Pembroke Watershed Association

2008 Water Quality Testing Report
Presented to the Town of Pembroke, Ma

Submitted by Charles Banks and Patricia McCabe,
Co-Chairs, Water Quality Committee, PWA, June 2008

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Goals of Water Quality Monitoring:

- Conduct physical and chemical testing based on a Quality Assurance Project Plan submitted and accepted by the State DEP in 2008.
- Provide an analysis of the data and make recommendations for remediation or maintenance of water quality based on previous studies and current problems.
- Present the water quality testing results completed by Pembroke Watershed Association on Furnace, Oldham, Stetson, Little Sandy Bottom, and Hobomock ponds in 2008 and trend water quality parameters over time.
- Support activities carried out around and on the ponds to reduce nutrient loading and pollution (best management practices).
- Pursue grant opportunities for remediation and education activities as possible.

Current Problems Impacting Pembroke Ponds:

- **Eutrophication:** occurs when excessively high nutrient loads of Phosphorus and Nitrogen exist, resulting in algae blooms (some toxic to animals) and weed growth. Sources include animal and human waste, fertilizers, sewage, sediment loads, and muck in pond bottoms. Waters subject to eutrophication are cloudy (turbid) and green or brown in color, often with bad odor and may be overrun with weeds, some of which might be invasive and algae which can be toxic.

- **Sedimentation:** sediment run-off from roads, storm drains, lawns, beach areas, land development projects, reducing water depth and increasing water temperature. Winter road sanding and loss of vegetative barriers near the water increase sediment loading. Urgency: Furnace Pond average depth is 5 feet.

- **Agricultural impacts:** cranberry bog water use, particularly bog effluent returns high in phosphorus, and possible pesticide run-off.

- **Non-point source run-off:** of nutrients in fertilizers and soaps, human and animal wastes, oil, grease, toxic chemicals and pesticides toxic to aquatic life, via storm drains, land development, streets and driveways, human activities. This is an important source of pollution, much of it controllable.

- **Loss of riparian vegetation and bank stabilization:** waterfront stripped of buffer zones: trees, shrubs, and wetland and aquatic plants, which impacts aquatic and wildlife habitats, encourages erosion of existing shoreline, increases non-point source pollution via run-off and provides no filtration of pollution.

- **Stream alterations via dams:** for bog cultivation or herring management, may lead to stagnation of water and enhanced effects of eutrophication, and alters natural habitats.

- **Septic failures:** This problem occurs occasionally and may exist in home sites very close to the water.

- **Conflicts in usage of the water:** water is drawn off to provide water for surrounding towns (Brockton, Abington-Rockland), irrigation for the bogs, water front homeowners use, public use

What was the problem in 2008 (and previous years)?

Eutrophication:

- 90% of Massachusetts ponds have symptoms of Eutrophication.

- Phosphorus and Nitrogen loads stimulate the growth of algae, which cloud the water and limit light diffusion. This halts the growth of native grasses and plants in the water, and permits growth of noxious weeds. The habitat for fish and native insects is altered, and algae growth has been identified as a major threat to the diversity and health of native fish populations in the northeast. Both nighttime plant respiration and algae decomposition reduce the available oxygen in the water, threatening the supply for fish- resulting in fish kills in early AM. Furnace and Oldham have intermittently experienced fish kills of this type this year.

- Furnace is a severely eutrophied pond: category 5 in 319 (D) water impairment levels established by the DEP, requiring a TMDL. Stetson pond is also a category 5 (c) in 319 (D) water impairment: listed as nutrients, organic enrichment / low DO and exotic species.

- Oldham pond is a category 4 (c) in 319 (D) water impairment: listed as exotic species. However, current water quality resembles that of Furnace Pond.

- Hobomock and Little Sandy Bottom Ponds are both Category 2 (unevaluated).

Value of Pembroke's Ponds:

- Aesthetic beauty: unique to Pembroke is the number of great ponds within the town, providing tremendous natural beauty.

- Part of the valuable South Coastal Watershed, and contributes to the Mass Bay estuary. Stetson Pond is part of the Taunton River Watershed.

- Natural resource: drinking water, irrigation for cranberry bogs and homes.

- Town well water recharge from the ponds.

- Aquatic and wildlife habitats.

- Unique natural features: herring spawning grounds in Oldham and Furnace.

- Recreational resource for the town, including town beaches and fishing access.

- Additional tax revenue from waterfront properties.

Value of testing and monitoring:

- Provides a credible method of collecting information about the health of the pond and the watershed that feeds it.

- Documents observations, sampling, and analysis of data/information utilizing methods supported by Mass. Water watch, DEP, and other government agencies.

- Creates a long term monitoring data set to determine impact of actions and restoration efforts. Long term monitoring demonstrates greater validity than short term, and multi-year sampling reduces the likelihood of inaccurate analysis due to testing bias.

- Testing and monitoring can be used to substantiate cost benefit ratios of restorative plans.

Our goal was to determine the ongoing conditions of five of Pembroke's Ponds, and correlate to the feasibility studies conducted in 1993 by Baystate Environmental Inc., and in 2001 by C.E.I. This was done using volunteers within the Pembroke Watershed association, trained in basic collection techniques, use of meters and sampling sticks, and delivering samples to a state certified lab. This will be described in further detail.

Pembroke Watershed Association: Water based testing

We filed a Quality Assurance Program Plan with MassDEP (QAPP). A QAPP sets out all testing procedures and assures consistency with State Standards. Our QAPP filing was approved by MassDEP to be effective 1/1/2008. As a result of our QAPP filing we amended our testing requirements to move testing into deeper water, reduce the number of tests needed and the number of sites. This will give us a better understanding of each ponds overall health.

Map One: overall map that shows all of the ponds

Map Two: Oldham Pond (Bathymetric)

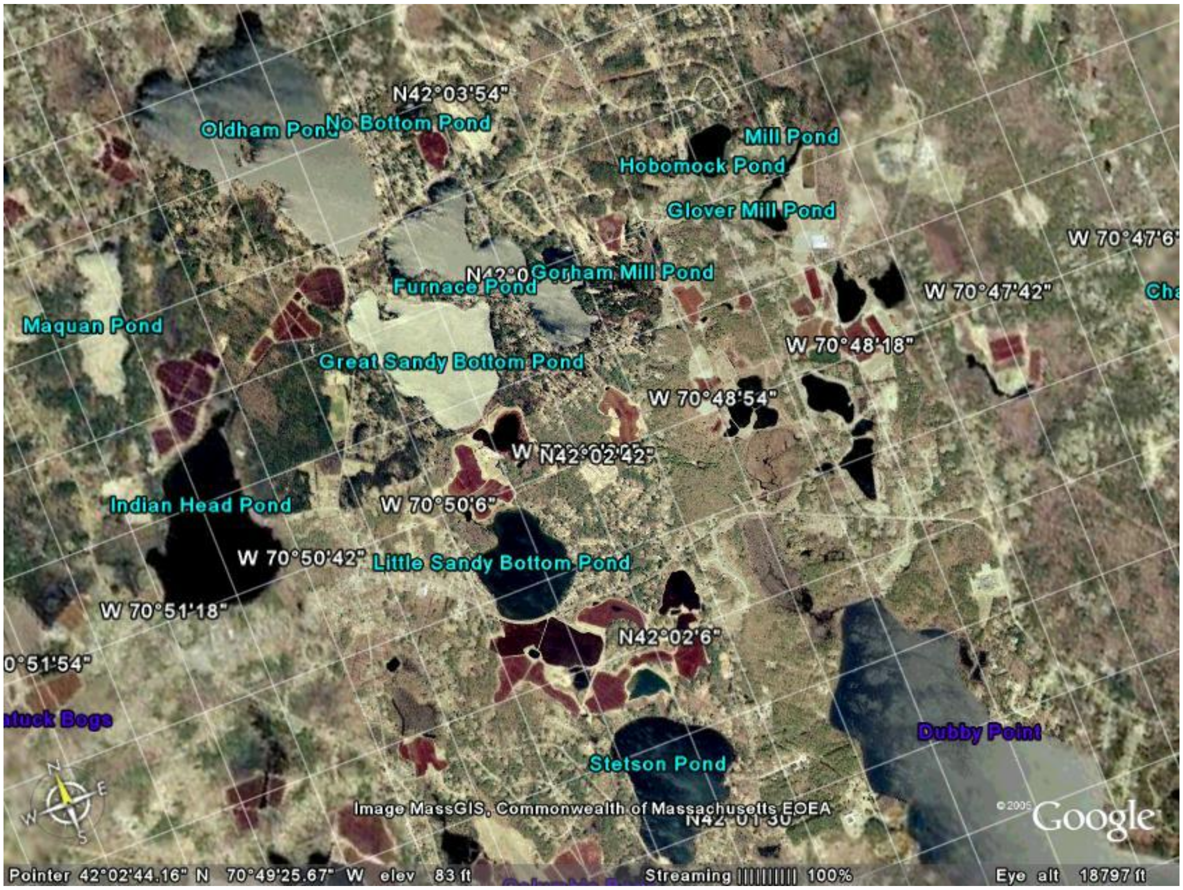
Map Three: Furnace Pond (Bathymetric)

