Lake Report 2013-2014

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EXECUTIVE SUMMARY: The first three pages of the report contain a brief history of the lake's problems and an executive summary of the report's findings. The rest of the report is a detailed discussion of those findings.

Introduction: This report to the Board of the Canal Run Homeowners Association (HOA) summarizes work I completed on my own and done in cooperation with Rick Masser, the Chief Environmental Compliance Inspector with Frederick County and Canal Run's Developer, Andy Macintosh, to improve the ability of the stormwater management lake to retain water and increase the supply of water to it. These actions have been taken in response to questions raised in the HOA about the adequacy of the lake system. Much of this work was completed pursuant to an agreement signed on May 21, 2013 between the Developer and the HOA. This report also provides background information and data to give context to the current condition of the lake.

Background:

The Developer completed construction of the HOA's stormwater lake in 2006-2007. The excavation of the lake included blasting of the rock formations. Given that the blasting might have created cracks that could lead to leakage and sinkholes, the County ordered the installation of a 12" clay liner. However, the letter to the Developer did not specify whether the clay liner should cover the entire lakebed. The Developer put down a clay liner, but only along the bottom of the lakebed and partially up the sloped sides.[1]

In subsequent years, residents complained of rapid lake level loss. The lake was often half full or less (see historic lake photos in Appendix C). The HOA retained a consulting firm to inspect the adequacy of the lake installation. In November 2012, the consultant report indicated the presence of large sinkholes on the sloped sections of the lakebed (Appendix B). These holes had grown substantially from when they were first noticed by residents. The report recommended repairing the sinkholes and installing an 18" clay liner on the entire lakebed.[2]

While many in the community wanted the Developer to install a full clay liner, the lack of clarity in the county instructions about the liner installation made the success of a lawsuit uncertain. The HOA signed an agreement with Mr. Macintosh to complete repairs identified in a May 2013 county inspection report.[3] The HOA agreed to pay the Developer $9,500 to complete the work in the inspection report and any other repairs identified by the County as the work progressed. The Developer was to be compensated when the lake "passed" inspection. The county report identified problems with sinkholes, multiple areas of erosion, and the washout of rockwork installed at the outfall of the large stormwater discharge pipes into the lake. In return for these repairs, the HOA agreed to release the Developer from future liabilities arising from issues associated with the lake.

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[1] There has been substantial disagreement about the degree to which the liner covers the lakebed. The HOA's consultant said it only covered the bottom of lake. County officials and the Developer have disputed that. During a lake inspection on September 17, 2014, Rick Masser told me that he was able to confirm that the liner covers about half of the sloped sections of the lakebed and comes up about ten feet short of the seawall. *See*, Geo-Technology Associates, *Report of Geotechnical Evaluation: Canal Run SWM Pond,* November 15, 2012, http://www.canalrunhoa.com/editor_upload/File/Canal%20Run%20SWM%20Pond%20Ltr%20(3).pdf.

[2] Geo-Technology Associates, *Report of Geotechnical Evaluation.*

[3] Inspection Report, May 2, 2013, http://www.canalrunhoa.com/editor_upload/File/May%202%202013%20lake%20inspection%20report.pdf

In the summer of 2013, the Developer completed the repairs identified in the May 2013 report. Some of the sinkholes proved to be very large and expensive to repair (see images in Appendix B). The work was finished in September. In October, I identified design flaws in the stormwater drainage system. Rick Masser concluded that the lake could not pass inspection until repairs and modifications were made. These defects are discussed in greater detail in Section 3 of this report. The May 2013 agreement compelled the Developer to complete these repairs as well since they were necessary to pass county inspection. The developer did not finish the repairs until September 2014. The May 2013 agreement proved to be a good deal for the HOA.

Over the past year, I decided to do a broader assessment of the lake system's performance in two key areas: (1) The lake's ability to retain water, particularly determine whether post-repair water losses in the lake are due to evaporation or ground leakage, and (2) whether the storm drain system was delivering as much water as it could to the lake.

Summary of Conclusions and Recommendations

The conclusions and recommendations listed in this summary are discussed more extensively in the body of the report.

PART A: What is Causing Most of the Water Loss? Leakage and It Can't be Fixed Cheaply.

1) **Most of the lake level loss is leakage to the ground**: Water loss at the lake is mostly in the form of ground leakage, not evaporation, likely from multiple small fissures in the rock formations below the lake and in retention structures.[4] The leakage rate appears to vary in proportion to the lake level. The leakage is greatest when the lake is full—about 2.8 inches per day. Measurements recorded when lake level has dropped at least six feet indicated the loss rate declines to only one inch per day. In the summer, there are additional losses due to evaporation (a significant minority contributor) and likely accounts for about 25 percent added daily loss. (Section 1 of the report)

   Recommendations:

   1) Fountain: During the summer months, the HOA should limit the operation of the lake fountain during the daytime.
   2) Plants: The HOA needs to be careful in considering plants for the lake, they may damage the liner. An expert and the County should be consulted if the HOA wants to consider this option.
   3) Leaks: If small sources of leakage are identified, they should be repaired. Some small leaks are visible now.
   4) Further Investigation: The HOA should consider further investigations to determine if there is a large single source of leakage in the upper reaches of the lakebed or in the structures in the stormwater system.

2) **Stopping the leaks with a liner is prohibitively expensive**: Repairs to the lakebed that would reduce or halt the leakage are expensive (about $300,000 to 350,000). There is unlikely to be community support for such expensive projects. (Section 2 of the report)

[4] HOA member Steve Green recently described the sources of the leakage as coming from "Sinkholes, loss of water through fissures created by blasting, loss of water at the manhole base (probably sitting on blasted rock and not cradled in CL material, loss of water at the core trench in the embankment, loss of water at the cut off trench in the embankment (i know that injections were done at the wier wall to try and alleviate this), loss of water at the weir wall cradle not set in CL properly, loss of water in the 18" storm pipe inletting to the pond (looks like its reversed sloped), loss of water at the end wall(s) footings not set in CL probably setting on shot rock."

