APPENDIX A
EVALUATION OF FRESHWATER PONDS

Bakers Pond, Boland Pond, Cedar Pond, Crystal Lake, Ice House Pond, Pilgrim Lake, Sarah's Pond, and Shoal Pond

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January 26, 2007

EVALUATION OF FRESHWATER PONDS

FRESH WATER PONDS BACKGROUND

One of the important aspects of the Comprehensive Wastewater Management Plan is to evaluate the potential for impacts of watershed loads of nutrients on the water quality and designated water uses in adjacent water bodies. In the case of freshwater ponds, unlike the estuarine and marine environments, the primary limiting nutrient (i.e., that which controls the amount of growth in the system) is phosphorus. Due to the importance of groundwater loads derived from residential land use as a source of phosphorus to ponds within Orleans, this evaluation becomes an important criterion for determining the extent to which off-site wastewater management options are warranted to protect, maintain, or improve the condition of the ponds.

Orleans has 63 named lakes or ponds of local interest of varying size, shape, and quality (CCC, 2003). For convenience, all Orleans fresh water bodies will be collectively referred to as ponds, regardless of size or name. As part of the CWMP, eight ponds were selected for evaluation of their current water quality and trophic condition (i.e., relative fertility of the pond), potential to meeting designated water uses, and relative susceptibility to current or future nutrient loads. The ponds include: Bakers Pond, Cedar Pond, Crystal Lake, Pilgrim Lake, Boland Pond, Ice House Pond, Shoal Pond, and Sarah's Pond. These ponds were selected to provide a spectrum of sizes, depths, water uses, and geographic representation in Orleans. Four of these ponds (Bakers, Cedar, Crystal, Pilgrim) are identified Great Ponds by the MA DEP (MA DEP, 2006). The location of these ponds is shown in Figure 2-5.

Data Sources

Currently publicly-available data were used to provide the evaluation of trophic conditions and meeting of designated uses. Water quality (nutrients) and trophic indicators (e.g., chlorophyll concentrations, dissolved oxygen (DO), and secchi disk transparency (SDT) depth) have been regularly monitored from 2001-2005 in many Orleans ponds as part of the Pond and Lake Stewards (PALS) program. Much of this information is described and summarized by the Cape Cod Commission (CCC) in two documents:

- Cape Cod Commission. 2003. *Cape Cod Pond and Lake Atlas. Final Report.* CCC Water Resources Office, Massachusetts Executive Office of Environmental Affairs, Umass School of Marine Sciences and Technology. May 2003; and
- Cape Cod Commission. 2006. *Review and Interpretation of Orleans Ponds Volunteer Monitoring Data* (Draft Final Report). CCC Water Resources Office. September 2006.

In addition to these two primary sources, additional information was used related to pond water quality data, water use, and general conditions. This additional information includes but is not restricted to: scientific articles, related technical reports (e.g., Horsley and Witten (H&W), 2003; SMAST, 2006), newspaper articles, etc. For further information on sources of pond data see Section 2.2.2.

Determination of contributing groundwater watershed areas was based on models and maps originally developed by the USGS and divided into areas contributing to Pleasant Bay, Nauset Harbor, and Cape Cod Bay (see Figure 2-4). For specific ponds, further refinement of

groundwater basins was conducted based on available information (e.g., CCC, 2006; SMAST, 2006) and best professional judgment.

Trophic Benchmarks and Pond Classification

One way of assessing whether ponds are currently supporting their designated water uses is by comparison of ambient values of trophic indicator data (i.e., phosphorus and nitrogen fractions, chlorophyll a, and SDT) to State water quality criteria or thresholds. The focus for water chemistry is principally phosphorus, since previous work has shown that most Cape Cod ponds are phosphorus limited (Ahrens and Siver, 2000), although in some cases, nitrogen may be seasonally limiting (i.e., late summer). The exception to this situation is Cedar Pond, which is a tidally-influenced pond, and therefore phosphorus is not likely to be the primary limiting nutrient.

Since the MA DEP is still in the process of developing a state water quality numeric total phosphorus criterion for Massachusetts lakes and ponds, this assessment considered a combination of alternative benchmarks such as the USEPA ecoregional water quality recommendations (U.S. EPA, 2001), the 25th percentile marks from the CCC database of more than 185 Cape Cod ponds (CCC, 2003), accepted trophic state boundaries from the limnological literature (e.g., Wetzel, 2001, Kalff 2002), or other benchmarks.

Ultimately, it was considered appropriate to use the numerical criterion suggested by CCC (2003) for classifying the trophic status of Cape Cod ponds (Table 1. *Orleans Pond Trophic Status).* This was due to the severe under-representation of Cape Cod ponds in the USEPA database for this ecoregion (Atlantic Coastal Pine Barrens; sub-ecoregion 84) and the acknowledgment that the CCC PALS database provides a more extensive collection of lakes, parameters measured and frequency of measurement that any other available source. For this same reason, the site-specific database and interpretation is preferred over relying on the geographically-diverse collection of northern temperature lakes discussed in standard limnological texts.

Two major caveats come with application of this system, however. This system identifies both reference (i.e., *"unimpacted")* and target *("healthy")* values for nutrient and trophic indicators. The CCC pond benchmark system derives nutrient and indicator (chl a) thresholds in a similar fashion to U.S.EPA water quality recommendation methodology through a fairly simplistic statistical approach, (i.e., the adoption of the upper or lower 25th percentile of an appropriate database).

