that walk it and oversee it.

Ultimately a permitting process to all citizens interested.

I believe a small amount of people would be interested.

Be aware many people that live in the area are descendants of the very people that built this reservoir and have strong feeling about protecting it including me. I had an great uncle that was killed in that process of building the wachusett reservoir also many others that worked it that did

not die in the process but went on to enjoy the lands by walking and riding it on horseback. To me it's hallowed grounds And always needs protection, who better than the people that use it daily.

We would definitely like to be free again to use it responsibly

Sincerely,
Philip Philbin
French Hill Farm
West Boylston

From: Fallavollita, Lynn [<mailto:Lynn.Fallavollita@umassmemorial.org>]
Sent: Wednesday, May 11, 2011 3:36 PM
To: Updates, DCR (DCR)
Subject: Wachusett Reservoir Access Plan

I am a 25 year resident of West Boylston and am an abutter to the Wachusett Reservoir - in fact you can walk thru by back year and enter the Reservoir from there. My daughter at an early age became familiar with the many trails from behind our house. I have often felt it was a shame not to allow horseback riding in this area. I am a horse person and it would be magnificant to be able to ride thru the 100s of acres the Reservoir provides.

Below are a list of my reasons why horseback riding would be ok to do in these woods:

- o Horseback riding would no more effect watershed than the current deer/other wildlife population.
- o Fisherman create much more damage to DCR Land than horseback riders would - they leave their trash behind like styrofoam coolers, beer cans, fishing line to name a few.
- o Horseback riders could be the eyes and ears for the DCR and would be able to travel to more areas than DCR Vehicles.
- o DCR Vehicles - trucks/atvs - create road damage and threaten to pollute with fuel.
- o There are hundreds of acres of beautiful land ideal for horseback riding.
- o Could open it up on a trial bases.
- o If not for public - at least to town residents and/or abbutters.
- o Could create revenue by requiring license to ride.
- o Riding would be limited anyway because of lack of parking.

thank you.

Lynn Fallavollita
272 Lancaster St
West Boylston, Ma

From: peggy rotti [<mailto:pegrotti2000@yahoo.com>]
Sent: Wednesday, May 11, 2011 11:21 AM
To: Updates, DCR (DCR)
Subject: Wachusett Reservoir Access Plan

In regards to the Public Access Plan:

As a long time resident of West Boylston and long time user of the Wachusett Reservoir property I have a few comments.

Horseback riding does not effect the watershed anymore then the thousands of deer / wildlife population. The state could collect revenue through licensing for permits for use age of the trails. In the Forty years I have used the trails for hiking, cross country skiing, fishing, and many years ago horseback riding I have never ran into anyone on horseback that there properties did not abut the Reservoir. Because of the lack of parking there would not be a problem of too many horses. Horse owners could be required to wear manure bags to prevent them from leaving any manure on the trails. Strict rules could be put in affect against horses being near the shore lines. There are hundreds of acres of beautiful land ideal for horseback riding. If not open for public-at least to town residents and/or abutters.

In the years since horseback riding has not been allowed the damages that had been done to the trails by the DCR vehicles -trucks/atvs and the vehicles in there cutting trees is a disgrace. The fuel that is spilled by the tree service is more of a pollutant then any horse. I can't ride a pedal bike because I will erode the trails and the the DCR vehicles have done so much damage.

Fisherman pay for a license to fish and leave Styrofoam cooler, coffee cups, beer cans, fishing line to name a few. Myself and my friends that us the Reservoir has NEVER so much a left a tissue on the ground.

Best Regards:
Peggy Rotti

From: Erin Palumbo [<mailto:eafitz@gmail.com>]
Sent: Monday, May 09, 2011 11:49 AM
To: Updates, DCR (DCR)
Subject: comments regarding the watershed

I fully support increased access for the public. The quality of water in the watershed should be a top priority. However, the more people are restricted from using the land surrounding the watershed, the less respect and understanding they will have for the water. We must work to educate and use people as a resource rather than simply restrict them from going on the land. If horses, dogs, mountain bikes were allowed, these groups would likely help maintain the trails and provide fundraisers to support the area. When all access is denied, it simply builds

resentment toward the DCR. People must, as with all fragile environmental systems, work to cohabitate. There is a better answer than what we currently have.

From: Pat Pepi [<mailto:patpepi@charter.net>]
Sent: Monday, May 09, 2011 9:49 AM
To: Updates, DCR (DCR)
Subject: Wachusett Reservoir Access Plan

As a resident of West Boylston for over 50 years, I think it is appropriate to open the Wachusett watershed to horseback riding and driving in the watershed area.

Regards,

Patricia Pepi
181 Fairbanks Street
West Boylston, Ma 01583



Clinton Greenway

February 5, 2011

John Scannell, Regional Director
180 Beaman St.
West Boylston, MA 01583

Dear John,

The Clinton Greenway Conservation Trust (CGCT) is very interested in supporting your efforts to update the Wachusett Public Access Plan. Several of our members participated in the kickoff meeting on October 28, 2010. Since that initial meeting we have discussed a few ideas for inclusion in your plan.

The included document describes our ideas.

We reviewed the format of the Wachusett Reservoir Public Access Plan 2003 and have tried to mimic that format in our suggestions for the plan. We used a format that defines the goal and then lists specific actions to accomplish the goal.

We would be very happy to meet with DCR to discuss this so that any ideas that are not in line with DCR's overall goals and objectives can be refined.

We noticed that the 2003 plan describes your partnership with Wachusett Greenways. We would like to setup a similar partnership with the Clinton Greenway Conservation Trust.

Please let me know if there is a convenient time for you or your designate to meet with the CGCT.

Kind regards,

Frannie Hodge
Member, Clinton Greenway Conservation Trust Board of Directors

cc: Dianne Mather, President, Clinton Greenway Conservation Trust

PO Box 683 · Clinton, MA 01510 · 978.365.9377

www.clintongreenway.org

Wachusett Reservoir Watershed Public Access Plan Update 2011 Input to Draft Plan from Clinton Greenway Conservation Trust

Overview of Clinton Greenway Conservation Trust (CGCT) and interest in Wachusett Reservoir Watershed Public Access Plan Update

The Clinton Greenway Conservation Trust is a land trust based in Clinton, Massachusetts, that is dedicated to the protection and enjoyment of open space. The charter of the CGCT is to provide protection for, awareness of, and access to the open spaces in Clinton. The Wachusett Reservoir area represents the largest parcel of open space in Clinton. We are very interested in the continued protection of this precious resource balanced with public access to this beautiful parcel as appropriate.

Our current projects include the implementation of the Town of Clinton Open Space and Recreation Plan including development of trails and providing for the ongoing maintenance and protection of Rauscher Farm. Short term goals include developing trails on existing rail beds and other open areas.

One of our trail projects is the continuation of the Mass Central Rail Trail (MCRT) through Clinton. The Wachusett Reservoir is one of the unique and appealing features of the MCRT. The section of the MCRT through the Wachusett Reservoir area provides the critical connection to the MCRT sections that have already been developed by Wachusett Greenways with the MCRT sections that the CGCT plans to develop. Continuing the MCRT through the DCR property seems to be the best and safest option. Users of the MCRT will be protected from vehicle traffic. The additional "eyes" on the reservoir provides protection for the water.

Trail sections immediately to the east of the Wachusett Reservoir will be developed by the CGCT and the Berlin Conservation Commission. Trail sections from Berlin and continuing to the East are currently controlled by the MBTA with a planned transfer to DCR. Trail sections west of the reservoir are under development by Wachusett Greenways. The section of the MCRT from South Meadow Road to Campground Road continues to be an active rail line.

We would like for you to consider a few goals and objectives for the update to the Wachusett Reservoir Public Access Plan that are aimed at continued development of the Mass Central Rail Trail.

J. Goal – Continue the development of the Mass Central Rail Trail

a. Actions to accomplish goal

- i. Continue the partnership that DCR has developed with Wachusett Greenways.
- ii. Initiate a partnership with the Clinton Greenway Conservation Trust for the Clinton sections of the trail.
- iii. Improve the trail surface between Gates 39 and 42 to better accommodate bicycle traffic
- iv. Determine options for extending bicycle traffic from gate 39 to Gate 33. Options may include:
 1. *Modify trail on the North Dike so that it slopes and drains away from the reservoir (to prevent dirt that kicks up from rolling toward the water).*
 2. *Develop a trail parallel to route 110 on the grassy section*
 3. *Build boardwalk or other protected access where the reservoir meets route 110. Gate 36 – Gate 35*
 4. *Determine best trail surface to protect the water.*
- v. Add Mass Central Rail Trail signs along this trail to make it clear to users that this is part of the larger MCRT trail.
- vi. Investigate Potential paths for multi-use between Gates 35 and 26

II. Goal – Additional multi-use recreational trail

a. Actions to accomplish Goal

- i. Investigate possibilities for a recreational trail that circles the reservoir
 1. *Complete a feasibility study on the potential path. This study would itemize the requirements to improve existing trail or create new trail that provides access while continuing to protect the water supply, wildlife, and any other sensitive areas. (Idea is to use the existing trails from Gate 42 to Gate 39, continue from Gate 39 to Gate 36 on the north dike if developed to an acceptable standard or on new trail from gate 39 to gate 36. Develop trail between Gate 36 and Gate 35. Use existing trail or develop new trail from Gate 35 to Gate 26. Follow road to Gate 25. Use existing trail or develop new trail from Gate 25 to Gate 18. Develop trail between gate 18 and 17. Continue trail from Gate 17 to Gate 1 and then around the base of the dam to gate 42 to complete the circle).*
 2. *Work with DCR Greenways and Trails program for funding of studies*
 3. *Work with DCR Greenways and Trails program for funding of trail development.*
 4. *Work with open space committees of Wachusett communities (Clinton, Sterling, West Boylston, and Boylston) and local land trusts, including CGCT on planning, development, and funding.*

Appendix I. Public Information Contact List

DCR Division of Water Supply Protection Office of Watershed Management Wachusett/Sudbury Section January 2011		
Visitor Information		
Wachusett Watershed Rangers		978-365-3800
Regulation and Public Access Policy		
Wachusett Watershed Rangers		978-365-3800
Security Concerns		
Emergency		911
Wachusett Watershed Rangers		978-365-3800
State Police-Holden		508-829-8410
Geocache/ Letterbox Questions		
Wachusett Watershed Rangers		978-365-3800
Group Access Permit Request		
DCR Wachusett Headquarters		508-792-7806
Hunting Permit		
Request:		
DCR Headquarters		508-792-7806
Hunting Access Questions:		
Wachusett Watershed Rangers		978-365-3800
Water Quality Concerns		
Patricia Austin		508-792-7806
Wachusett/Sudbury Regional Director		
John Scannell		508-792-7806
DCR website		www.mass.gov/dcr
Division of Water Supply Protection		www.mass.gov/dcr/watersupply.htm

Turbidity Technical Review

Summary of Sources, Effects, and Issues Related to Revising the
Statewide Water Quality Standard for Turbidity



State of Oregon
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Executive Summary

The Oregon Department of Environmental Quality (DEQ) is revising its water quality standard for turbidity, which has been largely unchanged since 1977 and currently prohibits more than a ten percent cumulative increase in natural stream turbidities relative to an upstream control point. DEQ will use this document to inform the development of water quality standard regulations based on best available science. DEQ will also consider aspects of how the standard is expressed, including the duration of an exceedance that would result in not meeting the water quality standard, exceedances that are limited in duration, and other issues. DEQ expects this rule development effort will ultimately require some difficult policy choices, which will be discussed by an external workgroup of affected parties in the summer and fall of 2010.

Turbidity is a relative measurement of reduced visual clarity (scattering and absorption of light by particles in water) versus a calibrated standard. Increased turbidity levels are caused by suspended particles, dissolved organic matter, and planktonic organisms in the water column.

Chapters 1 and 2 of this report include an introduction, a discussion of the definition of turbidity, turbidity measurement instrumentation and associated uncertainties, sources of turbidity, and other states' turbidity criteria. Chapter 3 presents adverse effects of increased turbidity on beneficial uses, including aquatic life, recreation, and treatment of domestic water supplies. Chapter 4 presents data regarding natural variability of turbidity in Oregon. Chapter 5 provides conclusions and identifies data gaps.

Turbidity readings can differ based on instrument design, operator, substrate and other factors. These differences potentially affect the approach that DEQ takes in expressing its water quality standard. Turbidity measuring instruments use different types of light sources and detection arrangements. Turbidity measurements on the same sample using different instruments, even those employing the same type of light and detector arrangement, can yield different results. Alternative measures of water clarity, such as Secchi Depth, black disk measurement, and transmissometry, have been used in some regulatory settings.

Elevated turbidity in streams and lakes can affect primary productivity, zooplankton density (lakes only), and fish. Although not a direct effect of reduced visual clarity, turbidity is correlated with reductions in measures of macroinvertebrate density and diversity. The extent of effects can depend both on the level of turbidity and the duration of exposure. For example, small, but chronic (several months or longer) increases in turbidity levels have been shown to decrease growth and reproduction of some algae and macrophytes, although some, but not all of this could be due to abrasion of algae by suspended sediment during periods of high flow. Studies show that reduced primary productivity due to turbidity can result in decreased zooplankton and fish density in lakes. Some studies show that aquatic plants and periphyton can compensate for the decrease in PAR by increasing photosynthetic efficiency; however, such an effect comes at a net energy and growth loss to the plants.

Studies indicate that reduced water clarity affects the ability of visually-oriented fish to detect and capture prey due to decreased reactive distance, which is the distance at which a fish detects and orients toward a prey item. Literature has shown that this effect results in decreased feeding success in fish in

short trials (a few minutes to a few hours) without a corresponding increase in food availability. Nevertheless, studies do indicate that fish exposed to moderately high turbidity levels in natural settings are able to feed, although at a lower rate and with increased energy expenditure due to a more active foraging strategy. Over a period of several days or more, reduced feeding resulting from increased turbidity can translate into reduced growth rates. In natural regimes, increased food availability that can accompany turbidity spikes somewhat counteracts reduced feeding success. At the same time, studies show that increased turbidity causes fish to switch from a passive to an active searching strategy, resulting in overall energy loss, which would further reduce growth.

A few studies have linked increased turbidity with other behavioral effects in fish, such as changes in territorial behavior, avoidance of turbid water, and increases in blood sugar levels; however, in some cases, it may be difficult to separate the visual effects from direct effects of suspended sediment.

Several studies have documented the use of turbid waters by juvenile fish as cover from prey. Some of these studies also have shown that streamside vegetation appears more important than “cloudiness” as cover. Moreover, models indicate that the use of “cloudy” water is more than offset by the loss of feeding efficiency, unless accompanied by an increase in food availability.

Research in estuaries has focused on the effects of turbidity on growth of submerged aquatic vegetation (SAV) and algae. Recent research in Oregon has indicated that water clarity is a major controlling factor in determining where SAV grows in the Yaquina Bay Estuary, but data from other Oregon estuaries have proven inconclusive. EPA has recommended water clarity levels (expressed as light attenuation factor) to protect SAV in the Yaquina Bay Estuary. Research on turbidity effects on juvenile fish feeding and growth rates in estuaries indicates that these fish prefer moderately turbid water over clear or highly turbid water.

One important consideration for setting a water quality standard for turbidity is not only the level of turbidity expected to result in an impact on beneficial uses, but also duration of exposure. As such, DEQ has examined the duration of exposure in the various studies cited. This information will assist DEQ and the policy workgroup that it is convening to evaluate this aspect of the standard

A major caveat in interpreting the effects literature on aquatic life is that many studies use different instruments to report turbidity readings or do not report instrumentation at all. Given the variation between meters in reporting turbidity, comparability of such studies is subject to great uncertainty.

There is a limited body of research on the effects of reduced water clarity on the desire of people to recreate in streams and lakes. Studies on turbidity effects on aesthetics and swimming are primarily limited to surveys conducted in New Zealand. These surveys show that relatively low (~3 nephelometric turbidity units, NTU) turbidity levels are considered unsuitable for swimming and aesthetic purposes.

As turbidity in drinking water source areas increases, the cost to meet Safe Drinking Water Act-mandated turbidity levels similarly increases due to increased material and maintenance costs. In addition, some public water systems in Oregon using slow sand filtration must shut down when source waters exceed 5 NTU.

Natural weathering and decomposition of rocks, soils, and dead plant materials and the transport or

dissolution of the weathered products in water contributes a “background” of turbidity-causing suspended and dissolved materials to natural waters. This natural component of turbidity varies temporally and geographically due to differences in precipitation, gradient, geology, flow, and natural disturbances, such as landslides. In some cases, natural background can be quite variable even in different sub-basins of the same watershed. Reduced water clarity in some lakes and estuaries can result from high levels of phytoplankton or from dissolved organic matter, which causes waters to color. In estuaries, the mixture of the marine-dominated and riverine-dominated portions of the estuary results in high levels of suspended particulate matter and low visibility called the estuarine turbidity maximum (ETM). Potential anthropogenic sources of turbidity include industrial and municipal discharges, forestry, agriculture, construction and urbanization, mining, and in-channel use of equipment, as in dredging.

DEQ data indicate that during the summer dry season, median turbidity levels are very low throughout the state (1-2 NTU). However, during the rainy season, turbidity levels are much more variable. Robust year-round turbidity data sets available for this analysis were limited to continuous turbidity monitoring stations maintained by the U.S. Geological Survey (USGS). DEQ performed a “concentration-duration-frequency analysis” from stations on least-disturbed sites. The analysis indicated that natural levels of turbidity occasionally exceed levels that are shown to have adverse effects. DEQ also examined turbidity and discharge data from stations in four watersheds to examine natural turbidity patterns. Five of the eight stations showed similar relationships between discharge and turbidity. Moreover, in some cases, effects of land use on baseline turbidity levels were quite apparent. However, at other stations, effects of reservoirs confounded the analysis.

In summary, the literature indicates that chronic and low levels of turbidity (as low as 2-3 NTU) are correlated with adverse effects on aquatic life, such as primary productivity. Such effects are shown cascade into higher trophic levels, resulting in population-level reductions to zooplankton and fish. In the Yaquina Bay Estuary, literature indicates reduced light penetration is a major controlling factor for SAV presence, but there is insufficient information at this time to evaluate light requirements for SAV growth in other estuaries in Oregon. Reactive distance of fish decreases with increasing turbidity levels; consequential effects on fish growth and feeding generally are reported around 20-30 NTU for exposures lasting a day or more and around 50 NTU for exposures lasting less than one day. One study has shown that feeding rates of fish in lakes can decrease when exposed to 10 NTU in for only 5 hours. At the same time, several studies have documented fish feeding even at relatively high turbidities. Juvenile fish are adapted to and benefit from higher levels of turbidity in estuaries. Studies indicate that turbidity as low as 2-5 NTU can affect people’s perception of the desirability of waters for recreation. Increased suspended sediment levels that are associated with turbidity have a small effect on drinking water treatment costs; however, levels as low as 5 NTU can cause some drinking water treatment operators to shut down their operations.

A major caveat to the results presented conclusions presented above is that levels reported in studies are subject to some uncertainty due to differences in instruments used to measure turbidity. This uncertainty can impact the approach that DEQ takes in setting the water quality standard for turbidity and will be addressed during policy discussions.

Chapter 1. Background and Purpose

Introduction

Turbidity measures the “cloudiness” of water; more precisely, it measures the extent to which light is scattered and absorbed by suspended sediment, dissolved organic matter, and, to a lesser extent, plankton and other microscopic organisms (Clesceri, et al. 1994). Turbidity is measured using a variety of instruments that detect the amount of light that is scattered by a sample and detected at a specific angle or angles. DEQ regulates excess turbidity resulting from point- and non-point sources of pollution into Oregon waters that can adversely affect aquatic life and other beneficial uses.

DEQ is currently in the process of reviewing its water quality standard to address turbidity (Oregon Administrative Rule 340-041-0036). Section 303 of the Clean Water Act requires States to periodically review their water quality standards. DEQ is undertaking such a review to incorporate the best available science regarding the effects of turbidity on beneficial uses of Oregon waters. The purpose of this document is to summarize data and literature that are relevant to the effects of turbidity on beneficial uses of Oregon waters.

The water quality standard for turbidity was last reviewed 2003-2006. Although a proposed water quality standard for turbidity underwent public notice and hearings, the Environmental Quality Commission ultimately did not adopt a revised rule. This document builds on the research and information in DEQ’s 2005 *Draft Technical Basis for Revising Turbidity Criteria*. This document incorporates additional scientific literature published since 2005, additional literature that was not considered in the earlier document, and data and literature that DEQ received as a result of a Call for Data sent out to interested parties in early 2010. In addition, this document addresses, to the extent data and information are available, comments DEQ received from the Independent Multidisciplinary Science Team, a scientific panel that advises the State of Oregon on matters of science related to fish recovery, watershed health, and water quality improvements.

Unlike pollutants such as toxics, where EPA has developed a standardized method for developing criteria, there is no standard method for developing criteria for turbidity. Some of the effects documented in the literature may support more than one conclusion regarding levels of turbidity protective of beneficial uses. As a result, this report does not contain conclusions regarding a specific criterion or set of criteria for turbidity in Oregon waters. Instead, DEQ’s intent in writing the technical review is to present the literature and data available on the effects of turbidity on beneficial uses and to document and discuss areas of uncertainty with respect to developing revised turbidity criteria. DEQ’s review is focused primarily on the effects of turbidity (i.e., reduced light penetration) on beneficial uses; it does not in general address direct effects of suspended sediment or bedded sediment, nor other water quality parameters often associated with turbidity, such as toxics, nutrients, or bacteria. In some cases, it is difficult to separate out the effects of turbidity from direct effects of suspended sediment, which contributes to and is generally highly correlated with increased turbidity levels. In addition, the report considers effects of suspended sediment on treatment of domestic water supplies. Such effects are generally reported in the literature in terms of turbidity and controlled under the Safe Drinking Water Act through limits placed on turbidity in finished drinking water.

DEQ will use this document to inform the development of water quality standard regulations based on best available science. This rule development effort will ultimately require some difficult policy choices, which will be discussed by an external advisory group in the summer and fall of 2010.

History of the Current Standard

Oregon's turbidity standard was first adopted in 1977 and has been revised once since that time. The current rule states:

No more than a ten percent cumulative increase in natural stream turbidities may be allowed, as measured relative to a control point immediately upstream of the turbidity causing activity. However, limited duration activities necessary to address an emergency or to accommodate essential dredging, construction or other legitimate activities and which cause the standard to be exceeded may be authorized provided all practicable turbidity control techniques have been applied and one of the following has been granted:

- (1) Emergency activities: Approval coordinated by the Department with the Oregon Department of Fish and Wildlife under conditions they may prescribe to accommodate response to emergencies or to protect public health and welfare;
- (2) Dredging, Construction or other Legitimate Activities: Permit or certification authorized under terms of section 401 or 404 (Permits and Licenses, Federal Water Pollution Control Act) or OAR 14I-085-0100 et seq. (Removal and Fill Permits, Division of State Lands), with limitations and conditions governing the activity set forth in the permit or certificate.

The turbidity standard is based loosely on EPA's 1976 criteria for Solids (Suspended, Settleable) and Turbidity developed to protect freshwater fish and other aquatic life (USEPA 1976). The only change to Oregon's water quality standard for turbidity in 1990 was a shift from measurement using Jackson Turbidity Units (JTUs), which are measureable at turbidity levels of 25 units and greater, to Nephelometric Turbidity Units (NTUs), which can be measured at turbidity levels of less than 1 and higher. At the time of this change to the water quality standard for turbidity, public comments noted that naturally occurring fluctuations for turbidity in many streams would violate the proposed standard and requested consideration of an approach that considers these natural fluctuations. At that time, DEQ adopted the change in units and recommended that a scientific panel be established for review of literature on effects of turbidity, suspended and settleable solids, and accumulated fines and make recommendations on appropriate standards and criteria (ODEQ 1990). This type of review has not been completed to date.

Under clear water background conditions (<5 NTU) that are prevalent in Oregon much of the year, implementation of the current standard in DEQ's Clean Water Act programs (e.g., NPDES permitting, section 401 certifications for dredging activities) has focused on implementing the narrative limited duration exceedance allowance, which lacks specificity regarding what duration and/or frequency of exceedances would constitute an exceedance of the standard (e.g., instantaneous, daily average, monthly average, etc.). As a result, DEQ identified the need to review the standard to address this issue, as well as to develop revisions to the turbidity standard based on science.

Scope of the Turbidity Water Quality Standard Review

The current analysis will focus on effects of increased levels of turbidity and other measures of reduced visual clarity on the following beneficial uses:

- Aquatic life
 - Reduced primary production and cascading effects on higher trophic levels
 - Effects on fish prey-predator dynamics and subsequent growth effects
- Recreation
 - Swimming and aesthetics
- Domestic water supply

In addition, DEQ examined the correlation between increased turbidity levels and reductions in measures of invertebrate density and diversity. Although this effect is not directly related to reduced clarity, but rather is attributable to suspended and bedded sediment, some literature recommends that turbidity be used as a surrogate to document such effects (Wagener and LaPerriere (1985)).

Effects on aquatic life are separated into effects in streams, lakes/reservoirs, and estuaries to assist DEQ in determining whether separate water quality criteria for these types of waters are appropriate.

In examining effects of increased turbidity levels on reduced primary production in streams and lakes, DEQ examined studies that were conducted worldwide, in part because literature has noted that responses of aquatic plants (phytoplankton and macrophytes) to reduced light penetration is fairly consistent and only one Oregon data set was identified. In addition, DEQ considered studies that looked at the effect of shading on plants, which can serve as a surrogate for increased turbidity. In examining effects of turbidity on primary production (particularly growth of submerged aquatic vegetation (SAV) in estuaries, DEQ's review focused on studies conducted in the Northwest, as research has shown that differences in tidal ranges and regimes, temperature, and winter irradiance make it impractical to extrapolate studies from other locations.

DEQ's discussion of the effects of increased turbidity levels on fish prey-predator dynamics generally focuses on research done on fish that are found in Oregon, as such effects depend on the relative sensory capabilities of predator and prey (B.C. Harvey *pers. comm.*).

Effects of reduced visual clarity on the desire of people to use waters to recreate is limited to consideration of a handful of studies conducted in New Zealand, as this was the only relevant research DEQ was able to identify. Such studies merit consideration, as local conditions in New Zealand and Oregon (in particular, west of the Cascades) are sufficiently similar, indicating that their perception of what can be considered "good" water for swimming and aesthetics should be similar (R. Petersen, *pers. comm.*). DEQ also has included a brief discussion of effects of increased turbidity levels on decreased catch rates for fishing. However, the literature identified on this category of effects is limited to anecdotal reports and cannot be used to equate a specific water quality criterion for turbidity.

DEQ's review of the effects of increased turbidity levels on drinking water focused on a handful of economic studies in the U.S., including one in the Willamette Valley, that examine the relationship between increased turbidity and drinking water treatment costs. DEQ also reviewed the findings of a recent study it conducted that examined changes in turbidity patterns at eight public water systems in

Oregon’s North and Middle Coast Range. The study examined how changes in turbidity levels can affect these systems and how human impacts can minimize or worsen those changes (DEQ 2010).

Where information is available, DEQ attempted to take into account both magnitude and duration of exposure of aquatic life in experiments. Such information will allow DEQ determine if there is a need for different criteria based on exposure duration (e.g., chronic and acute criteria; criteria based on daily, weekly, and monthly averages, or some other similar approach).

DEQ recognizes that increased turbidity levels are generally correlated with changes in other water quality parameters (Figure 1). Suspended sediment upstream that results in increased turbidity can result in high levels of bedded fine sediment, which can directly affect invertebrate populations and fish health and population through egg smothering and lower dissolved oxygen (Waters 1995). Suspended sediments that increase turbidity levels can also be important transporters of nutrients, bacteria and toxic compounds (Sorensen, et al. 1977). While cognizant of these relationships, DEQ considers that these parameters are best addressed as separate narrative or numeric criteria (e.g., toxics; nutrients; excess fine sediment; inter-gravel dissolved oxygen).

DEQ has not focused on direct effects of suspended sediment on aquatic life, such as gill abrasion in fish. In our review of literature, such effects generally occur at suspended sediment levels higher than those expected to cause effects due to reduced visibility. Setting a water quality standard based on effects of reduced water clarity (due to suspended sediment) would likely also protect beneficial uses from direct sediment effects. In some cases, it may be difficult to separate direct sediment effects versus those caused by increased turbidity levels (e.g., reduced primary production vs. algal abrasion in streams). Moreover, DEQ considered the effects of suspended sediment (expressed in terms of turbidity) on treatment of domestic water supply to ensure regulatory consistency with the Safe Drinking Water Act, which sets specific turbidity limits for finished drinking water.

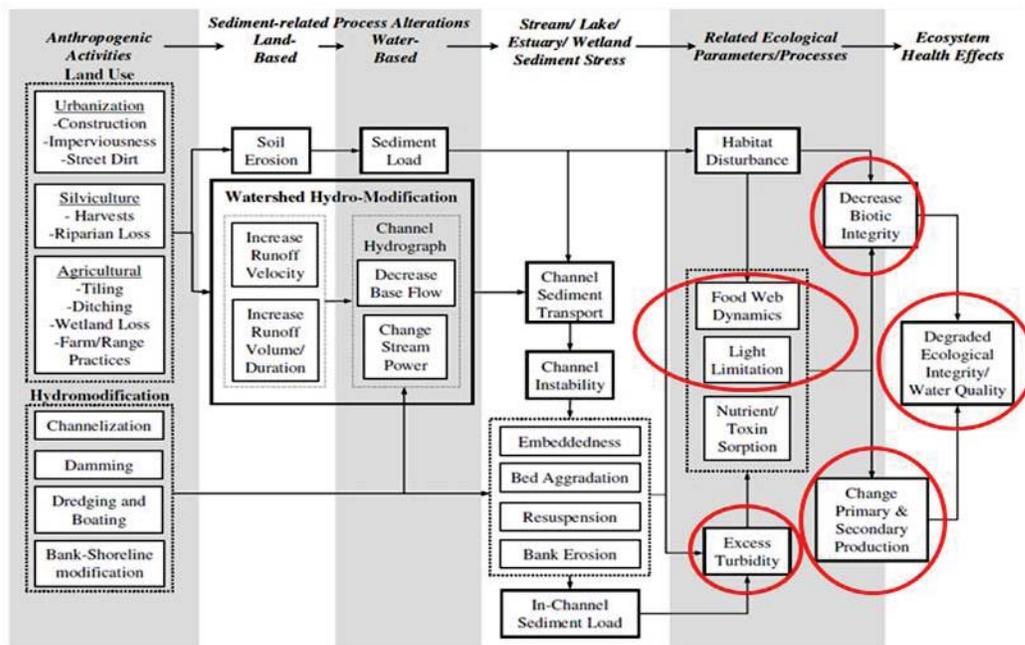


Figure 1. Effects of turbidity that are the focus of this analysis (circled boxes). From USEPA 2006.

Organization of this document

Chapter 2 of this document provides an overview of turbidity, sources of turbidity, turbidity regulations in other states, and a discussion of turbidity measurement technologies and uncertainty with respect to turbidity measurement.

Chapter 3 discusses effects of turbidity on beneficial uses including aquatic life, recreation, and drinking water. DEQ bases its water quality standards on effects of a pollutant (e.g., turbidity) on the most sensitive beneficial uses. Effects of turbidity on aquatic life are presented by type of water body (streams, lakes/reservoirs, and estuaries), to assist DEQ in determining whether separate criteria are needed to protect aquatic life for different categories of waters.

Chapter 4 includes a discussion of natural variation in turbidity. DEQ examined continuous turbidity datasets collected by the U.S. Geological Survey (USGS). DEQ analyzed two USGS datasets using a “concentration-discharge-frequency” analysis that is useful to examine the extent to which natural turbidity levels would result in exposures of sufficient magnitude and duration to cause potential impairment to beneficial uses. DEQ also examined median turbidity levels, flow vs. turbidity relationships, and impact of land use on turbidity levels in eight USGS datasets.

Chapter 5 of this document includes a discussion of general conclusions and areas of uncertainty with respect to natural and anthropogenic influences on turbidity and variability, turbidity measurement, and the impact of turbidity on beneficial uses of the State’s waters.

Appendix A includes a summary of literature regarding sources of turbidity.

Chapter 2. Overview of Turbidity

Definition and Relationship to Suspended Solids

Turbidity measures the “cloudiness” of water; more precisely, it measures the extent to which light is scattered and absorbed by suspended sediment, dissolved organic matter, and, to a lesser extent, plankton and other microscopic organisms (Clesceri, et al. 1994). From a technical standpoint, turbidity is a relative measurement of scattering versus a calibrated standard, usually a formazin suspension (Davies-Colley and Smith 2001). Increased levels of turbidity reduce the amount of light that can penetrate into the water column, which can adversely affect aquatic life and other beneficial uses.

Turbidity is generally well correlated with total suspended solids concentration in the water column and can often be a less expensive alternative to measuring suspended solids (Gippel 1995). However, the relationship between turbidity and solids is confounded by variations in particle size, particle composition, and water color (Gippel 1995). As a result, there is no universal relationship between turbidity and suspended solids. In Oregon, site-specific relationships have been developed for a few sites, such as the Santiam River Basin (Uhrich and Bragg 2003) and Oak Creek and Flynn Creek watersheds (Beschta 1980). However, even these relationships can vary from storm-to-storm, seasonally, and from year-to-year (Beschta 1980). Eco-regional-specific suspended sediment-turbidity relationships have not been developed to DEQ’s knowledge.

Sources of Increased Turbidity

Natural and anthropogenic inputs of sediments and dissolved organic matter into the water column can result in increased turbidity levels. Algae, whether natural or induced by anthropogenic nutrient inputs, also can increase turbidity levels, but to a lesser extent than suspended sediments. Major controlling factors of turbidity magnitude, duration, frequency and composition include precipitation, stream gradient, geology, natural disturbance and land use, all of which can be highly variable. Land use practices and wildfires, particularly preceding large storms, can result in massive inputs of turbidity-causing sediment to stream channels (May and Lee 2004).

Once in the system, turbidity-causing materials may be conserved in the water column, deposited in the channel, washed out into the flood plain, or transported downstream. Subsequent high flow events can re-suspend turbidity-causing sediments into the water column. Larger, heavier particles tend to settle first, while smaller clay particles remain suspended for a longer period of time, contributing to downstream turbidity levels. Organic matter (i.e. phytoplankton and zooplankton) can reduce light penetration in some lakes, which can impact predator-prey relationships (Beauchamp, et al. 1999).

Certain types of land uses can also result in increased turbidity, especially if best management practices (BMPs) are poorly followed. In agricultural and grazing areas, removal of vegetation and compacting of soil can cause runoff to carry eroded topsoil into rivers. Improper application of fertilizer also may increase loads of nutrients that result in turbid algal growths. In areas with forestry operations, past timber-harvesting practices, road construction, slash disposal, and site preparation can increase inputs of turbidity-causing sediment to streams. Overall, urbanization prevents rain from penetrating into the soil,

resulting in transport of soil into streams directly or in stormwater outfalls. Erosion of soils at construction sites without proper controls can result in turbidity-causing soil loadings. Placer mining operations, past and present, expose soils and can result in chronic turbidity issues. Industrial effluents and stormwater directly input turbidity-laden water into streams. Once sediment settles out of water, activities such as dredging without proper controls can re-suspend fine sediments, which may persist in the water column in some conditions. Moreover, erosion of stream beds and banks that are destabilized through removal of vegetation or altered hydrology can contribute to turbidity.

Appendix A provides a summary of literature regarding sources of increased turbidity. Many waters in Oregon are subject to multiple types of sources, as well as natural sources of turbidity-causing sediments and algae.

Turbidity and Other Measures of Water Clarity

This section describes different types of turbidimeters, as well as other methods for measuring water clarity. Beginning in the early 20th century, turbidity was measured using a Jackson Candle Turbidimeter, which consisted of a special candle and a flat-bottomed glass tube (Sadar 1996). The Jackson Candle turbidimeter was calibrated by a series of standard suspensions using diatomaceous earth in distilled water. Measurement was made by slowly pouring a turbid sample into the tube until the image of the candle flame diffused to a uniform glow (Sadar 1996). Eventually, formazin became the primary standard for Jackson Candle Turbidimeters (and nephelometric units). However, Jackson turbidimeters cannot measure turbidity lower than 25 JTU, are cumbersome, and depend on human judgment to determine the extinction point.

Eventually, photoelectric detectors were developed and became the accepted method to measure turbidity. Since then, measurement of turbidity has been done by different methodologies and instruments involving different light sources and detector arrangements. Some instruments are “ratiometric,” with multiple detectors arranged at various angles. These instruments then calculate turbidity using a ratio of the light received by the different detectors. The U.S.G.S. has developed a data reporting protocol based on the type of light source and detector arrangements of various turbidity instruments (Anderson 2005). The headings for each of the instruments described below include reporting units using the U.S.G.S. protocol.

Nephelometric instruments

Turbidity is most commonly measured using nephelometry, which measures light scattering through a restricted range of angles, typically 90°, to the incident light beam relative to a standard suspension, usually of formazin.

Non-ratiometric, white light (Nephelometric Turbidity Units, NTUs)

One type of nephelometric instrument is a non-ratiometric, white light turbidimeter, which has a single detector centered at 90° from the incident light path. Non-ratiometric, white light turbidimeters are compliant with EPA Method 180.1 for determining turbidity by nephelometry, which requires that the light source for the nephelometer be a tungsten lamp (white light) operated at a color temperature of 2200-3000° K and that the detector is centered at 90° from the incident light path and does not exceed ± 30° from 90° (EPA 1993). The accepted range for such meters is 0-40 NTU. Oregon’s current water quality standard for turbidity requires that turbidity be expressed in terms of nephelometric turbidity units (NTUs).

Ratiometric, white light (Nephelometric Ratiometric Turbidity Units, NTRUs)

The ratio turbidimeter design is also considered compliant with EPA Method 180.1. The difference between a ratiometric and non-ratiometric instrument is additional photodetectors located at angles other than 90° from the incident light. The ratiometric turbidimeter combines signals from each of these detectors mathematically to calculate the turbidity of the sample. Ratio nephelometers purportedly perform better with colored samples than traditional nephelometers (USEPA 1999).

Near infra-red (IR) light, non-ratiometric and ratiometric (Formazin Nephelometric Unit, FNU and Formazin Ratiometric Turbidity Unit, FNRU)

Near IR instruments utilize a light-emitting diode with wavelength 860 ± 60 nm. The detector angle must not exceed $\pm 2.5^\circ$ from the 90° incident path. These types of nephelometric turbidimeters are compliant with the ISO 7027 standard, which is commonly used in Europe. The vast majority of *in situ* turbidimeters conform to this geometry including the U.S.G.S. continuous turbidity monitoring stations in Oregon, the data of which are used in this report in the discussion of natural variability in turbidity in Chapter 4.

Backscatter/ratiometric turbidimeters, white light or near IR light (Backscatter Unit, BU or Formazin Backscatter Unit, FBU)

Backscatter turbidimeters use incident beams at $30^\circ \pm 15^\circ$ to the incident sample for high levels of turbidity and nephelometric detection (90° angle) for low-levels. Such devices determine turbidity using light scatter from or near the surface of a sample. These types of meters are most appropriate for high-level turbidities (up to 10,000 units).

Multiple-beam turbidimeters, white light or near IR light (Nephelometric Turbidity Multibeam Unit, NTMU or Formazin Nephelometric Multibeam Unit (FNMU)

Multiple-beam turbidimeters have multiple light sources and detectors to provide reference and active signals with at least four independent measurements for each reading. The final reading is determined with a ratio algorithm.

Other methods for measuring water clarity

Light transmissometry

In contrast to nephelometry, transmissometry measures light extinction in a water column as a function of both scattering and absorbance of light from a sealed submersible light source and a detector optimized for maximum transmission *in situ* by a selective filter. Transmissometers display data as percent transmission, volume attenuation coefficient (Telesnicki and Goldberg 1995). Some authors have expressed a preference for using transmissometry over nephelometry for measuring visual clarity because it is an absolute measurement and can be used to calculate a scattering coefficient which is more explicitly related to suspended solids concentrations (Davies-Colley and Smith 2001).

Secchi Depth

Since the 19th century, water clarity has been measured in lakes, reservoirs, and estuaries using a Secchi Disk. The Secchi Disk is an alternating black-and-white disk with a 30 cm diameter that is lowered into water by a rope until the disk is judged to disappear from view. Secchi depth, z_{SD} provides a simple (and inexpensive) indicator for the clarity of natural waters (Preisendorfer 1986). Secchi depth can vary depending on the reflectance of the white face of the disk and the reflectance of the water. Secchi depth readings are thus dependent on lighting conditions and are difficult in shallow systems (Davies-Colley and Smith 2001). However, Smith (2001) has recommended procedures for increasing precision.

Black disk measurement

Recently, researchers, particularly in New Zealand, have utilized a different device for measuring clarity, called black disk measurement. Black disk measurement is the maximum sighting distance of a perfectly black target, viewed horizontally, instead of the vertical measurement of the Secchi disk. Because the target is viewed horizontally, black disk measurement can be used in both shallow and deep waters. Researchers have used black disk measurement to estimate a beam attenuation coefficient with reasonable precision at a wide range of conditions (Davies-Colley and Smith 2001). However, the relationship between turbidity and black disk measurements is still site-specific. This method has not gained wide use in Oregon, if at all, and thus is not appropriate for regulatory purposes unless site-specific relationships can be developed.

Variability among turbidimeters and turbidity units

Turbidimeters, even those employing the same light source and detector arrangement, can produce a range of turbidity readings for the same water sample due to optical differences, calibration techniques, and the user. The uncertainty in turbidity readings can confound extrapolating from effects levels that are expressed in the literature presented in this paper, especially as many of the papers cited do not report which meter was utilized to measure turbidity. This statement is particularly true at turbidity levels above 10 NTU, the level below which Telesnicki and Goldberg (1985) observed that turbidity could be accurately determined based on correlations with light transmission measurements.

In an early study, Duchrow and Evenhart (1971) found that the relationship between turbidity and concentration of solutions of seven different materials differed among three different types of turbidimeters. In a study comparing turbidimeters of different technologies, Gippel, et al. (1991) found that an attenuation turbidimeter gave absolute readings of 2.5 to 4 times higher than a nephelometric turbidimeter despite being identically calibrated. The authors noted that the attenuation turbidimeter was more sensitive to the presence of color, particularly at low levels of suspended sediment.

Davies-Colley and Smith compared turbidity readings from a non-ratiometric and a ratiometric nephelometer from the same manufacturer, on 77 water samples from New Zealand rivers. The results from the study, as shown in Figure 2, indicate that readings from the ratio nephelometer were consistently higher by about 30% (Figure 2; Davies-Colley and Smith 2001). Barter and Deas (2003) tested readings of primary formazin standards (five replicates for each of six standards) by five portable nephelometers (two non-ratiometric, white light meters; one ratiometric white light meter, and two IR light, non-ratiometric meters) and found that coefficients of variation between the meters ranged from 1.5 to 6.8%. The difference between the maximum and minimum reading was approximately 13% for the 10 NTU calibration, 10% for the 40, 100, and 200 NTU calibrations, 5% for the 400 NTU calibration, and 21% for the 800 NTU calibration. When using the same turbidimeters to test the turbidity of different effluents and receiving waters, coefficients of variations ranged from 6.6% to 44.1%. In that

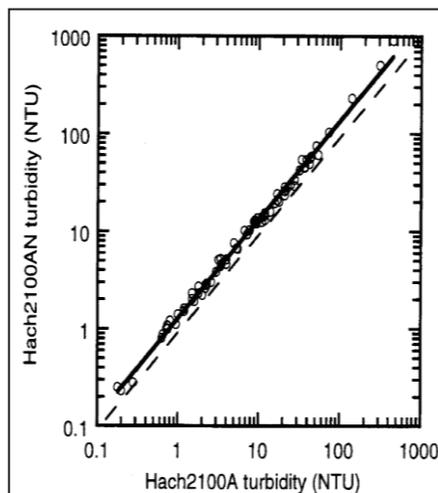


Figure 3. Comparison of Turbidity Measured Simultaneously Using Two Different Nephelometers. A Hach 2100A nephelometer (vertical incident light beam) and its modern replacement, a Hach 2100AN ratio nephelometer (horizontal incident light beam) were used side-by-side on the same batch of 77 New Zealand river water samples. (Average ratio = 1.3, coefficient of variation of the ratio = 12 percent.)

Figure 2. Comparison of readings from two turbidimeters on 77 water samples from New Zealand rivers (Davies-Colley and Smith 2001).

study, higher coefficients of variation were associated with the samples with the low mean turbidity readings (0.14-1.6 NTU) and high or very high mean turbidities (66.9-506.04 NTU). Lower coefficients of variation were generally for samples with low-to-medium mean turbidities (2.8-110 NTU).

Lewis, et al. (2007) studied measurements from eight turbidimeters (two IR-light, backscatter instruments; four IR-light, nephelometric instruments; and two white light, nephelometric instruments) of samples created with filtered sediment from 10 Coast Range watersheds in California. Six of the instruments studied were *in situ*, one was a portable device that could be used in the field, and one was a benchtop device. The study found that the mean error between sensor pairings was 12%, but maximum errors occasionally exceeded 100% (Figure 3). In Figure 3, black lines represent the relationship if $x=y$. The x variable for a given plot is the sensor whose name appears on the diagonal in the same column. The y variable for a given plot is the sensor whose name appears on the diagonal in the same row. Lewis, et al. (2007) made several conclusions in comparing instruments:

- Sensors that conform to the same standards (backscatter, EPA Method 180.1 or ISO 7027) do not necessarily give similar turbidity readings.
- Relationships between sensors of the same design were more consistent, for different sediments, than relationships between sensors that used different methods.
- Conversion of *in situ* sensor readings to laboratory readings is prone to relatively large errors unless the laboratory meter is set to use the same method as the *in situ* meter.

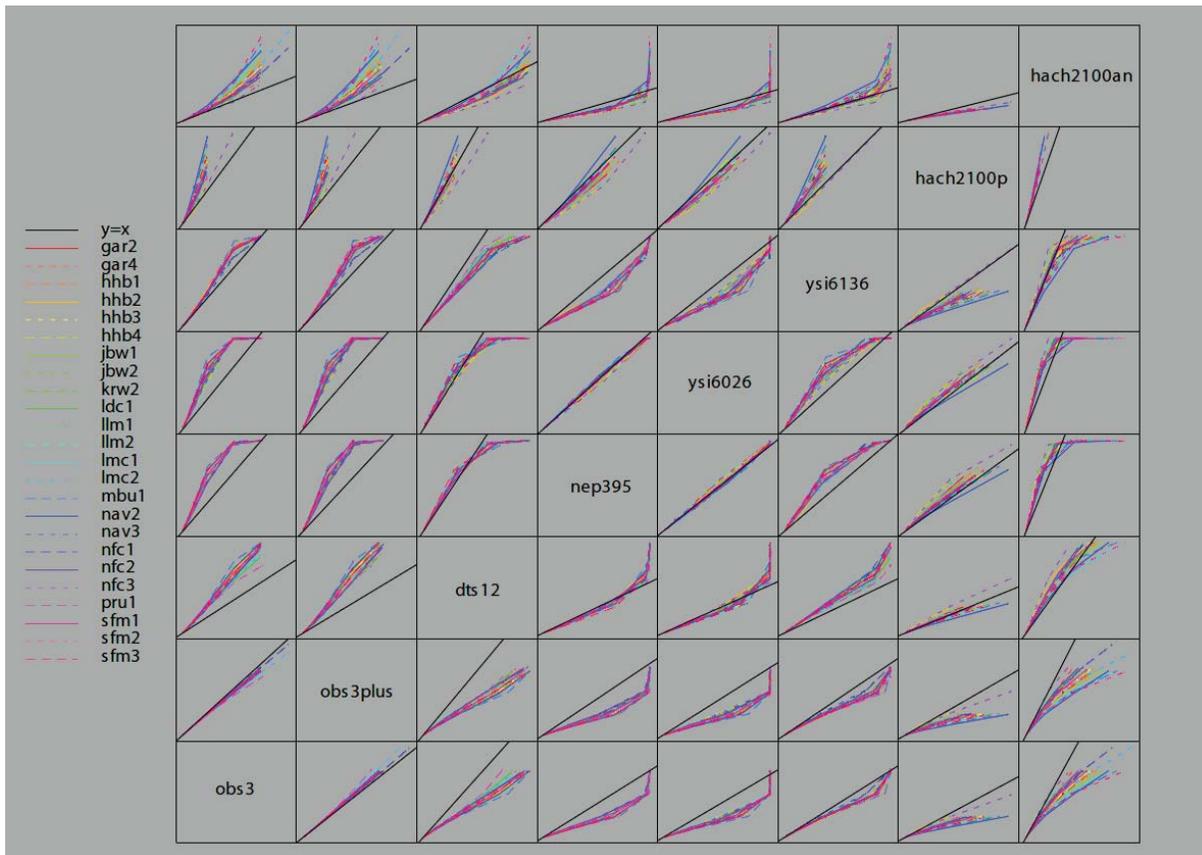


Figure 3. Relationship among turbidity readings for eight sensors tested in 10 Coast Range, California watersheds. Colored lines represent one location. Source: Lewis, et al. (2007).

In addition to effects of different technologies, the choice of calibration standard can significantly affect turbidity measurements. Telesnicki and Goldberg (1995) tested the relationship between light transmittance and turbidity readings for field samples and calibrations of Formazin and marl. The study found that a field turbidity reading of 4.4% was equivalent to 29 NTU. At the same light transmittance, the formazin calibration produced a turbidity of 14.5 NTU (50% difference) and the marl calibration produced a turbidity of 22 NTU (24% difference).

