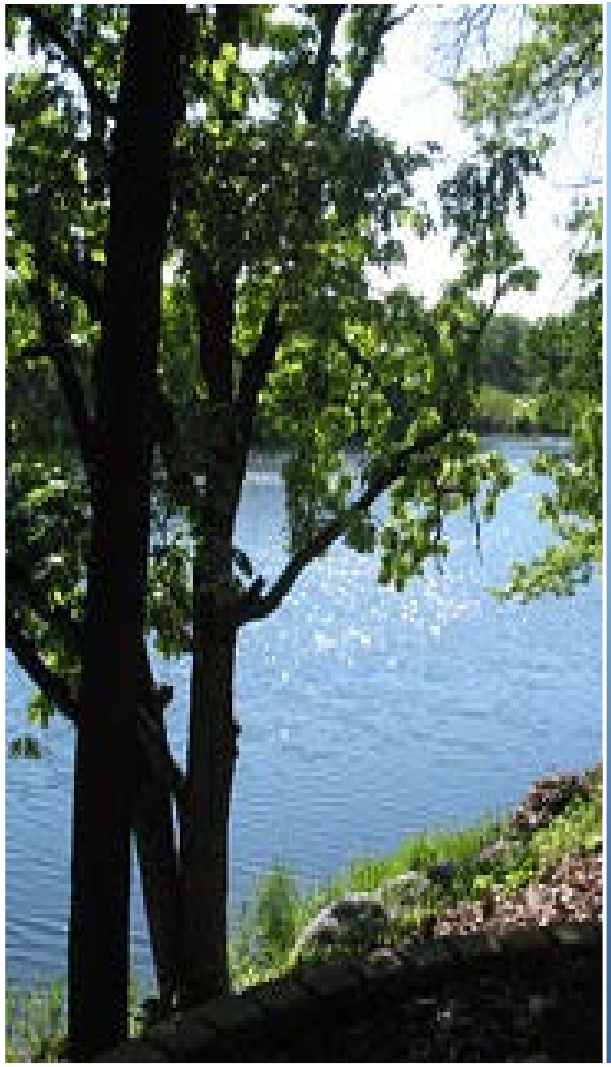
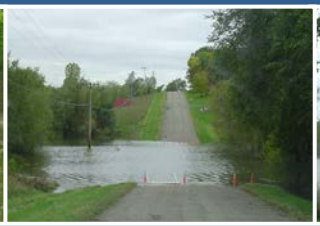


Model Update and Analysis Report
Central Draw and
Bailey Lake Watersheds

November 2007

South Washington Watershed District

HDR

MODEL UPDATE AND ANALYSIS REPORT
CENTRAL DRAW AND BAILEY LAKE WATERSHEDS

Prepared for

SOUTH WASHINGTON WATERSHED DISTRICT
NOVEMBER 2007

I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota

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APPENDICES

Appendix A Bailey Lake Pump Station Permit Letter
Appendix B Review Letter for the Ravine Parkway

1.0 EXECUTIVE SUMMARY

The Northern Watershed and the Central Draw Storage Facility are a critical part of the South Washington Watershed District. The Central Draw Storage Facility is part of the plan amendment completed in 2002 by the watershed to provide a primary outlet to the Northern Watershed and to function as a regional storm water management facility. Bailey Lake is the downstream limit of the northern watershed collecting drainage from Lake Elmo, Oakdale, Afton, and the City of Woodbury. The Central Draw Storage Facility extends across the municipal borders of Woodbury and Cottage Grove, providing storage for pumped flow from Bailey Lake and accepting local runoff. The present effort detailed in the following memorandum includes updates to the effective models, revisions to the grading plan within the storage basins, and evaluation of the volumes and rates of runoff from Bailey Lake and the drainage areas within the Central Draw areas and the need and size of the overflow pipe from the Central Draw Storage Facility.

First, the Northern Watershed and the Central Draw Storage Facility (CDSF) models were updated to reflect present day conditions. Subsequently, these models were updated to reflect the land use and infrastructure in the respective surface water management plans. These updated models were executed to complete a complex matrix of scenario to help answer the following primary questions:

- What is the capacity needed for the overflow from the CDSF
- When does it need to be constructed
- What are the impacts the surface water management plans for Cities of Woodbury and Cottage Grove on the CDSF
- Can the CDSF function as a local storm water management facility

This report includes detail of the following efforts:

- The model update procedures
- The model scenarios explored
- Present conceptual operating parameters for the CDSF storage areas
- The key elements and issues affecting the overall connectivity to the storm water management system
- The impact of local drainage to the CDSF area
- The drainage into Bailey Lake and subsequently into the CDSF system
- Potential flow assessment points with a direct impact on CDSF

The main points of that are discussed within this report are:

- The rate and volume of runoff from the Bailey Lake watershed moderately increased for the proposed conditions reflected in the surface water management plan. The outlet structure planned for the Danner gravel pit in the surface water management plan leaves excess, unused storage that can be maximized by installing a revised outlet structure design
- The Bailey Lake pump station, when operated without any flow restrictions, forces approximately 2200-acft of volume into CDP-85, spread over a fourteen day period during a 6.3-inch 24-hour design rain event. This volume results in uncontrolled overflows across 70th Street in Cottage Grove
- The available storage volume at Bailey Lake can be utilized by optimizing the operations at the pump station during a 6.3-inch, 24-hour event. When pumping is controlled, the water surface elevations in the CDSF system would stay below the maximum overflow elevations without uncontrolled overflows. However, the water surface elevations would exceed target elevations and ponded areas would encroach onto current flowage easements. The current configuration and the proposed grading plan configuration for the CDP-86 basins can accommodate a 6.3-inch, 24-hour event with no expected uncontrolled overflows if the Bailey Lake pump station has optimized operating rules
- Storm runoff volumes for the 6.3- and 7.8-inch, 24-hour events from the direct drainage areas affecting the CDSF, without pumping from Bailey Lake, is contain within the CDSF without uncontrolled overflows. In this scenario, the basins work to manage the local runoff. Base flood elevations are contained below the target elevations for the basins under the proposed grading plan
- Uncontrolled overflows across 70th Street would result under a 7.8-inch, 24-hour event or back to back 100-year 6.3-inch, 24-hour events even when pumping is controlled at Bailey Lake. In light of the probabilities of these events occurring, the construction of an overflow does not present an immediate or emergency need. However, it is strongly recommended that an implementation plan for an overflow be compiled so that one can be funded, planned, designed, and constructed within a reasonable time span such as the next 3 to 5 years
- The proposed concept plan for the Ravine Parkway will have significant impacts to all the discussion points above. These impacts were discussed in a separate memorandum and are attached as Appendix B

The modeling results were also used to generate hydrographs at key flow assessment points within the direct drainage areas into Bailey Lake and the CDSF. These hydrographs can be used to manage inflow rate and volume within these basins.

The following conclusions are based on the analysis completed and discussed in this document:

- The Central Draw Storage Facility needs an overflow pipe to provide an adequate level of protection for the watershed. Present modeling indicates a 48-inch diameter pipe capacity, at a minimum, is required to adequately convey the overflow
- It is recommended that an implementation plan for an overflow be compiled so that one can be funded, planned, designed, and constructed within the next 3 to 5 years
- The surface water management plans for both Cities of Woodbury and Cottage Grove maintain peak flow rates within the exiting values but, result in moderate increases in runoff volume from the contributing watersheds. Controlled and managed pumping from Bailey Lake can increase the functionality of the Central Draw Storage Facility
- The Central Draw Storage Facility can contain the 100-year runoff from the immediate watershed. Hence, the CDSF can function as a local storm water management facility within the immediate CDSF contribution drainage areas

2.0 BACKGROUND INFORMATION

The Northern Watershed currently represents about 23 of the 52 square miles that make up the South Washington Watershed. From north to south, the Northern Watershed includes the drainage areas of Armstrong, Markgrafs, Wilmes, Powers, Colby, and Bailey Lakes. The entire Northern Watershed eventually drains to Bailey Lake, a water body that would be landlocked if not for the pump station located at its southern most lobe. The pump station discharges water to the Central Draw Storage Facility (referred to as the CDSF in this memorandum), starting first at CDP-85, which is located and owned by the City of Woodbury, and then to CDP-86 in Cottage Grove (Figure 1). The CDP-86 basin is further separated into the CDP-86N (north lobe), CDP-86Sn (north part of the south lobe), and CDP-86 Ss (the south part of the south lobe past present Military Road). It requires operating parameters because the basin CDP-86 is landlocked, undergoing development within its watershed, and receiving water from both Woodbury and Cottage Grove. The function of the CDSF is to act as both an overflow from the Northern Watershed and to store local runoff from the new developments in Cottage Grove and Woodbury. This project is part of the minor plan amendment developed by the South Washington Watershed District (SWWD) in 2002.

The last update to the CDP-85/86 (CDSF) plan in 2002 called for coordination between land developers, the Cities of Woodbury and Cottage Grove, and the SWWD because the land would be privately owned, possibly deeded to the City, and/or easements would be recorded for storm water management purposes. Final grading plans and development agreements were not finalized at that time. Since this last update, the SWWD has purchased the land areas that contain the CDP-86 flood storage basins. The bulk of the CDP-86N flood storage area has been placed within a conservation easement. HDR, at the SWWD's request, has compiled a draft grading plan for the remaining CDP-86 South area on SWWD property. This grading plan provides a planning tool for the final configuration of the flood storage areas, identifies infrastructure needs to support these storage areas (e.g. culverts and control weirs), and confirms the amount of storage available should the SWWD property be configured for storm water detention and conveyance. The proposed CDP-86 South grading plan information is included in the CDSF model update process.

