Lake Conway 2010 Canal Siltation Study
(Including All Canals)
Publication Date: September, 13, 2011

Prepared for:

Orange County Lake Conway Water and Navigation Control District
Advisory Board
Orange County Environmental Protection Division
800 Mercy Drive, Suite 4, Orlando, FL 32808

Prepared by:

TEC Engineering, Inc.
3042 Hoffner Ave.
Belle Isle, FL 32802

David W. Woods P.E.
Fla. Reg. 36902
407-859-8737
DWoodstec@cfl.rr.com
Lake Conway 2010 Canal Siltation Study
(Including All Canals)

Summary

A baseline study, “Lake Conway Canal Mud Removal Baseline Study” was performed in 2005 to establish baseline data for future studies to determine the rate of siltation of the canals of the Lake Conway chain. In May 2010 the “Lake Conway 2010 Canal Siltation Study” reported updated readings from the Barby, Landings, and Willoughby Canals. In December 2010 the “Lake Conway 2010 Canal Siltation Study” was updated to include readings from the Backacre, Bayfront, Hoffner, Montmart, Overlake, Venice, and Waterfront Canals to estimate the amount and rate of siltation in these canals over the past 5 years. This report completes the study by including Gatlin, Lisa, Harbor Oaks, Mandalay, Venetian, and Daetwyler canals. Since 2005 two canals (Venetian and Lisa) have been de-mucked. Excluding these the results show siltation has occurred. On the average the bottom elevation has raised 0.28 feet. The result is an average reduction in the navigability (using the 2010 30 Year Lake Stage profile) from 83% to 80%.

To evaluate the need for maintenance, a canal rating system was developed which divides the current average depth of the canal less the navigability depth by its rate of siltation to yield an approximate number of years until the 20% navigability point is reached. Negative numbers indicate the depth of the canal has improved. Large positive numbers indicate there has been little decrease in depth. These ratings were between -74 and 1161 years with an average of 197 years (including de-mucked canals). This means the canals are in fairly good shape. The Barby and Wiloughby Canals are in poor shape with ratings of 35 and 23 years, respectively.

Data Collection

In the 2005 study bottom depth and mud depth measurements were mechanically obtained at 125 locations near the centerline of the Conway canals at approximately 200’ intervals. The nature of the data collection method necessarily misses some deep areas and shallow areas. It was observed that there are many fluctuations in the canal depth that did not show up in this data for some canals (particularly Hoffner).

The results were tabulated and compiled on a base map from the County GIS system to aid in the visual relocation of the probe locations. To assist in relocating points at some distance from shore navigational level GPS (with WAAS enhancement) coordinates were obtained for all probe locations. The results were compared to the 2010 - 30 Year Lake Stage data to assess the navigability at each location. This project returns to those data points in the remaining canals to sample the data again for the purpose of determining the changes which have occurred. Daetwyler Lagoon baseline data was added with this survey.

The depth information was collected at each probe location using mechanical means to eliminate...
interference experienced by digital depth indicators. The sand probe was a 20’ long 1” diameter capped PVC pipe calibrated in 0.1’ intervals. To reach the theoretical sand bottom it was pushed down into the bottom until it stopped with approximately 20 pounds force. The mud probe was a 9” square plastic grate weighted to have approximately 2 pounds of negative buoyancy when submerged resulting in a contact pressure of 0.025 pounds per square inch. It was found this was sufficient to push through the aquatic growth but would only penetrate the mud surface about 1/2 inch. The mud pad was arranged to freely slide over the sand probe with its gauge measuring indicator one foot above the mud pad. Therefore, each mud pad reading was reduced by 1 foot to obtain the actual mud thickness. A cam lever operated by a lifting line would lock the mud pad to the sand probe for extraction and reading (Figure 1). Due to the awkwardness of this arrangement the entire mechanism was supported by a 10’ high 2” diameter PVC mast arranged vertically on the study boat (Figure 2).

Within canals, probes were taken when aligned with property lines and as near as practical to the middle of the canal. Comments in the data tables indicate which property lines were used. When no location comment was present the GPS coordinate and visual location on the map was used to re-locate the point. To further improve future probe re-locations, at least two annotated digital images were taken of the surrounding area from each probe location. These images are provided with this report on CD.

It was found that over time a fixed location could be reported by the GPS receiver anywhere within a 40’ diameter circle. This equates to a tolerance of +/- 20’. To reduce the relative imprecision of the navigational GPS readings, they were taken as an average of at least 10 readings over about as many seconds, plotted on the drawing, adjusted to better fit the map and recalculated for display in the tables. The averaging of the readings does not actually resolve the coordinate shift but it does reduce the possibility of a seriously stray reading. The resulting coordinates appear to be at a tolerance of +/- 10’ when combined with visual location on the water. Improved relocation precision is anticipated for the 2015 survey since two photographs have been taken for each probe location in this survey.