Map Four: Stetson Pond (Bathymetric)

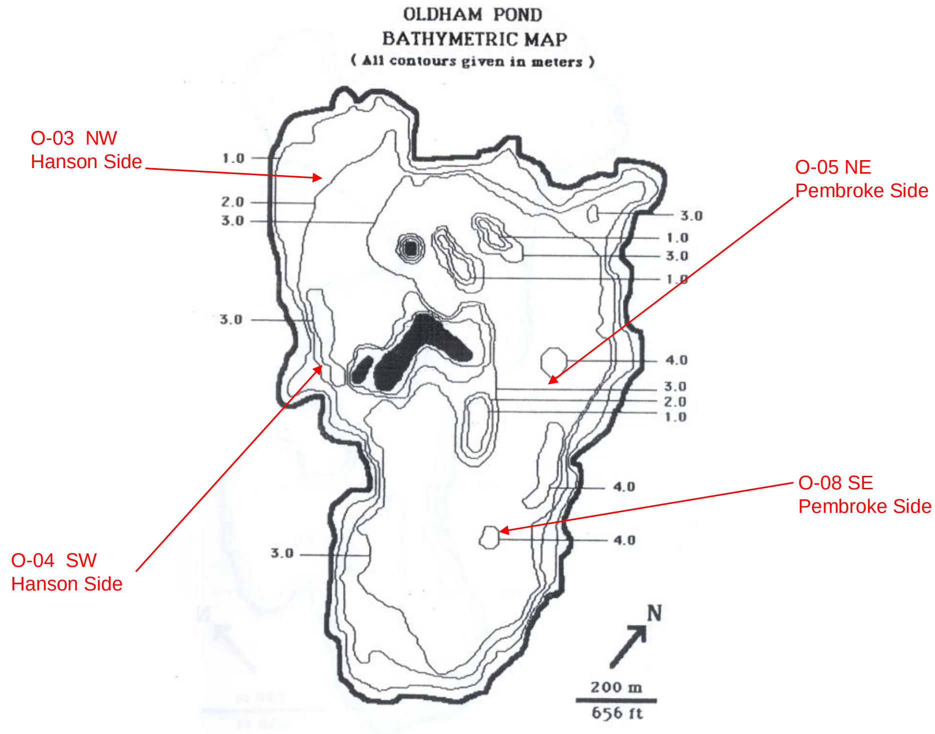
Map Five: Little Sandy Bottom Pond (Bathymetric)

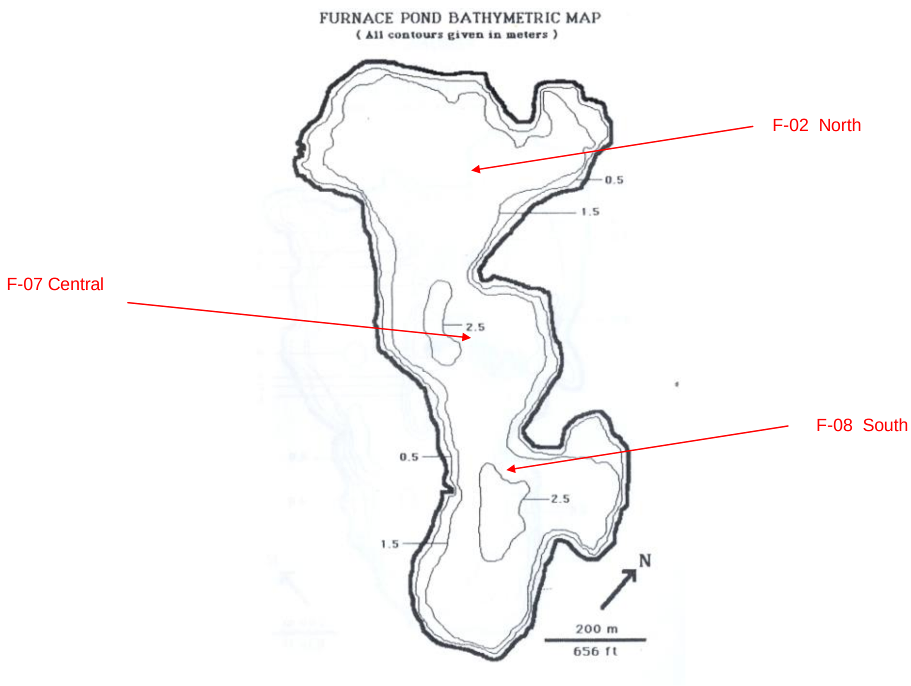
Map Six: Hobomock Pond (Google Earth)

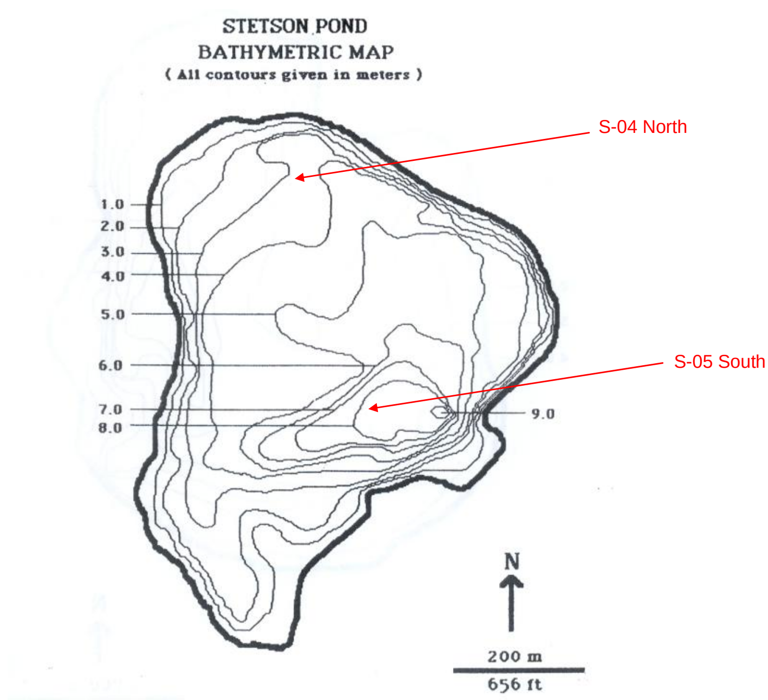
Test sites are identified on Bathymetric maps where available. As possible we maintained existing site designations, but altered designations as necessary.