The current Northern Watershed Model (developed in XP-SWMM modeling software, version 10.0) of the SWWD was updated for the watersheds draining to Wilmes Lake. It was part of the study evaluating the behavior of Wilmes Lake during the October 2005 rain event. The results of this study demonstrated the utility and importance of model updates for storm water planning and evaluation of proposed development plans. Subsequently, the SWWD has commissioned an update of the CDSF model and the Bailey and Colby Lakes sub-watersheds, of the Northern Watershed model, to analyze the CDSF for ongoing watershed planning activities. This update includes coordination of current and future development activities within Woodbury and Cottage Grove.

The present effort is focused on four critical items:

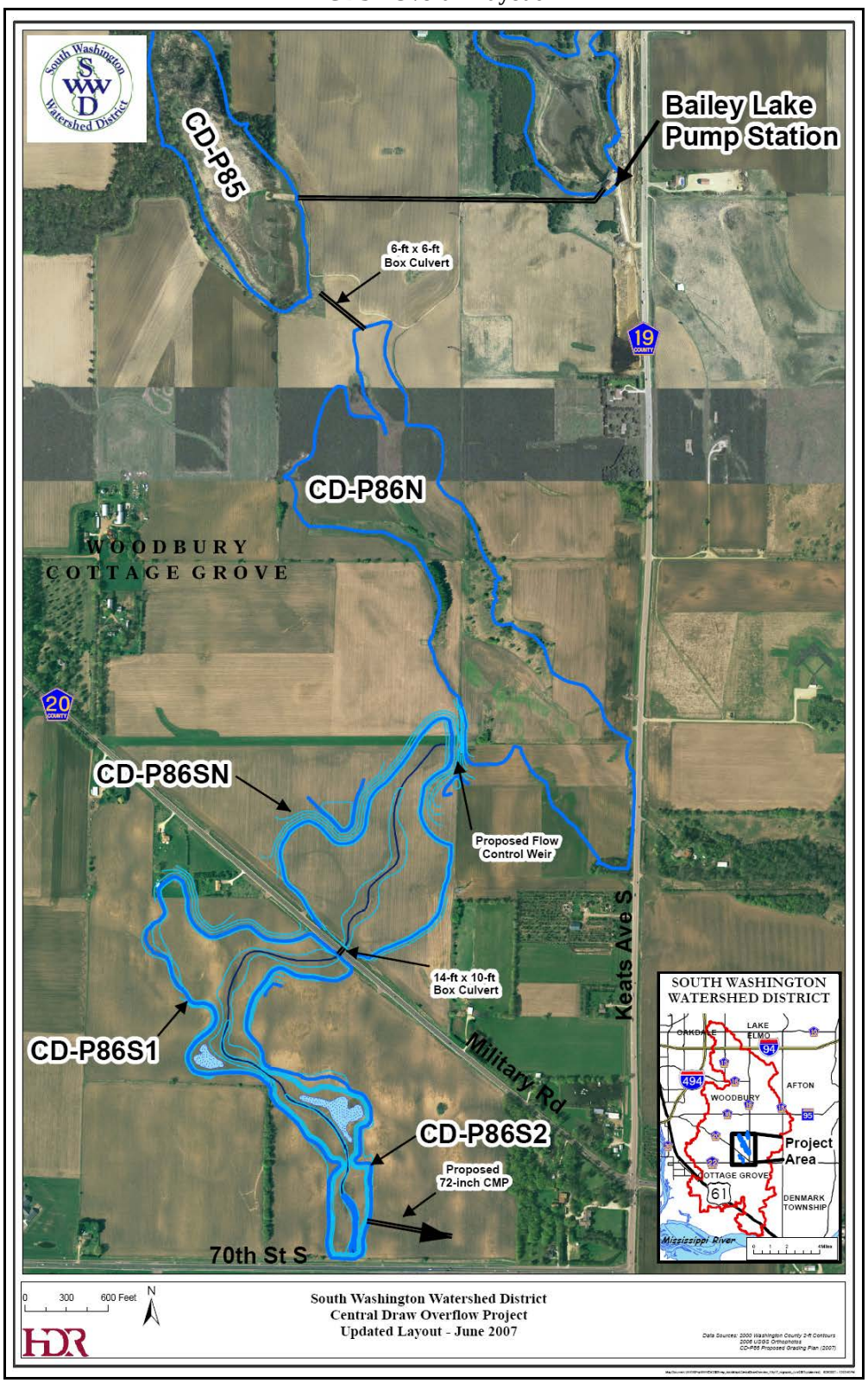
1) The rate and volume of storm water flowing into Bailey Lake from under existing and proposed conditions
2) Water pumped from Bailey Lake to the CDSF under existing and projected conditions
3) Storm water inflow into the CDSF independent of the Northern Watershed under existing and proposed conditions
4) The functionality of the storage volumes within the CDSF.