All data was collected in the calmest conditions practical. Each reading was taken as a depth from the water surface. The water surface elevation was determined from reading the attenuated lake gauge located at 3042 Hoffner Road. This gauge has been calibrated to correspond with benchmark L-1058-005 (elev. 92.22) located on the west headwall of the Lake Conway Discharge at Daetwyler Road. On 3/22/2010 it was determined this benchmark may have settled about 0.05’ due to erosion of the headwall foundation. From this date forward, OC benchmark L-1058-006 (elev. 92.287, NGVD 29) located on the east headwall of the Lake Conway Discharge at Daetwyler Road will be used. Elevations take this adjustment into account.

**Data Tables**

Data Tables 1 and 3 are summaries of the data contained in the Excel spreadsheets on the included CD. The following information is provided within the data tables:

**Point** - The point number of the probe location which should be used to correlate the table data to the maps.
GPS – The waypoint number placed on the GPS to record the present location and time of probe.

Depth - The depth from the water surface to the hard bottom (bottom of mud).

Raw Mud - The physical rod reading taken at the top of the mud. This number is 1 foot greater than the actual mud thickness.

Mud - The actual mud thickness above the bottom elevation

Comments - Information peculiar to the data point including physical conditions and location reference information.

Elevation - The calculated hard bottom elevation based on the water surface elevation on the data collection date.

Canal - The name of the canal system where the point is located.

Time – The time of the probe. This is used to coordinate the probe locations with the digital images.

Latitude - The adjusted GPS Latitude in decimal degrees (see discussion above).

Longitude - The adjusted GPS Longitude in decimal degrees (see discussion above).

Navigability - This represents the percentage of time this location is likely to have a Minimum Safe Navigational Depth (MSND) of 3 feet of water above the top of the mud for the purpose of navigating a boat. Using the 2010 - 30 Year Lake Stage data as the basis for comparison the expected usability of each location for navigation was determined. For example 100% indicates it is expected there will always be at least 3' of water above the mud at this location. A value of 33% would indicate that in the past 30 years there were 10 years with at least 3 feet of water above the top of the mud as it is today. More specific information is given in Discussion below.

Map Sheets 2 – 9 show the adjusted locations of the probes on County GIS maps. Each probe location shows the point number (top number), the 2010 hard bottom elevation (descending the list), mud thickness above the hard bottom elevation, the change in bottom elevation from 2005, and change in mud thickness from 2005. Daetwyler Lagoon data only contains the first three data types since no 2005 data exists. These maps should be used whenever reestablishing these probe locations for future studies.

The accompanying CD also contains images taken from each probe location. They were taken to assist in relocating the probe location for the next survey. They also serve to give a visual indication of the conditions in the canals. Each image is labeled with the point number, date, and water surface elevation. The file names are structured in this format:

PPP YYYYMMDD SS CCCC.jpg

Where:
PPP = Probe Number
YYYY = Year number (ie. 2010)
Discussion

2005

The original 2005 project resulted in 125 data points. It was found the median top of mud elevation was 80.16 which equates to a navigability of 79%. 35 points had a top of mud elevation below 81.0 meaning that 72% of the areas are considered navigable 80% of the time. Only 3 probe locations were not navigable at any lake stage. **Table 1, 2005 Canal Summary Data**, contains summary data for all canals in 2005. The canals are organized according to those which are either connected or adjacent to each other. The horizontal dividing lines illustrate which canals can be found on the same sheet of the point maps.

Key to the analysis is the Navigability which is based on Lake Stage as shown in **Table 2, Lake Conway Lake Stage 1981 - 2010**. The derivation of Lake Stage was done in the TEC Engineering 2001 report “Lake Conway Water Level Analysis as Related to Recreational Use.” Lake Stage illustrates the percentage of months the water level is below a particular level over the course of a 30 year period. Navigability is essentially the inverse of the Lake Stage. Navigability is concerned with the percentage of months the water is above the elevation, and Lake Stage is concerned with the number of months the water is below the elevation. In tables 1 and 3 Navigability above 20% is shown in green and below 20% is shown in yellow.

Navigability (Figure 3) is related to the bottom elevation and assumes a Minimum Safe Navigational Depth (MSND) of 3 feet to safely operate a boat. A Navigability of 10% occurs at a bottom elevation of 83.65 (water surface elevation 86.65) and is the same as a Lake Stage of 90% which occurs at a water surface elevation 86.65. With the lake 90% full (Lake Stage) and a bottom elevation just 3 feet below that surface, at 83.65, it would only be possible to navigate for the 10% (Navigability) of the time the lake is above that elevation. A key element in Navigability is the MSND which for this study has been chosen to be 3 feet. The Navigability is found by adding the MSND of 3 feet to the top of mud elevation for a point, looking up the corresponding Lake Stage in
Table 2 then subtracting it from 100%.

