

To:	Matt Moore, South Washington Watershed District		
From:	HDR Engineering, Inc.	Project:	Wilmes Lake Overflow Study
cc:	File		
Date:	12/10/07	Job No:	58355-164

**Re: Wilmes Lake Overflow Study**

**EXECUTIVE SUMMARY**

This memorandum is supplemental to the SWWD Storm Water Modeling Report dated July 2006. The conclusion is consistent with that report; Non-structural improvements are recommended to mitigate potential flood damages at Wilmes Lake. The results indicate that for the standard design event, there is minimal to no reduction at Wilmes Lake and there are downstream impacts at Lakeview Park Pond and at Powers Lake if overflow from Wilmes Lake is conveyed to these locations. Additionally, the benefits gained from an improved overflow for events larger than the design event are minimal. There are safety considerations to the overland flow options that need to be carefully evaluated. The Flood Proofing Grant program that the City of Woodbury is planning is a good example of a non-structural change and will provide the optimum solutions for protection from flooding at Wilmes Lake.

Based on the results of the present analysis, a safe overflow option is not economically viable and a low cost option is not very safe. The maximum stage reduction achieved with a pipe installed and for a 7.8-inch event, which is larger than the design event, is one foot and costs \$1.45 million. In addition, potential flood damages are incurred downstream at both Powers Lake and Lakeview Park Pond. Downstream impacts increase potential flooding of structures and associated flood damages beyond current conditions. Of particular concern, the overflow causes additional flooding and adverse downstream impact at Lakeview Park Pond and Powers Lake, which is contrary to watershed and City policy.

All the overflow options for Wilmes Lake:

- 1) provide minimal benefits in terms of reductions to potential flood damages around Wilmes Lake
- 2) increase flooding risks to downstream properties around Lakeview Pond and at Powers Lake
- 3) pose potential safety risks in the case of surface overflow options
- 4) provide no feasible option to mitigate flood elevations around Lakeview Pond due to insufficient hydraulic gradients to move the water from Lakeview Pond to Powers Lake
- 5) and have high capital costs.

Given these facts, HDR does not recommend construction of or modifications to the Wilmes Lake overflow. The City of Woodbury and the SWWD should continue to pursue flood mitigation solutions, such as the non-structural solutions, recommended in previous study reports and as currently implemented by the City of Woodbury and the SWWD.

## **BACKGROUND**

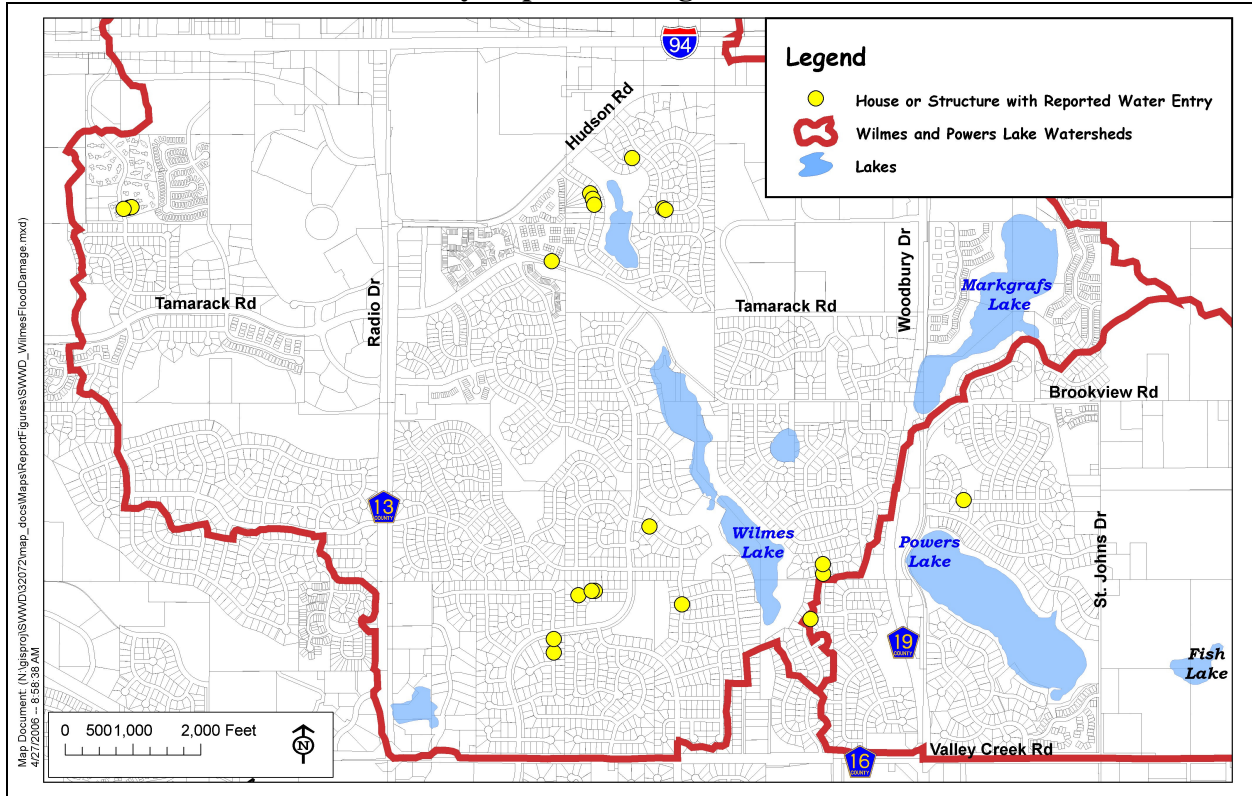
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On October 4-5, 2005 (October Storm), a large storm event over Washington County caused high water levels throughout the watershed, including Wilmes Lake. The October Storm's average intensity and overall volume for the storm duration exceeded the traditional design storm for the existing drainage system. The Standard Design Storm adopted by the South Washington Watershed District (SWWD) in 2002 is the 6.3-inch, 24-hour event with a SCS Type II distribution, replacing the 5.9-inch, 24-hour event. The October Storm spurred documented reports of houses and other structures with various degrees of water entry, within the City of Woodbury. Figure 1 shows the locations of the flooding complaints that were received during the October Storm in the vicinity of Wilmes Lake. In general, the majority of reported water intrusion or minor flooding was caused by surface stormwater flows. Damages due to high water elevations in Wilmes Lake were minimal with reports of water in one or two basements.

Following the October Storm, HDR Engineering, Inc. (HDR) completed a detailed analysis of the rainfall event and the associated watershed response and issued a report to the SWWD in July 2006. The report included details of the storm water model updates, analysis of the rainstorm, detailed event modeling that included discretized rainfall data generated from radar traces of the October Storm, and preliminary discussion of possible mitigation alternatives.

The SWWD, responding to a request by the City of Woodbury, has directed HDR to further analyze the option to improve the operation and safety of the emergency overflow from Wilmes Lake. The 2006 report indicated using downstream impacts and was not fully analyzed during the effort for that report. This memorandum is supplemental to that report, further analyzing overflow improvement options that allow excess storm water from Wilmes Lake to flow to Powers Lake.