For Cape Cod ponds the CCC established *"unimpacted"* levels as the upper 75% of values from reference ponds judged not to have been significantly altered from historic (1948) trophic levels and *"healthy"* levels as the upper 25% of values from all ponds in the database. This approach for derivation of nutrient criteria has not been adopted by any of the New England states without significant modification. Some criticisms of this method include the relatively arbitrary choice of the 25th percentile (indicating that 75% of ponds are always out of compliance), that selected levels may not be correlated with important ecological shifts in ponds, or that it does not consider the rooted aquatic plant community (i.e., aquatic macrophytes), which often comprises an important ecological component, particularly in shallow ponds on Cape Cod (e.g., Roman et al., 2001).

The second concern, more semantic than limnological, has to do with use of the term *"healthy"*, as the criterion for non-impacted ponds. While the term *"unimpacted"* seems appropriate with regard to near-pristine or reference natural water quality conditions, the term *"healthy"* is much more ambiguous in the limnological sense, and may likely be misinterpreted in popular usage since if follows that ponds not meeting these target criteria may be considered not *"healthy."* This will be misleading since many mesotrophic ponds that provide water quality and habitats for a diverse biological assemblage and support all designated water uses may be considered not *"healthy"* under a strict application of these criteria (i.e., minor exceedances of criterion). It is suggested that the less judgmental term "target" criterion be considered here.

These criticisms aside, the CCC criteria provide a useful screening tool for sorting ponds into classes with various trophic characteristics. This information was used as part of the assessment of the present and future conditions of the Orleans Ponds of interest.

Protection of Designated Water Uses

All of the eight ponds are classified as Class B waters under the Massachusetts surface water quality standards (314 CMR 4.00); with the additional designation of Outstanding Resource Water (ORW) for Crystal Lake, Pilgrim Lake and Sarah's Pond. The MA water quality standards identify a series of water uses that must be supported for Class B waters. These include: protection of aquatic life, contact (e.g., swimming) and non-contact (e.g., boating) recreation, fish consumption, irrigation, and navigation. Due to the depth of some of the Orleans ponds (e.g., Bakers, Crystal), both cold water (i.e., trout) and warm water fishery habitat may be ecologically appropriate, but only the warm-water fishery is designated.

Based on the information available, it was assumed that non-contact recreational uses (both motorized and non-motorized) were supported by all ponds. Irrigation such as transfer of water to cranberry bogs is limited (Crystal Lake historic use) and navigational uses are not relevant to these ponds. No information was available regarding fish consumption, but the existence of a State-mandated fish consumption advisory (e.g., for mercury) is not based on pond-specific conditions.

Accordingly, the focus was on evaluating the ability of the ponds to support aquatic life and contact recreational water uses. The trophic information available for the pond was most useful to evaluate protection of aquatic life (based on DO) and support of swimming (SDT visibility criterion of 4 ft (1.3 m)). Additional evidence for aquatic life support can be inferred from other trophic indicators (nutrients, chl).

Based on the available water quality and trophic indicator data, the selected Orleans ponds were assessed as to

- data indicates the pond is meeting designated water uses;
- data indicates the pond is impaired (i.e., not meeting designated water uses); or
- the data are ambiguous or are not available (i.e., do not allow a classification).

Comments on the ability of ponds to meet their designated uses are contained in Table 1.

Assessment of Potential Groundwater Contribution in Watershed

Numerous studies have shown that many freshwater ponds on Cape Cod receive a sizeable fraction of their nutrient budget from nutrient inputs from groundwater discharge from the watershed to the pond (septic systems, fertilizer, infiltrated stormwater, etc). Due to this importance of this, the potential susceptibility of ponds to meet their designated water uses was qualitatively estimated from examination of land use in the watershed, proximity to the pond and potential for future development. The Needs Assessment identified the number of dwellings in the pond watershed and the relative nutrient loads to the ponds within the three larger Orleans contributing zones of coastal interest (i.e., Pleasant Bay, Nauset Harbor or Cape Cod Bay). Dwellings were further delineated as to whether they were located within a 300-ft distance from the pond. This 300-ft distance has been selected by some to represent the distance that phosphorus in groundwater is likely to travel over a sufficient time period (91 years) to allow full assessment of future nutrient impacts to the pond (CCC, 2006). This 300-ft distance is considered an approximate linear limit of temporal groundwater influence during the planning horizon. While distance could be refined further on a pond-specific basis, it is sufficient to serve as an indicator of future water quality for this data assessment. This information is summarized in Table 2 *Summary of Freshwater Pond Watershed Wastewater Sources.* It is also important to recall that due to the age of development in a watershed not all the nutrients derived from dwellings, etc. may have arrived at a pond.

Based on this qualitative evaluation, the Orleans ponds were assessed as to:

- potentially high risk of water quality degradation from future development in the watershed (i.e., future development could produce marginal or impaired conditions);
- potentially low risk of water quality degradation from future development in the watershed (current status unlikely to significantly change), or
- the available data do not allow a prediction.

POND-SPECIFIC EVALUATIONS

Each of the Orleans ponds of interest was evaluated for current water quality or trophic state, potential susceptibility to watershed inputs and potential applicability for off-site sanitary management as a potential watershed nutrient management tool. Surface areas were taken from relevant CCC reports (CCC, 2003; 2006).