Navigability = 100% - Lake Stage of (Mud Elevation + MSND)

Table 1 is broken into three groups: Average, Maximum, and Minimum. The Average section shows the average for all the points within each canal. The average Navigability does not match the Navigability as calculated above of the average Top of Mud since average Navigability is the average of the Navigabilities of each probe location in the canal. Since Navigability is not a linear function of elevation the individual average will not match the group average. This average Navigability does not truly represent the access to the canal. It is simply used to give an indication of the quality of the canal as a whole. It was found that there is often a shallow restriction near the entrance of each canal. This would, of course, prevent access to the deeper parts of the canal in a low water situation. Conversely some canals have very shallow terminal ends which will also skew the overall result for the canal.

The Maximum section shows the highest bottom point elevation, thickest mud, and highest top of mud elevation for each canal. You may note the bottom elevations and mud thicknesses do not add up. It is rare that the thickest mud is at the highest bottom elevation. Mud usually accumulates in the low points (as shown in Figure 3) while it is usually cleared from the high points by boat movement. Here the Navigability is directly related to the associated elevation. This is because each is a single number rather than a composite of many. The minimum elevation is related to the maximum Navigability which explains why the largest Navigability is shown in the minimum row.

The Minimum section shows the lowest bottom point elevations and least mud thicknesses. The data relationships are similar to how they were described in the previous paragraph.

A summary of the average state of the canals in 2005 and 2010 is shown visually in Figures 4 and 5 respectively. These show the average bottom elevation of each canal with the average mud thickness stacked on top. Here the Navigability (read off the right hand scale) is an average of the Navigability of each probe location in the canal. These are the best charts to quickly compare the condition of each canal.

The highest canal elevations and thickest mud for each canal in both 2005 and 2010 is illustrated in Figures 6 and 7 respectively. These charts are a reasonable second check for potential restricted points in the canals. The sand bars illustrate the highest hard bottom in the canals. The mud bar on top of them illustrates the thickest mud in each canal. The top of the mud bar does not represent a real elevation in the canal since the thickest mud usually occurs in the deeper parts of the canal while the thinnest mud usually occurs at the shallowest locations (shown in this chart). The Navigability for this chart was determined from the actual shallowest mud elevation. For the most part the shallow areas occur at either the entrance or the end of the canals.

The lowest canal elevations and thinnest mud for each canal in 2005 and 2010 is illustrated in Figures 8 and 9 respectively. These charts show the elevation of the deepest holes in each canal. The Navigability shown here is for these deep locations only. To see the true relationship of the mud and bottom elevation at each probe location use the Canal Profiles described in the next section.
Canal Profiles

To get a good understanding of the true navigability of the canals it is best to look at the individual profiles of the canal bottom. To the right is a listing of the Canals, the Dates of data collection, the Map Sheets on which they are shown, and the Figure numbers where you may see each profile. The bottom of each chart shows the probe location number which can be found on the Map Sheet as referenced below the figure title. The probe point numbers are arranged so the lowest point number (left end of chart) is at the entrance to the canal and the highest point number is at the closed end of the canal. Exceptions to this rule are Hoffner, Montmart, and Venetian canals which have an entrance at each end.

The figures show the sand elevation, top of mud elevation, and Navigability for each probe location on each canal. Heavier lines show the same data for the re-visited probe locations. All of these charts are set up with the same vertical scale making visual comparison possible. With some of the larger canals, such as Hoffner, Landings, and Venetian, the probe locations are not entirely in order of the line of natural travel. Some points were interspersed from lobes to avoid the necessity of additional charts with few data points. Using the map sheets as a reference one can connect the points of interest on the charts to get an approximate profile. Remember, these probes only represent depths a particular locations and do not show all of the variations in canal depths.

In 2005 the median mud thickness was 1.06 feet, and only 10 readings showed mud thicknesses greater than 2.8 feet. None of these occur at a bottom elevation that would have restricted navigation at any expected water level. In general, greater mud depths occur in greater water depths and consequently have no effect on the navigability of the water body.

In 2005 the Lisa, Harbour Oaks, Mandalay Shores, and Waterfront canals were very heavy in weed growth even though the mud depths were not extraordinary.

2010

The 2010 data was actually collected over a period of time from March 2010 to August 2011. Table 3, 2010 Canal Summary Data, contains the summary data. It shows the average, maximum and minimum elevation data for each canal. These data items are as described earlier for Table 1. Additionally, the absolute change in these parameters and the annual rate of change is also reported. A summary chart of the absolute change can be found in Figure 10. The annual rate of change was derived by dividing the absolute change by the number of years between the readings.
The rate of change in Navigability is not directly proportional to the rate of change of top of mud elevation. Navigability is a statistical number based on 30 years of lake elevation data and its rate of change depends on what absolute elevation is being considered. Elevation differences at either end of the Navigability scale will result in small changes in the actual Navigability. In the center of the scale a small elevation change will have a greater effect. On this basis it is not possible to predict future navigability simply by multiplying the Navigability rate of change by a number of years. The proper way to predict a future Navigability is to multiply the rate of change of top of mud by the number of years of interest then add that to the original top of mud elevation. With that new elevation use Table 2 to find the Lake Stage and use the Navigability formula on page 5 to find the new Navigability value.