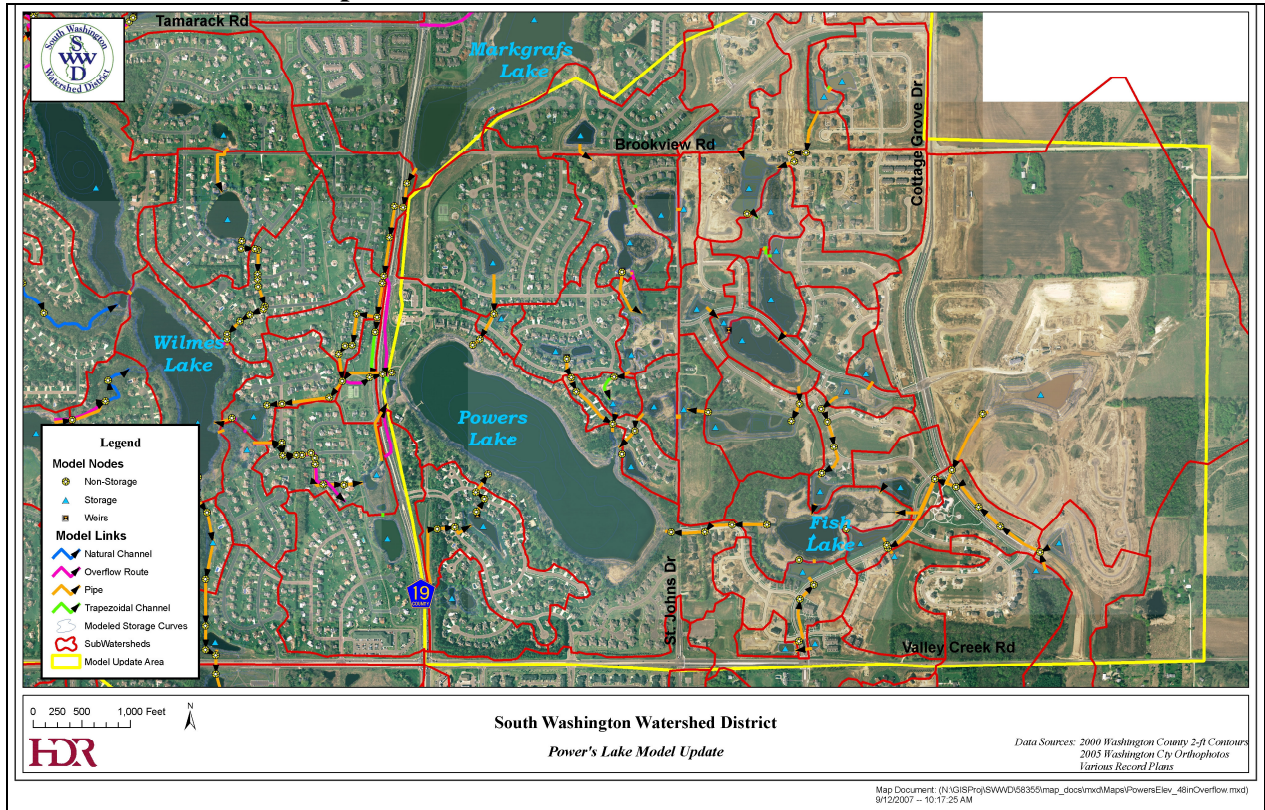
**Figure 1**  
**Water Entry Reports during the October Storm**



**MODEL UPDATES**

The storm water model information for the Powers Lake Watershed was updated to the present development conditions. Record and construction plans provided by Bonestroo and the City of Woodbury were utilized to update the watershed geodatabase to reflect the present storm sewer infrastructure. Survey information, obtained after the October Storm, was also added to the geodatabase. Figure 2 shows the updated areas within the watershed. The results for these model runs also reflect overall updates to the watershed model. These updates include changes to watershed flows based on the Bailey Lake watershed update, updated techniques to calculate percent impervious for the watersheds, and other land use changes within the watershed during the past year.

**Figure 2**  
**Updated areas of the Powers Lake Watershed**



## **MODELING AND ANALYSIS**

Modeling was completed to analyze the impacts of the overflow improvement options from Wilmes Lake. The pump station functions as the only outflow from Powers Lake and was set as inoperative during the present modeling process, except for a model run to determine the period of inundation at Powers Lake. The three main options modeled, as shown in Figure 3, are:

### ***1. Lowering Bike Path with Uncontrolled Street Overflow***

The October Storm resulted in street flow along Clippership Drive and Spinaker Drive, eventually entering the sewer system at the intersection of Spinaker Drive and Regatta Drive. The lowest cost option that can be used to improve the overflow from Wilmes Lake is to do limited grading to lower the bike path one foot (along which overflow occurred during the October Storm) to an elevation below the low-lying houses. The lowered bike path would connect directly to Clippership Drive and allow the flow to follow the road. Flows along residential streets will cause wear and tear on the pavement which can lead to failure over time.

### ***2. 36-inch Sewer to Lakeview Park Pond (PL2E1-1)***

This option looks at installing an outlet structure in wetland WL1S1-1 at an elevation of 908-ft and upgrading the existing outlet from a 15-inch pipe to a 36-inch pipe.

### ***3. 48-inch Sewer to Lakeview Park Pond (PL2E1-1)***

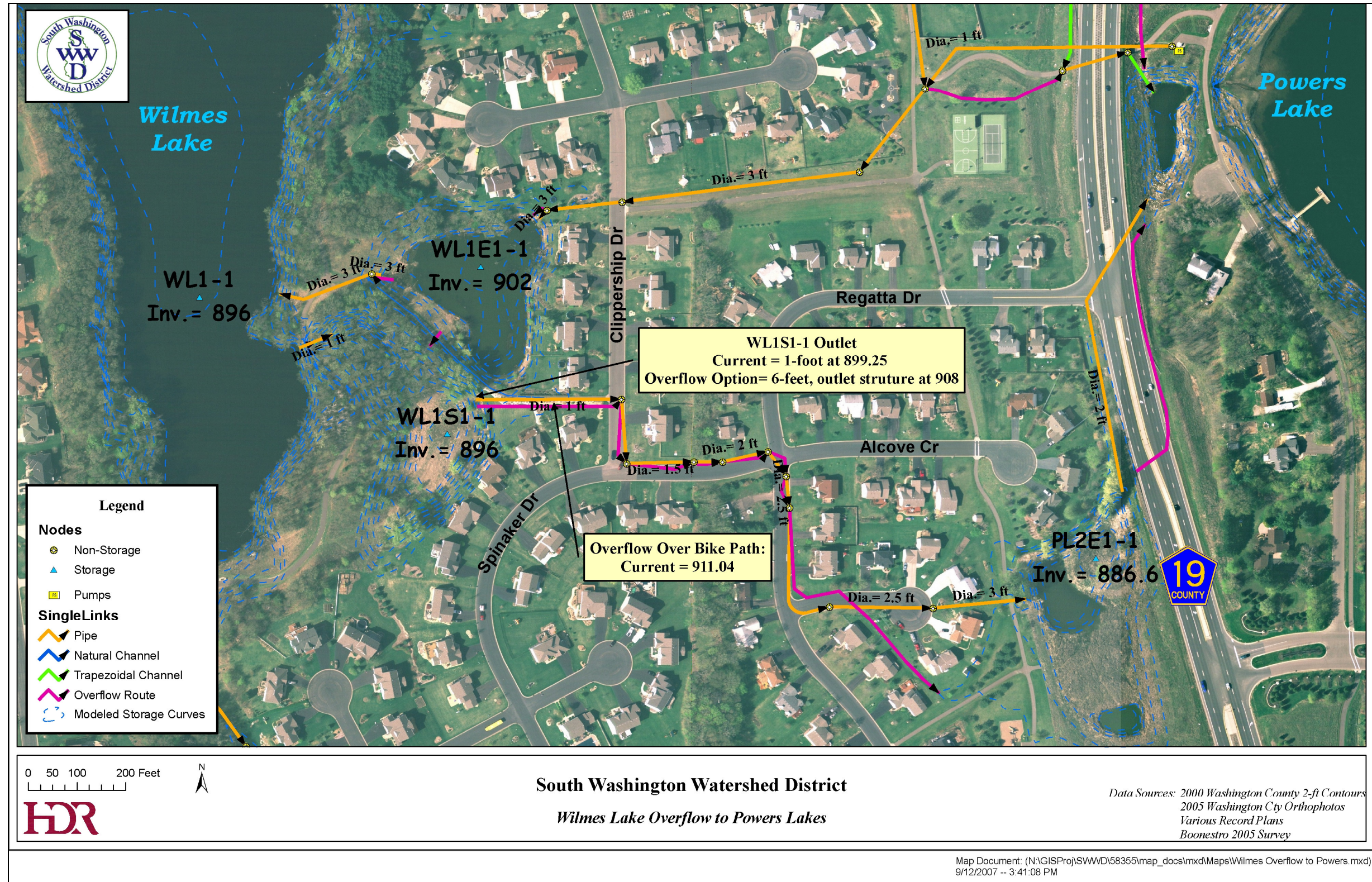
Similar to the 36-inch option, a 48-inch pipe option was also considered to provide increased overflow capacity from Wilmes Lake.