Recommendations:

1) Education: The Board needs to educate HOA members that they cannot expect the lake will ever stay full for very long, especially in the dry summer months. Lake level does not seem to appreciably stabilize until level drops near the bottom of the vertical pipe—about six feet.
2) Inexpensive Fixes: While a grand repair is likely too expensive, the HOA should continue to pursue low-cost strategies to eliminate leaks in the lakebed with patching and increase the water supply. While the HOA can't keep the lake full, these steps are essential to keeping some water in the lake for aesthetic purposes and, even more importantly, keep alive the fish and other aquatic wildlife that depend on the lake. This can be done as proposed in the next section of the summary.
3) Contract with a Lake Management Company: Pursuing inexpensive ways of limiting leakage will require the assistance of a lake management company to locate and repair sources of leakage and develop other strategies to control erosion and improve the visual appeal of the lake.

PART B: Can the HOA Put More Water in the Lake? Yes, small additions are possible.

While the HOA can't make it rain more, the current storm drain system has been improved with the recent repairs, and it can be optimized further.

1) **Modifications to the Storm Drain System**: Although the recent repairs to the drain system have increased the volume of stormwater entering the lake and satisfies county's standards, there are small modifications that can increase stormwater even more from HOA neighborhoods. This work will not be covered by the lake repair agreement with the Developer, but it should not be expensive. (Section 3)
2) **Drainage Issues along the Walking Path**: The installation of the walking path between Canal Clipper Court and Conrads Ferry Drive is preventing water runoff from Ballenger Creek Pike and the firehouse from reaching the stream. Instead it is running down the path and pooling in the backyards on Canal Clipper Court. Redirecting this flow back to the stream will increase the stormwater contribution to the lake and reduce erosion of the walking path and bridge. Some of this work could be done for free if it is captured in the Developer's modification to the culverts that run under Ballenger Creek Pike. This work is expected to commence in the coming year. (Section 4)

Detailed Discussion of Conclusions and Recommendations

The following four sections detail the summary conclusions above:

PART A: What is Causing Most of the Water Loss? (Page 5)

Section I analyzes the water loss studies I conducted.

Section II details some possible repairs to the lakebed and some rough estimates of their costs that have been supplied by knowledgeable HOA members.

PART B: Can the HOA Put More Water in the Lake? (Page 9)

Section III discusses repairs that have been made to the stormwater drain system under the 2013 agreement with the developer, as well as some additional modifications that can be done at minimal expense. These modifications will maximize the amount of storm water reaching the lake.

Section IV provides an overview of a situation that is unknown to most members of the HOA. The walking path along the stream has become a conduit for stormwater runoff from Ballenger Creek Pike and the firehouse. Much of this water does not reach the lake and is damaging the path and the bridge.

PART A: What is Causing Most of the Water Loss?

Section I: Study of Lake Leakage vs. Evaporation

There has been a great deal of debate in the community regarding the source of water loss in the lake. Much of the disagreement centered on whether the losses were due to leakage or evaporation. Before discussing the current sources of water loss, a historic perspective on lake water loss is useful. Until 2013, the lake never dropped so low that the fish died or it dried up. Although the months of August and September 2013 were below average, rainfall over the entire summer was abundant (see Appendix D). Rainfall data indicates the lake had survived a much worse drought in 2007, its first year of operation (Figure 1). The lake dryout of 2013 demonstrates that water losses at the lake were getting worse, which is not surprising given the formation of very large sinkholes. Thus, the sinkhole repairs were an essential fix to restore the lake to normal function.

It is also clear, however, that the repairs did not eliminate all sources of leakage. This year residents located small sinkholes that were evaluated by Rick Masser. He concluded that they are not the more troublesome cover-collapse sinkholes that were repaired in 2013, but are cover-subsidence sinkholes that do not usually develop into large holes that could impair the function of the lake. While they are not expected to grow over time, these holes are a small source of loss to the lake. The HOA will need to develop a plan to repair these on an ongoing basis.[5]

FIGURE 1: This image is from July 2, 2007, the lake's first year of full service. Although precipitation in summer 2007 was the second lowest in over fifty years, the lake never went dry.

With the 2013 repairs completed, the amount of lake loss that the HOA should expect from evaporation vs. leakage was an open question. I decided to do a small study. I found that water loss varies considerably with lake level and is mostly due to leakage. When the lake is full there is substantial leakage. When less than half full, as is often the case in late summer, ground leakage drops off to about one third the rate when the lake is full and evaporation becomes more important though it is still a minority contributor to the loss.

[5] For a brief explanation of different types of sinkholes, see Geohazards, Inc., "Sinkhole Types," http://www.sinkholes.com/causes/sinkhole-types/.

Leakage vs. evaporation in the summer

I measured level losses in the summer of 2014 to determine the contribution of evaporation and ground water leakage during warm months. In August and September, I used a simple plastic bucket filled with water and placed at the lake water line. Since a plastic bucket has no water leakage, its losses come entirely from evaporation. Its level drop can be compared to the drop in the lake surrounding it. The difference between the two levels is due to leakage since both the bucket and lake will experience evaporation at the same rate. I picked a period where the temperature remained consistent, stream flow was negligible, and there was no rain. Since it is a potential source of evaporation, I performed tests with the lake fountain turned on and off. Recently, I performed a test in mid-September when temperatures were a bit cooler and the lake level had dropped at least a foot from the previous readings. The results were as follows:

	Test #1 Fountain On	Test #2 Fountain Off	Test #3 Fountain On
Total test time/ date	58 hours--8/26-28/14	71 hours—8/28-31/14	72 hours—9/16-19/14
Daily Highs	90, 92, and 81 degrees	82, 84, and 92	79, 80, 73, 86 degrees
Cloud Cover	Sunny all days	Sunny, cldy, ptly cldy	Sunny, cldy, ptly cldy, sun
Bucket Level Drop	1 inch	¾ inch	7/8 inches
Lake Level Drop	3 ½ inches	3 ¾ inches	4 3/8 inches
Leakage	2.5 inches= 1inch/day	3.0 inches=1 inch/day	3 1/2 inches=0.78 inches/day
Evaporation	1 inch=0.41 inch/day	0.75 inch=0.25 inch/day	0.7/8 inches=0.19 in/day
Evap. Share of Total Loss	29 percent	20 percent	20 percent

The loss due to leakage was the same for both August test runs, about 1 inch per day, indicating that my measurements were mostly accurate. The slightly cooler days and cloud cover may be the reason that there was less evaporation on the second test, or it may be within the margin of error. By combining the results of the two tests, I conclude that in the summer months when the lake level is low, about 75 percent of the total loss is leakage and 25 percent evaporation. The fountain did not make a measurable difference in evaporation rates (but as discussed later on the fountain does contribute to losses when considered over the course of an entire summer). The reading in September showed a slightly slower rate of leakage and evaporation than the previous runs. This may be because of the lower lake level (and less leakage), cooler temperatures, and/or measurement error. More tests would help resolve the uncertainty.

Leakage with a full lake:

The lake is not designed to hold water at the top of the sea wall. The water level is supposed to sit about in the middle (elevation 266').[6] Using that fact, I determined the leakage rate for the lake when it is full by analyzing photos taken of the lake that were posted on the HOA Facebook page in October 2013. The

[6] The stabilized level of the lake was described by County inspector Dave Crable in an email to HOA member Mark Johnson: "As designed, there is a permanent pool within the facility that is approximately 10-feet in depth. The bottom elevation of the facility is approximately 256 and a surface elevation of approximately 266. In order to combat "thermal pollution" to the receiving stream, a 21" low flow pipe was installed that extends down into the permanent pool and protrudes through the concrete weir wall of the facility's control structure. As shown in the detail below, the low flow pipe comes through the weir at approximately elevation 266. There is a galvanized steel plate bolted to the inside of the weir wall that covers the 21" low flow pipe with a 12" orifice cut into the plate. This allows the controlled outflow of stormwater from the facility to the predeveloped rate prior to the development of Canal Run in accordance with the stormwater management regulations. Please note that the low flow weir elevation is approximately 267.5. Being that the 12" orifice invert is located 1.5-feet below the top of the bottom weir wall elevation."

lake level fell at least 36 inches from a completely full condition between October 14 and 27, a rate of approximately 2.8 inches per day.[7] Rick Masser said this loss rate was acceptable and not a major concern. The lake is intended for stormwater detention, and unless the leakage degraded its function, as did the very large sinkholes, the County was not worried about it.

Conclusions:

Most of the level loss in the lake is due to leakage. The very rapid loss when the lake is full leads to a very unsatisfying conclusion, in its current condition, it is impossible to keep the lake full except during and in the wake of large storms. The level seems to stabilize near the bottom of the vertical pipe as leakage losses drop off to about one inch per day. This conclusion is also supported by historic satellite photos of the lake dating back to 2007. With the exception of the 2011 image (a very wet year), the lake shoreline receded in each picture to just beyond the vertical pipe. (see images in Appendix C) Further measurements are planned to more accurately determine the where losses stabilize.

There are limited options available to the community to limit water loss.

1) Run the fountain less in the summer: While the fountain made little difference during the tests, Canal run HOA resident and civil engineer, Ryan Terry estimates that the fountain will contribute roughly 1.5 feet to evaporation losses during the warm months. He recommends putting the fountain on a timer to stop the fountain in late morning and afternoon, i.e. the hottest hours of the day where evaporation is at its peak.

2) Water plants might make the problem worse unless done carefully: There have been suggestions that the HOA reduce lake evaporation with plants such as water lilies. The county inspector has recommended against this practice since the rooting by the plants could violate the integrity of the clay liner. This recommendation against plantings is supported by National Park Service practice. The NPS uses large tubs to plant water lilies rather than plant them directly into clay liners.[8] Still there may be other vegetation that would work near the shoreline. The HOA should consult experts in this area, as well as the County on what might work without exacerbating liner leakage.

3) Continue to search for leaks. It is very likely that ground leakage is coming from many small fissures in the bedrock and flaws in the installation of the lake system. Small sinkholes have been located along the shoreline. When found, these should be repaired. However, the HOA should look for larger sources of loss, particularly in the weir wall structure and piping to it.

4) Liner: Should the HOA consider the installation of a lakebed liner (see next section)?

Section II: Cost Estimates for a Lake Liner

Repairing the leaks to the lakebed with a liner has been mentioned often within the community. There seems to be an expectation that a lakebed repair is a realistic option for the HOA.

I collected estimates for such work from two HOA community members with extensive experience in this area, Steve Green and Ryan Terry. Both offered similar cost estimates for a bentonite liner of about

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[7] This was a period when there was almost no rainfall and temperatures were moderate, which were ideal conditions to get a clear reading on ground losses. The 2.8 inches/day figure should be taken as an estimate only. A number of factors make the true number uncertain, including uncertainty as to where a stable lake level would be in the pictures evaluated, evaporation rates, and the volume of water added to the lake by the stream between October 14 and 27. The key point is that leakage rates are high when the lake is full.

[8] National Parks Service, *National Historic Landmark Nomination: Lincoln Park Lily Pool,* December 2004, http://www.nps.gov/nhl/find/statelists/il/LilyPool.pdf. See page 6 for the methods used by the NPS to allow lilies to be placed at the bottom of the pond.