The Nav. Rating was developed to create a single number which assesses the long term quality of the canal based on Navigability and rate of degradation. It is shown as the right-most column in Table 3. This value represents the expected number of years it will take for the canal to silt in (based on the current annual rate of siltation) to the point that it will have a Navigability of 20% (Min. Normal Navigation Elevation).

Nav. Rating = (Top of Mud Elevation – Min. Normal Navigation Elevation)/Annual Siltation Rate

This means a canal with a Nav. Rating of zero (0) years would already be silted in to the point where the top of the mud is at an elevation of 83.35 (based on the 2010 Lake Stage of 80%). This is where the mud is at a level 3 feet (MSND) below the water surface when the lake is at a level of 86.35. Given the lake water surface elevation of 85.74 (as it was at on 11/10/2010 during this study) a canal in this same condition would not be considered passable since the water depth would only be 2.39 feet.

The Nav. Ratings of the 16 canals tested varied widely from -74 years for Venice to 1161 years for Gatlin with an average rating of 197 years. Venice Canal’s negative Nav. Rating indicates the canal is actually getting deeper. This is understandable since it was de-mucked in 2009 resulting in the lower bottom elevations and improved navigability. Unfortunately, no data was collected immediately prior to the de-mucking so it is not possible to determine the actual siltation rate of that canal. Backacre’s unusually high Nav. Rating is a result of virtually no change in average top of mud elevation. Barbie and Willoughby canals have low Nav. Ratings since they are relatively shallow and have relatively high siltation rates.

It was found the GPS positions were not nearly as reliable as visual alignment with property lines. Over all the average accuracy of the positions was about four feet by four feet. However, the variance was as much as 50 feet. On that basis visual orientation is considered the more reliable method. The GPS points were a second check to avoid blunders such as alignment with the wrong property line. Most of the GPS “error” can be attributed to satellite timing variances intentionally entered into the public GPS signals at the system level. These effectively make it impossible to reacquire an exact point without extremely long observation times or a differential GPS system using a known base point. In the future the use of photographic alignment evidence will make re-acquisition of the probe locations more consistent. Based on the narrowness of the canals and the usage of property lines as alignment points it is estimated the points were re-acquired to within less than 3 feet along the axis of the canal and about 5 feet laterally in the canal.

The imprecision of the re-acquired points could lead one to conclude the data is not reliable. The fact that some probe points showed a deeper bottom reading supports this. However, the average difference of all bottom elevation points for 2005 and 2010 is 0.28 feet indicating an overall reasonable correlation. Since the objective is simply to get a handle on the siltation rate it is not necessary to have absolute accuracy in the locations. With sufficient data points the errors of location average out. Also photo records of each probe location transmitted with this report will improve the locational accuracy of future studies.
Specific Probe Issues

Anomalies in some of the data points indicate possible probe location errors. These are listed according to the canal order used for the profiles.

Lisa – Probes 42-45 – This area was not dredged in 2010 but appears to have had substantial siltation.
Lisa – Probes 45-48 – This area was dredged in 2010.
Lisa – Probe 48 – This location does not have any associated location photos.
Venice – Probes 79-82 – This canal was de-mucked in 2009.
Venice – Probes 153 – This is a new probe location created in 2010.
Waterfront – Probe 90 – This is a new probe location created in 2010.
Hoffner – Probe 152 – This is a new probe location created in 2010. It is directly under the Hoffner Bridge.
Montmart – Probes 144-149 – This canal is fairly wide with an irregular bottom created by dredging when the subdivision was built. It is suspected most of the variation in elevations was due to error of location. This is the deepest canal in the system and is 100% navigable.
Venetian – Probes 129-137 – This canal was dredged in 2009.
Venetian – Probe 134 – This is only 8’ from the headwall at the end of the canal.
Venetian – Probe 139 – This is apparently a poor replication of the 2005 location. 2011 photographs should make it easier to relocate in 2015.
Venetian – Probe 140 – This was relocated to a more meaningful and easier to relocate location in 2011.
Landings – Probes 99, 104-106 – These are probably poorly relocated in 2010. Photographic information should improve location in 2015.
Barby – Probe 110 – This area appears to have been scoured by propeller wash during a period of low water (2007) between measurements. This canal is in the poorest overall condition of those surveyed.