Bakers Pond

Bakers Pond is a 28-acre Great Pond that is an important regional recreational resource for Orleans (see Figure 2-5). Recreational uses include swimming (public beach), boating and fishing. The lake is considered a coldwater fishery and is stocked by the State with trout species during spring and fall periods (CCC, 2003).

Evaluation of the trophic indicators shows that the current water quality in the pond is excellent and meeting all designated uses, including good support of coldwater fishery (Table 1). There is a slight trend of increasing hypolimnetic anoxia (and reduction of summertime coldwater fish habitat) and a small increase of hypolimnetic TP release from the sediments under low DO conditions. This pond would be considered oligotrophic based on its current water quality and

trophic indicators.

The pond watershed is located at the northern edge of the contributing zone to Pleasant Bay. Upgradient land use in the pond watershed is favorable; Bakers Pond gets recharge from groundwater flowing northwest from largely undeveloped land in Brewster. The current number of Orleans parcels in the Bakers Pond watershed is estimated at 10, with 7 of these in the 300-ft buffer (Table 2). There are several developed parcels in Brewster, and several parcels with development potential, that were included in the evaluation of potential water quality degradation with respect to phosphorus from septic tank effluent. Table 2 only includes Orleans parcel data. The entire pond shoreline is described as sparsely developed with single family homes (CCC, 2003). Projected future septic system discharges in the entire watershed increases from the estimated existing 1,100 gallons per day (gpd) to a future estimated 1,700 gpd. Within the proximal 300-ft buffer zone, a more modest increase from 800 to 1,400 gpd is projected.

Due to the current excellent water quality, small amount of existing and future Orleans or Brewster development in the watershed (much of which is protected and located in Brewster), and the potential for assimilation of the projected increase, significant investment in off-site sanitary management is not warranted for the Bakers Pond watershed. Application of general watershed best management practices such as timely septic system repair and maintenance, stormwater management, and reduction of nutrient fertilizers and/or incorporation of naturalistic buffers is appropriate.

Boland Pond

Boland Pond is a 4.7-acre pond located in the northern portion of Orleans (see Figure 2-5). Due to its small size, dense surrounding vegetative cover, and poor public access, Boland Pond doesnot have a public beach or a boat landing and is not considered an important recreational waterbody, but it does provide ecological and aesthetic functions. Due to its proximity to the local middle and elementary schools, this pond is assumed to have educational value as well.

Evaluation of the trophic indicators shows that the current water quality in the pond is poor with high nutrient concentrations and significant excursions below acceptable DO levels. There is some indication that phosphorus recycling from the sediments is an important component of nutrient loading to the pond. The SDT depth indicates poor visibility would impair swimming uses there. Based on this data, it is clear that Boland Pond is not meeting all designated uses. This pond would be considered eutrophic based on its current water quality and trophic indicators.

The pond watershed is located at the northern edge of the contributing zone to Town Cove in the Nauset estuarine system. Upgradient land use in the pond watershed to the south is mixed. There is a significant number of contributing parcels in the watershed, but much of the immediate upgradient watershed (i.e., 300-ft buffer) is undeveloped or used as playing fields for the local schools (but which may be well fertilized for turf management). The current number of parcels in the Bolands Pond watershed is estimated at 45 with only 4 of these within the 300-ft buffer (Table 2), but one of these parcels is a large inn located to the southwest. Projected future septic system discharges in the entire watershed increases from the estimated existing 10,100 gallons to 14,100 gpd. Within the proximal 300-ft buffer zone, the present input of 2,100 would only increase to 2,500 gpd. The modest increase in the 300-ft buffer is apparently due to the lack of developable parcels in this zone.

Due to the current impaired water quality, location in fairly close proximity to Town Cove (a presumed nitrogen-sensitive embayment), and the availability of publicly-owned land in the near watershed area, this pond watershed should be considered for off-site sanitary management. This is particularly attractive for management of sanitary waste from a large single source (inn). The expectations for reduction of inputs to Bolands Pond would be for gradual improvement to surface water quality (TP, DO) in the upper waters of the pond, although nutrient recycling from bottom sediments might persist for a longer period. Another advantage of reducing nutrient inputs to Boland Pond is to reduce nutrient loading (especially nitrogen) to Town Cove as well.

Cedar Pond

Cedar Pond is a 15.1-acre, relatively shallow (maximum depth is 15 ft) Great Pond located in the northern portion of Orleans (see Figure 2-5). This pond is subject to tidal influence through two culverts that are hydrologically connected to Rock Harbor. Pond salinity ranges from 6 to 18 parts per thousand (ppt) (CCC, 2006), thus the pond is not considered freshwater (freshwater limits are typically 1-2 ppt). Cedar Pond does not a formal boat landing and is not considered an important active recreational waterbody for Orleans, but it does provide ecological and aesthetic functions.

Evaluation of the trophic indicators shows that the current water quality in the pond is poor with high concentrations of both TP and TN and significant excursions below acceptable DO levels. The poor DO and high nutrients in bottom waters may also reflect poor mixing due to density-based stratification (i.e., freshwater water overlies saltier, denser water). The SDT depth indicates poor visibility below the swimming criterion (< 4-ft). Based on these data, it is clear that Cedar Pond is not meeting all designated uses. This pond would be considered eutrophic based on its current water quality and trophic indicators. However, since it is not a freshwater pond, the nature of its nutrient limitation is still not fully resolved (CCC, 2006).