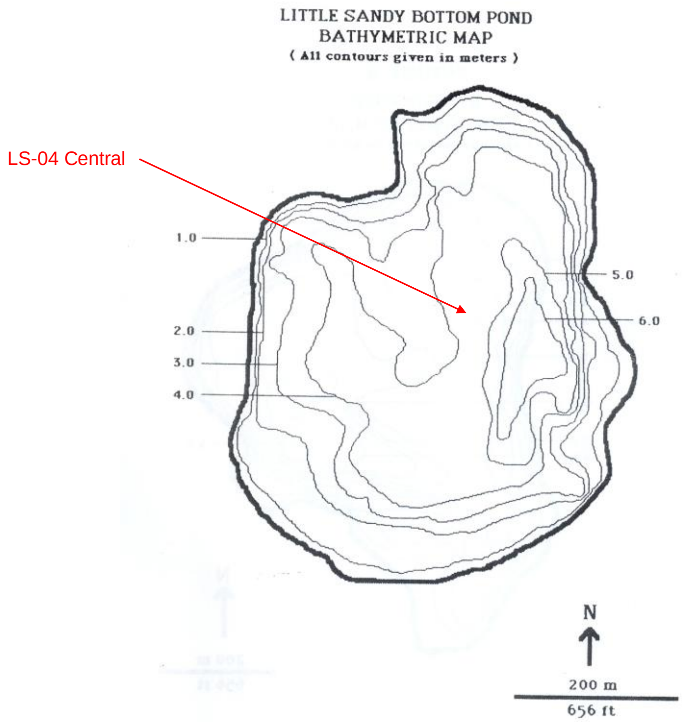


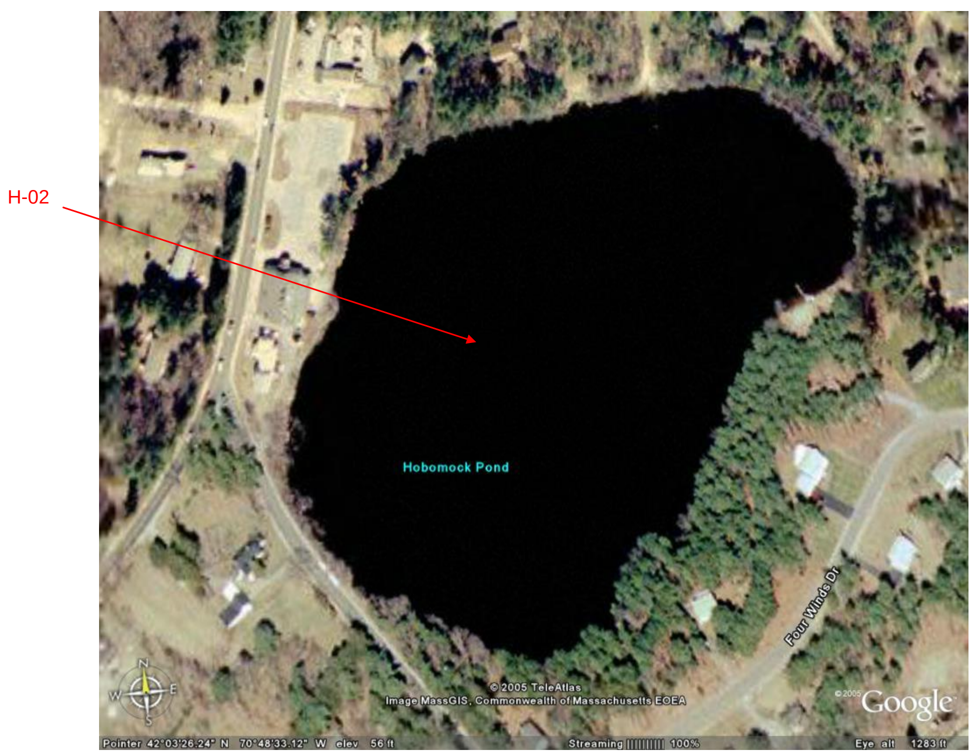
N42°03'54"
Oldham Pond
No Bottom Pond
Mill Pond
Hobomock Pond
Glover Mill Pond
W 70°47'6"
Gorham Mill Pond
Furnace Pond
W 70°47'42"
Maquan Pond
W 70°48'18"
Great Sandy Bottom Pond
W 70°48'54"
N42°02'42"
Indian Head Pond
W 70°50'6"
W 70°50'42"
Little Sandy Bottom Pond
W 70°51'18"
N42°02'6"
Dubby Point
Stetson Pond
Image MassGIS, Commonwealth of Massachusetts EOEA
Google
Pointer 42°02'44.16" N 70°49'25.67" W elev 83 ft
Streaming 100%
Eye alt 18797 ft


OLDHAM POND
BATHYMETRIC MAP
(All contours given in meters)
O-03 NW
Hanson Side
O-05 NE
Pembroke Side
O-04 SW
Hanson Side
O-08 SE
Pembroke Side
1.0
2.0
3.0
3.0
3.0
1.0
3.0
1.0
4.0
3.0
2.0
1.0
4.0
4.0
3.0
N
200 m
656 ft


FURNACE POND BATHYMETRIC MAP
(All contours given in meters)
F-02 North
0.5
1.5
F-07 Central
2.5
F-08 South
0.5
2.5
1.5
N
200 m
656 ft


STETSON POND
BATHYMETRIC MAP
(All contours given in meters)
S-04 North
1.0
2.0
3.0
4.0
5.0
6.0
S-05 South
7.0
8.0
9.0
N
200 m
656 ft


LITTLE SANDY BOTTOM POND
BATHYMETRIC MAP
(All contours given in meters)
LS-04 Central
1.0
2.0
3.0
4.0
5.0
6.0
N
200 m
656 ft


H-02
Hobomock Pond
Four Winds Dr
© 2005 TeleAtlas
Image MassGIS, Commonwealth of Massachusetts EOEA
Google
Pointer 42°03'26.24" N 70°48'33.12" W elev 56 ft
Streaming 100%
Eye alt 1283 ft

GPS Coordinates for Test sites

Oldham Pond

O-03	**Northwest**	**Hanson Side**	**42^0 04.155 N**	**70^0 50.584 W**
O-04	**Southwest**	**Hanson Side**	**42^0 03.950 N**	**70^0 50.378 W**
O-05	**Northeast**	**Pembroke Side**	**42^0 04.014 N**	**70^0 49.969 W**
O-08	**Southeast**	**Pembroke Side**	**42^0 03.645 N**	**70^0 49.910 W**

Furnace Pond

F-02	**North**	**42^0 03.510 N**	**70^0 49.719 W**
F-07	**Central**	**42^0 03.358 N**	**70^0 49.550 W**
F-08	**South**	**42^0 03.233 N**	**70^0 49.315 W**

Stetson Pond

S-04	**North**	**42^0 01.882 N**	**70^0 49.779W**
S-05	**South**	**42^0 01.741 N**	**70^0 49.330 W**

Little Sandy Pond

LS-04	**Central**	**42^0 02.495 N**	**70^0 50.055 W**

Hobomock Pond

H-02	**Central**	**42^0 03.393 N**	**70^0 48.618 W**

What are we testing for?

- **Nitrogen -** is a fundamental nutrient and is required by all living plants and animals for building proteins
  Measured in mg/liter
  - Natural range is between 0.1 and 2 mg/l
  - For concentrations >5 mg/l negative impact is certain

- **Phosphorus -** is normally scarce in a <u>normal</u> aquatic environment, is necessary for plant growth, and is abundant on land.
  Measured in mg/liter
  - Concentration should be between .01 and .1 mg/l
  - For concentrations >.05 mg/l impact is light
  - For concentrations >.10 mg/l negative impact is certain

- Note: marked increase in Nitrogen or Phosphorous loads in a pond will encourage the proliferation of algae fueling an overpopulation of bacteria that eat the decomposing algae. Less light diffuses through the water, impacting aquatic plant life. Aquatic life and algae compete for dissolved oxygen, and oxygen levels will plummet, resulting in eutrophic conditions and loss of habitat.