Another major source of uncertainty is the effect of dilutions on turbidity readings. Both U.S. EPA method 180.1 and ASTM standard D7315-07 recommend diluting samples exceeding 40 turbidity units and adjusting the turbidity measurement proportionally to the dilution (e.g., for a 5:1 dilution measuring of 30 NTU, turbidity would be reported as 180 NTU) (USEPA 1993; ASTM 2007). However, both methods also say to avoid dilutions, which can dilute the matrix (i.e., the liquid part of the sample), thus changing particle distribution and solubility gradient. This, in turn, can skew turbidity values (M. Sadar, HACH Corporation, *pers. comm.*)

Human error also plays a big part in variation of turbidity measurements. As part of a workshop on turbidity and sediment surrogates, Landers (2002) asked fourteen participants to calibrate nine different turbidimeters and measure samples of three different concentration/substrate combinations. Although by its own admission, the exercise was not quantitative, the results indicated fairly high coefficients of variation ranging from 21% for samples with a sediment concentration of 150 mg/L (median turbidity 53 NTU) to 42% for a samples with sediment concentrations of 600 mg/L and 93-94% fines (median NTU 268 NTU). The study indicated that factors associated with the operator, sub-sampling, and other factors in an uncontrolled environment could contribute to variability.

The issues related to variability in turbidity measurements affect the choice of an absolute versus a relative standard. If an absolute standard is adopted, choice of turbidimeter could potentially result in either under- or overestimation of water quality exceedances and impairments. On the other hand, if a relative approach is adopted, with use of the same calibrated instrument for both up-source and down-source readings, measurement variability will become less of an issue, except at high turbidities. As noted elsewhere in this report, there are other advantages and disadvantages to both of these approaches, but for the sake of minimizing instrumentation errors, a relative approach has a decided advantage.

Other States' Turbidity Criteria

U.S. EPA conducted a study of published criteria for turbidity and other sediment-related water quality standards in all states (USEPA 2006). According to the study, 30 states had numeric criteria for turbidity. These were in the form of a limited increase above background, such as the current Oregon criteria, or absolute values (e.g., "not greater than 25 NTU"). Table 1 presents turbidity criteria from select states in the western U.S., as well as British Columbia. Northwest states and territories generally have statewide criteria that differ depending on beneficial use. California and Nevada have developed regional-, or site-specific criteria that are based on beneficial uses found in that region or waterbody. Most western states and British Columbia have relative criteria, meaning that turbidity is measured relative to "background," "natural conditions," or some similar metric. Arizona's criteria and some of the site-specific criteria in Nevada are absolute criteria. For example, for protection of aquatic and wildlife in cold water fisheries in Arizona, turbidity cannot exceed 10 NTU in rivers, streams, other flowing waters, lakes, reservoirs, tanks and ponds.

Table 1. Water Quality Criteria for Turbidity for Western States and British Columbia

State/Territory	Turbidity Criteria or Guidelines (by Beneficial Use)
<p>Alaska</p>	<p>Drinking, Culinary, and Food Processing Water Supply. May not exceed 5 NTU above natural conditions when the natural turbidity is 50 NTU or less, and may not have more than 10% increase in turbidity when the natural turbidity is more than 50, not to exceed a maximum increase of 25 NTU.</p> <p>Agricultural and Industrial Water Supply. May not cause detrimental effects on indicated use.</p> <p>Aquaculture Water Supply and Aquatic Life. May not exceed 25 NTU above natural conditions. For all lake waters, may not exceed 5 NTU above natural conditions.</p> <p>Contact Recreation. May not exceed 5 NTU above natural conditions when the natural turbidity is 50 NTU or less, and may not have more than 10% increase in turbidity when the natural turbidity is more than 50, not to exceed a maximum increase of 15 NTU. May not exceed 5 NTU above natural turbidity for all lake waters.</p> <p>Secondary Contact Recreation. Shall not exceed 5 NTU above natural conditions when natural turbidity is 50 NTU or less, and not have more than 20% increase in turbidity when the natural condition is more than 50 NTU, not to exceed a maximum increase of 15 NTU. For all lake waters, shall not exceed 5 NTU over natural conditions.</p>
<p>Arizona</p>	<p>The following water quality standards for turbidity, expressed as a maximum concentration in Nephelometric Turbidity Units (NTU), shall not be exceeded:</p> <p>Full body contact and incidental human contact: Not to exceed 50 NTU in streams, or 25 NTU in lakes.</p> <p>Aquatic and Wildlife (cold water fishery): Not to exceed 10 NTU in rivers, streams, other flowing waters, lakes, reservoirs, tanks and ponds.</p> <p>Aquatic and Wildlife (warm water fishery): Not to exceed 50 NTU in rivers, streams, and other flowing waters. Not to exceed 25 NTU in lakes, reservoirs, tanks and ponds.</p>
<p>California</p>	<p>Each region of California’s Water Resources Control Board has developed separate criteria, as follows:</p> <p>North Coast Region. Turbidity shall not be increased more than 20 percent above naturally occurring background levels. Allowable zones of dilution within which higher percentages can be tolerated may be defined for specific discharges upon the issuance of discharge permits or waiver thereof.</p> <p>Central Valley Region. Where natural turbidity is less than 1 NTU, controllable factors shall not cause downstream turbidity to exceed 2. Where natural turbidity</p>

is between 1-5 NTU, increases shall not exceed 1 NTU. Where natural turbidity is between 5-50 NTU, increases shall not exceed 20 percent. Where natural turbidity is between 50-100 NTU, increases shall not exceed 10 NTU. Where natural turbidity is greater than 100 NTU, increases shall not exceed 10 percent. Exceptions are allowed for a dilution zone for dredging. There are some water body-specific criteria, as well.

Central Coast Region. Waters shall be free of changes in turbidity that cause nuisance or adversely affect beneficial uses. Where natural turbidity is between 0 and 50 Jackson Turbidity Units (JTU), increases shall not exceed 20 percent. Where natural turbidity is between 50 and 100 JTU, increases shall not exceed 10 JTU. Where natural turbidity is greater than 100 JTU, increases shall not exceed 10 percent.

San Francisco Bay Region. Waters shall be free of changes in turbidity that cause nuisance or adversely affect beneficial uses. Increases from normal background light penetration or turbidity relatable to waste discharge shall not be greater than 10 percent in areas where natural turbidity is greater than 50 NTU.

Los Angeles Region. Waters shall be free of changes in turbidity that cause nuisance or adversely affect beneficial uses. Where turbidity is between 0 and 50 NTU, increases shall not exceed 20%. Where natural turbidity is greater than 50 NTU, increases shall not exceed 10%. Allowable zones of dilution within which higher concentrations may be tolerated may be defined for each discharge in specific Waste Discharge Requirements.

San Diego Region. Waters shall be free of changes in turbidity that cause nuisance or adversely affect beneficial uses. The transparency of waters in lagoons and estuaries shall not be less than 50% of the depth at locations where measurement is made by means of a standard Secchi disk, except where lesser transparency is caused by rainfall runoff from undisturbed natural areas and dredging projects conducted in conformance with waste discharge requirements of the Regional Board. Otherwise, turbidity limits are as follows:

<u>Natural Turbidity</u>	<u>Maximum Increase</u>
0-50 NTU	20%
50-100 NTU	10 NTU
Greater than 100 NTU	10%

Santa Ana Region. Estuaries, enclosed bays, and inland waters shall be free of changes in turbidity which adversely affect beneficial uses. The secondary drinking water standard for turbidity is 5 NTU. Otherwise, turbidity limits are as follows:

<u>Natural Turbidity</u>	<u>Maximum Increase</u>
0-50 NTU	20%
50-100 NTU	10 NTU

	<p>Greater than 100 NTU 10%</p> <p>Lahontan Region. Waters shall be free of changes in turbidity that cause nuisance or adversely affect the water for beneficial uses. Increases in turbidity shall not exceed natural levels by more than 10 percent.</p> <p>Colorado River Basin Region. Waters shall be free of changes in turbidity that cause nuisance or adversely affect beneficial uses.</p>
Idaho	<p>Cold Water Aquatic Life: Turbidity, below any applicable mixing zone, shall not exceed background turbidity by more than 50 NTU instantaneously or more than 25 NTU for more than 10 consecutive days.</p> <p>Small Public Water Supplies: shall not exceed background turbidity by more than 5 NTU above natural background, when background turbidity is 50 NTU or less, or increase by more than 10% above natural background, not to exceed 25 NTU, when background turbidity is greater than 50 NTU.</p>
Nevada	<p>Nevada has numerous site-specific instantaneous and annual average turbidity requirements. Some of these are absolute criteria that range from 3-50 NTU. Others are relative criteria requiring no more than a 10 NTU or JTU increase. Extinction coefficient is used as the metric for water clarity in Lake Tahoe.</p>
Washington	<p>Char Spawning and Rearing; Core Summer Salmonid Habitat; Salmonid Spawning, Rearing, and Migration; and Non-anadromous Interior and Redband Trout: 5 NTU over background turbidity when the background turbidity is 50 NTU or less, or a 10% increase in turbidity when the background turbidity is greater than 50 NTU.</p> <p>Salmonid Rearing and Migration Only; and Indigenous Warm Water Species: 10 NTU over background turbidity when the background turbidity is 50 NTU or less, or a 20% increase in turbidity when the background turbidity is greater than 50 NTU.</p> <p>Specific mixing zone requirements apply.</p>
British Columbia	<p>Treated Raw Drinking Water, Livestock Watering, and Recreation & Aesthetics. Change from background of 5 NTU when background is <50 NTU; change from background of 10% when background is >50 NTU.</p> <p>Untreated Raw Drinking Water. Change from background of 1 NTU when background is < 5 NTU; change from background of 5 NTU at any time.</p> <p>Aquatic Life. Change from background of 8 NTU at any one time for a duration of 24 hours in all waters during clear flows or in clear waters; change from background of 2 NTU at any one time for a duration of 30 days in all waters during clear flows or in clear waters; change from background of 5 NTU at any time when background is 8-50 NTU during high flows or in turbid waters; change from background of 10% when background is >50 NTU at any time during high flows or in turbid waters.</p>

	<p>Wildlife Irrigation and Industrial Water Supplies. Change from background of 10 NTU when background is <50 NTU. Change from background of 20% when background is >50 NTU. should not exceed 10 NTU when background is < 50 NTU, nor should be greater than 20% of background when background is > 50 NTU. For industrial water supplies only, there is a narrative criterion requiring no induced increase in turbidity that interferes with established industrial water supplies.</p>
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Chapter 3. Effects of Increased Turbidity on Beneficial Uses

Aquatic Life

Effects of increased turbidity levels on aquatic life vary with the magnitude of turbidity, duration and frequency of exposure, the physical characteristics of the material and other factors. These factors can result in decreased clarity and affect the sensitivity of the organisms present in a body of water (for example, some fish have been shown to be more tolerant to turbid conditions than others). To better understand the potential effects of turbidity on aquatic life, DEQ reviewed the following types of literature:

- DEQ considered peer-reviewed literature and agency publications regarding effects of turbidity on primary productivity, regardless of where the research was conducted. While our review found that there are site-specific differences in the relationship between turbidity and primary productivity, Lloyd, et al. (1987) found that effects of turbidity on these endpoints was similar in Alaska and other regions of the country. As such, DEQ considered that general findings of research that was conducted outside of Oregon and the Pacific Northwest could be extrapolated to local conditions.
- DEQ considered research regarding cascading effects of reduced primary productivity on higher trophic levels (e.g., zooplankton and fish).
- Literature regarding effects of turbidity on submerged aquatic vegetation in estuaries relies primarily on investigations conducted on the West Coast. While this topic has been studied in depth on the east coast of the United States, especially in the Chesapeake Bay, and in northern Europe, Thom, et al. (2008) and others note that systems in the Pacific Northwest differ substantially from those areas, due to differences in tidal ranges and regimes. As a result, DEQ focused its review to literature on West Coast estuarine effects.
- Fish-effects literature examines effects of turbidity on both native Oregon fish species and recreationally important non-native fish species. Water quality standards are designed to protect a broad range of aquatic organisms, and DEQ accordingly included a broad array of fish-effects literature. In its review, DEQ highlighted the potential effects of turbidity on native species, in addition to its review of potential effects to other species of fish.

DEQ presented effects separately for streams, lakes, and estuaries to determine if separate water quality criteria are necessary to protect aquatic life for each type of ecosystem. A summary table of reported literature is provided at the end of the streams and lakes/reservoirs sections (pages 33 and 41, respectively). The tables present effects in order of increasing turbidity measurements. In addition, DEQ presented information regarding duration of exposure for each study (e.g., chronic, 5 days, 1 hour, etc.), as effects of short, but sharp increases in turbidity levels are expected to be different from those of

chronic, low level turbidity increases. Such information will assist DEQ in developing water quality criteria that include magnitude, duration, and frequency considerations. The summary table also notes whether each study was conducted in the laboratory or the field, and what instrument was used to measure turbidity, if reported at all.

DEQ did not provide a summary table for the estuary section (page 43) as the different metrics used to describe turbidity effects in estuaries (e.g., irradiance, attenuation coefficient, NTU, suspended sediment concentration) makes it impractical to compare studies to one another.

Turbidity Effects in Streams

Primary Productivity

Primary productivity, which is the growth of periphyton and aquatic plants, provides the base of the food chain in aquatic systems, influencing food available for invertebrates and fish. Primary productivity depends on the availability of light in the water body, among other things. Increased turbidity levels can decrease available light in the water column, potentially decreasing productivity, which, in turn, can have cascading effects on higher trophic levels (Sorensen 1977). The USEPA based its recommended 1976 turbidity criteria, which is purportedly the basis for Oregon’s current standard, on primary productivity, and specifically on the compensation point, which is the depth in the water column at which photosynthetic rates are equal to respiration rates. EPA recommended that the:

Combined effect of color and turbidity should not change the compensation point more than 10 percent from its seasonally established norm, nor should such a change place more than 10% of the biomass of photosynthetic organisms below the compensation point. (USEPA 1976)

The ability of light to penetrate through water depends upon the irradiance or reflectivity of the water surface, the absorption of light by color and the reflection and absorption of light by particles and other matter in the water column. Light penetration through water is represented by the Beer-Lambert law: $I_z = I_0 e^{-K_d z}$; where I_0 is the irradiance at the water surface, I_z is the irradiance with a penetration of light at depth = z , and where the light attenuation with depth is related to the light attenuation rate, K_d (m^{-1}). With respect to productivity, K_d is termed the photosynthetically active radiation (PAR) attenuation coefficient, which is the vertical attenuation rate for the photosynthetic waveband (400 nm-700 nm) (Kirk 1985). The proportion of light making it through water is dependent on K_d , which is itself affected by turbidity.

The relationship between light penetration and increased turbidity levels is curvilinear, but varies in different stream conditions. For example, Van Nieuwenhuysse (1983) related light penetration to turbidity in placer-mined Alaska streams using the equation $I_z = 10^{(2.00 - N_t Z)}$, where N_t was the total extinction coefficient and was related to turbidity (NTU) according to the equation $N_t = 1.00 + 0.024 * T$. Parkhill and Gulliver (2002) developed a similar

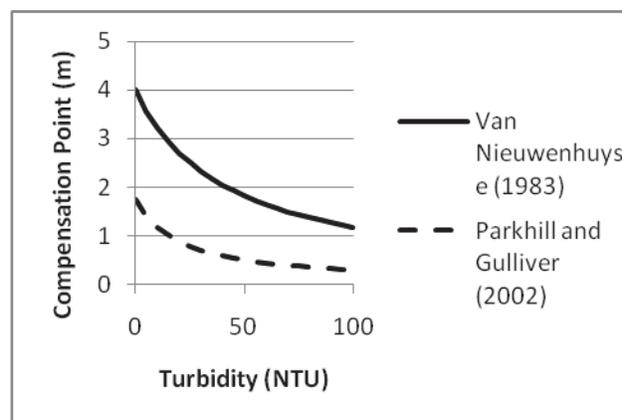


Figure 4. Relationship of turbidity to Compensation Point in placer-mined streams in Alaska (Van Nieuwenhuysse) and experimental streams in Minnesota (Parkhill and Gulliver).

equation for experimental streams in Minnesota: $N_t = 2.619 + 0.129 * T$. The relationship between turbidity and compensation point (the point at which irradiance is 1% of that at the water surface) using these two equations is shown in Figure 4.

As a result of the reduced penetration of light, research shows that small, yet chronic reductions in water clarity decrease aquatic primary productivity. Van Nieuwenhuysse (1983) and Van Nieuwenhuysse and LaPerriere (1986) related gross primary productivity in Alaska streams and found a linear relationship between productivity and incident PAR and PAR available at mean depths, themselves dependent on turbidity. Using these relationships, Lloyd, et al. (1987) developed equations linking gross primary productivity to turbidity. This relationship indicated that a 5 NTU increase in turbidity above clear water conditions could potentially decrease primary productivity in clear streams by 3-13%, and a 25 NTU increase could decrease primary productivity in clear streams by 13-50 %, depending on stream depth (Figure 5). Negative effects on primary production in streams were predicted to be even larger at depths of greater than 0.5 meters. Lloyd, et al. (1987) cautioned that the model was conservative because the light extinction coefficient of clear water was greater than had been measured in clear water elsewhere.

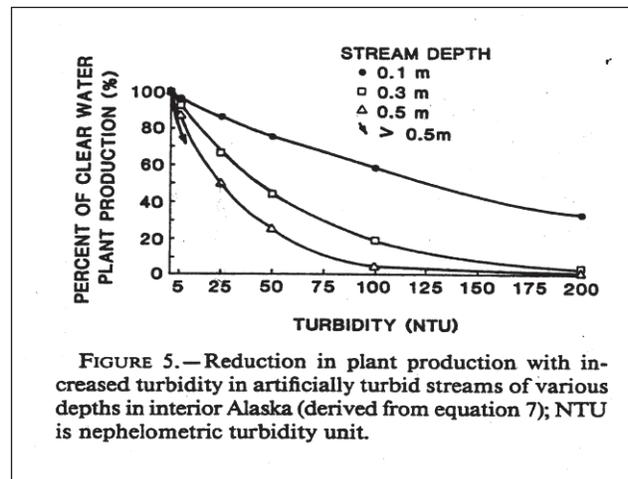


Figure 5. Relationship between turbidity and primary productivity from Lloyd, et al. (1987).

A field study on a New Zealand stream receiving chronically increased turbidity showed significant decreases in periphyton productivity and biomass at six paired upstream (low turbidity) and downstream (high turbidity) sites (Davies-Colley, et al. 1992). The study suggested that turbidity increases were responsible for these effects and ruled out effects of color, nutrient levels, and other sources of shading on periphyton productivity and biomass. The data from Davies-Colley et al. (1992) indicate a significant ($r^2=0.815$) logarithmic relationship between periphyton primary productivity and turbidity (Figure 6). Based on these data, the authors estimated a 50% decrease in production at a chronic increase of 1.1 NTU over background. These observations indicate that low level increases in turbidity that occur for an extended period can have a large impact on primary productivity in streams.

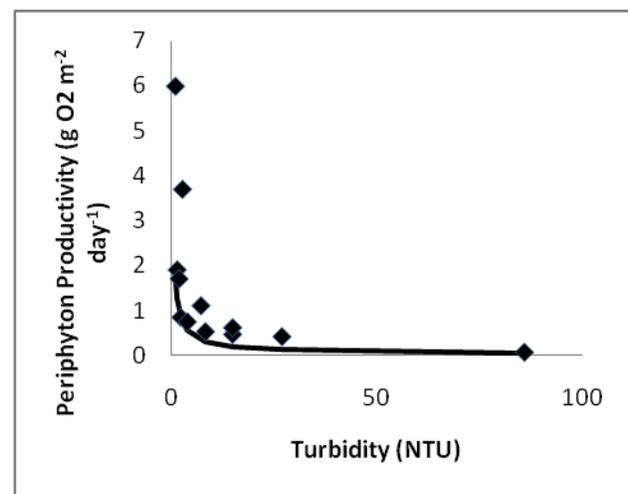


Figure 6. Relationship of Turbidity and Periphyton Production (Data from Davies-Colley, et al. 1992).

Blanch, et al. (1998) studied the effect of irradiance levels and turbidity on various growth measures of a submersed macrophyte. The study found that the relative growth rate was negatively impacted by turbidity ($RGR=21-0.047 * Tu$, $r^2=0.933$; $P < 0.0001$). The authors concluded that in highly turbid water the macrophyte maintains roots and stamens in preference to leaves, providing a reserve for rapid leaf

production when turbidity declines. They found that shoot recruitment was lower at 209 NTU than at 90 NTU, and zero at 504 NTU. However, the turbidity levels studied were much higher than those normally found in Oregon streams except during major storm events; as a result, the study may not be applicable to a water quality standard for turbidity in Oregon.

Some studies examined the effects of shaded conditions on primary productivity. Although it would be difficult to translate such studies into water quality criteria expressed in turbidity, such studies provide a good surrogate for examining the impact of increased turbidity on primary production. McIntire and Phinney (1965) found in a laboratory study that primary productivity increased with increasing carbon dioxide in light-adapted periphyton communities, but not in shade-adapted communities. However, photosynthetic efficiency was lower in the light-grown community than the shade community. The light-grown community stabilized by the end of third month, whereas it took longer for the shade-grown community to stabilize. Consistent with other studies, the results of the McIntire and Phinney study indicate that, while plants can acclimatize to shaded (or turbid) conditions, there is still a growth cost from reduced light.

In a study of a shaded stream in Tennessee, Hill, et al. (1995) determined that “shade significantly constrained primary and secondary production.” That study also found primary production to be saturated at a photon flux density (PFD) of $7 \text{ mol}\cdot\text{m}^{-2}\cdot\text{d}^{-1}$. A study modeling the interaction of light, primary productivity, and pressure from a grazer (zebra mussel) in the Hudson River indicated that decreasing the light attenuation factor associated with suspended sediment from 1.2 m^{-1} to 0.2 m^{-1} , resulted in increased *chlorophyll a* levels despite the associated increased grazing (Caraco, et al. 1997).

While the literature indicates that chronic water clarity issues can result in reduced productivity, other factors, such as increased velocity and algal abrasion by suspended sediment, may also play a role, particularly during flood events. For example, Francoeur and Biggs (2006), in a series of laboratory experiments, found that increased water velocity (up to 1.8 m/s) removed 20-40% of algae. The studies also found that addition of suspended sediment removed additional algae; as TSS concentrations increased, percent chlorophyll removed increased for loosely-attached algal communities, but not with tightly-attached communities. In addition, suspended clay particles can get entrapped in the epilithon, reducing primary productivity and food quality for invertebrates (Davies-Colley, et al. 1992).

While velocity and algal abrasion may play a role in reducing primary productivity, the studies relating increased turbidity levels to decreased primary productivity (e.g., Van Nieuwenhuysse and LaPerriere 1986; Davies-Colley, et al. 1992) remain relevant to setting a water quality standard for turbidity for the following reasons:

- The studies were conducted at sites within the same watershed or within a relatively small area, which would seem to imply that any effects of flooding and increased velocity would be similar among sites;
- Turbidity measurements were conducted several times over a long enough period (e.g., weekly for two months, or daily for several months) that the effects of periodic episodes of flooding would be less important than chronic turbidity levels.

One source of uncertainty in relating turbidity to reduced primary productivity is research that has documented instances in which plants have shown an ability to grow under more turbid conditions than previously thought. For example, Parkhill and Gulliver (2002) found in a study of eight experimental

streams in Minnesota that turbidity had little effect on daily photosynthetic production of a species of macrophyte (measured as *chlorophyll a*), but found that turbidity affected whole stream metabolism at 25-35 NTUs. The authors concluded that, while turbidity may affect autotrophic productivity less due to increased photosynthetic efficiency, whole-stream metabolism in the test streams confirmed that even small loads of sediment in the system decreased overall biological activity in streams (Parkhill and Gulliver 2002). This is consistent with Odum (1985), who suggested that, while plants can adapt to higher turbidity levels, such an adaptation would divert energy from growth and production to maintenance (Odum 1985).

The results presented here lead to some general conclusions. First, in field conditions, low levels of chronic turbidity appear to decrease primary production in a negative exponential relationship in streams where production is light-limited. Even in cases where plants may be able to adapt to turbidity with higher photosynthetic efficiency, there is an overall energy cost, which can lead to reduced growth and, presumably, cascading effects up the food chain. Second, the relationship between turbidity and primary productivity is affected by local conditions, including stream depth, color, nutrient levels, shading, and background turbidity levels, leading to the different relationships shown in the Davies-Colley et al. (1992), Van Nieuwenhuysse (1983), and Parkhill and Gulliver (2002) studies.

Benthic Invertebrates

A number of studies correlate increased turbidity with decreased benthic macroinvertebrate health. In some cases, this may result from reductions in availability of food due to decreased primary production resulting from chronic turbidity increases. However, in some cases, correlations between turbidity and benthic invertebrate health are the result of bedded sediment (often correlated with turbidity), which reduces interstitial space on the stream bottom, clogging habitat and causing macroinvertebrates to drift (move with the current), disrupting their habitat and decreasing macroinvertebrate density. However, Wagener and LaPerriere (1985) recommended using turbidity as a surrogate for sedimentation of streambeds, which alters invertebrate habitat. As a result, while reduced clarity is not necessarily the cause of reduced benthic macroinvertebrate health, this section includes a discussion of the literature and available data correlating turbidity with reduced macroinvertebrate density.

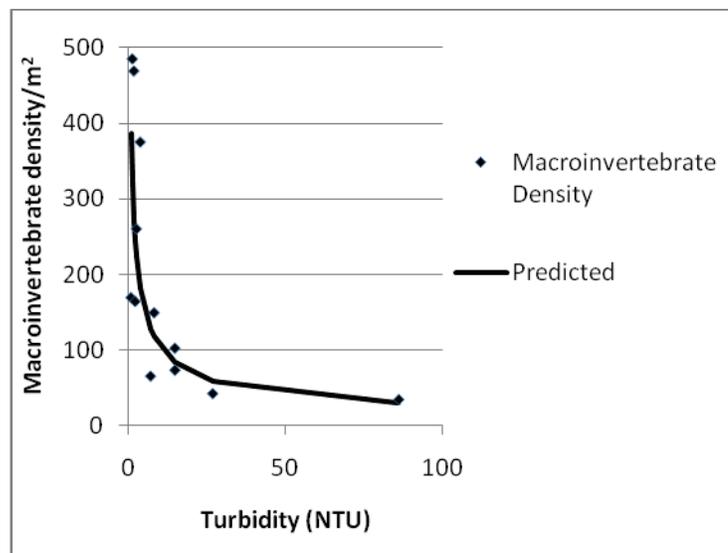


Figure 7. Relationship between macroinvertebrate density and turbidity in six New Zealand streams. Data from Quinn, et al. 1992.

Reduced food availability for invertebrates

Quinn et al (1992), in a long-term study of mining-impacted streams in New Zealand, found invertebrate density decreased with increasing turbidity between all six upstream and downstream paired sites studied. Effects of invertebrate taxonomic richness decreased significantly between all but two of the upstream/downstream pairs. Even relatively small increases in turbidity resulted in decreased macroinvertebrate density. The authors suggested that lower primary productivity and degraded food

quality, both potentially affected by turbidity, were the likely explanations for the decreased invertebrate densities. Using the data from the Quinn study, turbidity was highly correlated with invertebrate density (Figure 7; $r^2=0.72$). Based on that relationship, a 50% decrease in invertebrate density would correspond to a chronic (two month) turbidity increase of 2.6 NTU. It should be noted that the streams studied by Quinn, et al. (1992) were 0.2 – 0.4 meters in depth. It's likely that turbidity effects would be different in deeper streams or systems with different plant and algal communities adapted to lower light conditions (IMST 2006).

Macroinvertebrate drift

DEQ only found one published study in the peer-reviewed literature equating a specific turbidity level to reductions in macroinvertebrate density and diversity due to increased drift. Shaw and Richardson (2001) found in an experimental stream in British Columbia that sediment pulses of 23 NTU for nine days and 19 days decreased abundance and species richness of benthic macroinvertebrates, and that such decreases were more prominent as the length of the pulse increased. As Figure 8 demonstrates, the Shaw and Richardson study indicates that, as the duration of the pulses increases, abundance and richness decrease. The effect is more pronounced after 19 days of exposure of invertebrates to sediment pulses. These findings are consistent with the findings of Culp et al. (1986), who showed increased macroinvertebrate drift in British Columbia with increased concentrations of fine sediments. Their results also indicate a reduced benthic macroinvertebrate density and diversity in the benthos.

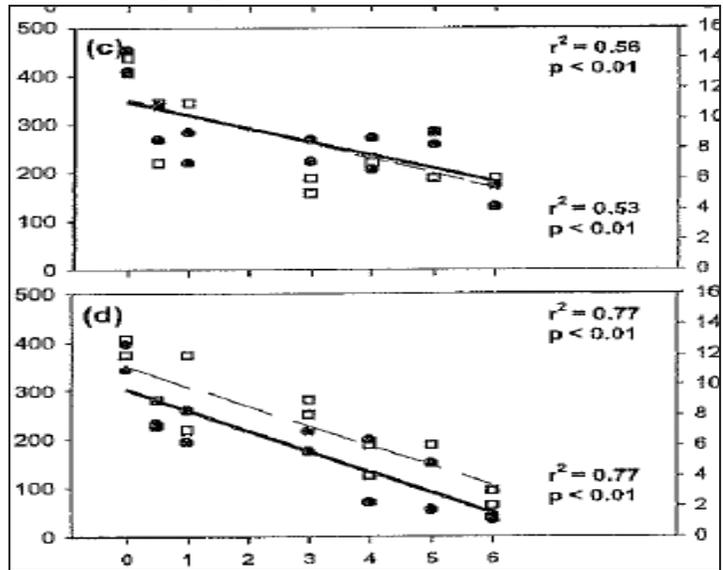


Figure 8. Relationship between sediment pulses (23 NTUs) duration, in hours, and macroinvertebrate abundance (black circles) and richness (white squares) at 9 days (top graph) and 19 days (bottom graph). Source: Shaw and Richardson (2001).

Oregon Data

As demonstrated below, DEQ data indicate a negative correlation between turbidity and measures of macroinvertebrate density and diversity, but this correlation may be confounded by covarying changes in temperature and other water quality measures (IMST 2006). For this report, DEQ examined available paired turbidity-macroinvertebrate data from approximately 250 sites collected during summer low-flow periods. Macroinvertebrate data were scored using DEQ's multivariate statistical predictive model, the PREDictive Assessment Tool for Oregon (PREDATOR), which compares observed macroinvertebrate taxa versus expected taxa (Hubler 2007a). PREDATOR scores were graphed against log-transformed turbidity (Figure 9). The results indicate a significant, if only moderately explanatory,

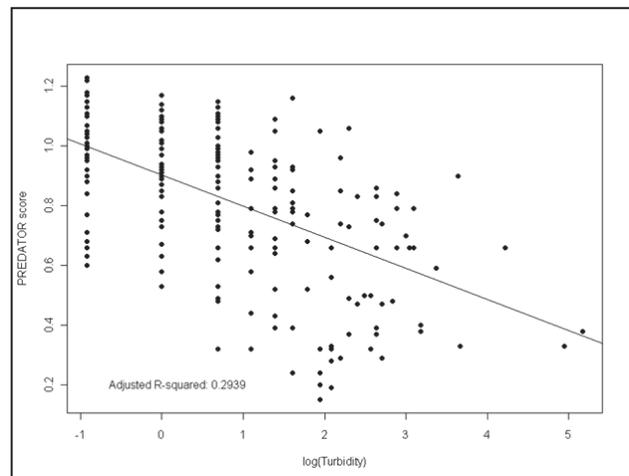


Figure 9. Relationship between PREDATOR score and log-transformed turbidity at Oregon sites. (summer data).

negative correlation ($p < 0.02$; $r^2 = 0.29$) between turbidity and PREDATOR score.

DEQ also conducted a relative risk analysis, using the paired turbidity-PREDATOR scores to assess the relative importance of a given stressor to the macroinvertebrate community (Van Sickle, et al. 2006). The relative risk analysis measures the likelihood that the biological condition will be impaired if the condition of an indicator is also poor. For the relative risk analysis, site visits conducted at the same site during the same year were averaged. Turbidity values were classified into ‘Good’, ‘Fair’, and ‘Poor’ categories based on level three ecoregion benchmarks developed by DEQ (Hubler 2007b).

DEQ excluded sites judged as “fair” in the relative risk analysis. The calculated relative risk for turbidity is 1.8, with a 95% Confidence Interval of 1.2 to 2.6, indicating that, if a site has a ‘Poor’ turbidity score, there is a 1.8 times greater risk of having an impaired macroinvertebrate community than at a site with a ‘Good’ turbidity score.

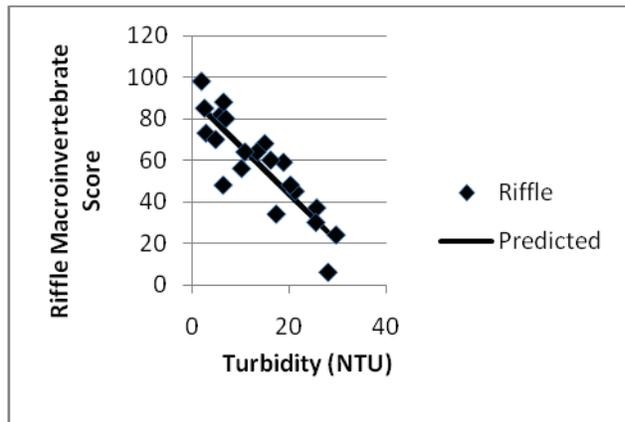


Figure 10. Relationship between macroinvertebrate scores and winter turbidity in Oregon Coast Streams. Data from Mulvey and Hamel 1998.

In another study, DEQ compared observed biotic integrity measurement with observed winter turbidity measurement in a study completed in 1997 at 27 first to third order coast ecoregion streams (Mulvey and Hamel 1998). The study used continuous turbidity measurements (using Data Sonde 3 Hydrolabs) at four north coast streams for eight days, during which there were two storm events, and at three mid coast streams for four days, during which there was one storm event. Grab samples were taken 1-3 times at 20 additional locations and turbidity was measured using a Hach 2100P turbidimeter in the field and a Hach 2100 AN turbidity in the laboratory. Pooled data from the study indicate a significant ($r^2 = 0.77$) linear relationship between mean turbidity and measures of riffle macroinvertebrate scores when two outliers were removed (Figure 10). Based on the data, a turbidity of approximately 8 NTU would result in moderate impairment using the scoring method described in Mulvey and Hamel (1998). Given differences in how data were collected (e.g., different meters, different time frames, etc.), such results are subject to uncertainty; however, they are consistent with other DEQ data that indicate benthic macroinvertebrate impairment at turbidity levels of approximately 7-10 NTU (Drake, *pers. comm.*)

Fish

In this section, DEQ has reviewed literature regarding the following categories of effects of increased turbidity on fish:

- Modified natural movements and migrations
- Behavioral and physiological effects
- Reduction of food abundance and availability
- Effects on prey detection, feeding success, and growth

Behavioral and physiological effects associated with increased turbidity levels may in fact be due to direct suspended sediment effects; however, they have been reported in terms of specific turbidity levels in the literature and thus are included in this report. With regard to the third category, DEQ was unable

to identify any relevant studies that studied such effects in streams. One study (Lloyd 1987) relevant to lakes is discussed in that section of this report.

In the subsequent discussion of effects of reduced water clarity on fish, DEQ focused on fish that are found in Oregon. In addition, DEQ incorporated discussion of exposure duration where possible, as this may be important for setting a water quality standard for turbidity.

Modified Natural Movements and Migrations

A few studies examined fish avoidance of waters with increased levels of turbidity. Bisson and Bilby (1982) found that juvenile coho salmon acclimated to clear water exhibited significant avoidance response to suspended sediment at ~ 70 NTUs (30 minute exposures), while similar test fish acclimated to more turbid water conditions (2 - 15 NTUs) exhibited significant avoidance response at ~ 100 NTUs (Bisson and Bilby 1982). However, Noggle (1978) in a laboratory study found that juvenile coho did not avoid waters with turbidities commonly found in nature. Servizi and Martens (1992) found that coho salmon exposed to a gradient of suspended sediment preferred the surface, where suspended sediment concentrations were lower. Whitman, et al. (1982) found that adult male Chinook salmon preferred clear water over ash-laden water.

Behavioral Effects

A few studies in the literature examined behavioral responses to increased turbidity levels. Berg (1982) conducted several experiments to examine the effects of turbidity pulses on different aspects of juvenile coho salmon behavior. The study found that juvenile coho exposed to pulses of 60 NTU spent significantly more time on the bottom substrate than in the water column (3-day exposure, although movement to the substrate was reported about 4 hours after exposure). Fish returned to the water column as turbidity levels were lowered to 10-20 NTU. Territorial behavior decreased and activity levels increased in 60 NTU turbidity pulses (3 days) then began to return to normal levels at 10 NTU. Turbid (20 and 60 NTU) treatments also increased the frequency of collisions between fish. Berg and Northcote (1985) performed similar studies on juvenile coho and found that territoriality and aggression decreased at a 30 NTU exposure for one hour.

Servizi and Martens (1992) conducted several studies on sublethal responses of coho salmon to suspended sediments from the Fraser River. Mean blood sugar levels, a secondary stress indicator, increased positively with turbidity, with 25% and 50% increases corresponding to turbidities of 42 and 80 NTU, respectively. However, it is unclear whether such increases are related to reduced visual clarity, other effects of suspended sediment (e.g., gill abrasion), or some combination.

These behavioral studies indicate that increased turbidity levels are associated with reduced territorial behavior and stress indicators. Threshold levels for such effects appear higher than those shown to affect feeding as described in the section below, however, so feeding effects may be the more important endpoint for setting a water quality standard for turbidity based on the most sensitive beneficial use.

Effects of turbidity on prey detection, feeding, and growth

Increased turbidity levels reduce the range at which visually-oriented fish can detect a contrast between a prey item and its surroundings. This effect reduces the distance at which these fish can detect their prey, called the reactive distance, which can reduce foraging success, growth rate, and long-term survival assuming constant food concentrations (Utne-Palm 2002). In addition, as visibility decreases due to increasing turbidity, piscivorous fish change from passive to active feeding strategies, potentially resulting in decreased growth rate due to extra energy expenditure (Sweka and Hartman 2001b). These

effects are more pronounced for piscivorous fish, which detect prey at longer distances, more than planktivorous fish (DeRobertis, et al. 2003).

In the context of setting water quality criteria to protect aquatic life, the pertinent questions in examining effects of increased turbidity on fish are, “What constitutes an effect?” and “What level and duration of turbidity are sufficient to cause such an effect?” A good way to illustrate such effects is using an inverted pyramid (Figure 11). At the base of the pyramid are studies examining reductions in reactive distance. Such effects do not depend on duration. The next level corresponds to turbidity levels/exposure durations that result in decreased foraging rates. These studies generally (but not exclusively) look at moderate turbidity levels (30 NTU and higher) with short durations (a few minutes to a few hours). At the next level are studies examining how turbidity may affect growth rates in fish. Such studies are generally conducted at low-to-moderate turbidity levels (10-20 NTU) over a period of several days to a few weeks. At the top level are studies that model the effect of increased turbidity over a season or longer. These studies typically focus on population reductions in fish.

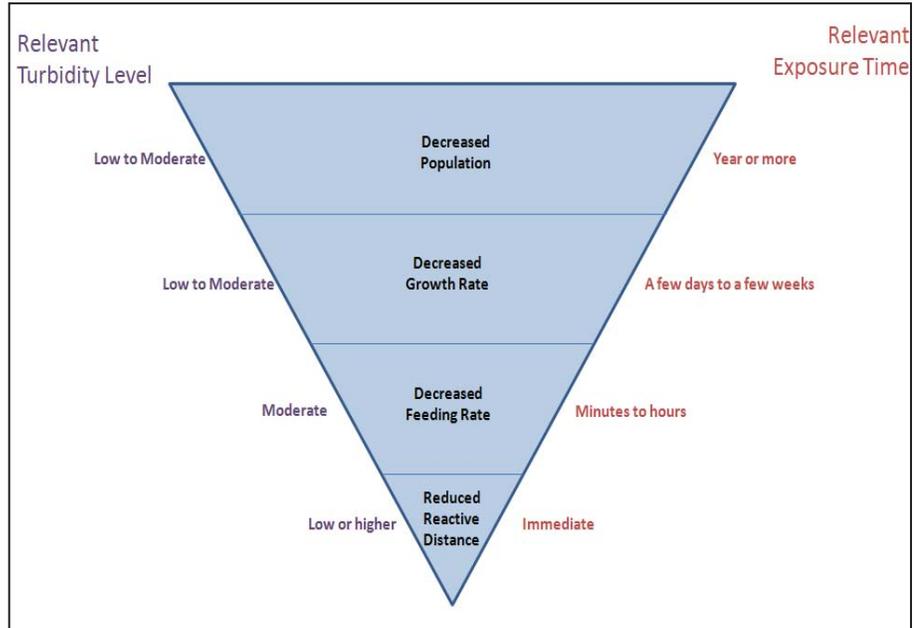


Figure 11. Illustration of turbidity effects on fish.

Reactive Distance Studies

A few studies have looked at how turbidity reduces reactive distance of fish by studying the distance at which a fish visually orients itself to a prey item. These studies indicate that reactive distances of adult fish decrease exponentially with increasing turbidity levels (Sweka and Hartman 2001a; Barrett, et al. 1992). For example, Sweka and Hartman (2001a) found that, compared to clear water, reactive distance of brook trout decreased by 20% at around 3 NTU and 50% at 10 NTU. At the same time, once a fish had reacted to its prey, the probability of capture was not affected

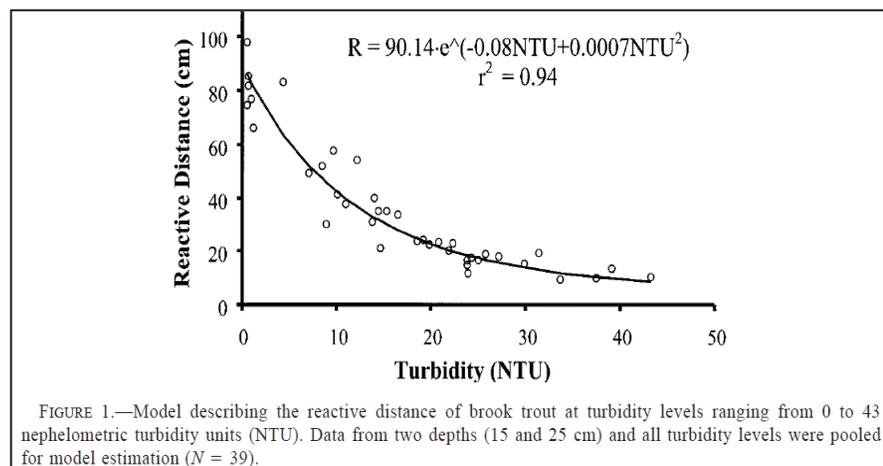


FIGURE 1.—Model describing the reactive distance of brook trout at turbidity levels ranging from 0 to 43 nephelometric turbidity units (NTU). Data from two depths (15 and 25 cm) and all turbidity levels were pooled for model estimation (N = 39).

Figure 12. Relationship of reactive distance and turbidity for brook trout. Source: Sweka and Hartman 2001a.

by turbidity. Berg and Northcote (1985) found that reactive distance in juvenile coho salmon decreased from 30 cm to 10 cm in a turbidity pulse of 60 NTU and did not recover to normal levels when turbidity decreased to 0 NTUs post-treatment.

Feeding Studies

A number of studies have shown that increased turbidity levels result in decreased feeding rates in fish. For example, Noggle (1978) found that feeding rates of juvenile coho salmon on aquatic insects decreased to zero above 300 mg/L of suspended sediment. Berg (1982) found that juvenile coho salmon consumed significantly less prey when exposed to a turbidity pulse that was initially at 60 NTU (for 3 days) and gradually decreased over an additional 3 days. Prey consumption decreased even when turbidities fell to 10 NTU. Juvenile coho also had more misstrikes at 10 NTU in Berg's experiment and their response time was significantly higher at 10, 20, and 60 NTU. Berg and Northcote (1985) found that prey capture success was significantly reduced at 20, 30, and 60 NTU, and most prey at these turbidity levels were captured downstream of the captor, whereas they were almost exclusively captured upstream in clear water conditions.

In contrast with the preceding studies, a few studies have demonstrated that, even at moderate turbidity levels, fish can successfully feed. However, these studies also indicate that such fish feed more in the benthic zone during periods of higher turbidity. In a field study, White and Harvey (2007) found that feeding success of rainbow trout and coastal cutthroat trout collected from two northern California streams did not differ sharply for fish collected in high turbidity (66-317 NTU) and low turbidity (2-11 NTU) conditions. Harvey and White (2008) tested the foraging success of juvenile cutthroat trout and coho salmon on drift and benthic prey at turbidities ranging from 0-400 NTU. Proportion of drift prey consumed fell sharply at 50 NTU and continued to decrease as turbidity levels increased. Benthic foraging success exceeded 50% up to 100 NTU and fell sharply at higher turbidities (Figure 14). The study also found that foraging success of

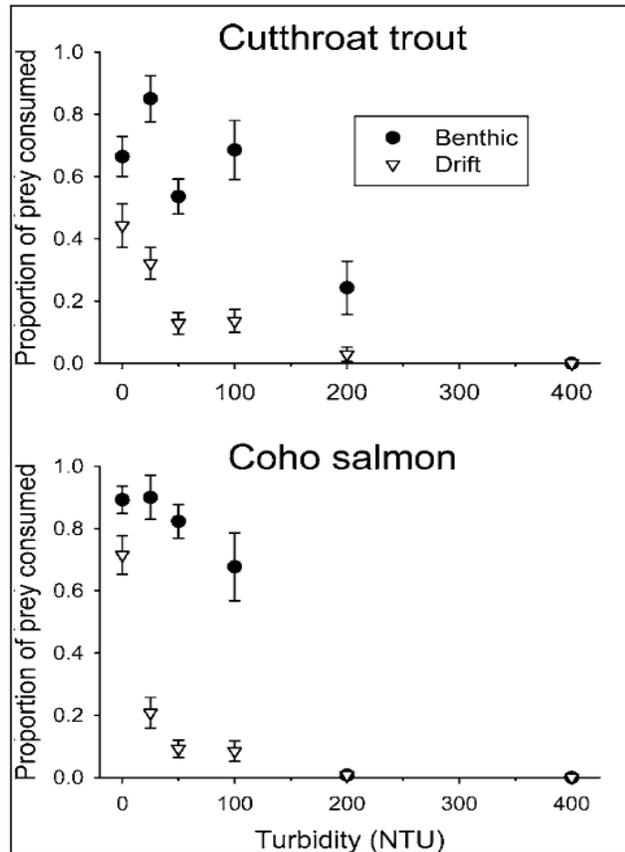


Figure 14. Relationship between turbidity and foraging success of cutthroat trout and coho salmon. Source: Harvey and White 2008.

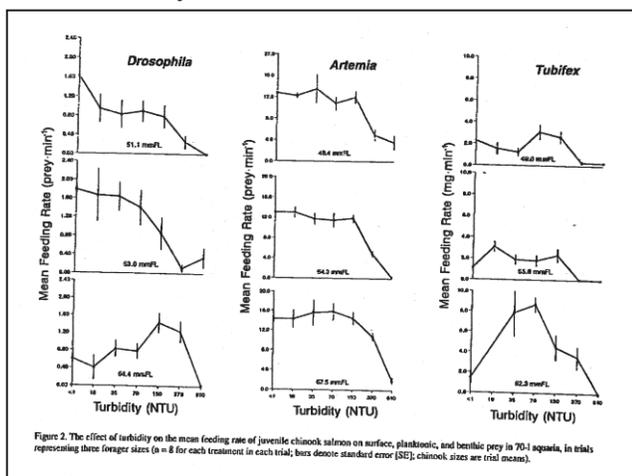


Figure 13. Feeding rates of juvenile Chinook salmon on surface, planktonic, and benthic prey at different turbidity levels. Source: Gregory (1994).

cutthroat trout feeding on live, mobile oligochaetes was decreased at 50 NTU as compared to a clear water control. Gregory (1994) found that small- and medium-sized juvenile Chinook salmon exhibited reduced feeding rates on surface *Drosophila* at all turbidity levels tested (18, 35, 70, 150, 370, and 810 NTU) with almost no feeding at 370 and 810 NTU. Large-sized juvenile Chinook maximized feeding on *Drosophila* at 150 and 370 NTU. Feeding on the plankton *Artemia* was generally not affected except at 370 and 810 NTU for all three size classes. Foraging on benthic *Tubifex* was highest for all size categories between 18 and 150 NTUs (Figure 15). The Gregory (1994) study did not report overall feeding rates.

Growth Studies

A few studies have looked at how increased turbidity may affect growth rates in fish. Such effects may result from a combination of: 1) a reduced ability to detect prey; 2) a switch from a passive to an active foraging strategy, resulting in increased energy expenditure; and 3) reductions in food availability. Sweka and Hartman (2001b) found that, even though mean daily consumption was unrelated to increased turbidity, specific growth rate was affected by increased turbidity, as fish used active foraging at higher turbidities, thus expending more energy (Figure 15). In that study, a linear relationship was developed between turbidity and growth rate in 5-day experiments; the relationship corresponded to a 50% decrease in growth rate at 50 NTU and a 20% decrease at 10 NTU.

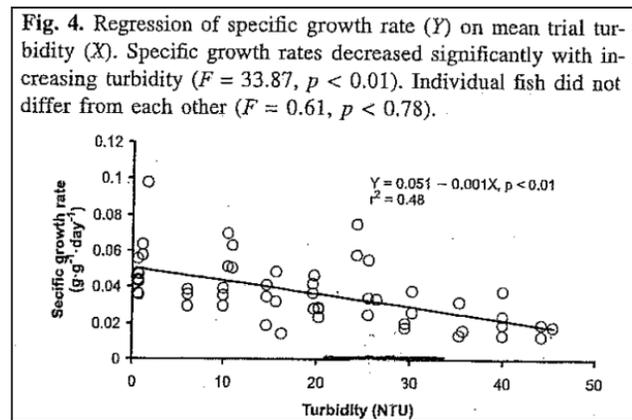


Figure 15. Effect of increased turbidity on specific growth rate of brook trout. Source: Sweka and Hartman (2001b).