The pond watershed is located within the contributing zone to Cape Cod Bay. Cedar Pond has a large watershed that incorporates some of the more developed urban land uses in Orleans. The current number of parcels in the Cedar Pond watershed is estimated at 69 with 13 of these in the 300-ft buffer (Table 2). Projected future septic system discharges in the entire watershed increase from the estimated existing 31,100 gallons to 35,300 gpd. Within the proximal 300-ft buffer zone, the present input of 500 would only increase to 800 gpd since further shoreline development is not likely.

Cedar Pond may be a future candidate for off-site sanitary management but this decision should be deferred for now. It is a good candidate due to the large number of contributing parcels, large sanitary flow and direct hydrologic connection with Cape Cod Bay. However, at the present time, the influence of the watershed, pattern of mixing with tidal water and resulting nutrient fluxes to Rock Harbor are not fully understood. As recommended by CCC (2006), this waterbody will require future investigation, probably as part of the planned Massachusetts Estuary Project (MEP) modeling of the Cape Cod Bay system before informed management decisions can be reached regarding the necessity or magnitude of nutrient reductions.

Crystal Lake

Crystal Lake is a 37-acre Great Pond that is an important regional recreational resource for Orleans (see Figure 2-5). Recreational uses include swimming, boating and fishing and there are

two town landings (H&W, 2003). The lake is considered a coldwater fishery and stocked by the State with trout (rainbow trout, brown trout) during spring and fall periods.

Evaluation of the trophic indicators shows that the water quality in the pond is good to excellent and meeting all expected designated uses (Table 1). There is some concern regarding a trend of increasing hypolimnetic anoxia (and reduction of summertime coldwater fish habitat) and accompanying release of TP from the sediments under low DO conditions. This pond would be considered oligo-mesotrophic based on its current water quality and trophic indicators.

The pond watershed is located at the northern edge of the contributing zone to Pleasant Bay. Upgradient land use in the pond watershed seems generally favorable; Crystal Lake is downstream of Bakers Pond and undeveloped land in Brewster. The pond shoreline is described as moderately developed with single family homes (CCC, 2003). It has also been noted that a discharge pipe from Route 28 may be a potential source of pollutants (H&W, 2003).

The current number of parcels in the Crystal Lake watershed is estimated at 60 with 1/3 of these in the 300-ft buffer (Table 2). Projected future septic system discharges increase in the buffer zone from 2,300 to 3,600 gpd or an approximate 50% increase; slightly less than the expected increase in flow from the entire watershed.

Due to the current good-to-excellent water quality, signs of deterioration in the DO levels and hypolimnetic release of TP, and the status of the pond as oligo-mesotrophic, this pond watershed should be considered for off-site sanitary management. The rationale is that there is an expected 50% increase in septic load for a pond that could easily shift Crystal Lake to a mesotrophic category. While a mesotrophic condition is not necessarily incompatible with meeting all fully designated uses, it would be likely the reduction in water quality would eliminate the possibility of a viable summertime cold water fishery. In addition, the presence of the public beach indicates that water transparency would be important parameter to preserve and reduction of groundwater nutrients would help support this. Overall, the Crystal Lake watershed would be a good candidate for watershed management of septic wastes (including off-site solutions) and/or application of best management practices regarding septic system repair, stormwater management, and maintenance to prevent accelerated eutrophication of Crystal Lake.

Ice House Pond

Ice House Pond is a relatively small 5.7-acre, shallow (non-stratified) pond located in northeastern Orleans (see Figure 2-5). Based on its small size, dense surrounding vegetative cover, and poor public access, Ice House Pond is not considered an important active recreational waterbody, but it does provide ecological and aesthetic functions.

Evaluation of the trophic indicators shows that the water quality in the pond is good to excellent and meeting all expected designated uses (Table 1). Nutrient levels and chlorophyll slightly exceed the “healthy” levels but are considered acceptable for a small pond. Surface water DO levels are good and SDT levels are very high for a small pond. There is significant anoxia in the bottom station but TP at depth is not especially elevated indicating low amounts of phosphorus release from the sediments. This pond would be considered oligo-mesotrophic based on its current water quality and trophic indicators. No information was available on the aquatic macrophyte community, which are often important ecological components in shallow ponds.

The pond watershed is located within the contributing zone to Nauset Harbor near the

groundwater divide between flows going to Town Cove and thus going to Nauset Harbor. Upgradient land use in the pond watershed is generally residential, but there are few houses in the buffer zone and a sizeable wetland is also present.

The current number of parcels in the Icehouse Pond watershed is estimated at 66 with only 5 of these in the 300-ft buffer (Table 2). Projected future septic system discharges in the entire watershed increases from the estimated existing 6,400 gallons to 9,500 gpd. Projected future septic system discharges increase in the buffer zone from 300 to 800 gpd.

Due to the current good to excellent water quality, small amount of future development in the immediate watershed and the potential for natural attenuation of nutrients from more distant watershed sources through existing wetland features, off-site sanitary management is not warranted for the Ice House Pond watershed. Application of general watershed best management practices such as timely septic system repair and maintenance, stormwater management, reduction of nutrient fertilizers and/or incorporation of naturalistic buffers are appropriate, however.

Pilgrim Lake

Pilgrim Lake is the largest pond in Orleans at 43 acres located in the central portions of the town (see Figure 2-5). It is a Great Pond that is an important regional recreational resource for Orleans. Recreational uses include swimming, boating and fishing and there is large public beach and boat ramp on the northeast shore. There is a herring run leading to Kescayogansset Pond at the northern end of the lake (CCC, 2003).