Conclusion

In general it was found the mud levels in the canals were an average of 0.93’ which is less than the 2005 average of 1.01’ for the same canals in 2005. Since the thicker mud was found in the deeper sections this number somewhat overstates the mud in the shallower reaches of the canals. The average siltation rate was found to be about 0.04’ (or ½”) per year for sand and -0.01” (or 1/8”) per year for the mud. This effectively results in the top of mud rising 0.03’ per year. This indicates the mud is not really the issue but it is the sand being washed in from the canal sides.

The only canals which improved in the last 5 years are those which have been de-mucked or dredged. The others have, on the average, decreased their navigability by only 2.3%. The de-mucked canals have navigability which has improved by 25% for Lisa, 3% for Venice, and 19% for Venetian. Gatlin canal is virtually unchanged. The canals in the poorest condition are Barby and Willoughby.

It is known deeper canals allow water to pass more slowly around boats traveling in them. Slower moving water decreases the scour rate and reduces the rate of erosion of the canal side walls. As a consequence, slow travel speed in canals will serve to extend the canals’ serviceable life.
Recommendations

1. It is recommended that this study be repeated every five years to provide a consistent gauge of quality of the canals.

2. It is recommended two digital photographs be taken from each probe location in future studies to document the visual state of the canals and more precisely define the probe point. To maintain consistency these images should be 1600x1200 pixel resolution and be taken from the probe location toward aligning landmarks at approximately 90° to each other in a clockwise order. Each photo should be clearly marked with the probe number, date, and water surface elevation.

3. In the event of a canal cleaning or de-mucking it is recommended supplementary data is collected within a year both before and after the cleaning to provide siltation rate data and new baseline data for that canal.

4. Boaters should travel at minimum speed in canals to reduce the rate of sidewall erosion.

5. Property owners can slow the rate of canal degradation by keeping yard debris out of the canals.

6. In order to maintain consistency in analysis and decision making it is recommended the Orange County Lake Conway Water and Navigation Control District Advisory Board (Nav. Board) consider the ramifications of the base values which lead to the indicators used in this report. The key base values are:

   a. Minimum Safe Navigational Depth (MSND) – This is the minimum distance from the surface to the bottom of a body of water necessary to allow navigation of most watercraft without endangering people or wildlife and without causing damage to either the vessel or habitat. This could be broken down further to MSNDs for various vessel speeds. It is recommended this be established at a depth of between 3.0 and 3.5 feet.

   b. Normal Minimum Navigability% - This is the percentage of time it would be expected over the course of 30 years that it would not be possible to operate a vessel with at least the Minimum Safe Navigational Depth. This value needs to be established as a balance between the cost of maintaining the MSND compared to the inconvenience of the vessel operators. It is not possible to set this at 100% as it would necessitate dredging and installation of new seawalls in many of the canals at a cost far in excess of the tax revenue available. It is recommended this value be set between 20% and 30%.

7. The Orange County Lake Conway Water and Navigation Control District Advisory Board should consider the use of Nav. Ratings as described in this document as a method of determining which canals may be in need of maintenance.
Tables
Table 1, 2005 Canal Summary Data