Sigler, et al. (1984) examined how chronic turbidity increases affected density and growth of newly emerged steelhead and coho salmon. In a laboratory test in an oval channel, weight and length gains of newly emerged steelhead were significantly less in a 19 day exposure at 45 NTU compared to clear test waters. In a raceway channel, weight and length gains by steelhead were also reduced in a 19 day exposure at 38 NTU. Newly emerged coho salmon exposed to 22 NTU for 11 days in oval channels, and to 11-32 NTU for 14 days in raceway channels also experienced smaller length and weight increases during exposure. In raceway channels, biomass of juvenile Chinook was significantly reduced across the range of test levels (11-49 NTU) compared to the clear water control. The Sigler study suggests that juvenile fish exposed to even moderate levels of turbidity for several days would experience decreased growth assuming that food availability is constant.

Shaw and Richardson (2001) found that sediment pulses of 23 NTU that released every other day into an experimental stream for various durations reduced rainbow trout length and weight increase. Length gain was significantly reduced compared to control when turbidity pulses lasted a minimum of four to five hours; weight gain was reduced when turbidity pulses lasted, at a minimum, five to six hours.

Population Studies

A few studies have examined how different turbidity levels over a long time can affect abundance, reproduction, biomass, and other measures of fish population health. For example, Harvey and Railsback (2004) modeled how turbidity affected fish abundance (coastal cutthroat trout) and biomass in

twelve-year simulations. Turbidity was modeled based on data from two creeks in northwestern California and was assumed to reduce reactive distance, while simultaneously reducing the risk of predation. Model results indicated that the high turbidity regime consistently correlated with lower levels of abundance, reproduction, and biomass than low turbidity regimes, except in instances where food availability doubled. Further elaborating that model, Harvey and Railsback (2009) examined how different patterns in food availability and foraging strategy influenced population-level outcomes in 15 year simulations of different turbidity regimes. In the model, the low-turbidity regime produced modest variation in biomass over time within individual simulations. However, fish abundance under the high-turbidity regime fell to zero unless the fish utilized a search-based strategy at least 75 percent of the time. Results for intermediate-turbidity scenarios with the drift-based food calibration suggested significant effects on fish resulting from modest increases in turbidity. Biomass was insensitive to feeding regimes in the low turbidity regime.

The preceding studies indicate turbidity can affect the ability of fish to detect and capture prey. Reductions in ability for fish to react to prey occur at even very low turbidities, although translation to feeding and growth effects is not apparent at such levels. Literature shows that fish can feed in moderate to high turbidity regimes, but that lower feeding rates and a more active feeding strategy may result in reduced growth. Growth rates in salmonids have been shown to decrease by as much as 20% at turbidities as low as 10 NTU and 50% reduction at 50 NTU in exposures lasting as few as five days. Modeling efforts indicate that moderate turbidity regimes can reduce overall fish abundance and biomass and high turbidity regimes can completely eliminate fish populations.

Use of turbidity by fish as cover

Several papers indicate that juvenile fish use “cloudy” waters as cover from predators. Consideration of literature regarding use of cloudy water by juvenile fish, as described below, suggests that, while there is a temporary benefit to increased turbidity, this benefit may be outweighed by other factors, such as effect of turbidity on growth rates of fish. Moreover, streamside vegetation (i.e., shade) appears to be more important for use as cover than turbid waters.

Gregory (1993) found that juvenile Chinook salmon exhibited a startled response to models of predators in clear water conditions, but not in turbid (23 NTU) conditions. Abrahams and Kattenfeld (1997) found that fathead minnows use “dangerous habitats” (those in proximity to a predator) more often in turbid (13 NTU) water than clear water, indicating that perceived risk is less in turbid waters. However, turbidity did not affect mortality rates of minnows in a parallel experiment conducted at 11 NTU over three days. Ginetz and Larkin (1976) found reduced predation of juvenile sockeye salmon by rainbow trout under turbid conditions. In a study in British Columbia, Gregory and Levings (1998) found significantly less predation on

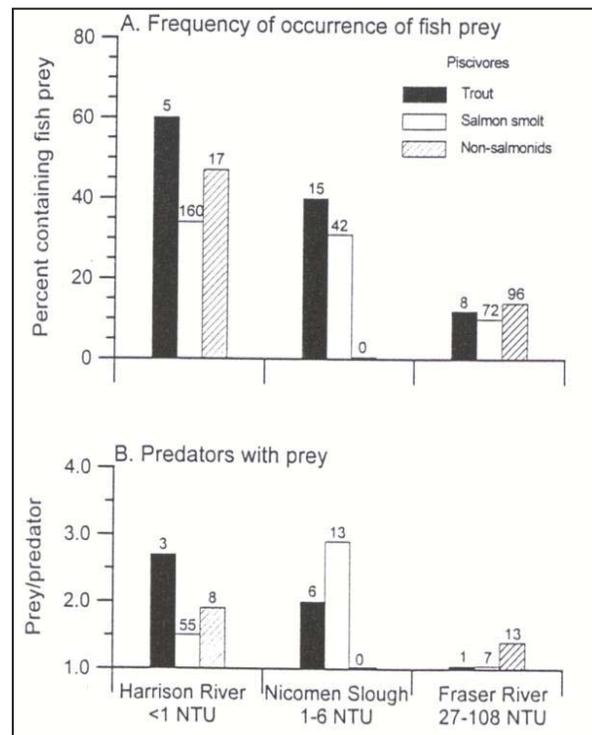


Figure 16. Predation of juvenile Chinook salmon by piscivorous fish in streams of different turbidities. Source: Gregory and Levings 1998.

juvenile Chinook salmon by piscivorous fish in the highly turbid Fraser River (27 to 108 NTUs) than in the clear water Harrison River (<1 NTU) and slightly turbid Nicomen Slough (1-6 NTUs) (Figure 16).

While many of the studies presented in this section support the argument that turbidity is beneficial to juvenile fish, the positive effects of turbidity must be weighed against potential negative effects. For example, in individual-based model simulations, Harvey and Railsback (2009) found that if salmonids mainly rely on drifting prey, any benefit of elevated turbidity via reduced predation risk is more than offset by the loss of feeding efficiency. These simulations suggested that the effect of turbidity on predation risk for fish might offset negative effects on feeding only if elevated turbidity was accompanied by a substantial increase in food availability.

In addition, literature suggests that vegetation may be more important than turbidity as cover for important fish species in Oregon. For example, Gadowski and Parsley (2005) found decreased predation of white sturgeon with increasing turbidity; at the same time, vegetative cover also was associated with decreased predation. This is consistent with the findings of Gregory and Levings (1996) who found that streamside vegetation was more important than turbidity in providing cover for juvenile salmonids. Given these considerations, it appears that these studies, while important, do not pose a good argument for setting a less stringent water quality standard for turbidity.

The preference of juvenile fish for “cloudy” water isn’t universal. For example, Gradall and Swenson (1982) found that brook trout showed no preference for moderately (5.8 NTU) or highly turbid (56 NTU) water. Johnson and Hines (1999) found that razorback suckers preferred clear over turbid (68 and 541 NTU) waters, although higher rates of survival occurred in predation trials at 541 NTU than in clear water or at 68 NTU.

Meta-analysis of turbidity effects on fish

A difficulty in developing water quality criteria for turbidity based on the studies presented above is that duration of exposure is very different from study-to-study and thus such studies are difficult to compare to each other. Basing water quality criteria on long-term studies at high turbidity levels would overstate effects in waters that only experience short-term turbidity spikes. Conversely, water quality criteria based on short-term studies could understate chronic effects. As a way to incorporate turbidity levels *and* exposure duration into effects analysis, Newcombe (2003) developed a meta-analysis that assigned a severity of ill effect (SEV) score (Table 2) to the results of laboratory and field experiments. Turbidity effects considered for the model include fish reactive distance, predator prey dynamics, egg and larval development growth rates, and habitat alteration effects. Newcombe (2003) assigned SEV scores to the results of the studies, and then regressed against water clarity measurements and exposure duration from literature to develop a log-linear regression. Table 2 presents levels of turbidity and exposure durations that would result in various levels of impairment described in Newcombe (2003). Figure 17 presents various turbidity levels and duration that would expect to result in Newcombe’s model values.

Table 2. Turbidity levels and exposure duration at which ill effects are expected to occur to clear water fish (NTUs).

	Slight impairment	Moderate Impairment	Severe impairment
Effect	Changes in feeding and other behaviors	Reductions in growth rate or habitat size	Poor “condition” or habitat alienation
SEV Score	0.5 – 3.5	3.5 – 8.5	8.5 – 14.5
1 hour	38	160	
2 hours	28	120	
3 hours	23	100	
8 hours	15	65	710
24 hours	10	39	440
5 days	5	19	215
3 weeks	3	10	115
>10 months		3	35

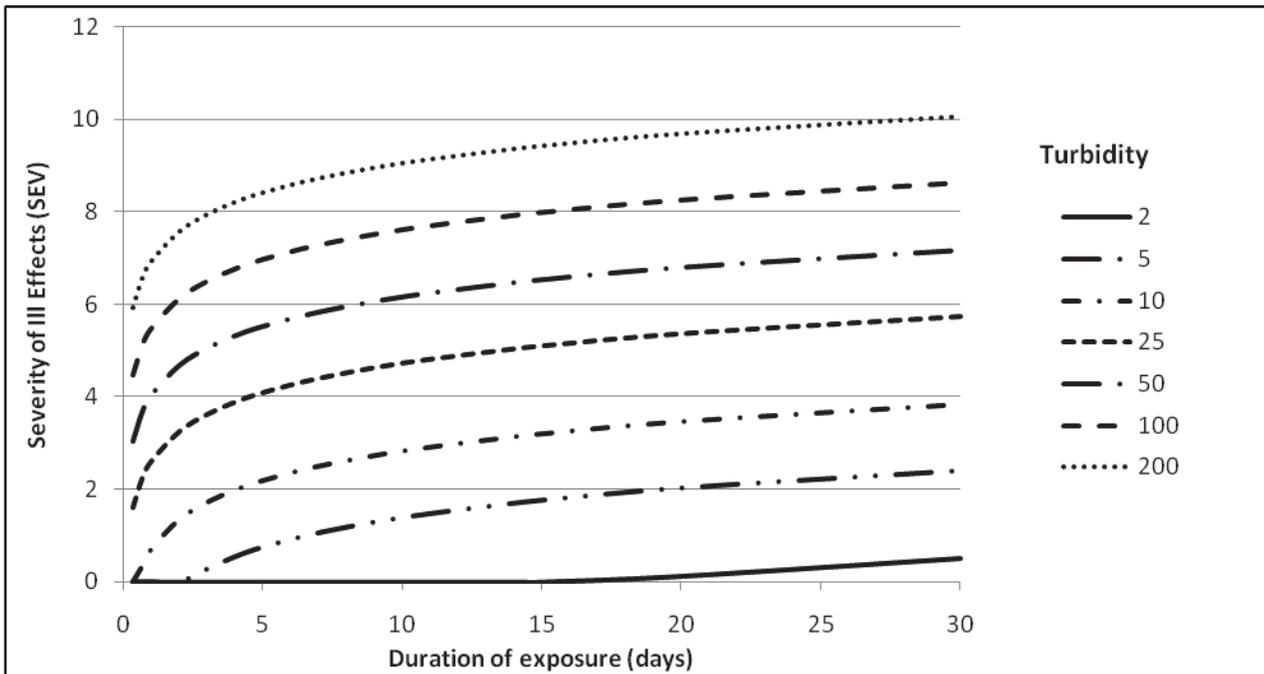


Figure 17, SEV for various exposure durations and turbidities. Data from: Newcombe 2003.

The Newcombe model is useful in that it provides a method to estimate the potential risk of impairment over a range of turbidity conditions and durations of potential exposure effects to clear water fish. However, the IMST (2006) questioned reliance on it to develop water quality criteria for turbidity and noted that it is not definitive in its conclusions and that it wasn't clear if the model had been validated. Moreover, Newcombe calibrated the model based on studies reporting visual clarity as a black disk sighting range and beam attenuation, rather than turbidity (see Chapter 2 for a discussion of these measures of clarity). For the purposes of presenting the information in Table 2 and Figure 15, black disk sighting range was transformed to turbidity using an equation based on turbidity data taken from New

Zealand. The relationship between turbidity and other measures of clarity is site-specific. As such, caution should be exercised when extrapolating these results to Oregon or other geographic locations. Another caution in using Newcombe's model is that it was developed from turbidity-effects literature reported from around the world. Thus, the model is not specific to fish species native to or found in Oregon.

While caution should be exercised in relying on this model to develop water quality standards for turbidity to protect beneficial uses in Oregon, it can serve as a useful reference during development of such criteria to see if they would be generally protective of species over the short- or long-term.

Summary of turbidity effects on aquatic life in streams.

Table 3 summarizes studies presented in this section that could be used to equate a specific turbidity level to potential effects on aquatic life in streams. The table includes relevant duration of exposure data where available. One of the major uncertainties in presenting such a table is that the studies utilize different instruments to measure turbidity and some do not describe their instrumentation at all. Thus, comparison of studies is subject to some uncertainty. One way to address this uncertainty is to provide some margin of error in the results. Based on the findings of Lewis, et al. (2007), mean errors between turbidimeters were approximately 12%; to be conservative, DEQ noted a 25% margin of error in each summary of study results. Rows that are highlighted in grey indicate studies demonstrating use of turbidity by juvenile fish as cover.

Table 3. Summary of effects of turbidity on aquatic life in streams.

Turbidity Level (margin of error)	Duration	Effect	Source	Turbidity Measurement	Type of Study
Effects at reported turbidity levels at ≤5 turbidity units					
1.6 NTU (1.2 – 2.0)	Chronic	25% decrease in periphyton production in a New Zealand stream	Davies-Colley, et al. 1992	Hach 2100A	Field
2.6 NTU (1.9 – 3.3)	Chronic	50% decrease in periphyton production in a New Zealand stream	Davies-Colley, et al. 1992	Hach 2100A	Field
2.6 NTU over background (1.9 – 3.3)	Chronic	50% decrease in macroinvertebrate density in shallow (0.2-0.4 m) streams	Quinn et al. 1992	Hach 2100A	Field
5 NTU (3.8 – 6.3)	none given	Decrease in primary productivity in clear Alaska streams by 3-13% (stream depth 0.1 – 0.5 m)	Lloyd, et al. 1987	Hach “Portalab”	Field
Effects at reported turbidity levels from 6-10 turbidity units					
8 NTU (5 – 10)	n/a	Moderate impairment in macroinvertebrate scores in Oregon stream riffles (winter data)	Mulvey and Hamel, 1998	Data Sonde 3 Hydrolab (continuous) and Hach 2100P (grab)	Field
9 NTU (6.8 – 11.3)	n/a	20% decrease in PREDATOR score using Oregon data	ODEQ turbidity data	n/a	Field
10 NTU (7.5 – 12.5)	5 days	20% decrease in brook trout growth	Sweka and Hartman 2001b	Lamotte 2020 turbidimeter	Laboratory
10-60 NTU (7.5 – 75)	4-6 days	Decrease in prey consumption by juvenile coho salmon; also, higher response time and increased number of mis-strikes at prey.	Berg 1982	DRT-150 Turbidimeter	Laboratory
Effects at reported turbidity levels from 11-20 turbidity units					
11 NTU (8.3 – 13.7)	14 days	Reduced weight and length gains in newly emerged coho salmon (raceway channels)	Sigler, et al. 1984	Hach 2100A Turbidimeter	Laboratory
13 NTU (9.8 – 16.3)	n/a	Increased use of “dangerous habitats” by fathead minnows	Abrahams and Kattenfield 1997	Not reported	Laboratory

Turbidity Level (margin of error)	Duration	Effect	Source	Turbidity Measurement	Type of Study
15 NTU (11.3 – 18.8)	n/a	20% reduction in rainbow trout reactive distance	Barrett, et al. 1992	Not reported	Laboratory (artificial stream channel)
18 NTU (13.5 – 22.5)	1-10 minutes	Reduced feeding rates of small-medium juvenile Chinook salmon on surface prey	Gregory 1994	Fisher DRT-400 Turbidimeter	Laboratory
Effects at turbidity levels from 21-30 turbidity units					
22 NTU (16.5 – 27.5)	11 days	Reduced weight and length gains in newly emerged coho salmon (oval channels)	Sigler, et al. 1984	Hach 2100A Turbidimeter	Laboratory
23 NTU (17.3 – 28.8)	1-6 hour daily pulses over 9 and 19 days	Reduced abundance and species richness of benthic macroinvertebrates. In addition, reduced rainbow trout length and weight gain when turbidity pulses lasted 4-5 and 5-6 hours, respectively.	Shaw and Richardson 2001	Not reported (converted from suspended sediment concentrations, but does not report relationship)	Laboratory
25 NTU (17.3 – 28.8)	12 days	Reduced startle response by juvenile Chinook salmon	Gregory 1993	Fisher DRT-400 Turbidimeter	Laboratory
25 NTU (18.8 – 31.3)	none given	Decrease in primary productivity in clear Alaska streams by 13-50% (stream depth 0.1 – 0.5 m)	Lloyd, et al. 1987	Hach “Portalab”	
25-35 NTU (18.8 – 43.8)	3 months	Decrease in whole stream metabolism	Parkhill and Gulliver 2002	Not reported	Controlled field (laboratory streams)
27 NTU (20.3 – 33.8)	1.5 hours	Predation rates on juvenile Chinook salmon by piscivorous fish significantly reduced in the Fraser River	Gregory and Levings 1998	Fisher DRT-100 Turbidimeter	Field
30 NTU (22.5 – 37.5)	n/a	55% reduction in rainbow trout reactive distance	Barrett, et al. 1992	Not reported	Laboratory (artificial stream channel)

Turbidity Level (margin of error)	Duration	Effect	Source	Turbidity Measurement	Type of Study
30 NTU (22.5 – 37.5)	One hour	Decrease in reactive distance, capture success and percentage of prey ingested for juvenile coho salmon. In addition, dominance hierarchies broke down and gill flaring occurred more frequently	Berg and Northcote 1985	Fisher 400 DRT Turbidimeter	Laboratory
30 NTU (22.5 – 37.5)	24 hours	Increased cough frequencies in coho salmon	Servizi and Martens 1992	HF Instruments DRT 100	Laboratory
Effects at turbidity levels from 31-50 turbidity units					
38 NTU (28.5 – 47.5)	19 days	Decreased weight and length gains of newly emerged steelhead (raceway channel)	Sigler, et al. 1984	Hach 2100A Turbidimeter	Laboratory
42 NTU (31.5 – 52.5)	96 hours	25% increase in blood sugar levels in coho salmon	Servizi and Martens 1992	HF Instruments DRT 100	Laboratory
45 NTU (33.8 – 56.3)	19 days	Decreased weight and length gains of newly emerged steelhead (oval channel)	Sigler, et al. 1984	Hach 2100A Turbidimeter	Laboratory
50 NTU (37.5 – 62.5)	5 days	50% decrease in brook trout growth rate	Sweka and Hartman 2001b	Lamotte 2020 Turbidimeter	Laboratory
50 NTU (37.5 – 62.5)	15 minutes	Decrease in proportion of drift prey consumed in juvenile cutthroat trout and coho salmon	Harvey and White 2008	DTS-12	Laboratory
50 NTU (37.5 – 62.5)	15 minutes	Decrease in proportion of live oligochaetes drifting along an experimental stream bottom by juvenile cutthroat trout	Harvey and White 2008	DTS-12	Laboratory
Effects at turbidity levels >50 turbidity units					
70 NTU (52.5 – 87.5)	30 minutes	Avoidance of juvenile coho salmon to turbid waters	Bisson and Bilby 1982	Not reported	Laboratory

Turbidity Level (margin of error)	Duration	Effect	Source	Turbidity Measurement	Type of Study
80 NTU (60 – 100)	96 hours	50% increase in blood sugar level in coho salmon	Servizi and Martens 1992	HF Instruments DRT 100	Laboratory
150 NTU (112.5 – 187.5)	15 minutes	Decrease in proportion of benthic prey consumed by juvenile cutthroat trout and coho salmon	Harvey and White 2008	DTS-12	Laboratory
541 NTU (405.8 – 676.3)	10 minutes	Increased survival of razorback suckers in predation trials	Johnson and Hines 1999	Not reported	

Turbidity Effects in Lakes/Reservoirs

Primary Productivity

The effects of increased turbidity levels on primary productivity in lakes are similar to that in streams. Turbidity can cause a decrease in compensation point, reducing the volume of the water body in which photosynthesis can occur (PAR) (Kirk 1985; Lloyd, et al. 1987). DEQ identified one study conducted in Oregon relating increased turbidity to primary productivity. Shrader (2000) studied the interactions of turbidity, phosphorus, and productivity in Prineville Reservoir on the Crooked River and concluded that turbidity may significantly affect energy allocation and transfer between trophic levels (from phytoplankton to zooplankton to fish) in the Prineville Reservoir. The study also noted that phosphate adsorbing onto turbidity-causing clay particles might be partially responsible for decreased chlorophyll-*a* levels found in the reservoir, although this effect was minor with respect to the effects of decreased light in the water column.

Lloyd, et al. (1987) noted that a seasonal 5 NTU increase in turbidity above clear water conditions reduced the volume of PAR of naturally clear lakes in Alaska by as much as 80% (Figure 18). Koenings, et al. (1990) found significantly lower chlorophyll *a* levels in glacial lakes than in clear or stained lakes, which the authors hypothesized was due to a combination of higher turbidity and lower temperature and food levels. Lloyd, et al. (1987) noted that the decreases in productivity in glacial Alaskan lakes correspond with decreases in production of fish food organisms, production of juvenile sockeye salmon and return of adult sockeye salmon to lake systems. Lloyd, et al. (1987) also suggested that compensation of photosynthetic efficiency for low-light conditions is limited in moderate to high turbidity (30 NTUs and higher).

As in streams, some literature demonstrates that plants can compensate for low light conditions by increasing photosynthetic efficiency (see Krause-Jensen and Sand-Jensen (1998) for a detailed review). Barko and Filbin (1983) found higher total chlorophyll levels in low light conditions ($PAR = 100 \mu E m^{-2} s^{-1}$) in three species of submerged macrophytes than in medium ($600 \mu E m^{-2} s^{-1}$) and high light ($1500 \mu E m^{-2} s^{-1}$) conditions. Temperature also was highly correlated with total chlorophyll levels. The authors noted that the relationship between total chlorophyll levels and light was not universal, however. Moreover, these studies did not look at overall growth; thus, it is not certain if the adaptation to low light conditions comes at a growth cost. Based on the findings of Blanch, et al. (1998) regarding response of a stream macrophyte to turbid conditions, even with such adaptations, lower light would result in reduced growth, at least until conditions became less turbid.

Zooplankton and invertebrates

DEQ found few studies linking turbidity to zooplankton and invertebrates in lakes and reservoirs. Lloyd et al. (1987) illustrates how turbidity levels that decrease primary productivity may also have cascading effects on higher levels in the food chain. Data from Lloyd, et al. (1987) indicate a high correlation between increased turbidity levels and reduced zooplankton densities in Alaskan lakes ($r^2=0.93$, Figure 19). Turbid lakes exhibited less than 5% of the zooplankton densities often associated with clear lakes

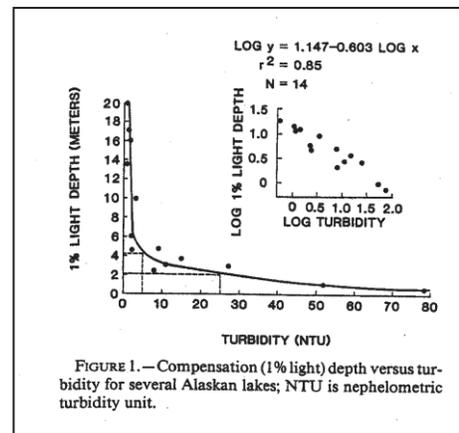


Figure 18. Relationship between turbidity and compensation point for Alaskan lakes. From Lloyd, et al. 1987.

(Lloyd, et al. 1987). However, some literature suggests that increased turbidity is beneficial to large zooplankton due to decreases in susceptibility to visually searching predators (e.g., Fiksen and Giske 1995).

Other studies of turbidity's effects on invertebrates are not as conclusive in their findings. For example, survival of the opossum shrimp *Mysis relicta* was not significantly affected by high levels of turbidity (760 and 1500 NTU) after two, four, six, and eight days (Gregg and Bergerson 1998). Van de Meutter, et al. (2005) found that damselfly larvae showed increased activity (swimming and walking) in turbid conditions than in clear conditions, but did not show any change in foraging behavior. However, vegetation density seemed to have a more profound effect than turbidity in damselfly larvae survival in the presence of a fish (Van de Meutter, et al. 2005).

Fish

In lakes, as in streams, research on the effects of reduced water clarity on fish focuses primarily on changes in predator-prey dynamics due to changes in reactive distance of predatory fish, in particular species of centrarchidae (sunfish). Results from these studies indicate feeding effects at turbidity levels as low as 5 NTU for relatively short (3.5-42.6 hour) exposures. However, studies have found that certain fish in lakes and reservoirs, such as crappie, appear to be more tolerant of turbid conditions.

One study discussed behavioral changes and found that increased turbidity levels decreased the response of fathead minnows to a chemical alarm signal at 21 NTU (Hartman and Abrahams 2000). A few studies focus on chronic turbidity effects on fish density, presumably due to decreased food availability; however, these studies are generally anecdotal and are not useful for setting a water quality standard for turbidity.

Changes in feeding behavior

As in riparian systems, increased turbidity in lake systems has been shown to affect reactive distance in fish, which may result in reduced feeding rates in the short-term, reduced growth rates over several days, and reduced biomass and population over months and years.

Reactive Distance Studies

Vogel and Beauchamp (1999) determined that reactive distances in lake trout to juvenile rainbow and cutthroat trout decreased at 3.18 and 7.40 NTUs but not at the lowest turbidity level tested (0.9 NTUs). Mazur and Beauchamp (2003) found that reactive distance of lake, rainbow, and cutthroat trout didn't decrease when turbidity increased from 0.08 to 0.55 NTU, but did decrease at 1.50 NTU (Figure 20), suggesting a threshold turbidity exists between those levels, consistent with the findings of Vogel and Beauchamp (1999). Cowl (1989) found the reactive distance of largemouth bass to be significantly less in turbid (~18 JTU) water than in clear water. Miner and Stein (1996) found in a laboratory experiment that reactive distance of bluegill decreased as a power function of turbidity with a 50% reduction occurring at 1.2 NTU. Similarly, Vinyard and O'Brien (1976) found that reactive distance of bluegills to daphnia decreased with increasing turbidity and became more pronounced as prey size increased.

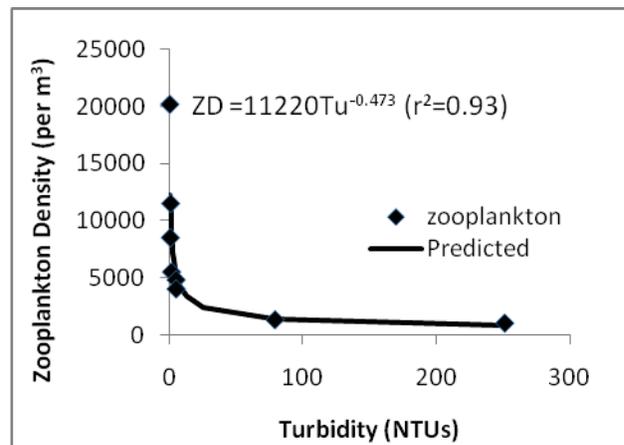


Figure 19. Relationship between zooplankton density and turbidity in Alaskan lakes. Data from Lloyd, et al.

Feeding rate studies

Some studies focusing on fish in lakes describe effects of turbidity on prey consumption. In general, these studies indicate that turbidity levels affecting fish feeding rates are not significantly different between rivers and lakes. DEQ is unable to conclude whether the effects of turbidity on growth rates are different between rivers in lakes since none of the studies reviewed examined overall effects on growth rate.

Feeding rates of Lahontan redbside shiner and cutthroat trout on daphnia decreased 60-80% from 3.5 NTU to 25 NTU (Figure 21; Vinyard and Yuan 1996). Decreases in feeding rate were evident as low as 6-10 NTU, although the differences at these levels were not tested for significance. Carter, et al. (2010) found that prey consumption of smallmouth bass decreased as turbidity increased from 0-40 NTU, with significant decreases in consumption in the lowest turbidity level tested (5 NTU). Similarly, Shoup and Wahl (2009) found that size selectivity of prey by largemouth bass was impacted at 10 NTU (19-49 hour trials) and 40 NTU (42-77 hours), and a reduced overall predation rate at 40 NTU compared to 0 and 5 NTU treatments. Reid, et al. (1999) in one hour trials found that predation rates of largemouth bass were affected at 70 NTU compared to a clear water control, but not at 18 or 37 NTU. These studies suggest that, as exposure increases, effects will be seen at lower turbidity levels. In a six-year study in Lake Sorell, Tasmania, stomach contents of brown trout decreased by more than 80% as mean monthly turbidity increased from 26 to 141 NTU (Stuart-Smith, et al. 2004). Gardner (1981) found that prey consumption rates decreased in bluegill at 60, 90, and 120 NTU compared to a clear water control.

A few studies indicate that turbidity does not affect certain fish. Rowe, et al. (2003) found that the feeding rates of rainbow trout from New Zealand lakes did not decrease at 160 NTU over controls. However, the study found that in clear water, rainbow trout ate primarily larger prey, whereas, selectivity decreased as turbidity increased. The study did not report if the change in size selectivity affected growth rates. In another study, growth rates of juvenile white and black crappie were not affected by turbidities ranging from 7 to 174 FTU and growth

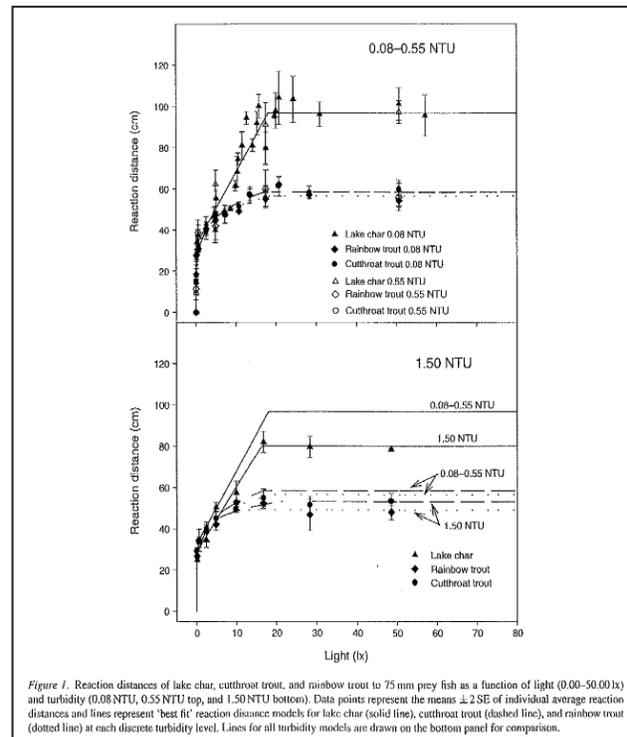


Figure 20. Relationship between turbidity and reactive distance of trout at different light intensities (Mazur and Beauchamp 2003).

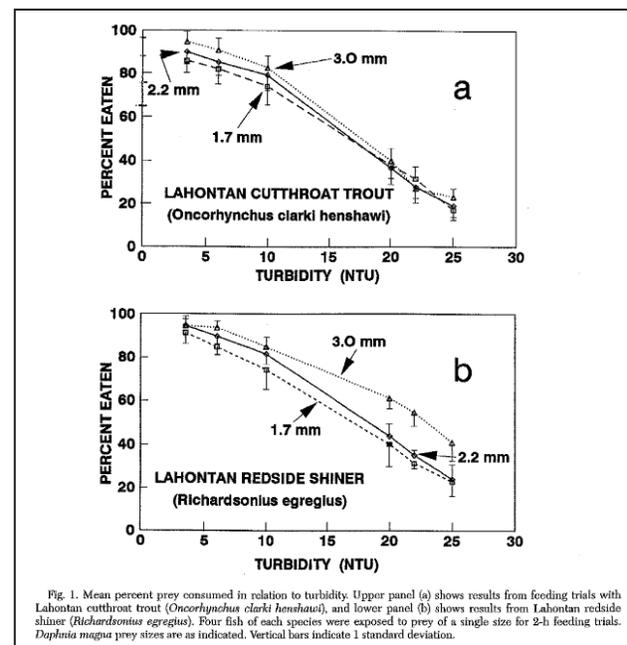


Figure 21. Relationship between turbidity and feeding rate of Lahontan cutthroat trout and redbside shiner (Vinyard and Yuan 1996).

rates of adult crappie were not affected in 13-144 FTU treatments in 25 week studies (Spier and Heidinger 2002). Crappie are generally thought to be tolerant to changes in turbidity and other measures of water quality (Buck 1956).

Population decreases in fish

DEQ was unable to find any modeling efforts that examined how higher turbidity regimes might affect populations. However, in one study, Lloyd, et al. (1987) noted that the number of juvenile sockeye salmon in glacial lakes in Alaska, measured as number of outmigrating smolts, related significantly ($r^2=0.99$) to euphotic volume, which decreases due to increases in turbidity; however, information was not available to indicate a level of turbidity that might be associated with a specific decrease in number or density of smolts. Shrader (1999) predicted that a 10% decrease in suspended solids in the Prineville Reservoir in Oregon would lead to an approximate 17% increase in fish yield due to increased primary production. Most other studies examining fish abundance and turbidity are anecdotal. For example, Ewing (1991) found that chronic turbidity levels greater than 100 formazin turbidity units (FTU) were the likely causal factor for the small fish population in a Louisiana bottomwood backwater system. When turbidity levels decreased as a result of restoration of natural flood patterns, fish populations of centrarchids, such as sunfish and bass, increased markedly. Buck (1956) found a much greater total weight of fish per acre in clear (average turbidity 25 ppm) ponds than in intermediate (25-100 ppm) or high-turbidity (>100 ppm) ponds in Oklahoma. He noted that bluegills and redear sunfish were particularly affected.

Summary of effects of turbidity on aquatic life in lakes

A summary of literature presented above related to effects of increased turbidity levels on aquatic life in lakes and reservoirs is presented in Table 4. As in the streams section, the summary includes information on exposure duration and, where reported, the type of instrument used to measure turbidity. In addition, as in the summary table for effects of increased turbidity on streams, DEQ noted a 25% margin of error for each result to take into account potential instrumentation differences.

In summary, in lakes and reservoirs, effects of chronically low increases of turbidity result in decreased primary productivity with cascading effects on higher trophic levels (i.e., reduced populations of zooplankton and fish. Low-to-moderate levels (0-20 NTU) of turbidity decrease reactive distance of fish (both prey and predator) and can result in changes to size selectivity of prey. In addition, at 5 NTU, smallmouth bass show decreased prey consumption at durations lasting less than 2 days (Carter, et al. 2010). At moderate turbidity levels (20-40 NTU), additional effects include reduced response to chemical alarm signals in fathead minnows, reduction of chlorophyll *a* levels in glacial lakes, and decreased predation rates for redbreast shiners, Lahontan cutthroat trout, and largemouth bass. Effects of higher turbidities include decreased predation rates by bluegills and largemouth bass in short trials, decline in stomach contents of brown trout, and population level decreases of centrarchids. As noted, a few studies indicate the lack of effects of turbidity on certain fish. Specifically, predation rates of rainbow trout in a Colorado reservoir were not affected at high turbidities; similarly, growth rates of juvenile and adult crappies were not affected by high turbidity levels. The crappie studies are consistent with the findings of others (e.g., Buck 1956), who have noted that they are tolerant of turbidity.

In general, it does not appear that levels of turbidity related to aquatic life effects in rivers are significantly different from those in lakes. However, there are some significant data gaps, particularly those examining effects of increased turbidity on fish growth, as well as modeling efforts looking at effects on fish populations.

Table 4. . Summary of effects of turbidity on aquatic life in lakes and reservoirs.

Turbidity Level	Duration	Effect	Source	Turbidity Measurement	Lab or Field
Effects at turbidity levels ≤5 turbidity units					
~1.2 JTU (0.9 – 1.5)	chronic	50% decrease in reactive distance of bluegill trout to avoid largemouth bass	Miner and Stein 1996	Not reported	Laboratory
1.5 NTU (1.1 – 1.9)	4 hours	Decrease in reactive distance of lake, rainbow, and cutthroat trout	Mazur and Beauchamp 2003	LaMotte 2008	Laboratory
3.18 NTU (2.39 – 3.98)	4 hours	Decrease in reactive distance of lake trout to juvenile rainbow and cutthroat trout at optimum light intensity	Vogel and Beauchamp 1999	LaMotte 2008	Laboratory
3.6 NTU (2.7 – 4.5)	n/a	50% reduction in zooplankton density in glacial lakes	Data from Lloyd, et al. 1987	DRT-100	Field
5 NTU (3.8 – 6.3)	n/a	80% reduction in compensation depth	Lloyd, et al. 1987	HF DRT-150 Turbidimeter	Field
5 NTU (3.8 – 6.3)	3.5 – 42.6 hours	Significant decrease in consumption of prey by smallmouth bass	Carter, et al. 2010	LaMotte 2020	Laboratory
Effects at turbidity levels from 6-10 turbidity units					
10 NTU (7.5 – 12.5)	19-49 hour	Change in size selectivity of prey by largemouth bass	Shoup and Wahl 2009	Cole-Parmer Model 8391-40	Laboratory
Effects at turbidity levels from 11-20 turbidity units					
17-19 JTU (12.8 – 23.8)	n/a	Decrease in reactive distance of largemouth bass to crayfish	Crowl 1989	Not reported (Jackson turbidimeter)	Laboratory
Effects at turbidity levels from 21-30 turbidity units					
21 NTU (15.8 – 26.3)	12 hours	Reduced response of fathead minnows to a chemical alarm signal	Hartman and Abrahams 2000	Not reported	Laboratory
25 NTU (18.8 – 31.3)	2 hours	60-80% decrease in feeding rates of Lahontan reidside shiner and cutthroat trout on daphnia	Vinyard and Yuan 1996	DRT-15 Turbidimeter	Laboratory
Effects at turbidity levels from 31-50 turbidity units					
30+ NTU (22.5+)	n/a	Limitation in compensation of photosynthetic efficiency for low-light	Lloyd, et al. 1987	n/a	Field

Turbidity Level	Duration	Effect	Source	Turbidity Measurement	Lab or Field
		conditions			
33 NTU 24.8 – 41.3)	n/a	Reduction in chlorophyll <i>a</i> levels in glacial lakes	Koenings, et al. 1990	DRT-100	Field
40 NTU (32 – 48)	42-77 hours	Decrease in predation rate by largemouth bass	Shoup and Wahl 2009	Cole-Parmer Model 8391-40	Laboratory
Effects at turbidity levels >50 turbidity units					
60 NTU (45 – 75)	3 minutes	Decrease in prey consumption by bluegill	Gardner 1981	DRT-100	Laboratory
70 NTU (52.5 – 87.5)	one hour	Decrease in predation rates by largemouth bass	Reid, et al. 1999	DRT-15B	Laboratory
100 FTU (75 – 125)	n/a	Population level declines of centrarchids in a Louisiana bottomwood backwater system	Ewing 1991	Hach DR-EL/1	Field
141 NTU (105.8 – 176.3)	n/a	Decrease in stomach contents of brown trout in Lake Sorell, Tasmania	Stuart-Smith, et al. 2004	Not reported	Field
144 FTU (108 – 180)	25 weeks	No effect on growth rate of adult crappie	Spier and Heidinger 2002	Hach DR-2000	Field
160 NTU (120 – 200)	3 hours	No decrease in predation rate by rainbow trout; however, size selectivity was affected.	Rowe, et al. 2003	Hach 18910 Turbidimeter	Laboratory
174 FTU (130.5 – 217.5)	25 weeks	No decrease in growth rates of juvenile white and black crappie	Spier and Heidinger 2002	Hach DR-2000	Field

Turbidity Effects in Estuaries

Effects on Primary Productivity and Submerged Aquatic Vegetation

The sediment dynamics of estuaries, which affect turbidity and light levels, are extremely variable, particularly in the region where the marine- and river-dominated portions of the estuaries combine. In these areas, tides force saline marine water beneath the fresh river water, resulting in high amounts of suspended sediment. This area of estuaries is defined as the estuarine turbidity maximum (ETM) and is an area where light attenuation is high (Cloern 1987). However, light attenuation also is affected by particle size (Campbell, 1987). In the Columbia River Estuary, the position of the ETM and its concentration of suspended sediments can vary on semidiurnal, fortnightly and seasonal time scales coinciding with changes in tidal forcing and volume of discharge (Morgan 1992). Studies have shown that the turbidity maximum is generally most pronounced during summer low flow periods (e.g., in the Columbia River Estuary: Callaway, et al. 1988).

In many coastal plain estuaries, such as the Columbia River estuary, suspended sediment-caused turbidity limits phytoplankton production (Morgan 1992; Cloern 1987). Lara-Lara, et al. (1990) found a negative correlation between the daily phytoplankton production in the Columbia River estuary and the light extinction coefficient, although other factors (solar irradiance, temperature, chlorophyll *a* concentrations, and suspended sediment concentration) also affect phytoplankton production. However, populations of certain zooplankton are positively correlated with increased levels of suspended particulate matter in the Columbia River estuary (Morgan, et al. 1997).

Much of the literature examining water clarity in estuaries in Oregon and elsewhere focuses on the effect of light on algal growth and growth of submersed macrophytes (commonly referred in the literature as submerged aquatic vegetation, SAV). The literature places a particular focus on the effects of light attenuation on presence and growth of eelgrass, *Zostera marina*. Eelgrass serves as an important refuge for juvenile fish, protecting them from predation. Seagrass also moderates current velocity, increases water clarity by promoting sediment deposition, removes nutrients from the water column, and provides other environmental benefits (Brown, et al. 2007).

Several papers document that reduced light penetration limits growth of SAV in estuaries and a decline in eelgrass around the world caused by anthropogenic sources of nutrients (Giesen, et al. 1990; Moore, et al. 1996). Goldsborough and Kemp (1988) found that a submerged macrophyte exposed to shaded conditions equaling 11% of ambient light for seventeen days experienced significant reductions in biomass and stem density; reproduction was eliminated entirely. Duarte (1991) suggested that coastal seagrasses require 11% of surface irradiance at the sea bottom in order to grow. U.S. EPA set water quality criteria for visual clarity in the Chesapeake Bay, which range from 0.2 to 1.9 meters Secchi Depth depending on the salinity regime and application depth (USEPA 2003). Batiuk, et al. (2000) recommended a water clarity criterion for SAV ranging from 15-22% of surface irradiance depending on salinity zones in the Chesapeake Bay.

Key differences exist between estuarine systems in the Chesapeake Bay and those in Oregon that indicate that water clarity criteria designed to protect SAV in the former should not be extrapolated to the latter. These factors include differences in tidal ranges and regimes (Thom, et al. 2008), temperature (Boese, et al. 2009), and winter irradiance (Boese, et al. 2005). Brown, et al. (2007) recommended water clarity criteria (expressed as the light attenuation coefficient) of 0.8 m^{-1} and 1.5 m^{-1} in the marine

dominated and riverine-dominated portions of the Yaquina Bay Estuary, respectively. These limits are based on the relationship between light attenuation coefficient and eelgrass lower depth limit, which is the lowest depth at which eelgrass will grow (Figure 22).

One question that remains for setting water quality criteria for visual clarity for Oregon estuaries is whether light attenuation and eelgrass depth limit the relationships that can be developed in locations other than the Yaquina Estuary. Boese, et al. 2009 conducted a study of seven Oregon estuaries that attempted to determine whether the lower depth limits of eelgrass were correlated with water clarity differences within and across estuaries. Water clarity was reported in terms of light attenuation coefficient, K_d . The study only found a significant relationship between K_d and lower depth limit in the Yaquina Bay estuary, but not in the other estuaries studied. The authors noted that, in addition to water clarity, other factors including current velocity, sediment characteristics, water temperature and salinity affected the eelgrass range. In addition, additional information is needed on light gradients and SAV distributions in other estuaries, as well as seasonal patterns in light between estuaries and salinity (C. Brown, *personal communication*). Thus, at present, there is not sufficient information to develop water clarity criteria for estuaries that would be applicable statewide.

3.1.1.1. Fish

A few studies examine the effects of turbidity on fish present in Oregon estuaries. These studies indicate that feeding is optimal at moderate turbidity levels as compared to clear water or highly turbid conditions. Boehlert and Morgan (1985) found that Juvenile Pacific herring feed optimally at suspended sediment concentrations of 500-1000 mg/L, but exhibited less feeding in clear water and in sediment concentrations higher than 1000 mg/L. Gregory (1990), examining foraging behavior of juvenile Chinook salmon in estuarine conditions, found that, while reactive distance declined inversely with turbidity, feeding rates on benthic *Tubifex* were highest at 50-100 mg/L suspended sediment, and were less in clear water and in concentrations higher than 100 mg/L (Figure 23). Gregory (1990) suggests that reduced perceived risk from predation may allow for more foraging. Gregory and Northcote (1993) found similar results, with juvenile Chinook salmon exhibiting higher overall feeding rates on surface, planktonic and benthic prey at 35 and 150 NTU than at 0 and 810 NTU.

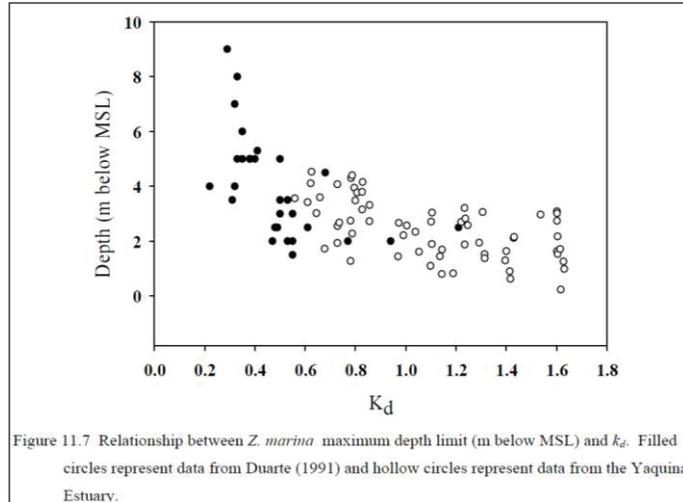


Figure 22. Relationship between eelgrass lower depth limit and light attenuation coefficient in the Yaquina estuary (Brown, et al. 2007).

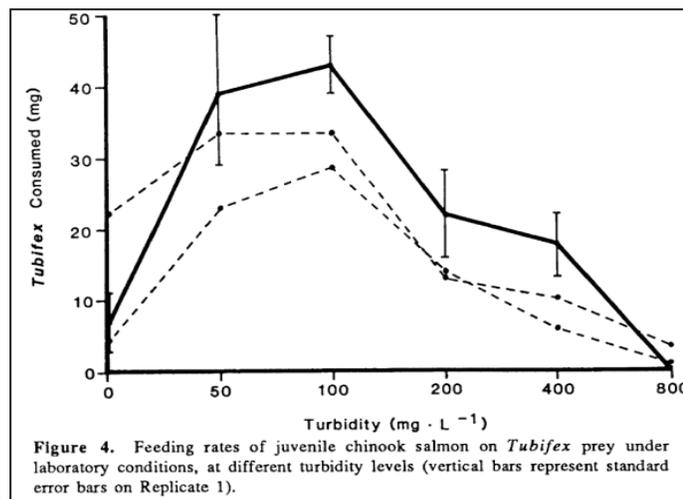


Figure 23. Relationship between turbidity and feeding rates of juvenile Chinook salmon on *Tubifex*. (Gregory 1990)

Recreation/Aesthetics

Increased turbidity levels can affect recreational use of waters in Oregon and elsewhere, both directly and indirectly. Directly, turbidity reduces visibility, which can diminish “suitability” of waters for swimming (Smith, et al. 1991) and fishing (Lloyd, et al. 1987). Indirectly, turbidity induced reductions in fish populations can reduce catch rates and reduce “desirable species” (Buck 1956).

Effects on Aesthetics and Swimming

Turbidity can have deleterious effects on perceptions of water quality, which may in turn reduce use of waters for recreational uses and swimming. Most of the research that DEQ found related to the effects of turbidity and visual clarity on perceptions of aesthetics and the “suitability” of waters for use has been conducted in New Zealand. Smith, et al. (1991) in a New Zealand survey found that 60% of people considered waters yielding a black disk sighting range of 1.2 meters to be suitable for swimming. In the same study, 90% of those surveyed considered waters yielding a black disk sighting range of 2.2 meters suitable for swimming. Using an equation from Smith, et al. (1997), these measures correspond to turbidities of 4.2 and 1.5 NTU, respectively. The study indicates that clear or near-clear conditions are required for most people to consider water suitable for swimming. In another study, Smith and Davies-Colley (1992) surveyed 15 field staff of the New Zealand Water Resource Survey in New Zealand with respect to recreational bathing and aesthetic suitability-for-use in streams. Results are presented in Table 5.

Table 5. Relationship between visual clarity and suitability of water for swimming and overall aesthetics. Data from Smith and Davies-Colley, 1992.