$300,000. Steve Green also included possible repairs to the lake weir wall and other small construction fixes to come up with a total of at least $350,000. Terry also discussed the possibility of installing a polyurethane liner at a similar price of $300,000.

All of these estimates are quite high, as much as $1,000 per household. It is unlikely the HOA community would be willing to pay such an assessment. What is more feasible is to hire a lake management company that will regularly inspect the lake and make more modest repairs to leaks in the lakebed and lake structures that develop in the future.

As the lake level is impacted by both water loss and the flow of water into the lake, the HOA should also be alert for inexpensive ways to maximize the water supply to the lake. As discussed in Sections III and IV, the Board has pursued this strategy in the last two years and should continue to do so in the coming year.

PART B: Can the HOA Put More Water in the Lake?

Section III: Lake Repairs Under the 2013 Agreement:

Since the stormwater management lake began operating, HOA residents have complained that the lake has rapidly lost water level. As noted earlier, the HOA and the Developer signed an agreement where he would repair sinkholes and other issues. In the summer of 2013, the Developer excavated and repaired sinkholes identified on the north side of the lake near Lockhouse Drive. Two of the holes were so large that the County inspector observed that water was "swirling like water going out of a bathtub." The holes proved so large that water from a fire truck could not fill them. As the report noted, "500+ gallons of water [disappeared] out [the bottom] in a matter of seconds." These holes required special repairs, which were completed by early October. All that was needed to release the $9,500 was a county inspection. [9]

A change in the weather soon revealed new problems with the lake system. The heavy rains in early October 2013—7.39 inches in about a week—were of such magnitude that they completely refilled the lake. The large inflow of water revealed design flaws in the stormwater discharge system. Stormwater enters a small underground room called a splitter (see Figure 4 on page 10). The splitter is designed to send small amounts of early storm runoff to the lake's two forebays, which look like small ponds next to the lake. (see Figure 2 and Appendix A) The forebays act as an anti-pollution, water-filtration system. As a storm builds in intensity, the bulk of the runoff is supposed to feed directly to the lake through the three large outfall pipes next to the forebays (see Appendix A photo for outfall locations). This was not happening. All of the runoff entering the splitters flowed exclusively to the two forebays. The flow was so large that it overwhelmed the discharge opening in the forebays, known as a "weir windows," leading to the lake.[10] Instead, the water discharged across the entire front of the forebay. (Figure 2)

FIGURE 2—Overflowing forebay near the clubhouse, October 11, 2013. Meanwhile the large outfall pipe near the clubhouse discharged almost no water to the lake.

This was a problem for two reasons. 1) In large storms, this defect caused substantial erosion in the lakebed near the forebays, and in time would damage the forebays themselves. 2) Much of the water entering the forebays did not reach the lake. Instead it percolated into the ground reducing the supply of water to the lake.

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[9] For background and inspection reports on the sinkholes, see the Canal Run website at http://www.canalrunhoa.com/info.php?pnum=40. See especially reports filed on September 5, 20, and 26, 2013.

[10] The forebay weir windows, are small cutouts in the seawall that channel overflow water from the forebays and discharge it to the lake.

I sent these photos to Rick Masser. Given the design flaws in the system, Masser concluded that the lake could not pass inspection. He insisted the forebay piping be restricted with orifice plates (Figure 3) and to improve the weir windows, openings in the forebay that spill water to the lake.[11] This work was completed under the 2013 agreement. Thus, without incurring HOA expense, the system was redesigned to ensure proper function, reduce maintenance costs, and improve the volume of water flowing to the lake.

FIGURE 3: The lightly shaded area seen inside the pipe is an orifice plate to limit stormwater flow to the forebay. Limiting flow to the forebay directs more water to the lake.

Substantial progress was made on the modifications during the summer of 2014. Rockwork was added to the forebays to improve weir window discharges. To reduce flow to the forebays, a combination of orifice plates and brickwork (in only one of the three splitters) were added. This work is now complete. On September 18, 2014, Rick Masser issued a County report indicating the County had passed inspection. The HOA has issued the $9,500 payment to the Developer.

I believe the benefit of the repairs is already evident. The rainstorm that occurred over Labor Day weekend contributed 0.44 inches of precipitation. From that storm, the lake gained a foot of water level. The stormwater drains from HOA neighborhoods contributed at least half of the total where previously they would have added very little.[12] Had these modifications been completed a few months sooner, the HOA would likely enjoy a higher lake level now. For example, in July 2014 there were four storms of similar intensity to the Labor Day storm. In August there were two of similar size plus three others that had more than twice the precipitation of the Labor Day storm.

Things might have been different during summer 2013 too. The early summer had seen a great deal of precipitation, and even though August 2013 had below normal rainfall, there were storms of 0.25, 0.75, 0.41 and 0.18 inches. Those storms should have contributed at least a few feet of water, but did not. As can be seen in the pictures in Appendix B, the lake had reached a crisis point by the end of the summer. Even though there had been a substantial storm just three days earlier, the fountain had to be turned off on August 26 due to low water level. On September 12, a resident reported that the fish were dying. By early October, the lake was dry. Clearly, the lake could not hold water with the large sinkholes.

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[11] See "Inspector's Report," December 9, 2013, http://www.canalrunhoa.com/editor_upload/File/Field_Investigation_Report_11434_552571.pdf.

[12] There is a lag in the time water from the stream entered the lake. I was able to measure the contribution that came from the storm drains alone before the stream contributed a significant volume to the lake.

This year the lake is holding water better. September 2014 has been one of the driest on record. Nevertheless there is still about two feet of water left in the lake. I am optimistic that the sinkhole repairs and stormwater drain modifications will make a lake crisis less likely.