These options all direct additional storm water flow and volume to Lakeview Park Pond (PL2E1-1) and Powers Lake above the current conditions. The analysis explored impacts to the Lakeview Park Pond (PL2E1-1) and Powers Lake as a result of Wilmes Lake overflow improvements. Table 1 shows the modeling results at these locations.

For all of the options, the modeling results are presented as a change from the high water elevations in feet of lake level seen at Wilmes Lake, Lakeview Park Pond, and Powers Lake for the 6.3-inch, 24-hour Design Storm. Results calculated by the storm water model for the 6.3-inch event (Standard Design Storm), 7.8-inch event (90% confidence interval design storm), and the October 2005 event are presented for each overflow option studied. Note that results for the 7.8-inch and October Storm event are shown for comparison purposes. Additionally, the overflow does not activate for the Design Storm event

At present, the data sources that provide the rainfall depths for this region do not include information for return periods higher than the 100-year event. Both Technical Paper 40 and Bulletin 71 (Huff and Angel, 1992) include rainfall depths up to the 100-year event. The 7.8-inch rainfall depth is higher than the 100-year, 24-hour return period for this region. Hence, it is not possible to statistically equate the 7.8-inch event to a return period within the 50<sup>th</sup> percentile.

Figure 3  
Overflow Route from Wilmes Lake



**Table 1**  
**Change in Peak Elevation from Existing Conditions at Key Locations (feet)**

Option	Wilmes Lake			Powers Lake			Pond at Lakeview Park ( PL2E1-1)		
	6.3-inch event	7.8-inch event	October Storm	6.3-inch event	7.8-inch event	October Storm	6.3-inch event	7.8-inch event	October Storm
<b>1-Lowered Bike Path</b>	No street overflow	-0.4	-0.3	No street overflow	0.5	0.5	No street overflow	0.6	2.7
<b>2-36-inch sewer</b>	<b>-0.6</b>	-0.7	-1.1	<b>0.6</b>	2	1.7	<b>1.9</b>	2	4.3
<b>3-48-inch sewer</b>	<b>-0.6</b>	-1	NM*	<b>0.6</b>	2	NM*	<b>2</b>	2	NM*

\*NM= this alternative not modeled for the October 2005 event

***Cost versus Stage Reduction at Wilmes Lake***

As evident during the October Storm, Wilmes Lake can experience flooding conditions during an extreme storm event. As discussed in the July 2006 report, the modeling analysis of the October Storm was consistent with the watershed response for the storm event. Although Wilmes Lake reached a flood stage of approximately 911.7 ft during the October Storm, the actual damage to property and infrastructure at Wilmes Lake was minimal. As the primary goal for the emergency overflow is to provide flood mitigation at Wilmes Lake for an extreme storm event, stage reduction is used as a measure of the effectiveness for each option. Based on this measure of impact, a planning level cost per foot stage reduction at Wilmes Lake analysis was also completed for each of the above options. The planning level cost analysis for each option is listed in Appendix A.

**Table 2**  
**Cost per foot of Stage Reduction at Wilmes Lake**

Options	Estimated Cost to Install	6.3-inch, 24-hour event,	7.8-inch, 24-hour event	October Storm
<b>1-Lowered Bike Path</b>	\$25,000	-	\$71,500/ft	\$71,500
<b>2-36-inch sewer</b>	\$1,300,000	<b>\$2.1 mil/ft</b>	\$1.85 mil/ft	\$1.2 mil/ft
<b>3-48-inch sewer</b>	\$1,450,000	<b>\$2.5 mil/ft</b>	\$ 1.45 mil/ft	-

## DISCUSSION

The above results indicate that the overall impact of the improved overflow at Wilmes Lake is less than one foot. Results for all the overflow improvement options indicate downstream impacts which increase the risk of flooding for homes around Lakeview Park Pond. Surface routing of overflows also presents significant safety concerns. The impacts of each of the options are individually discussed below.

As previously mentioned, the 7.8-inch, 24-hour and October Storm events were modeled and analyzed for comparison purposes. It is important to note that the **surface overflow option does not activate for the Standard Design Storm**. The Standard Design Storm does not reach a stage high enough to trigger an overflow. Hence, the improved surface overflow option activates only for storm events larger than the 6.3-inch, 24-hour Standard Design Storm. Presently, the 100 year (1% probability) design storm is generally accepted as the standard for design and analysis of flood mitigation options within the SWWD.

### *Surface Overflow with Lowered Bike Path (option 1)*

The stage for the 6.3-inch, 24-hour design storm does not reach an elevation at Wilmes Lake to trigger overflow along the bike path. If a storm event larger than the Standard Design Storm is considered, such as a 7.8-inch, 24-hour event, the surface overflow can be about a foot deep with a velocity of 5.5 feet-per-second (Figure 4). This combination of flow depth and velocity falls within the “judgment zone” for hazardous flow conditions, as indicated in Figure 5, and is approaching the dangerous flow conditions. Additionally, as shown in Figure 4, the flow along the bike path and along the street lasts three days, which will significantly impact the service of these roads for the neighborhood. Using streets for significant flows can create failure of the pavement, added maintenance requirements, and debris issues that will have to be addressed. Reinforcing the streets with concrete pavement can help with the sustainability of overflow along the street, but is a costly addition.