	Swimming Suitability		Aesthetic Suitability	
	Black disc sighting range (meters)	Turbidity (NTUs) [from Smith, 1997]	Black Disc sighting range (meters)	Turbidity (NTUs) [from Smith, 1997]
Eminently suitable	≥2.7	≤1	≥3.0	≤1
Suitable	<2.7 - 1.6	>1 - 2	<3.0 - 1.7	>1 - 2
Marginally suitable	<1.6 – 1.1	>2 - 3	<1.7 - 1.0	>2 - 3
Unsuitable	<1.1 – 0.5	>3 - 8	<1.0 – 0.4	>3 - 11
Totally unsuitable	< 0.5	> 8	< 0.4	>11

In laboratory tests, Smith and Perrone (1996) observed that the percent change in clarity required to present perceptible differences to surveyed viewers decreased as the control condition for comparison increased in turbidity. A greater than 300% (or 15 NTU) increase above a turbidity sample of 5 NTUs was needed to reveal a ‘conspicuous’ difference between samples; with a similar response by those surveyed at approximately 16 NTUs (160%) above a control sample of 10 NTUs, and 70 NTUs (140%) above a control sample of 50 NTUs. ‘Somewhat of a noticeable difference’ was perceived at 8.5 NTUs (170%), 9 NTUs (90%), and 35 NTUs (70%) above 5, 10, and 50 NTU control levels, respectively. ‘Barely noticeable differences’ occurred at 3.4 NTUs (68%), 3.2 NTUs (32%), and 10 NTUs (20%) above 5, 10, and 50 NTU control levels, respectively. The appearance of disparity between these statistics and Table 5 results may be due to perceived differences above perfectly clear water (0 NTUs) and perceived differences above turbidity levels of 5 NTUs or greater.

One area of uncertainty in presenting these studies is the applicability of New Zealand studies to impacts on recreation in Oregon. However, there are a number of similarities between Oregon and New Zealand. For example, Oregon (especially Western Oregon) and New Zealand have a comparable array

of lakes, reservoirs and streams. New Zealand has many highly oligotrophic and transparent lakes as well as many eutrophic and dystrophic lakes which are not very transparent. Streams and rivers include a wide variety of turbidity regimes as well (R. Petersen, *pers. comm.*). Smith, et al. (1995 a, b) noted that the perception of a water body depends on the use an observer expects to make of it as well as the observer's prior experience. For example, if the water quality was perceived to be "natural", users were more accepting of reduced transparency or color resulting from dissolved organic matter. In as much as people in both Oregon and New Zealand have an equivalent "reference set" of natural water bodies on which to base their opinions, the results of research in New Zealand are applicable as a basis for setting criteria in Oregon.

Effects on Fishing

In locations where chronic turbidity results in decreased fish populations and diversity, a number of studies have noted an indirect effect on the quality of fishing in those locations. For example, Buck (1956), in a study of a clear and a turbid reservoir in Oklahoma, found that fish species grew faster in the clear reservoir. In addition, catch per unit effort in the clear reservoir was reported as 3-4 times higher in the clear reservoir than the turbid reservoir. Drenner, et al. (1997) found that catch rates of largemouth bass were significantly and linearly correlated with

turbidity in an experimental pond (Figure 24). Ewing (1991) hypothesized that chronic turbidity (>100 NTU) was the culprit for the decline in fish populations in a bottomland hardwood backwater system. Lloyd, et al. (1987) reported a 55% decline in sport fishing downstream from mine discharges on the Chatainika River, Alaska, which was attributed to avoidance by fishers of increased turbidities of 8-50 NTU. The authors did not note whether this decline was due to a decrease in fish numbers or a preference to fish in clear waters due to safety or aesthetic concerns.

One study contradicts the findings reported above. Catch per unit effort of rainbow trout was higher in turbid (>480 NTU) than in clear water in the Colorado River (Speas, et al. 2004).

Water Treatment

In this report, DEQ reviewed the effect of increased turbidity levels on drinking water treatment operations and costs. These effects are not related to reduced visibility, but rather to meeting Safe Drinking Water Act (SDWA) turbidity treatment maximum contaminant limits, which protect against pathogens, disinfection by-products, and compounds associated with suspended sediment (excess nutrients, metals, pesticides, etc.). DEQ manages a cooperative drinking water protection program with the Oregon Department of Human Services, which is responsible for implementing the SDWA in Oregon. The water quality standards identify domestic and private water supply as a beneficial use to be protected. The standards addressing toxic pollutants also protect for exposure related to drinking water. As one of the endpoints generally included in water quality standards, DEQ has compiled relevant data

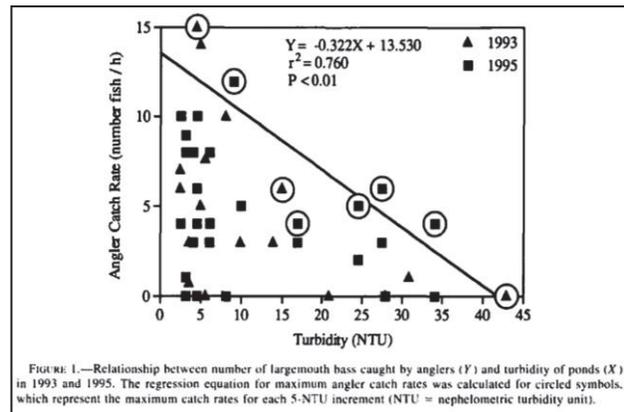


Figure 24. Relationship between turbidity and angler catch rate of largemouth bass in an experimental pond (Drenner, et al 1997).

in order to review the potential effects of increased turbidity in the context of whether DEQ should set a water quality standard to protect domestic water supply.

Oregon water quality regulations list domestic and private water supply as a beneficial use in nearly all fresh waters in the state, with a few exceptions. While treatment and delivery of drinking water is regulated under the Safe Drinking Water Act (SDWA), the level of turbidity in Oregon waters that serve as drinking water source areas can have a direct effect on treatment costs; turbidity as low as 5 NTU can cause smaller drinking water systems to shut down. As such, DEQ is considering the effects of turbidity on drinking water treatment to inform whether specific water quality standards for turbidity should be developed for this endpoint.

Turbidity is an indicator of excessive levels of suspended fine sediment in drinking water, which can reduce the effectiveness of disinfection treatments (LeChevallier et al 1981), harbor pathogens (Meschke & Sobsey 1998), contribute to formation of disinfection by-products (Nikolaou et al 1999), and carry nutrients, heavy metals, pesticides, and other toxic chemicals (Lick 2008). Under the SDWA, the level of allowable turbidity in drinking water is 0.3 NTU in 95% of samples for direct and conventional filtration and 1 NTU in 95% of samples for other types of filtrations. Most drinking water treatment facilities run by public water systems (PWSs) have the capacity to remove turbidity-causing sediments during treatment of raw water; however, the amount of turbidity that can be effectively removed depends on the treatment technology in use (US EPA 1999). For example, water can be treated using a flocculent/coagulant agent to collect fine sediments into larger particles which are then removed by rapid pressurized filtration through a bed of sand. More flocculent and coagulant are needed as turbidity increases (Moore and McCall 1987). Another common drinking water treatment system, slow sand filtration, allows water to slowly percolate through a large bed of sand to be collected through an underdrain. When source water turbidity exceeds 5 NTU, a treatment plant using these treatment systems will usually need to shut down (National Drinking Water Clearinghouse 1996). PWSs with additional pre-filtration or pre-sedimentation basins can treat source water with turbidity higher than 5 or 10 NTU (US EPA 2004). Some systems in Oregon with frequent high turbidity install advanced filtration systems that can treat water with turbidity higher than 50 or 100 NTU, but these systems are expensive and may not be affordable for all small PWSs (ODEQ 2010).

Turbidity, especially during periods of heavy rainfall, affects the ability of Oregon cities to provide safe drinking water to residents. In 1996, a heavy storm caused a dramatic spike in turbidity, causing the City of Salem to shut down their PWS for eight days and increasing turbidity at many other drinking water intakes in the Willamette and Lower Columbia River basins (USGAO 1998). DEQ recently released a study of turbidity for public water systems (PWSs) in Oregon with drinking water source areas (DWSAs) in the North and Mid Coast Ranges (ODEQ 2010). The report includes case studies of eight PWSs and status reports of an additional ten PWSs. Some systems, such as Falls City and the Arch Cape Water District, must cease purification at turbidities higher than 5 NTU to prevent their filtration systems from clogging. Some systems, such as Astoria and Forest Grove, may switch from a primary to a secondary DWSA in the case of high turbidity. The City of Yamhill's system can handle episodes of high turbidity, but maintenance and treatment costs increase during these episodes.

A number of studies have linked turbidity to higher drinking water treatment costs. Moore and McCarl (1987) studied overall costs of sediment in the Willamette Valley including those related to drinking water treatment using data from the water treatment in Corvallis. The study indicated that the amount of alum (flocculent) and lime (used to adjust pH in the presence of alum) used by the water treatment plant,

as well as maintenance costs due to sediment pond cleaning and sludge disposal, was significantly related to turbidity with an elasticity of 0.35, indicating that a 1% decrease in turbidity from the source water would result in a 0.35% decrease (~\$0.27 per day for the Corvallis plant) in the amount of sediment-related treatment costs. The authors then extrapolated that cost across the entire Willamette Valley and concluded that a 50% decrease in sediment loads across the Willamette Valley would yield a savings of greater than \$200,000.

The findings of Moore and McCarl (1987) were similar to those of studies in other areas of the United States. Dearmont, et al. (1998) found in a study of 12 treatment plants in Texas that elasticity of cost of chemicals to treat water with respect to turbidity was 0.25. Foca (2002) studied two water systems in North Carolina serving approximately 25,000 people and found that, if turbidity was fixed to an average of 5 NTU, annual savings could be \$7200. Forster, et al. (1987), in a study of twelve treatment systems in Ohio, found that a 25% reduction in soil erosion statewide could result in a \$2.7 million savings in water treatment costs. Holmes (1988) estimated that the cost of treating suspended sediment nationally ranged from approximately \$35 million to \$661 million.

Chapter 4. Natural Variability in Turbidity

Natural weathering and decomposition of rocks, soils, and dead plant materials and the transport or dissolution of the weathered products in water contributes a natural “background” of turbidity-causing suspended and dissolved materials to natural waters (Sorensen, et al. 1977). Large fluctuations of turbidity can be caused by natural disturbances or episodic events, such as fires, floods, and landslides. Natural background varies seasonally and geographically depending on geology, precipitation, and other factors. Turbidity generally increases with rapid increases in stream discharge, generally corresponding to storm events. However, there often are differences in the timing of peak turbidity and peak discharge in forested watersheds, with peak turbidity occurring before discharge (Bogen 1980). The term “hysteresis” is used to describe this effect. In addition, the first storm flows following the summer dry period generally result in higher turbidity than subsequent larger flows due to an initial flush of suspended-sediment (Paustian and Beschta, 1979).

While such patterns would be expected to occur in Oregon streams dominated by rainwater, in systems dominated by glacial meltwater, such as Hood River, natural patterns in turbidity are much different. In such systems, turbidity peaks are generally highest in the summer months due to higher temperatures causing sediment-laden glacial melt to dominate summer stream flows (Bonnie Lamb, ODEQ, pers. comm.) For example, DEQ data collected from two branches of the Middle Fork Hood River in 1999 indicate that turbidity increased beginning in May, peaked in July and August, and began to decrease in September (Figure 25).

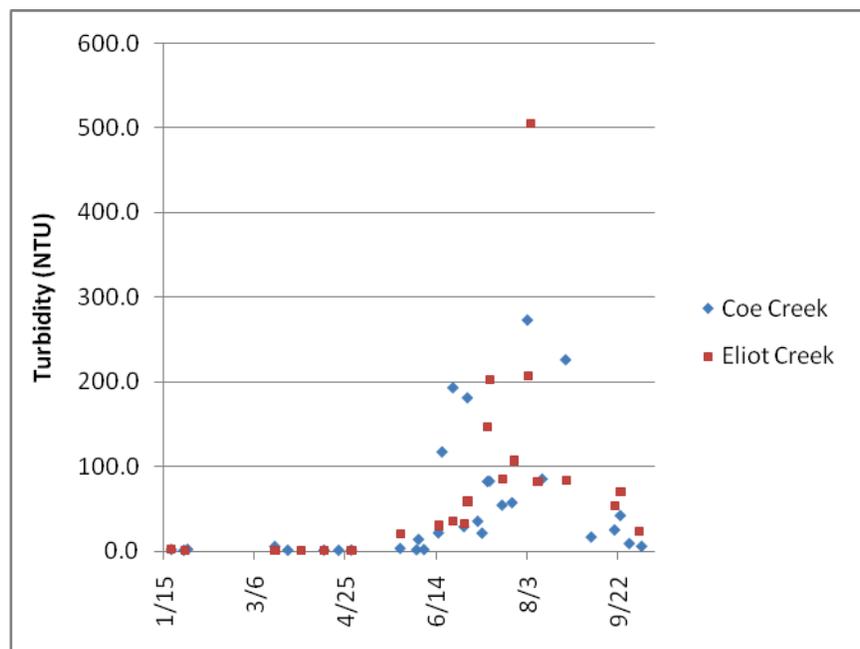


Figure 25. Turbidity in Middle Fork Hood River Tributaries, 1999. Source: DEQ LASAR database.

Water quality in the Hood River is strongly influenced by Mt Hood glaciers. The transport of glacial flour, or fine ground-up sand and stone, from glacial headwater tributaries during summer melt can dramatically increase water turbidity in downstream areas. Literature indicates that glacial turbidity levels such as those found in the Hood River subbasin are high enough to decrease primary production, macro-invertebrate production, and subsequent fish growth and survival (SWCD 2004).

In some cases, natural turbidity levels can be quite variable even in different subbasins of the same watershed due to differences in lithology. For example, Uhrich and Bragg (2003) examined the geology of three subbasins of the North Santiam River above Detroit Creek (Breitenbush River, Blowout Creek,

and North Santiam River) and postulated that Blowout Creek and Breitenbush River were more likely to have turbidity-causing clay materials than the North Santiam. Figure 26 shows daily mean turbidity data at the three sites. The data indicate that, while turbidity at the three sites generally had similar patterns of response to storm events, the magnitude of the response differed from site-to-site. In addition, turbidity at Blowout Creek following a storm event in late January/early February 2000 continued to be elevated, while turbidity at the other sites fell to lower levels.

In estuaries, high levels of suspended sediment naturally occur at the “estuarine turbidity maximum,” the area where the marine- and river-dominated portions of the estuary meet.

This natural background and variability in turbidity ultimately impacts the approach available to Oregon for revising its water quality standard for turbidity. For example, an absolute standard would likely not be achieved in many locations during rain events under natural conditions. At the same time, a relative standard, such as Oregon’s current requirement, potentially allows for cumulative increases in turbidity throughout a stream. Because of these challenges, this report includes a discussion of natural sources and patterns of turbidity to help inform policy decisions.

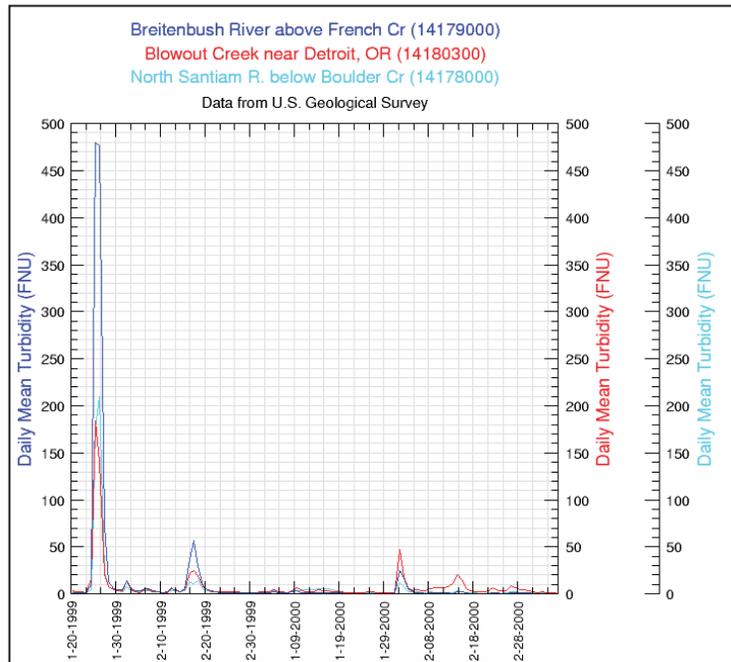


Figure 26. Turbidity in the North Santiam River basin (data from <http://or.water.usgs.gov/grapher/>).

During the dry season, background turbidity levels are relatively low and consistent in small streams throughout Oregon. A six-year DEQ ambient monitoring study completed during the dry season in 2002 inventoried small wadeable stream sites in Oregon’s eight ecoregions (Drake 2004). The study noted that overall median turbidity levels were approximately 1 NTU, regardless of lithology (resistant or erodible), or the degree of human disturbance. Reference site medians for all ecoregions were 1 NTU, except for the Willamette Valley ecoregion with a median of 2 NTUs. However, the Drake (2004) study did not examine wet season conditions, when higher levels of sediment-laden runoff from precipitation and snowmelt contribute to higher turbidity levels from natural and anthropogenic sources, nor did it examine background turbidities in higher order streams, which are of most interest for many point sources that discharge to these waters and could have permits with limits based on water quality standards.

Concentration-Duration-Frequency Analysis

A useful way of examining turbidity data is to conduct a “concentration-duration-frequency” (CDF) analysis (Schwartz, et al. 2008). A CDF analysis analyzes the frequency that a particular “concentration” (e.g., turbidity level) is exceeded for a particular duration. CDFs are useful in examining data to determine if turbidity is exceeding “concentration/duration” thresholds that would be

expected to result in an adverse effect on aquatic life. This method illustrates that, even in relatively undisturbed conditions, turbidity can exceed thresholds at which an effect is expected to occur.

For the CDF analysis, DEQ utilized continuous monitoring stations operated and maintained by the U.S. Geological Survey (USGS) and available at the USGS Oregon Water Science Center (<http://or.water.usgs.gov/grapher/>.) The USGS monitoring stations collect turbidity, discharge¹ and other water quality data at 30 minutes intervals. Turbidity readings are reported in Formazin Nephelometric Units (FNU). For the analysis, DEQ utilized two stations that were identified as being in areas relatively void of anthropogenic influences (C. Anderson, *pers. comm.*) The first station is on the South Fork McKenzie River, just above Cougar Lake. The second station is on the North Santiam River near Mehama. DEQ analyzed turbidity data taken from both stations between February 10, 2003, and September 30, 2006. Using the method described in Schwartz, et al. (2008), DEQ compared turbidity readings at the stations to thresholds of 7, 20, 55, and 150 FNU, which are based on turbidity effect levels contained in Newcombe (2003), as described in Chapter 3. Events exceeding 7 FNU for only one reading were excluded from the analysis, as these could be due to vegetation debris passing by the optical sensor or another inaccuracy (Schwartz, et al. 2008). CDF curves for the two sites are presented in Figures 27 and 28. The charts show the number of “events” (continuous exceedances) lasting a given duration or longer. For example, at the South Fork McKenzie River, there were ten events exceeding 20 FNU that lasted 1.5 hours or longer and two events exceeding 150 FNU that lasted 3.5 hours or longer. Looking at it from a slightly different perspective, the longest 7 FNU “event” was just over three days (81.5 hours), the longest 20 FNU event was just over two days (53.5 hours), the longest 55 FNU event was 1 ½ days (36.5 hours), and the longest 150 FNU event was less than ½ day (10.5 hours).

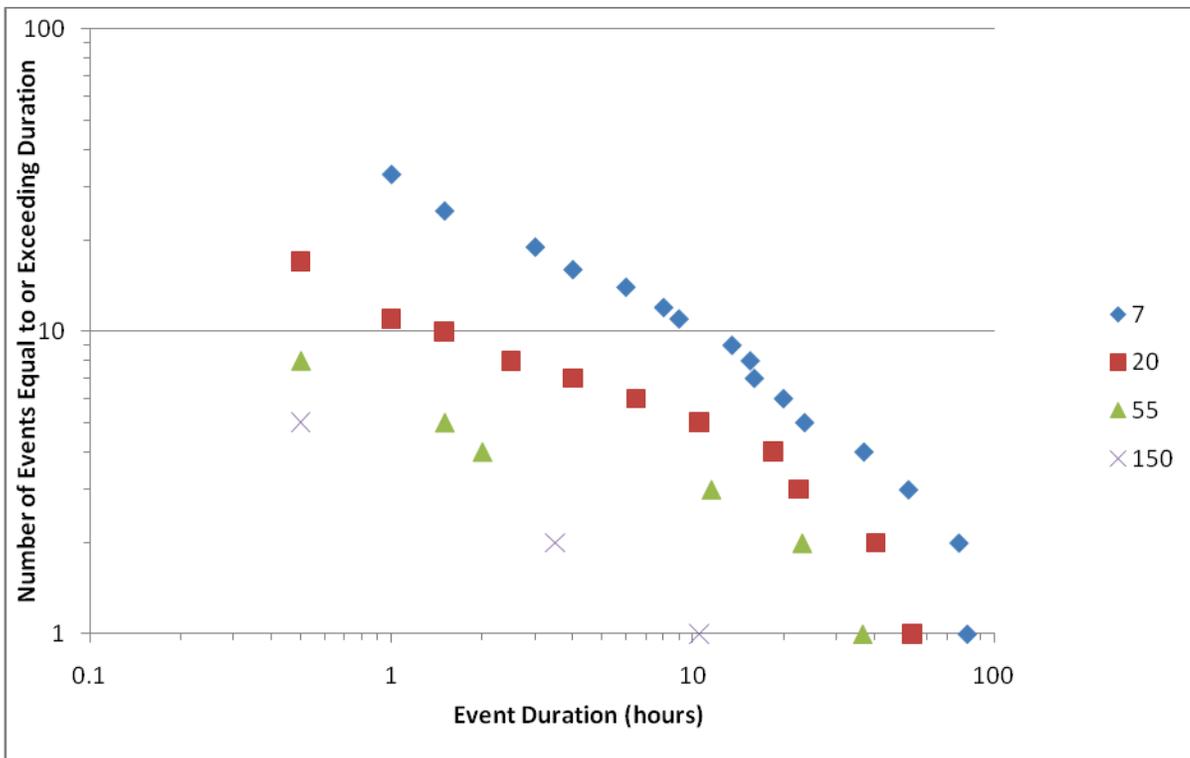


Figure 27. Turbidity CDF Curves for South Fork McKenzie River above Cougar Lake. Data from USGS.

¹ Discharge refers to streamflow, measured in ft³/s.

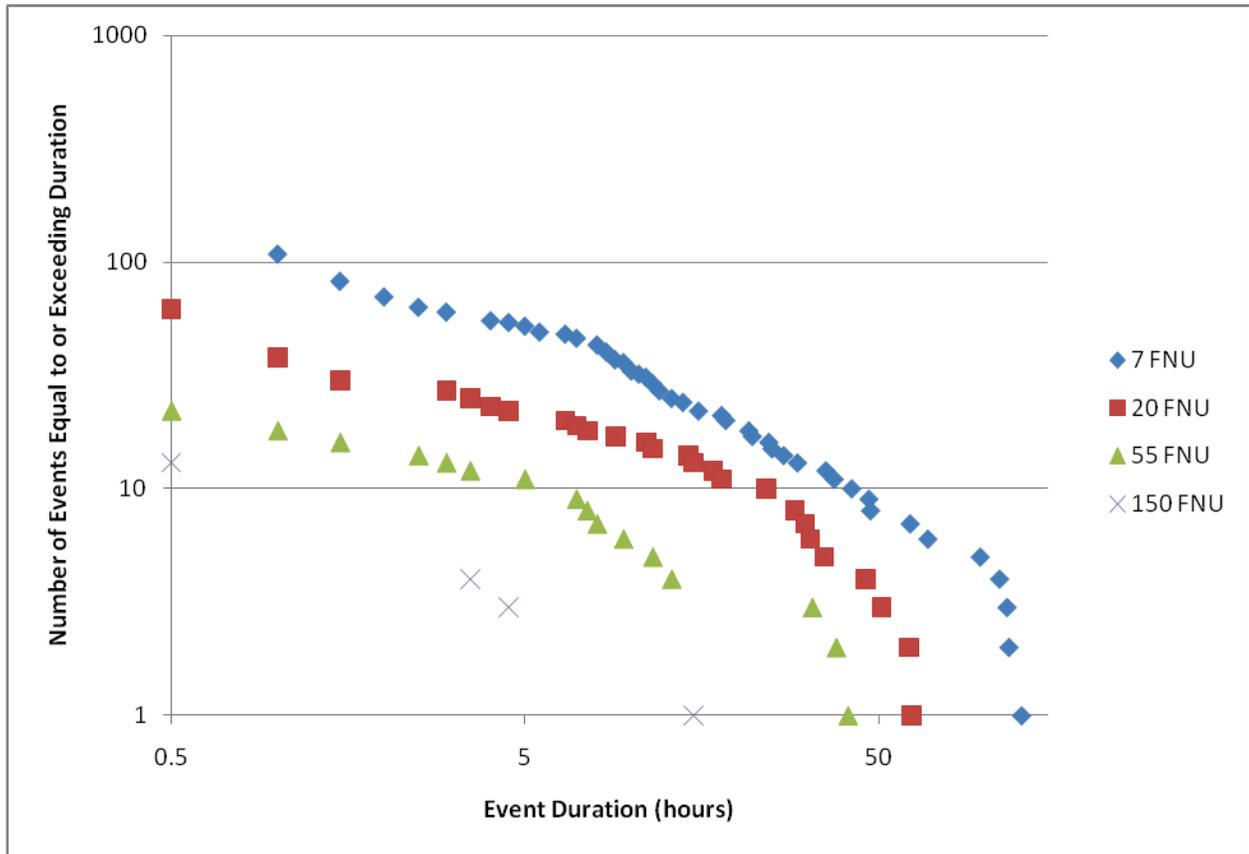


Figure 28. Turbidity CDF Curves for Little North Santiam River at Mehama Station. Data from USGS.

DEQ used the information in the two figures to determine how often continuous turbidity readings exceed a given “concentration/duration” threshold that would expect to have an effect on aquatic life. For the purpose of illustration, DEQ compared the data to “concentration/duration” thresholds expected to produce SEV scores of 2 and 4, corresponding to the midpoint of “slightly impaired” effects and the onset of “significant impairment.” Table 6 presents the results of this analysis.

Table 6. Occurrences of exceeding "concentration/duration" effects thresholds for two continuous turbidity stations in Oregon. The numbers in parentheses in the first column correspond to the duration (hours) at which the turbidity levels are expected to result in an SEV of 2 and 4, respectively)

Concentration/ Duration Combination	SEV =2		SEV = 4	
	South Fork McKenzie Station	Little North Santiam Station	South Fork McKenzie Station	Little North Santiam Station
7 FNU (150 /2980)	0	0	0	0
20 FNU (20/150)	3	10	0	0
55 FNU (2.5/20)	3	14	2	3
150 FNU(<1/2.5)	5	13	2	4

There are some challenges inherent in the method that could underestimate the number of occurrences of impairments. For example, if turbidity readings exceeded 55 FNU for 2 hours, fell to 40 FNU for one reading, then exceeded 55 FNU again for one hour, the methodology would count these periods as two separate “events,” neither of which would be counted as exceeding an SEV threshold of four. From a biological standpoint, such a short duration between “events” would be insufficient to allow recovery of aquatic life. Regardless of this issue, the data show that, even in natural undisturbed conditions, turbidity can exceed levels expected to result in slight-to-significant impairment per the definitions in Newcombe (2003).

Turbidity-Discharge Relationships and Land Use Impacts

In this section, DEQ presents an analysis of seasonal and spatial relationships in turbidity data to assess whether any patterns emerged. DEQ examined continuous turbidity datasets from the USGS in four watersheds for general patterns in turbidity readings. DEQ used mean daily turbidity for the analysis. For each station, DEQ examined adjacent land use patterns, median turbidity, the percentage of days each station had a mean daily turbidity greater than 5 and 10 FNU.

In addition, DEQ modeled the relationship between discharge and turbidity for each station using the equation $T=a*Q^b$, where T is turbidity, Q is discharge, and a and b are parameters associated with an ordinary least squares, log-transformed regression. DEQ created a graph at each station illustrating how turbidity and discharge varied over a single year and analyzed how the relationship compares to what might be expected in Oregon streams. In many streams, the relationship between discharge and turbidity during storm events show “looped-shape” relationships between the two variables, referred to as “hysteresis.” For example, Figure 29 illustrates the hysteresis effect on the Clackamas River over approximately three days during a storm. Bogen (1980) notes that in many forested streams, the highest concentration of sediment (and, generally, turbidity measurement) occurs before the peak discharge when the discharge increases at the most rapid rate. In many systems, suspended sediment transport

(and associated increased turbidity levels) are dependent upon the rate of increase in flow, the period of time since the last time water flowed over the area contributing to sediment, and other factors (Bogen 1980). However, in some cases, the peak sediment concentration occurs after the discharge peaks. In relation to this analysis, such a pattern may indicate anthropogenic causes of increased sediment and turbidity levels in the water column. Williams

(1989) attributed this case to three possible reasons: 1) the suspended sediment flux

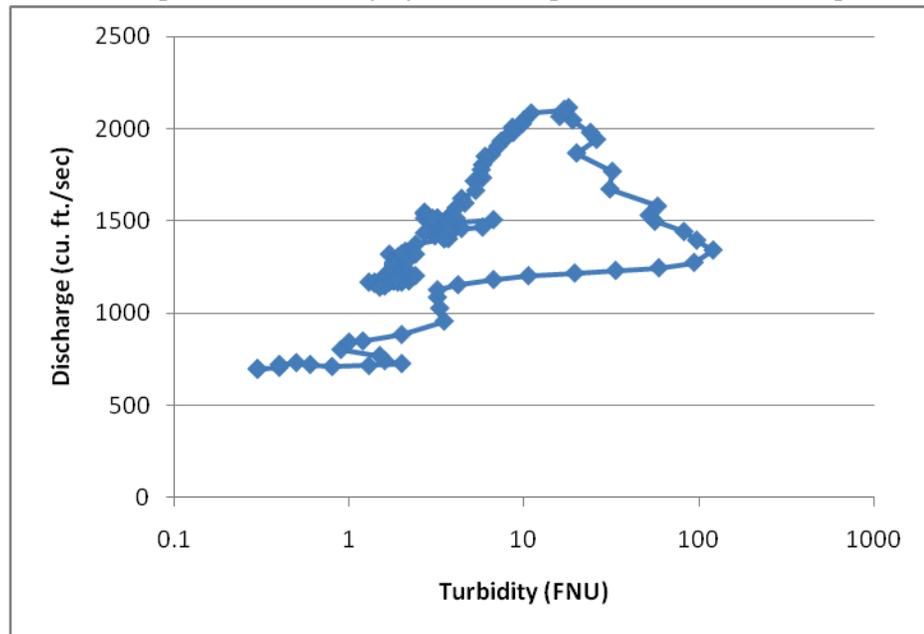


Figure 29. Example of hysteresis effect in turbidity vs. flow relationship for the Clackamas River at Estacada station. Data from USGS (<http://or.water.usgs.gov/grapher/>)

travelling at a velocity slower than the flood wave; 2) high erodibility in combination with a prolonged period of erosion; and 3) seasonal variability in rainfall and sediment production.

Johnson Creek. DEQ analyzed turbidity data sets from two stations in Johnson Creek. The first is in Gresham near Regner Road. The other station is in Milwaukie (Figure 30). Land surrounding the Regner station includes medium-intensity urban development with some agricultural land use and mixed and evergreen forest. Land use at the Milwaukie station is primarily medium-to-high intensity urban development. DEQ examined turbidity data dating from November 9, 2004, to April 25, 2010. Turbidities at both sites are characterized by frequent spikes throughout the rainy season. Overall, turbidities were lower at the downstream site than the upstream site with median turbidities of 15 FNU at the Regner site and 9.5 FNU at the Milwaukie station. These median turbidities were the highest of any of the four watersheds examined. At the Regner station, 94% of daily mean turbidities exceeded 5 FNU and 68% exceeded 10 FNU. At the Milwaukie station, these numbers are 81% and 47%, respectively. Discharge was a better predictor of turbidity at the Milwaukie station ($T=0.383*Q^{0.892}$, $r^2=0.77$) than at the Gresham station ($T=4.96*Q^{0.483}$, $r^2=0.59$). Turbidity data from 2007-2008 at the Milwaukie station indicate a close correlation between turbidity and discharge, with peaks often occurring simultaneously (Figure 31). Data from the Regner Road site indicate a much flashier turbidity pattern; turbidity levels increase substantially even with small flow increases (Figure 32). For example, turbidity increased to 116.7 FNU on March 2, 2008, concurrent with a very small flow increase.

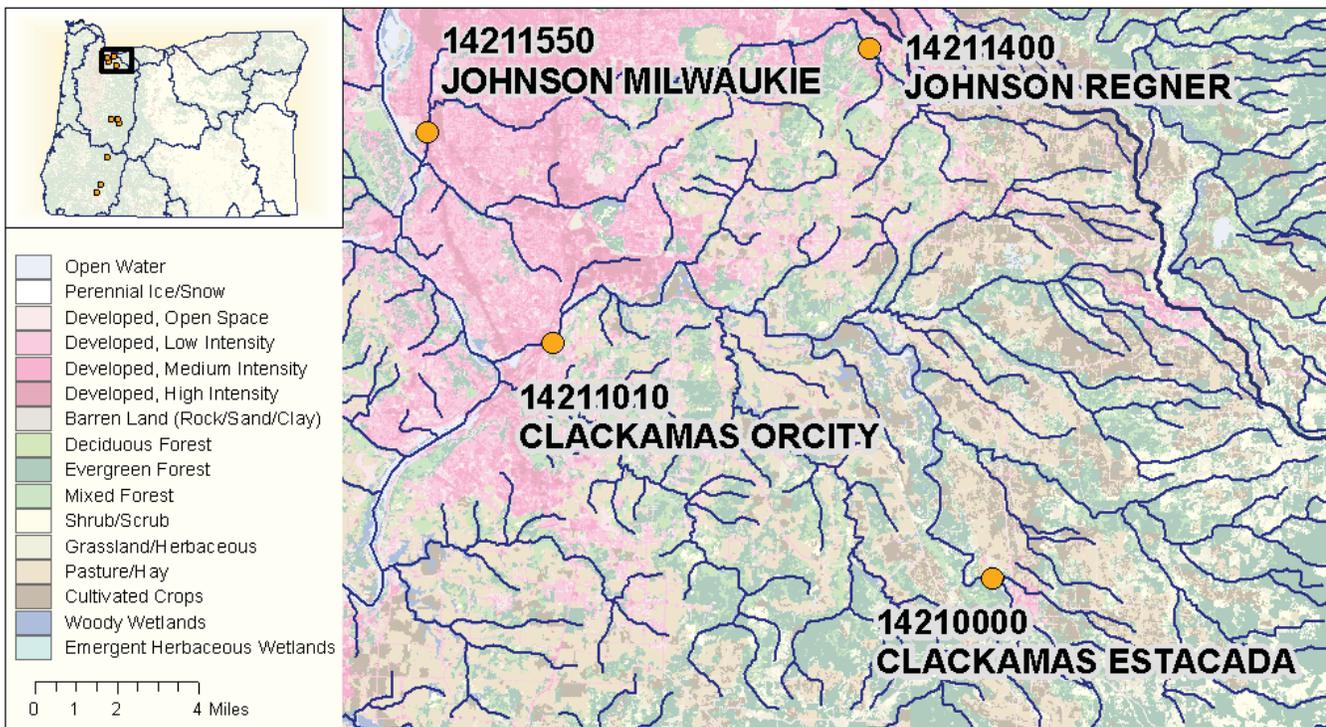


Figure 30. Location of turbidity data stations in Johnson Creek and Clackamas River from <http://or.water.usgs.gov/grapher/>.

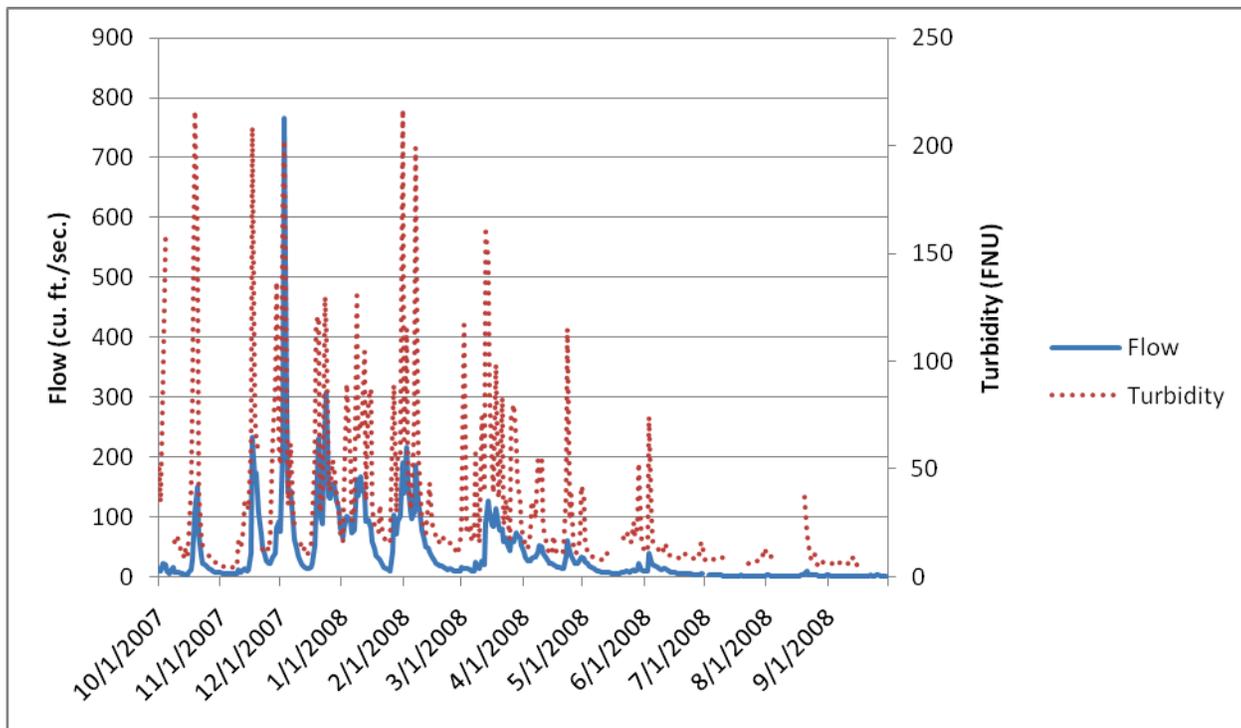


Figure 31. Turbidity vs. Flow, Johnson Creek at Regner Road, 2007-2008. Data from USGS Data Grapher, <http://or.water.usgs.gov/grapher/>.

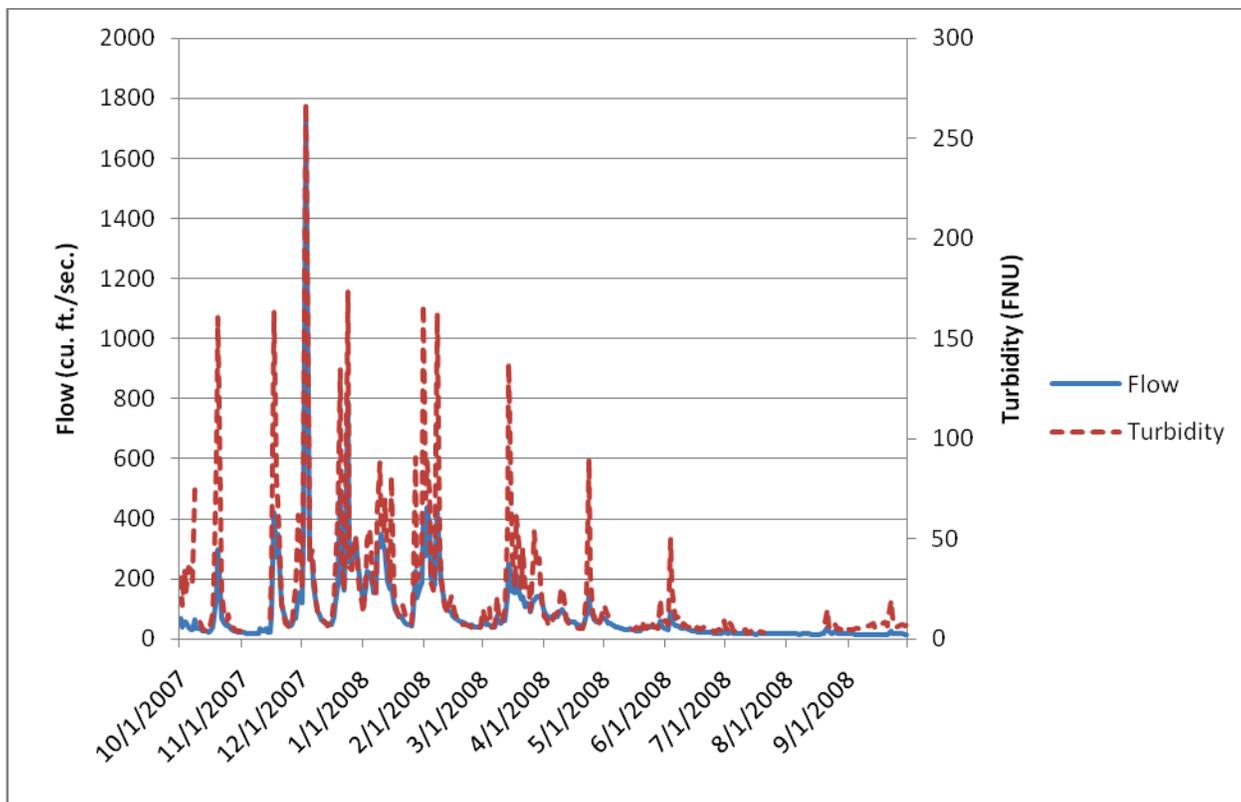


Figure 32. Turbidity vs. Flow, Johnson Creek at Milwaukie, 2007-2008. Data from USGS Data Grapher, <http://or.water.usgs.gov/grapher/>.

Clackamas River. The two Clackamas River stations are located in Estacada and Oregon City (Figure 30). Land use at the Estacada station is primarily pasture and cultivated crops with some forested areas. The station is directly below a series of reservoirs. Land use at the Oregon City station is primarily low-to-medium intensity development with some agriculture and forested areas. The station is in an area that is rapidly urbanizing. DEQ examined turbidity data dated from June 20, 2002, to April 26, 2010. Turbidities at both stations were very low overall with median turbidities of 1.1 FNU at the Estacada station and 1.2 FNU at the Oregon City station. At the Estacada station, 9.6% of turbidity readings exceeded 5 FNU and 4.7% exceeded 10 FNU. At the Oregon City station, these numbers are 13.5% and 6.5%, respectively. Turbidity and discharge were more correlated at the Oregon City station ($T=2.27*10^{-4}*Q^{1.14}$, $r^2=0.71$) than at the Estacada station ($T=8.65*10^{-4}*Q^{0.976}$, $r^2=0.48$), which could be at least partially due to reservoir effects. This is consistent with the turbidity versus discharge patterns in 2008-2009 (Figures 33 and 34). The data at the Estacada stations indicate that turbidity responded to the first storm-related flow peak in mid November 2008 and a subsequent higher peak flow in January 2009 (Figure 33). Turbidity responses to later peak flows of lesser magnitude appears slightly lower until another high peak flow event in May 2009, during which turbidity also increased substantially. At the Oregon City station, turbidity and flow appear to correlate well throughout the year.

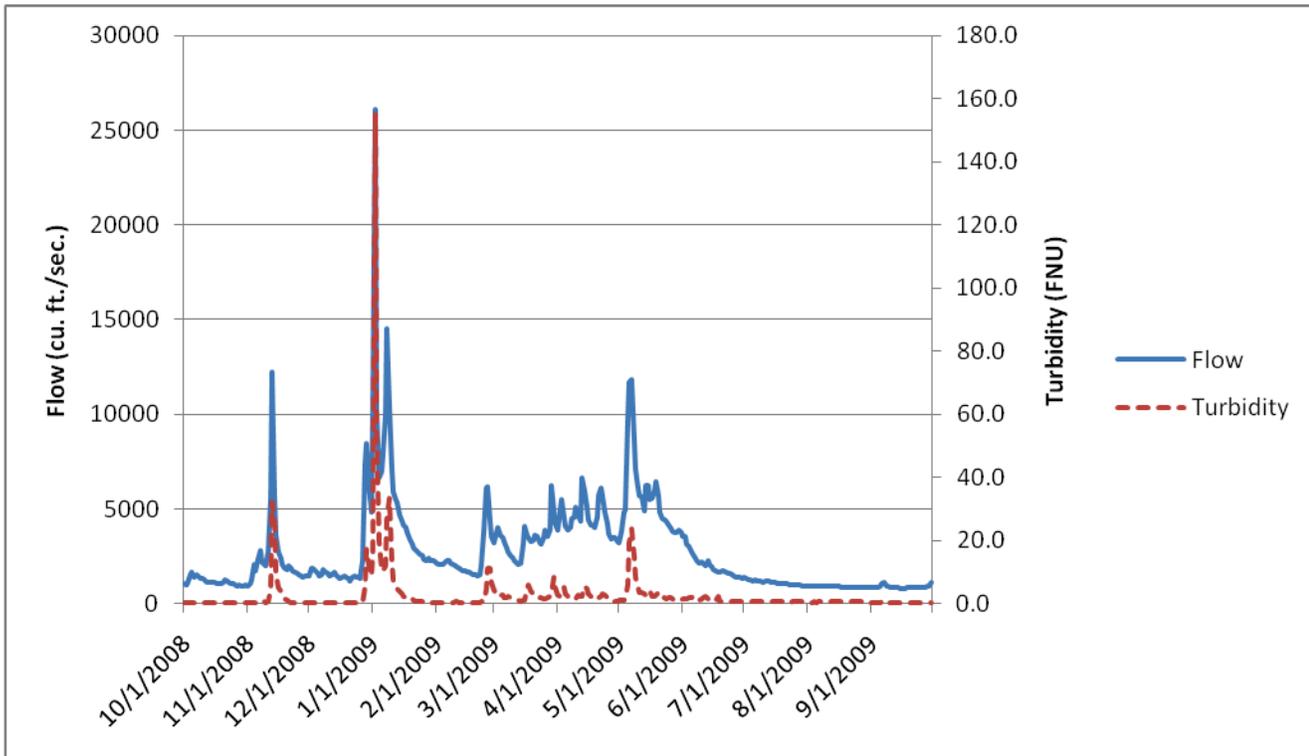


Figure 33. Turbidity vs. Flow, Clackamas River at Estacada, 2008-2009. Data from USGS Data Grapher, <http://or.water.usgs.gov/grapher/>.

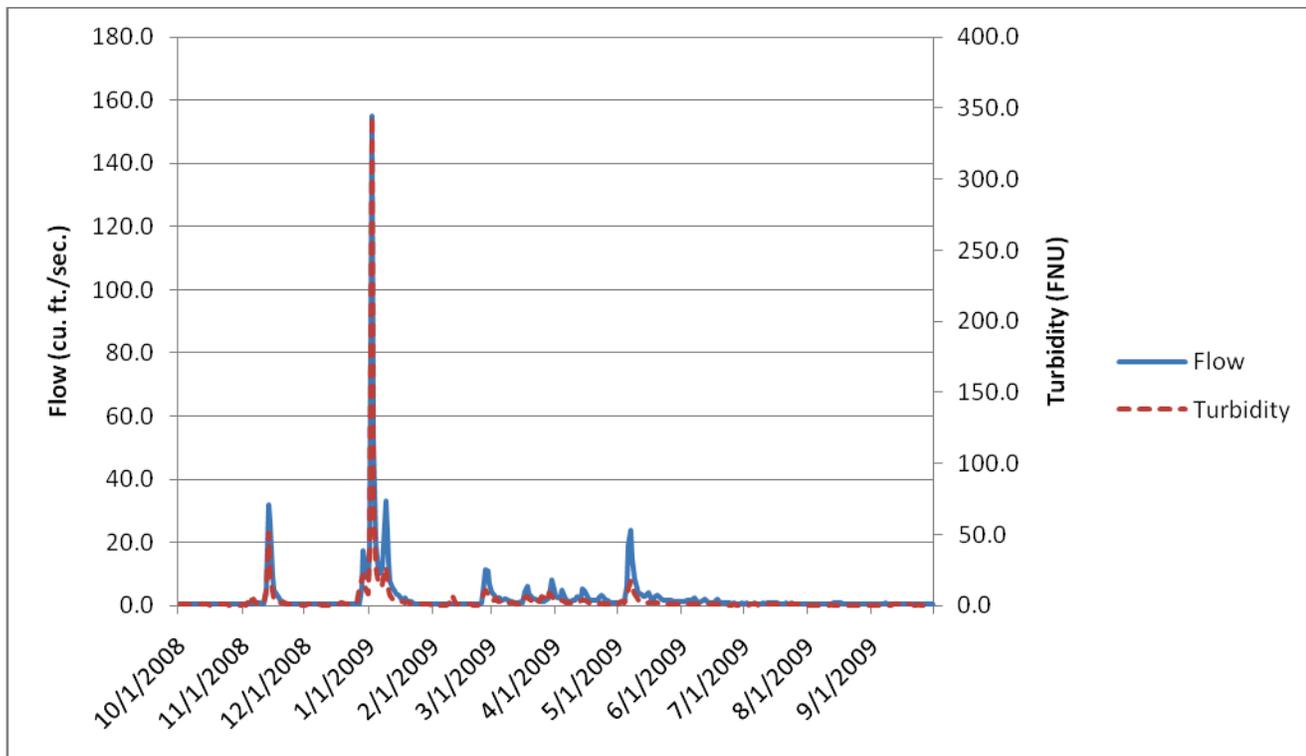


Figure 34. Turbidity vs. Flow, Clackamas River at Oregon City, 2008-2009. Data from USGS Data Grapher, <http://or.water.usgs.gov/grapher/>.

