RESPONSES TO SURVEY RESULTS RELATIVE TO CANAL WATER QUALITY

From the Canal Water Quality Committee

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A. INTRODUCTION

The purpose of this report is to document the Canal Water Quality Committee's analysis and response to four of the topics addressed by the 860 homeowners' responses to the *2011 Town of South Bethany Comprehensive Plan Community Survey.* The results from that survey are documented in *The April 2011 Comprehensive Plan Community Survey Results Report – July 2011* and can be viewed at http://www.southbethany.org/survey/2011%20Comprehensive%20Plan%20Community%20Survey%20Results%20Report.pdf (Be patient it takes a while to load.) The four topics addressed by this report are:

1. Canal Maintenance Service
2. Storm Water Management Service
3. Maintain Dredged Canals Future Need
4. Aerators in Canals Future Needs

Even though the numerical score for the homeowners' responses showed that the homeowners were "Satisfied" with the two town services listed above; the two town services, when sorted by numerical score, were ranked in the 19th and 20th position, only above Mediacom TV. The numerical scores and the written comments have helped the Water Quality Committee to explore potential adjustments that can be made to improve the satisfaction with the two services and potentially move both services into the "Very Satisfied" category. This is particularly important since the homeowners ranked the two future needs listed above as the 2nd and 3rd most important among the 15 future needs listed, only behind Maintain Replenished Beach Future Need**.**

B. REPORT ORGANIZATION

The report is organized into three main sections:

1. **Summary of Survey Results** – This section is a very brief summary of the homeowners' responses to the 2011 survey for the four topics listed above. It forms the focus for the Water Quality Committee's responses to the homeowners' concerns relative to canal water quality and stormwater management.
2. **Canal Water Quality Committee Response to Survey Results** – This section is divided into two subsections;
    - Recommended Actions that the Town Should Take – This subsection lists:
        - Programs that the town currently has in place that are working and should be continued
        - Programs that will be initiated to decrease the amount of algae, debris, sludge, trash, etc., that accumulate in the South Bethany canals
        - A program to create a reserve for future canal dredging
        - Programs that will be initiated to decrease the amount of "large puddles" or "flooding" or "too much standing water":
            1. Due to lack of adequate control of stormwater runoff along South Bethany's streets. Observations after Hurricane Irene indicate that this is not an issue.
            2. Due to improper grading of private properties within South Bethany
            3. Due to tidal flooding
    - Recommended actions that homeowners should take

3. **Rationale For Response** – This section is to provide the reader with information that was used by the Water Quality Committee to formulate their recommendations for water quality and stormwater management improvements. It contains the following:
    - Studies conducted over the past 20 years relative to canal water quality
    - Actions resulting from studies
    - Observations of the "flooding" and "puddles" left by Hurricane Irene
    - Water Quality Committee's philosophy relative to stormwater management
    - Information relative to diffusers/aerators

C. SUMMARY OF SURVEY RESULTS

1. **Canal Maintenance Service** – This service scored 3.78, indicating a numerical response of "Satisfied." There were 79 written comments.
    - About 30 comments complained about algae or "dirty" canals.
    - About 20 comments complained about trash or debris in canals.
    - 12 specifically complained about a dredging issue.
    - About 15 were general about needing more maintenance.
    - 2 complained about overhanging trees.
    - 2 complained about the "trash" collecting in the basin at the east end of Anchorage Canal. (The northeast end is actually private property.)
    - A couple said they would like to see something like a Tidal Pump or aeration.

2. **Stormwater Management Service** – This service scored 3.87, indicating a numerical response of "Satisfied." There were 68 written comments.
    - Almost every comment complained about "large puddles" or "flooding" or "too much standing water" due to lack of adequate control of stormwater runoff. Streets specifically mentioned were: Bristol, Tamarack, Cattail, York, Carlisle, Layton, Bay Shore, Elizabeth, W. 3rd, Cat Hill, and Black Gum.
    - A couple said that we should not allow storm water to drain into our canals.
    - A couple talked about back bay flooding onto the roads and property.
    - A few talked about low areas of their property being flooded.

3. **Maintain Dredged Canals Future Need** – This future need scored 4.22, putting it solidly in the "Needed" category. There were 18 written comments.
    - 7 indicated that more dredging was needed.
    - One said to do nothing.
    - Five talked about cleaning up algae, debris and sludge.
    - One said Little Bay had to be dredged.
    - One said that the basin at the east end of Anchorage needed to be cleaned up.
    - One said that we needed a Tidal Pump

4. **<u>Aerators in Canals Future Need</u>** – This future need scored 3.45, putting it right on the line between the "Needed" and "Not Needed" category. There were 47 written comments.
   - 21 indicated that they did not understand the issues or needed more data to make a decision.
   - 8 said that aerators were needed.
   - 8 said that they cost too much.
   - One person asked about Ocean Pines experience.
   - 5 said that those who live on the canals should pay for them.
   - 3 said that we should try it in one canal and see how it works.
   - 6 said that we needed a Tidal Pump or wanted to know the status of the Tidal Pump.

D. CANAL WATER QUALITY COMMITTEE RESPONSE TO SURVEY RESULTS

1. **<u>Recommended Actions that the Town Should Take</u>**
   - **Programs that are working and that should be maintained**:
     - Continue to control stormwater along South Bethany streets as recommended in the 1995 GMB report so that flooding is minimized while also allowing some time for the stormwater to be absorbed by the ground.
     - Continue to implement recommendations from the 2010 Anchorage Canal Drainage Area Study like the median project currently under construction.
     - Continue to conduct the water quality monitoring program.
     - Continue and expand the oyster gardening program through the Center for Inland Bays (CIB).
     - Continue the education program to inform homeowners of water quality initiatives and to supply them with information as to how they can help to improve the quality of water in the South Bethany canals.
   - **Programs that will be initiated to decrease the amount of algae, debris, sludge, trash, etc. that accumulates in the South Bethany canals:**
     - Submit to the Budget & Finance Committee a line item of $21,000 to permit, procure and install a diffuser system in the east-west portion of the Anchorage Canal as a pilot project for two years to improve the water quality in that canal and to determine the actual improvement in water quality that results from the diffusers. Also included would be a line item of $2,300 per year for the operation and maintenance of the pilot system.
     - Submit to the Budget & Finance Committee a line item of $12,000 for the implementation of a study to determine potential retrofits to improve stormwater management (maintain existing flooding control while also minimizing canal pollution) particularly along the east side of Route 1 and any other areas that contribute significant volumes of stormwater into the South Bethany canals with no consideration for water quality issues.

- Communicate more often with DNREC at http://www.dnrec.state.de.us/macroalgae/contact and at Ariane.Nichols@state.de.us to request the microalgae harvester to harvest algae from the South Bethany canals.
- Look into developing an "Adopt a Canal" program that would involve homeowners with boats to adopt a canal that they will keep clean of trash and debris. Encourage recreational users of the canals to remove any trash that they may encounter. The emphasis here is on trash, not algae or scum.