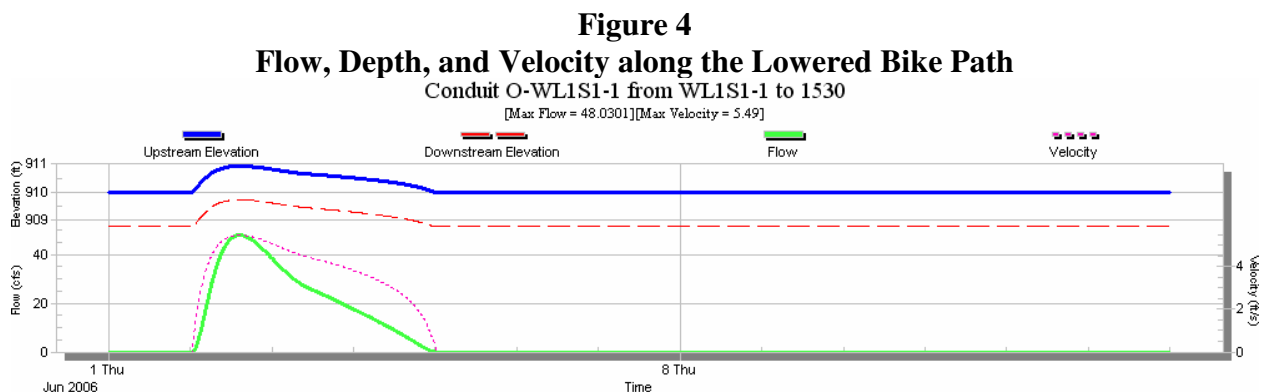
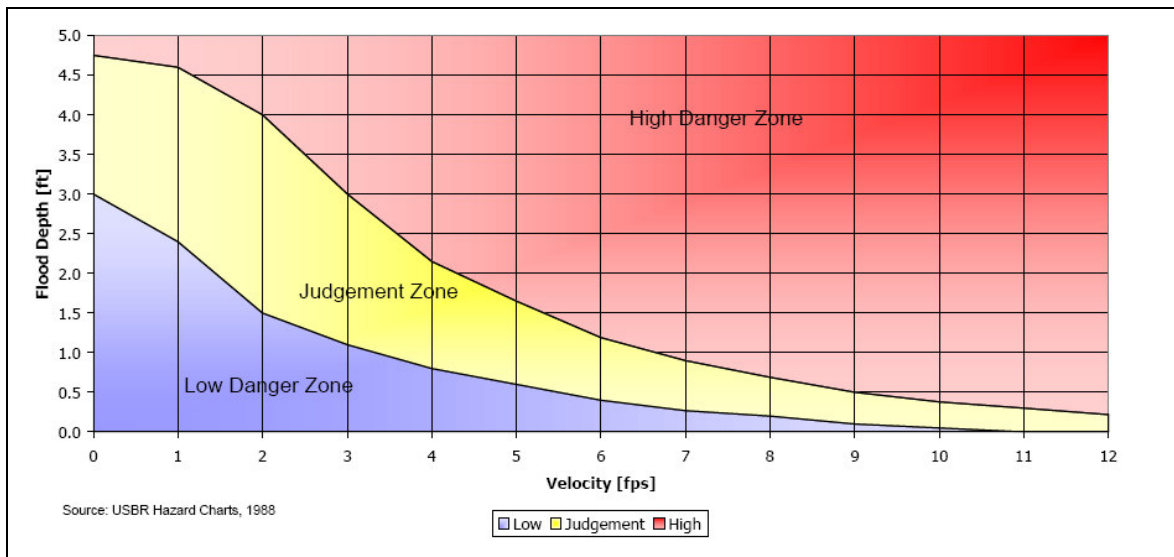


Figure 5 is taken from the United States Bureau of Reclamation Hazard Classification Document. This Figure provides a nomograph that classifies hazard conditions to humans during

surface flow conditions. An average human can stand in slower moving flows up to three feet deep. As the flow depth increases, careful judgment is needed prior to engaging the water in anyway. Higher velocity flows, those exceeding 7 feet per second, can be hazardous even at 6 inches of depth suggesting that a person can get washed away at this flow and depth. This figure provides a guide and is not a definitive determination of when flowing water can be dangerous to people, especially when younger children are concerned. Debris and other matter carried with the flow can create much more dangerous conditions even at much slower flow conditions than described in Figure 5.

**Figure 5  
Flood Danger for Adults**



### ***36-inch and 48-inch Piped Overflow***

Adding an outlet structure and improving the existing storm sewer from WL1S1-1 to a 36-inch or a 48-inch diameter pipe can provide a stage reduction at Wilmes Lake of approximately half of a foot for the Standard Design Storm and up to a foot for events larger than the 100-year storm. This option provides a safer overflow option from Wilmes Lake. The outlet control structure at the Lake can also be adjusted, which can add a degree of flexibility that is not possible when allowing overflow along the bike path. Based on available alignment, however, the upgraded pipe would have to be installed under the street, which makes this a rather expensive alternative to consider when the stage reduction at Wilmes Lake is only around one foot.

### ***Impacts to Downstream water bodies due to Overflow from Wilmes Lake***

As previously mentioned, the improved surface overflow (Option 1) does not activate for the Standard Design Storm and there is no impact at or downstream of Wilmes Lake. As indicated in Table 1, if storm events larger than the 100-year Standard Design Storm are considered, all the

options result in an increase in stage over the base condition at Lakeview Park Pond and Powers Lake.

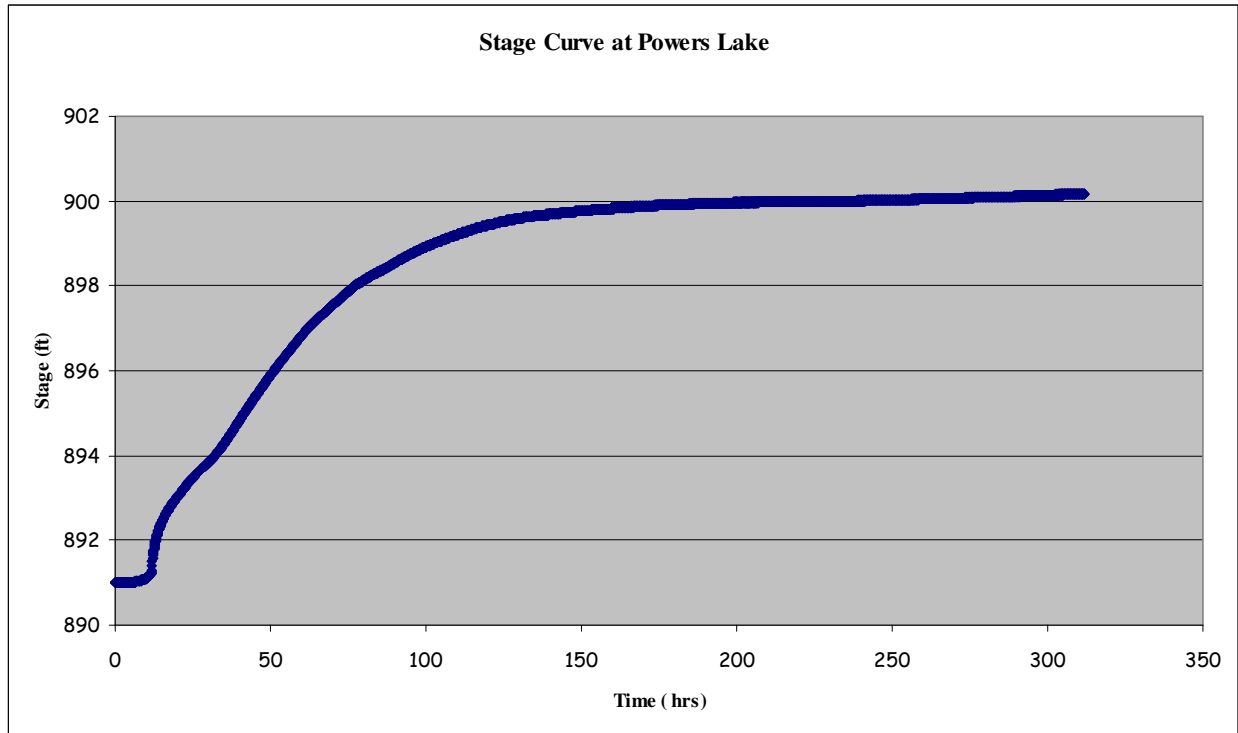
As indicated in Table 1, the increase in flood stage at Lakeview Park Pond is over 2.0 ft as a result of activating the Wilmes Lake overflow for the 7.8-inch event. Evaluation of the structures around Lakeview Park Pond was conducted based on the City of Woodbury freeboard criteria established by the City during the analysis of the October 2005 rainfall event. Figures B1 through B6 in Appendix B show the houses around Lakeview Park Pond. They are classified based on the criteria for both the existing and improved overflow options. Figure B-1 shows the impact at Lakeview Park Pond for the 6.3-inch, 24-hour event for both existing conditions and the lowered bike path options. Since the Standard Design Storm does not reach elevation 910 at Wilmes Lake, the downstream impacts are the same. The downstream impacts are similar for the 36- and 48-inch outlet options (Figure B-2) for the Standard Design Storm, with six properties having some flood risk. For the 7.8-inch, 24-hour event, however, there are several properties that has some flood risk under existing conditions (Figure B-3) and this flood risk increases with the flood risk increases with the improved overflow (Figure B-5). These figures indicate the change in available freeboard around Lakeview Park based on the alternative and rainfall event considered.