McKenzie River. DEQ analyzed data from two stations in the McKenzie River; the first is on the South Fork McKenzie River upstream of Cougar Lake; the second is in the mainstem McKenzie River near Vida (Figure 35). Initially, DEQ looked at turbidity data from a third station, just below the Cougar Dam, but ultimately excluded these data because of influences of controlled water releases from the dam on turbidity. Land use at the Cougar Lake station is almost exclusively forested. Land use at the Vida station is primarily forested and shrub/scrub. DEQ examined turbidity data dating from January 13, 2003, to September 30, 2006. Turbidity at both stations occasionally spiked during the rainy season, but overall remained very low, although turbidity at the Vida station (median=1.2 FNU) was somewhat higher than at Cougar Lake station (median of 0.1 FNU), which had the lowest median turbidity of any station considered in this analysis. Some of the higher turbidity at Vida may be explained by some controlled releases from the reservoir at Cougar Lake in 2003. At the Cougar Lake station, 2.2% of turbidity readings exceeded 5 FNU and 1.1% exceeded 10 FNU. At the Vida station, these numbers were 8.6% and 4.0%, respectively. Discharge was slightly better at predicting turbidity at the Cougar Lake station ($T=6.40 \times 10^{-5} * Q^{1.24}$, $r^2=0.46$) than at the Vida station ($T=2.95 \times 10^{-5} * Q^{1.32}$, $r^2=0.40$), but both relationships were generally weak compared to other sites. The turbidity versus discharge pattern in 2005-2006 at both stations was consistent with what would be expected in a forested stream (Figures 36 and 37). Turbidity was more responsive to the first storm-related flow peak in late October/early November 2005 than subsequent flow peaks of lesser magnitude. When flow greatly increased in early January of 2006, turbidity again responded, but was less responsive to flow increases for the remainder of the year.

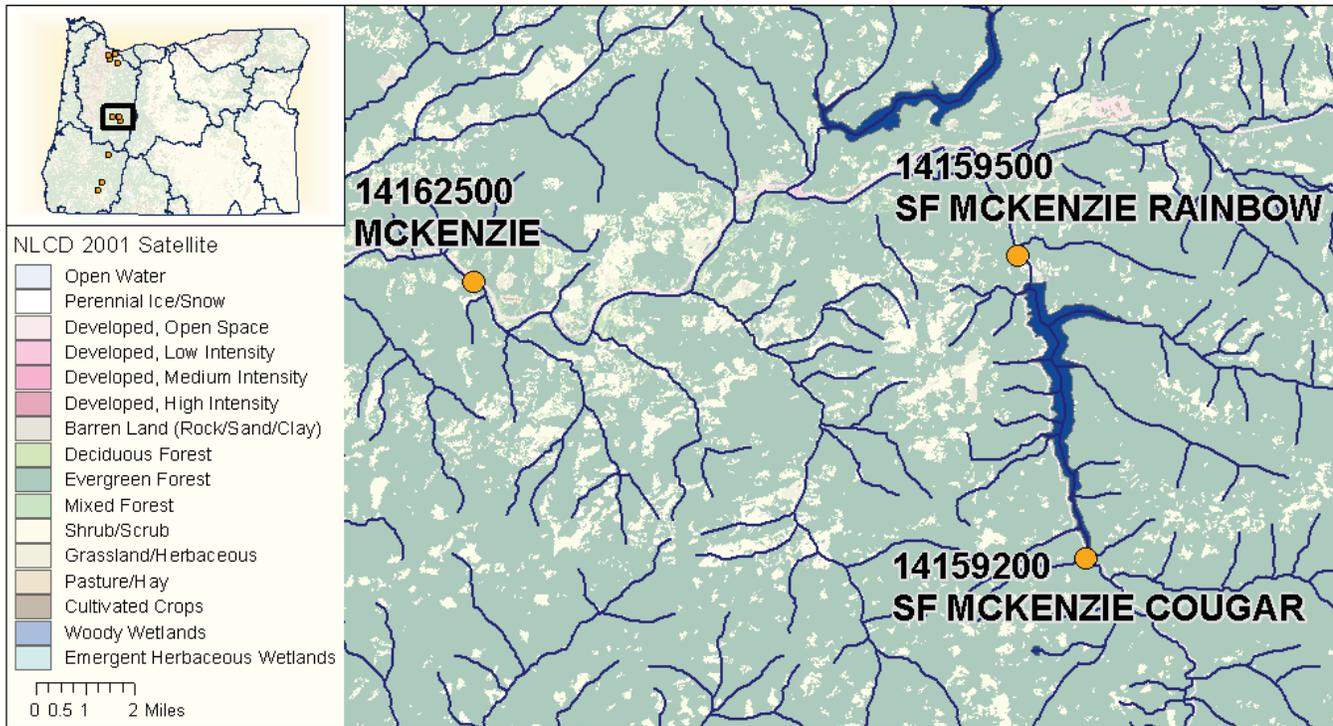


Figure 35. Location of turbidity data stations in South Fork McKenzie River from <http://or.water.usgs.gov/grapher/>.

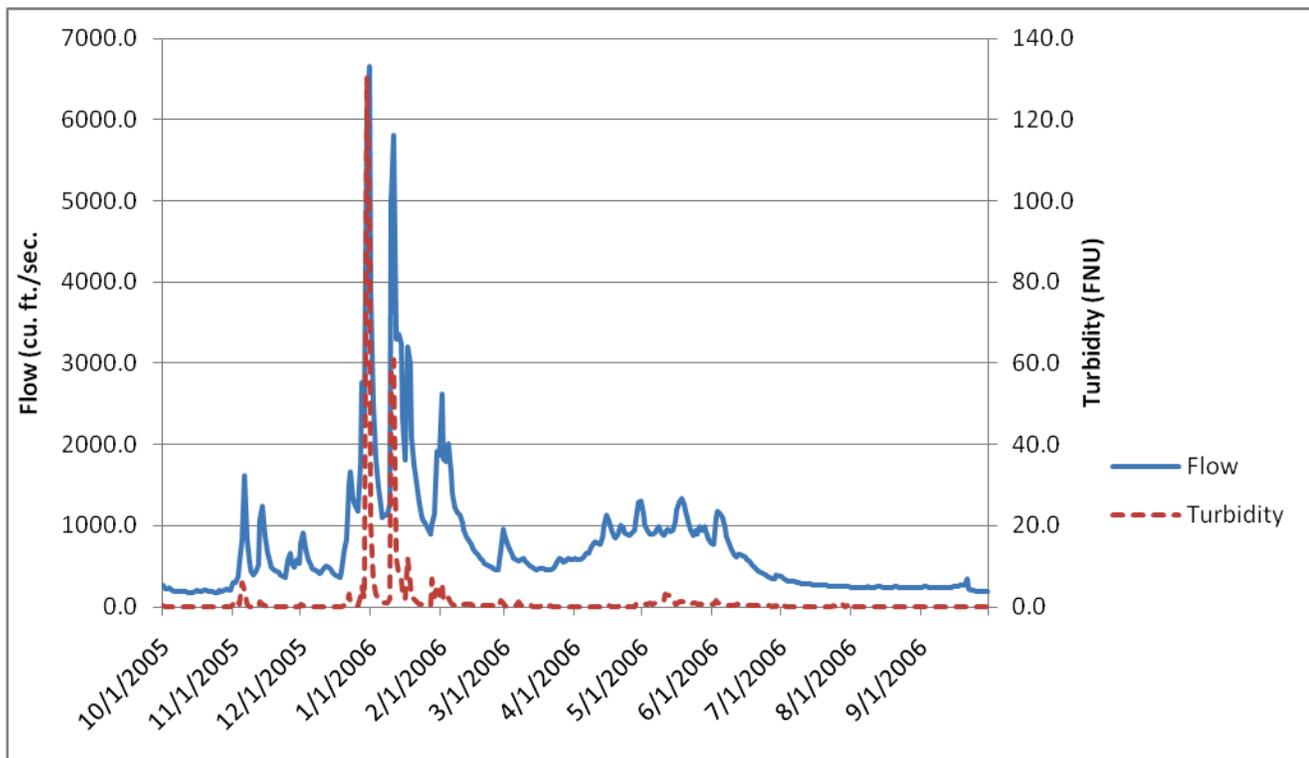


Figure 36. Turbidity vs. Flow, South Fork McKenzie River upstream of Cougar Lake, 2005-2006. Data from USGS Data Grapher, <http://or.water.usgs.gov/grapher/>.

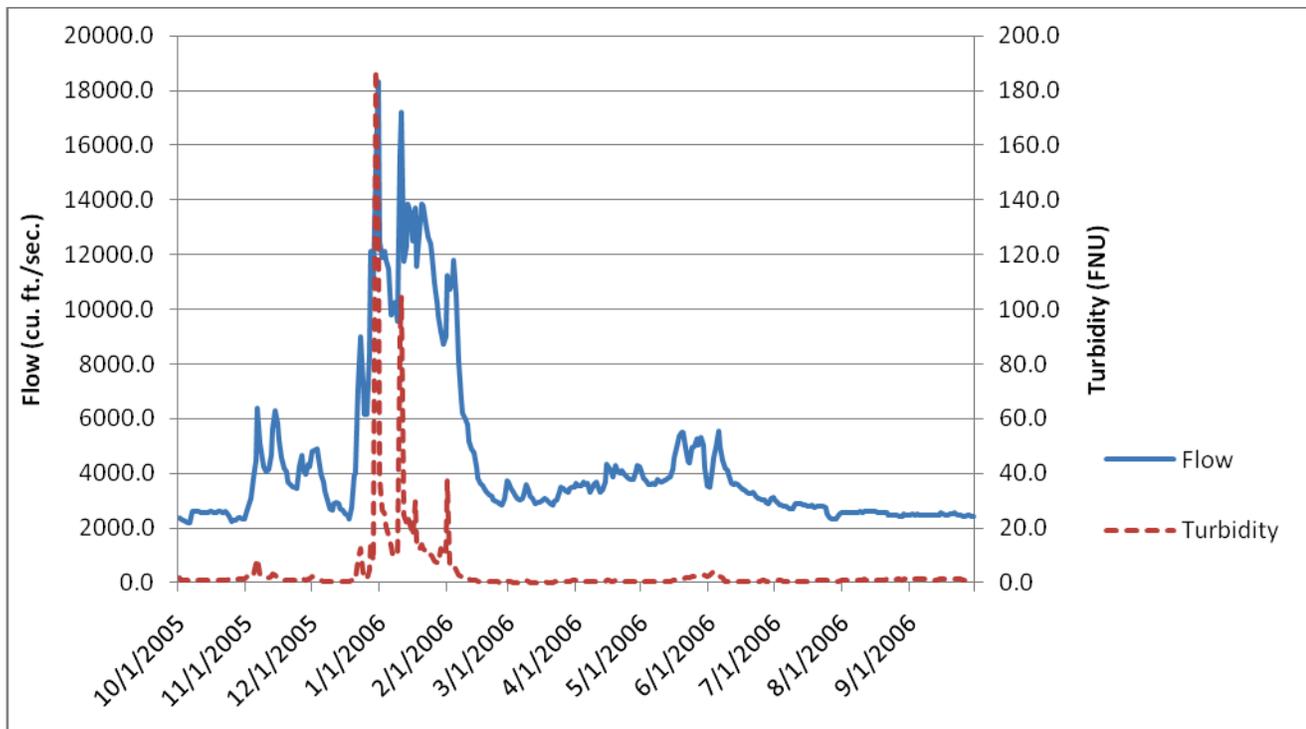


Figure 37. Turbidity vs. Flow, McKenzie River near Vida, 2005-2006. Data from USGS Data Grapher, <http://or.water.usgs.gov/grapher/>.

Rogue River Basin. Two stations from the Rogue River Basin were examined: the first on Elk Creek near Trail; the second on the mainstem Rogue River near Eagle Point (Figure 38). Land use at the Elk Creek station is almost exclusively forested. Land use at the Eagle Point station is primarily agricultural with woody wetlands in the immediate vicinity. A reservoir immediately downstream of the Elk Creek Station may decrease turbidity at the Eagle Point station. DEQ examined turbidity data dating from June 1, 2001, to June 12, 2006. Median turbidities were 2.6 FNU at the Elk Creek station and 1.9 at the Eagle Point station. At the Elk Creek station, 27.6% of turbidity readings exceeded 5 FNU and 12.0% exceeded 10 FNU. At the Eagle Point station, these numbers were 24.9% and 14.2%, respectively. The discharge-turbidity relationship was stronger at the Elk Creek station ($T=0.311 * Q^{0.499}$, $r^2=0.57$) than at the Eagle Point station ($T=2.99 * 10^{-4} * Q^{1.19}$, $r^2=0.22$), which is likely due to reservoir effects. Turbidity and flow data from 2004-2005 generally follow expected patterns at both sites, with peaks occurring concurrently and quickly returning to baseline levels shortly after peak flows (Figures 39 and 40).

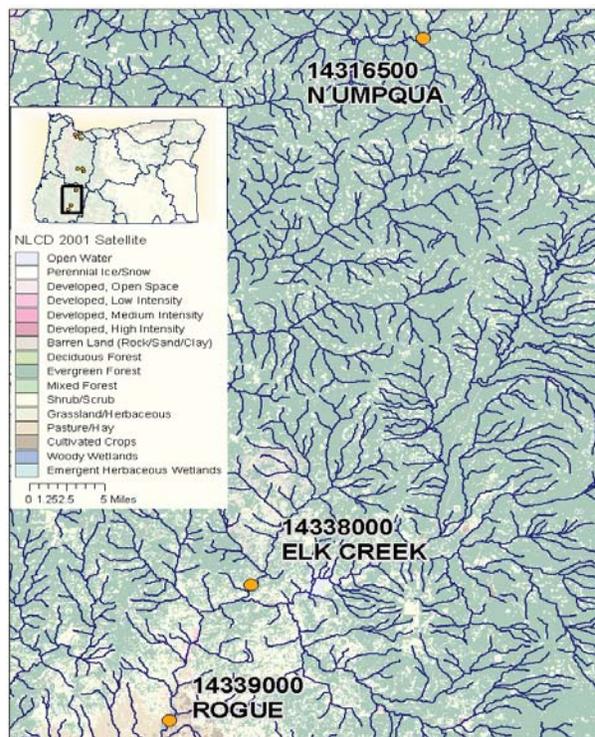


Figure 38. Location of turbidity data stations in the Rogue River station South Fork McKenzie River from <http://or.water.usgs.gov/grapher/>.

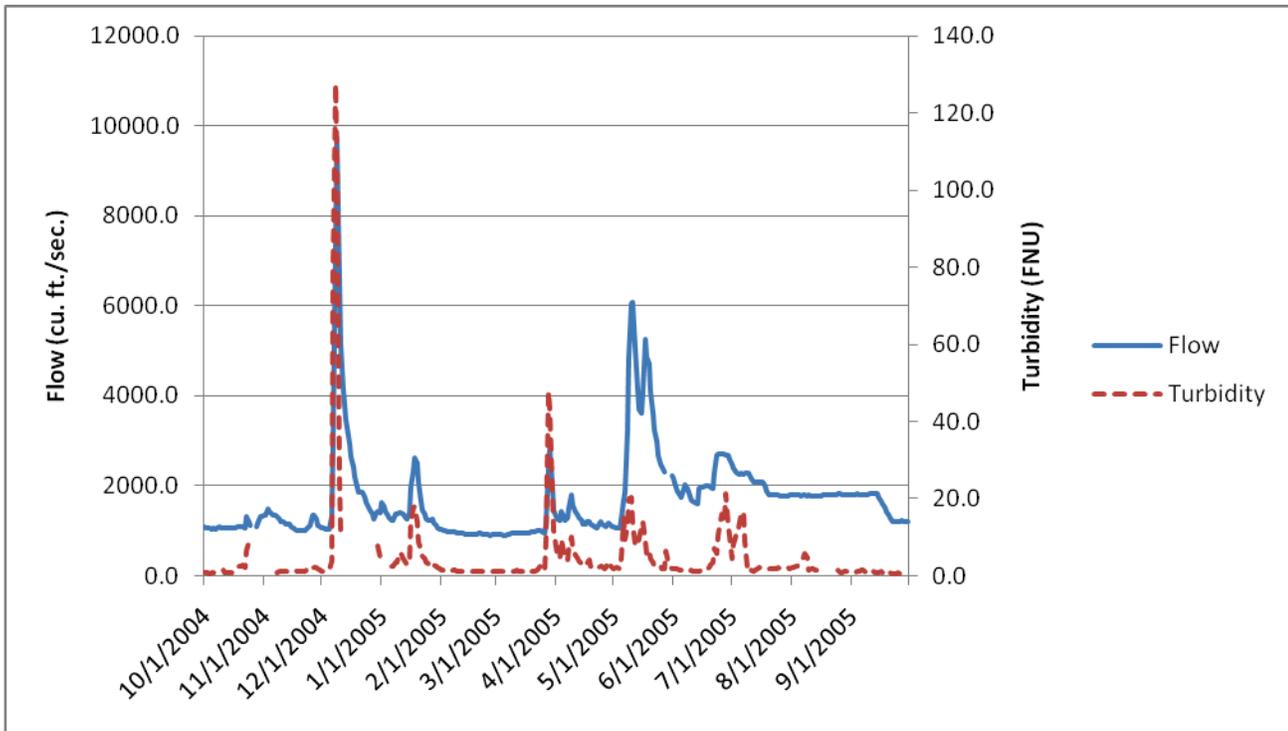


Figure 39. Turbidity vs. Flow, Rogue River at Eagle Point, 2004-2005. Data from USGS Data Grapher, <http://or.water.usgs.gov/grapher/>.

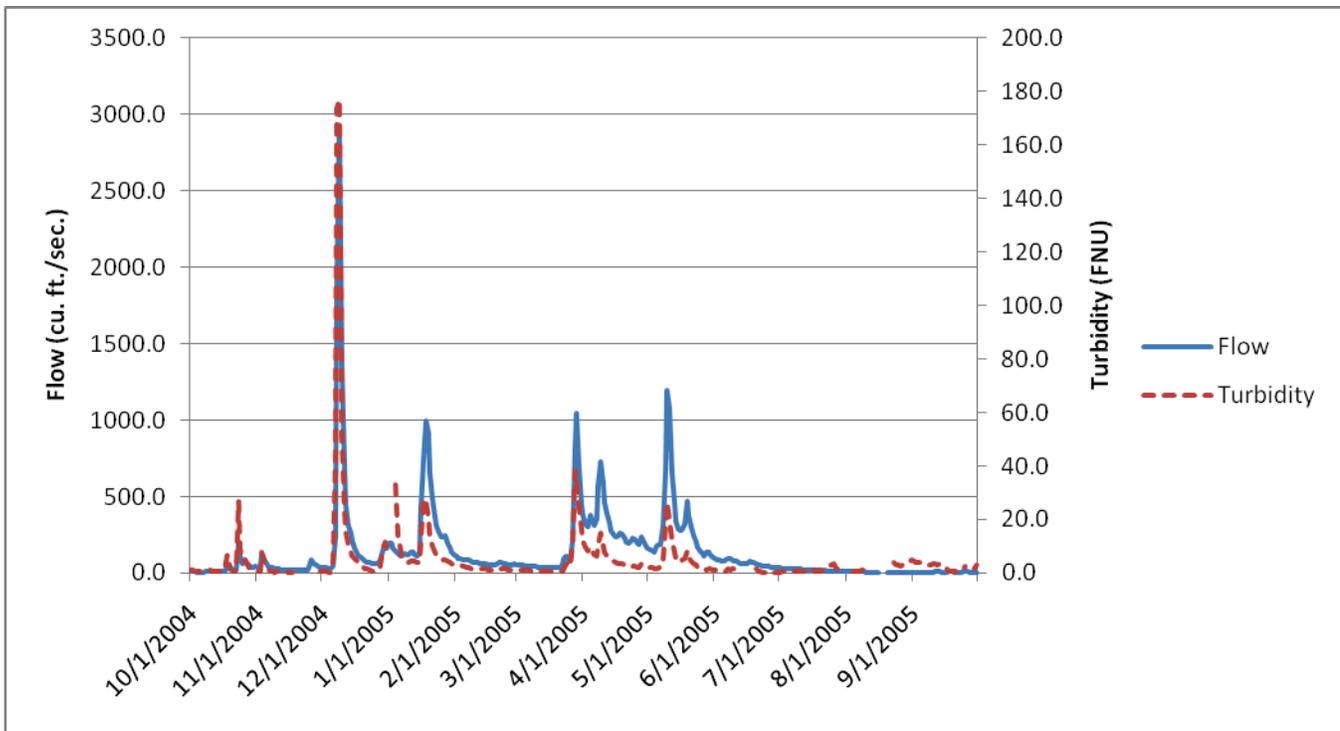


Figure 40. Turbidity vs. Flow, Elk Creek, 2004-2005. Data from USGS Data Grapher, <http://or.water.usgs.gov/grapher/>.

Longitudinal Patterns in Turbidity

Only a handful of studies have examined longitudinal changes in turbidity along the course of water bodies in Oregon. Many things can influence how turbidity may differ between locations. Influences such as dams, inputs of clear water from tributaries, and settling in water of slower velocity may result in turbidity decreasing from upstream to downstream. However, resuspension, inputs of turbid water, erosion, and anthropogenic inputs of turbid water can potentially increase turbidity.

Hughes and Gammon (1987) measured turbidity and several other parameters two times at each of 26 sites along the mainstem Willamette River in August 1983 to examine the interaction of fish assemblage data and water quality. The data indicate a general increase in turbidity from upstream to downstream, with a few peaks associated with a wastewater treatment plan, a pulp-and-paper mill, a landfill, and a natural slough (Figure 41). However, this is only a snapshot of the Willamette in one month and is limited as to its applicability to other locations and time periods.

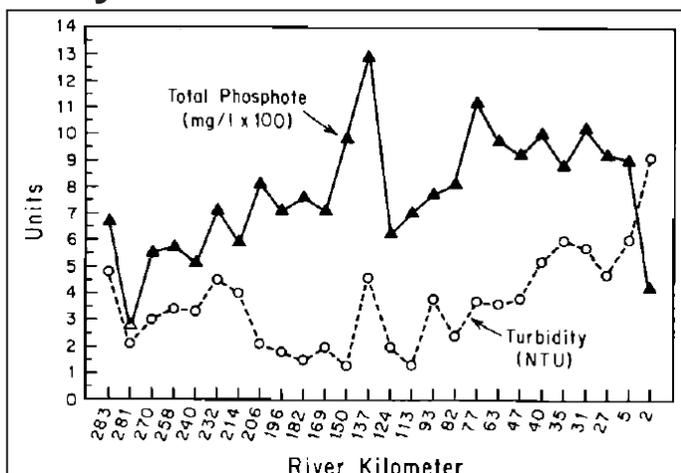


Figure 41. Turbidity at 26 Willamette River sites in August 1983. Source: Hughes and Gammon (1987).

The National Council for Air and Stream Improvement (NCASI), as part of a Long-Term Receiving Water Study (LTRWS) has collected turbidity data periodically since 1997 on the Willamette and McKenzie Rivers. NCASI measured turbidity at four sites along the mainstem McKenzie River between river miles 26.5 and 6. In addition, turbidity was measured on a tributary, the Mohawk River, upstream of its confluence with the McKenzie River (at river mile 14 of the McKenzie River) (NCASI 2002). NCASI measured turbidity at four sites along the Willamette River between river miles 160 and 132, as well as on one site on the Long Tom River upstream of its confluence with the Willamette at approximately river mile 147 (NCASI 2002).

DEQ examined 1997-2009 NCASI data at these sites. Data were categorized as “dry season” (June-September), “early wet season” (October-January) and “late wet season” (February-May). Figures 42 and 43 show how median turbidity changes from upstream to downstream in the Willamette and McKenzie Rivers for each “season.” Median turbidity at the Mohawk River site is indicated by the dots in Figure 40. Median turbidity for the Long Tom River, which enters the Willamette between the RM 156 and RM 136 stations, was 3.2 NTU in the dry season, 36 NTU in the early wet season, and 20 NTU in the late wet season.

The McKenzie River data indicates that the turbidity trends mildly higher from upstream to downstream in all seasons. The Willamette River data indicate upward trends in turbidity from upstream to downstream during the early and late wet seasons, but no consistent trend during the dry season. Turbidity readings in both rivers, and, in particular, the Willamette, could be influenced by a number of factors, which makes it difficult to explain such trends. For example, on the Willamette, turbidity readings could be influenced by inputs from the Long Tom River and Muddy Creek. Turbidity at both sites can be influenced by direct runoff into the rivers, settling of particles in slower reaches, effluent discharges, and other influences.

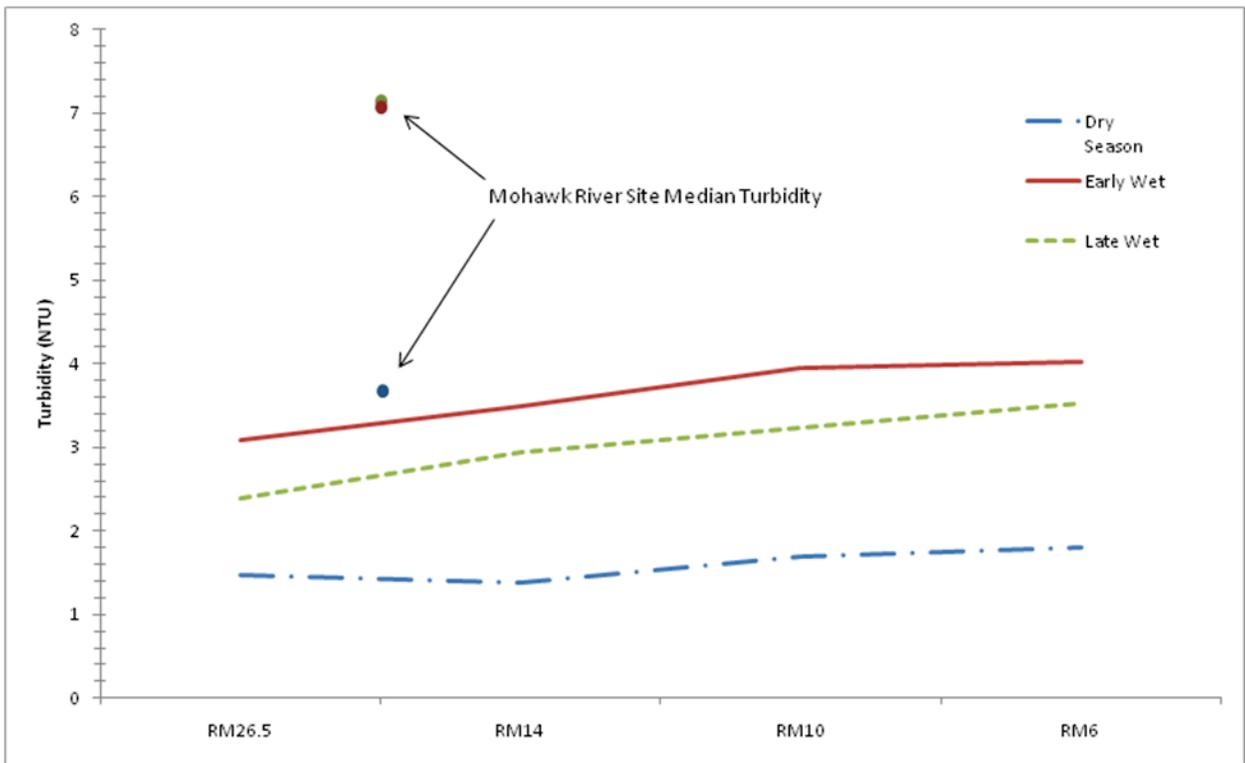


Figure 42. Turbidity at four sites on the McKenzie River, OR, 1997-2009. Data provided by NCASI.

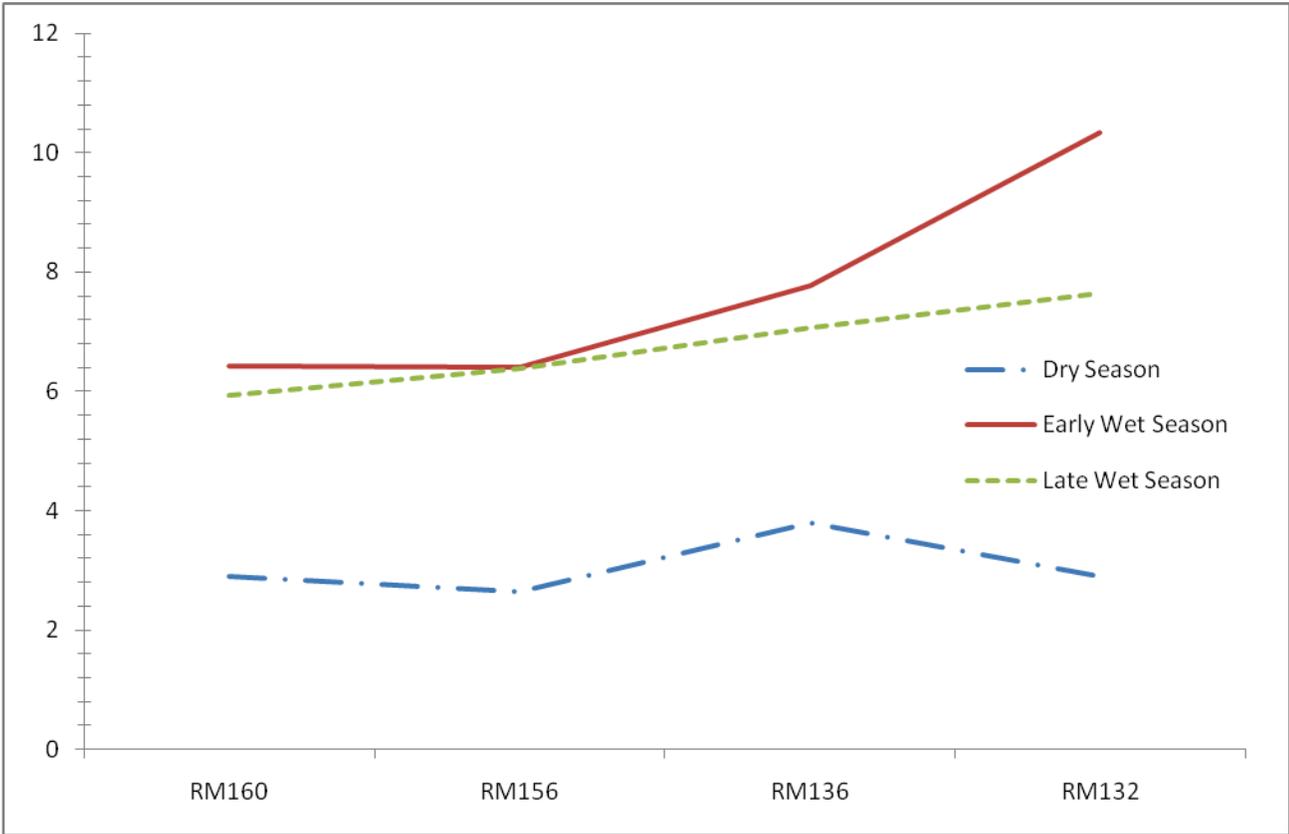


Figure 43. Turbidity at four sites on the Willamette River, OR, 1997-2009. Data provided by NCASI.

Conclusions. The information examined here highlights the difficulty in characterizing natural turbidity regimes in Oregon. In most forested streams, data indicate that turbidity increases with flow during storm events and generally peaks before or at the same time as peak flow. Turbidity generally returns to baseline within 72 hours of peak flow. However, in areas that are prone to higher erosion, turbidity can persist for longer. At the same time, even in watersheds/regions with high clay content, the transport of sediment will likely be a hydrologically-driven phenomenon (Beschta, 1987). In streams where flow is dominated by glacial melt, data indicate turbidity patterns are significantly different than in forested areas. In such streams, turbidity peaks during the summer months, when glacial melt carries large amounts of sediment. In addition, turbidity exhibits a diurnal pattern, peaking in the late afternoon/early evening in response to warmer temperatures, and decreasing as temperatures decrease.

The data also appear to indicate that land use patterns have an impact on turbidity patterns. For example, areas with intense land use (Johnson Creek) had higher turbidity readings; areas within the influence of a reservoir showed dampened turbidities. Several stations showed a fairly consistent relationship between stream discharge and turbidity. However, in more disturbed areas, such as Johnson Creek, turbidity patterns appeared flashier, perhaps more prone to small precipitation events, whereas less disturbed areas appear less susceptible to such influences. More analysis would have to be done to determine if such differences are due to lithology, hydrology, or other factors.

Few studies have examined longitudinal changes in turbidity in Oregon streams. A few data sets examined related to the Willamette and McKenzie Rivers generally indicate an increase in turbidity from upstream to downstream; however, there are exceptions, and, without additional analysis, more work would need to be done to determine what influences are behind such trends, or lack thereof. In addition, it would be helpful to examine longitudinal changes in turbidity in streams outside of the Willamette Valley and lower Cascades ecoregions.

Chapter 5. Conclusions and Data Gaps

To better understand the potential effects of turbidity on aquatic life, DEQ considered peer-reviewed literature and agency publications regarding effects on the following endpoints that are correlated with increased turbidity:

- primary productivity;
- cascading effects of decreased primary productivity on zooplankton and fish;
- decreased macroinvertebrate density;
- SAV in estuaries on the West Coast;
- fish feeding dynamics and behavior focusing on native Oregon fish and non-native recreationally important fish species;
- recreation; and
- drinking water treatment.

In general, DEQ did not find that effects of increased turbidity on aquatic life in rivers differed from that in lakes. In estuaries, juvenile fish appear to be better adapted to the naturally higher turbidity levels in their environments. Based on the studies reviewed for this report, even very low levels of chronic increases in turbidity (as low as 1-2 NTU above clear water conditions) are shown reduce primary productivity in lakes and streams where productivity is limited by light (Lloyd, et al. 1987; Quinn, et al. 1992; Davies-Colley, et al. 1992). A few studies indicate that increased photosynthetic efficiency can compensate for effects of turbidity on primary productivity (e.g., Parkhill and Gulliver 2002); however, the same Parkhill and Gulliver (2002) study also showed decreased periphyton biomass and macrophyte cover associated with increased turbidity. Thus, it appears that increased photosynthetic efficiency does not counteract negative effects of chronic turbidity overall.

Chronic turbidity levels as low as 2.6 NTU in streams have been correlated with reduced invertebrate density in streams; Oregon data show that turbidity levels as low as 7-10 NTU are associated with “poor” benthic macroinvertebrate assemblages. Such effects are not directly from turbidity, but more likely from clogging of habitat. However, some literature suggests that turbidity is the best indicator of sediment effects on benthic macroinvertebrates in streams. In lakes, chronic turbidity levels as low as 1.3 NTU has been correlated with reduced zooplankton density in lakes, which is the result of reduced light penetration, which reduces the food base for zooplankton (Lloyd, et al. 1987).

A number of studies show that reactive distance of fish decreases exponentially with increased turbidity levels. At the same time, many studies show that fish, particularly salmonids, are able to feed even at moderate turbidities, although overall feeding rates may decrease. Moreover, increases in turbidity may cause fish to switch to a more active foraging strategy, ultimately reducing growth without a corresponding increase in food availability. Adverse growth effects on fish have been shown at

turbidities as low as 10 NTU for five-day exposures in streams (Sweka and Hartman 2001b). Other studies streams show growth effects at turbidity levels between 20 and 30 NTU. Daily pulses of turbidity (four-to-six hour pulses) of 23 NTU have been shown to affect fish growth (Shaw and Richardson 2001). Over the long-term, studies show that intermediate turbidity regimes in rivers result in reduced biomass of fish depending on foraging strategy; such models show that high turbidity regimes ultimately result in fish dying out from starvation (Harvey and Railsback 2004; 2009).

Literature shows that juvenile fish utilize turbidity as cover from predators. Several studies (Abrahams and Kattenfeld 1997; Ginetz and Larkin 1976; Gregory and Levings 1998) indicate preferential use of turbid over clear waters in juvenile fish. However, juvenile fish also exhibit reduced anti-predator behavior in turbid waters, resulting in no significant change in predation rate compared to clear water (Abrahams and Kattenfeld 1997). Moreover, streamside vegetation has been shown to be more important than turbidity as cover in some cases (Gregory and Levings 1996; Gadomski and Parsley 2005). Even if turbidity does provide cover, it can reduce foraging success (Noggle 1978; Berg 1982; Berg and Northcote 1985; Harvey and White 2008). Models indicate that use of turbidity as cover would not counteract other effects unless accompanied by a significant increase in prey for juvenile fish (Harvey and Railsback 2009), which is not likely given that higher turbidity levels are generally accompanied by lower levels in zooplankton and macroinvertebrates.

In estuaries, reduced light penetration limits growth of submerged aquatic vegetation (SAV) in some areas; however, many other factors, such as current velocity, sediment characteristics, temperature, and salinity, also may be important. The U.S. EPA derived a significant relationship between water clarity and SAV growth in the Yaquina Bay and recommended light attenuation coefficients of 0.8 m^{-1} (marine-dominated portion of the estuary) and 1.5 m^{-1} (riparian-dominated portion of the estuary) to protect SAV growth. However, additional data is needed to determine light requirements for SAV growth in other estuaries. For fish in estuaries, the evidence suggests that juvenile fish prefer moderate levels of suspended sediment to balance the need for protection against predators with effects of turbidity on foraging.

Studies indicate that turbidities as low as 2 NTU may affect public perceptions of the suitability of water for swimming and aesthetics. As noted in section 3.2.1, these levels are based on studies in New Zealand; however, “perceptual set” theory would indicate that perceptions of recreational users of Oregon waters would be similar to those in New Zealand, given similarities in climate and types of lakes and rivers in the two locations; this is especially the case in western Oregon. Effects of turbidity on fishing are primarily related to catch rates; thus, setting a water quality standard for turbidity based on aquatic life protection should simultaneously ensure that fishing is protected.

Studies have shown that turbidity reductions from source waters can reduce treatment costs for public water systems (PWSs). However, such costs appear to be minor when spread across all users of a system. What is perhaps more significant is that turbidity levels as low as 5 NTU have caused the shutdown of PWSs that treat water using slow sand filtration, including the eight day shutdown of the Salem PWS in 1996 (USGAO 1999) and periodic closures of other smaller systems (ODEQ *in publication*).

A major difficulty in reporting turbidity effects literature is that studies used different turbidimeters; some studies don't report the type of turbidimeter used at all. As noted in Chapter 2, different turbidimeters can report significantly different turbidity readings, even when using the same type of

light source and detector configuration. As such, confidently comparing effects reported from different studies presents an analytic challenge, particularly at turbidities less than 10 units (Telesnicki and Goldberg 1985). However, when looking at short-term effects of turbidities higher than 10 units, primarily effects on predator-prey interactions in fish, differences among turbidimeters poses a challenge to drawing definitive conclusions. For the purposes of this report, however, DEQ reported turbidity levels shown to cause effects as they were in the literature. DEQ will further address this uncertainty relative to setting a water quality standard for turbidity as part of policy discussions during rule development.

Variations in turbidity measurement using different devices, as well as natural fluctuation in turbidity levels in Oregon waters support the use of a water quality standard for turbidity expressed in terms of a relative increase from ambient concentrations. At the same time, such an approach could result in underprotection of beneficial uses by allowing numerous discharges of turbid water within a single watershed. In streams with few or no anthropogenic influences, turbidity occasionally exceeds “concentration/duration” thresholds for negative impacts on aquatic life. If DEQ adopted a relative criterion for turbidity, such issues would be minimized, assuming that measurements upstream of a source were performed using the same instrument and same operator as the downstream measurement. At the same time, an absolute standard may make most sense for landscape-level turbidity impacts where identification of “background turbidity” or a “control point” are complicated.

Data Gaps

There are a number of data gaps with respect to our understanding of turbidity and its effect on beneficial uses. With current resource constraints, DEQ is not able to perform the data collection needed to conduct such an extensive analysis to examine all the gaps identified in its development of water quality standards for turbidity. However, it is important to acknowledge that, given such data gaps, there will be some uncertainty as DEQ moves forward with developing and adopting a water quality standard for turbidity that is both protective of beneficial uses and can be implemented across water quality programs.

There is a general lack of local data in Oregon regarding how increased turbidity levels can impact primary productivity in Oregon streams. NCASI has been collecting information regarding primary productivity and turbidity on stretches of the Willamette and McKenzie River. Additional studies in shallower streams would also be helpful in determining how conditions in Oregon differ from those in Alaska and New Zealand where such relationships have been studied.

One difficulty in analyzing fish effects literature is that each study differs somewhat in method, exposure duration, turbidity regime, and other features. As such, DEQ is limited in being able to examine if turbidity affects different fish species differently. Such information could assist DEQ in determining if different turbidity criteria might be appropriate depending on the most sensitive fish present in a given stream, similar to the approach DEQ has taken on the temperature standard (OAR 340-041-0028).

A major data gap that constrains DEQ’s approach to a water quality standard is a general lack of understanding of natural patterns of turbidity. While dry season data indicate that, in wadeable streams, natural levels of turbidity are very low (1-2 NTU), there isn’t a robust analysis regarding natural turbidity levels in the wet season, when most turbidity-causing sediment moves through the system. The IMST (2006) suggested several methods that might be helpful for taking into account natural

backgrounds of turbidity. These suggestions include using anthropogenically least disturbed or minimally disturbed eco-regional reference sites, landscape based models, and turbidity constituent analyses. While such approaches would greatly assist in characterizing natural turbidity regimes in Oregon, they would require a great deal of data collection. Given current resource constraints, DEQ is not able to collect sufficient data to implement any of these approaches. Another approach would entail additional “concentration-duration-frequency” analyses (page 51) in reference sites outside of the west Cascades, assuming such data are available. Additional information on longitudinal changes in turbidity would be helpful outside of the limited data that are available on the Willamette and McKenzie Rivers. Finally, it would be helpful to model suspended sediment and turbidity relationships based on substrate. Such information has been developed by the USGS in the North Santiam River and would be helpful in other streams, as well.

As noted in Chapter 2, turbidity readings can differ greatly among different meters using different technologies. Some researchers have begun to use transmissometry and black disk measurement as more reliable measures of water clarity. Additional data utilizing these approaches would be helpful, as would an examination of the relationship of these measures to turbidity. A study similar to that done by Lewis, et al. (2007), examining the differences between turbidity readings using different instruments and different substrates, would also assist in decreasing some of the uncertainty inherent in measuring turbidity.

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Appendix A. Sources of turbidity in Oregon

Natural Sources of Turbidity

Natural weathering and decomposition of rocks, soils, and dead plant materials and the transport or dissolution of the weathered products in water contributes a natural “background” of turbidity-causing suspended and dissolved materials to natural waters (Sorensen, et al. 1977). Transport of sediment and organic matter in mountain streams is the result of numerous interacting processes (Beschta, et al. 1981). Vegetation absence or loss from natural attrition, windthrow, fire, and/or seismic events, along with precipitation (or wind) events can increase soil erosion and contribute to hydraulic and airborne transport of turbidity-causing sediments into waterways. In steeper, forested headwaters in much of Oregon, canopies and associated detrital material make such areas resistant to erosion (Sorensen, et al. 1997).

In lakes and reservoirs, while coarser sediment inputs from streams generally settles out of the water column rapidly, small particles, such as clay, can remain in the water column for days and weeks (Kirk 1985). Moreover, sediment can be re-suspended by wind and waves (Arruda 1983). In addition, plankton blooms can result in turbid water in lakes (Utne-Palm 2002).

In estuaries, plankton blooms, bioturbation, soil erosion, and resuspension of sediments by wind, waves and currents can result in turbidity (Wilber and Clarke 2001). Wilber and Clarke (2001) summarize studies of natural suspended sediment levels reaching as high as 10,000 mg/L due to climactic events. Turbidity in estuaries can be influenced by wind speed, particle size and wave action (Cyrus & Blaber 1987). Tidal influences can cause a great fluctuation in suspended sediment-caused turbidity (Wilber and Clarke 2001).

Anthropogenic Sources of Turbidity

The following section presents literature regarding practices that can contribute to anthropogenically increased turbidity. With proper best management practices and/or treatment, such sources can be controlled, preventing significant impacts to beneficial uses. However, if done improperly or without the right safeguards in place, these sources can be significant contributors to increased turbidity levels.

Agriculture

Agricultural practices without proper BMPs have been shown to increase suspended sediment loads into rivers, reservoirs, and lakes that can contribute to increased turbidity levels (Arruda 1983). In Oregon, studies have shown that erosion from cropland is a major contributor to suspended sediment. In 2003, water (sheet and rill) erosion on cropland was estimated to be 5.8 million tons in Oregon (NRCS 2007). A DEQ study found that more than half of rivers near agricultural land in Oregon showed suspended sediment (and, presumably, turbidity) in mid- to most-disturbed conditions (Mulvey, et al. 2009). This is consistent with a 1997 study that found that agriculture in the Willamette Basin contributes the greatest amount of suspended sediment to the River (Miller, et al. 1997).

Construction and Urbanization

Urban development and construction of roads and buildings without proper BMPs have the potential to contribute substantial amounts of turbidity-causing sediments to Oregon’s waters. Urban sites in the Willamette River basin contribute the greatest amount of suspended sediment to the river per acre (USGAO 1998). Construction sites without proper controls can contribute 35 to 45 tons of sediment to waters per year (USGAO 1998). Approximately 29% of streams near high and medium-intensity urban land uses and 17% of streams in low-intensity urban land uses were found to be in poor condition for total suspended solids in the Willamette Valley (Mulvey, et al. 2009). Total suspended solids at construction sites were significantly elevated compared to reference sites in a Colorado study (Cline, et al. 1982). However, one study found that road construction in forested watersheds of western Oregon was not a major influence on turbidity for domestic water sources (Grizzel and Beschta 1993). A study of the impacts of highways on sediment loads in the Navarro River watershed in California found that the major highway in the area contributed less than 1% of total sediment loads (Johnson, et al. 2002).

Direct Discharges (municipal, industrial and stormwater)

As compared to nonpoint sources, relatively little work has been done to examine the extent to which direct discharges impact turbidity levels. A longitudinal study on the Willamette River indicated turbidity peaks (an increase of 1-2 NTU compared to the nearest upstream station) downstream of a sewage treatment plant and a pulp mill, as well as from landfill and a pulp mill lagoon (Hughes and Gammon 1987). The National Council for Air and Stream Improvement (NCASI) has been measuring effluent turbidities from mills in Halsey and Springfield as part of a long-term receiving water study. Measurements from these mills taken from 1998 to 2001 indicate turbidities ranging from 7.7 to 33.1 NTU (NCASI 2002; 2003a; 2003b). Barter and Deas (2003) present the mean turbidity of different effluents measured with five different turbidimeters in New Zealand (Table A1).

Source	Mean NTU (±SD)
Stormwater	22.08±1.83
Fish processing effluent	110.70±11.01
Domestic waste water A	88.40±10.87
Domestic waste water B	170.51±18.89
Domestic waste water C	204.46±16.52
Dairy wash water	251.43±53.04
Apple processing effluent	305.90±65.09
Meatworks effluent	506.04±80.36

Table A1. Mean Turbidities from New Zealand effluents (from Barter and Deas 2003)

Dredging

Wilber and Clarke (2001) summarize potential impacts of dredging on suspended sediment concentrations. In general, concentrations of resuspended sediments vary depending on dredge and sediment types and environmental conditions at the time of dredging. Mechanical dredging (bucket and clamshell) increase sediment concentrations more than hydraulic dredging unless hydraulically pumped sediments are allowed to overflow. For a clamshell dredge, the maximum concentration of a sediment plume was 1,100 mg/L and extended as far as 1000 meters along the bottom. For hydraulic dredges, maximum concentrations are generally less than 500 mg/L and the plume usually extended 500 meters from the dredge (LaSalle 1990).

Forestry

Road construction and maintenance, harvesting, slash disposal, and site preparation associated with forest operations have the potential increase the availability of turbidity-causing sediment to streams (Everest, et al. 1987). A number of studies have looked at the potential for forest operations to increase turbidity. An eight-year study of the effects of logging in the Alsea Watershed found that suspended sediment levels were more than 200% higher in a basin that was clearcut without buffer strips than in an unharvested subbasin, and more than 50% higher in a basin that was clearcut with buffer strips than in

the unharvested basin (Moring 1975). Studies of two subbasins (Kilchis and Tillamook) of the Tillamook Bay Watershed found a correlation between timber harvest and increased July-August turbidity (from 0.2 to 1.2 NTUs) (Naymik, et al. 2005; Ford and Rose 2000). ODF found in a two-year study of turbidity associated with wet weather use of roads on private and state forests in western Oregon that median turbidity increased below stream-crossing culverts (Mills, et al. 2003). Grizzel and Beschta (1983), in a study of 13 western Oregon municipal water sources, found that timber harvesting and road construction operations were not causing sustained increases in turbidity levels. Although forest operations preceding a storm appear to have triggered several landslides that impacted a municipal water source, turbidity increases were short-lived. A study in the Centennial Creek, British Columbia found that the main source of sediment was the main haul road and, to a lesser extent skid trails, landings, and clearcut stream channels (Slaney, et al. 1977).

Since the promulgation of Oregon's Forest Practices Act in the mid-1970s, best management practices on forested watersheds have evolved in response to various monitoring and research efforts. Many of these changes in forest practices have been directed at minimizing road-generated sediment, as well as sediment from other sources. Recently, Reiter, et al. (2009) found, in comparing different sections of the Deschutes River watershed in Washington State, that improved forest management, particularly with respect to road construction and maintenance, were correlated with declining turbidity levels.