- Recommend to the Budget & Finance Committee a line item for dredging our canals as a capital depreciation item with a book value of $300,000 with a yearly assessment of about $15,000 to be held in reserve for dredging the canals as may be required at a future date. Currently the canals are dredged to at least 3 feet at mean low tide.
- Programs that will be initiated to decrease the amount of "large puddles" or "flooding" or "too much standing water":

I. Due to lack of adequate control of stormwater runoff along South Bethany's streets:
   - Observations after hurricane Irene indicate that there were minimal issues relative to adequate control of stormwater. The 'flooding" was due to private property grading issues and to the extremely high tide that back flooded storm drains and overflowed bulkheads.
   - Document locations of all stormwater drains in South Bethany and document to make sure that they are not plugged up and that they were installed with perforated pipes per the recommendations in the 1995 GMB report so that flooding is minimized while also allowing some time for the stormwater to be absorbed by the ground.
   - Request inputs from homeowners to identify specific areas where there are problems.

II. Due to improper grading of private properties within South Bethany:
   - Encourage homeowners to grade their properties toward the property lines so that stormwater will flow towards the street as required by Town Code Section § 104-11, Grading and Drainage.
   - Encourage homeowners to fill low areas on the properties or convert the low areas into rain gardens.

III. Due to tidal flooding:
   - Consider adding check valves to stormwater management drains that would keep high canal tides from back flowing that floods streets such as Layton, New Castle and Carlisle.
   - Provide a contour map and bulkhead heights for South Bethany so that homeowners understand the elevation of South Bethany and of their properties within South Bethany. (See pages 11 & 12 of this report)
   - Accept the fact that the tides cannot be held back. The only solution would be to raise the roads and properties in low areas. This is not a recommendation at this time.

2. **Recommended Actions That Homeowners Should Take**
   - Voluntary disconnection of all piping that dumps water (rain water, sump pump water, washing machine water, outdoor shower water, etc.) into the canals even if they are grandfathered in under the current ordinances.
   - Refrain from installing impervious surfaces (patios, driveways, decks, etc.) even if they are allowed under current ordinances.
   - Minimize or eliminate use of fertilizer by planting native vegetation. Consider fertilizer with reduced amounts of nitrogen and phosphorous. Native plants need no fertilizers vs. planting turf grass which needs fertilizer.
   - Do not let any trash such as trash cans, plastic bags, lumber, yard waste, fertilizer, detergents, solvents, boat fuel, paint, animal waste, weed killer, pesticides, antifreeze, brake fluid, etc. enter the canals.
   - Communicate more often with DNREC at http://www.dnrec.state.de.us/macroalgae/contact and with Ariane.Nichols@state.de.us to request the microalgae harvester to harvest algae from the South Bethany canals. The more e-mails they get the more likely the harvester will arrive.
   - Consider adopting a canal to keep it free from trash.
   - Consider becoming an oyster gardener.

E. RATIONALE FOR RESPONSE

1. **Studies conducted over the past 20 years relative to canal water quality:**
   a) 6-27-1990 – 25 locations sampled. Lowest dissolved oxygen measurement was 6.1 mg/L. Salinity was 14 ppt and the highest enterococcus level was 103 colony forming units/100mL. This was really not too bad when compared to the measurements that are currently being recorded by the citizen monitoring volunteers. The lowest DO measured was 6.1mg/L in 1990. This is not close to 4.0 mg/L that would cause stress to fish. In 2011, occasionally, we are seeing readings at canal ends close to zero mg/L.
   b) February, 1995 – *Stormwater Management Plan Best Management Practice Alternatives* report issued by George, Miles & Buhr (GMB) Architects & Engineers. Report describes ways that homeowners and the Town can manage stormwater so as to minimize flooding while also minimizing the impact to the canals due to stormwater runoff.
   c) 1-17-1996 – *South Bethany Canal Survey Report of Results*, 1995 by Renee J. Karrh. 13 sites were monitored. The lowest average dissolved oxygen was 2.73 mg/L at the end of the highway canal near the Bay Shore Canal. Nutrients were very high at the east end of both the Anchorage and Petherton Canals and at the Bay Shore Canal.
   d) *1996 South Bethany Bacteria Lagoon Water Quality/Rainfall Study* by Jack Pingree. There is a weak correlation between enterococcus level and rainfall. High enterococcus levels (>3,000 colony forming units/100mL) were recorded at the east and west end of Anchorage and Petherton. The highest levels were at the east ends.
   e) November, 2000 – *The Evaluation of Aeration as a Method for Improving the Ecological Condition of Dead End Canals* – Year 1 by Robert W. Scarborough. The aerator used was actually a horizontally

placed fountain. It did eliminate stratification for about 600 feet of canal but did not significantly increase dissolved oxygen.

f) February, 2002 – *The Evaluation of Aeration as a Method for Improving the Ecological Condition of Dead End Canals* – Year 2 by Robert W. Scarborough. The aerator used was actually a horizontally placed fountain. It did eliminate stratification for about 600 feet of canal but did not significantly increase dissolved oxygen.

g) January, 2001 – *Volume and Characteristics of Collected Stormwater Discharges into the Loop Section of the Anchorage Canal, South Bethany*, Delaware by Martin, Farrell, and Balascio. A ½ inch rainfall causes about 50,000 cubic feet of rainwater to enter the east end of the Anchorage Canal. This rainwater carried significant amounts of nutrients that support excessive algae growth into the canal. The first flush (the first 1,000 cubic feet) carried in excess of 100,000 colony forming units of total coliforms/100mL and 10,000 colony forming units of fecal coliforms/100mL.

h) August 2001 - Entrix completed a report, *Hydrodynamic and Water Quality Modeling and Feasibility Analysis of Indian River, Rehoboth Bay, and Little Assawoman Bay* for DNREC. They concluded that flushing would have a positive impact on water quality, yet it would cost 50 to 100 million dollars to complete the recommended project. For the Little Assawoman Bay the flushing would be accomplished by creating an inlet at the narrows between Little Bay and the Little Assawoman Bay.

i) November, 2003 – *Tidal Pump – Improved Water Quality through Innovation* by Lloyd D. Hughes. Detailed the concept of how the Tidal Pump would work.

j) August, 2005 – *Evaluation of the Stormwater Sediment Control Forebay at Anchorage Canal, South Bethany, DE* by Scarborough and Mesinger. The sediment control forebay installed by DelDOT in early 2004 is about 30% efficient due to the small size and minimal retention time of the forebay.

k) September, 2005 – *South Bethany Canals Flushing Study – Proposed Tidal Pump System Residence Time Analysis* by Mike Fichera of Entrix, Inc. Showed that the Tidal Pump would reduce residence times in the South Bethany Canals from over 120 days to just a few days. Report cost $17,000.

l) May, 2007 – *South Bethany Canals Tidal Pump System Preliminary Engineering Study* by Oceaneering and KCI Technologies. Showed that the tidal pump would work. Showed where improvement could be made to the initial concept. Determined that the cost would be about 7 million dollars and that it would take about two years for design and construction. The study cost the Town of South Bethany $50,000.

m) July 17, 2008 – *Tidal Pump – Town of South Bethany Joint Processing (JPP) Meeting* Presentation to JPP Committee. The South Bethany Tidal Pump Committee met with the Joint Permit Processing Committee. The Committee shared their concerns, specifically focusing on the uniqueness of the project and the potential ecological impact. They stated that we would need a consultant to lead our efforts through the permitting process and that we would probably need to complete additional studies. They felt that the permitting process would be long – at least 12-24 months, if not longer. They felt that the benefits would be concentrated only in South Bethany and would have little impact on the Inland Bays.

n) January, 2010 – Grant Proposal for The Evaluation of Diffusers as a Method for Improving the Ecological Condition of Dead-End Canals submitted by SBPOA to the Financial Assistance Branch, Division of Water Resources Department of Natural Resources and Environmental Control. The SBPOA proposal was not selected.

o) June, 2010 – *Conceptual Pollution and Stormwater Control Strategy for the Anchorage Canal Drainage Area* by the Center for Watershed Protection and JMT. Presents 25 potential retrofits (conceptual designs and budgetary costs) that would minimize nutrient loading into the Anchorage Canal while also

controlling floodwater caused by rainfall. This was funded by a grant that South Bethany was instrumental in getting from the US Army Corps of Engineers. The grant plus matching funds amounted to about $72,000.

p) 2007 to the present – South Bethany Citizen Monitoring of 10 sites along the canals – The results show that the further the monitoring site is from Snap Gut the lower the water quality is at the site.