- **Turbidity:** The amount of suspended solids in the water.
  - Measured in NTU (Nephelometric Turbidity units)
  - Level should be between 1.0 and 10.0 NTU
  - Turbidity directly effects transparency (clarity) of the water

- **Dissolved Oxygen (DO):** The amount of oxygen in the water
  - Measured in mg/liter
  - Fish need a DO level >6.0 for warm water species, >7.0 for cold water species
  - DO levels will be higher near the surface due to wind effects, therefore should be measured at a minimum depth of 4 feet

- **pH and Alkalinity:** ability of water to handle acid and basic solutions
  - A pH of 7.0 is neutral, a higher pH means alkaline, a lower pH means acidic.
  - Pond water pH should range between 6.5 and 8.5
  - Alkalinity refers to the ability of the body of water to neutralize incoming acids from precipitation or discharges. Low alkalinity indicates low buffering ability.
  -

- **Secchi Disk Transparency:** directly relates to turbidity, measures clarity.
  - Measured in feet
  - Water clarity: how far down can a Secchi disc be seen.
  - Expected depth should be > 10 feet, with high water quality exceeding 16 feet

Determination of Test Sites:

- The 1988-1993 and 2001 Diagnostic Feasibility studies were used as guides to start our testing program.
- Test locations were determined by the Pond captains through thorough analysis of each pond consisting of:
  - A tour by boat to determine those locations that appeared to require further study, utilizing a GPS to mark the various sites
  - A walk around conducted on land to identify non-point source problems
  - The feasibility studies
  - Pond maps were then utilized to determine test sites.
- Final designations were made based on our experiences since 2005 and 2008 QAPP.

Testing Protocol:

- Testing procedures were developed utilizing the following resources:
  - We filed for a QAPP with Mass DEP and adjusted our procedures as they suggested.
  - "Testing the Waters" published by the River Network.
  - "Putting Together a Watershed Management Plan: A Guide to Partnerships" published by Mass DCR.

- Test criterion was developed and testing forms were created based on sample forms shown in the publications. The forms were modified to capitalize on what we learned 2005 - 2008. Tests are documented and required forms are completed. A water sample form was created to be used at each site/location including:
  - Previous days weather conditions and rainfall amounts
  - Water height as measured for each pond
  - Air & water temperature
  - Conditions at each site: water use, wave action, odor, water color, weeds, algae, bottom condition, depth
  - Dissolved Oxygen measurements
  - Quality control measures and data

- Testing schedules were chosen by the Water Quality Committee after determining what tests were to be conducted and how quality control measures would be implemented. Weather patterns might alter the schedule slightly.

- Water Quality sampling training was broken down into several procedures, Volunteers were trained on land first and then by actually doing a live testing. Two to three volunteers were trained at one time and included:
  - Setting up and calibrating the DO meters, pH meters
  - Taking the actual sample, labeling, storing
  - Using the Secchi Disk and View Scope
  - Obtaining additional required information
  - Filling out paperwork properly and completely.
  - Accountability signatures for all documentation and sample management.

- Water quality Co-Chairs and pond captains were provided additional training to be qualified as instructors and serve as team leaders on testing days.

Test Equipment

- Secchi Disc for measurement of water clarity
- Viewscope to assist with secchi disc accuracy
- Testing sticks for collection of samples to be delivered to the lab.
- YSI Mdl 85 Dissolved oxygen meters to measure dissolved oxygen, temperature, Salinity, and conductance.
- Chekmite pH meters(note: these have proven to be unreliable and we have received for 2009 testing a pH meter upgrade from the DEP).
- GPS were purchased and used to verify test site locations
- We have requested via grants portable depth finders/GPS for 2009 testing.

Our plan is to have 3 complete testing kits with all equipment and instructions for the start of the 2009 testing season.

Data Collection Methods

- We tested for:
  - Dissolved oxygen, salinity, and conductance.
  - pH
  - Secchi Disk transparency - Utilizing a Secchi Disk and a View Scope
  - Grab sample using a testing stick for:
    - Turbidity
    - Alkalinity
    - Chloride
    - Total Phosphorus
  - One annual Nitrogen series for each pond
    - Ammonia
    - K Nitrogen
    - Nitrates
    - Nitrites
    - Total Nitrogen - calculated from K nitrogen, Nitrates and Nitrites

- Analytical Balance Corporation Lab, 422 West Grove Street, Middleboro Ma conducted the required laboratory testing.

- Chain of custody rules were followed and adhered to. We utilized Analytical Balance Corporation laboratory chain of custody forms.

QAPP process:

The Water Quality Committee was heavily involved with the PWA's filing for a Quality Assurance Project Plan (QAPP) with MassDEP. This was approved effective 1/1/2008.

An approved QAPP on file with the state gives credibility to our testing program and means that the state will consider our results to be valid.

As part of this process we:

- ❖ Rewrote our training and qualification procedures and published an amended training program.
- ❖ Implemented a comprehensive Quality Control (QC) program.
- ❖ Reviewed and adjusted our testing program to better serve the needs of our ponds
- ❖ Reviewed and amended our testing forms
- ❖ Obtained grants for additional testing equipment.

Testing locations and Schedule:

- **Dissolved Oxygen, Turbidity, Total Phosphorus, Alkalinity, Chloride, Secchi Disk Clarity Conductivity and pH**
  - Oldham - (4 test sites) - June, July, Aug., Sept. 16 samples
  - Furnace - (3 test sites) - June, July, Aug. Sept. 12 samples
  - Stetson - (2 test sites) - June, Aug. 4 samples
  - Hobomock - (1 test site) - June, Sept. 2 sample
  - Little Sandy - (1 test site) - Aug. 1 sample

- **Nitrogen Series - Ammonia, K Nitrogen, Nitrates, Nitrites and Total Nitrogen tests were requested once per year per pond**
  - Oldham - (4 test sites) - June, July, Aug., Sept. 4 samples
  - Furnace - (3 test sites) - June, July, Aug. Sept. 3 samples
  - Stetson - (2 test sites) - June, Aug. 2 samples
  - Hobomock - (1 test site) - June, Sept. 1 sample
  - Little Sandy - (1 test site) - Aug. 1 sample

- . **Quality Control - We Completed a quality control schedule of once per pond per year**
  - Oldham - (4 test sites) - June, July, Aug., Sept. 1 sample
  - Furnace - (3 test sites) - June, July, Aug. Sept. 1 sample
  - Stetson - (2 test sites) - June, Aug. 1 sample
  - Hobomock - (1 test site) - June, Sept. 1 sample
  - Little Sandy - (1 test site) - Aug. 1 sample