Mining

There is a significant body of literature on the effects of placer and suction dredge mining on increased levels of suspended sediments and turbidity. Studies of placer mining indicate that its impact on turbidity can be long-lasting and acute. An early study of the effects of placer mining in the Rogue River Basin indicated that increased suspended sediment concentrations were only found on two of 13 mining impacted sites as compared to an un-mined site (Ward 1938). However, a study of placer mining on the Kenai Peninsula in Alaska found that high values of turbidity in one drainage were associated with mining activity (Huber and Blanchet 1992). Wastewater discharges from mining operations in that study averaged 167 NTU and reached as high as 1150 NTU. Turbidity that was measured daily in a placer mined-creek in Alaska averaged 727 NTU over three months; turbidity in an un-mined site averaged 1.3 NTU (Reynolds, et al. 1989). In a study of the same drainage, the average turbidity at five un-mined sites was approximately 7 NTU over a period of three weeks; average turbidity in eleven mined sites was 175 NTU over the same period (Scannell 1988).

As compared to placer mining, turbidity due to suction dredge mining appears to be short-lived and limited to a small stretch of stream where the dredge is operated. However, cumulative effects of several miners working in the stream, or of mining in the same area over weeks or months, are not clear. According to a literature review by Harvey and Lisle (1998), suction dredging can carry turbidity-causing fine sediment (clay, silt, and fine sand) downstream. Turbidity measurements taken above and below suction dredging on two California streams indicated a localized effect of suction dredge mining (Harvey 1986). At a study of suction dredge impacts in two Alaskan rivers, increased turbidity was noted downstream, but returned to upstream levels 160 meters downstream when an 8-inch dredge was used (Prussian, et al. 1999). A study of three suction dredge sites in Idaho showed that initial increases of turbidity were from 5-37 NTU above background, depending on the type of dredge used. Visible plumes were noted from 70-150 meters downstream, although the plumes were described as either "pulse-like" or "sporadic" (Stewart and Sharp 2003). A study of a 2.5-inch suction dredge in Montana showed increased suspended sediment levels immediately downstream of the dredge; these levels returned to normal within 11 meters downstream (Thomas 1985).

AIIS

Aquatic Invasive Species

ZEBRA MUSSEL



COMMON NAME: Zebra Mussel

The zebra mussel gets its name from the dark and light stripes on its shell that resembles those on a zebra.

SCIENTIFIC NAME: *Dreissena polymorpha*

Zebra mussels are in the Dreissenidae family, the false mussel and zebra mussel family.

DISTRIBUTION: Natively the zebra mussel inhabits parts of western Russia near the Caspian Sea and the Ural River. From its native origin, the species has spread to the point where the zebra mussel now affects the waters of most of Europe. The Canadian provinces of Quebec and Ontario have confirmed populations. As of 2005, sightings have been received from the following states: Alabama, Arkansas, Connecticut, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Michigan, Minnesota, Mississippi, Missouri, Nebraska, New York, Ohio, Oklahoma, Pennsylvania, Tennessee, Vermont, Virginia, West Virginia, and Wisconsin. For the latest distribution of zebra mussels in the United States, please visit the following website:

http://nas.er.usgs.gov/taxgroup/mollusks/zebramussel/maps/current_zm_map.jpg

Indiana: To view a list of the known bodies of water in Indiana that contain zebra mussels, please visit:

http://www.in.gov/dnr/invasivespecies/zebra_mussels_sightings.pdf

DESCRIPTION: Zebra mussels have a triangular shaped shell that rarely exceeds 1.5 inches in length. Their shell is bivalve meaning it has two halves. Usually the shell will have alternating dark and light bands resembling the stripes of a zebra, hence their name. However, not all zebra mussels will have this characteristic coloring pattern, some may

be entirely dark or light. The most distinguishing characteristic to look for would be the tuft of fibers called the byssal threads that grow from the foot and through the hinge of the mussel. These threads allow the mussel to attach to any hard surface. A similar species that may be confused with the zebra mussel is the quagga mussel, another exotic species.



LIFE CYCLE BIOLOGY: Zebra mussels are able to reproduce their second year. Over one spawning season a single female zebra mussel is capable of releasing one million eggs. The eggs will be fertilized when the male and female expel their gametes at the same time. Fertilized eggs develop into larvae called veligers. These veligers are not visible to the naked eye and are about the width of a human hair. They can remain suspended in the water for 3 to 4 weeks before they find a hard surface to attach to; those that don't find a substrate to attach will die. Once attached it takes one year for it to grow one inch and become sexually mature. The maximum age reported in the U.S. is 3 years while in Europe they have been reported to live 4 to 6 years.

Their ability to attach to hard surfaces is due to the tuft of fibers located at the hinge of their shell called byssal threads. These threads produce a powerful glue that anchors the mussel in place. Any hard surface is a suitable place for a mussel to live such as rock, metal, wood, vinyl, glass, rubber, fiberglass, paper, plants, other mussels, and the bodies of slow moving animals like crustaceans and turtles. Zebra mussels will layer over each other forming a dense covering over the substrate. Juveniles have the ability to break their attachment and generate new threads which allows them to drift downstream and find a new home.

Zebra mussels are filter feeders and can filter one liter of water per day. Almost all matter in the water is filtered. Zebra mussels feed on phytoplankton and some small zooplankton. Other matter filtered is expelled as pseudofeces. The zebra mussel has some limiting factors such as water temperature, calcium, pH, substrate, salinity and nutrients. Zebra mussels can only tolerate temperatures from 32 °F to 96°F. They need a temperature of at least 54°F. to reproduce. A calcium level of more than 20 parts per million is necessary in order to survive. The zebra mussel needs an alkaline environment as well with a pH from 7.2 to 9.0. They do best in water where there is an abundance of hard substrate, but they can proliferate in soft sediments. They like freshwater environments with a salinity level of less than 4 parts per thousand. Zebra mussels also do not do well in water that has a high nutrient content.

PATHWAYS/HISTORY: From its native range in the Caspian Sea, the zebra mussel invaded Eastern Europe through a series of shipping canals that were built in the late 1700's and early 1800's. Most of Europe was invaded by the mollusk by 1830. The first zebra mussel sighting in the United States was in 1988 in Lake St. Clair. This lake connects Lake Huron to Lake Erie.

DISPERSAL/SPREAD: It is believed that the zebra mussel arrived in Lake St. Clair via the ballast water of transoceanic ships. It did not take long for the zebra mussel to spread. By 1990, they could be found in all of the Great Lakes. In 1991, zebra mussels

had found their way into the Illinois and Hudson Rivers. From here they had even more access to other rivers and to disperse ever further. Just one year later, established populations were found in the Arkansas, Cumberland, Hudson, Illinois, Mississippi, Ohio and Tennessee Rivers. It was only a matter of time before the zebra mussel made its way into the inland waters of some states. Populations are now known from at least 23 states, primarily within the Great Lakes and Mississippi River watersheds. To see a progression of the invasion of the mollusk in the United States you may visit the following website: http://cars.er.usgs.gov/Nonindigenous_Species/ZM_Progression/zm_progression.html

Both the movement of adult zebra mussels and the larval form, known as veligers, can infect other bodies of water. If an adult zebra mussel attaches to a boat it has a free ride to new water by individuals who trailer their boats from one body of water to another. Adult zebra mussels are able to close their shell and survive for several days in cool, moist conditions. In its veliger stage of life a zebra mussel is able to hitchhike to other lakes and streams in water being held in the bilge, live wells, or bait buckets, or they may cling to plant fragments, the boat or trailer, or any other equipment or recreational items coming into contact with water. Once in a new body of water, their prolific breeding allows them to easily establish a viable population. Once a population is established the downstream waters are at risk of infestation since veligers can float downstream for 3 to 4 weeks in search of a hard object to settle on.

RISKS/IMPACTS: Ecologically, the zebra mussels cause many problems. One such problem is that they need to attach to a hard surface to survive, and these hard surfaces could be anything from many manmade objects to other animals. Zebra mussels will attach to crayfish, turtle shells as well as other mussels. When a native mussel has zebra mussels attached, the native mussel loses its ability to move, feed, breath, and breed. Eventually this will lead to the death of the native mussel. In



Lake St. Clair and Lake Erie, the native mussel populations have been severely reduced due to the dense populations of zebra mussels. This dramatic drop happened only two years after the zebra mussel was discovered in the Great Lakes. This sends up a red flag for Indiana managers. With many of Indiana's native mussels already on state or federal endangered and threatened species list, zebra mussels could spell eventual extinction.

Zebra mussels have the ability to filter up to 1 liter of water per day. They eat the phytoplankton that is suspended in the water, which is in competition with the nearly microscopic animals called zooplankton. The food chain is very delicate and the zebra mussels could be disrupting it by taking out the very bottom link, the phytoplankton. This affects all the higher organisms including the fishes

Because zebra mussels filter large amounts of water, infested lakes have become clearer. While this may sound like a good thing, this can cause problems as well. With clearer water, sunlight penetrates to deeper water; this allows for more vegetative growth. This vegetation can become so thick that it could hinder swimming and boating.

While zebra mussels feed on phytoplankton, they do not eat blue-green algae. Because the blue-green algae are not being eaten, there is a competitive advantage over other algae resulting in a blue-green algae bloom. Such blooms occur in Lake Huron and Lake Erie much more frequently than ever before. Some forms of blue-green algae produce toxins. If enough blue-green algae toxin is produced, harm can occur to fish, waterfowl and any other animals that drink the water, including humans.

Yet another ecological impact that the zebra mussels impose on our native fauna is the fact that they are bioaccumulators. Any contaminant in the water is multiplied up to 10 times the water concentration in the zebra mussels. When the mussels are eaten, the contaminant concentration increases through the food chain. As zebra mussels become more prevalent more animals will eat them increasing the chance that higher levels of toxins will be accumulated throughout the food chain.

The zebra mussel is also economically detrimental. The mussel's need to attach to hard surfaces creates problems. Water intake structures are prime locations for attachment. These intakes provide a continuous flow of water and protection from predators. Once inside a pipe the zebra mussels layer on top of each other eventually causing reductions in pumping capabilities and even complete blockages. Industrial water pipes are not the only ones at risk. Residents whose cottages rely on lake water could see clogging of their supply lines. These pesky mussels get into engine cooling systems on boats, increase the deterioration of piers, increase the corrosion of steel and concrete, they have even sunk navigational buoys because the buoy could not support the additional weight. Beaches can become covered in the sharp zebra mussel shells and the odor given off by decaying mussels can be unpleasant, both of which result in reduced recreation. There is not just one problem associated with zebra mussels, as you can see they create a complex web of problems that are not easily fixed.

MANAGEMENT/PREVENTION: Once a population of zebra mussels has become established it is impossible to eradicate them without complete destruction of everything else that also lives in the water.

Research is ongoing in an attempt to find a way to disrupt the reproductive cycle of zebra mussels. Researchers are looking to try to mimic male hormones that trigger females to release their eggs. If successful, they can disrupt the breeding of the mussels by having the males and females release their gametes at different times, preventing fertilization.

Introducing natural predators, parasites, or diseases of the zebra mussel into an infested body of water is another way of lowering a population. This is known as biological control. Native Indiana predators of zebra mussels include waterfowl, sturgeon, yellow perch, freshwater drum, catfish, and sunfish. The exotic round goby, present in all of the Great Lakes and some of its tributaries, also has quite a liking for zebra mussels. One laboratory study observed one round goby eating 78 zebra mussels in a day. Unfortunately, anything that feeds heavily on zebra mussels will build up high levels of contaminants in its body. Due to the high reproductive capacity of zebra mussels, it is unlikely that predation will have a profound effect on reducing the nuisance caused by the invasive mussels.

There have been some successful procedures developed to prevent the invasive mussels from clogging water intakes. These include using molluscicides to kill mussels

at the entrance of water intake pipes, physically removing the mussels by scrapping, pigging, or high pressure washing, hot water or steam injection into infested pipes, and using toxic coatings containing copper or zinc on screens of intake pipes and boat bottoms to discourage attachment.

Many states have regulations prohibiting the import, transport, or possession of this species in order to limit the spread. In Indiana, it is illegal to possess live zebra mussels, quagga mussels, or Asiatic clams (312 IAC 9-9-3).

Most management efforts are geared at preventing any further spread of the zebra mussel. Spread is mainly caused by human recreational activities like boating, fishing, and diving. Some simple steps can be taken to help prevent spreading zebra mussels.

- ✓ Remove all plants and animals from your boat, trailer, and accessory equipment before leaving the access area.
- ✓ Drain live wells and bilge water before you leave the access site.
- ✓ Empty bait buckets on land rather than in the water.
- ✓ Wash your boat, tackle, downriggers, and trailer with hot water (above 104°F) when you get home. Flush your motor's cooling system, live wells, bilge and other boat parts that get wet. Let all equipment dry for at least five days before transporting your boat into a new body of water. If planning to move to another body of water sooner, you should disinfect everything that came into contact with water using a 5% bleach solution.
- ✓ Learn to identify the zebra mussel so you can report new sightings. If you find a zebra mussel in a lake that is not currently identified as an invaded lake, preserve the mussel in rubbing alcohol or freeze it, and contact the fisheries biologist in your area for positive identification. Visit the following website to locate your district fisheries biologist:

<http://www.in.gov/dnr/fishwild/fish/fishing/fishbiol.htm>

If you want to find out if there are zebra mussels in a body of water, you can monitor for adults by immersing hard substrate, such as a concrete blocks, in different areas around the lake and check them periodically during summer and fall for attached mussels. You can check any submerged portions of your boat, dock supports, floats, etc. for attached zebra mussels as well.

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Photos courtesy of Sea Grant Great Lakes Network

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Berlin Pond Watershed Conservation Plan



Commissioned by the Montpelier and Berlin Conservation Commissions
Prepared by the Vermont River Conservancy
February 2002

DRAFT Berlin Pond Watershed Conservation Plan
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EXECUTIVE SUMMARY

To protect the City of Montpelier's water supply, over a century of restrictions on development, access, and recreational activity have allowed Berlin Pond and its surrounding wetlands and forestlands to evolve into a unique natural area, one unparalleled in central Vermont. Berlin Pond, however, is more than just the water supply for the City of Montpelier. The area is a valuable habitat area, one that provides important scenic values, and a quiet, undisturbed place in which to enjoy nature.

The quality of Berlin Pond drinking water supply and the ecological health of the Berlin Pond natural area are both affected by activities in the Berlin Pond watershed. The Berlin Pond watershed contains a diversity of habitats and human land uses. Over the long term, the many values and benefits to humans and wildlife provided by Berlin Pond and its watershed are highly susceptible to cumulative threats associated with development, such as loss of open space, habitat fragmentation, increased traffic, and stormwater pollution.

The purpose of the **Berlin Pond Watershed Conservation Plan** is to provide an integrated set of recommendations to governing bodies towards protection of the drinking water supply **and** the ecological values of Berlin Pond, its wetlands and watershed. The Montpelier and Berlin Conservation Commissions commissioned the study and organized a 12-member Advisory Committee to guide the writing of the plan.

In the plan, **Current Uses and Public Use Suggestions** (Section III.) are analyzed for their potential impact on seven **Conservation Goals** (Section II.) identified by the committee (see **Threats**, Section IV.) The **Recommendations** (Section V.) set forth in the plan address these threats.

The City of Montpelier, Town of Berlin, and non-governmental partners should strive to increase awareness of regulations protecting Berlin Pond. While acknowledging a limited public desire on the part of some to boat, fish, or swim in the waters of Berlin Pond, these uses and associated activities are generally inconsistent with the seven Conservation Goals defined in the plan. Wildlife observation, while it certainly has the potential to harm plants and animals in the watershed and at the pond, is generally consistent with the seven Conservation Goals, provided visitors are prevented from visiting fragile areas or nest sites. The City of Montpelier, Town of Berlin, and non-governmental partners should also foster greater awareness among visitors and residents of the unique and fragile community and ecological resources found at Berlin Pond and should encourage community stewardship of these resources. To this end, the City of Montpelier, Town of Berlin, and non-governmental partners should coordinate adequately funded efforts in the areas of Community Relations and Public Outreach, Land Protection, Research and Monitoring, and Recreation Management.

Summary of Recommendations

I. Community Relations and Outreach (see page 32)

1. Increase awareness of regulations protecting Berlin Pond.
2. Increase awareness of ecological importance of area.
3. Educate landowners and recreational visitors about implications of land use and activities.

II. Land Protection and Conservation (see page 33)

1. Work with willing sellers to acquire and/or conserve priority tracts. Priority tracts include properties at risk of current or future development that
 - protect and buffer tributaries,
 - protect scenic or recreational values, and
 - link habitats.
2. Work with the City of Montpelier to place permanent conservation restrictions on its shoreline and watershed properties.

III. Research and Monitoring (see page 34)

1. Monitor populations of uncommon species.
2. Continue species inventory work.
3. Monitor breeding populations

IV. Recreation Management (see page 35)

1. Manage wildlife observation and recreation activities on roads around the Pond.
2. Manage recreation activities in watershed uplands.

V. Implementation (see page 36)

1. Coordinate efforts.
2. Secure funding for implementation.

I. Background

Berlin Pond: a Special Place

In 1884, the City of Montpelier began using Berlin Pond as its public water supply. As fears grew that agricultural and recreational uses of surrounding lands were threatening the quality of this new drinking water source, both the State Board of Health and the City of Montpelier initiated measures to protect the water from activities that might pollute it.

The Board of Health imposed prohibitions on swimming and boating in the 250-acre pond and activities along its 13 tributaries. The City of Montpelier began to purchase the lands around the pond, and by 1925, owned most of the Berlin Pond shoreline. Several court cases upheld the prohibition of swimming, fishing, and boating in Pond waters.

Over a century of restrictions on access and recreational activity have allowed Berlin Pond and its surrounding wetlands and forestlands to evolve into a unique natural area, one unparalleled in central Vermont. Berlin Pond is more than just the water supply for the City of Montpelier. The area and its environs are a valuable habitat area, one that provides important scenic values, and a quiet, undisturbed place in which to enjoy nature.

Increasingly, throughout Vermont, development pressure threatens undeveloped lake shores. Only a very few large Central Vermont ponds have retained their undeveloped shorelines. There are no structures on the shoreline of Berlin Pond (with the exception of a small pump station), and roads come close to the Pond in only a few places. A 1992 study of lakes 20 acres in size or greater found that Berlin Pond was one of only a few large water bodies with a high percentage of undeveloped shoreline. Berlin Pond stands out as a pond of intact and healthy natural communities with an undeveloped shoreline.

Berlin Pond hosts a very diverse community of aquatic plants. Its open waters and high-quality wetlands attract migratory waterfowl and provide nesting habitat for many species of birds. The pond serves as breeding habitat for a number of sensitive species. In 1999, the National Audubon Society's Vermont State Office officially designated Berlin Pond as a Vermont Important Bird Area (IBA), one of only four areas chosen in the state at that time.

There are numerous ponds in the vicinity of Berlin Pond where recreational activities are allowed. Thirty-four lakes and ponds (ranging from 23 to 849 acres) found within a 20-mile radius of Berlin Pond allow fishing, swimming, or boating, or all three, and some allow camping (See appendix). Nearly 60% of these also allow internal combustion engines. Few, if any of these water bodies are as ecologically significant as Berlin Pond.

Activities in the Watershed affect Berlin Pond water quality and the ecological health of the Berlin Pond natural area.

Water enters Berlin Pond in three ways. It enters as precipitation, as subsurface flow (groundwater), and as water that flows over the land of the watershed.

A “watershed” is all the land where surface flow of water ends up in the same “receiving” water, in this case, Berlin Pond.

The quality of Berlin Pond drinking water supply and the ecological health of the Berlin Pond natural area are both affected by activities in watershed. The Berlin Pond watershed contains a diversity of habitats and human land uses. There are wetlands and forests and meadows; there are trails and roads; there are residential dwellings. Most of the watershed, however, is presently undeveloped and rural.

Recently, the City of Montpelier commissioned a Source Protection Plan (SPP) for the Berlin Pond (raw water supply for City of Montpelier). The SPP was prepared by Dufresne & Associates, PC for the City of Montpelier. The SPP was prepared as required under the Vermont Water Supply Rule—Chapter 21, subchapter 7—in order for the Montpelier Filtration Plant to receive its operating permit. As such, the SPP focuses on drinking water protection and does not consider the ecological value of Berlin Pond. The SPP also does not fully address the cumulative impacts of potential development within the watershed, nor does it address recreational use in the watershed.

Over the long term, the many values and benefits to humans and wildlife provided by Berlin Pond and its watershed are highly susceptible to the cumulative threats associated with development, such as loss of open space, habitat fragmentation, increased traffic, and stormwater pollution.

In recent years, studies have quantified the relationship between development and the health of water bodies in developing watersheds, indicating a decrease in water quality with increasing development of the watershed. In urban lakes and ponds, higher stormwater pollutant loads are the major cause of water quality impacts. The ability of municipalities to control common behaviors and practices in urbanizing areas are imperfect at best.

The construction and coming-on-line of the new water filtration plant does not obviate the need to protect the source of Berlin Pond waters. Furthermore, the presence of the plant does not protect the ecological value of the Pond waters, wetlands, and shoreline as important and recognized natural resources from threats such as increased development within the watershed.

The Purpose, Development and Use of

DRAFT Berlin Pond Watershed Conservation Plan
February, 2001

the Berlin Pond Watershed Conservation Plan

The purpose of the Berlin Pond Watershed Conservation Plan is to provide an integrated set of recommendations to governing bodies towards protection of the drinking water supply and the ecological values of Berlin Pond, its wetlands and watershed. The Montpelier and Berlin Conservation Commissions commissioned the study and organized a 12-member Advisory Committee to work with the Vermont River Conservancy in the writing of the plan.

The Advisory Committee represents a diversity of interests and expertise in water quality, wildlife conservation, and recreation. The Committee includes representatives who reside in the watershed, serve on commissions in the City of Montpelier and the Town of Berlin, or otherwise are familiar with Berlin Pond, its history, functions, and values.

Through the Plan, the Advisory Committee hopes to accomplish the following vision:

To protect and maintain the complex association of open waters, wetlands, and upland communities of the Berlin Pond Watershed, over the long-term, as a place where human uses of the watershed sustain or enhance the biodiversity and undeveloped nature of the Pond and are consistent with the ecological health and the rural character of the watershed.

The Berlin Pond Watershed Conservation Plan is intended to supplement and complement the Source Protection Plan for Montpelier's Water Supply (SPP) and the Montpelier Water Conservation Plan.

The Plan should also be read in the context of statutes, decisions, and existing regulations regarding Berlin Pond and the Berlin Pond watershed.

The Vermont River Conservancy prepared the Berlin Pond Watershed Conservation Plan under the guidance of the 12-member Advisory Committee. The Plan begins with a **Background Section (Section I.)** followed by a set of **Conservation Goals (Section II.)** identified by the Advisory Committee. The Plan then reviews current uses and suggested uses (see **Current and Public Use Suggestions (Section III.)**), analyzing them for their potential threat to the conservation goals (see **Threats to Conservation Goals, Section IV.**). Lastly, the Plan recommends a set of strategies and actions that are intended to help achieve conservation goals (see **Recommended Strategies and Actions, Section V.**).

II. Conservation Goals

The Berlin Pond Watershed Conservation Plan is a planning document focused on conservation. This section of the plan lists and explains objectives for seven conservation goals as developed and refined by the Advisory Committee. Clearly outlined goals direct the planning effort to minimize threats to the pond and its watershed.



Conservation Goals:

DRAFT Berlin Pond Watershed Conservation Plan
February, 2001

1. Maintain and enhance the undisturbed nature of Berlin Pond waters, the undeveloped nature of the Berlin Pond shore lands, and the rural nature of the watershed.

Objectives

- Maintain the undisturbed nature of Berlin Pond waters with respect to human presence, sound, movement, stirring of bottom sediments, and presence of aquatic plants and wildlife.
- Maintain and/or increase vegetation along the Berlin Pond shoreline to achieve target of high-quality forest or wetland communities.
- Maintain an appropriate ratio of undeveloped to developed acreage in the watershed

2. Protect water quality in the Berlin Pond Watershed.

Objectives

- Maintain current nutrient levels or reduce nutrient loading in Pond waters
- Minimize sedimentation in Pond and tributaries
- Minimize and prevent introduction of pathogens, toxic chemicals and pesticides to Pond waters.

3. Maintain suitable habitat for rare and uncommon species, such as common loon (*Gavia immer*)

Objective

- Maintain suitable habitat for nesting loons to maintain or increase incidence of successful loon nesting on the Pond. Improve loon-nesting success over the long term.

- pied-billed grebe (*Podilymbus podiceps*)

Objective

- Maintain suitable habitat for nesting pied-billed grebes to maintain or increase incidence of pied-billed grebe nesting success in Pond wetlands.

- osprey (*Pandion haliaetus*)

Objective

- Maintain suitable habitat for nesting osprey to increase incidence of osprey nesting success.

- sora (*Porzana carolina*)

Objective

- Maintain suitable habitat for nesting sora to maintain or increase incidence of sora nesting success in Pond wetlands.

4. Identify, maintain, and encourage natural communities in the Berlin Pond Watershed.

Objectives

- Maintain the current diversity of aquatic plant communities.

- Maintain a dynamic mosaic of wetland types (scrub-shrub wetlands, wet meadows, pond-side marshes, northern white cedar swamp) and forest community types and ages within the Berlin Pond watershed where natural processes and natural disturbance regimes can occur.
- Maintain or re-establish robust buffers and forested habitat around vernal pool communities.
- Allow reversion of plantations to native forest communities.

5. Protect general wildlife habitat in the Berlin Pond Watershed

Objectives

- Maintain sufficiently intact and connected natural communities.
- Minimize fragmentation of large forest plots within the watershed.
- Identify and protect important corridors between Pond waters, wetlands and forested uplands.
- Identify and protect vernal pool habitat and sufficient acreage of surrounding uplands for migratory amphibians that breed in vernal pools.

6. Protect scenic vistas and scenic qualities of the Berlin Pond Watershed

Objectives

- Maintain quality of scenic views of the Pond.
- Maintain and improve scenic views of the forested watershed and ridgeline.

7. Maintain areas in the vicinity of Berlin Pond and the Berlin Pond shore land and watershed for environmental education, ecological research, and low-impact recreation activities that are consistent with the above goals

Objectives

- Designate potential areas important to environmental education, ecological research, and low-impact recreation activities that are consistent with conservation goals.
- Protect and ensure the proper management of these areas.

III. Current Uses and Public Use Suggestions

This section is divided into

- A. Summary of Citizen’s Vision for Berlin,*
- B. Public Comment: Berlin Pond Waters, Wetlands, and Public lands around the shoreline, and*
- C. Public Comment: Berlin Pond watershed uplands”*

*The section catalogs current human uses and reviews a variety of uses that have been suggested by the public for Berlin Pond waters, shoreline, and watershed. The evaluation of public opinion included consulting the “**Citizen’s Vision for Berlin,**” and solicitation of public opinion through written comment sheets and a public hearing.*

*The **Citizen’s Vision for Berlin** was a planning effort by the Berlin Planning Commission to assess planning goals and develop a strategy for the future. Community meetings and a questionnaire gave Berlin residents an opportunity to voice opinions about the priorities for Berlin.*

The Advisory Committee also solicited public comment through written forms and a public hearing. Participants were asked to comment about their interest in using Berlin Pond, the shoreline, and the watershed for various activities, including “no use.”

*In this section, “**Berlin Pond waters, wetlands, and publicly-owned lands around the shoreline**” refer to approximately 615 acres of land owned by the City of Montpelier, a small parcel owned by the Town of Berlin, and portions of the Brookfield and Mirror Lake Roads.*

*“**Berlin Pond watershed uplands**” refers to all other public and private lands within the watershed boundaries.*

A. Citizens' Vision for Berlin

The Berlin Planning Commission began a process in March of 1999 to reassess planning goals and develop a strategy for the future.

The effort was received enthusiastically with many residents participating. Residents discussed and debated the future of Berlin in a number of community meetings. In addition, 137 questionnaires were returned, often representing two or more Berlin residents.

The Berlin Citizen's Vision, the result of these community meetings and questionnaires, found that Berlin residents felt very strongly about protecting natural resources. The report also emphasized restricting urban growth and sprawl and improving recreation opportunities for residents – the highest percentage thought bike and hiking trails were the most important recreational needs.

An issue that Berlin residents felt particularly strongly about was the need to protect Berlin Pond and the Irish Hill Ridgeline.

B. Current Uses and Public Use Suggestions for

Berlin Pond waters, wetlands, and public lands around the shoreline

Participants at a public meeting and respondents to a questionnaire were asked to comment about their interest in using Berlin Pond, waters and public lands around the shoreline for various activities, including “no use.”

1. *Drinking water. The City of Montpelier uses Berlin Pond waters for raw drinking water. Berlin Pond stores in excess of 1.5 billion gallons of water and has an approximate surface area of 260 acres. The water receives treatment at a new facility that uses a package system of adsorber clarifiers and mixed media filters. Withdrawal is capped at 1.7 million gallons of water per day (MGD) at present.

2. Recreation. Current or suggested recreational uses include a broad range of activities.

a. *Fishing.* Fishing is prohibited at Berlin Pond. Five participants at the public meeting and twelve respondents to public comment sheets expressed an interest in fishing at Berlin Pond. Most participants and respondents, however, expressed the belief that fishing should not be allowed at Berlin Pond.

b. *Boating (hand launchable, non-motorized).* Boating of any type is prohibited at Berlin Pond. Four participants at the public meeting and thirteen respondents to public comment sheets expressed interest in boating (hand-launchables) at Berlin Pond. Most participants and respondents, however, expressed the belief that hand-launchables should not be allowed at Berlin Pond.

c. *Powerboat, electric motor.* Boating of any type is prohibited at Berlin Pond. Two participants at the public meeting and two respondents to public comment sheets expressed interest in boating using electric motor only at Berlin Pond. Most participants and respondents, however, expressed concerns about use of boats with electric motors at Berlin Pond.

d. *Powerboat, internal combustion.* Boating of any type is prohibited at Berlin Pond. Participants at the public meeting and respondents to public comment sheets did not express interest in boating with internal combustion engines at Berlin Pond. The great majority of meeting attendees and respondents expressed concerns with the concept of boats with internal combustion engines at Berlin Pond. Although there has been rumor of interest in powerboat use at Berlin Pond, public opinion seems to overwhelmingly oppose the idea.

e. *Personal Watercraft.* Personal watercraft use is prohibited at Berlin Pond. Participants at the public meeting and respondents to public comment sheets did not express interest in personal watercraft use at Berlin Pond. Although there has been rumor of interest in personal watercraft use at Berlin Pond, the participants and respondents overwhelmingly oppose such use.

f. *Swimming.* Swimming is prohibited at Berlin Pond. Three participants at the public meeting and four respondents to public comment sheets indicated an interest in

swimming. Most participants and respondents expressed the belief that swimming should not be allowed at Berlin Pond.

g. *Osprey platform*. In the summer of 1999, the Department of Fish and Wildlife (VT DFW), Berlin Conservation Commission and Montpelier Conservation Commission obtained approval from the City of Montpelier to put up an osprey platform. The groups erected the platform on the pond in late October. The Berlin Development Review Board notified the groups in November 1999 that they had jurisdiction and that a permit was required. VT DFW applied for a permit and met with the Board in December 1999 and January 2000. The Board issued a permit in April that required moving the platform from the site opposite the pump house to a location at the south end of the pond. The Board further conditioned the permit requiring that the platform would need to be hidden from view as much as possible and that VT DFW would have to post roadside "no stopping, no parking" signs. The Department couldn't meet these conditions and dismantled the platform in April 2000 until a time when a better resolution might be reached. There is still interest by VT DFW and the two conservation commissions to erect an osprey platform somewhere on the pond.

h. **Wildlife observation*. Wildlife observation, birdwatching in particular, is already a very popular activity on the roads around Berlin Pond. Berlin Pond is a designated "Important Bird Area" (IBA) by the National Audubon Society because of the presence of unique habitats, species of concern, and the importance of the site for bird breeding and the congregation of migratory species. Numerous other local, regional, and statewide groups also recognize the site for its ecological significance. These include Central Vermont Audubon Society, Vermont Institute for Natural Science, and the Vermont Nongame and Natural Heritage Program, among others. The roads around Berlin Pond see frequent visitation by birding groups who come to watch breeding and migratory birds. Nearly all participants at the public meeting and respondents to the public comment sheet listed wildlife observation as an important desired use. There have been suggestions at various times that wildlife observation stations be established to channel recreational use around the pond.

i. **Hiking/walking/running—road*. Hiking, walking, and running on roads around Berlin Pond are all current uses.

j. *Hiking/walking/running—trail*. There have been suggestions at various times that a nature trail or educational trail be established to channel recreational use around the pond. Several participants and respondents, however, commented that they were not in favor of off-road walking, hiking, or running on public lands around the Berlin Pond shoreline.

k. **Biking—road*. Biking on roads around Berlin Pond is a current and relatively popular use.

l. *Biking—trail*. There was no strong indication from participants at the public meeting or respondents to public comment sheets that off road biking on public lands around the Berlin Pond shoreline was a desired use. Several participants and respondents, however, did comment that they opposed off-road biking near the Berlin Pond shoreline.

n. *Ice skating.* Under “other uses” two respondents to the public comment sheets mentioned their interest in ice-skating on Berlin Pond ice in the winter.

o. *“No recreational use of waters or shoreline”.* Many participants at the public meeting expressed concern with any recreational use of pond waters or shoreline. Twenty-one respondents to the public comment sheets opposed any recreational use of Berlin Pond waters or shoreline except for passive enjoyment of scenic values, and/or observation from appropriate vantage points on the shoreline.

3. *Research and Education. There is interest by several groups to study the use of Berlin Pond waters, wetlands and public lands around the shoreline by rare and uncommon species. There is also interest by groups for educational study of natural resources of Berlin Pond, including natural communities and populations of plant and animal species that use the Pond.

4. Development

a. *Residential or commercial.* Although there was no suggestion that any group proposes residential or commercial development of the shoreline of Berlin Pond, shorelines in central Vermont are extremely popular places for development. Although public ownership that has protected the land around Berlin Pond up to now, how the land will be used in the future, or whether all the land will even remain under City ownership (and protection) are always up to the discretion of each Montpelier City Council and Mayor. The fate of the land cannot now be guaranteed, as future elected officials may not share a commitment to the perpetual protection of these lands for water quality, open space, and wildlife values. Unless formally protected by conservation restrictions, the Berlin Pond shoreline could easily become at risk of development in the future.

b. *Boat access.* Any proposed use of boats on Berlin Pond (see above) would require development of infrastructure for parking and for boat access.

c. *Fishing access.* Any proposed use of Berlin Pond for fishing (see above) could require development of infrastructure for parking or for, at a minimum, foot access to Berlin Pond waters at some points along the shoreline.

C. Current Use and Public Use Suggestions for the Upland Watershed of Berlin Pond

Participants were asked to comment about their interest in using the uplands of the Berlin Pond watershed for various activities, including “no use.” “Berlin Pond watershed uplands” includes all public and private lands within the watershed boundaries that are not Berlin Pond waters, wetlands, or public lands around the Berlin Pond shoreline.

1. **Residential areas.** According to the SPP, the Berlin Pond watershed includes 294 property parcels located either completely or partially within the watershed. There are currently 181 private residences in the watershed. Some of these residences have buried fuel storage tanks. Many have subsurface septic systems. The use of pesticides, herbicides, fertilizers, and hazardous materials (such as oil and gasoline or household solvents) that might find their way into groundwater or stormwater runoff is undetermined.

2. ***Residential or commercial development.** The Berlin Pond watershed is located near the much larger population and employment centers of Barre and Montpelier. The State of Vermont is the area’s largest employer. The Town of Berlin is a stable residential community with good access to regional employment. The mountainous topography and predominance of large tracts of woodland make the town an attractive place to live.

The Berlin portion of the watershed is zoned either “Highland Conservation” or “Rural Residential”. Collectively, these zones allow agricultural and forestry uses, one-family dwellings, public and private outdoor recreation, camps, wildlife refuge, accessory use, home occupation, and professional residence-offices and cemeteries. Collectively, with the granting of a conditional use permit by the Development Review Board, these zones might also allow business offices, planned residential developments, schools, religious institutions, state or municipal buildings or facilities, flea markets, private clubs, and licensed daycare homes for children.

The Northfield portion of the watershed is zoned “Conservation and Forestry,” “Secondary Agricultural,” or “Rural Residential.” Collectively, these zones allow single family dwellings, accessory buildings, windmills for private use, forestry and agriculture, planned residential developments, public and private utilities, public outdoor recreation, sand and gravel pits, and cemeteries. Some of these would require a conditional use permit.

The rural nature of the watershed, proximity to employment centers, proximity to public wooded lands, proximity to Berlin Pond, and the existence of good to extraordinary views put 15-20% the watershed at high risk of residential development. Pressure for additional development of single-family homes in the watershed could increase in coming years.

3. **Agriculture.** Very little commercial farming still occurs in the watershed despite the presence of prime agricultural soils. According to the SPP there is one agricultural operation (livestock). Gardening at private residences is the primary agricultural use

within the watershed. Increased development would likely increase the loss of woodland and the incidence of lawns and gardens.

4. *Forestry. From a recent scan of aerial photographs, it appears that about 85% or 4675 acres of the Berlin Pond watershed is forested. The western half of the watershed, including Irish Hill, is dominated by northern hardwoods with minor components of softwoods scattered throughout the lower elevations. The eastern half of the watershed appears more evenly balanced between hardwoods and softwoods. Approximately 30% (1650 acres) of the watershed is in public ownership and another 10% is private land enrolled in Vermont's Current Use Appraisal Program.

All forest land in the watershed is natural second growth or plantation. Forestry activities in the watershed have been typical of almost any other in the central Vermont area. The typical timber sale might involve 25 to 50 acres and be cut on a selection basis. A 1 to 3 man crew would perform the cutting with a skidder or crawler tractor, and a forestry professional would have input on 30% - 40% of these operations.

Recently, however, there were several heavy cuts along the upper elevations of Irish Hill. Approximately 550 affected acres have recently been brought into public ownership and are now conserved lands that have or soon will have responsible forest management plans.

5. Recreation. Current or suggested recreational uses include a broad range of activities, each with varying degrees of impact depending on location, frequency, and intensity of the activity.

a. **Hiking/walking/running--road.* Hiking, walking, and running on roads in the upland watershed of Berlin Pond are all current uses.

b. **Hiking/walking/running—trail.* Hiking, walking, and running on roads in the upland watershed of Berlin Pond are all current uses. There is an extensive network of informal trails on both public and private lands in the watershed. Trails on Irish Hill/Paine Mountain are described in William E. Osgood's "Paine Mountain Guidebook". Darling Road is a class four trail, as designated by the Town of Berlin.

c. **Biking—roads.* Biking on roads around Berlin Pond is a current use.

d. **Biking—trails.* Biking on trails in the upland watershed of Berlin Pond is a current use. The Advisory Committee received communication from a mountain biking organization suggesting that there is considerable interest in mountain biking on present or future trails on Irish Hill.

e. **Wildlife observation.* Wildlife observation is a current use in the upland watershed of Berlin Pond. Excepting only a few, participants at the public meeting and respondents to the public comment sheet all listed wildlife observation in the upland watershed of Berlin Pond as a desired use.

f. **Hunting.* Hunting on Irish Hill is very popular current use.

g. **ATV and dirtbike.* ATV and dirtbike use is popular on Irish Hill among local residents and is done either by permission of landowners or is unauthorized.

i. **Snowmachine.* Snowmachine use is popular among local people on Irish Hill and is done either by permission or is unauthorized.

6. Roads and Motor Vehicles. Numerous roads exist in the watershed, from class 4 roads to Interstate 89, which bisects the watershed. As described extensively in the SPP, trucks carrying substantial amounts of hazardous materials travel I-89 daily. In addition, there are secondary roads, including several class 2 and 3 gravel roads within the watershed that service traffic, among other vehicles, from fuel delivery trucks.

Many public meeting and survey respondents mentioned a perceived increase traffic on several of the roads surrounding Berlin Pond (along Brookfield Road, Paine Turnpike south, and Mirror Lake Road). Participants also cited parking problems at certain locations along these same roads as a problem, one that had the potential to worsen.

Some pond residents have expressed displeasure in particular about birdwatchers stopping, parking, and scoping within or too close to travel lanes in the roads.

7. Research and Education. Research at Berlin Pond has included water quality monitoring and ecological inventory work. Educational use has included a small number of educational programs about natural history and the annual Berlin Pond elementary school “Berlin Pond Walk”.

IV. Threats to Conservation Goals

This section of the Plan identifies and evaluates the degree to which current or suggested uses threaten or could potentially threaten the seven Conservation Goals described in Section II. Analysis of these potential threats, and their impact on the 7

Conservation Goals, led to the recommendations for conservation strategies and actions in the Section V.



A. Threats Posed by Potential Use of Berlin Pond waters, wetlands, and public lands around the shoreline

The following section discusses threats that potential uses might pose to Berlin Pond waters, wetlands, or publicly owned lands around the Berlin Pond shoreline. Many but

not all of the listed potential uses are prohibited under existing regulations, so discussion of potential threats is hypothetical.

Pond or Shoreline Activity	Potential Threat To Conservation Goal If Implemented						
	U n d i s t u r b e d n a t u r e o f p o n d	W a t e r q u a l i t y	S e n s i t i v e s p e c i e s	N a t u r a l c o m m u n i t i e s	W i l d l i f e h a b i t a t	S c e n i c v i s t a s	R e s e a r c h e d u c a t i o n l o w - i m p a c t
* (denotes current use)	1	2	3	4	5	6	7
*Drinking Water Use	Yes	No	Yes	Yes	No	No	No
Recreation							
Fishing	Yes	Yes	Yes	Yes	No	Yes	No
Boating (hand-launchable, non-motorized)	Yes	Yes	Yes	Yes	No	Yes	No
Powerboat, electric motor	Yes	Yes	Yes	Yes	No	Yes	No
Powerboat, internal combustion	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Jetski	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Swimming	Yes	Yes	Yes	No	No	Yes	No
Osprey platform	Yes	No	No	No	No	Yes	No
*Wildlife observation	Yes	Yes	Yes	No	No	Yes	No
*Hiking, walking, running—existing roads	No	No	No	No	No	No	No
Hiking, walking, running—trail	Yes	Yes	Yes	No	No	No	No
*Biking—road	No	No	No	No	No	No	No
Biking—trail	Yes	Yes	Yes	Yes	Yes	Yes	Yes
*Research and Education	No	No	No	No	No	No	No
Development							
Residential or commercial	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Boat access	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fishing access	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Threats Posed by Potential Use of Berlin Pond waters, wetlands, and public lands around the shoreline

1. *Drinking water. Berlin Pond waters are currently used for drinking water, posing no threat to conservation goals. Increased withdrawal of water beyond certain limits, however, would pose a threat to the undisturbed nature of the Pond, sensitive species, natural communities, wildlife habitat, and scenic vistas. Drawdowns in excess of 1.68 mgd would have undesirable consequences to the natural condition of Berlin Pond. Water fluctuations would threaten waterfowl and wildlife food sources and habitat, wetland communities, and plant diversity. Approximately 30 acres of wetland along pond shoreline would experience the greatest impact from excessive water removal. Excessively low pond levels would reduce the open-water available to migrating waterfowl and remove nesting habitat. Fluctuations during late fall and early winter could decrease access to food supply and dwellings of beavers and muskrats. Increased drawdowns would also threaten the highly productive shallow water littoral areas, which in turn would negatively impact mussels and aquatic insects. Late fall drawdowns could allow frost to penetrate hibernating areas and reduce the survival of hibernating reptiles and amphibians as well as perennial emergent and aquatic plants that are not adapted to freezing (Berlin Zoning Board of Adjustment, 1996).

According to the Berlin Zoning Board of Adjustment report, “water withdrawals greater than 2.19 mg could make it extremely difficult for common loons to nest successfully on the pond. A water level drop of one foot or more during incubation could strand the loon nest, making it impossible for the adult loons to reach their eggs” (Berlin ZBA, 1996).

Drawdowns beyond acceptable levels that extend into winter are likely to have serious adverse impacts on deep marsh and aquatic vegetation communities.

2. Recreation. *It should be noted that there are numerous ponds in the vicinity of Berlin Pond where many of the various recreational activities suggested for Berlin Pond are allowed. Thirty-four lakes and ponds (ranging from 23 to 849 acres) found within a 20-mile radius of Berlin Pond allow either fishing, swimming, or boating, or all three, and some allow camping (See appendix). Nearly 60% of these also allow internal combustion engines. Few, if any are as ecologically significant as Berlin Pond. Many recreational uses suggested for Berlin Pond would pose a significant threat to one or more of the conservation goals identified in Section II.*

a. *Fishing.* Fishing, whether from the waters of Berlin Pond or the shoreline (if it were to become legal, would threaten the undisturbed nature of the pond and shoreline, water quality, and sensitive species. To a lesser extent, fishing might also threaten natural communities and scenic vistas. The greatest threat would occur if fishing were to be permitted from boats (see 2.b, c, and d below). Pond waters and shoreline have been undisturbed since the late 1800s, and to permit fishing, even from the shoreline, would alter this, threatening habitat of sensitive species. The common loon, listed as endangered in Vermont, visits Berlin Pond virtually every year. Loons have nested on

Berlin Pond, successfully fledging one chick twice, in 1990 and 1992. The common loon is highly sensitive to human disturbance and experiences nesting failure as a result of human activities (Ream, 1976, Heimberger et al., 1983, Titus and Van Druff, 1981). Research has shown that anglers fishing off shore can have essentially the same negative impact on wildfowl as boats in that they create an area where birds won't enter (Liddle and Scorgie, 1980).

There is the possibility that some anglers would mistreat the resource through unacceptable behaviors such as the use of lead sinkers or the depositing of shoreline litter that frequently accompanies fishing.

Lead sinkers pollute the water and if ingested by waterfowl can cause bird deaths (Finely and Dieter, 1978). Lead poisoning from ingestion of fishing sinkers has been identified as the cause of death for half of the dead loons necropsied in New England studies (Pokras, et al., 1992).

The allowance of fishing would also be very likely to increase use of surrounding roads, increasing traffic around the pond, disturbing local residents.

b. *Boating (hand launchable, non-motorized)*. The use of hand-launched boats, were their use to become legal at Berlin Pond, would threaten the undisturbed nature of pond and shoreline, sensitive species, and, to a lesser extent, natural communities and scenic vistas. Surprisingly, canoes, kayaks, and rowboats can potentially disturb wildlife as much as power boats, because they can reach secluded areas where waterfowl nest, surprising sensitive species (Parren, personal communication). The 1992 Breeding Status study of common loons in Vermont reported that canoeists on Green River Reservoir were coming too close to chicks on several occasions (Renfrew and Rimmer, 1992).

Although less so than motorized boats, hand-launched boats would also require infrastructure for launching, further threatening conservation goals.

c. *Powerboat, electric motor*. Powerboats with electric motors, if ever their use became legal at Berlin Pond, would threaten the undisturbed nature of pond and shoreline, sensitive species, and to a lesser extent, natural communities and scenic vistas. As with hand-launched boats, powerboats with electric motors might enable users to surprise sensitive species. Boats could introduce and increase the spread of aggressive invasive exotic species such as water chestnut, Eurasian water milfoil, and purple loosestrife, among others, from infested waters.

d. *Powerboat, internal combustion; Personal Watercraft*. Powerboats with internal combustion engines, if ever their use became legal at Berlin Pond, would threaten the undisturbed nature of pond and shoreline, water quality, sensitive species, natural communities, and scenic vistas. The most obvious impact of this use would be water, air, and noise pollution, negatively affecting humans and wildlife alike. Powerboats can cause shoreline erosion, eutrophication, and mechanical disturbance to aquatic vegetation and bottom sediments, disturbing fish and aquatic life, in addition to above surface species (Hammir and Cole, 1998). It is well documented that boat engines, particularly two-stroke engines, are a source of water pollution. Two-stroke engines can discharge between 20-40% of the fuel used directly into the water (Muratori, 1968). Two-stroke engines from motor boats can deposit contaminants that degrade ground and surface waters, negatively impacting aquatic life (Ruzycki and Lutch, 1998). Boat

engines discharge a variety of hydrocarbon compounds directly into the water. Research has shown that even small levels of hydrocarbon pollution can cause chromosomal damage, retard growth and development, disrupt normal biological functions, and kill fish (Ruzycki and Lutch, 1998). Other contaminants from motor vehicle exhaust include carbon monoxide, Methyl-tert-butyl ether (MTBE), nitrous oxides (NOx) and particulate matter (White and Carrol, 1998). The effects of these vary, but have been known to cause a reduction of zooplankton populations, a decrease in fish growth rates, enzyme function, immune response, and reproductive impacts (Balk, et al., 1994). Also, the nitrogen found in nitrous oxides can be a limiting agent in aquatic systems and contribute to eutrophication. Noise pollution is another source of disturbance caused by powerboats.

e. *Swimming*. Swimming in Berlin Pond, if ever it became legal at Berlin Pond, would have the potential to threaten the undisturbed nature of pond and shoreline and sensitive species. Swimming would also increase traffic and parking problems and require resources to ensure safety and enforcement. Swimming, and a tendency to desire the removal of vegetation in swimming areas, would not be compatible with the high incidence and important diversity of aquatic plants in the pond.

f. *Osprey platform*. There has been some concern in Berlin that an osprey platform, if not appropriately located, would threaten the undisturbed nature of the pond and would increase traffic problems on surrounding roads.

g. **Wildlife observation*. Wildlife observation activities have the potential to create or exacerbate traffic and parking problems on surrounding roads. Wildlife observation activities, at certain levels of activity, and if occurring in certain areas, could threaten sensitive species.

h. **Hiking/walking/running—road*. Increased use of surrounding roads for walking and running, at certain levels of use, could threaten the undisturbed nature of the pond and create traffic and parking problems.

i. *Hiking/walking/running—trail*. Use of trails on public lands around the Berlin Pond shoreline could threaten the undisturbed nature of the pond and shoreline and sensitive species.

j. **Biking—road*. Increased use of surrounding roads for walking and running, at certain levels of use, could threaten the undisturbed nature of the pond and create or exacerbate traffic and parking problems.

k. *Biking—trail*. Use of trails on public lands around the Berlin Pond shoreline could threaten the undisturbed nature of the pond and shoreline and sensitive species.