The impact to Powers Lake requires careful consideration due to the low capacity pump station that serves as the primary outlet for the Powers Lake. This pump station, when activated, also pumps water back into Wilmes Lake. The modeling results above are all for cases in which the pump is not set to activate. Again, it is important to note that these impacts are when storm events larger than the 100-year event are considered, which was included in this analysis for comparison purposes. The lake bounce (change in elevation during a storm event) increases, on average, 1 foot with an improved overflow from Wilmes Lake. There are many wooded areas that can be sensitive to extended periods of flooding, the potential for which is increased by the overflow from Wilmes Lake. The City of Woodbury owns all the shoreline with one minor exception. Flood damages around Powers Lake as a result the improved overflow and extended duration of high water is minimal. A structure survey was not done to determine the extent of freeboard variation at Powers Lake. Figure 6 shows the Stage Curve for Powers Lake for the 7.8-inch event with a 48-inch pipe installed and the Powers Lake pump set to activate and operate at a rate of 5 cfs for the whole duration of the storm. Figure 7 shows the extent of flooding for the 6.3-inch and 7.8-inch events for the base model and 48-inch outlet pipe option. Again, with the pump turned on, it is assumed that the pump is working at a rate of 5 cfs for the whole duration of the storm.

Based on the modeling results, Powers Lake reaches a peak elevation approximately 2.5 days after the rainfall event. The low capacity of the pumped outlet does not have much of an impact in drawing down Powers Lake through the modeling period. Hence, the stage remains above

elevation 900 ft for an extended period of time subjecting Powers Lake to possible follow-on events.

**Figure 6**  
**Stage Curve at Powers Lake for the 7.8-inch event with a 48-inch pipe overflow from Wilmes Lake and the Powers Lake Pump on**



An option to try and mitigate the potential flooding impacts at Lakeview Park Pond due to additional flow from Wilmes Lake during extreme storm events was also investigated. The investigated option was to upgrade the existing pipe connection from Lakeview Park Pond to Powers Lake. The connecting sewer was upgraded from the existing 24-inch sewer to a 36-inch pipe and with lowered profile by two feet. The increase in flood stage and risk of flooding at Lakeview Park Pond due to the overflow from Wilmes Lake cannot be mitigated as a result of this option as stage at Powers Lake creates a level pool condition during extreme storm events. This modification would also cost in the range of \$400,000 to \$600,000 based on construction approach and alignment. There is no change in elevations with or without this pipe for the lowered bike path option.

Figure 7 Flooding Extents and Duration at Powers Lake



## **Present Flood Mitigation Activities within the Watershed**

The SWWD and the City of Woodbury are engaged in various activities that will help reduce the potential for widespread flooding within the watershed. These activities include:

- Continuous review of all development activities for water quantity and quality impacts
- Optimizing storage and rate control, where applicable, for development projects
- Optimizing storage, where applicable, in conjunction with capital improvement projects within the City of Woodbury
- Flow Control gates at Markgraf Lake and Evergreen wetland
- Updated Watershed plan, as approved in September 2007
- City of Woodbury flood proofing grant program

## **RECOMMENDATION**

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This memorandum is supplemental to the SWWD Storm Water Modeling Report dated July 2006; the conclusion is consistent with that report: Non-structural improvements are recommended to mitigate potential flood damages at Wilmes Lake. The results indicate that for the standard design event, there is minimal to no reduction at Wilmes Lake and there are downstream impacts at Lakeview Park Pond and at Powers Lake if overflow from Wilmes Lake is conveyed across to these locations. Additionally, the benefits gained from an improved overflow for events larger than the design event are minimal. There are safety considerations to the overland flow options that need to be carefully evaluated. The Flood Proofing Grant program that the City of Woodbury is planning is a good example of a non-structural change and will provide the optimum solutions for protection from flooding at Wilmes Lake.

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## **SUMMARY**

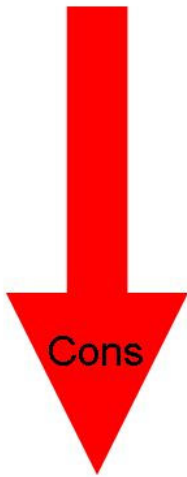
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As requested by the City of Woodbury and directed by the SWWD, HDR conducted a detailed analysis of the improved overflow options discussed in the report dated July 2006. The present study included further examination of the three options: 1) street overflow, 2) 36-inch overflow pipe, and 3) a 48-inch piped overflow to relieve flooding at Wilmes Lake. A planning level cost estimate was developed and a comparison of cost versus impact of each option at Wilmes Lake was also completed. The overall impact of each option was determined by the reduction in stage at Wilmes Lake.

The results of the modeling and analysis indicate that there is minimal to no benefit gained by an improved overflow option to relieve flood damages at Wilmes Lake for the 100-year design storm. The improved surface overflow option does not activate and the pipe options can increase downstream flood risks for the design storm. The street overflow alternative, which only activate for an event more extreme than the 100-year design storm, can have serious safety hazards. An improved overflow from Wilmes Lake can result in adverse downstream impacts which are inconsistent with the watershed and the City of Woodbury surface water management policies. Figure 8 summarizes the pros and cons of the improved overflow options. Non-structural improvements, such as flood proofing measures, should be considered to mitigate any damage from potential flooding.