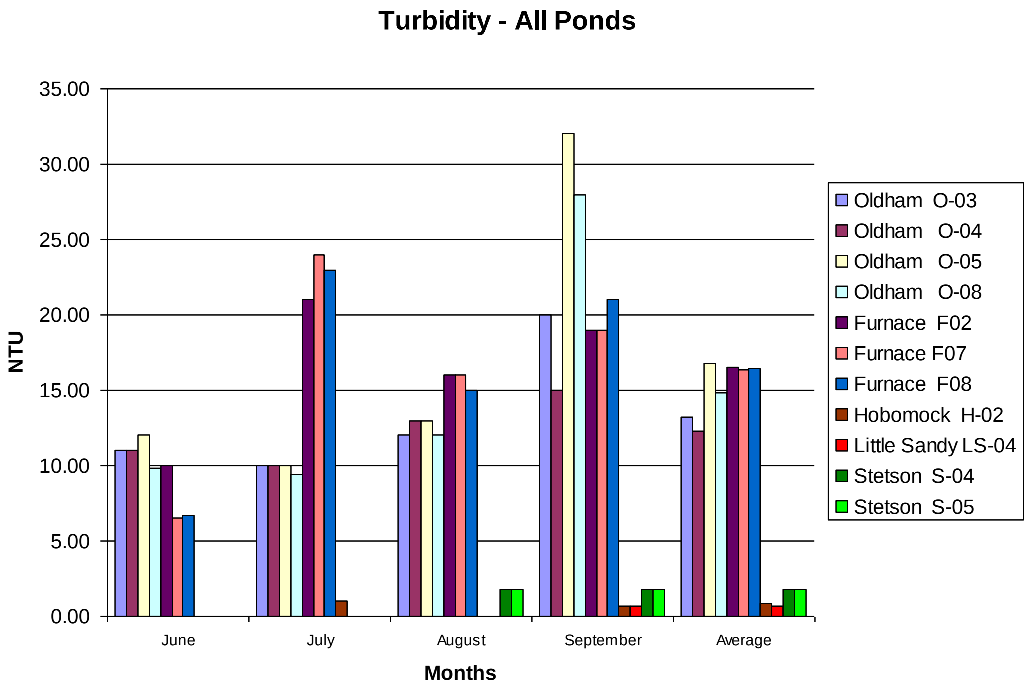
Our goal was to complete 80% of our planned total number of samples/measurements. Results are:

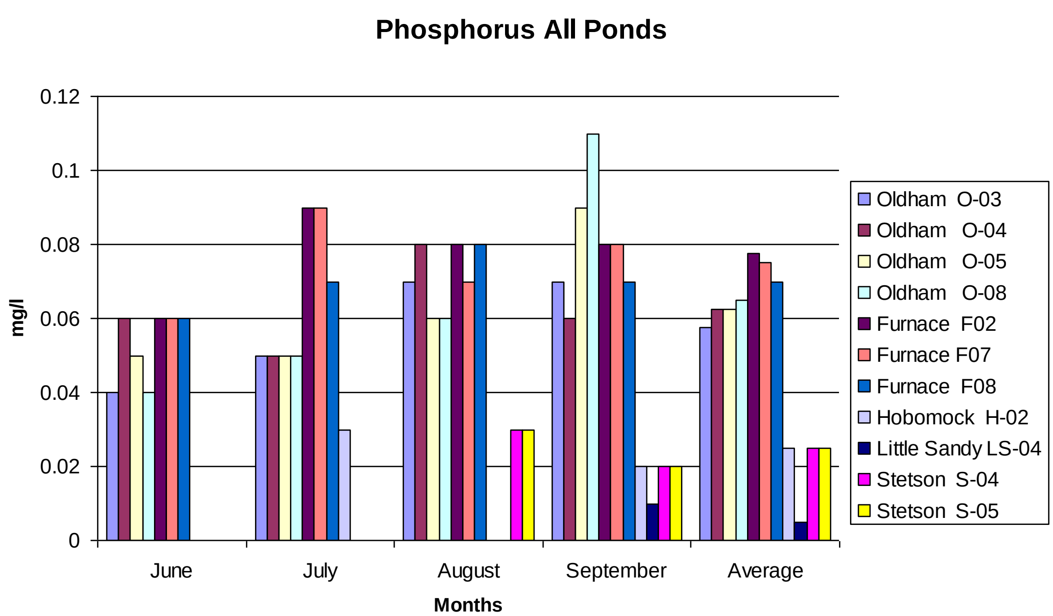
Parameter	Number of Valid samples/measurements	Number Completed	Percentage
pH	35	23 *	66
Secchi Disk Clarity	35	35	100
Dissolved Oxygen	35	34	97
Specific Conductance	35	34	97
Alkalinity	35	35	100
Chloride	35	34	97
Total Phosphorous	35	35	100
Turbidity	35	35	100
Nitrogen Series	11	8 **	73
Quality Control	5	4	80

We met 94% of our total required testing (267 out of 285).

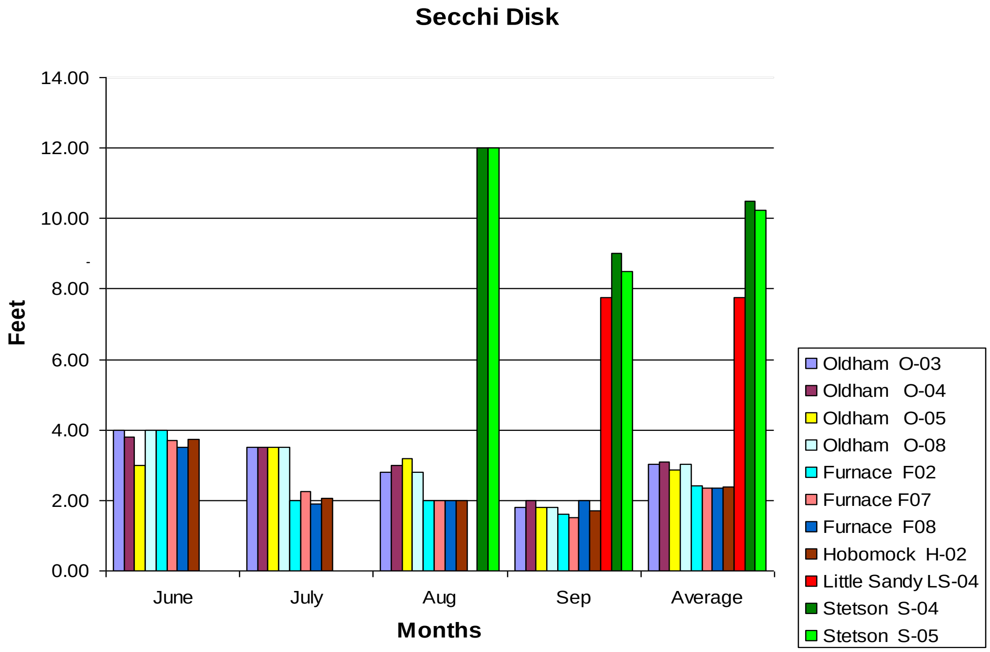
*pH meters results were unreliable on a number of tests and were discarded
** Nitrogen series missed on Little Sandy and Stetson (3 sites)

We averaged our 2008 results for Turbidity and Phosphorous at all sites for pond comparison.





Secchi Disk results for all ponds



Summary of 2008 results:

Physical Characteristics of Pond water: Summer rainfall was substantially lower than previous years resulting in significant drop in water volume in all of the ponds.
During the summer months we recorded the presence of algae at testing sites:

Furnace: July-5%, August – 100%, September >75%
Oldham: August 5-25%, September > 50 -75%
Stetson: 10%- 15% in August
Hobomock and Little Sandy: Minimal to none.

Furnace Pond had one documented test site in August with blue-green algae (toxic) with all sites either a thin or very thick 100% coating. There were intermittent sitings of blue-green algae in mid June and in late August-early September in shallow areas.

Oldham Pond had one documented test site in August with blue-green algae (toxic), and also had extensive heavy weed growth in shallow water during the latter months. There was heavy infestation of blue-green algae species in the south-western cove in June and late August into September.

Heavy weed infestation was particularly significant on Oldham and to a lesser degree in Furnace. Stetson also noted increased weed growth in shallow areas.

Furnace Pond had water temperatures exceeding 85 degrees at multiple sites in August, with excessive algae growth. The high temperatures were due to a lack of overhead canopy that is usually provided by trees and an average depth of less than 5 feet.

Physical finding trends demonstrate continued eutrophication of Furnace and Oldham ponds, with extensive algae blooms, and additional impacts observed in Furnace and Stetson in the fall, relating to bog effluent return. Lack of buffer zones, failed or clogged storm drains, effluent from old and active bog channels, and non-point source pollution excess from storm water runoff have been the primary culprits.