3.*Research and Education. Research activities, if not appropriately undertaken and managed, could potentially threaten sensitive species. Educational activities, at certain use levels, could create or exacerbate traffic and parking problems.

4. Development

Any residential development of the public lands around the Berlin Pond shoreline, if ever allowed, would negatively impact the seven conservation goals identified in Section II.

While development of an individual lot in the upland areas of the Berlin Pond watershed might seem insignificant, development of even a single lot along or near the Berlin Pond shoreline could have a disastrous effect upon sensitive species, natural communities, scenic vistas, water quality and the undisturbed nature of the pond waters and shoreline.

Sensitive species are attracted to Berlin Pond largely because of its size and undeveloped shoreline. Noise and activity associated with even small amounts of shoreline development could disturb sensitive species and result in rejection of Berlin Pond as breeding or migratory habitat.

Development of any type along the shoreline of Berlin Pond would alter its value as a popular scenic vista.

Development of any type along the shoreline of Berlin Pond would alter the undisturbed nature of pond waters and the shoreline. Berlin Pond has only one structure (the pumphouse) close to the shoreline. Only a handful of similar-sized ponds in the Winooski River Basin have as high a percent of undisturbed (by structures) shoreline as Berlin Pond. Peacham Pond, Curtis Pond, Forest Lake, Lake Greenwood, Sabin Pond, Valley Lake, and Wrightsville Reservoir all have a higher percentage of shoreline development than Berlin Pond. Only Gillette Pond and Shelburne Pond have less development than Berlin Pond and each is partially or wholly protected and in State (Gillette Pond) or non-profit (Shelburne Pond—The Nature Conservancy) ownership.

Development of any type along the shoreline of Berlin Pond would degrade water quality in a number of ways. The ability of a municipality to control common behaviors and practices at private residences (i.e. removal of vegetation, application of fertilizers and pesticides, dumping or spillage of vehicular fluids, improper disposal of household toxics, just to name a few) is limited at best. Because of this, it is always cheaper and more effective in the long run to avoid generating pollution than it is to clean it up later. Research on stormwater management for drinking water supplies has determined that the single most important tool in reducing the impacts of urban stormwater are the minimization of impervious surface areas and pollution prevention through source reduction and effective land use planning.

Residential development of a single site could easily open up the Pandora's Box of additional development. Everyone is familiar with a lakeshore that has been overbuilt. Along many Vermont lakeshores, the density of residential development is extreme. While it is public ownership that has protected the shoreline of Berlin Pond up to now, how the land will be used in the future, or whether all the land will even remain under City ownership (and protection) are always up to the discretion of each City Council and Mayor. Unless the Berlin Pond shoreline is protected through formal and perpetual legal measures, development of the shoreline will remain a lingering threat.

B. Threats Posed by Potential Use of Watershed Uplands

The following section discusses threats that potential uses of the watershed uplands might pose to conservation goals.

Upland Watershed Activity	Potential Threat to Conservation Goal of Implemented						
	U n d i s t u r b e d n a t u r e o f P o n d	W a t e r q u a l i t y	S e n s i t i v e s p e c i e s	N a t u r a l c o m m u n i t i e s	W i l d l i f e h a b i t a t	S c e n i c v i s t a s	R e s e a r c h e d u c a t i o n l o w - i m p a c t
	1	2	3	4	5	6	7
Residential or Commercial Development	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Agriculture	No	Yes	Yes	Yes	Yes	No	No
Forestry	No	Yes	Yes	Yes	Yes	Yes	Yes
Recreation							
Wildlife observation	No	No	No	No	No	No	No
Hiking, walking, running—existing roads	No	No	No	No	No	No	No
Hiking, walking, running—trail	No	No	No	No	No	No	No
Biking—existing roads	No	No	No	No	No	No	No
Biking—trail	Yes	Yes	Yes	Yes	Yes	No	No
Hunting	No	No	No	No	No	No	No
ATV	Yes	Yes	Yes	Yes	Yes	No	Yes
Dirtbike	Yes	Yes	Yes	Yes	Yes	No	Yes
Snowmachine	Yes	Yes	Yes	Yes	Yes	No	No
Research and Education	No	No	No	No	No	No	No
Roads/Motor Vehicles Development	Yes	Yes	Yes	Yes	Yes	Yes	No
Residential or commercial	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Threats Posed by Potential Use of Watershed Uplands

1.*Residential or commercial development. The Source Protection Plan addresses the threats current land uses pose to the water quality of Berlin Pond. The SPP, however, does not fully address the implications of increased development of the watershed.

Increased development in the Berlin Pond watershed would threaten water quality, the undisturbed nature of Berlin Pond, the rural feeling of the watershed, and scenic vistas. Over the past decade, numerous studies have linked increasing development with water quality degradation (Center for Watershed Protection, Article 25). The threat lies in the cumulative effect of altering a rural landscape, gradually, to an urban or suburban landscape and the accompanying increase in roads, traffic, and impervious surface areas.

It is well documented in the literature that development has a profound influence on water quality (Center for Watershed Protection, Article 63). While development of an individual lot might not seem significant, the long-term effect resulting from cumulative development should not be underestimated. Stormwater runoff from roads can seriously degrade water quality by increasing the concentrations in receiving waters of pathogens, nutrients, oxygen demanding materials, suspended solids, chlorides, metals (such as copper, lead, cadmium, chromium, zinc, and arsenic), synthetic organic compounds (such as pesticides and polycyclic aromatic hydrocarbons), petroleum hydrocarbons, and trash and debris. Many of these pollutants are derived from motor vehicles. Delivery of these pollutants from developed land to surface waters is very efficient because much of the opportunity for chemical or biological absorption or breakdown of pollutants in soil or vegetation has been lost.

In recent years, research has firmly established the relationship between development and the health of receiving waters that are used as drinking water supplies, indicating impairment of water quality with increasing development of the watershed. Although pathogens may be filtered out of drinking water supplies, filtration does not solve all water quality problems associated with development. Elevations in total phosphorus can lead to excessive algal blooms, causing taste and odor problems and formation of a cancer-causing agent THM (Tri-Halo-Methanes). Heavy metals that accumulate on paved surfaces are easily washed into stormwater and are of great concern because of their ability to contaminate drinking water supplies. Pesticides that find their way into water supplies, even in low concentrations, can pose severe health risk to humans.

The ability of a municipality to control common behaviors and practices in urbanizing areas (application of fertilizers and pesticides, dumping or spillage of vehicular fluids, improper disposal of household toxics to name a few) is imperfect at best. Because of this, it is always cheaper and more effective in the long run to avoid generating pollution than it is to clean it up later. Research on stormwater management for drinking water supplies has determined that the single most important tool in reducing the impacts of urban stormwater are the minimization of impervious surface areas and pollution prevention through source reduction and effective land use planning.

2.* Agriculture/Lawncare/Garden. Agriculture is a permitted use in both the Rural

Residential and Highland Conservation zones of the Berlin zoning ordinance. Although there is little commercial agriculture in the watershed at present, increased agricultural use could, potentially, threaten water quality.

Many landowners in the source protection area use fertilizers and or pesticides on lawns and gardens. These uses, and any increases in the current levels of use, pose a threat to water quality, sensitive species, and wildlife. Pesticide/herbicide/fungicide delivery to streams can occur through runoff, drift and deposition onto impervious surfaces, and through inappropriate disposal or sprayer cleaning. Even low concentrations can harm downstream aquatic plants. The greatest risk of toxicity lies with a relatively few insecticides such as diazinon and chlorpyrifos. The toxicity of diazinone, for example, to geese, songbirds, and amphibians is well documented. (Shueler, 1995; CWP Technical Note 57).

3.*Forestry. Certain forestry activities, if not properly managed, have the potential to threaten water quality, scenic vistas, and wildlife habitat. These include heavy cutting, cutting on steep slopes, cutting within riparian zones or vernal pool buffers, and excessive creation or poor design of skid trails, log landings, and truck roads.

a. *Heavy cutting.* Excessive cutting can cause excessive nutrient loss through leaching; increase the rate of snowmelt and storm runoff (increasing erosion); adversely affect the forest floor habitat affecting herbaceous plants, amphibians, insects, fungi, mosses, and soil microbes; reduce the amount of mature or late-successional habitat; create even-aged stands that do not retain diverse structural characteristics; and threaten scenic values.

b. *Timber harvest within riparian zones or vernal pool or other wetland buffers.* Forestry activities that can affect water quality include construction of roads, landings, and skid trails; stream and wetland crossings; handling of slash; removal of forest cover; spilling of petroleum products; and application of chemicals. The most important aspect of protecting water quality is maintaining the integrity of wetlands and riparian areas.

Timber harvest activities in the vicinity of riparian areas and wetlands can result in habitat alterations detrimental to wildlife species that depend on these wetlands. This is particularly true of vernal woodland pools. Vernal woodland pools are particularly at risk because they only contain water for a part of the year and may not be recognized as wetlands. Loss of shade around the pools and heavy equipment impacts to the pool areas and surrounding buffers, can be particularly harmful.

c. *Miscellaneous forest practices.* Excessive construction of skid landings and roads or poor design of skid landings and roads can threaten water quality. Timber harvest or road/skid landing construction on steep slopes can lead to excessive erosion and increased storm runoff. Other factors that potentially threaten conservation values are the size of forestry equipment and the time of year of harvest. Removal of deer wintering areas, mast trees, and cavity trees, dens, and snags can harm important food and habitat for many species of mammals and birds. Removal of dead and down woody material in various stages of decay can inhibit critical forest system functions.

4. Recreation

- a. **Wildlife observation.* Increased use of uplands for wildlife observation is could exacerbate traffic and parking problems.
- b. **Hiking/walking/running road/trail.* Increased use of surrounding roads and trails for hiking, walking, and running in watershed uplands, at certain levels of use, could exacerbate traffic and parking problems and increase erosion.
- c. **Road biking/*mountain biking.* Increased use of surrounding roads and trails for biking in watershed uplands, at certain levels of use, could exacerbate traffic and parking problems and increase erosion.
- d. **Hunting.* Increased use of surrounding road and trails were increased hunting to occur in watershed uplands, at certain levels of use, could exacerbate traffic and parking problems.
- e. **ATV/dirtbike.* Off-road motor vehicle use in the watershed has the potential to harm plant and wildlife habitat, wetlands, and water quality through soil displacement and compaction, air and water pollution, noise pollution, and vegetation damage. If not properly managed, use of the watershed by ATVs, dirtbikes, and other off-road motor vehicles could lead to serious erosion problems, soil compaction problems, damage of small wetlands, destruction of vegetation, and disturbance of wildlife. Certain off road motor vehicles generate excessive noise and can disturb wildlife that depend on quiet. Off road motor vehicle use can also cause substantial damage to plants, particularly when the vehicles leave designated trails. Off-road motor vehicles may also leak fuel, oil, antifreeze, and other chemicals. Many are powered by highly inefficient two-stroke engines, so any fuel/oil combination not burned efficiently as the vehicle operates, including toxic fuel additives, is emitted directly onto the ground.
- f. **Snowmachine.* When not properly managed, snowmachine use in the watershed has the potential to threaten wildlife and water quality. Two-stroke engines from snowmachines discharge up to one-third of their fuel unburned into the environment, threatening air and water quality. Certain levels of use of snowmachines in the watershed could introduce significant levels of toxic pollutants into the snowpack whose effect might be magnified in sudden release during snowmelt (Ingersoll, et al., 1997) (Shaver, et al., 1988). Snowmachines are also capable of operating at high speeds and can generate excessive noise.

5. Roads/Motor Vehicles. Roads and motor vehicles threaten the water quality at Berlin Pond, and secondarily threaten the undisturbed nature of the pond, sensitive species, natural communities, wildlife habitat, and scenic vistas. The threats come from the potential for spills or illegal disposal of toxic chemicals or fuel; the potential for prolonged and cumulative delivery of vehicular fluids through stormwater runoff; road maintenance activities or inactivities; and increases in noise, traffic, and parking pressure.

V. Recommendations

Conservation Strategies and Actions



Conservation Strategies and Actions

This section recommends broad actions to preclude or mitigate stresses which currently or potentially threaten conservation goals for Berlin Pond and the Berlin Pond Watershed.

I. Community Relations and Outreach (see page 32)

1. Increase awareness of regulations protecting Berlin Pond
2. Increase awareness of ecological importance of area.
3. Educate landowners/recreation users about implications of land use.

II. Land Protection and Conservation (see page 33)

1. Work with willing sellers to acquire and/or conserve priority tracts. Priority tracts include properties at risk of current or future development that
 - link habitats
 - protect and buffer tributaries
 - protect scenic or recreational values
2. Work with City of Montpelier to place permanent development restrictions on its shoreline and watershed properties. Work also with Berlin, Northfield, and Williamstown selectboards to institute additional measures to protect lands.

III. Research and Monitoring (see page 34)

1. Monitor populations of rare, threatened, or endangered species
2. Complete species and population inventories for noteworthy taxa
3. Monitor breeding populations

IV. Recreation Management (see page 35)

1. Manage wildlife observation and other recreation on roads around the Pond.
2. Manage recreation activities in upland.
3. Explore establishing designated wildlife observation areas.

V. Implementation (see page 36)

1. Coordinate efforts.
2. Secure funding for implementing actions.

I. Community Relations and Outreach

1. Increase awareness of regulations protecting Berlin Pond

Residents of local communities as well as visitors to the watershed should be fully aware of the regulations governing Berlin Pond. There is at present a lack of understanding of these regulations, their history and purpose, and of the various jurisdictions responsible for their monitoring and enforcement.

Recommended action: The City of Montpelier and Town of Berlin should develop and a summary or regulations, to distribute with educational materials about the Berlin Pond water supply and natural area/ecological values.

2. Increase awareness of the importance of the Berlin Pond Natural area, species, ecological systems, and public water supply.

Residents of local communities as well as visitors to the watershed should be fully aware of the ecological importance of the Berlin Pond Natural area and watershed.

Recommended actions: The City of Montpelier, Town of Berlin, and other partners should organize periodic public events about the pond and its significance. The City of Montpelier, Town of Berlin, and other partners should develop an educational pamphlet that explains the ecological importance of the Berlin Pond Natural Area and the need for drinking water supply source protection, perhaps in parallel with educational materials about regulations governing Berlin Pond. The City of Montpelier, Town of Berlin, and other partners should also investigate the possibility of establishing and maintaining a nature trail with wildlife observation posts at appropriate locations around the Pond.

3. Educate landowners and recreational visitors about land use and recreational activities that affect conservation goals.

Watershed landowners and those that visit the pond and watershed for recreation and wildlife observation need to be educated about the implications of their land use and recreational activities on the conservation goals identified in this report. As noted in the source protection plan, landowners need to understand the implications of underground storage tanks or activities such as fertilizer application or the use of pesticides. Those who use the watershed for recreation, whether it is bird watching from the Mirror Lake Road or mountain biking on Irish Hill should understand the implications of their activities on the watershed and on local residents.

Recommended action: the City of Montpelier and Town of Berlin should cooperate to develop educational programs that inform residents and recreational users about water supply source protection and protection of the Berlin Pond Natural Area.

II. Land Protection and Conservation

1. Work with willing sellers to acquire and/or conserve priority tracts.
Priority tracts include properties at risk of current or future development that

- **link habitats**
- **protect and buffer Berlin Pond tributaries**
- **protect scenic or recreational values**

Conservation organizations, the Berlin and Montpelier Conservation Commissions and other partners should continue their work with willing landowners to permanently protect priority tracts through fee-simple purchase or the purchase of development rights. 550 acres have recently been conserved on Irish Hill, much of it within the watershed.

Additional parcels that link habitats, protect pond tributaries, and protect scenic or recreational values should have highest priority for protection. Land protection and conservation partners should examine and prioritize parcels in the watershed for potential conservation, contact landowners, develop strategies for implementing conservation efforts, and set in motion the conservation of high priority parcels.

Recommended actions: The Vermont Land Trust, Berlin Conservation Commission, Montpelier Conservation Commission should continue ongoing conservation efforts.

2. Work with City of Montpelier to place permanent development restrictions on its shoreline and watershed properties.

In 1999, the Vermont Land Trust and Montpelier Conservation Commission met to discuss long-term protection of Montpelier's City lands around Berlin Pond. The two groups believe that City land around the pond is such a very high quality resource that it deserves protection beyond simple municipal ownership. While it is this public ownership that has protected the land up to now, how the land will be used in the future, or whether all the land will even remain under City ownership (and protection) are always up to the discretion of each City Council and Mayor. Because the special character of these lands is so widely recognized, they should be protected through a formal and perpetual commitment to their importance to water quality, open space, and wildlife values. A permanent conservation easement, donated to the Vermont Land Trust with its vast experience in this field would solidify the protection of these values forever.

Recommended action: The Vermont Land Trust and Montpelier Conservation Commission should work with the City of Montpelier to place permanent development restrictions on its shoreline and watershed properties.

III. Research and Monitoring

1. Monitor populations of rare and uncommon species.

The waters and wetlands of Berlin Pond provide important habitat for a number of rare and uncommon bird species, including common loon (state endangered), pied-billed grebe (special concern), and sora (special concern), among others. The Central Vermont Audubon Society and the Vermont Institute for Natural Sciences should take the lead in monitoring individuals and populations of noteworthy birds and other taxa. Other rare and uncommon species may be found in the watershed.

Recommended action: The Central Vermont Audubon Society and VINS should coordinate additional monitoring of rare and uncommon species and devise ways to inform land managers, planners, land conservation organizations, and those responsible for water supply decisions with good solid data on these species to promote sensible, land-use planning and fact-based habitat management.

2. Continue to update species inventory work

Although there have been very comprehensive efforts within certain taxa (birds, aquatic plants) species inventory work for the Berlin Pond waters, wetlands, and watershed is incomplete. It would be helpful to gather additional data with regards to mammals, amphibians and reptiles, fish (including non-game fish), invertebrates, and plants. There may be additional rare and uncommon native plants and animals in the watershed that have not yet been discovered.

Recommended action: Central Vermont Audubon and VINS should coordinate additional inventory work in the watershed.

3. Monitor breeding populations

The waters of Berlin Pond, its wetlands, and watershed provide important breeding habitat for birds and other taxa. It would be helpful to have data with regards to use of public lands in the watershed by breeding birds and amphibians.

Recommended action: Central Vermont Audubon and VINS should coordinate additional work to monitor and inventory breeding populations in the watershed.

IV. Recreation Management

1. Manage wildlife observation activities and other recreational activities on roads around the Pond.

Much of the public land around the Pond is off limits to recreation. Brookfield Road, Mirror Lake Road, see significant traffic related to recreation. This has created a need to

give clear direction to those who come to Berlin Pond to observe wildlife, or otherwise use the roads around the pond (for running, hiking, dog-walking, etc.) with regard to parking and other activities.

While acknowledging a limited public desire on the part of some to boat, fish, or swim in the waters of Berlin Pond, these uses and associated activities are generally inconsistent with the seven Conservation Goals. Wildlife observation, while it certainly has the potential to harm plants and animals in the watershed and at the pond, is generally consistent with the seven Conservation Goals, provided visitors are prevented from visiting fragile areas or nest sites.

Recommended actions: Members of the Montpelier and Berlin Conservation Commissions, or their appointee, should periodically and regularly visit the pond to observe and talk with those using the area. A committee consisting of local residents, Conservation Commission members, wildlife observation enthusiasts, runners/walkers and representatives from other such groups should form to make recommendations to the Town of Berlin and City of Montpelier regarding parking areas and educational signage. The City of Montpelier, Town of Berlin, and other partners should also investigate the possibility of establishing and maintaining a nature trail with wildlife observation posts at appropriate locations around the Pond.

2. Manage recreational activities in upland.

The management of recreational activities in the upland watershed of Berlin Pond is under a number of jurisdictions, including the State of Vermont, Town of Berlin, and City of Montpelier, the Vermont Land Trust, and the Vermont Housing & Conservation Board. Land managers should develop thoughtful management plans for public properties and should communicate with one another with regards to management issues such as off road motor vehicles, mountain bikes, trails, and forest practices.

Recommended action: Berlin Conservation Commission and State of Vermont Department of Forests, Parks and Recreation, in consultation with the Vermont Housing & Conservation Board and the Vermont Land Trust, should develop or update management plans for public lands in the watershed.

V. Implementation

1. Coordinate and integrate SPP effort, water conservation effort, ecological protection efforts and land protection efforts.

There has been little coordination or communication between the several efforts and initiatives to protect and manage the resources of Berlin Pond and its watershed. It is

important to avoid redundancy in efforts or confrontations the inevitably result when groups attempt to take action at cross-purposes. For instance, the SPP recommends that the City of Montpelier apply for a conditional use permit that allows for increased water withdrawals from Berlin Pond, a recommendation that could have serious negative implications for the Berlin Pond natural area. There are many opportunities for groups and individuals to work together and coordinate the multi-benefit protection of the watershed.

Recommended actions: The Berlin and Montpelier Conservation Commissions should take the lead in devising ways to increase coordination and communication between the Source Protection Plan, the Berlin Pond Watershed Conservation Plan, the Montpelier Water Conservation Plan, and the Important Bird Area (IBA) Program. This could take the form of a series of meetings or an afternoon forum or conference. There should be formal efforts undertaken to involve watershed residents, citizens, and recreational users in these forums or meetings.

2. Secure funding for implementing the above.

Implementation of many of the actions and recommendations in this Plan will require funding and dedication of human resources.

Recommended actions: The two municipalities and various conservation and recreation groups should meet to discuss ways to pool efforts and share information, resources, and access to funds.

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THE GLOBAL WATER CRISIS



The real crisis
is NOT oil.

ITS ALL
ABOUT
WATER

AN ESSAY BY MIKHAIL GORBACHEV

Water, like religion and ideology, has the power to move millions of people. Since the very birth of human civilization, people have moved to settle close to water. People move when there is too little of it. People move when there is too much of it. People journey down it. People write and sing and dance and dream about it. People fight over it. And all people, everywhere and every day, need it.

We need it for drinking, for cooking, for washing, for food, for industry, for energy, for transport, for rituals, for fun, for life. And it is not only we humans who need it; all life is dependent on water to survive.

But we stand today on the brink of a global water crisis. The two major legacies of the 20th Century - the population and technological explosions - have taken their toll on our water supply. More people lack drinking water today than they did two decades ago. More and more freshwater sources are being used-up and contaminated. Modern technologies have allowed us to harness much of the world's water for energy, industry and irrigation - but often at a terrible social and environmental price - and many traditional water conservation practices have been discarded along the way.

Most of the solutions to the crisis must be developed and implemented locally, and always with the view that water is not to be taken for granted, or unjustly appropriated by particular groups for particular needs.

Water is the most important single element needed in order for people to achieve the universal human right to "a standard of living adequate for the health and well-being of himself and his family." (Article 25, Universal Declaration of Human Rights) Without access to clean water, health and well-being are not only severely jeopardized, they are impossible: people without basic water supplies live greatly reduced and impoverished lives - with little opportunity to create better futures for their children.

Let us acknowledge that clean water is a universal human right, and in so doing accept that we have the corresponding universal responsibility to ensure that the forecast of a world where, in 25 years' time, two out of every three persons face water-stress is proven wrong. In this issue, United Nations' Secretary General Kofi Annan asks us to face up to the threat of a catastrophic water crisis and counter such bleak forecasts by adopting a new spirit of stewardship. To do otherwise would be nothing less than a crime and history will rightly judge current generations harshly for it.

The world's growing population should be seen not only as one of the causes of the water crisis, but also as the source of its solution, as is stressed by Former President of the Philippines, Fidel Ramos, using the example of the enormous potential of people-power in South East Asia. Human solidarity is the only force capable of facing a task of this magnitude. There must be solidarity in international and regional governance; there must be solidarity between sectors and stakeholders; and there must be political will amongst governments to work in good faith both with their neighbors and with their own people. These people, including often marginalized groups such as women and minorities, must have a voice, and the information and means necessary to use it.

Without water security, social, economic and national stability are imperiled. This is magnified where water flows across borders - and becomes crucial in regions of religious, territorial or ethnic tension. In some cases, as between India and Pakistan over the Indus River, successful cooperation over water resources can be cited as proof that even states with difficult relations can work together. In other cases, the opportunities to improve regional relations which a common watercourse presents have not yet been grasped. The Jordan Valley, shared by the people of Israel, Palestine, Jordan, Syria and Lebanon, is one such example.

Water has been a fundamental security matter in the arid Middle East since antiquity. The allocation, use and rights to the increasingly scarce water resources of this volatile region remain sensitive, and potentially explosive, issues. Water is also largely sidelined, or hidden, in the mainstream peace negotiations. Hanan Sher of The Jerusalem Post sheds light on the trials and tribulations encountered on the road towards achieving water for peace in the Middle East, a road which I myself have recently revisited. Earlier this year I met with Prime Minister Barak, Chairman Arafat and King Abdullah of Jordan, and obtained their commitment to work with my organization, Green Cross International, and our partners, the Center for Middle East Peace and Economic Cooperation, to find solutions to the escalating regional water crisis.

These three leaders explicitly recognized that there can be no unilateral solutions to their essentially trans-boundary water problems. This is as true in the Middle East as it is regarding watercourses shared between the United States and its neighbors. In all of the world's 261 international basins, joint management should be built on a system of effective interdependence; a pooling rather than a restriction of each nations' sovereignty.

While armed, inter-state conflicts over water are unlikely, it must be remembered that these are not the only types of conflicts facing water-stressed societies. Internal conflicts between ethnic groups, regions, users and small communities can and do arise over water. Inter-state cooperation is essential to the search for regional water solutions. Where such solutions are not easily forthcoming, international mediation and support should be available. A movement to provide such support has been initiated by Secretary of State Madeleine Albright with the establishment of a Global Alliance for Water Security.

In most cases, however, the practical solutions required are local, reflecting the geographically and culturally specific nature of water-use. The Cold War era of "the bigger the better", which prompted the construction of 45,000 large dams throughout the world, is over. This thoughtless tampering with nature has left a terrible legacy, not least in my own region where thousands of acres of fertile land have been lost, and man-made catastrophes such as in the Aral Sea region cause immeasurable suffering. The articles provided by Kader Asmal of the World Commission on Dams, and water expert Anil Agarwal, seek the path to a new era where social and environmental considerations are given precedence and the benefits of large constructs like dams are questioned. The United States, the second most "dammed" nation, after China, is already breaching many of its dams; elsewhere, particularly in the developing world, the question is how to provide the services supplied by dam projects through other initiatives, like rainwater harvesting and demand management.

At the heart of the matter is the value which we assign to different uses of water. Again, there is no universal blueprint, but it is clear that neither of the two extreme stances, one advocating that water should be free for all, and the other promoting full cost pricing for all water supplies, are desirable. We must remember that the *value* and the *price* of water are two very different things; it is substance which must be used efficiently, but must be available for the sustenance of all - including natural ecosystems. This makes the pricing of water a tricky business, as we gather further from World Commission on Water Chairman, Ismail Serageldin, and Douglas B. MacDonald's insights on the subject.

Thus we are faced with a mighty challenge. Fortunately we have a history of meeting great challenges using imagination and our irrepressible capacity to adapt. To ensure that we journey in the right direction, we must allow our knowledge, experience and institutions to catch up with the overwhelming progress of science and technology, and learn how to become both good neighbors for each other and good guests of the natural environment.

Just as we are moved by water, we must move quickly in order to save it.

Introductory article written for Civilization, the Magazine of the US Library of Congress, October-November 2000, by Guest Editor Mikhail Gorbachev.



Water, water nowhere

September 11, 2013

The complaining will soon begin at the convenience store down the road from you as gasoline prices inch closer to \$4 a gallon. It shouldn't be too long. Last time I checked with friends in Ireland, gasoline at a Dublin convenience store cost \$8 a gallon.

Curiously, those down the road who will complain the loudest won't think twice about dropping a dollar on the counter for a 1.25-pint bottle of Poland Spring water, which translates to \$6.40 a gallon for artesian well spring water that bubbled up out of the ground.

Flip to the business section of most any daily newspaper and you'll see unleaded gasoline among the commodities listed, along with gold, copper, cattle, corn, wheat and other staples of domestic and international commerce. Last week, unleaded gasoline was listed at \$2.97 a gallon. What you won't find included in the commodities list is fresh water. At least not yet. But you will.

Perhaps not in my lifetime, but sooner or later, fresh water will be sold by the barrel, much as crude oil is today. Fresh water will be carried by pipelines and transported by tankers to countries of means. Their citizens who can afford it will survive, while the have-nots who live in countries that can't afford it won't survive.

U.S. Agency for International Development officials told a congressional hearing last month that it expects two-thirds of the world's population to be living under "severe water stress conditions" by the year 2025 due to lack of access to clean fresh water. That's only 12 years from now. Between now and then, a problem that is already devastating wide areas of Africa as well as Pakistan, India and China will be exacerbated by growing populations and rising sea levels and drought conditions being driven by climate change.

While 70 percent of Mother Earth is covered by water, only 2.5 percent of that water is fresh water, and only 1.7 percent is easily accessible, much of it trapped in glaciers and snowfields, according to the National Geographic Society. A mere 0.007 percent of the planet's water is readily available to meet the needs of the 6.8 billion people who can't survive without it. By one estimate 1.8 billion people will be living by 2027 in areas where fresh water is scarce.

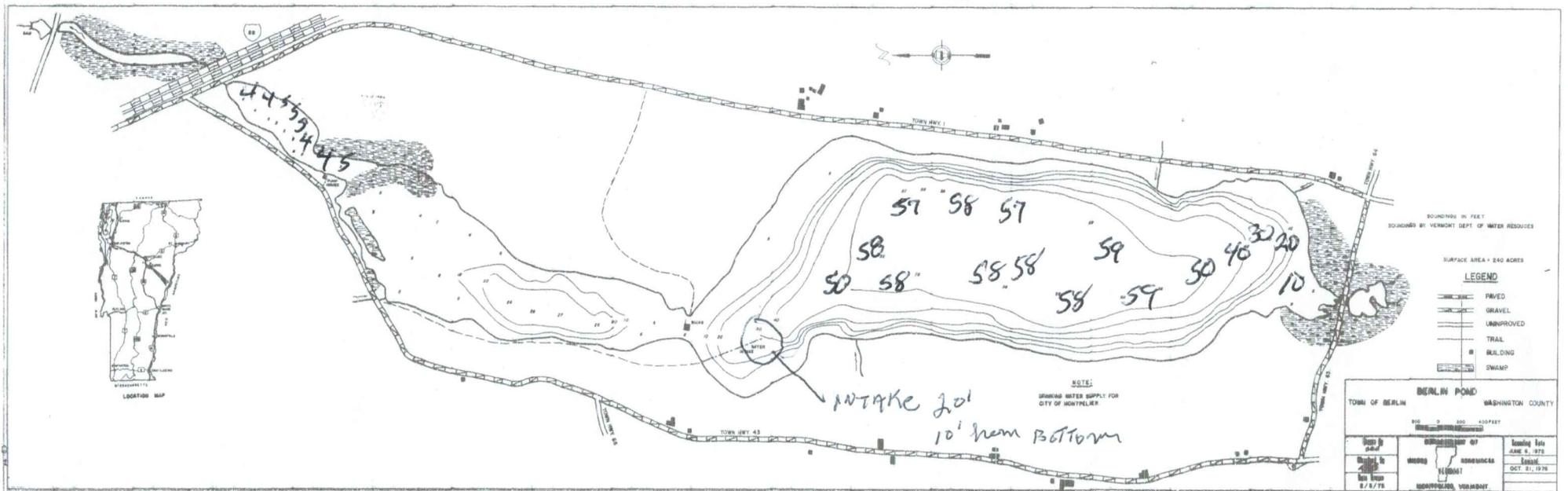
By volume, most of the world's fresh water reserve is in Brazil, which has a population of 188 million. Russia, the world's largest country in terms of area, is second in terms of fresh water supply but has a population of 142 million. Canada is in the enviable position of laying claim to 20 percent of the world's fresh water supply, with a population of only 33 million people, which is 5 million fewer citizens than the state of California. With a population of 305 million, prolonged Western and Southeastern drought is taxing America's claim to the world's fourth-largest fresh water inventory.

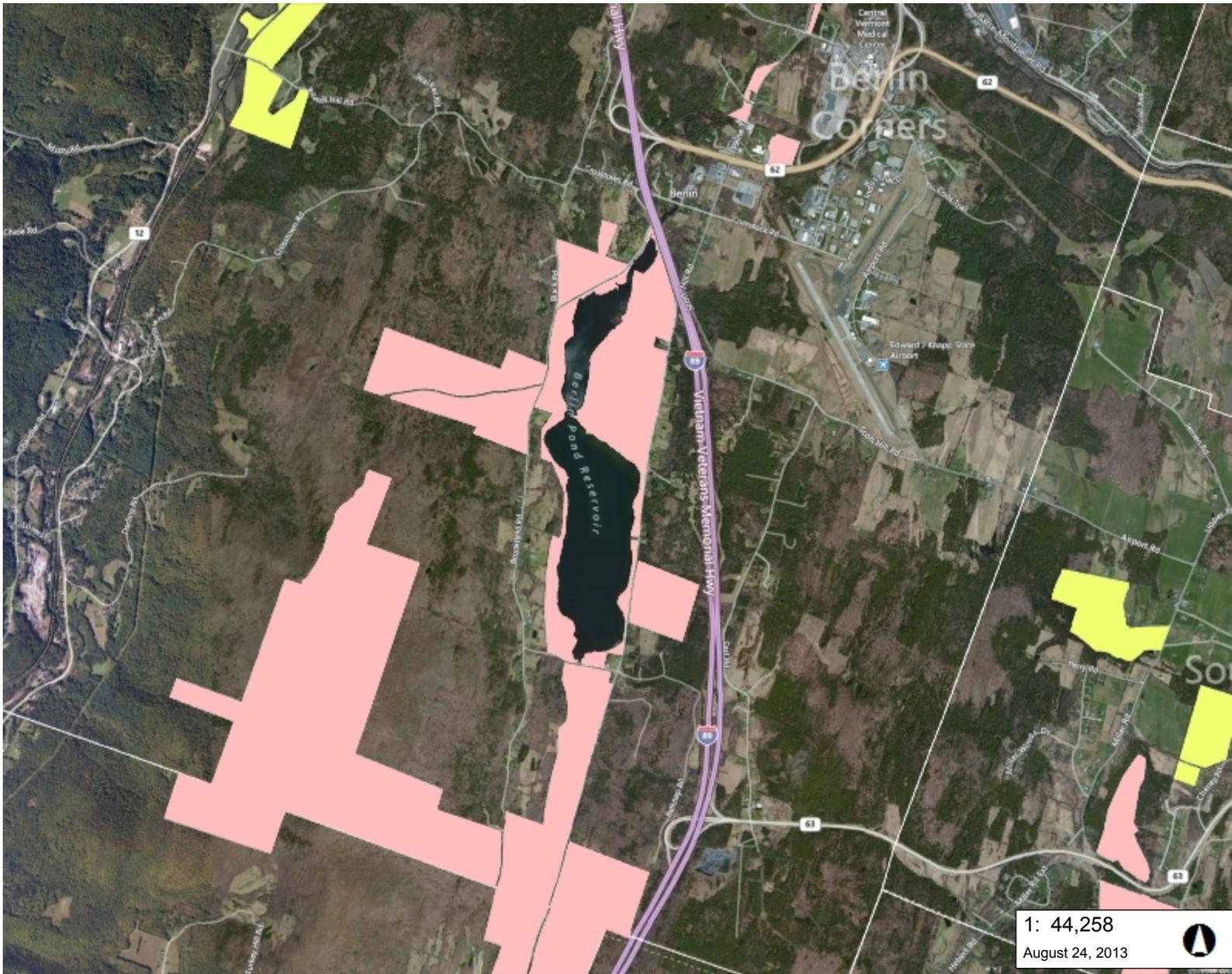
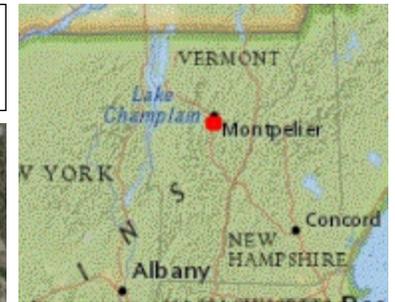
"I think it's pretty clear we're operating as if water were a resource that would never dry up, and I think it's pretty clear we're wrong," Bill McKibben, a distinguished scholar and climate change expert from Middlebury College, recently told me. "Just look at the headlines of the last few days about the drying of the lakes behind Glen Canyon and Hoover dams. We're in uncharted territory here."

To no small degree, fresh water consumption is an out-of-sight, out-of-mind phenomenon. You know those hamburger patties you intend to throw on the grill for tonight's dinner? Each required 630 gallons of fresh water to produce. The milk you'll serve the kids tonight? Each gallon required 880 gallons of fresh water. And that 750 milliliter bottle of Napa Valley red wine you've set aside for dinner? Just over 1,000 gallons.

Bon appetit. I think that's French for "get it while you can."

Tom Walsh is an award-winning science writer who lives in Maine and writes for newspapers around New England





LEGEND

- Conserved Lands**
- Housing and Conservation Board
 - Local Government
 - Private Organization
 - US Dept. of Defense
 - US Fish and Wildlife Service
 - US National Park Service
 - UVM and State Colleges
 - VT Dept. Buildings and General Se
 - VT Division for Historical Preservati
- Town Boundary**

1: 44,258
August 24, 2013

NOTES

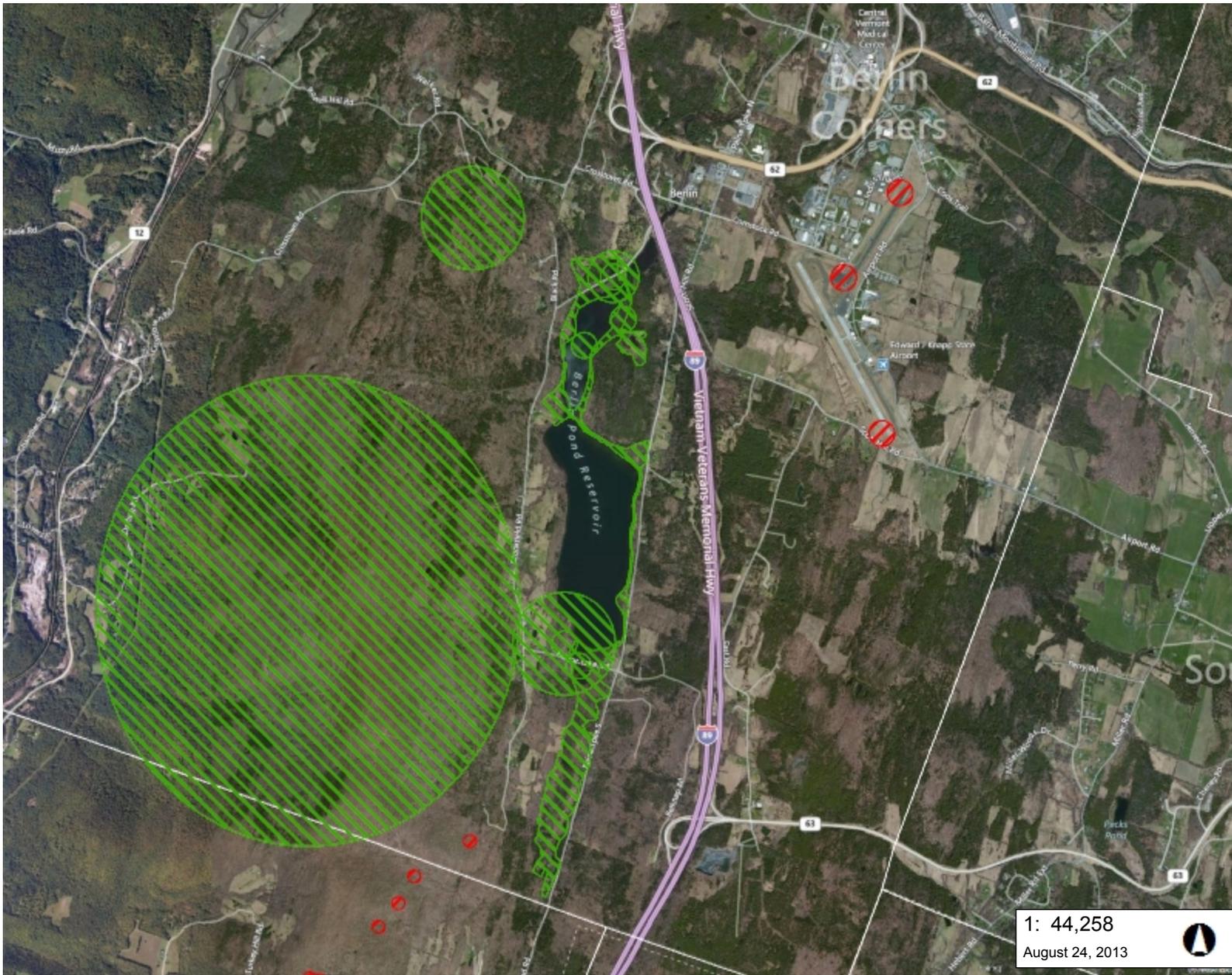
Map created using ANR's Natural Resources Atlas

2,248.0 0 1,124.00 2,248.0 Meters

WGS_1984_Web_Mercator_Auxiliary_Sphere 1" = 3688 Ft. 1cm = 443 Meters

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LEGEND

- Rare Threatened Endangered
- Threatened or Endangered
- Rare
- Town Boundary

1: 44,258
August 24, 2013



NOTES

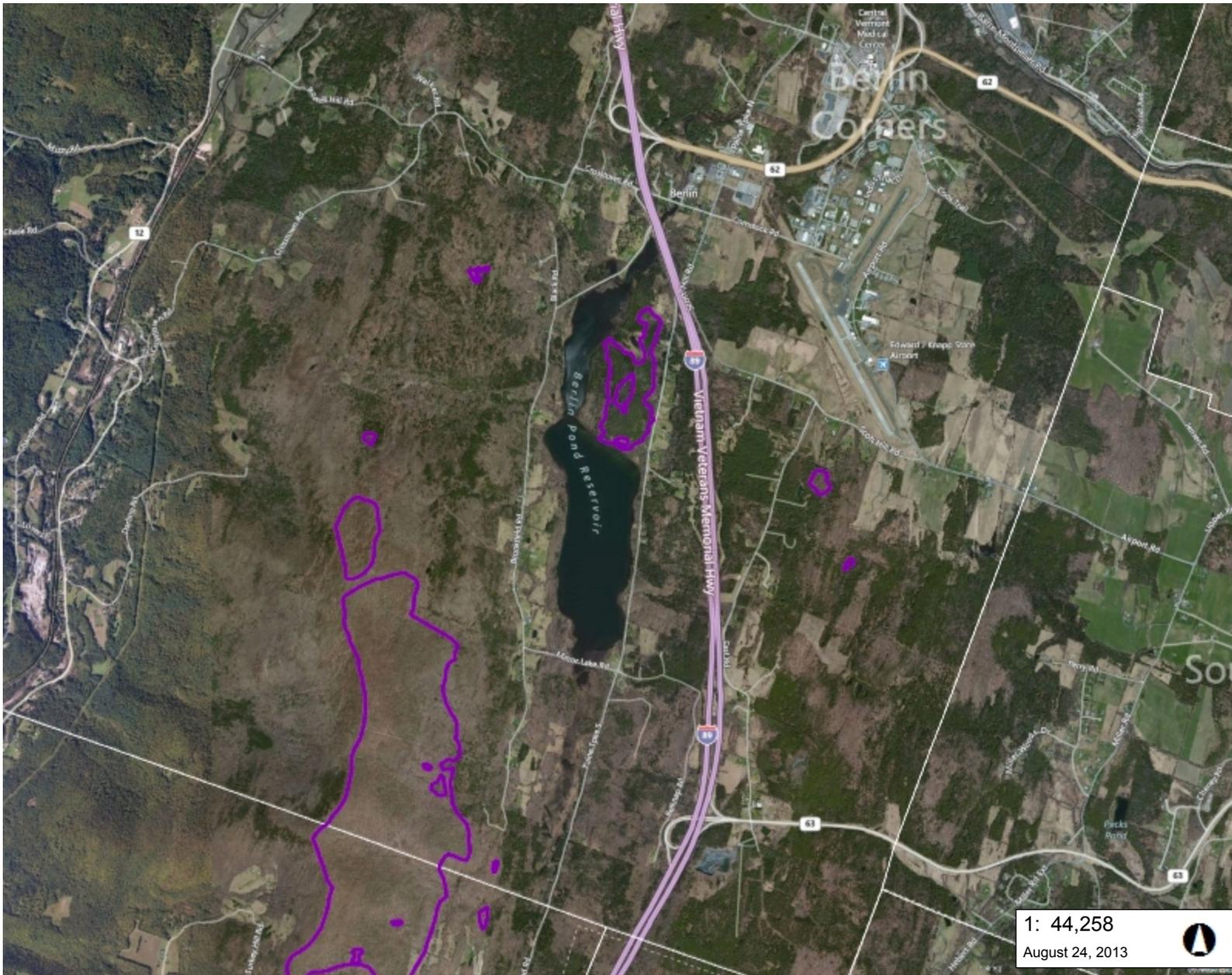
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LEGEND

- Significant Natural Community
- Town Boundary

1: 44,258
August 24, 2013

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LEGEND

- SurfaceWaterSPA
- Town Boundary

1: 44,258
August 24, 2013

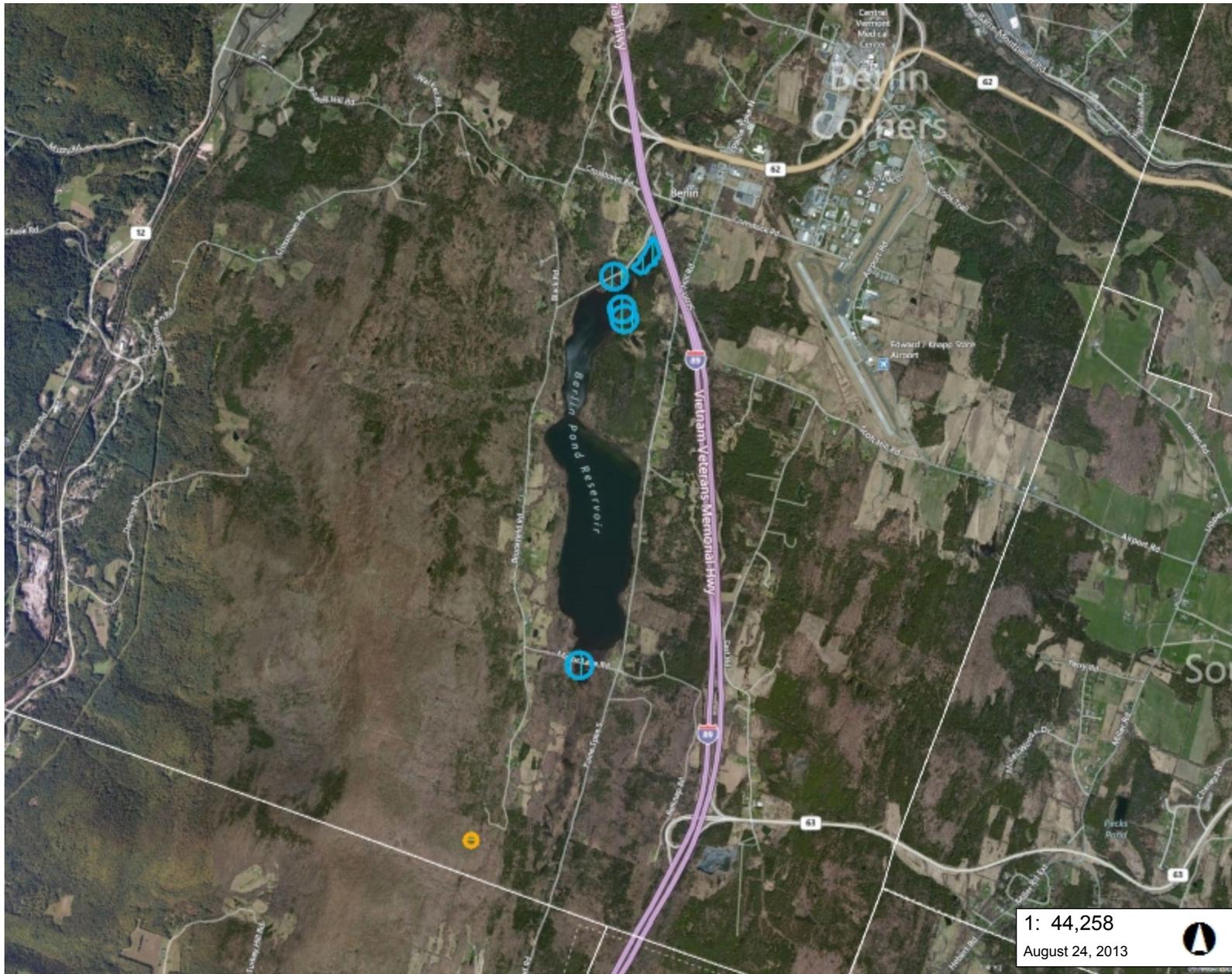
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LEGEND

Uncommon Species and Other

- Animal
- Plant
- Natural Community
- Town Boundary

1: 44,258

August 24, 2013



NOTES

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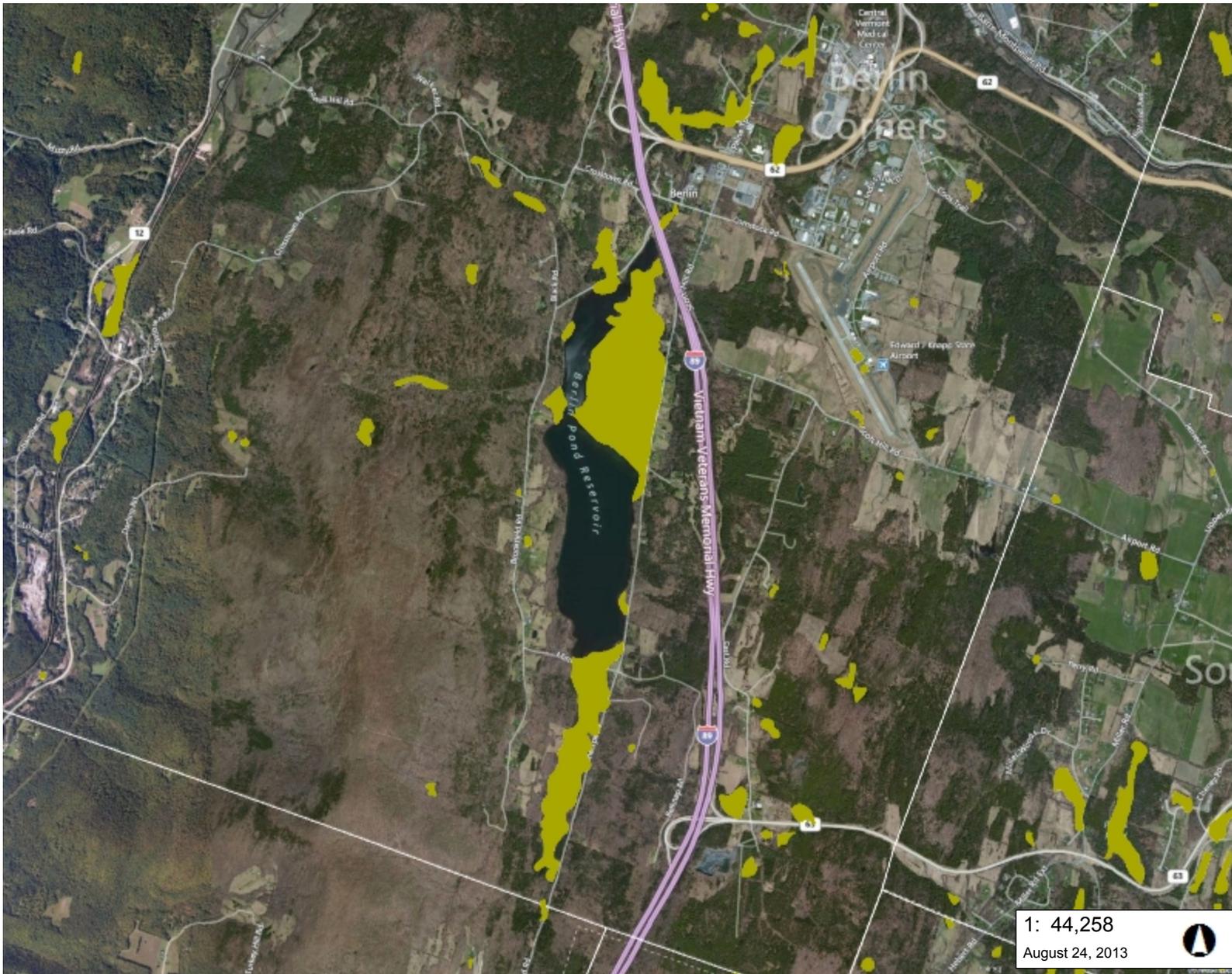
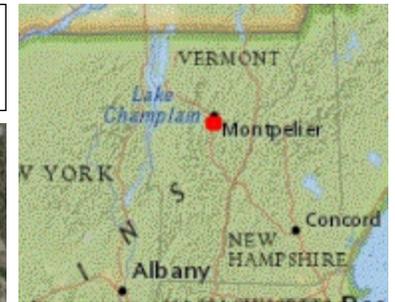
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LEGEND

- Wetlands - VSWI
 - Class 1 Wetland
 - Class 2 Wetland
- Town Boundary

1: 44,258
August 24, 2013

NOTES

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HSPD 7 Full Text

Homeland Security Presidential Directive-7

December 17, 2003

SUBJECT: Critical Infrastructure Identification, Prioritization, and Protection

Purpose

1. This directive establishes a national policy for Federal departments and agencies to identify and prioritize United States critical infrastructure and key resources and to protect them from terrorist attacks.