Evaluation of the trophic indicators shows that the water quality in the pond is good and meeting all expected designated uses (Table 1). There is some concern regarding a trend of increasing hypolimnetic anoxia and accompanying release of TP from the sediments under low DO conditions. This pond would be considered mesotrophic based on its current water quality and trophic indicators.

The pond watershed is located within the contributing zone to Pleasant Bay. The lake is recharged by groundwater flow from the west, included area which is protected for water supply. Upgradient land use in the pond watershed includes a good number of residential homes. The pond shoreline is described as lightly developed with single family homes (CCC, 2003). It has also been noted that the pond also appears to receive stormwater from Rohmer's Road which may be a potential source of pollutants (H&W, 2003).

The current number of parcels in the Pilgrim Lake watershed is estimated at 55 with 16 of these in the 300-ft buffer (Table 2). Projected future septic system discharges increase in the entire watershed is from 7,100 gpd to a future estimated 12,400 gpd. Within the proximal 300-ft buffer zone, an increase from 1,500 to 2,700 gpd is projected.

Due to the current good water quality, signs of deterioration in the DO levels and significant hypolimnetic release of TP, and the status of the pond as mesotrophic, this pond watershed should be considered for off-site sanitary management. The rationale is that there is a large expected increase in groundwater loading for a pond for both the entire watershed as well as the more critical 300-ft buffer zone. This increase in nutrients could easily shift Pilgrim Lake into a meso-eutrophic or fully eutrophic category. This would likely result in a reduction in water quality and support of aquatic life. Recreational water quality at the public beach could also

suffer from decreases in water transparency and increased frequency of nuisance algal blooms. Overall, the Pilgrim Lake watershed would be a good candidate for watershed management of septic wastes (including off-site solutions) as well as application of best management practices regarding septic system repair, stormwater management, and maintenance to prevent accelerated eutrophication of Pilgrim Lake.

Sarah's Pond

Sarah's Pond is a relatively small (5.6-acre), shallow (non-stratified) pond located in southern Orleans (see Figure 2-5). Based on its small size, dense surrounding vegetative cover, and poor public access, Sarah's Pond does not have a public beach or a boat landing and is not considered an active recreational waterbody, but it does provide significant ecological and aesthetic functions.

Evaluation of the trophic indicators shows that the water quality in the pond is moderate and meets most expected designated uses (Table 1). Nutrient levels and chlorophyll do exceed the "healthy" levels and the TN and chlorophyll levels at the bottom are particularly high. Surface water DO levels are good but there is significant anoxia in the bottom station. SDT levels are low and can occasionally fail the 4-ft visibility criterion. This pond would be considered mesotrophic based on its current water quality and trophic indicators. Despite the moderate water quality levels, Sarah's Pond is considered one of the more pristine pond environments in the Pleasant Bay watershed. It has a shoreline stand of the regionally rare Atlantic White Cedar *(Chamaecyparis thyoides)* and dense stands of slender pondweed *(Potamogeton pusillus)* observed in the pond (H&W, 2003).

Sarah's Pond is located within the contributing zone to Pleasant Bay. It has a long linear watershed which originates to the west near Brewster. Upgradient land use in the pond watershed is residential, but there is very little in the 300-ft buffer zone. The pond shoreline is described as having two single family homes and a single dock (H&W, 2003).

The current number of parcels in the Sarah's Pond watershed is estimated at 59 with only 5 of these in the 300-ft buffer (Table 2). Projected future septic system discharges in the entire watershed increase from the estimated existing 6,700 gallons to 13,900 gpd. Projected future septic system discharge increases in the buffer zone from 100 to 300 gpd.

Sarah's Pond constitutes an excellent ecological resource for Orleans. While the water quality is at best moderate, existing evidence suggests that the pond is providing important ecological functions for shoreline vegetation, aquatic macrophytes and wildlife. This is a naturally mesotrophic lake that is unlikely to be significantly impacted by nutrients in groundwater due to the small amount of existing and predicted future loadings from the immediate watershed as well as the large amount of open space and protected land in the vicinity. Accordingly, off-site sanitary management is not warranted for the Sarah's Pond watershed. Application of general watershed best management practices such as timely septic system repair and maintenance, stormwater management, and reduction of nutrient fertilizers in the upper watershed portions are appropriate, however.

Shoal Pond

Shoal Pond is a small (8.6-acre) and very shallow (non-stratified) pond located in southern

Orleans between Twinings Pond and Deep Pond (see Figure 2-5). Shoal Pond does not have a public beach or a boat landing and is not considered an important recreational waterbody, but it may provide ecological and aesthetic functions.

Evaluation of the trophic indicators shows that the water quality is poor and does not support expected designated uses (Table 1). Nutrient levels and chlorophyll significantly exceed the "healthy" levels." Shoal Pond was the only Orleans pond reviewed by CCC that did not meet acceptable average DO levels even in the surface waters (CCC, 2006). The SDT in this pond is also consistently below the visibility criterion, which may be related to its overall shallowness. This pond would be considered eutrophic based on its current water quality and trophic indicators.