In addition, the City of Cottage Grove has proposed a Ravine Parkway and Park project that are located directly in the CDP-86 flood storage area. The Parkway layout has potential to change the form and function of the CDSF from the present plan, which is discussed in a previous memorandum (attached as Appendix B).

This technical memorandum discusses:

- The model update procedures
- The model scenarios explored
- Present conceptual operating parameters for the CDP-85/86 storage areas
- The key elements and issues affecting the overall connectivity to the storm water management system
- The impact of local drainage to the CDSF area
- The drainage into Bailey Lake and subsequently into the CDSF system
- Potential flow assessment points with a direct impact on CDSF

Figure 1
CDSF Overall Layout



3.0 CENTRAL DRAW STORAGE FACILITY

The SWWD, in coordination with the cities of Woodbury and Cottage Grove, is developing the CDSF as part of the minor plan amendment created in the year 2002. The purpose of CDSF is to:

- Provide the communities upstream of Bailey Lake a principle outlet capable of managing the excess runoff associated with a 100-year, 24-hour event
- Function as a local storm water management resource for development within the City of Cottage Grove.

A 100-year return period and 24-hour duration is generally considered the maximum level of service provided by previously constructed drainage systems within the watershed. The overflow from Bailey Lake is pumped into storage location CDP-85, with the flow then following a southerly route through two lobes (N and SN) of CDP-86 before flowing under Military Road to end up finally in the two south lobes (S1, and S2) of CDP-86 (Figure 1). An overflow pipe from CDP-86S is planned to carry the excess flow from the CDSF to the East Ravine which will then flow down to the Mississippi River.

3.1 Updated Grading Plan and Storage Curve

The initial layout of the CDSF involved minimal grading, with storage curves based on the area's existing topography. New developments proposed within the CDSF area and the property limits acquired by the SWWD have forced a change in the land available for storage and has necessitated revisions to the grading plans for the CDSF storage basins as they were presented in the 2002 report. This change is primarily in the CDP-86 south lobe. Figure 2 and Figure 3 show the new grading concept for the CDP-86 south lobe and is based on the premise that the CDSF must store water within the property boundaries and areas owned by the SWWD. Generally, the maximum target stage that keeps the stored water within the property boundaries is at an approximate elevation of 902-ft for storage areas CDP-86SN, CDP-86S1, and CDP-86S2 (southern areas of the CDP-86 basin).

Table 1 is a breakdown of the target storage elevations and storage volumes for the five sub-basins that comprise the CDSF storage basins.

Table 1
Storage Volumes Available with the Revised Grading Plans Incorporated

Basin	Target Flood Storage Elevation	Storage Volume-ac-ft	Maximum Storage Elevation	Storage Volume-ac-ft
CDP-85	910	356	912*	406
CDP-86N	904	577	906	696
CDP-86SN	902	173	906	298
CDP-86S1	902	125	906	213
CDP-86S2	902	109	906	201

*This is the maximum elevation modeled. Actual crest elevation of the CDP-85 basin is above 914-ft.

The total storage volume available within the project after implementation of the revised grading plan is approximately 1350 ac-ft, based on these target elevations. This volume is 170 ac-ft less than the 1510 ac-ft of flood storage volume developed during the initial 2002 grading plan. This decrease in available storage volume supports the need to update the CDSF model with the information from the Cottage Grove Storm Water Management Plan, develop interim pumping scenarios at Bailey Lake (for use by the City of Woodbury), and update the operational parameters for the proposed CDSF basin overflow.