2. <u>Actions resulting from studies:</u>

a) 1995 – The Town of South Bethany began implementing the recommendation in the GMB Engineering report as to how to eliminate flooding along roads by piping the water to the canal by using a "French Drain" in order to minimize the pollution entering the canals.

b) Fall 2002 – Lloyd Hughes begins design of the Tidal Pump System.

c) April, 2004 – DelDOT installs the sediment forebay at the east end of the Anchorage Canal.

d) Spring 2006 – Al Allenspach leads the South Bethany Oyster Gardening Program.

e) June, 2007 – Town of South Bethany forms the current Water Quality Committee that reports to the council once a month at the Town Council Meeting.

f) Summer 2007 – Town of South Bethany forms the Tidal Pump committee to investigate the feasibility of implementing the Tidal Pump.

g) Spring 2009 – Tidal Pump Committee disbanded due to lack of interest from the DNREC technical community and the 7 million dollar cost of the program. All data developed has been retained for future use.

h) May 8, 2009 – Ordinance (Town Code Section § 104-11. Grading and drainage) passed to prohibit rain gutters and down spouts from directing runoff water straight into the canals. The ordinance also prohibits outside showers to drain closer than 10 feet from a canal or body of water.

i) May 14, 2010 – Ordinance (Town Code Section § 145-14.3. Ground covering allowed in setback area) passed to require that at least 55% of the setback area to be covered with pervious material.

j) Spring 2010 – Chris Bason from the CIB awarded a grant from the DNREC to implement some of the recommendations made in the *Conceptual Pollution and Stormwater Control Strategy for the Anchorage Canal Drainage Area* report along the east side of South Pennsylvania Ave. in front of Sea Colony. This retrofit is projected to remove about 10% of the nutrients identified by all the retrofits in the above report.

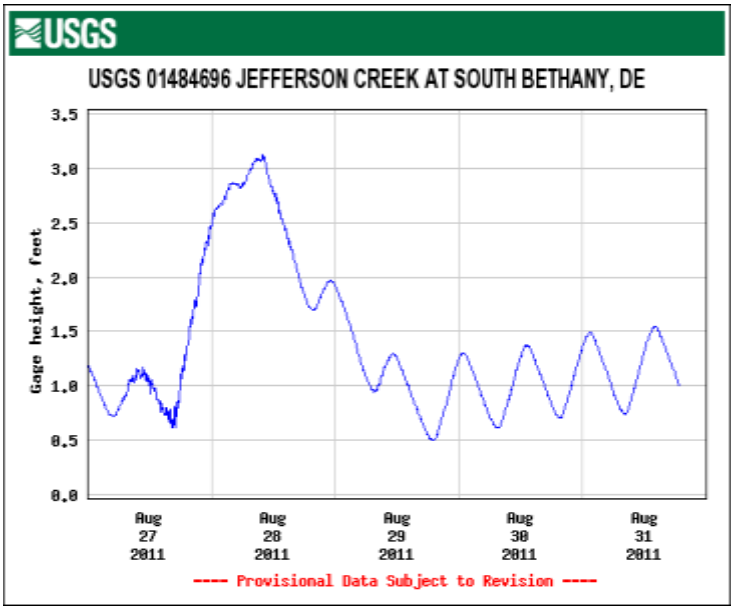
k) Summer 2011 – In process – Chris Bason from the CIB awarded a grant from the DNREC to implement some of the recommendations made in the *Conceptual Pollution and Stormwater Control Strategy for the Anchorage Canal Drainage Area* report in the Route 1 median from Sea Colony through Middlesex and into South Bethany. These retrofits are projected to eliminate about 6% of the nitrogen and 12% of the phosphorous nutrients identified in the above report. Chris has extended the retrofit to include all of the medians in South Bethany. This will remove about the same amount of nutrients as the part that goes through Middlesex. The project cost is about $92,000 including the grant, funds from the CIB and matching funds.

3. Observations of the "flooding" and "puddles" left by Hurricane Irene.

We had about 5 inches of rain and the canal tide level rose to 3.12 feet NGVD on Sunday at about noon. The cause for "flooding" and "puddles" can be attributed to three potential sources: high tide, poor property grading and poor stormwater management along the town streets. As will be seen later little flooding was caused by poor stormwater management.

a) The high tide level caused a flooding problem in low lying areas of South Bethany. The maximum tide was 3.12 feet at about 11 am EST on Sunday, August 28, 2011.

- The first picture below shows Layton Dr. The canal water rose and back flowed out of the storm drains into the streets. The picture was taken at about 1:30 pm EST when the tide level was about 2.55 feet.
- The second picture is of Carlisle Rd. at about 1:45 pm EST. Here the bulkheads are not as high as the tide was. There is also a storm drain that back flows when the tide is about 2.5 feet NGVD.
- These are just samples of roads that were flooded by the high tide. They were not flooded by a failure to adequately provide drainage for the rain water. The flooding left when the tide receded.
- There is a Tide Gage located at the end of West 1st Street that records the tide every 6 minutes. This data is accessible at http://waterdata.usgs.gov/nwis/uv?01484696. Data from the hurricane time frame is shown below.



It is not surprising that there was flooding when about 50% of South Bethany has an elevation of less than 5.80 feet NGVD (National Geodetic Vertical Datum 1929) and the maximum tide in the canals was 3.12 feet NGVD. The area in white below is less than 5.80 feet NGVD.

Many bulkheads have an elevation that is less than 3.12 feet NGVD and thus were overflowed on August 28, 2011 due to Irene. On September 19, 2003 South Bethany experienced its highest measured canal tide of 3.52 feet NGVD. The tables below show some of the bulkheads that overflowed.