The pond watershed is located within the contributing zone to Pleasant Bay. It has a long linear watershed which originates to the west; about half of the watershed area is located in Brewster. Upgradient land use in the pond watershed is generally residential, with less in the buffer zone. The current number of parcels in the Shoal Pond watershed is estimated at 40 with 7 of these in the 300-ft buffer (Table 2). Projected future septic system discharges in the entire watershed increase from the estimated existing 4,700 gallons to 8,000 gpd. Projected future septic system discharges increase in the buffer zone from 1,200 to 2,200 gpd.

Shoal Pond is not well studied relative to other Orleans Pond. While it is deemed a eutrophic waterbody based its water quality parameters, no additional information was available on other ecological features of the pond. No bathymetric map was available for this pond, but sampling depths reported suggest that much of the pond is less than 2 meters (CCC, 2006), which would be conducive to colonization by aquatic macrophytes. Aerial photographs suggest that at least some of the pond basin is already filling in (east and northern embayment (Google-Earth ®, 2006). The pond watershed has residential development largely located outside of the 300-ft buffer but there is not a great deal of open space within an intermediate distance. It is also uncertain how the nutrient budget of Shoal Pond may be affected by imports/exports from adjacent water bodies.

It seems unlikely that reduction in groundwater nutrients would significantly improve water quality in the Shoal Pond. It appears that this waterbody will move towards more wetland characteristics, improvement in water quality would be unlikely to restore or enhance designated uses. Therefore, off-site sanitary management is not recommended for the Shoal Pond watershed. Application of general watershed best management practices such as timely septic system repair, stormwater management, and maintenance and reduction/elimination of nutrient fertilizers is warranted.

SUMMARY OF FRESHWATER POND ASSESSMENT

A summary of the evaluation of the eight freshwater ponds is shown in Table 3. This table summarizes the important water quality concerns, potential impairments to designated uses (slight impairments were interpreted as no concerns), and watershed concerns relative to potential groundwater nutrient loading. Finally, the potential applicability for off-site sanitary management was evaluated. Based on the information assessed, each pond was categorized as (1) high priority for nutrient reduction through wastewater management; (2) low priority for nutrient reduction through wastewater management; or (3) decision deferred at this time but should revisited when additional information is available (i.e., relevant MEP report).

Ponds which were recommended as a high priority for wastewater management include Bolands Pond, Crystal Lake, and Pilgrim Lake. Those ponds recommended as a lower priority for wastewater management include Bakers Pond, Ice House Pond, Sarah's Pond and Shoal Pond. Cedar Pond is of potential interest, but due to the complexity of the mixing and nutrient exchange in this tidally-influenced pond, this decision is deferred until further information is available as part of the Cape Cod Bay MEP investigation. The use of watershed BMPs for reduction of nutrient loading from point (stormwater) and non-point sources or good environmental stewardship (e.g., reduction or elimination of fertilizer inputs) is recommended for all watersheds.

It should be recognized that there are several sources of uncertainty regarding these pond assessments and recommendations. Some of the more important sources include:

- Interpretation of ecological significance and potential designated use impairment from exceedances of CCC "healthy" thresholds;
- Use of 300-ft buffer as limits of potential near-term groundwater loading;
- Determination of the future projected or "buildout" totals for watershed; and
- Uncertainty regarding morphometric data of some of the smaller ponds.

Phosphorus from the septic systems discharging in the 300-foot buffer zones of these eight ponds may not have reached the ponds yet, and it is unclear when those loads will fully reach the ponds and to what extent they may be attenuated. In contrast, the phosphorus loads derived from stormwater and lawn fertilizer (since they enter via the much quicker overland runoff route) may be both larger in magnitude and more likely to have reached the ponds than the septic loads. Accordingly, sewering of up-gradient lots within the 300-foot buffer is a good long-term investment for limiting the wastewater phosphorus load to all these ponds, but should not be undertaken without having considered and addressed the stormwater loads, near-shore fertilization practices and establishment of vegetated buffers. It will therefore be appropriate to proceed with sewering plans for the watersheds of Crystal Lake, Pilgrim Lake, and Bolands Pond concurrent with actions on stormwater.

Finally, it should be noted that this assessment has only dealt with 8 of the 63 identified ponds in Orleans (albeit many of the eight included are considered major recreational or aesthetic resources for the Town). Therefore it is possible that improvement in the water quality, ecological health and recreational function of other Orleans ponds could be achieved due to watershed nutrient reductions and adaptive wastewater and/or stormwater management. Additional water quality data and/or watershed information would be required to make such a determination. As with most long-term watershed management programs, protection of the water quality in ponds in Orleans will likely be achieved in an iterative fashion, through diagnosis and treatment of larger or societally important water bodies first, then successive efforts focusing on smaller or less prominent ponds as time and resources allow. Therefore, an assessment of all phosphorus sources for the remaining ponds is warranted before sewering is considered, Integration of this purpose with the Town-wide wastewater planning and management effort inherent in the CWMP is an important first step.