Figure 2
CDP-86 North Lobe Grading Plan

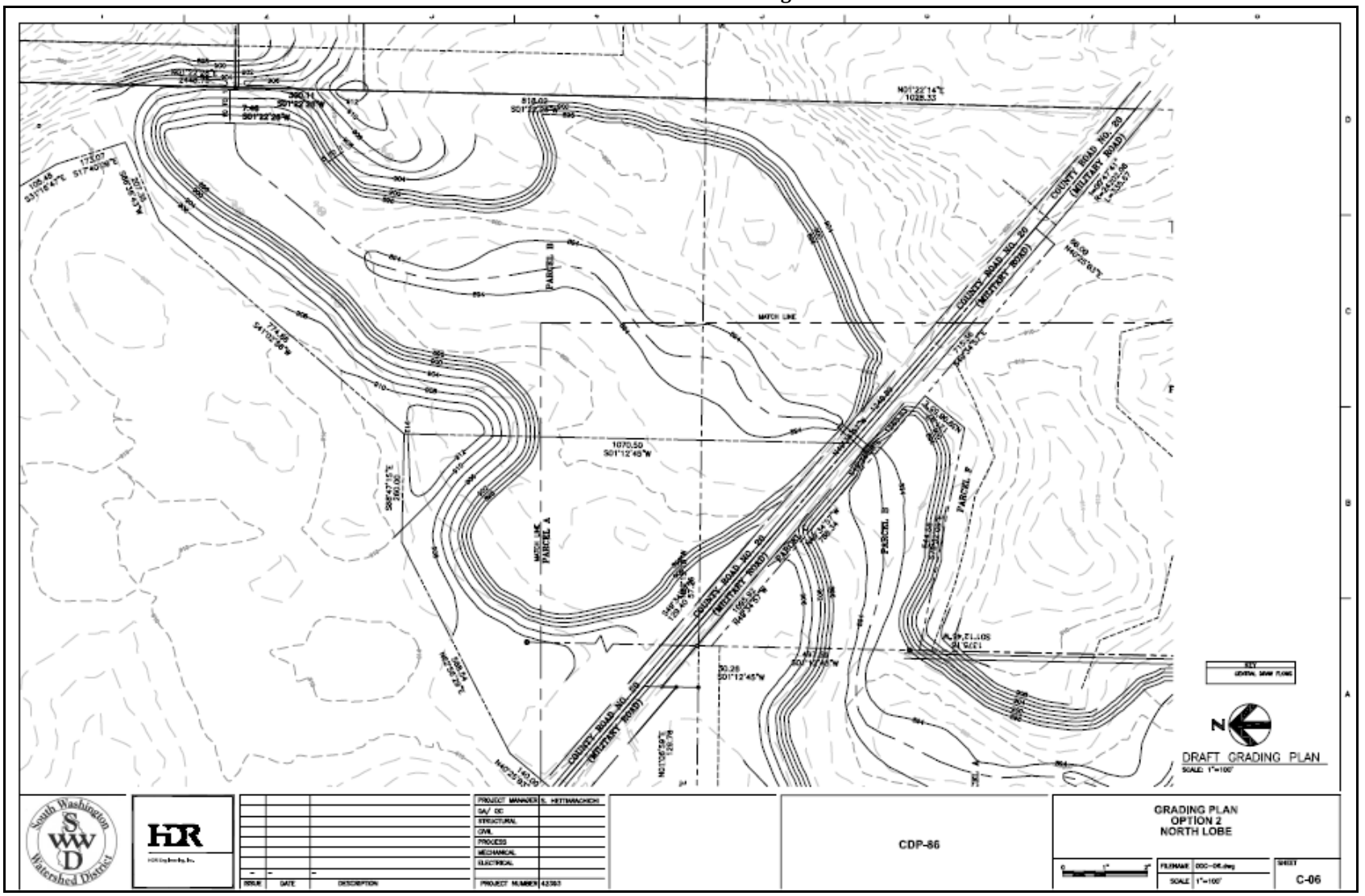
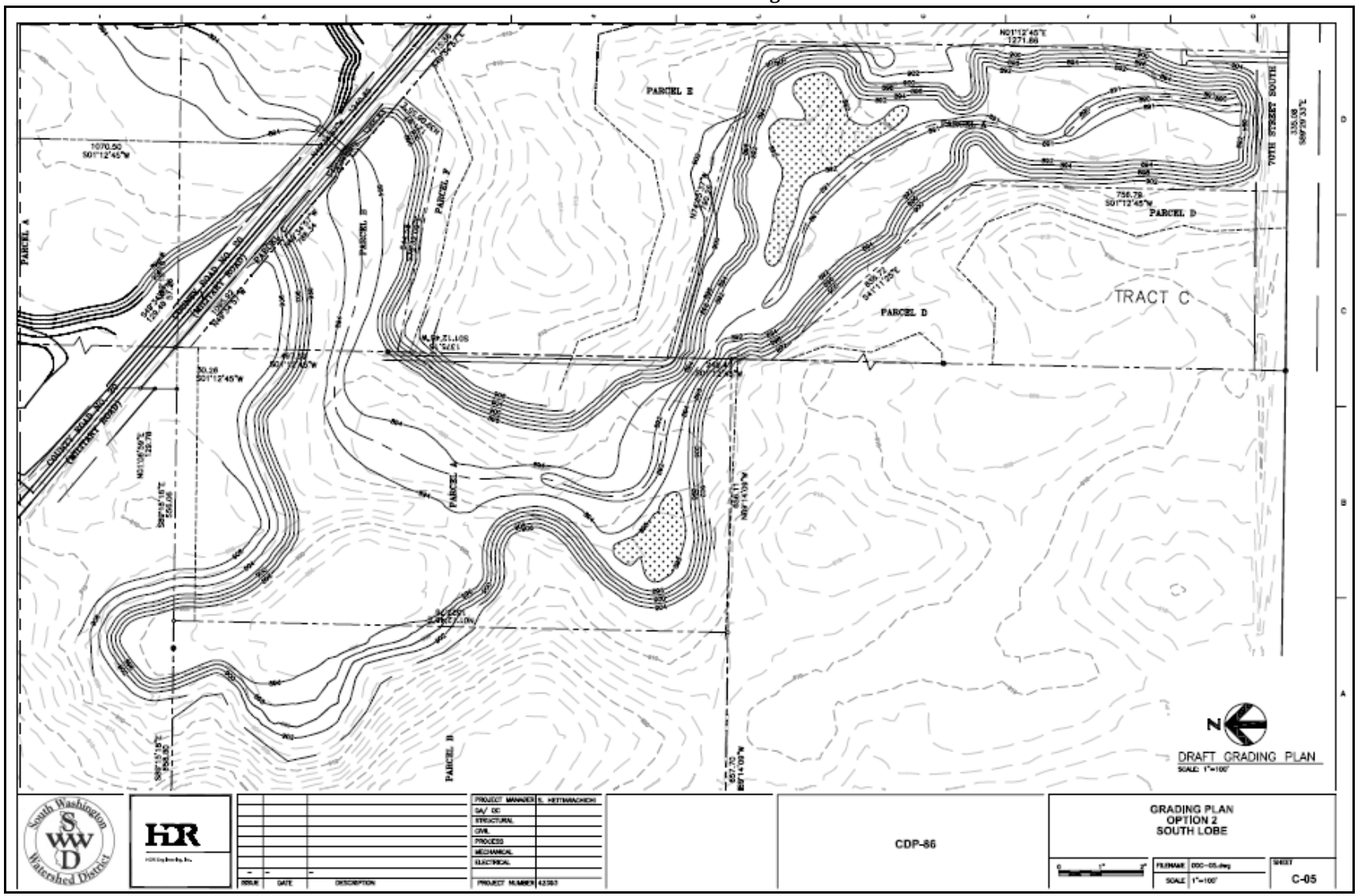