2005 Canal Summary Data

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Gatlin</td>
<td>79.55</td>
<td>1.2</td>
<td>80.75</td>
<td>84%</td>
<td>80.96</td>
<td>5.6</td>
<td>81.06</td>
<td>80%</td>
<td>74.56</td>
<td>0.1</td>
<td>80.16</td>
<td>91%</td>
</tr>
<tr>
<td>Harbour Oaks</td>
<td>78.92</td>
<td>1.4</td>
<td>80.36</td>
<td>89%</td>
<td>80.06</td>
<td>3.0</td>
<td>80.76</td>
<td>84%</td>
<td>77.06</td>
<td>0.7</td>
<td>79.96</td>
<td>93%</td>
</tr>
<tr>
<td>Lisa</td>
<td>81.06</td>
<td>1.6</td>
<td>82.62</td>
<td>45%</td>
<td>84.56</td>
<td>2.6</td>
<td>85.06</td>
<td>0%</td>
<td>78.06</td>
<td>0.2</td>
<td>80.66</td>
<td>85%</td>
</tr>
<tr>
<td>Mandalay</td>
<td>79.19</td>
<td>1.3</td>
<td>80.46</td>
<td>87%</td>
<td>80.26</td>
<td>2.1</td>
<td>81.16</td>
<td>78%</td>
<td>77.56</td>
<td>0.3</td>
<td>79.66</td>
<td>97%</td>
</tr>
<tr>
<td>Backacre</td>
<td>79.72</td>
<td>1.2</td>
<td>80.96</td>
<td>80%</td>
<td>81.36</td>
<td>2.0</td>
<td>81.86</td>
<td>66%</td>
<td>78.46</td>
<td>0.1</td>
<td>80.16</td>
<td>91%</td>
</tr>
<tr>
<td>Overlake</td>
<td>79.53</td>
<td>0.6</td>
<td>80.16</td>
<td>91%</td>
<td>80.16</td>
<td>1.6</td>
<td>80.46</td>
<td>88%</td>
<td>78.66</td>
<td>0.3</td>
<td>79.56</td>
<td>97%</td>
</tr>
<tr>
<td>Venice</td>
<td>80.14</td>
<td>0.6</td>
<td>80.69</td>
<td>84%</td>
<td>80.46</td>
<td>0.7</td>
<td>80.96</td>
<td>81%</td>
<td>79.66</td>
<td>0.5</td>
<td>80.16</td>
<td>91%</td>
</tr>
<tr>
<td>Waterfront</td>
<td>80.56</td>
<td>0.5</td>
<td>81.01</td>
<td>79%</td>
<td>82.16</td>
<td>0.9</td>
<td>82.16</td>
<td>59%</td>
<td>79.26</td>
<td>0.0</td>
<td>79.66</td>
<td>97%</td>
</tr>
<tr>
<td>Hoffner</td>
<td>76.27</td>
<td>1.2</td>
<td>77.45</td>
<td>92%</td>
<td>81.26</td>
<td>3.7</td>
<td>81.26</td>
<td>78%</td>
<td>68.06</td>
<td>0.0</td>
<td>71.46</td>
<td>100%</td>
</tr>
<tr>
<td>Montmart</td>
<td>72.74</td>
<td>2.4</td>
<td>75.12</td>
<td>100%</td>
<td>77.09</td>
<td>4.2</td>
<td>77.29</td>
<td>100%</td>
<td>68.79</td>
<td>0.2</td>
<td>70.79</td>
<td>100%</td>
</tr>
<tr>
<td>Venetian</td>
<td>79.39</td>
<td>1.2</td>
<td>80.55</td>
<td>67%</td>
<td>82.79</td>
<td>5.7</td>
<td>83.39</td>
<td>22%</td>
<td>68.56</td>
<td>0.0</td>
<td>72.89</td>
<td>100%</td>
</tr>
<tr>
<td>Landings</td>
<td>78.40</td>
<td>1.0</td>
<td>79.42</td>
<td>93%</td>
<td>81.67</td>
<td>2.9</td>
<td>81.77</td>
<td>68%</td>
<td>75.57</td>
<td>0.1</td>
<td>77.37</td>
<td>100%</td>
</tr>
<tr>
<td>Barby</td>
<td>81.33</td>
<td>0.9</td>
<td>82.27</td>
<td>54%</td>
<td>82.72</td>
<td>3.9</td>
<td>84.41</td>
<td>0%</td>
<td>77.92</td>
<td>0.0</td>
<td>80.92</td>
<td>81%</td>
</tr>
<tr>
<td>Willoughby</td>
<td>81.22</td>
<td>0.3</td>
<td>81.48</td>
<td>71%</td>
<td>82.02</td>
<td>0.8</td>
<td>82.12</td>
<td>59%</td>
<td>80.12</td>
<td>0.0</td>
<td>80.92</td>
<td>81%</td>
</tr>
<tr>
<td>Ave.</td>
<td>79.14</td>
<td>1.1</td>
<td>80.24</td>
<td>80%</td>
<td>81.25</td>
<td>2.8</td>
<td>81.69</td>
<td>62%</td>
<td>75.88</td>
<td>0.2</td>
<td>78.17</td>
<td>93%</td>
</tr>
<tr>
<td>Max.</td>
<td>81.33</td>
<td>2.4</td>
<td>82.62</td>
<td>45%</td>
<td>84.56</td>
<td>5.7</td>
<td>85.06</td>
<td>0%</td>
<td>80.12</td>
<td>0.7</td>
<td>80.92</td>
<td>81%</td>
</tr>
<tr>
<td>Min.</td>
<td>72.74</td>
<td>0.3</td>
<td>75.12</td>
<td>100%</td>
<td>77.09</td>
<td>0.7</td>
<td>77.29</td>
<td>100%</td>
<td>68.06</td>
<td>0.0</td>
<td>70.79</td>
<td>100%</td>
</tr>
</tbody>
</table>

Canals are arranged by display sheet
Navigability is based on 1979 - 2010 Lake Stage criteria.