Canal End	Elevation of Bulkhead (feet NGVD)	Flood over Bulkhead on 8/28/2011 (feet)	Flood over Bulkhead on 9/19/2003 (feet)
W. 2nd	2.86	0.26	0.66
W. 3rd	2.77	0.35	0.75
W. 4th	3.02	0.10	0.50
W. 5th	3.61	-0.49	-0.09
W. 6th	3.11	0.01	0.41
W. 7th	3.19	-0.07	0.33
W. 8th	3.61	-0.49	-0.09
W. 9th	3.86	-0.74	-0.34
W. Russell	3.36	-0.24	0.16
E. Russell	4.00	-0.88	-0.48
W. 10th	4.00	-0.88	-0.48
W. 11th	3.92	-0.80	-0.40
Anchorage	3.42	-0.30	0.10
Petherton	4.19	-1.07	-0.67
Brandywine	3.36	-0.24	0.16
S. Bayshore	3.19	-0.07	0.33
York	2.52	0.60	1.00
Rebeca	3.94	-0.82	-0.42
Kimberly	2.69	0.43	0.83
Victoria	2.86	0.26	0.66
Bristol	2.69	0.43	0.83
Boone	4.02	-0.90	-0.50
N. Highway	2.78	0.34	0.74
W. May	3.04	0.08	0.48
E. May	3.52	-0.40	0.00
Layton	2.71	0.41	0.81
Henlopen			

Street End	Elevation of Bulkhead (feet NGVD)	Flood over Bulkhead on 8/28/2011 (feet)	Flood over Bulkhead on 9/19/2003 (feet)
Plymouth			
Bristol			
Victotia			
Kimberly			
Rebecca	3.46	-0.34	0.06
W. Bayshore	2.88	0.24	0.64
Layton	2.72	0.40	0.80
New Castle	3.08	0.04	0.44
Henlopen	3.34	-0.22	0.18
Brandywine	3.66	-0.54	-0.14
Petherton	4.43	-1.31	-0.91
Sussex			
Kent			
Godwin	3.19	-0.07	0.33
107 Godwin	2.86	0.26	0.66
W. Anchorage	3.58	-0.46	-0.06
W. 11th	4.50	-1.38	-0.98
W. 10th	4.51	-1.39	-0.99
W. 9th	3.28	-0.16	0.24
W. 8th	4.13	-1.01	-0.61
W. 7th	4.06	-0.94	-0.54
W. 6th	3.60	-0.48	-0.08
W. 5th	3.68	-0.56	-0.16
W. 4th	3.69	-0.57	-0.17
W. 3th	3.61	-0.49	-0.09
W. 2th	2.78	0.34	0.74
W. 1th	2.79	0.33	0.73

A homeowner is able to determine the height of their bulkhead by measuring the height of their bulkhead from the water level and then going to http://waterdata.usgs.gov/nwis/uv?01484696 to find the height of the water at the time they made the measurement, remembering that the time on the website is Eastern Standard Time (EST). Then they add their measurement to the tide level to determine their bulkhead height relative to the National Geodetic Vertical Datum (NGVD 1929).

b) Grading on some properties caused a flooding problem

- The pictures below show one such property. The first picture was taken on Sunday afternoon. The second picture was taken Tuesday afternoon and shows that the flooding has been absorbed into the ground and is significantly reduced.
- A second example of low property is shown next. Here is a driveway that is significantly lower than the surrounding property. Picture taken Sunday afternoon. The picture to the right of it was taken Monday afternoon.
- If property is graded so that there is a slope from the house to the property line then stormwater will run along the property line towards the road. The next picture shows that there is little water accumulated on a property that is graded correctly. The first picture was also taken Sunday afternoon. On Tuesday the puddled water was almost completely gone as can be seen in the second picture.
- These are just samples of property that is graded incorrectly, thus causing "puddles," vs. property that is graded correctly.
- Town Code Section § 104-11. Grading and Drainage describes the proper way to grade.

c) Town storm drains did not cause a significant flooding issue

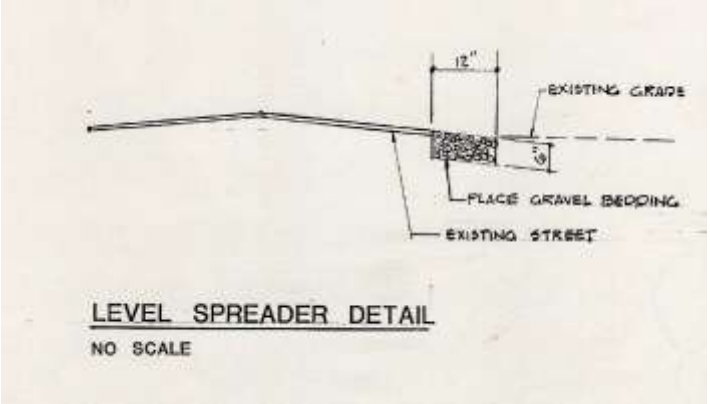
- The first set of pictures below probably shows the worst case. The first picture was on Sunday afternoon. One day later on Monday afternoon the "puddle" was gone.
- There were numerous examples of puddles along the streets Sunday afternoon, about 12 hours after the rain stopped. Two typical samples are shown below, taken Sunday afternoon.
- On Tuesday it was very hard to find puddles along the side of the streets. The worst two are shown below.

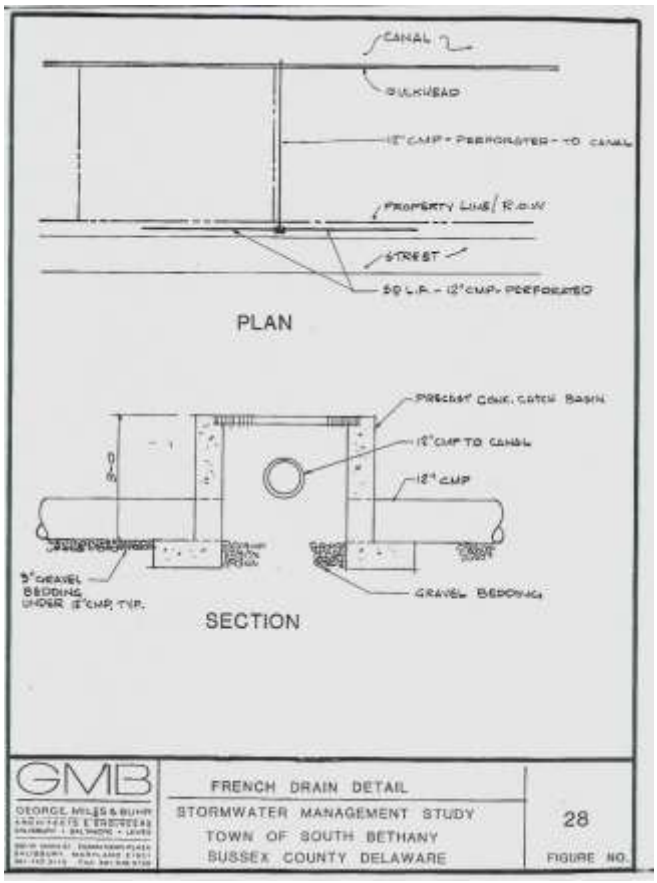
4. **<u>Water Quality Committee's philosophy relative to stormwater management</u>**