### **Figure 8 Comparison of Pros and Cons for an improved Surface Overflow Option**

- Minimal High Water level reduction for events greater than the 100-yr event.
- Controlling and Augmenting the Existing Overflow



- Not Effective for the Design Event
- High Cost of Installation
- Present a Safety Hazard
- Increased Risk of Potential Flood Damages Downstream
- No properties on Wilmes Lake are removed from risk criteria

**Appendix A**  
**Planning level cost estimates**

<b>36 inch Pipe</b>					
Mobilization		1	each	\$10,000.00	\$10,000.00
36 inch pipe		1570	LF	\$175.00	\$274,750.00
Street Reconstruction		16500	SF	\$25.00	\$412,500.00
Curb		925	LF	\$60.00	\$55,500.00
Manholes and Attachments		8	each	\$15,000.00	\$120,000.00
structures		2	each	\$20,000.00	\$40,000.00
Incidentals		10%			\$91,275.00
Contingencies		25%			\$251,006.25
<b>Total</b>					<b>\$1,255,031.25</b>
<b>48 inch Pipe</b>					
Mobilization		1	each	\$10,000.00	\$10,000.00
48 inch pipe		1570	LF	\$250.00	\$392,500.00
Street Reconstruction		16500	SF	\$25.00	\$412,500.00
Curb		925	LF	\$60.00	\$55,500.00
Manholes and Attachments		8	each	\$15,000.00	\$120,000.00
structures		2	each	\$20,000.00	\$40,000.00
Incidentals		10%			\$103,050.00
Contingencies		25%			\$283,387.50
<b>Total</b>					<b>\$1,416,937.50</b>
<b>Lower Bike Path</b>					
Mobilization		1	each	\$2,000.00	\$2,000.00
Earth Work		240	CY	\$25.00	\$6,000.00
Paving		300	LF	\$25.00	\$7,500.00
Curb		50	LF	\$60.00	\$3,000.00
Incidentals		10	%		\$1,850.00
Contingencies		25	%		\$5,087.50
<b>Total</b>					<b>\$25,437.50</b>

# Appendix B

## Figure B-1

**Freeboard at Lakeview Park Pond for the 6.3-inch Event under both Existing Conditions and with the Lowered Bike Path Condition (Powers Lake Starting elevation 891-ft)**