Figure 3
CDP-86 South Lobe Grading Plan



4.0 MODEL UPDATE PROCEDURE

4.1 Model Update to the Bailey Lake Sub-Watershed

The 23 square-mile Northern Watershed starts at Armstrong Lake in Oakdale, and then flows through Wilmes and Colby Lakes before ending up in Bailey Lake. With the pumped outlet connection from Power's Lake Watershed, the entire Northern Watershed eventually ends up at Bailey Lake, which currently does not have a natural outlet. Approximately 20 percent of the direct drainage area to Bailey Lake is developed, and the remaining area is slated for future development. Figure 4 shows the area of the Existing Conditions model (executed with XP-SWMM modeling software, Version 10.0) that was updated with added detail within the Bailey Lake sub-watersheds. The proposed conditions model was developed based on the future development infrastructure as represented in the City of Woodbury Storm Water Management Plan (SWMP; also executed with XP-SWMM modeling software, Version 10.0).

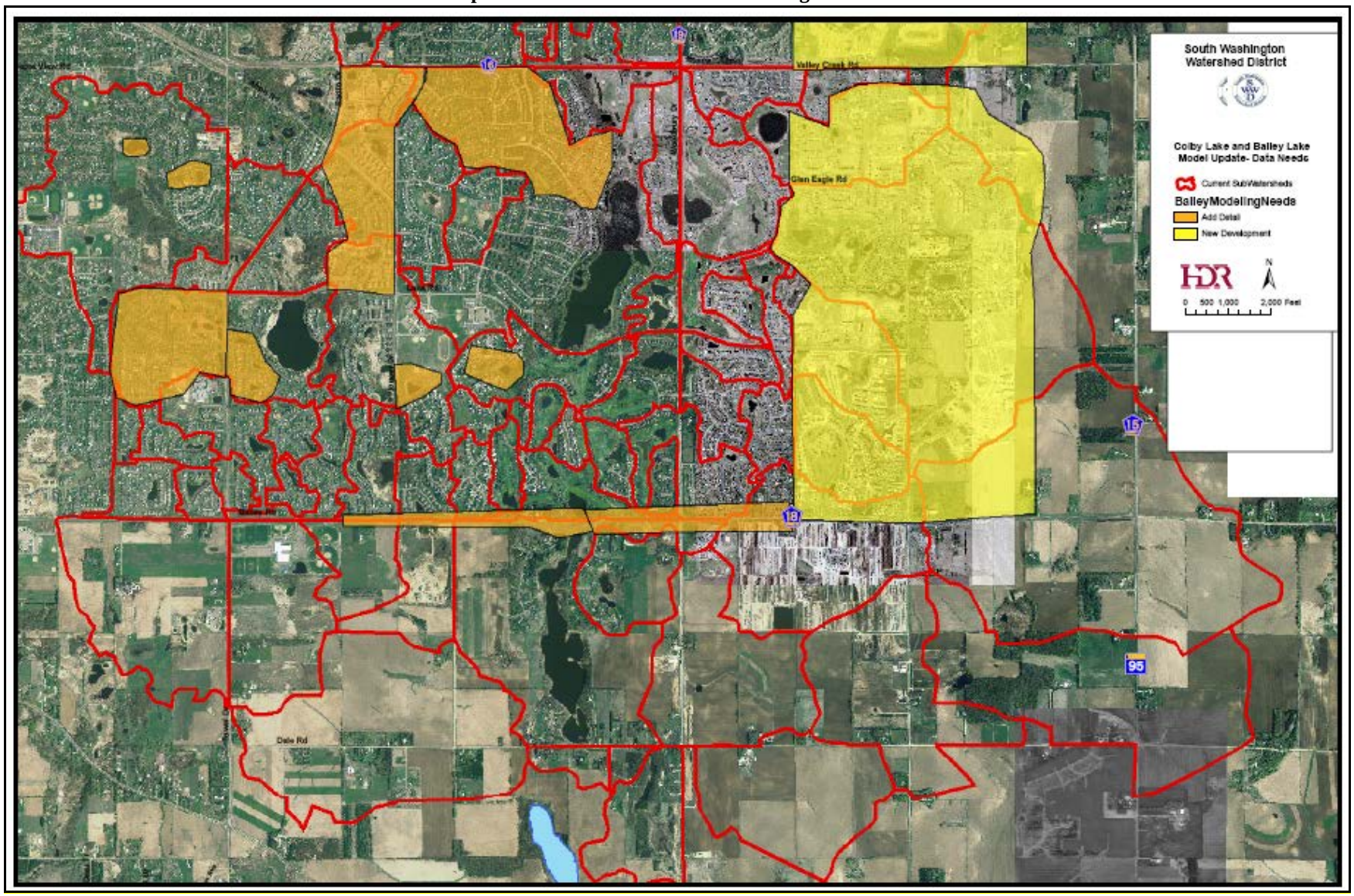
The critical connection between the Northern Watershed and the CDSF is the pump facility from Bailey Lake. The CDSF is dependant on the rate and volume of water pumped from Bailey Lake, both in its general function as a storage facility, and in the potential for uncontrolled overflows. An accurate estimate of the total inflow rate and volume into Bailey Lake is important; it determines how much pumping from the Bailey Lake lift station is required to prevent flooding in the Northern Watershed. The updated Existing Conditions and Proposed Conditions models are fundamental tools for estimating these quantities.