- The best situation is for stormwater to go directly into the ground to keep nutrients that are carried by the stormwater from entering the canals.
- Impervious surfaces cause the biggest problem to managing stormwater and should be minimized.
- House roofs, Town streets, Route 1 and homeowners' patios and driveways are examples of impervious surfaces.
- The ordinance that currently minimizes impervious surfaces is a good start; however it "grandfathered" existing impervious ground covers that would be in violation of the new ordinance.
- The ordinance that restricts stormwater from roofs from flowing directly into the canal is a good start; however it "grandfathered" existing systems that would be in violation of the new ordinance.
- Since development brings impervious surfaces, stormwater must now be managed.
- Since there is almost no circulation in the dead end canals (Residence time greater than 120 days, see page 17), the canal ends act as stormwater management ponds. From Wikipedia, the free encyclopedia, "Stormwater management ponds collect and retain urban stormwater." These are the functions that the South Bethany canals provide relative to stormwater management. While collecting and retaining the stormwater the canals also collect and retain all the nutrients and pollutants that are carried by the stormwater.
- The primary goal of stormwater management in the past was to get rid of the water into the canals as fast as possible so as to eliminate flooding and puddles.
- From a development point of view this "non-flooding" goal must still be maintained; however from a water quality point of view there is an equally important goal which is to minimize the amount of nutrients and other pollution that enter the canals with the stormwater.
- From a water quality point of view the stormwater must be slowed down so that there is a chance for sediment, nutrients and other pollution to be settled out and captured.
- In 1990 laws were enacted that required new development to have stormwater management facilities that minimize the sediment, nutrients and other pollutants from entering rivers, lakes, canals, etc. Examples of these facilities are:
    - Stormwater management ponds with aeration to control the water quality.
    - Bioretention ponds that capture stormwater to allow time for the ground to absorb it.
    - Rain gardens
    - Forebays similar to the one at Anchorage Canal
    - Sand Filters
- These laws do not apply to South Bethany since it was developed prior to 1990. Thus in order for South Bethany to improve water quality, retrofits are required.
- Two studies listed in section E.1. describe what the Town and homeowners should do to improve water quality.
    - *Stormwater Management Plan Best Management Practice Alternatives* report issued by George, Miles & Buhr Architects (GMB) & Engineers, 1995.

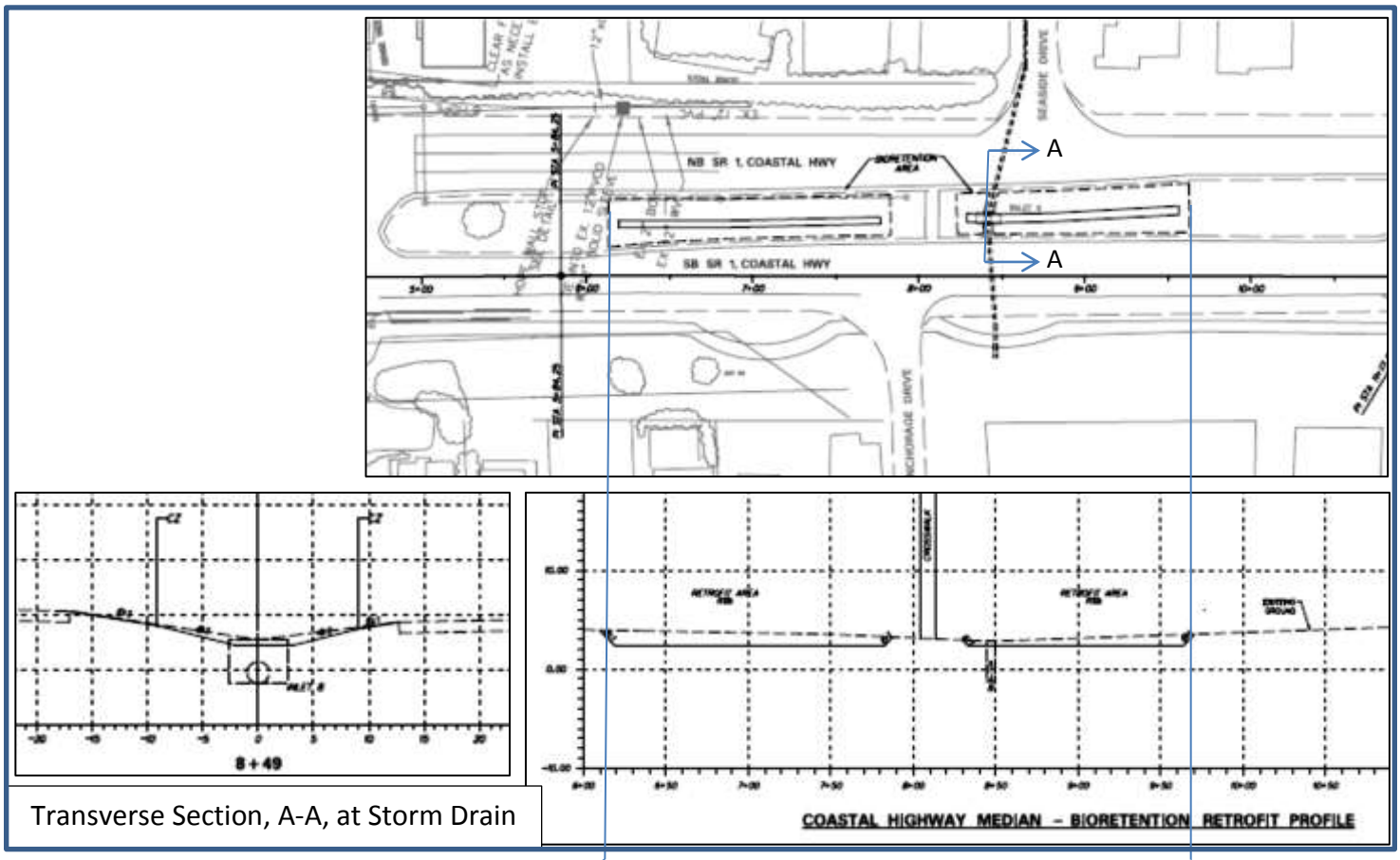
- *Conceptual Pollution and Stormwater Control Strategy for the Anchorage Canal Drainage Area* by the Center for Watershed Protection and JMT, 2010.

- One example (shown to the right and below) from the GMB report shows what the town is currently doing to minimize flooding along the sides of streets while also allowing some time for the stormwater to be absorbed by the ground.



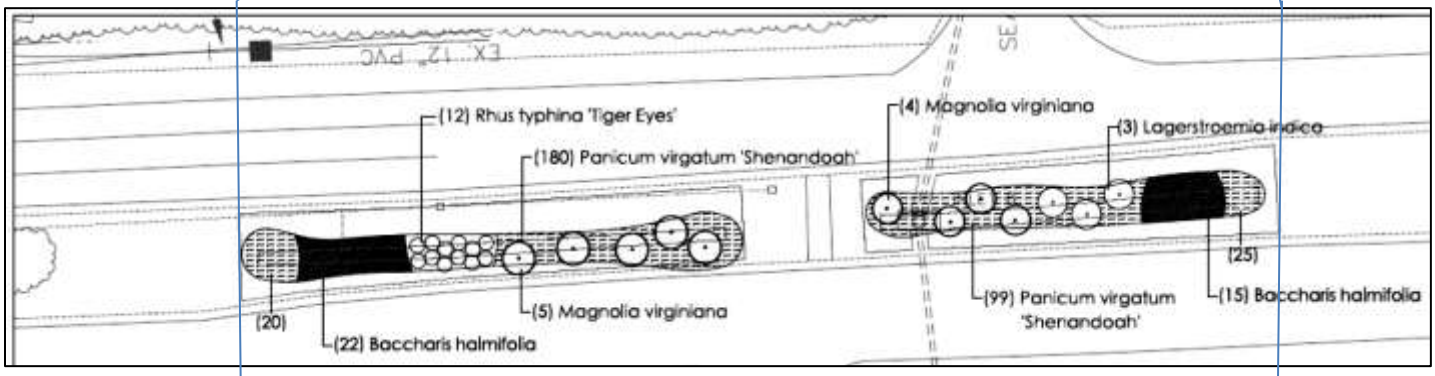


- An example from the 2010 report is the project currently being executed in the Route 1 median. The excavation plans and the planting plans for the median at Anchorage Drive are shown on the next page. The project involves excavating the median to create Bioretention areas or rain gardens so that the "first flush" of stormwater is captured and allowed to settle into the ground. These Bioretention areas are planted with numerous native trees and other indigenous shrubs and herbaceous plants that will help improve stormwater management and introduce regionally appropriate trees and plants with enough diversity to avoid a monoculture while beautifying the Route 1 median. By keeping the stormwater drains at their current elevations there is no change in the flooding potential. Lowering the ground surface a few inches below the drain elevation allows for the collection of the "first flush." If there is more rain than this basin holds, it then overflows into the storm drain that carries the overflow to the canals. It is expected that 48 hours after a rain event there will be minimal standing water in the Bioretention area.