Color Legend
Acceptable
Unacceptable
Table 2, Lake Conway Lake Stage 1981 - 2010

<table>
<thead>
<tr>
<th>Elev.</th>
<th>Stage</th>
<th>Elev.</th>
<th>Stage</th>
<th>Elev.</th>
<th>Stage</th>
<th>Elev.</th>
<th>Stage</th>
</tr>
</thead>
<tbody>
<tr>
<td>83.0</td>
<td>7.22%</td>
<td>83.0</td>
<td>7.22%</td>
<td>85.0</td>
<td>38.33%</td>
<td>87.0</td>
<td>98.61%</td>
</tr>
<tr>
<td>83.1</td>
<td>9.44%</td>
<td>83.1</td>
<td>9.44%</td>
<td>85.1</td>
<td>40.56%</td>
<td>87.1</td>
<td>98.61%</td>
</tr>
<tr>
<td>81.2</td>
<td>0.00%</td>
<td>81.2</td>
<td>0.00%</td>
<td>85.2</td>
<td>42.50%</td>
<td>87.2</td>
<td>99.44%</td>
</tr>
<tr>
<td>81.3</td>
<td>0.28%</td>
<td>81.3</td>
<td>0.28%</td>
<td>85.3</td>
<td>44.72%</td>
<td>87.3</td>
<td>99.72%</td>
</tr>
<tr>
<td>81.4</td>
<td>0.56%</td>
<td>81.4</td>
<td>0.56%</td>
<td>85.4</td>
<td>46.39%</td>
<td>87.4</td>
<td>100.00%</td>
</tr>
<tr>
<td>81.5</td>
<td>0.56%</td>
<td>81.5</td>
<td>0.56%</td>
<td>83.5</td>
<td>14.17%</td>
<td>85.5</td>
<td>48.06%</td>
</tr>
<tr>
<td>81.6</td>
<td>1.11%</td>
<td>81.6</td>
<td>1.11%</td>
<td>83.6</td>
<td>15.00%</td>
<td>85.6</td>
<td>51.11%</td>
</tr>
<tr>
<td>81.7</td>
<td>1.39%</td>
<td>81.7</td>
<td>1.39%</td>
<td>83.7</td>
<td>16.39%</td>
<td>85.7</td>
<td>54.44%</td>
</tr>
<tr>
<td>81.8</td>
<td>1.67%</td>
<td>81.8</td>
<td>1.67%</td>
<td>83.8</td>
<td>17.78%</td>
<td>85.8</td>
<td>58.89%</td>
</tr>
<tr>
<td>81.9</td>
<td>1.67%</td>
<td>81.9</td>
<td>1.67%</td>
<td>83.9</td>
<td>19.17%</td>
<td>85.9</td>
<td>62.22%</td>
</tr>
<tr>
<td>82.0</td>
<td>1.67%</td>
<td>82.0</td>
<td>1.67%</td>
<td>84.0</td>
<td>19.72%</td>
<td>86.0</td>
<td>65.83%</td>
</tr>
<tr>
<td>82.1</td>
<td>1.67%</td>
<td>82.1</td>
<td>1.67%</td>
<td>84.1</td>
<td>21.67%</td>
<td>86.1</td>
<td>68.89%</td>
</tr>
<tr>
<td>82.2</td>
<td>1.94%</td>
<td>82.2</td>
<td>1.94%</td>
<td>84.2</td>
<td>22.22%</td>
<td>86.2</td>
<td>72.50%</td>
</tr>
<tr>
<td>82.3</td>
<td>1.94%</td>
<td>82.3</td>
<td>1.94%</td>
<td>84.3</td>
<td>24.72%</td>
<td>86.3</td>
<td>77.78%</td>
</tr>
<tr>
<td>82.4</td>
<td>1.94%</td>
<td>82.4</td>
<td>1.94%</td>
<td>84.4</td>
<td>26.67%</td>
<td>86.4</td>
<td>81.94%</td>
</tr>
<tr>
<td>82.5</td>
<td>2.78%</td>
<td>82.5</td>
<td>2.78%</td>
<td>84.5</td>
<td>28.06%</td>
<td>86.5</td>
<td>85.28%</td>
</tr>
<tr>
<td>82.6</td>
<td>3.06%</td>
<td>82.6</td>
<td>3.06%</td>
<td>84.6</td>
<td>31.67%</td>
<td>86.6</td>
<td>88.61%</td>
</tr>
<tr>
<td>82.7</td>
<td>3.61%</td>
<td>82.7</td>
<td>3.61%</td>
<td>84.7</td>
<td>32.50%</td>
<td>86.7</td>
<td>91.67%</td>
</tr>
<tr>
<td>82.8</td>
<td>5.00%</td>
<td>82.8</td>
<td>5.00%</td>
<td>84.8</td>
<td>33.89%</td>
<td>86.8</td>
<td>94.72%</td>
</tr>
<tr>
<td>82.9</td>
<td>6.67%</td>
<td>82.9</td>
<td>6.67%</td>
<td>84.9</td>
<td>35.83%</td>
<td>86.9</td>
<td>98.06%</td>
</tr>
</tbody>
</table>

The percentages shown are the percent of time during the referenced 30 years where water surface was below the specified elevation. The range in green represents "normal" water levels. The Orange County Normal High Water is shown in dark pink. The nominal weir elevation is 86.4.
### Table 3, 2010 Canal Summary Data