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TABLE 1
POND TROPHIC DATA

Waterbody	WQ Para.	units	CCC (2003) benchmarks Unimpacted	Healthy	Representative Pond Data			CCC Criteria Compliance	Designated Water Use Comments
Baker's Pond	**TP**	ug/L	7.5	10	epilimion	5.1-5.4 ug/L	(a)	Unimpacted	Meets all designated uses including
			7.5	10	hypolimnion	11.8 ug/L	(a)	Sl. Impacted	CW fishery; oligotrophic conditions.
	TN	mg/L	0.16	0.31	mean	0.16 > TN < 0.31 mg/L	(b)	Healthy	
	Chl a	ug/L	1.0	1.7	epilimnion	most chl a < 1.0 ug/L	(b)	Unimpacted	
	SDT	m		> 1.3	mean&range	7.5 m; 3.2 -10.4 m	(a)	Meets visibility criteria	
	DO	mg/L	6.0	>1.0	epilimion	>6.0 mg/L	(b)	Meets CW criteria	
		mg/L	6.0	>1.0	hypolimnion	>2.0 mg/L	(b)	Healthy	
Boland's Pond	**TP**	ug/L	7.5	10	pond	> 30 ug/L	(a)	Heavily impacted	Concerns meeting aquatic life uses
	TN	mg/L	0.16	0.31	mean	TN > 0.31 mg/L	(b)	Impacted	due to low DO; high TP, chl a in
	Chl a	ug/L	1.0	1.7	pond	chl a > 1.7 ug/L	(b)	Impacted	bottom waters; visibility may not be
	SDT	m		> 1.3	mean&range	1.4 m; 0.4 -2.6 m	(a)	Can fail visibility criteria	suitable for swimming at times;
	DO	mg/L	5.0	>1.0	lake	DO << 5.0 mg/L at times	(b)	Impacted; much anoxia	eutrophic condtions.
Cedar Pond	**TP**	ug/L	7.5	10	pond	77 ug/L	(a)	Not Healthy	Concerns meeting aquatic life uses
	TN	mg/L	0.16	0.31	mean	TN > 0.31 mg/L	(b)	Impacted	due to low DO; high TP, chl a in
	Chl a	ug/L	1.0	1.7	pond	chl a > 1.7 ug/L	(b)	Impacted	bottom waters; visibility may not be
	SDT	m		> 1.3	mean&range	1.0 m; 0.7 -1.4 m	(a)	Fails visibility criteria	suitable for swimming; eutrophic
	DO	mg/L	5.0	>1.0	pond	DO << 5.0 mg/L at times	(b)	Impacted; much anoxia	conditions, but may be N-limited.
Crystal Lake	**TP**	ug/L	7.5	10	epilimion	6.2-7.2 ug/L	(a)	Unimpacted	Meets all major designated uses but
			7.5	10	hypolimnion	11.3-33.8 ug/L	(a)	Impacted	poor DO support of CW fishery;
	TN	mg/L	0.16	0.31	mean	0.16 > TN < 0.31 mg/L	(b)	Healthy	oligo-mesotrophic conditions
	Chl a	ug/L	1.0	1.7	epilimnion	1.0 > chl a < 1.7 ug/L	(b)	Healthy	
	SDT	m		> 1.3	mean&range	5.1 m; 1.8 - 7.6 m	(a)	Meets criteria	
	DO	mg/L	6.0	>1.0	epilimion	>6.0 mg/L	(b)	Meets CW criteria	
		mg/L	6.0	>1.0	hypolimnion	DO < 1.0 mg/L at times	(b)	Impacted	
Ice House Pond	**TP**	ug/L	7.5	10	pond	0.10 > TP < 0.31 mg/L	(b,c)	Healthy	Meets all major designated uses but
	TN	mg/L	0.16	0.31	mean	TN > 0.31 mg/L	(b)	Sl. Impacted	some anoxia in bottom waters;
	Chl a	ug/L	1.0	1.7	pond	chl a > 1.7 ug/L	(b)	Impacted	oligo-mesotrophic conditions
	SDT	m		> 1.3	mean	> 4 m	(b)	Meets visibility criteria	
	DO	mg/L	5.0	>1.0	pond	>5.0 mg/L; some <2.0	(b)	Sl. Impacted	
Pilgrim Lake	**TP**	ug/L	7.5	10	epilimion	11.8-14.6 ug/L	(a)	Not Healthy	Supports all designated uses, but
			7.5	10	hypolimnion	72.1 ug/LL	(a)	Not Healthy	aquatic life support is declining in the
	TN	mg/L	0.2	0.31	mean	TN > 0.31 mg/L	(b)	Not Healthy	hypolimnion; mesotrophic conditions.
	Chl a	ug/L	1.0	1.7	epilimnion	chl a > 1.7 ug/L	(b)	Not Healthy	
	SDT	m		> 1.3	mean&range	3.4 m; 1.4 - 5.2 m	(a)	Meets visibility criteria	
	DO	mg/L	6.0	>1.0	epilimion	> 6.0 mg/L	(b)	Meets CW criteria	
		mg/L	6.0	>1.0	hypolimnion	<5.0 mg/L; often <2.0	(b)	Impaired	

TABLE 1 (CONTINUED)
POND TROPHIC DATA

Waterbody	WQ Para.	units	CCC (2003) benchmarks Unimpacted	Healthy	Representative Pond Data		CCC Criteria Compliance	Designated Water Use Comments
Sarah's Pond	**TP**	ug/L	7.5	10	pond	approx. 20 ug/L (b,c)	Not Healthy	Meets most major designated uses
	TN	mg/L	0.16	0.31	mean	TN > 0.31 mg/L (b)	Impacted	but some anoxia in bottom waters
	Chl a	ug/L	1.0	1.7	pond	chl a > 1.7 ug/L (b)	Impacted	and low transparency; mesotrophic.
	SDT	m		> 1.3	mean&range	approx. 2.3 m (b)	Can fail visibility criteria	Excellent ecological habitat
	DO	mg/L	5.0	>1.0	pond	<2.0 in bottom waters (b)	Impacted	
Shoal Pond	**TP**	ug/L	7.5	10	pond	approx. 30+ ug/L (b,c)	Not Healthy	Concerns meeting aquatic life uses
	TN	mg/L	0.16	0.31	mean	TN > 0.31 mg/L (b)	Impacted	due to low DO; high TP, and chl a
	Chl a	ug/L	1.0	1.7	pond	chl a > 1.7 ug/L (b)	Impacted	SDT depth not suitable for swimming
	SDT	m		> 1.3	mean&range	< 2 m all year (b)	Fails visibility criteria	shallow, wetland characteristics
	DO	mg/L	5.0	>1.0	pond	low DO throughout (b)	Heavily impacted	eutrophic condtions.