I do not believe, however, that the completed design is optimal. While the system now meets County approval, there is still too much water flowing to the forebays, especially near the clubhouse (figure 3). Further restricting the pipe will divert more water to the lake. I have consulted with Rick Masser on this issue. He has no objection to the HOA adding the brickwork installed in one splitter in to the other two. (See Figures 4 & 5) I recommend funding these modifications. An informal estimate provided to me indicates the work would cost about $1,500, but this needs to be confirmed.

<u>FIGURE 4</u>: The "splitter" in these two images sends early stormwater to the forebay through the 18 inch pipe on the right of the image. As larger volumes flow to the splitter, water is supposed to back up and spill to the 36 in pipe on the left side leading to the lake. However, the 18 inch pipe was too large for its intended purpose and water rarely went to the lake. The image on the right shows the 18" opening restricted to only a 4" opening. The other two splitters should receive the same modification.

<u>FIGURE 5</u>: Due to its contoured shape, the splitter near the clubhouse will be more difficult to restrict as was done in Figure 4. The HOA should seek out cost estimates.

Section IV: Repairs to the Ballenger Creek Pike Culvert and Firehouse Drain

In June and July of 2014, I noticed another problem with the drainage to the lake. The heavy rains of the late spring had engorged the stream feeding the lake (Figure 6). What caught my eye in this photo, was not the flow of water over the bridge but the water running down the path toward the bridge. There were clear signs of erosion to the path (Figure 7). This was clearly a reason why there had been potholes on the approach to the bridge in the past year. Where was this water coming from?

FIGURE 6: Across from the bridge, water can be seen running down the walking path.

FIGURE 7: Erosion near bridge.

The path's stream led all the way to Ballenger Creek Pike. Much of the runoff from the intersection of Lockhouse Drive and Ballenger Creek Pike does not reach the stream. Instead it turns off down the HOA walking path, picks up a contribution from a drainpipe at the firehouse, and forms a stream running down

the path and through the yards along Canal Clipper Court. Finally, it dumps into the stream at the footbridge (Figures 8 & 9).

FIGURE 8: This drain pipe near Ballenger Creek Pike discharges to the walking path (left). The water damage to the walking path is evident in the image on the right.

FIGURE 9: Flooded back yard on Canal Clipper Court due runoff from Ballenger Creek Pike.

There are several reasons why the HOA should remedy this situation. (1) The stream flow will continue to erode the path and the footing for the new footbridge. (2) The water is flooding the yards of homeowners on Canal Clipper Court. (3) The water that ends up in the yards on Canal Clipper Court is absorbed and doesn't make it to the lake. (4) Directing more water into the stream should result in an increase to the lake level.

Remedying much of this situation could be cost-free if the next Board is vigilant. The Developer still needs to make modifications to the culvert under Ballenger Creek Road. During an informal inspection

of the area with Rick Masser and Board President Mark Hershfield, Masser indicated that the culvert work can be modified to capture the runoff from the road and divert it to the stream and away from the path (Figure 10). This work by the Developer, however, may not be done until the spring or summer of 2015. A member of the Board needs to be tasked with keeping track of this work and ensuring that the work on the culvert suits the HOA's needs.

Even with this work by the Developer, a drain may still be needed to capture the runoff from the firehouse and direct it to the stream. It is likely this work could be done with a relatively simple drain trench run under the path.

FIGURE 10: Runoff from the road needs to be directed to the stream. Developer work on the nearby culvert may solve this problem.

Conclusion

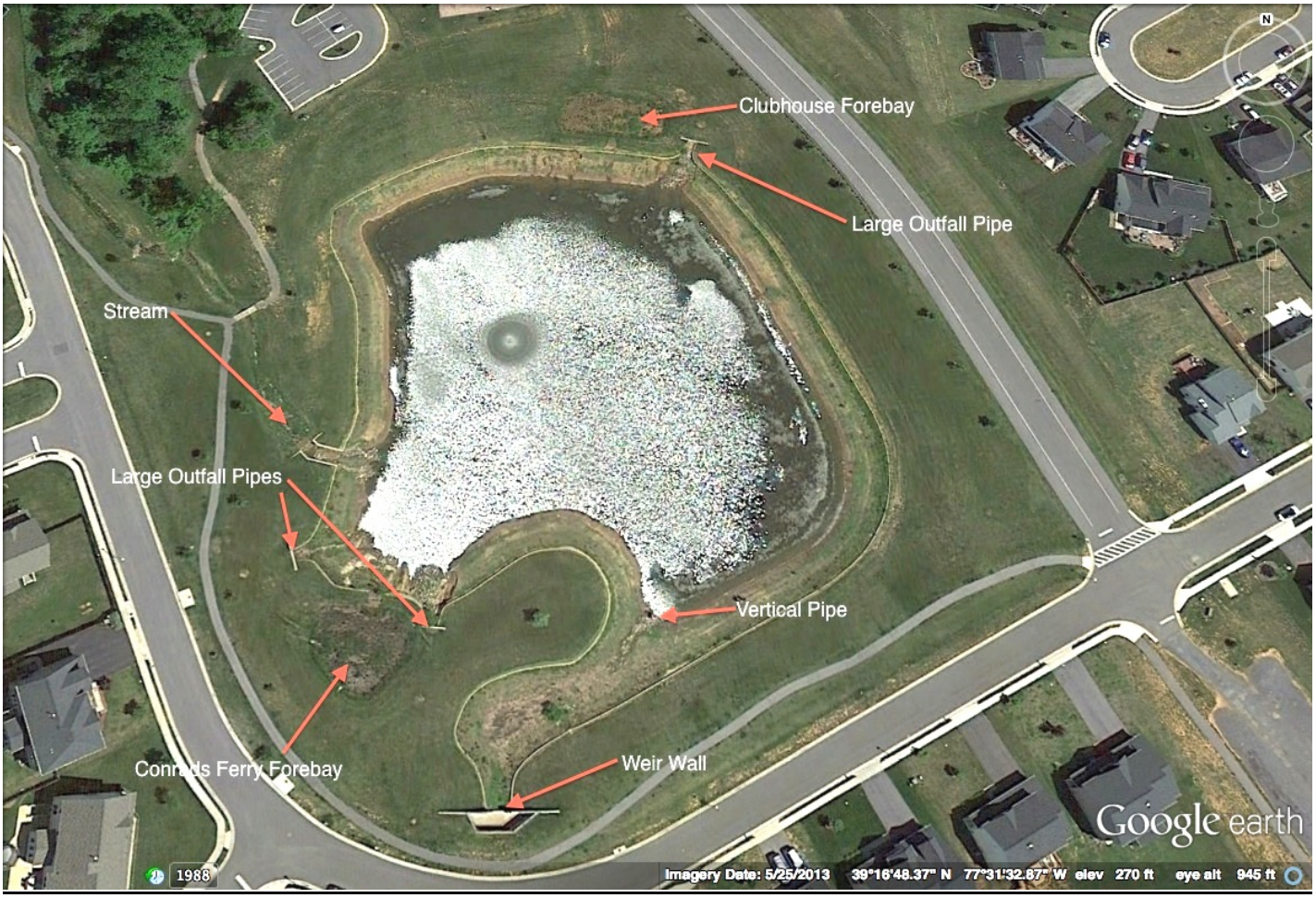
I will continue to monitor lake level over the next year and have installed a staff gauge on the vertical pipe for that purpose. My aim is to get a more complete picture of the rate of lake level loss at various elevations. Hopefully, this information will guide HOA efforts to improve the condition of the lake.