Chemical Findings:

All of the ponds exhibit some degree of water quality disturbance, however, Furnace and Oldham ponds continue to show accelerating deterioration and require urgent attention.

The primary problems found through chemical testing were:

- Elevated turbidity readings (coupled with low Secchi disc readings) indicating poor clarity due to algae, organic material degradation, and silt run-off, on Oldham and Furnace.
- Elevated phosphorus readings which continued to rise through the summer months
- Elevated chloride readings, which mirror road run-off into the ponds.
- Low dissolved oxygen readings in mid summer, primarily on Oldham and Furnace ponds, generally at the 5-7 foot depth, to levels incompatible with fish life. These readings occurred on the southern sites of Oldham and all sites on Furnace.

Furnace Pond Assessment:

- Furnace is a category 5 severely impaired pond, with 10 feet of muck holding a tremendous amount of reactive phosphorus. This means that even with no additional source of phosphorus the pond will continue to deteriorate rapidly.

- Furnace experienced extensive algae blooms, weed overgrowth, invasive species of weeds, intermittent low dissolved oxygen levels, further loss of depth (average depth 5 feet, max depth 8.5 feet), increased temperature which impairs the fish habitat. Blue-green algae proliferated in June, and August into September.

- Gorham Mill pond, the Furnace pond outlet, has become a shallow, algae and weed choked swamp, evidenced by the increase in amphibious species, minimal fish, and high mosquito breeding areas due to stagnation.

- Loss of Furnace Pond will result in loss of recharging some of the wells upon which our drinking water supply is maintained, the ultimate loss of Oldham which drains into Furnace, loss of tax revenue from waterfront property, health issues related to mosquito infestations, the loss of the Herring run which is dependent upon a continuous water connection from Oldham to the Herring run, and bog water use, and a major recreational resource to the town of Pembroke.

Furnace Pond Recommendations:

- Overall plan should include: restore the depth, remove the phosphorus sources (muck, non-point source and bog effluent), increase the buffer zones, and insist on best management practices (street sweeping, storm drain management) around the pond and in the watershed.

- A Dredging Feasibility study was conducted by CEI in the spring 2007. They recommended some find of dredging solution be found. We agree with this recommendation and per the recommendations from the 1993 feasibility study and our current findings, this is absolutely necessary for the survival of this pond.

- CPA funding was requested and approved to finalize required testing of bedrock as preparation for dredging. Plan is in place to complete this in summer 2009.

- **Long term** monitoring of both land and water based water quality will be paramount to determine the success of the action plan to restore and preserve Furnace Pond. **Short term**: algae treatment is highly recommended.

- The Town of Pembroke has taken steps to purchase the cranberry bogs that effect Furnace. This provides a solid first step to limit point source pollution. Management of waterways and non-point pollution sources between the bog channels and pond will need to be addressed.

- Additionally action must be taken to increase buffer zone management around the pond, through tree planting, encouragement of buffering at the water's edge on residential properties, and cleaning of storm drains to reduce sediment loading.

Oldham Pond Assessment:

- Oldham Pond is a category 4 impaired pond with conditions congruent with those of Category 5 Furnace Pond. Oldham flows into Furnace Pond and is equally as developed. Oldham has greater depth and water volume, which probably explains why the pond has not demonstrated quite the biological degradation found in Furnace. The muck is as deep, and has high loads of reactive phosphorus, which is the primary phosphorus source, along with old northeast cranberry bog streams. Oxygen levels have been a problem, and Oldham continues to experience fish kills. Additionally, excessive weed growth is choking the shoreline in many areas.

- In 2007 Oldham pond did not have high levels of nutrients; however the pond was overcome with heavy weed growth in almost all shallow areas. Blue-green algae were prevalent over much of the shallow areas around the pond in June, then in August and September, with other algae species proliferating all summer.

- Loss of Oldham would be tragic, resulting in loss of a primary recreational resource for the community, loss of the Herring spawning site, tax revenues from water-front homes, loss of some of Pembroke's wells that would not be recharged, primary water source for Furnace pond, and a habitat for many species.

Oldham Pond Recommendations:

- Non-point source contamination needs to be addressed, particularly with storm drain management, beach erosion and drainage, and need for buffer zones in public areas. Streams running from the northeast (Hanson) areas bring contaminants from old bog sites and new neighborhood development resulting in significant increases in silt loading, and chemical and physical deterioration.

- It is our recommendation that in concert with the dredging of Furnace Pond, some form of remediation must also be conducted on Oldham Pond if both Furnace and Oldham are to survive. We are recommending that a feasibility study be conducted to identify the actual problem areas and necessary remediation.

- **Long term** monitoring of both land and water based testing of the ponds is mandatory to determine the success of actions taken to restore and preserve Oldham and Furnace Ponds. Therefore we recommend chemical testing at a regular interval for the foreseeable future.

- Oldham Pond is currently rated as a category 4(c) on the 2006 list of impaired waters. One of our goals for the near future is to have MassDEP change this to reflect the actual condition of the pond and change the rating to a category 5.

- **Short term** management: A proposal to treat Oldham for algae control was developed and we have met with Aquatic Control Corp. for possible treatment in 2009. A presentation to the membership was made and articles have been submitted to both Pembroke and Hanson warrants 2009 for funding.

Stetson, Little Sandy Bottom, and Hobomock Ponds Assessment and Recommendations:

- **Stetson Pond**: This pond is currently rated as a category 5 by MassDEP. Stetson has one large source of phosphorus loading that must be checked: the cranberry bog effluent that is returned to Stetson in the fall. The Town of Pembroke has purchased the cranberry bogs that affect Stetson and will maintain as open space. Utilization of best management practices to reduce non-point source pollution, improvement in storm drain management, and management of the cranberry bog effluent would be of value on this pond**.** Close monitoring for invasive weeds is important. The pond should start see improvement once the bogs stop production. Long term management includes treatment of invasive weeds and continued water quality testing.

- **Little Sandy Bottom Pond**: Results show that the water quality is good. The removal of the bog effluent a few years ago has improved the water quality results (comparing 1993 to current test results), showing that reducing phosphorus loading can significantly improve water quality. Little Sandy Bottom Pond needs buffer zones put in at route 27 and the old beach front area and attention to best management practices, storm drains, and run-off.

- **Hobomock**: Results show that water quality is good, but weeds are over-abundant and clarity is a problem. After attending a weed watchers program this summer a member identified hydrilla in Hobomock pond. The state was notified and EPA is now managing Hobomock. There will be no public use of the pond until the hydrilla has been well controlled. Aquatic Control Corp has been awarded the contract for eradication of hydrilla and will conduct all testing on Hobomock in the foreseeable future.

All Ponds: worsening chloride readings correspond with road runoff, primarily in the form of silt and salt. Even low salt zones will demonstrate increased chloride with sand intrusion. We strongly recommend the use of the street sweeper at least two times in the winter/spring and again later in the season to reduce road run-off.