Notes on WQ data:
(a) Water quality values cited in Eichner et al (2006)
(b) Data extrapolated from tables or figures in Eichner et al (2006)
(c) Available data considered from Eichner et al (2003).

TABLE 2
SUMMARY OF POND WATERSHED WASTEWATER SOURCES

WATER BODY	WATERSHED						TOTAL	
	PLEASANT BAY		NAUSET SYSTEM		CAPE COD BAY SYSTEMS			
	GW Basin	300-ft Buffer	GW Basin	300-ft Buffer	GW Basin	300-ft Buffer	GW Basin	300-ft Buffer
CEDAR POND								
Number of Parcels					69	13	69	13
Current Flow, gpd					31,100	500	31,100	500
Future Flow, gpd					35,300	800	35,300	800
BOLANDS POND								
Number of Parcels			45	4			45	4
Current Flow, gpd			10,100	2,100			10,100	2,100
Future Flow, gpd			14,100	2,500			14,100	2,500
ICE HOUSE POND								
Number of Parcels			66	5			66	5
Current Flow, gpd			6,400	300			6,400	300
Future Flow, gpd			9,500	800			9,500	800
PILGRIM LAKE								
Number of Parcels	55	16					55	16
Current Flow, gpd	7,100	1,500					7,100	1,500
Future Flow, gpd	12,400	2,700					12,400	2,700
BAKERS POND								
Number of Parcels	10	7					10	7
Current Flow, gpd	1,100	800					1,100	800
Future Flow, gpd	1,700	1,400					1,700	1,400
CRYSTAL LAKE								
Number of Parcels	60	20					60	20
Current Flow, gpd	6,000	2,300					6,000	2,300
Future Flow, gpd	14,700	3,600					14,700	3,600
SHOAL POND								
Number of Parcels	40	7					40	7
Current Flow, gpd	4,700	1,200					4,700	1,200
Future Flow, gpd	8,000	2,200					8,000	2,200
SARAH'S POND								
Number of Parcels	59	5					59	5
Current Flow, gpd	6,700	100					6,700	100
Future Flow, gpd	13,900	300					13,900	300
TOTAL								
Number of Parcels	224	55	111	9	69	13	404	77
Current Flow, gpd	25,600	5,900	16,500	2,400	31,100	500	74,100	8,800
Future Flow, gpd	50,700	10,200	23,600	3,300	35,300	800	109,600	14,300

TABLE 3
SUMMARY OR FRESHWATER POND ASSESSDMENT

	Bakers Pond	Boland Pond	Cedar Pond	Crystal Lake	Ice House Pond	Pilgrim Lake	Sarah's Pond	Shoal Pond
Major watershed	Pleasant Bay	Nauset Inlet	Cape Cod	Pleasant Bay	Nauset Inlet	Pleasant Bay	Pleasant Bay	Pleasant Bay
Pond Morphometrics								
Pond surface area (acres)	28	5	15	37	6	43	6	9
Pond volume (m^3)	809,200	41,400	113,400	976,300	57,500	770,700	61,300	52,100
Residence time (yr)	1.2	0.4	0.4	1.2	NA	0.5	NA	NA
Public Beach or Boat Ramp Access	PB, BR	-	PB, BR	-	-	PB, BR	-	-
Water Quality Concerns								
Phosphorus	-	**X**	**X**	**X**	-	**X**	**X**	**X**
Chlorophyll	-	**X**	**X**	-	**X**	**X**	**X**	**X**
Secchi Depth	-	**X**	**X**	-	-	-	**X**	**X**
Dissolved Oxygen	-	**X**	**X**	**X**	-	-	**X**	**X**
Trophic Status *	Oligotrophic	Eutrophic	Eutrophic	Oligo-mesotrophic	Oligo-mesotrophic	Mesotrophic	Mesotrophic	Eutrophic
Designated Use Impairment								
Aquatic Life Support	-	**X**	**X**	**X**	-	**X**	**X**	**X**
Contact Recreation	-	**X**	**X**	-	-	-	**X**	**X**
Non-contact Recreation	-	-	-	-	-	-	-	-
Concern Over P Loading								
Current development in 300-ft buffer	-	-	-	**X**	-	**X**	-	-
Future development in 300-ft buffer	-	-	-	**X**	-	**X**	-	-
Development in entire watershed	-	**X**	**X**	-	**X**	**X**	**X**	**X**
Nutrient Reduction								
High Priority	-	**X**	-	**X**	-	**X**	-	-
Low Priority	**X**	-	-	-	**X**	-	**X**	**X**
Deferred	-	-	**X**	-	-	-	-	-
Application of general BMPs	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**

X = positive indication

* watershed nitrogen impacts are being separately addressed by Massachusetts Estuary Project.

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