Transverse Section, A-A, at Storm Drain

Typical Excavation Plans



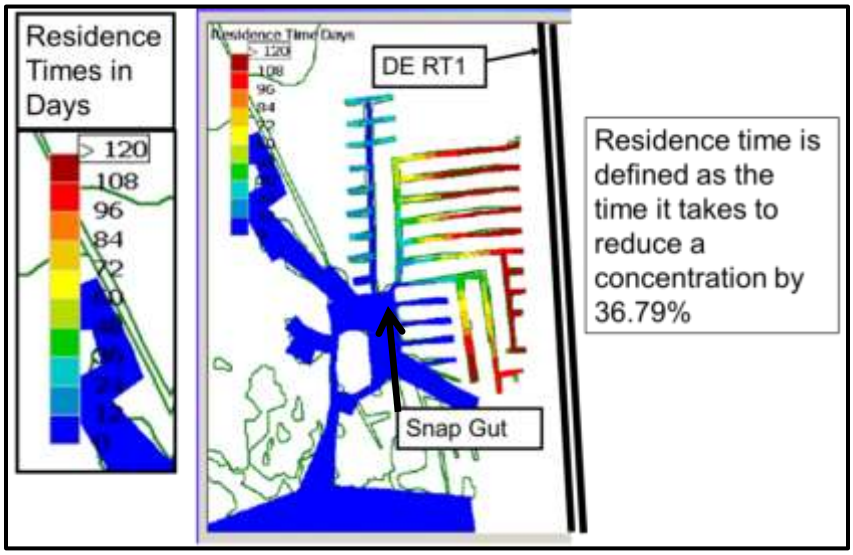
Typical Planting Plans

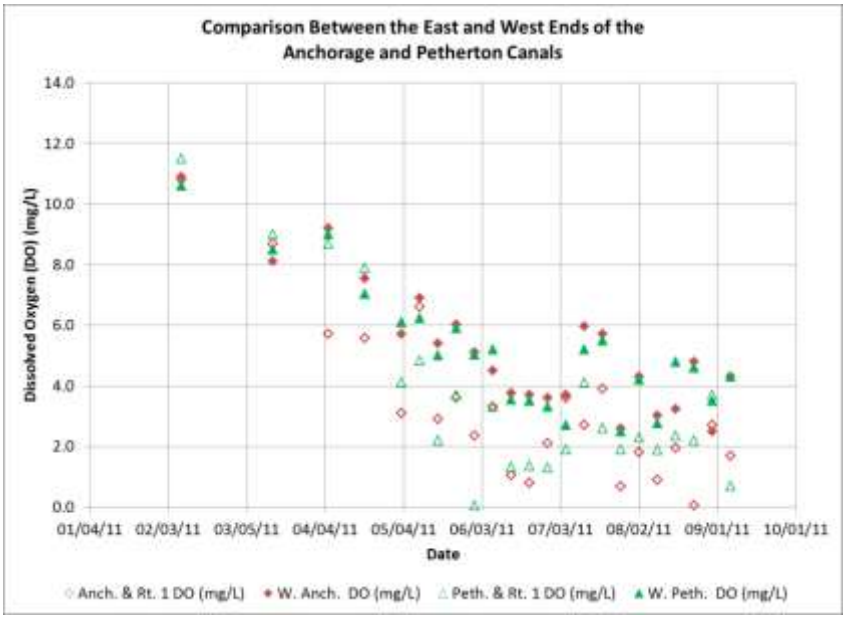
5. Information relative to diffusers/aerators

a) Why Something is Needed to Improve Water Quality in South Bethany Canals

Background

- Canal water quality has degraded over the last 50 years. Development and impervious surfaces have caused the degradation. See pictures on the right.
- Currently during the summer dissolved oxygen (DO) near the ends of the dead end canals is at a level that does not support a mature fish habitat.
- Currently bacterial levels do not support a safe swimming environment.
- The Entrix Analysis Report (See Section E.1.) shows that the canals act as "stormwater management ponds" with minimal circulation. The areas in red in the chart to the right are where the worst water quality is. This is due to the fact that there is minimal exchange of water with the Little Assawoman Bay. What goes into the dead ends of the canals (red areas shown in chart) stays in the canals for 120 days or more.
- Water quality monitoring shows (see chart at right) that dissolve oxygen is significantly lower at the east end of the canals (where the above chart shows red; very, very high residence times) as compared to the west end.