HDR completed the Bailey Lake sub-watershed modeling update using the following information:

- 2005 Washington County aerial photographs supplemented by 2006 USGS aerial imagery
- Record Plan sets provided by the City of Woodbury (through Bonestroo)
- Surface Water Management Plan model for Woodbury provided by Bonestroo
- Washington County Digital Terrain Model and contours developed in 2000
- Year 2000 Metropolitan Council land use (modified to 2006 conditions)

The objective of the model update was to combine and update the information from these various sources into an updated storm water model mirroring the detail and utility of the Wilmes Lake portion of the Northern Watershed Existing Conditions model. This update also helped analyze land use changes occurring in the watershed.

Figure 4
Updated Northern Watershed Modeling Area



4.2 Bailey Lake Pump Station Operating Plan

The Bailey Lake Discharge Facility Operating Plan dated March 1, 2004 (Appendix A) describes the various conditions and pumping rates from Bailey Lake to CDP-85. The schematic in Figure 1 of the operating plan, shows six pumps in series, with five pumps for operation during the design event, and one pump for redundancy. Each pump is rated to a peak flow of 30-cfs, combining for a peak pumping rate of 150-cfs. Based on the operating scenarios listed in Tables 4 and 5 of the plan, the pumps could operate at a peak capacity of 150-cfs for 5 days, resulting in a total volume of approximately 1500 ac-ft of water (permit maximum) being pumped out of Bailey Lake to CDP-85.

4.3 Central Draw Storage Facility Area Model Updates

The CDSF base model was updated using the Cottage Grove SWMP model for Neighborhood 1. The storage capacity for the CDP-86 storage basins were then revised based on the updated grading plans (Figures 3 and 4). The inflows from the City of Woodbury to the CDSF, other than from Bailey Lake, were updated based on the modeling completed and provided by Bonestroo for Woodbury's SWMP[1]. The flow hydrograph from the Bailey Lake pump station was modeled based on the pump operation scenarios listed in the pump station permit document (Appendix A) and the modeled output from the Northern Watershed models.

[1] XP-SWMM model *SCEN2_6pt3.xp* received 6/13/07; HydroCAD model *Eagle Crest South Branch021407.hcp* received 6/13/07

5.0 MODELING AND ANALYSIS SCENARIOS

The CDSF area model was updated to reflect both the SWMP for the City of Cottage Grove and the grading revisions within the CDP-86 basin. The model does not represent changes that might be required based on the proposed Ravine Parkway. The updated model was then used to analyze the response of the CDSF to the eighteen different model scenarios presented in Table 2 and Table 3. These scenarios include both existing and proposed conditions in the Northern Watershed and the CDSF under different pumping plans at the Bailey Lake lift station.