Background

2. Terrorists seek to destroy, incapacitate, or exploit critical infrastructure and key resources across the United States to threaten national security, cause mass casualties, weaken our economy, and damage public morale and confidence.
3. America's open and technologically complex society includes a wide array of critical infrastructure and key resources that are potential terrorist targets. The majority of these are owned and operated by the private sector and State or local governments. These critical infrastructures and key resources are both physical and cyber-based and span all sectors of the economy.
4. Critical infrastructure and key resources provide the essential services that underpin American society. The Nation possesses numerous key resources, whose exploitation or destruction by terrorists could cause catastrophic health effects or mass casualties comparable to those from the use of a weapon of mass destruction, or could profoundly affect our national prestige and morale. In addition, there is critical infrastructure so vital that its incapacitation, exploitation, or destruction, through terrorist attack, could have a debilitating effect on security and economic well-being.
5. While it is not possible to protect or eliminate the vulnerability of all critical infrastructure and key resources throughout the country, strategic improvements in security can make it more difficult for attacks to succeed and can lessen the impact of attacks that may occur. In addition to strategic security enhancements, tactical security improvements can be rapidly implemented to deter, mitigate, or neutralize potential attacks.

Definitions

6. In this directive:
 1. The term "critical infrastructure" has the meaning given to that term in section 1016(e) of the USA PATRIOT Act of 2001 (42 U.S.C. 5195c(e)).
 2. The term "key resources" has the meaning given that term in section 2(9) of the Homeland Security Act of 2002 (6 U.S.C. 101(9)).
 3. The term "the Department" means the Department of Homeland Security.
 4. The term "Federal departments and agencies" means those executive departments enumerated in 5 U.S.C. 101, and the Department of Homeland Security; independent establishments as defined by 5 U.S.C. 104(1); Government corporations as defined by 5 U.S.C. 103(1); and the United States Postal Service.
 5. The terms "State," and "local government," when used in a geographical sense, have the same meanings given to those terms in section 2 of the Homeland Security Act of 2002 (6 U.S.C. 101).
 6. The term "the Secretary" means the Secretary of Homeland Security.
 7. The term "Sector-Specific Agency" means a Federal department or agency responsible for infrastructure protection activities in a designated critical infrastructure sector or key resources category. Sector-Specific Agencies will conduct their activities under this directive in accordance with guidance provided by the Secretary.
 8. The terms "protect" and "secure" mean reducing the vulnerability of critical infrastructure or key resources in order to deter, mitigate, or neutralize terrorist attacks.

Policy

7. It is the policy of the United States to enhance the protection of our Nation's critical infrastructure and key resources against terrorist acts that could:

1. cause catastrophic health effects or mass casualties comparable to those from the use of a weapon of mass destruction;
 2. impair Federal departments and agencies' abilities to perform essential missions, or to ensure the public's health and safety;
 3. undermine State and local government capacities to maintain order and to deliver minimum essential public services;
 4. damage the private sector's capability to ensure the orderly functioning of the economy and delivery of essential services;
 5. have a negative effect on the economy through the cascading disruption of other critical infrastructure and key resources; or
 6. undermine the public's morale and confidence in our national economic and political institutions.
8. Federal departments and agencies will identify, prioritize, and coordinate the protection of critical infrastructure and key resources in order to prevent, deter, and mitigate the effects of deliberate efforts to destroy, incapacitate, or exploit them. Federal departments and agencies will work with State and local governments and the private sector to accomplish this objective.
 9. Federal departments and agencies will ensure that homeland security programs do not diminish the overall economic security of the United States.
 10. Federal departments and agencies will appropriately protect information associated with carrying out this directive, including handling voluntarily provided information and information that would facilitate terrorist targeting of critical infrastructure and key resources consistent with the Homeland Security Act of 2002 and other applicable legal authorities.
 11. Federal departments and agencies shall implement this directive in a manner consistent with applicable provisions of law, including those protecting the rights of United States persons.

Roles and Responsibilities of the Secretary

12. In carrying out the functions assigned in the Homeland Security Act of 2002, the Secretary shall be responsible for coordinating the overall national effort to enhance the protection of the critical infrastructure and key resources of the United States. The Secretary shall serve as the principal Federal official to lead, integrate, and coordinate implementation of efforts among Federal departments and agencies, State and local governments, and the private sector to protect critical infrastructure and key resources.
13. Consistent with this directive, the Secretary will identify, prioritize, and coordinate the protection of critical infrastructure and key resources with an emphasis on critical infrastructure and key resources that could be exploited to cause catastrophic health effects or mass casualties comparable to those from the use of a weapon of mass destruction.
14. The Secretary will establish uniform policies, approaches, guidelines, and methodologies for integrating Federal infrastructure protection and risk management activities within and across sectors along with metrics and criteria for related programs and activities.
15. The Secretary shall coordinate protection activities for each of the following critical infrastructure sectors: information technology; telecommunications; chemical; transportation systems, including mass transit, aviation, maritime, ground/surface, and rail and pipeline systems; emergency services; and postal and shipping. The Department shall coordinate with appropriate departments and agencies to ensure the protection of other key resources including dams, government facilities, and commercial facilities. In addition, in its role as overall cross-sector coordinator, the Department shall also evaluate the need for and coordinate the coverage of additional critical infrastructure and key resources categories over time, as appropriate.
16. The Secretary will continue to maintain an organization to serve as a focal point for the security of cyberspace. The organization will facilitate interactions and collaborations between and among Federal departments and agencies, State and local governments, the private sector, academia and international organizations. To the extent permitted by law, Federal departments and agencies with cyber expertise, including but not limited to the Departments of Justice, Commerce, the Treasury, Defense, Energy, and State, and the Central Intelligence Agency, will collaborate with and support the organization in accomplishing its mission. The organization's mission includes analysis, warning, information sharing, vulnerability reduction, mitigation, and aiding national recovery efforts for critical infrastructure information systems. The organization will support the Department of Justice and other law enforcement agencies in

their continuing missions to investigate and prosecute threats to and attacks against cyberspace, to the extent permitted by law.

17. The Secretary will work closely with other Federal departments and agencies, State and local governments, and the private sector in accomplishing the objectives of this directive.

Roles and Responsibilities of Sector-Specific Federal Agencies

18. Recognizing that each infrastructure sector possesses its own unique characteristics and operating models, there are designated Sector-Specific Agencies, including:
 1. Department of Agriculture -- agriculture, food (meat, poultry, egg products);
 2. Health and Human Services -- public health, healthcare, and food (other than meat, poultry, egg products);
 3. Environmental Protection Agency -- drinking water and water treatment systems;
 4. Department of Energy -- energy, including the production refining, storage, and distribution of oil and gas, and electric power except for commercial nuclear power facilities;
 5. Department of the Treasury -- banking and finance;
 6. Department of the Interior -- national monuments and icons; and
 7. Department of Defense -- defense industrial base.
19. In accordance with guidance provided by the Secretary, Sector-Specific Agencies shall:
 1. collaborate with all relevant Federal departments and agencies, State and local governments, and the private sector, including with key persons and entities in their infrastructure sector;
 2. conduct or facilitate vulnerability assessments of the sector; and
 3. encourage risk management strategies to protect against and mitigate the effects of attacks against critical infrastructure and key resources.
20. Nothing in this directive alters, or impedes the ability to carry out, the authorities of the Federal departments and agencies to perform their responsibilities under law and consistent with applicable legal authorities and presidential guidance.
21. Federal departments and agencies shall cooperate with the Department in implementing this directive, consistent with the Homeland Security Act of 2002 and other applicable legal authorities.

Roles and Responsibilities of Other Departments, Agencies, and Offices

22. In addition to the responsibilities given the Department and Sector-Specific Agencies, there are special functions of various Federal departments and agencies and components of the Executive Office of the President related to critical infrastructure and key resources protection.
 1. The Department of State, in conjunction with the Department, and the Departments of Justice, Commerce, Defense, the Treasury and other appropriate agencies, will work with foreign countries and international organizations to strengthen the protection of United States critical infrastructure and key resources.
 2. The Department of Justice, including the Federal Bureau of Investigation, will reduce domestic terrorist threats, and investigate and prosecute actual or attempted terrorist attacks on, sabotage of, or disruptions of critical infrastructure and key resources. The Attorney General and the Secretary shall use applicable statutory authority and attendant mechanisms for cooperation and coordination, including but not limited to those established by presidential directive.
 3. The Department of Commerce, in coordination with the Department, will work with private sector, research, academic, and government organizations to improve technology for cyber systems and promote other critical infrastructure efforts, including using its authority under the Defense Production Act to assure the timely availability of industrial products, materials, and services to meet homeland security requirements.
 4. A Critical Infrastructure Protection Policy Coordinating Committee will advise the Homeland Security Council on interagency policy related to physical and cyber infrastructure protection. This PCC will be chaired by a Federal officer or employee designated by the Assistant to the President for Homeland Security.

5. The Office of Science and Technology Policy, in coordination with the Department, will coordinate interagency research and development to enhance the protection of critical infrastructure and key resources.
 6. The Office of Management and Budget (OMB) shall oversee the implementation of government-wide policies, principles, standards, and guidelines for Federal government computer security programs. The Director of OMB will ensure the operation of a central Federal information security incident center consistent with the requirements of the Federal Information Security Management Act of 2002.
 7. Consistent with the E-Government Act of 2002, the Chief Information Officers Council shall be the principal interagency forum for improving agency practices related to the design, acquisition, development, modernization, use, operation, sharing, and performance of information resources of Federal departments and agencies.
 8. The Department of Transportation and the Department will collaborate on all matters relating to transportation security and transportation infrastructure protection. The Department of Transportation is responsible for operating the national air space system. The Department of Transportation and the Department will collaborate in regulating the transportation of hazardous materials by all modes (including pipelines).
 9. All Federal departments and agencies shall work with the sectors relevant to their responsibilities to reduce the consequences of catastrophic failures not caused by terrorism.
23. The heads of all Federal departments and agencies will coordinate and cooperate with the Secretary as appropriate and consistent with their own responsibilities for protecting critical infrastructure and key resources.
 24. All Federal department and agency heads are responsible for the identification, prioritization, assessment, remediation, and protection of their respective internal critical infrastructure and key resources. Consistent with the Federal Information Security Management Act of 2002, agencies will identify and provide information security protections commensurate with the risk and magnitude of the harm resulting from the unauthorized access, use, disclosure, disruption, modification, or destruction of information.

Coordination with the Private Sector

25. In accordance with applicable laws or regulations, the Department and the Sector-Specific Agencies will collaborate with appropriate private sector entities and continue to encourage the development of information sharing and analysis mechanisms. Additionally, the Department and Sector-Specific Agencies shall collaborate with the private sector and continue to support sector-coordinating mechanisms:
 1. to identify, prioritize, and coordinate the protection of critical infrastructure and key resources; and
 2. to facilitate sharing of information about physical and cyber threats, vulnerabilities, incidents, potential protective measures, and best practices.

National Special Security Events

26. The Secretary, after consultation with the Homeland Security Council, shall be responsible for designating events as "National Special Security Events" (NSSEs). This directive supersedes language in previous presidential directives regarding the designation of NSSEs that is inconsistent herewith.

Implementation

27. Consistent with the Homeland Security Act of 2002, the Secretary shall produce a comprehensive, integrated National Plan for Critical Infrastructure and Key Resources Protection to outline national goals, objectives, milestones, and key initiatives within 1 year from the issuance of this directive. The Plan shall include, in addition to other Homeland Security-related elements as the Secretary deems appropriate, the following elements:
 1. a strategy to identify, prioritize, and coordinate the protection of critical infrastructure and key resources, including how the Department intends to work with Federal departments and agencies, State and local governments, the private sector, and foreign countries and international organizations;

2. a summary of activities to be undertaken in order to: define and prioritize, reduce the vulnerability of, and coordinate the protection of critical infrastructure and key resources;
 3. a summary of initiatives for sharing critical infrastructure and key resources information and for providing critical infrastructure and key resources threat warning data to State and local governments and the private sector; and
 4. coordination and integration, as appropriate, with other Federal emergency management and preparedness activities including the National Response Plan and applicable national preparedness goals.
28. The Secretary, consistent with the Homeland Security Act of 2002 and other applicable legal authorities and presidential guidance, shall establish appropriate systems, mechanisms, and procedures to share homeland security information relevant to threats and vulnerabilities in national critical infrastructure and key resources with other Federal departments and agencies, State and local governments, and the private sector in a timely manner.
29. The Secretary will continue to work with the Nuclear Regulatory Commission and, as appropriate, the Department of Energy in order to ensure the necessary protection of:
1. commercial nuclear reactors for generating electric power and non-power nuclear reactors used for research, testing, and training;
 2. nuclear materials in medical, industrial, and academic settings and facilities that fabricate nuclear fuel; and
 3. the transportation, storage, and disposal of nuclear materials and waste.
30. In coordination with the Director of the Office of Science and Technology Policy, the Secretary shall prepare on an annual basis a Federal Research and Development Plan in support of this directive.
31. The Secretary will collaborate with other appropriate Federal departments and agencies to develop a program, consistent with applicable law, to geospatially map, image, analyze, and sort critical infrastructure and key resources by utilizing commercial satellite and airborne systems, and existing capabilities within other agencies. National technical means should be considered as an option of last resort. The Secretary, with advice from the Director of Central Intelligence, the Secretaries of Defense and the Interior, and the heads of other appropriate Federal departments and agencies, shall develop mechanisms for accomplishing this initiative. The Attorney General shall provide legal advice as necessary.
32. The Secretary will utilize existing, and develop new, capabilities as needed to model comprehensively the potential implications of terrorist exploitation of vulnerabilities in critical infrastructure and key resources, placing specific focus on densely populated areas. Agencies with relevant modeling capabilities shall cooperate with the Secretary to develop appropriate mechanisms for accomplishing this initiative.
33. The Secretary will develop a national indications and warnings architecture for infrastructure protection and capabilities that will facilitate:
1. an understanding of baseline infrastructure operations;
 2. the identification of indicators and precursors to an attack; and
 3. a surge capacity for detecting and analyzing patterns of potential attacks.

In developing a national indications and warnings architecture, the Department will work with Federal, State, local, and non-governmental entities to develop an integrated view of physical and cyber infrastructure and key resources.

34. By July 2004, the heads of all Federal departments and agencies shall develop and submit to the Director of the OMB for approval plans for protecting the physical and cyber critical infrastructure and key resources that they own or operate. These plans shall address identification, prioritization, protection, and contingency planning, including the recovery and reconstitution of essential capabilities.
35. On an annual basis, the Sector-Specific Agencies shall report to the Secretary on their efforts to identify, prioritize, and coordinate the protection of critical infrastructure and key resources in their respective sectors. The report shall be submitted within 1 year from the issuance of this directive and on an annual basis thereafter.

36. The Assistant to the President for Homeland Security and the Assistant to the President for National Security Affairs will lead a national security and emergency preparedness communications policy review, with the heads of the appropriate Federal departments and agencies, related to convergence and next generation architecture. Within 6 months after the issuance of this directive, the Assistant to the President for Homeland Security and the Assistant to the President for National Security Affairs shall submit for my consideration any recommended changes to such policy.
37. This directive supersedes Presidential Decision Directive/NSC-63 of May 22, 1998 ("Critical Infrastructure Protection"), and any Presidential directives issued prior to this directive to the extent of any inconsistency. Moreover, the Assistant to the President for Homeland Security and the Assistant to the President for National Security Affairs shall jointly submit for my consideration a Presidential directive to make changes in Presidential directives issued prior to this date that conform such directives to this directive.
38. This directive is intended only to improve the internal management of the executive branch of the Federal Government, and it is not intended to, and does not, create any right or benefit, substantive or procedural, enforceable at law or in equity, against the United States, its departments, agencies, or other entities, its officers or employees, or any other person.

STATUS OF BIRDS ON BERLIN POND

SCGN

Common Loon
Pied billed Grebe
American Bittern
Great Blue Heron
Blue Winged Teal
Black-crowned Night Heron
American Black Duck
Osprey
Bald Eagle
Coopers Hawk
Northern Goshawk
American Kestral

Sora

American Woodcock
Black-billed Cuckoo
Olive-sided Flycatcher
Gray Jay
Veery
Chestnut-sided Warbler
Field Sparrow
Bobolink
Eastern Meadowlark

SC

Pied-billed Grebe
Black-crowned Night Heron
Green-winged Teal
Blue-winged Teal

American Kestral

Sora

Gray Jay
Boreal Chickadee
Cape May Warbler

S1 (Very rare, critically imperiled)

Great Egret
Black-crowned Night Heron
Green-winged Teal
Ringed Neck Duck
Great Black Backed Gull
Tennessee Warbler
Palm Warbler
American Widgeon
Wilson's Warbler

S2 (Rare, imperiled)

Blue-winged Teal
Pied-billed Grebe
Common Goldeneye
Northern Goshawk
Gray Jay
Boreal Chickadee
Bay-breasted Warbler
Double Breasted Cormorant
Hooded Merganser

E Endangered

Bald Eagle

SC3 (Uncommon, vulnerable)

Common Loon

American Bittern

Great Blue Heron

American Black Duck

Greater Scaup

Turkey Vulture

Osprey

Sharp-shinned Hawk

Red-bellied Woodpecker

Great Horned Owl

Red-tailed Hawk

Bohemian Waxwing

Rusty Blackbird

Pine Siskin

Northern Shrike

Sources:

The Birds Of Berlin Pond. A seasonal checklist created by the Central Vermont Audubon Society, 1997.

(Status ratings) ***Birds of Vermont, Vermont Natural Heritage Inventory, Vermont Fish & Wildlife Department, 15 November 2012.***

Confirmed nesting species are in bold type.

Copies of sources are attached.

Lakes and ponds within close proximity to Berlin Pond

Pond/Lake Name	Town	Mileage from Berlin Pond
Baker Pond	Brookfield	17.2
Bancroft Pond	Plainfield	17.3
Bliss Pond	Calais	15.3
Blueberry Lake	Warren	33.8
Buck Lake	Woodbury	26.8
Coits Pond	Cabot	27.7
Cranberry Meadow Pond	Woodbury	22.5
Curtis Pond	Calais	17.7
Dog Pond	Woodbury	24
East Long Pond	Woodbury	28.6
Elmore Lake	Elmore	28.6
Greenwood Lake	Woodbury	26.4
Groton Pond	Groton	28.5
Hardwood Pond	Elmore	29.7
Joe's Pond	Cabot	28.9
Keiser Pond	Danville	32.4
Kettle Pond	Groton	28.3
Lamson Pond	Brookfield	15.6
Levi Pond	Groton	29.5
Little Elmore Pond	Elmore	25.6
Marshfield Dam	Cabot	22.6
Martin's Pond	Peacham	36.8
Mirror Lake	Calais	20.9
Molly's Ponda	cabot	27.2
Nelson Pond	Calais	12.2
Nichol's Pond	Woodbury	32.3
North Montpelier Pond	North Montpelier	13.7
Peacham Pond	Peacham	25.8
Pigeon Pond	Groton	20.5
Ricker Pond	Groton	27.8
Seyon Pond	Groton	25.5
Sodom Pond	East Montpelier	14.7
Sunset Lake	Brookfield	16.6
Turtlehead Pond	Marshfield	23
Waterbury Reservoir	Waterbury	22.4
West Hill Pond	Cabot	24.4
Woodbury Lake	Woodbury	23.8
Worcester Pond	Worcester	18.5
Wrightsville Reservoir	East Montpelier	12.2

Source of ponds and lakes - VT Fish and Wildlife
Mileage calculated using Google Maps



Birds of Vermont
Vermont Natural Heritage Inventory
Vermont Fish & Wildlife Department
15 November 2012



The following is a list of bird species known to regularly occur in Vermont. Historic species (not documented in Vermont in the last 25 years) are included, but extinct or extirpated species are not. Both breeding and non-breeding birds are included in the list. Accidental species are not included but transient (migrating) species are. The list is organized taxonomically to genus, then alphabetically within genus.

Species that are not native to Vermont are indicated with an asterisk (*).

Questions about this list can be directed to John Buck, Vermont Fish & Wildlife Department,
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Scientific Name	Common Name	State Rank	Global Rank	State Status	Federal Status	SGCN
<i>Chen caerulescens</i>	Snow Goose	SNA	G5			
<i>Branta bernicla</i>	Brant	SNA	G5			
<i>Branta canadensis</i>	Canada Goose	S5N	G5			
<i>Branta hutchinsii</i>	Cackling Goose	SNA	G5			
<i>Aix sponsa</i>	Wood Duck	S4B	G5			
<i>Anas acuta</i>	Northern Pintail	S1B	G5			
<i>Anas americana</i>	American Wigeon	S1B	G5			
<i>Anas clypeata</i>	Northern Shoveler	SNA	G5			
<i>Anas crecca</i>	Green-winged Teal	S1B	G5	SC		
<i>Anas discors</i>	Blue-winged Teal	S2B	G5	SC		SGCN
<i>Anas platyrhynchos</i>	Mallard	S4B,S5N	G5			
<i>Anas rubripes</i>	American Black Duck	S3B,S5N	G5	SC		SGCN
<i>Anas strepera</i>	Gadwall	S1B	G5			
<i>Aythya affinis</i>	Lesser Scaup	SNA	G5			
<i>Aythya americana</i>	Redhead	SNA	G5			
<i>Aythya collaris</i>	Ring-necked Duck	S1B	G5			
<i>Aythya marila</i>	Greater Scaup	S3N	G5			
<i>Aythya valisineria</i>	Canvasback	SNA	G5			
<i>Melanitta americana</i>	American Scoter	SNA	GNR			
<i>Melanitta fusca</i>	White-winged Scoter	SNA	G5			
<i>Melanitta perspicillata</i>	Surf Scoter	SNA	G5			
<i>Clangula hyemalis</i>	Long-tailed Duck	SNA	G5			
<i>Bucephala albeola</i>	Bufflehead	S4N	G5			
<i>Bucephala clangula</i>	Common Goldeneye	S2B,S5N	G5			
<i>Bucephala islandica</i>	Barrow's Goldeneye	S3N	G5			
<i>Lophodytes cucullatus</i>	Hooded Merganser	S4B,S2N	G5			
<i>Mergus merganser</i>	Common Merganser	S4B,S5N	G5			
<i>Mergus serrator</i>	Red-breasted Merganser	S1B	G5			
<i>Oxyura jamaicensis</i>	Ruddy Duck	SNA	G5			
* <i>Colinus virginianus</i>	Northern Bobwhite	SNA	G5			
* <i>Perdix perdix</i>	Gray Partridge	SNA	G5			
* <i>Phasianus colchicus</i>	Ring-necked Pheasant	SNA	G5			
<i>Bonasa umbellus</i>	Ruffed Grouse	S4S5	G5			SGCN
<i>Falcapennis canadensis</i>	Spruce Grouse	S1	G5	E		SGCN
<i>Meleagris gallopavo</i>	Wild Turkey	S4	G5			

Scientific Name	Common Name	State Rank	Global Rank	State Status	Federal Status	SGCN
<i>Gavia immer</i>	Common Loon	S3B	G5			SGCN
<i>Gavia pacifica</i>	Pacific Loon	SNA	G5			
<i>Gavia stellata</i>	Red-throated Loon	SNA	G5			
<i>Podilymbus podiceps</i>	Pied-billed Grebe	S2S3B	G5	SC		SGCN
<i>Podiceps auritus</i>	Horned Grebe	SNA	G5			
<i>Podiceps grisegena</i>	Red-necked Grebe	SNA	G5			
<i>Phalacrocorax auritus</i>	Double-crested Cormorant	S2B	G5			
<i>Botaurus lentiginosus</i>	American Bittern	S3B	G4			SGCN
<i>Ixobrychus exilis</i>	Least Bittern	S2B	G5	SC		SGCN
<i>Ardea alba</i>	Great Egret	S1B	G5			
<i>Ardea herodias</i>	Great Blue Heron	S3S4B	G5			SGCN
<i>Bubulcus ibis</i>	Cattle Egret	S1B	G5			
<i>Butorides virescens</i>	Green Heron	S4B	G5			
<i>Nycticorax nycticorax</i>	Black-crowned Night-heron	S1B	G5	SC		SGCN
<i>Coragyps atratus</i>	Black Vulture	SNA	G5			
<i>Cathartes aura</i>	Turkey Vulture	S3S4B	G5			
<i>Pandion haliaetus</i>	Osprey	S3B	G5			SGCN
<i>Haliaeetus leucocephalus</i>	Bald Eagle	S1B,S4N	G5	E		SGCN
<i>Circus cyaneus</i>	Northern Harrier	S3B	G5	SC		SGCN
<i>Accipiter cooperii</i>	Cooper's Hawk	S3B,S3N	G5			SGCN
<i>Accipiter gentilis</i>	Northern Goshawk	S2B,S3N	G5			SGCN
<i>Accipiter striatus</i>	Sharp-shinned Hawk	S3B,S3N	G5			
<i>Buteo jamaicensis</i>	Red-tailed Hawk	S3S4B,S5N	G5			
<i>Buteo lagopus</i>	Rough-legged Hawk	S4N	G5			
<i>Buteo lineatus</i>	Red-shouldered Hawk	S2B	G5			SGCN
<i>Buteo platypterus</i>	Broad-winged Hawk	S4B	G5			
<i>Aquila chrysaetos</i>	Golden Eagle	SNA	G5			
<i>Falco columbarius</i>	Merlin	S2B	G5			
<i>Falco peregrinus</i>	Peregrine Falcon	S3B	G4			SGCN
<i>Falco sparverius</i>	American Kestrel	S4B	G5	SC		SGCN
<i>Rallus limicola</i>	Virginia Rail	S4B	G5			
<i>Porzana carolina</i>	Sora	S3B	G5	SC		SGCN
<i>Gallinula galeata</i>	Common Gallinule	S1S2B	GNR	SC		
<i>Fulica americana</i>	American Coot	SUB	G5			
<i>Grus canadensis</i>	Sandhill Crane	S1B	G5			
<i>Pluvialis dominica</i>	American Golden-Plover	SNA	G5			
<i>Pluvialis squatarola</i>	Black-bellied Plover	SNA	G5			
<i>Charadrius semipalmatus</i>	Semipalmated Plover	SNA	G5			
<i>Charadrius vociferus</i>	Killdeer	S5B	G5			
<i>Actitis macularius</i>	Spotted Sandpiper	S5B	G5			
<i>Tringa flavipes</i>	Lesser Yellowlegs	SNA	G5			SGCN
<i>Tringa melanoleuca</i>	Greater Yellowlegs	SNA	G5			
<i>Tringa solitaria</i>	Solitary Sandpiper	SNA	G5			
<i>Bartramia longicauda</i>	Upland Sandpiper	S2B	G5	E		SGCN
<i>Arenaria interpres</i>	Ruddy Turnstone	SNA	G5			
<i>Calidris alba</i>	Sanderling	SNA	G5			
<i>Calidris alpina</i>	Dunlin	SNA	G5			
<i>Calidris bairdii</i>	Baird's Sandpiper	SNA	G5			
<i>Calidris fuscicollis</i>	White-rumped Sandpiper	SNA	G5			

Scientific Name	Common Name	State Rank	Global Rank	State Status	Federal Status	SGCN
<i>Calidris maritima</i>	Purple Sandpiper	SNA	G5			
<i>Calidris melanotos</i>	Pectoral Sandpiper	SNA	G5			
<i>Calidris minutilla</i>	Least Sandpiper	SNA	G5			
<i>Calidris pusilla</i>	Semipalmated Sandpiper	SNA	G5			
<i>Limnodromus griseus</i>	Short-billed Dowitcher	SNA	G5			
<i>Limnodromus scolopaceus</i>	Long-billed Dowitcher	SNA	G5			
<i>Gallinago delicata</i>	Wilson's Snipe	S5B	G5			
<i>Scolopax minor</i>	American Woodcock	S5B	G5			SGCN
<i>Phalaropus lobatus</i>	Red-necked Phalarope	SNA	G4G5			
<i>Rissa tridactyla</i>	Black-legged Kittiwake	SNA	G5			
<i>Xema sabini</i>	Sabine's Gull	SNA	G5			
<i>Larus philadelphia</i>	Bonaparte's Gull	SNA	G5			
<i>Larus ridibundus</i>	Black-headed Gull	SNA	G5			
<i>Larus minutus</i>	Little Gull	SNA	G5			
<i>Larus argentatus</i>	Herring Gull	S1B,S5N	G5			
<i>Larus delawarensis</i>	Ring-billed Gull	S1B,S5N	G5			
<i>Larus glaucoides</i>	Iceland Gull	SNA	G5			
<i>Larus hyperboreus</i>	Glaucous Gull	SNA	G5			
<i>Larus marinus</i>	Great Black-backed Gull	S1B,S5N	G5			
<i>Hydroprogne caspia</i>	Caspian Tern	S1B	G5			
<i>Chlidonias niger</i>	Black Tern	S1B	G4	E		SGCN
<i>Sterna hirundo</i>	Common Tern	S1B	G5	E		SGCN
<i>Stercorarius longicaudus</i>	Long-tailed Jaeger	SNA	G5			
<i>Stercorarius parasiticus</i>	Parasitic Jaeger	SNA	G5			
<i>Stercorarius pomarinus</i>	Pomarine Jaeger	SNA	G5			
* <i>Columba livia</i>	Rock Pigeon	SNA	G5			
<i>Zenaidura macroura</i>	Mourning Dove	S4B,S5N	G5			
<i>Coccyzus americanus</i>	Yellow-billed Cuckoo	S3B	G5			
<i>Coccyzus erythrophthalmus</i>	Black-billed Cuckoo	S5B	G5			SGCN
<i>Tyto alba</i>	Barn Owl	S1B	G5			SGCN
<i>Megascops asio</i>	Eastern Screech-Owl	S3	G5			
<i>Bubo scandiacus</i>	Snowy Owl	SNA	G5			
<i>Bubo virginianus</i>	Great Horned Owl	S3	G5			
<i>Strix varia</i>	Barred Owl	S4	G5			
<i>Asio flammeus</i>	Short-eared Owl	S1B,S1N	G5			SGCN
<i>Asio otus</i>	Long-eared Owl	S1B	G5			SGCN
<i>Aegolius acadicus</i>	Northern Saw-whet Owl	S3B,S3N	G5			
<i>Chordeiles minor</i>	Common Nighthawk	S1B	G5	E		SGCN
<i>Caprimulgus vociferus</i>	Eastern Whip-poor-will	S2B	G5	T		SGCN
<i>Chaetura pelagica</i>	Chimney Swift	S4B	G5	SC		SGCN
<i>Archilochus colubris</i>	Ruby-throated Hummingbird	S5B	G5			
<i>Megaceryle alcyon</i>	Belted Kingfisher	S4B	G5			
<i>Melanerpes carolinus</i>	Red-bellied Woodpecker	S3	G5			
<i>Melanerpes erythrocephalus</i>	Red-headed Woodpecker	S1B	G5	SC		
<i>Sphyrapicus varius</i>	Yellow-bellied Sapsucker	S5B	G5			
<i>Picoides arcticus</i>	Black-backed Woodpecker	S2	G5	SC		SGCN
<i>Picoides dorsalis</i>	American Three-toed Woodpecker	S1	G5			
<i>Picoides pubescens</i>	Downy Woodpecker	S5	G5			
<i>Picoides villosus</i>	Hairy Woodpecker	S5	G5			

Scientific Name	Common Name	State Rank	Global Rank	State Status	Federal Status	SGCN
<i>Colaptes auratus</i>	Northern Flicker	S5B	G5			
<i>Dryocopus pileatus</i>	Pileated Woodpecker	S5	G5			
<i>Contopus cooperi</i>	Olive-sided Flycatcher	S4B	G4	SC		SGCN
<i>Contopus virens</i>	Eastern Wood-Pewee	S5B	G5			
<i>Empidonax alnorum</i>	Alder Flycatcher	S5B	G5			
<i>Empidonax flaviventris</i>	Yellow-bellied Flycatcher	S3B	G5			
<i>Empidonax minimus</i>	Least Flycatcher	S5B	G5			
<i>Empidonax traillii</i>	Willow Flycatcher	S4B	G5			
<i>Sayornis phoebe</i>	Eastern Phoebe	S5B	G5			
<i>Myiarchus crinitus</i>	Great Crested Flycatcher	S5B	G5			
<i>Tyrannus tyrannus</i>	Eastern Kingbird	S5B	G5			
<i>Lanius excubitor</i>	Northern Shrike	S3N	G5			
<i>Lanius ludovicianus</i>	Loggerhead Shrike	SH	G4	E		
<i>Vireo flavifrons</i>	Yellow-throated Vireo	S4B	G5			
<i>Vireo gilvus</i>	Warbling Vireo	S5B	G5			
<i>Vireo olivaceus</i>	Red-eyed Vireo	S5B	G5			
<i>Vireo philadelphicus</i>	Philadelphia Vireo	S1B	G5			
<i>Vireo solitarius</i>	Blue-headed Vireo	S5B	G5			
<i>Perisoreus canadensis</i>	Gray Jay	S2	G5	SC		SGCN
<i>Cyanocitta cristata</i>	Blue Jay	S5	G5			
<i>Corvus brachyrhynchos</i>	American Crow	S5B,S5N	G5			
<i>Corvus corax</i>	Common Raven	S3	G5			
<i>Corvus ossifragus</i>	Fish Crow	S1B	G5			
<i>Eremophila alpestris</i>	Horned Lark	S2B,S5N	G5			
<i>Progne subis</i>	Purple Martin	S3B	G5	SC		SGCN
<i>Tachycineta bicolor</i>	Tree Swallow	S5B	G5			
<i>Stelgidopteryx serripennis</i>	Northern Rough-winged Swallow	S4B	G5			
<i>Riparia riparia</i>	Bank Swallow	S4B	G5			
<i>Petrochelidon pyrrhonota</i>	Cliff Swallow	S4B	G5			
<i>Hirundo rustica</i>	Barn Swallow	S5B	G5			
<i>Poecile atricapillus</i>	Black-capped Chickadee	S5	G5			
<i>Poecile hudsonicus</i>	Boreal Chickadee	S2	G5	SC		
<i>Baeolophus bicolor</i>	Tufted Titmouse	S5	G5			
<i>Sitta canadensis</i>	Red-breasted Nuthatch	S5	G5			
<i>Sitta carolinensis</i>	White-breasted Nuthatch	S5B,S5N	G5			
<i>Certhia americana</i>	Brown Creeper	S5B,S5N	G5			
<i>Thryothorus ludovicianus</i>	Carolina Wren	S4	G5			
<i>Troglodytes aedon</i>	House Wren	S5B	G5			
<i>Troglodytes hiemalis</i>	Winter Wren	S5B	G5			
<i>Cistothorus palustris</i>	Marsh Wren	S4B	G5			
<i>Cistothorus platensis</i>	Sedge Wren	S2B	G5	E		SGCN
<i>Poliptila caerulea</i>	Blue-gray Gnatcatcher	S3B	G5			
<i>Regulus calendula</i>	Ruby-crowned Kinglet	S4B	G5			
<i>Regulus satrapa</i>	Golden-crowned Kinglet	S5B	G5			
<i>Sialia sialis</i>	Eastern Bluebird	S5B,S3N	G5			
<i>Catharus bicknelli</i>	Bicknell's Thrush	S2B	G4	SC		SGCN
<i>Catharus fuscescens</i>	Veery	S5B	G5			SGCN
<i>Catharus guttatus</i>	Hermit Thrush	S5B	G5			
<i>Catharus minimus</i>	Gray-cheeked Thrush	SNA	G5			

Scientific Name	Common Name	State Rank	Global Rank	State Status	Federal Status	SGCN
<i>Catharus ustulatus</i>	Swainson's Thrush	S4B	G5			
<i>Hylocichla mustelina</i>	Wood Thrush	S5B	G5	SC		SGCN
<i>Turdus migratorius</i>	American Robin	S5B,S3N	G5			
<i>Dumetella carolinensis</i>	Gray Catbird	S5B	G5			
<i>Mimus polyglottos</i>	Northern Mockingbird	S4B	G5			
<i>Toxostoma rufum</i>	Brown Thrasher	S4B	G5	SC		SGCN
* <i>Sturnus vulgaris</i>	European Starling	SNA	G5			
<i>Anthus rubescens</i>	American Pipit	SNA	G5			
<i>Bombycilla cedrorum</i>	Cedar Waxwing	S4S5B,S5N	G5			
<i>Bombycilla garrulus</i>	Bohemian Waxwing	S3N	G5			
<i>Calcarius lapponicus</i>	Lapland Longspur	S3N	G5			
<i>Plectrophenax nivalis</i>	Snow Bunting	S4N	G5			
<i>Seiurus aurocapilla</i>	Ovenbird	S5B	G5			
<i>Parkesia motacilla</i>	Louisiana Waterthrush	S4B	G5			
<i>Parkesia noveboracensis</i>	Northern Waterthrush	S4S5B	G5			
<i>Vermivora chrysoptera</i>	Golden-winged Warbler	S3B	G4	SC		SGCN
<i>Vermivora cyanoptera</i>	Blue-winged Warbler	S3B	G5	SC		SGCN
<i>Mniotilta varia</i>	Black-and-white Warbler	S5B	G5			
<i>Oreothlypis celata</i>	Orange-crowned Warbler	SNA	G5			
<i>Oreothlypis peregrina</i>	Tennessee Warbler	S1B	G5			
<i>Oreothlypis ruficapilla</i>	Nashville Warbler	S5B	G5			
<i>Oporornis agilis</i>	Connecticut Warbler	SNA	G4			
<i>Geothlypis philadelphia</i>	Mourning Warbler	S5B	G5			
<i>Geothlypis trichas</i>	Common Yellowthroat	S5B	G5			
<i>Setophaga americana</i>	Northern Parula	S4B	G5			
<i>Setophaga caerulescens</i>	Black-throated Blue Warbler	S5B	G5			SGCN
<i>Setophaga castanea</i>	Bay-breasted Warbler	S2B	G5			SGCN
<i>Setophaga cerulea</i>	Cerulean Warbler	S1S2B	G4	SC		SGCN
<i>Setophaga coronata</i>	Yellow-rumped Warbler	S5B	G5			
<i>Setophaga discolor</i>	Prairie Warbler	S3B	G5	SC		SGCN
<i>Setophaga fusca</i>	Blackburnian Warbler	S5B	G5			
<i>Setophaga magnolia</i>	Magnolia Warbler	S5B	G5			
<i>Setophaga palmarum</i>	Palm Warbler	S1B	G5			
<i>Setophaga pensylvanica</i>	Chestnut-sided Warbler	S5B	G5	SC		SGCN
<i>Setophaga petechia</i>	Yellow Warbler	S5B	G5			
<i>Setophaga pinus</i>	Pine Warbler	S4B	G5			
<i>Setophaga ruticilla</i>	American Redstart	S5B	G5			
<i>Setophaga striata</i>	Blackpoll Warbler	S4B	G5	SC		SGCN
<i>Setophaga tigrina</i>	Cape May Warbler	S1B	G5			
<i>Setophaga virens</i>	Black-throated Green Warbler	S5B	G5			
<i>Cardellina canadensis</i>	Canada Warbler	S4B	G5	SC		SGCN
<i>Cardellina pusilla</i>	Wilson's Warbler	S1B	G5			
<i>Pipilo erythrophthalmus</i>	Eastern Towhee	S4B	G5	SC		SGCN
<i>Spizella arborea</i>	American Tree Sparrow	S5N	G5			
<i>Spizella pallida</i>	Clay-colored Sparrow	S2B	G5			
<i>Spizella passerina</i>	Chipping Sparrow	S5B	G5			
<i>Spizella pusilla</i>	Field Sparrow	S4B	G5	SC		SGCN
<i>Poocetes gramineus</i>	Vesper Sparrow	S2S3B	G5	SC		SGCN
<i>Passerculus sandwichensis</i>	Savannah Sparrow	S5B	G5			

Scientific Name	Common Name	State Rank	Global Rank	State Status	Federal Status	SGCN
<i>Ammodramus henslowii</i>	Henslow's Sparrow	S1B	G4	E		SGCN
<i>Ammodramus nelsoni</i>	Nelson's Sparrow	SNA	G5			
<i>Ammodramus savannarum</i>	Grasshopper Sparrow	S1B	G5	T		SGCN
<i>Passerella iliaca</i>	Fox Sparrow	SNA	G5			
<i>Melospiza georgiana</i>	Swamp Sparrow	S5B	G5			
<i>Melospiza lincolni</i>	Lincoln's Sparrow	S4B	G5			
<i>Melospiza melodia</i>	Song Sparrow	S5B	G5			
<i>Zonotrichia albicollis</i>	White-throated Sparrow	S5B	G5			
<i>Zonotrichia leucophrys</i>	White-crowned Sparrow	SNA	G5			
<i>Junco hyemalis</i>	Dark-eyed Junco	S5B,S5N	G5			
<i>Piranga olivacea</i>	Scarlet Tanager	S5B	G5			
<i>Cardinalis cardinalis</i>	Northern Cardinal	S5	G5			
<i>Pheucticus ludovicianus</i>	Rose-breasted Grosbeak	S5B	G5			
<i>Passerina cyanea</i>	Indigo Bunting	S5B	G5			
<i>Dolichonyx oryzivorus</i>	Bobolink	S5B	G5	SC		SGCN
<i>Agelaius phoeniceus</i>	Red-winged Blackbird	S5B	G5			
<i>Sturnella magna</i>	Eastern Meadowlark	S4B	G5	SC		SGCN
<i>Euphagus carolinus</i>	Rusty Blackbird	S3B	G4	SC		SGCN
<i>Quiscalus quiscula</i>	Common Grackle	S5B	G5			
<i>Molothrus ater</i>	Brown-headed Cowbird	S5B	G5			
<i>Icterus galbula</i>	Baltimore Oriole	S5B	G5			
<i>Icterus spurius</i>	Orchard Oriole	S2B	G5			
<i>Pinicola enucleator</i>	Pine Grosbeak	S3N	G5			
* <i>Carpodacus mexicanus</i>	House Finch	SNA	G5			
<i>Carpodacus purpureus</i>	Purple Finch	S5B,S4N	G5			
<i>Loxia curvirostra</i>	Red Crossbill	S1B,S2N	G5			
<i>Loxia leucoptera</i>	White-winged Crossbill	S3B,S3N	G5			
<i>Acanthis flammea</i>	Common Redpoll	S4N	G5			
<i>Spinus pinus</i>	Pine Siskin	S3B,S4N	G5			
<i>Spinus tristis</i>	American Goldfinch	S5B,S5N	G5			
<i>Coccothraustes vespertinus</i>	Evening Grosbeak	S5B,S4N	G5			
* <i>Passer domesticus</i>	House Sparrow	SNA	G5			

Species: 263

Explanation of Legal Status and Information Ranks

State Rank and Global Rank - Value that best characterizes the relative rarity (abundance) or endangerment of a native taxon within Vermont's geographic boundary or throughout its range, respectively. Ranks are as follows:

- 1 - Very rare (Critically imperiled): At very high risk of extinction or extirpation due to extreme rarity (often 5 or fewer populations or occurrences), very steep declines, or other factors
- 2 - Rare (Imperiled): At high risk of extinction or extirpation due to very restricted range, very few populations (often 20 or fewer), steep declines, or other factors
- 3 - Uncommon (Vulnerable): At moderate risk of extinction or extirpation due to restricted range, relatively few populations or occurrences (often 80 or fewer), recent and widespread declines, or other factors
- 4 - Common to uncommon (Apparently secure): locally common or widely scattered to uncommon, but not rare; some cause for long-term concern due to declines or other factors; or stable over many decades and not threatened but of restricted distribution or other factors
- 5 - Common (Secure): widespread and abundant
- H - Possibly extinct/extirpated: Missing; known from only historical occurrences but still some hope of rediscovery
- X - Presumed extinct/extirpated: Not located despite intensive searches and virtually no likelihood of rediscovery
- U - Unrankable: Currently unrankable due to lack of information or substantially conflicting information about status or trends
- NR - Not ranked: Not yet assessed
- NA - Not applicable. Element is not a suitable target for conservation for one of the following reasons: Hybrid, Exotic Origin, Accidental/Nonregular, Not Confidently Present, No Definable Occurrences
- ? - indicates uncertainty about the rank, may also be expressed in the form of a range rank (e.g. S1S3)

State Status - Legal protection under Vermont Endangered Species Law (10 V.S.A. Chap. 123)

E = Endangered: in immediate danger of becoming extirpated in the state

T = Threatened: with high possibility of becoming endangered in the near future

or informational category only- not established by law

PE = Proposed for Endangered status

PT = Proposed for Threatened status

PDL = Proposed for Delisting

SC = Special Concern: rare; status should be watched

Federal Status - Legal protection under the federal Endangered Species Act, U.S. Fish & Wildlife Service

LE = Listed Endangered

LT = Listed Threatened

PDL = Proposed for Delisting

SC = Species of Concern (does not denote legal protection)

C = Candidate for Listing (does not denote legal protection)

SGCN - Species of Greatest Conservation Need as identified in the Vermont Wildlife Action Plan; does not denote legal protection.

CERTIFICATE OF SERVICE

I hereby certify that I have served a copy of this Petition for Rule Change on the Surface Water for Berlin Pond, Berlin, Vermont, with supporting documents to the persons listed below. Unless otherwise noted, delivery was made by mail and email.

CITIZENS FOR BERLIN POND

BY: Paul W. Perley 2-6-2014
Paul W. Perley, Representative. Date

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