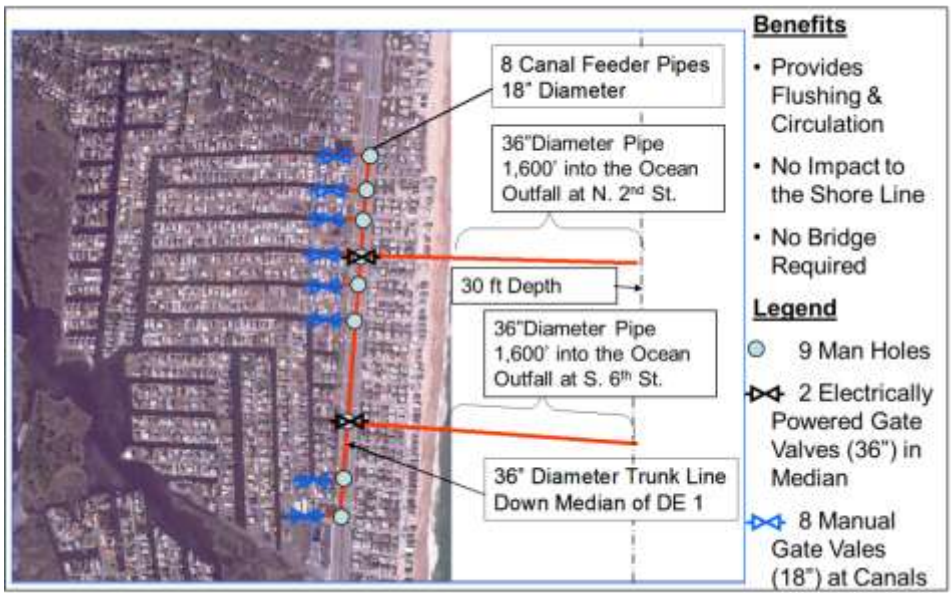




Two potential solutions have been investigated

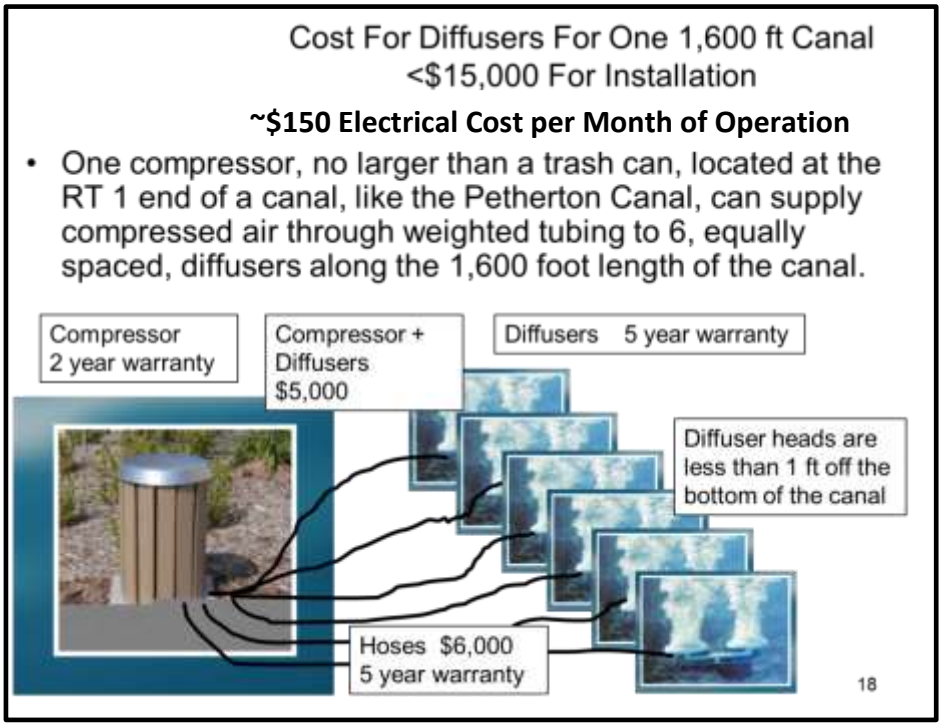
1. Tidal Pump

The Tidal Pump is thought to be the best hydraulic solution found so far for cleaning up the water quality in the canals. However it costs about $7 million to design and construct and so far the Town has not been able to get support for it because the benefit is mostly for South Bethany and not the Inland Bays.



2. Diffusers/Aeration

It is expected that a diffuser system would increase the dissolved oxygen in the east ends of the dead end canals so that it is closer to what exists in the west ends. (See the chart above which compares the east and west ends of the Anchorage and Petherton Canals.) It is also expected that there will be less microalgae in the canals that have a diffuser system.



b) Information from users relative to diffusers/aerators

3. Allan Garnaas - Villas at Bethany West Across from Wawa on the North side of 26
    - They have 3 diffusers in one tidal pond that is about 8 feet, maximum depth.
    - Diffusers in place for more than 15 months.
    - They had fountains before that did not do the job.
    - Diffusers are better than fountains – Less cost and more efficient. Here efficiency means the amount of oxygen that is supplied to the water per aerator horsepower. Diffusers get more oxygen into the water. They circulate the water from the bottom to the surface. They reduce the amount of "muck" on the bottom. See pictures on page 21. Fountains cannot make this claim.
    - Diffusers do what they are publicized to do – Improve water quality.
    - Envirotech is an excellent vendor.
4. Allan Garnaas - His home community in Alexandria, VA.
    - Diffusers in place for more than 22 years.
    - Diffusers do what they are publicized to do – Improve water quality.
5. Barry Mones - The Refuge on the north side of Route 54
    - They have at least two ponds, one is salt water and the deepest is 18 feet, maximum depth.
    - Diffusers in place for more than 5 years.
    - Diffusers are better than fountains – Less cost and more efficient.
    - Diffusers do what they are publicized to do – Improve water quality.
    - Envirotech is an excellent vendor.
6. Greg Ferese - The City of Rehoboth
    - They have at least one pond that is less than 10 feet deep.
    - Diffusers in place for more than 7 years.
    - Diffusers are better than fountains – Less cost and more efficient.
    - Diffusers do what they are publicized to do – Improve water quality. Before the diffusers they had fish kills, odor and algae.
    - Envirotech is an excellent vendor.
7. John Buono – Southampton Community on Beaver Dam Rd. just off of Muddy Creek Rd.
    - They have 5 ponds with diffusers in them and two ponds with fountains.
    - Their ponds are 2 to 6 feet deep.
    - The fountains were selected for aesthetic reasons and have been problematic.
    - Diffusers are better than fountains – Less cost and more efficient.
    - Diffusers do what they are publicized to do – Improve water quality. They did improve water quality. If they go off line people quickly see degraded water, more algae forming and more odors. Homeowners are quick to call management when the water degrades if a diffuser shuts off.

- Envirotech is an excellent vendor.
- To the right is the Southampton Community off of Beaver Dam Rd. Water quality is maintained in 5 of their ponds by using diffusers. Maintaining water quality means that the dissolve oxygen when measured early in the morning is higher than 4.0 mg/L. It means that algae on the surface is visually less than when the diffusers are not running. It means that there are no offensive odors coming from the pond.

c) Information from Vendor Web sites Relative to Diffusers/Aerators

From Organic Pond – Why Does Pond Aeration Work?

Aeration naturally restores the health of a pond by introducing oxygen and circulation to the entire water column. Stagnation is replaced by a column of bubbles capturing oxygen at the surface and allowing an exchange of toxic gases for oxygen. A convection current is generated, bringing oxygen to the lower layers. Naturally occurring aerobic bacteria are energized by the introduction of oxygen and a natural biological cleaning process begins to reduce the muck layer and subsequent plant and algae growth. Studies have demonstrated a doubling of water clarity, muck reduction measured in inches per season and healthy dissolved oxygen levels at all water depths.

Before pond and lake aeration many of our customers experienced:

- *Low dissolved oxygen levels*
- *Stagnation*
- *Poor circulation*
- *Thermal & Oxygen stratification*
- *Excess plant growth*
- *Noxious odors*
- *Frequent algae blooms*
- *Fish Kills*

The Pond Guy Airmax Aeration System. Please click on the link below to view the video at
http://www.thepondguy.com/video_step1

Features and Benefits Aqua Control 4 Diffuser Shallow Pond Aeration System **Includes:**

- Increases oxygen levels in pond which reduces fish stress.
- Increases the breakdown of fish waste by providing the habitat for beneficial pond bacteria to flourish.
- When operated continuously in freezing climates, these pumps will keep open areas in the ice to allow toxic gases to escape and sunlight to enter.