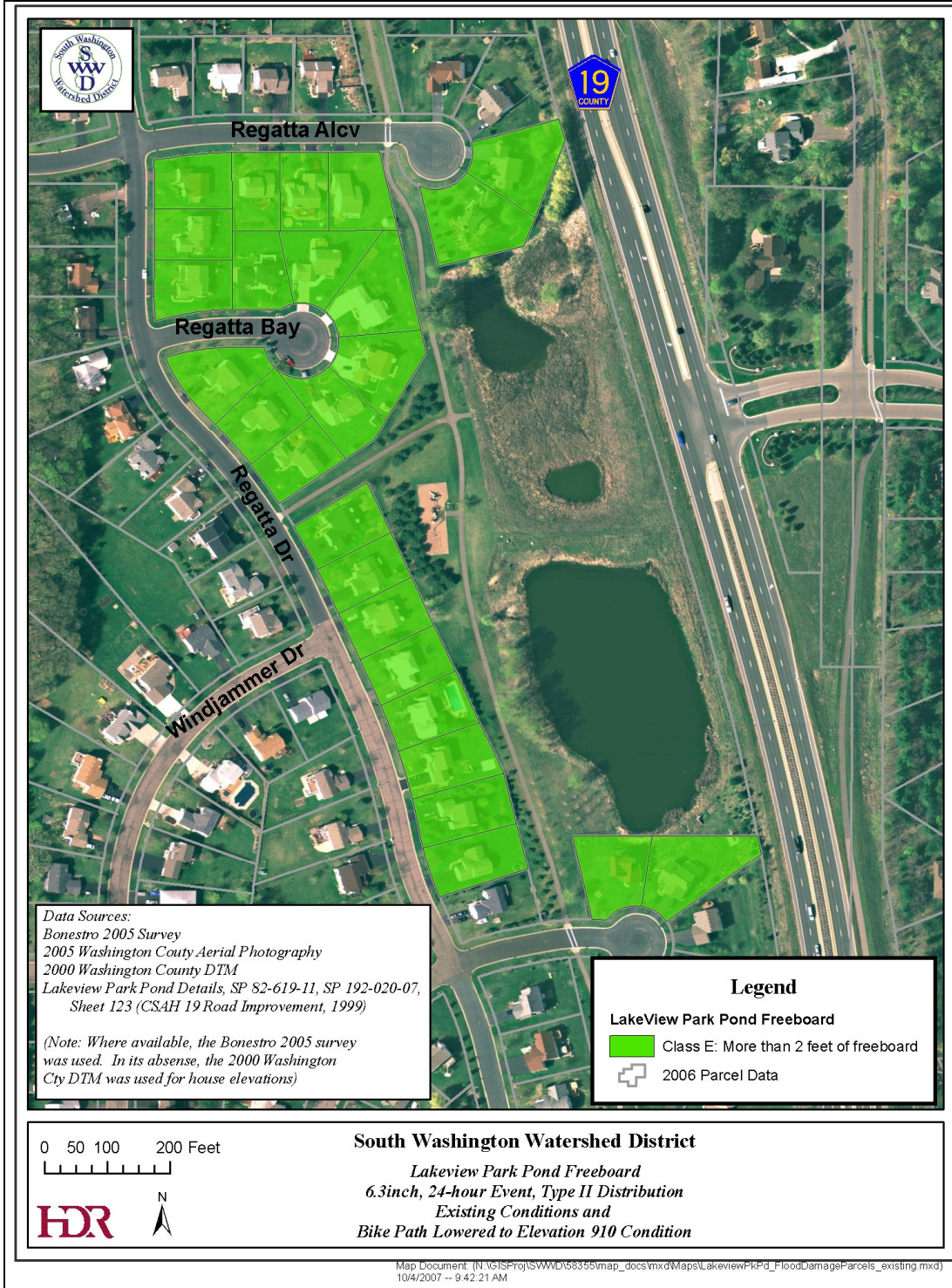
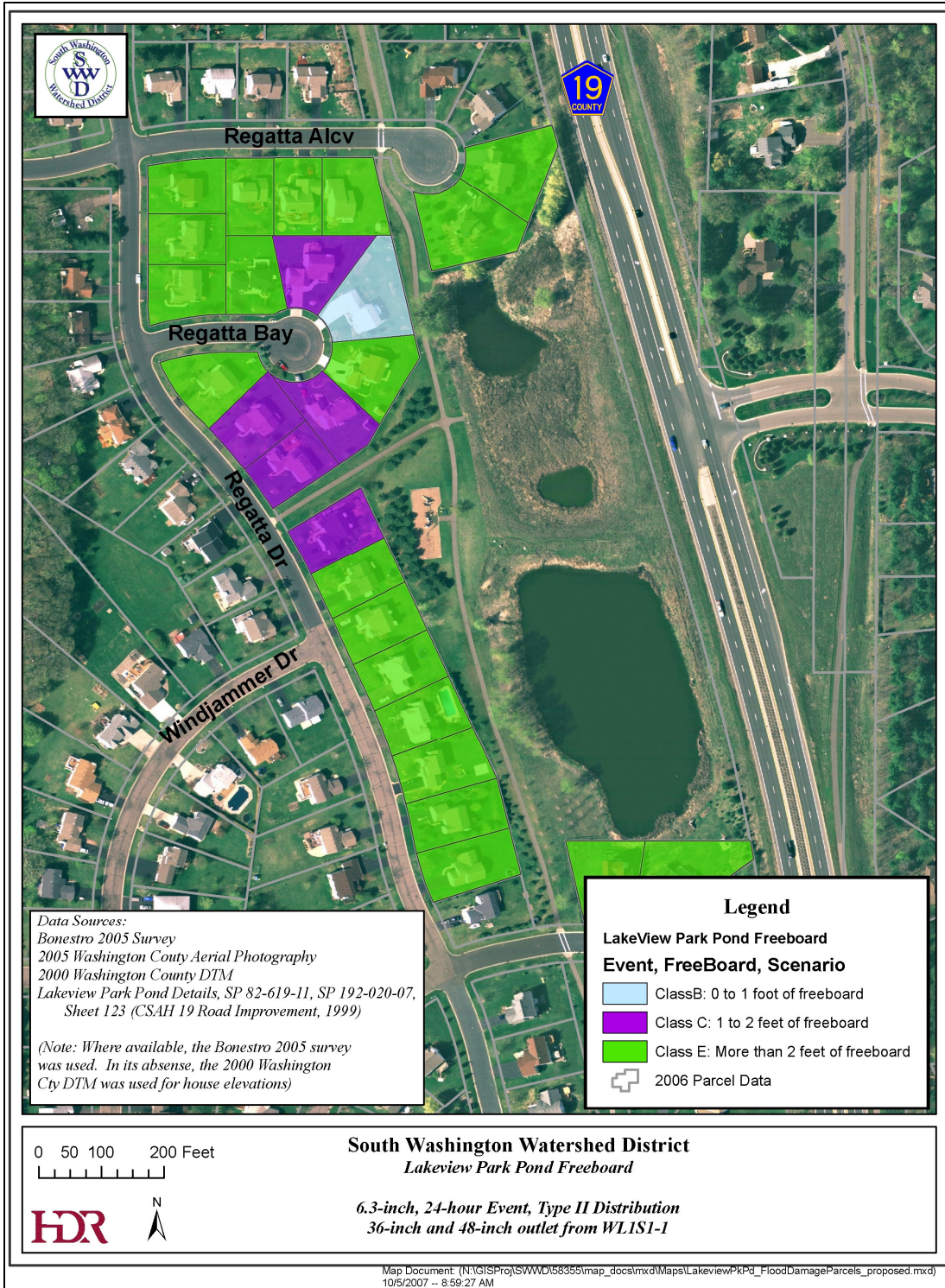
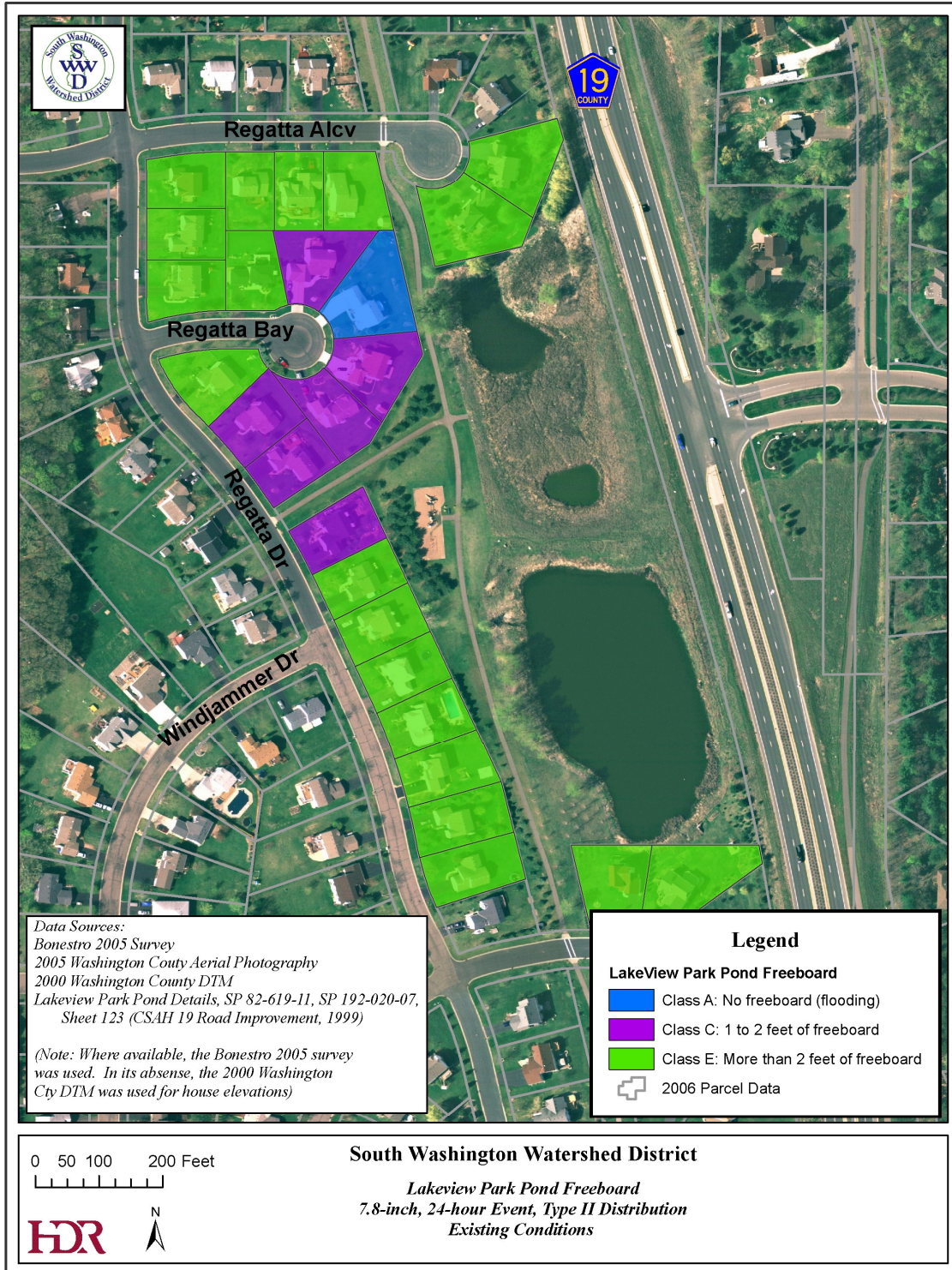


Figure B-2

Freeboard at Lakeview Park Pond for the 6.3-inch, 24-hour event with both the 36-inch and 48-inch Improved Overflows from WL1S1-1 (Powers Lake Starting elevation 891-ft)