The HOA has been successful in improving the supply of water. With the work already completed, the HOA can expect that storms will contribute more to the lake than in the past. A few minor modifications can improve the situation further.

The HOA has made modest progress in improving the lake situation, and there are additional improvements to be made. The lake has entered a new phase. The HOA will no longer pursue solutions through the County and Developer. The lake is now "ours," and improving its function will have to come with the assistance of a lake management firm and the talents of HOA residents. The 2013-2014 Board has begun soliciting bids from lake management companies. This work needs to be completed by the next Board.

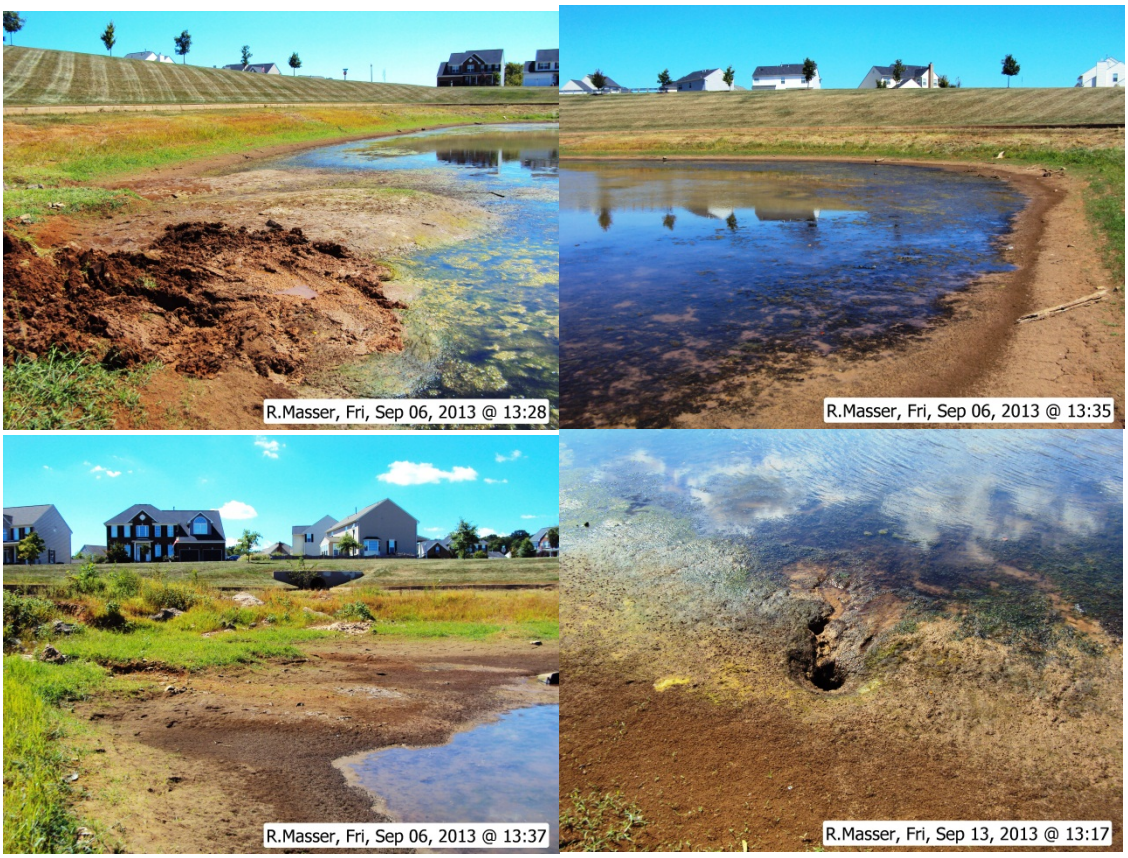
The sinkhole repairs completed in 2013 were essential to restoring lake function, and they reduced losses substantially. Given the high leak rate when the lake is full, however, it is likely the lake will almost always stay below its full level. The HOA community needs to look at a half-empty lake and see it as half full.

Appendix A: Layout of Stormwater Management Pond



Appendix B: Study and Repair Work on Large Sinkholes

A sinkhole identified in the HOA's 2012 consultant report (left). It's almost 18" wide. At right, a sinkhole identified in 2011; it is only 5 inches wide.