Pembroke Watershed Association water quality team, 2008
Co-Chairs of Water Quality Committee: Charlie Banks and Patti McCabe

Pond Captains:
Furnace: Patti McCabe
Oldham: Charlie Banks
Little Sandy Bottom: Arthur Boyle
Stetson: Jim McClarnon

Certified instructors for volunteer water quality training:
Charlie Banks, Patti McCabe. Jim McClarnon

Certified volunteer water samplers:

- Oldham Pond
  - Charlie Banks; Norm Shepard, Terry Banks, Tammy Stone
- Furnace Pond
  - Patti McCabe, Chuck McCabe, Ray Holman, Brian Shea, Deb Tranberg
- Stetson Pond
  - Jim McLarnon, Mitch Cahill, Fred Baker, Robert Shannon, Jim Muldoon
- Little Sandy Bottom Pond
  - Arthur Boyle; Becky Paul
- Hobomock Pond
  - Howard League; Andy Key, Jason Potrykus

Storm Drain Stencil Project:

- Patti McCabe, Scotty MacInnes, Cindy Champagne: Furnace
- Mitch Cahill: Stetson
- Andy Key and Miles Prescott: Hobomock
- Kathy Hanson: Oldham
- Boy Scouts in Pembroke participating in the program

Appendix 1:

On-going Land-based Efforts to Improve Water Quality:

- Reviewed the 1993 and 2001 Pond surveys as a basis for water quality management plan
- Utilized the Mass Water Watch website and DEP publications and classes through COLAP and the Rivernet Association to develop a knowledge base, obtain protocols and formats for surveying and documenting results.
- Conducted an overall pond survey to determine primary problems and create an action plan for 4 ponds. Hobomock pond completed their pond survey later in 2005 and presented their findings to the PWA.
- Identified Best Management Practices and worked with the town government to strive to implement these: DPW, Conservation Commission, and Selectmen were used as contacts and were very supportive of the efforts of the PWA.
- Provided BMP education to the public through presentations at PWA meetings, at the library, and via the news, and developed liaison with the schools.
- Held annual pond clean-up days on all ponds to remove debris from the shoreline/pond edges, over 40 participants, great success.
- Requested that the street sweeper be used to remove sand and debris from the roads in the spring and again in the summer around streets which directly impact the ponds.
- Asked that the town clean the storm drains directly draining into the pond, increase the number of storm drains, and look at newer retrofit and LID methods of reducing non-point source pollution.
- Placed signs at boat ramps to encourage clean-up of boats after removal from the ponds
- Catch basin stenciling was begun at all pond storm drain sites. This project will be ongoing, with the intent of stenciling storm drains at higher elevations and in neighborhoods, all of which drain into the ponds.
- Studied the impact of residential development on the buffering capacity of the shoreline. The findings are included in this report.
- Installed dog refuse stations on 3 ponds to encourage clean-up by owners
- Recommend fencing in of public beach areas to minimize impact by animals.

Best Management Practices for Water Quality Preservation is Buffer Zones:

Storm water run-off + pollutants = poor water quality!

- **Create and Maintain Vegetated Buffer Zones**: establish and maintain trees, bushes, perennials, sedges, and aquatic plants, next to the water, on hills, in all areas with run-off, to improve filtration capacity, maintain habitats. 90% of run-off will be captured by a well planned buffer zone and 80% of pollutants will be removed by the plants.

- **Native plantings:** within the waterfront 100 foot zone. Native plants don't require fertilizing or watering once established.

- **Remove exotic invasive plants:** destroys native habitats

- **Curve** ramps, walkways, grass or dirt paths to avoid run-off straight down to the water.

- **Avoid phosphorus based fertilizers:** try to avoid all fertilizers and use organic products which are environmentally friendly whenever possible.

- **Rain gardens** and **rain barrels:** to catch and filter runoff and conserve water.

- **LID efforts**, such as pervious pavements, new storm drain designs, and enviro-friendly landscape designs. Storm drain management cannot be emphasized enough!

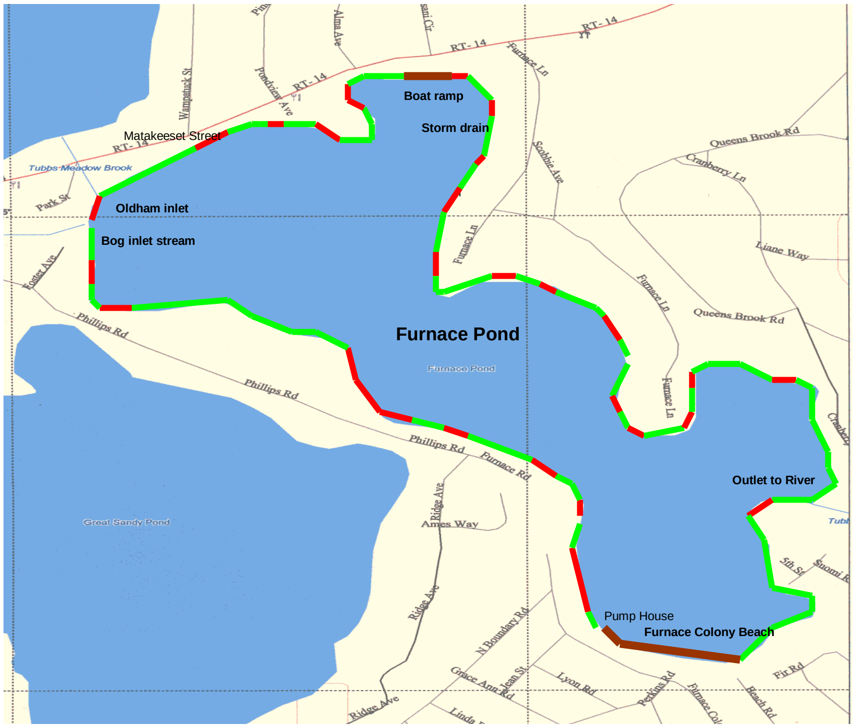
- **Support by-laws:** that improve water-quality and best management practices, and support efforts that improve water quality and natural landscaping.

Appendix #2: Buffer zone assessments (completed 2005)

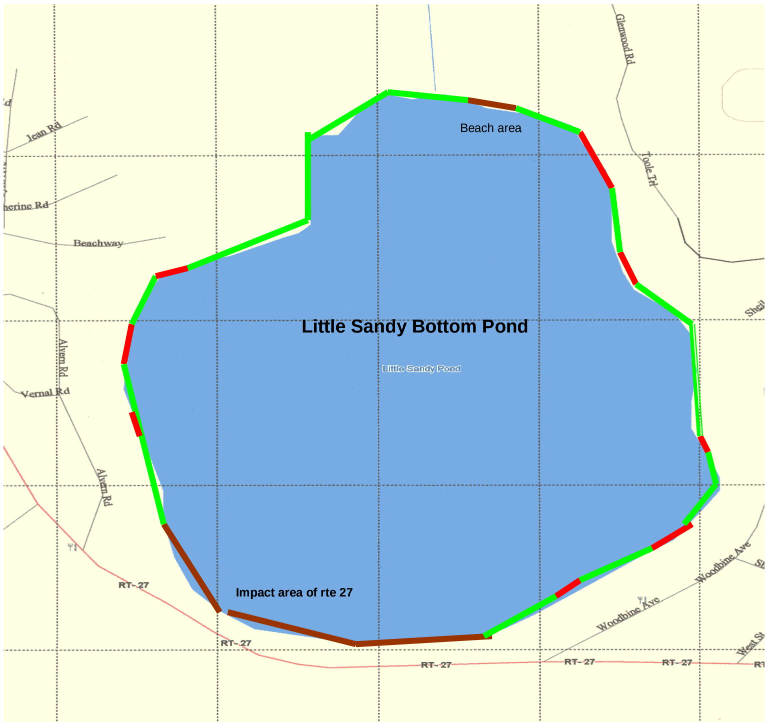
Shoreline Pond surveys

- The following slides indicate the approximate degree of suburban development at each of the ponds, including buffer zones, impervious public ramps, and impact of roads.