<table>
<thead>
<tr>
<th>Canal</th>
<th>Bottom Elev.</th>
<th>Mud Thick.</th>
<th>Top Elev.</th>
<th>Mud Thick.</th>
<th>Absolute</th>
<th>Change</th>
<th>Annual Rate of Change</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>80.12</td>
<td>0.7</td>
<td>80.77</td>
<td>83%</td>
<td>0.57</td>
<td>-0.55</td>
<td>0.02</td>
<td>1%</td>
</tr>
<tr>
<td>Gatlin</td>
<td>79.34</td>
<td>1.4</td>
<td>80.76</td>
<td>83%</td>
<td>0.42</td>
<td>-0.02</td>
<td>0.40</td>
<td>-6%</td>
</tr>
<tr>
<td>Harbour Oaks</td>
<td>80.70</td>
<td>0.9</td>
<td>81.60</td>
<td>70%</td>
<td>-0.36</td>
<td>-0.66</td>
<td>-1.02</td>
<td>25%</td>
</tr>
<tr>
<td>Lisa</td>
<td>79.51</td>
<td>1.0</td>
<td>80.51</td>
<td>86%</td>
<td>0.31</td>
<td>-0.27</td>
<td>0.05</td>
<td>-1%</td>
</tr>
<tr>
<td>Mandalay</td>
<td>80.08</td>
<td>0.9</td>
<td>81.00</td>
<td>80%</td>
<td>0.36</td>
<td>-0.32</td>
<td>0.04</td>
<td>0%</td>
</tr>
<tr>
<td>Backacre</td>
<td>79.92</td>
<td>0.4</td>
<td>80.36</td>
<td>88%</td>
<td>-0.15</td>
<td>-0.13</td>
<td>-0.27</td>
<td>3%</td>
</tr>
<tr>
<td>Venice</td>
<td>80.61</td>
<td>0.5</td>
<td>81.11</td>
<td>78%</td>
<td>0.05</td>
<td>0.04</td>
<td>0.09</td>
<td>-2%</td>
</tr>
<tr>
<td>Waterfront</td>
<td>76.68</td>
<td>1.1</td>
<td>77.82</td>
<td>91%</td>
<td>0.08</td>
<td>0.04</td>
<td>0.12</td>
<td>0%</td>
</tr>
<tr>
<td>Hoffner</td>
<td>73.76</td>
<td>1.9</td>
<td>75.68</td>
<td>100%</td>
<td>0.12</td>
<td>-0.47</td>
<td>0.55</td>
<td>0%</td>
</tr>
<tr>
<td>Montmart</td>
<td>78.06</td>
<td>1.2</td>
<td>79.21</td>
<td>85%</td>
<td>-1.34</td>
<td>0.00</td>
<td>-1.34</td>
<td>-19%</td>
</tr>
<tr>
<td>Venice</td>
<td>81.43</td>
<td>1.04</td>
<td>82.48</td>
<td>49%</td>
<td>0.10</td>
<td>0.11</td>
<td>0.21</td>
<td>-5%</td>
</tr>
<tr>
<td>Waterfront</td>
<td>80.24</td>
<td>2.4</td>
<td>80.74</td>
<td>84%</td>
<td>0.38</td>
<td>0.80</td>
<td>0.58</td>
<td>12%</td>
</tr>
<tr>
<td>Average</td>
<td>81.14</td>
<td>3.0</td>
<td>81.14</td>
<td>78%</td>
<td>2.58</td>
<td>0.20</td>
<td>0.28</td>
<td>5%</td>
</tr>
<tr>
<td>Maximum</td>
<td>80.24</td>
<td>1.8</td>
<td>81.64</td>
<td>68%</td>
<td>1.28</td>
<td>0.70</td>
<td>0.88</td>
<td>2%</td>
</tr>
<tr>
<td>Minimum</td>
<td>80.12</td>
<td>0.7</td>
<td>80.77</td>
<td>83%</td>
<td>0.57</td>
<td>-0.55</td>
<td>0.02</td>
<td>1%</td>
</tr>
</tbody>
</table>

Canals are arranged by display sheet. Color Legend:
- Acceptable/Improved
- Unacceptable/Degraded
Navigatability is based on 1979 - 2010 Lake Stage criteria.
Figures
Lake Conway 2005 Average Canal Bottom Elevations

Lake Conway 2010 Average Canal Bottom Elevations

Figure 4

Figure 5
Mandalay Canal 2005 - 2011 Bottom Elevations

Backacre Canal 2005 - 2010 Bottom Elevations

Figure 14

Figure 15
Lake Conway 2010 Canal Siltation Study Figures

Venice Canal 2005 - 2010 Bottom Elevations
(Sheet 4)

Waterfront Canal 2005 - 2010 Bottom Elevations
(Sheet 4)
Lake Conway 2010 Canal Siltation Study Figures

Hoffner Canal 2005 - 2010 Bottom Elevations
(Sheet 6)

Montmart Canal 2005 - 2010 Bottom Elevations
(Sheet 6)
Sheets