Images of the lake just prior to commencing repairs on the sinkholes.

Lake view just before work began on sinkholes (left). Excavation of sinkhole during repair work (right).

Appendix C: Historic Satellite Images of the Lake

June 2007

September 2008

May 2009

June 2011 was the only time in Google Earth's collection where the lake is captured when full. 2011 was an extremely wet year.


5/2013
1988
Imagery Date: 5/25/2013 39°16'48.11" N 77°31'33.21" W elev 267 ft eye alt 774 ft
Google earth

May 2013

Appendix D: Historic Precipitation Data: Dulles International Airport

Dulles VA Precipitation

*** PLEASE NOTE ***

Climate data on this page are PRELIMINARY (unofficial).
CERTIFIED (official) climate data are available from the
National Climatic Data Center (NCDC) - http://www.ncdc.noaa.gov/

*** PLEASE NOTE ***

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL	WINTER	SPRING	SUMMER	AUTUMN	1ST HALF	2ND HALF
1963			4.34	1.17	1.52	8.59	1.25	4.70	3.30	T	7.83	2.26	M	M	7.03	14.54	11.13	M	19.34
1964	5.56	4.50	2.82	3.68	0.80	1.36	3.09	2.49	3.72	1.96	1.80	4.19	35.97	12.32	7.30	6.94	7.48	18.72	17.25
1965	3.24	2.58	4.27	2.53	1.77	1.75	3.94	3.75	2.28	1.87	0.46	0.42	28.86	10.01	8.57	9.44	4.61	16.14	12.72
1966	4.22	3.90	1.24	4.38	3.84	0.94	2.17	1.79	9.39	3.01	1.50	3.67	40.05	8.12	9.46	4.90	13.90	18.52	21.53
1967	1.12	2.18	4.74	0.93	4.37	1.68	3.38	9.28	0.62	2.79	2.61	5.69	39.39	6.97	10.04	14.34	6.02	15.02	24.37
1968	2.31	0.68	3.36	1.29	5.90	5.20	4.08	4.90	2.10	2.77	3.57	2.32	38.48	8.68	10.55	14.18	8.44	18.74	19.74
1969	2.07	1.69	2.04	1.34	0.99	5.55	4.90	5.07	4.89	0.85	2.11	6.74	38.24	6.08	4.37	15.52	7.85	13.68	24.56
1970	1.32	2.76	2.98	4.19	2.86	2.48	6.00	2.65	1.03	2.79	6.00	3.88	38.94	10.82	10.03	11.13	9.82	16.59	22.35
1971	2.27	4.68	2.27	2.56	8.47	2.81	2.15	4.45	3.63	9.19	3.13	1.00	46.61	10.83	13.30	9.41	15.95	23.06	23.55
1972	2.28	5.44	2.37	4.40	4.76	18.19	1.53	2.09	1.40	3.44	7.09	6.06	59.05	8.72	11.53	21.81	11.93	37.44	21.61
1973	2.25	2.84	2.66	7.35	3.97	1.91	4.99	3.18	3.14	2.67	0.81	5.72	41.49	11.15	13.98	10.08	6.62	20.98	20.51
1974	3.07	1.14	3.09	2.14	3.78	5.41	2.69	4.84	4.02	0.71	1.97	5.26	38.12	9.93	9.01	12.94	6.70	18.63	19.49
1975	2.76	1.97	4.38	2.58	2.99	7.08	6.25	5.38	11.26	2.34	1.64	4.01	52.64	9.99	9.95	18.71	15.24	21.76	30.88
1976	2.81	1.42	4.15	1.31	4.18	2.88	2.33	3.13	3.75	7.88	0.57	1.78	36.19	8.24	9.64	8.34	12.20	16.75	19.44
1977	1.10	0.49	3.59	2.58	2.33	3.09	3.25	4.18	1.74	4.19	4.51	4.87	35.92	3.37	8.50	10.52	10.44	13.18	22.74
1978	6.55	0.25	2.85	1.62	5.05	4.36	4.52	4.29	0.78	0.79	3.02	3.58	37.66	11.67	9.52	13.17	4.59	20.68	16.98
1979	6.61	5.75	3.50	2.05	4.89	4.64	2.18	6.05	7.58	8.65	2.65	0.88	55.43	15.94	10.44	12.87	18.88	27.44	27.99
1980	2.95	1.00	4.82	3.64	3.86	1.89	4.41	1.67	2.70	2.77	3.42	0.68	33.81	4.83	12.32	7.97	8.89	18.16	15.65
1981	0.40	4.10	0.99	3.05	4.36	3.86	4.05	3.55	2.07	3.00	0.24	2.46	32.13	5.18	8.40	11.46	5.31	16.76	15.37
1982	2.10	4.09	3.47	2.82	3.57	5.49	2.11	3.36	4.22	2.21	2.87	2.25	38.56	8.65	9.86	10.96	9.30	21.54	17.02
1983	1.40	3.74	4.21	7.24	3.63	4.01	0.94	1.34	2.95	6.00	5.06	5.66	46.18	7.39	15.08	6.29	14.01	24.23	21.95
1984	1.42	4.13	5.81	5.01	4.23	2.19	2.46	10.71	1.49	1.73	3.64	1.25	44.07	11.21	15.05	15.36	6.86	22.79	21.28
1985	2.32	3.73	1.70	0.33	4.82	1.14	2.34	3.35	2.96	4.06	5.27	0.92	32.94	7.30	6.85	6.83	12.29	14.04	18.90
1986	1.58	3.16	1.12	3.01	1.19	1.40	1.86	5.72	1.04	1.30	4.17	4.83	30.38	5.66	5.32	8.98	6.51	11.46	18.92
1987	4.53	2.47	1.46	4.61	2.33	3.38	3.04	0.96	8.11	2.51	5.02	2.35	40.77	11.83	8.40	7.38	15.64	18.78	21.99
1988	2.47	2.06	2.31	2.35	10.26	0.52	7.12	3.92	1.80	1.60	4.48	0.92	39.81	6.88	14.92	11.56	7.88	19.97	19.84
1989	2.65	2.50	4.01	2.70	7.71	5.75	5.99	0.76	3.14	4.73	2.68	1.72	44.34	6.07	14.42	12.50	10.55	25.32	19.02
1990	3.14	1.65	2.78	5.06	4.37	1.77	5.42	5.56	1.49	6.53	2.56	5.00	45.33	6.51	12.21	12.75	10.58	18.77	26.56