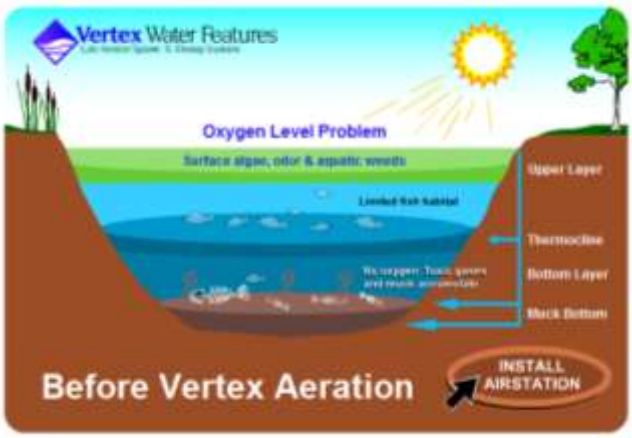
- These pumps degas a pond by lifting harmful gases such as hydrogen sulfide and carbon dioxide to the surface, and then replacing them with oxygen.
- Compressors pump high volumes of air at low pressure.
- Promotes a healthy ecosystem and larger fish by eliminating oxygen highs and lows and creating equal water temperatures from top to bottom.
- Operate in water bodies less than 6' deep.
- 3 – year warranty (not including diaphragm or filter).

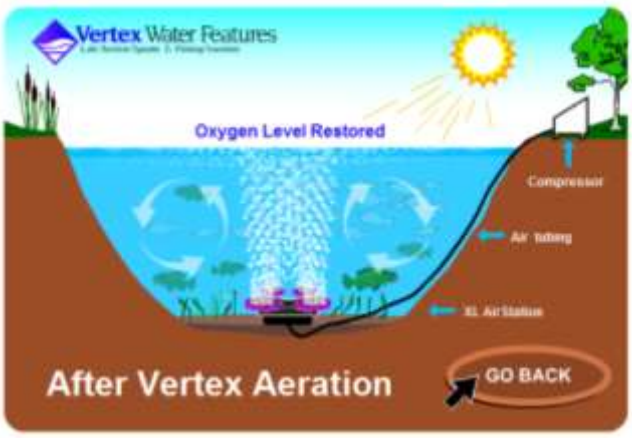
Advantages of AquAir® Diffuser System over fountain aerators:

- Mixes water in entire pond.
- Moves large volumes of water.
- Reduces some nutrients used by most algae.
- Oxygenates entire pond. Allows aerobic bacteria to quickly decompose bottom muck.
- Improves overall pond health and allows for a natural balance to return.

Vertex Bottom Diffuser Systems
The solution for problem waterways!

- During the summer months, when water is warm, oxygen can be consumed faster than it can be replenished. Lakes can become "stratified"; the warmer, oxygen-rich upper water laying on top of the cool, more dense, lower-oxygen deeper water.
- Such conditions inhibit levels of beneficial bacteria and their breakdown of organics. Bottom muck accumulation increases and excessive nutrients are readily available for plant/algae growth. This thermal stratification also makes conditions favorable for the production of noxious ammonia and hydrogen sulfide gases.
- Vertex bottom aeration systems create a vertical current using the rising force of millions of small bubbles to entrain the water column, "turning the lake over" and allowing oxygen to be absorbed at the lake's surface.
- By moving the lower-oxygen water up from the bottom and eliminating thermal stratification, oxygen levels throughout the water column are increased. Wide swings in oxygen are stabilized, preventing fish kills. Our systems also improve sport fisheries by allowing fish to expand their territory into formerly oxygen-deprived portions of the lake.
- Please click on the link, http://www.vertexwaterfeatures.com/aeration_system_flash.php, to see the demonstration shown below. A stagnate, stratified, low DO pond is rejuvenated by a diffuser that adds oxygen while eliminating the stratification by moving the water as shown below.





AquaAir™ System Features

- Entire water column circulation up to 4000 gpm depending on diffuser depth
- Elimination of thermal stratification
- Increased dissolved oxygen levels that help to stimulate the natural aerobic digestion process and decrease algae growth.
- Elimination of oxygen related fish kills and expansion of the oxygenated habitat and ecosystem.
- Reduction of mosquito and other aquatic midge infestations
- Elimination of mosquito and other aquatic midge infestations
- Elimination of foul odors from undesirable dissolved gases
- Reduction of organic bottom sediment

Vertex Water Features
Lake Aeration Systems & Floating Fountains

Aerators Case Study: Heron Cay

Placing Vertex AirStation™ into Heron Cay's lake.

Increased Oxygen to Promote Stratification Reduction

Heron Cay, a high-end gated residential development in South Florida, was experiencing a number of problems in their 21-acre lake which is central to the community.

With maximum water depths of over 20 feet, stratification had resulted in a lake with severely low oxygen levels at the bottom. Having no beneficial bacteria to break down organics, heavy muck accumulation and foul odors from hydrogen sulfide gases were present. The lake was consuming what little available oxygen there was faster than it could be replenished, and excessive nutrient levels from fertilizer runoff only made conditions worse. The lake's Biochemical Oxygen Demand (BOD) was extremely high.

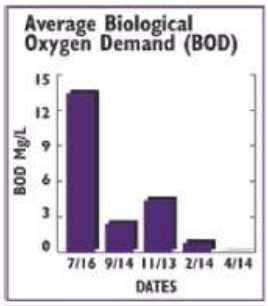
With the brunt of summer approaching, Heron Cay had a very real potential for a serious fish kill. Action needed to be taken, so the residents looked to Vertex to provide them with an efficient and cost effective method of bringing their lake system back to a healthy state.

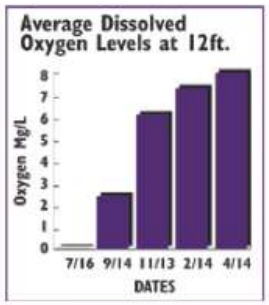
Results

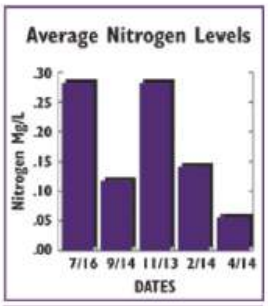
After the design and installation of a Vertex aeration system consisting of 11 diffuser stations being fed by compressors totaling only 2-1/4 horsepower, Heron Cay was set up on a monitoring schedule to determine how lake dynamics were being affected. The results over the four month monitoring period were dramatic. Within days of initial start-up, the systems main objectives were beginning to be realized:

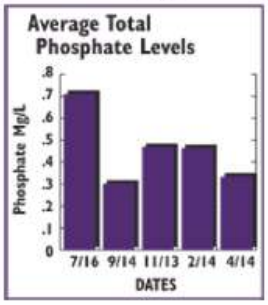
- The breakdown of temperature and oxygen stratification - the lake's water was being circulated.
- Increased oxygen levels throughout the entire water column - creating a healthy environment for both fish population and beneficial bacteria.
- Decreased the lake's Biochemical Oxygen Demand (BOD) - oxygen was no longer being consumed faster than it was being replenished.
- The residents of Heron Cay are no longer in danger of oxygen-related fish kills, odors have been
- eliminated and the lake is returning to natural, healthy conditions.

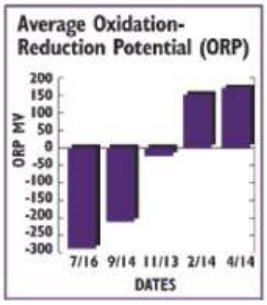
Gathering water samples. The lake was regularly monitored to determine water quality.

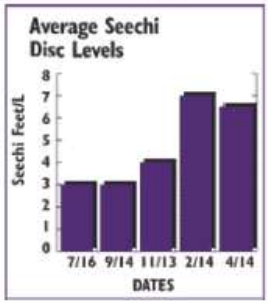












"I've never seen the lake look better"

- Mark Sanderson, President, Heron Cay HOA

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