- ___: buffered areas
- ___: no buffer zone
- ___: public unbuffered areas


Boat ramp
Storm drain
Matakeeset Street
Oldham inlet
Bog inlet stream
Furnace Pond
Outlet to River
Pump House
Furnace Colony Beach
RT- 14
Tubbs Meadow Brook
Park St
Queens Brook Rd
Cranberry Ln
Liane Way
Furnace Ln
Phillips Rd
Furnace Rd
Ridge Ave
Ames Way
Great Sandy Pond
N Boundary Rd
Lyon Rd
Perkins Rd
Beach Rd
Fir Rd
5th St


Blueberry lane beachfront
Bog inlet
Storm Drain
Stetson Pond
Hill with Ramp
Hill with ramp
Main Road
Outlet to Chaffin
Boat Ramp
and beach
Blueberry Ln
Kenholm Rd
Stetson Heights Rd
High Ave
Stetson Ave
Lake Ave
Plymouth St
Fish St
W Fish St
Marion Way
Bartlett St
B St
D St
Beech St
Carver St
Nye St
Johnson St



Buffered and Unbuffered Areas Around the Ponds

(conservative estimates)

Pond	Public Unbuffered	Private Unbuffered	Buffered
Oldham	7%	38%	55%
Furnace	10%	35%	55%
Stetson	5%	30%	65%
LSB	17%	18%	65%

Appendix #3 - Raw data for 2008

Oldham					
pH		(S.U)	DET	0.14	
	June	July	August	September	Mean
O-03	7.170	8.000	7.190		7.453
O-04	7.000	8.100	6.840		7.313
O-05	7.000	8.290	7.350		7.547
O-08	6.940	8.080	6.730		7.250
Turbidity		NTU	DET	0.25	
	June	July	August	September	Mean
O-03	11.000	10.000	12.000	20.000	13.250
O-04	11.000	10.000	13.000	15.000	12.250
O-05	12.000	10.000	13.000	32.000	16.750
O-08	9.800	9.400	12.000	28.000	14.800
Phosphorus, Total		(ug/l)	DET	0.01	
	June	July	August	September	Mean
O-03	0.040	0.050	0.070	0.070	0.058
O-04	0.060	0.050	0.080	0.060	0.063
O-05	0.050	0.050	0.060	0.090	0.063
O-08	0.040	0.050	0.060	0.110	0.065
Total Nitrogen		(mg/l)	DET	0.5	
	June	July	August	September	Mean
O-03			1.000		1.000
O-04			1.000		1.000
O-05			1.000		1.000
O-08			1.000		1.000
Dissolved Oxygen		mg/l			
	June	July	August	September	Mean
O-03	7.480	8.250	8.550	6.370	7.663
O-04	7.080	7.410	7.300	6.100	6.973
O-05	7.390	8.100	8.600	7.190	7.820
O-08	7.300	6.940	7.390	5.980	6.903
Kjeldahl, Nitrogen		(mg/l)	DET	0.05	
	June	July	August	September	Mean
O-03			0.5		0.5
O-04			0.75		0.75
O-05			0.5		0.5
O-08			0.5		0.5
Specific Conductance		um/cm	DET	0.5	
	June	July	August	September	Mean
O-03	232	265	216.8	235.5	237.325
O-04	234.5	252	232.8	238.1	239.35
O-05	232.7	266.4	237.8	238.5	243.85
O-08	230.3	262.5	235.7	238.8	241.825
Alkalinity			DET	4	
	June	July	August	September	Mean
O-03	21.3	25.9	26.6	17.8	22.9
O-04	17.9	26.7	24.2	19	21.95
O-05	20.5	25.6	27.1	19.1	23.075
O-08	28.5		9.42	17	13.73

Chloride		(mg/l)	DET	10	
	June	July	August	September	Mean
O-03	50.1	50.6	53.6	52	51.575
O-04	50	50	53.9	51.2	51.275
O-05	49.8	50	53.9	51.1	51.2
O-08	49.8	49.8	53.9	52.2	51.425

Furnace

pH		(S.U)	DET	0.14	
	June	July	August	September	Mean
F-02		7.74	7.6	7.35	5.67
F-07		7.71	7.8	7.34	5.71
F-08		7.31		6.9	

Turbidity					
	June	July	August	September	Mean
F-02	10	21	16	19	16.50
F-07	6.5	24	16	19	16.38
F-08	6.7	23	15	21	16.43

Phosphorus, Total		(ug/l)	DET	0.01	
	June	July	August	September	Mean
F-02	0.06	0.09	0.08	0.08	0.08
F-07	0.06	0.09	0.07	0.08	0.08
F-08	0.06	0.07	0.08	0.07	0.07

Total Nitrogen		(mg/l)	DET	0.5	
	June	July	August	September	Mean
F-02			1		0.25
F-07			1		0.25
F-08			1		0.25

Dissolved Oxygen					
	June	July	August	September	Mean
F-02	8.50	9.16	8.14	9.92	8.93
F-07	8.22	8.39	7.48	9.02	8.28
F-08	7.80	8.50	8.23	9.50	8.51

Kjeldahl, Nitrogen		(mg/l)	DET		
	June	July	August	September	Mean
F-02			0.65		0.16
F-07			0.74		0.19
F-08			0.66		0.17

Specific Conductance		um/cm	DET	0.5	
	June	July	August	September	Mean
F-02	224.6	250	216	214	226.15
F-07	224.7	249.4	216.8	214	226.23
F-08	224.8	236.3	217	214	223.03

Alkalinity			DET	4	
	June	July	August	September	Mean
F-02	20.3	25.9	20.6	15.2	20.50
F-07	25.4	24	19.4	15.4	21.05
F-08	29.3	27.7	22.5	15.4	23.73

Chloride		(mg/l)	DET	10	
	June	July	August	September	Mean
F-02	47	46.8	49.3	46.2	47.33
F-07	46.4	47.4	49.1	46.1	47.25
F-08	46.6	47.3	49.3	16.3	39.88

<u>Stetson /Little Sandy/Hobomock</u>

pH	(S.U)		DET	0.14	
	June	July	August	September	Mean
H-02					
LS-04					
S-04			7.77	7.01	4.93
S-05			7.79		2.60

Turbidity	(mg/l)		DET	0.25	
	June	July	August	September	Mean
H-02				0.65	0.22
LS-04				0.65	0.22
S-04			1.8	1.8	1.20
S-05			1.8	1.8	1.20

Total Nitrogen	(mg/l)		DET	0.5	
	June	July	August	September	Mean
H-02					
LS-04					
S-04					
S-05					

Phosphorus, Total	(ug/l)		DET	0.01	
	June	July	August	September	Mean
H-02				0.02	0.01
LS-04				0.01	0.00
S-04			0.03	0.02	0.02
S-05			0.03	0.02	0.02

Dissolved Oxygen					
	June	July	August	September	Mean
H-02				7.98	2.66
LS-04				7.79	2.60
S-04			6.71	8.5	5.07
S-05			6.5	7.8	4.77

Kjeldahl, Nitrogen		(mg/l)	DET	0.05	
	June	July	August	September	Mean
H-02					
LS-04					
S-04					
S-05					

				258.2	
Specific Conductance		um/cm	DET	0.5	
	June	July	August	September	Mean
H-02				212.9	70.97
LS-04				258.2	86.07
S-04			164.7	150.6	105.10
S-05			164.3	150.4	104.90

			4	5.07	
Alkalinity			DET	4	
	June	July	August	September	Mean
H-02				4	1.33
LS-04				7.21	2.40
S-04			4	5.07	3.02
S-05			5.52	5.07	3.53
			38.1	36.7	
Chloride	(mg/l)		DET	10	
	June	July	August	September	Mean
H-02				58.3	19.43
LS-04				66.1	22.03
S-04			38.2	36.6	24.93
S-05			38.1	36.7	24.93

Quality Control data

	Oldham Required	Actual	Furnace Required	Actual	Stetson/Little Sandy/Hobomock Required	Actual	Total Required	Actual	%
pH	16	12	12	8	7	3	35	23	66
Secchi Disk	16	16	12	12	7	7	35	35	100
Dissolved Oxygen	16	16	12	12	7	6	35	34	97
Specific Conductance	16	16	12	12	7	6	35	34	97
Alkalinity	16	16	12	12	7	6	35	34	97
Chloride	16	16	12	12	7	6	35	34	97
Phosphorus, Total	16	16	12	12	7	6	35	34	97
Turbidity	16	16	12	12	7	7	35	35	100
Total Nitrogen	4	4	4	4	4	1	11	8	73