Last Updated 8/25/2014

iadprecip

Dulles VA Precipitation

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL	WINTER	SPRING	SUMMER	AUTUMN	1ST HALF	2ND HALF	
1991	2.67	0.81	5.16	1.80	1.51	6.58	2.64	0.99	3.25	1.37	2.70	4.54	34.02	8.48	8.47	10.21	7.32	18.53	15.49	
1992	2.13	2.26	3.23	3.15	3.82	2.88	7.23	1.33	5.55	2.81	5.24	4.73	44.36	8.93	10.20	11.44	13.60	17.47	26.89	
1993	2.72	2.74	7.65	5.62	2.85	1.77	2.06	4.68	4.66	2.15	6.28	3.78	46.96	10.19	16.12	8.51	13.09	23.35	23.61	
1994	4.12	3.61	6.71	1.71	3.19	5.82	5.75	4.62	3.40	1.05	1.86	2.42	44.26	11.51	11.61	16.19	6.31	25.16	19.10	
1995	4.18	1.80	1.39	2.14	5.13	3.25	4.24	2.02	2.74	6.51	4.75	2.05	40.20	8.40	8.66	9.51	14.00	17.89	22.31	
1996	5.61	2.62	3.52	3.69	7.07	4.88	5.89	4.16	7.72	3.97	3.75	5.21	58.09	10.28	14.28	14.93	15.44	27.39	30.70	
1997	2.16	2.16	4.78	2.18	2.87	2.36	1.38	5.32	3.16	2.75	5.48	1.92	36.52	9.53	9.83	9.06	11.39	16.51	20.01	
1998	5.43	5.83	5.60	2.92	4.52	5.87	1.31	0.44	1.25	1.50	1.21	1.53	37.41	13.18	13.04	7.62	3.96	30.17	7.24	
1999	5.39	2.62	3.44	2.68	2.22	3.00	2.56	5.43	9.32	2.55	1.72	2.67	43.60	9.54	8.34	10.99	13.59	19.35	24.25	
2000	2.50	1.92	3.35	4.36	2.57	4.02	4.28	5.92	4.20	0.06	1.57	2.06	36.81	7.09	10.28	14.22	5.83	18.72	18.09	
2001	2.54	1.68	4.14	2.15	5.68	4.83	4.24	4.52	3.39	1.42	0.81	1.56	36.96	6.26	11.97	13.59	5.62	21.02	15.94	
2002	1.22	0.46	3.48	3.45	4.73	3.61	2.64	2.91	2.84	5.04	4.13	3.61	38.12	3.24	11.66	9.16	12.01	16.95	21.17	
2003	2.69	6.27	3.71	2.71	8.71	8.33	6.06	5.55	7.26	4.63	5.20	4.57	65.69	12.57	15.13	19.94	17.09	32.42	33.27	
2004	1.41	1.93	2.05	5.04	3.06	3.73	3.72	3.79	5.80	1.04	4.11	3.01	38.69	7.91	10.15	11.24	10.95	17.22	21.47	
2005	3.14	1.41	3.93	4.34	4.86	1.92	7.85	2.32	0.15	9.22	2.49	2.92	44.55	7.56	13.13	12.09	11.86	19.60	24.95	
2006	2.39	2.38	0.07	4.86	1.80	11.79	2.45	1.24	7.12	4.82	5.31	1.74	45.97	7.69	6.73	15.48	17.25	23.29	22.68	
2007	2.11	2.54	2.93	3.38	0.34	2.92	1.75	1.67	1.40	3.52	1.49	2.97	27.02	6.39	6.65	6.34	6.41	14.22	12.80	
2008	1.26	2.67	2.47	6.22	9.38	4.21	2.18	2.48	7.18	1.31	2.01	2.61	43.98	6.90	18.07	8.87	10.50	26.21	17.77	
2009	2.64	0.35	2.41	4.12	10.26	6.69	2.18	2.75	1.83	5.70	3.71	5.98	48.62	5.60	16.79	11.62	11.24	26.47	22.15	
2010	2.01	4.63	3.36	1.29	5.42	1.29	4.17	4.42	6.16	2.38	2.50	1.47	39.10	12.62	10.07	9.88	11.04	18.00	21.10	
2011	1.87	2.21	5.07	5.21	3.28	1.40	2.58	3.74	7.93	6.27	2.18	4.46	46.20	5.55	13.56	7.72	16.38	19.04	27.16	
2012	1.85	2.24	1.52	1.82	5.38	1.79	2.43	3.02	2.71	8.87	1.12	2.87	35.62	8.55	8.72	7.24	12.70	14.60	21.02	
2013	3.70	1.63	3.16	2.30	3.20	4.64	7.27	1.95	1.61	7.51	2.79	5.58	45.34	8.20	8.66	13.86	11.91	18.63	26.71	
2014	2.69	3.81	4.10	7.41	6.34	4.62							28.97	12.08	17.85			28.97		
NORM	2.68	2.74	3.38	3.47	4.55	3.98	3.67	3.53	3.92	3.25	3.41	2.96	41.54	8.38	11.40	11.18	10.58	20.80	20.74	1981-2010
YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL	WINTER	SPRING	SUMMER	AUTUMN	1ST HALF	2ND HALF	