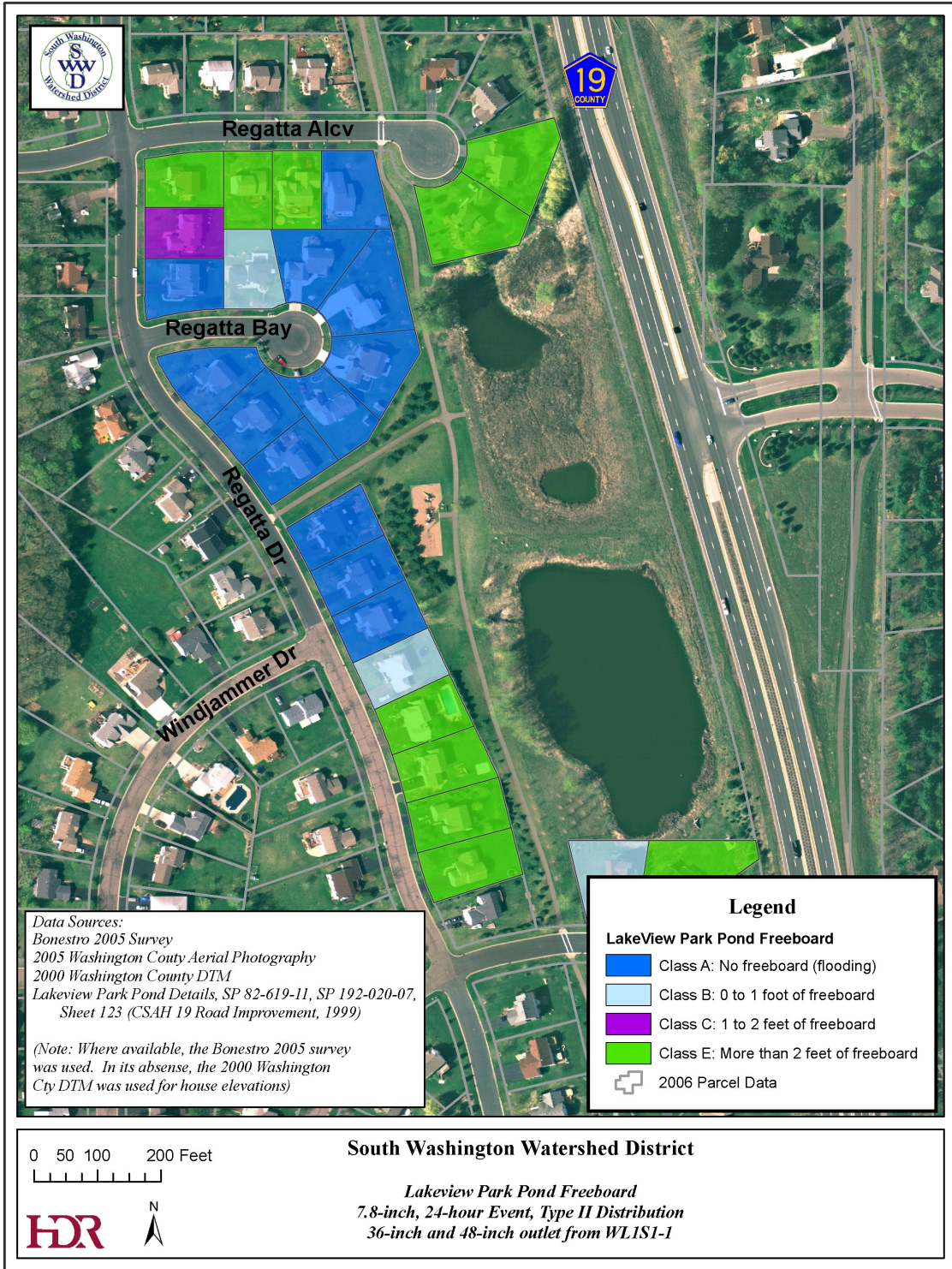
**Figure B-3**  
**Freeboard at Lakeview Park Pond for the 7.8-inch Event under Existing Conditions**  
**(Powers Lake Starting elevation 891-ft)**



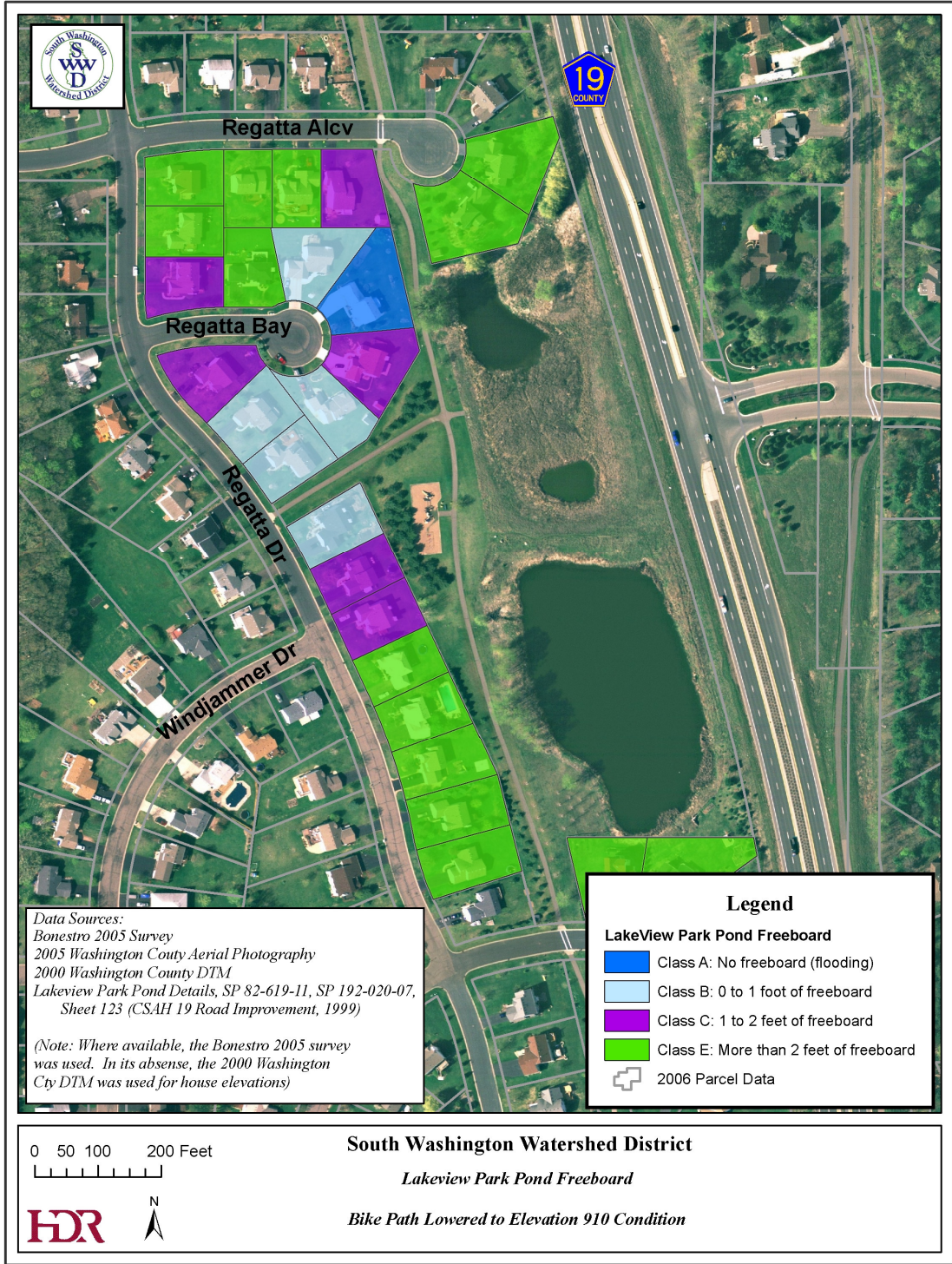
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**Figure B-4**

**Freeboard at Lakeview Park Pond for the 7.8 inch, 24-hour event with both the 36-inch and 48-inch Improved Overflows from WL1S1-1 (Powers Lake Starting elevation 891-ft)**



**Figure B-5**  
**Freeboard at Lakeview Park Pond for the 7.8 inch, 24-hour event with the Lowered Bike Path from WL1S1-1 (Powers Lake Starting elevation 891-ft)**



**Figure B-6**  
**Freeboard at Lakeview Park Pond for the October 2005 Storm Event with the Lowered**  
**Bike Path Condition (Powers Lake Starting elevation 885.74-ft)**