Table 2
Central Draw Modeling Scenarios

Scenario ID	Scenario Name	Modeled Storm	Pumping Condition from Bailey Lake	Objective and Discussion
CDP 1	Central Draw Existing Conditions-No outlet	6.3-inch, 24-hour, Type II Distribution	150-cfs for 5 days	This reflects the storm water infrastructure as of today. This will be the base condition for all other CDSF models as it is the closest representation of how things are today. Total drainage area is 1756 acres.
CDP 2	Central Draw Existing Conditions- With outlet	6.3-inch, 24-hour, Type II Distribution	150-cfs for 5 days	This reflects the storm water infrastructure as of today. This looks at the benefit of having an overflow with the existing conditions, assuming that Cottage Grove does not proceed with any development activity planned in the CGSWMP.
CDP 3	Central Draw Existing Conditions-Local flow only, No outlet	6.3-inch, 24-hour, Type II Distribution	no pumping from Bailey lake	This model run includes only the local drainage to CDSF. This model run is for reference only to determine how the local flow changes with the CGSWMP.
CDP 4	Central Draw CGSWMP- Local flow only, No outlet	6.3-inch, 24-hour, Type II Distribution	no pumping from Bailey lake	Following with the existing conditions, this model run will indicate how local drainage to the CDSF changes with the CGSWMP. The results indicate how the CDSF functions purely as a local storm water management system with the proposed development and infrastructure in place and prior to installing an overflow pipe.
CDP 5	Central Draw CGSWMP-150 cfs from Bailey, no outlet	6.3-inch, 24-hour, Type II Distribution	150-cfs for 5 days	This pumping scenario matches the permitted rate and duration for the 6.3-inch Design Event for the Northern Watershed. The modeling results indicate how the CDSF will function with this pumping rate and the Design Event for the local runoff from the CDSF watershed, prior to the overflow pipe being installed.
CDP 6	Central Draw CGSWMP-150 cfs from Bailey, With outlet	6.3-inch, 24-hour, Type II Distribution	150-cfs for 5 days	This model examines the benefit of installing the overflow pipe for the same scenario described in CDP 5. The modeling results indicate how the CDSF will function with this pumping rate and the Design Event for the local runoff from the CDSF watershed, after the overflow pipe being installed.
CDP 7	Central Draw CGSWMP Uncontrolled pumping, No outlet	6.3-inch, 24-hour, Type II Distribution	Hydrograph from NWS pump station with the pumps set to activate at elevation 870 and stop when the Bailey Lake elevation recedes back down to 875	The scenario indicate how the CDSF responds to uncontrolled pumping from Bailey Lake during the Design Event prior to installing the overflow Pipe. This scenario is based on the Bailey Lake lift station pumps automatically activating based on the elevation at Bailey Lake. No pumping controls are used during the model run other than turning off when Bailey Lakes recedes below elevation 875.

Scenario ID	Scenario Name	Modeled Storm	Pumping Condition from Bailey Lake	Objective and Discussion
CDP 8	Central Draw CGSWMP Uncontrolled pumping, With outlet	6.3-inch, 24-hour, Type II Distribution	Hydrograph from NWS pump station with the pumps set to activate at elevation 870 and stop when the Bailey Lake elevation recedes back down to 875.	Look at the benefit of installing the overflow pipe to handle uncontrolled pumping from Bailey Lake during a design event. This scenario is based on the Bailey Lake lift station pumps automatically activating based on the elevation at Bailey Lake. No pumping controls are used during the model run other than turning off when Bailey Lakes recedes below elevation 875.
CDP 9	Central Draw CGSWMP Controlled pumping, No outlet	6.3-inch, 24-hour, Type II Distribution	Hydrograph from NWS pump station with only three pumps set to activate. The 3 pump activation elevations are staggered at 875, 876, and 877 and set to shut down at **265 hrs** (receded to elevation 877)	This scenario looks at trying to optimize the storage at Bailey Lake to supplement the function of the CDSF prior to installing the overflow pipe. This scenario evaluates the options to mitigate potential uncontrolled overflow from the CDSF during a design event in the interim until an overflow pipe is installed.
CDP 10	Central Draw CGSWMP Limited controlled pumping, No outlet	6.3-inch, 24-hour, Type II Distribution	Hydrograph from NWS pump station with only two pumps (60 cfs) set to activate for a period of 260 hours.	This scenario looks at trying to further optimize the storage at Bailey Lake by allowing only 1300 ac-ft of water to cross over from Bailey Lake to the CDSF.

Table 3
Bailey Lake Modeling Scenarios

Scenario ID	Scenario Name	Modeled Storm	Pumping Condition	Objective and Discussion
NWS 1	NWS Pre-update	6.3-inch, 24-hour, Type II Distribution	5 pumps starting at 870-ft	This scenario is purely as a reference to evaluate any changes at Bailey Lake due to the update. This model run establishes the base elevations prior to updating the model
NWS 2	NWS- Existing Conditions	6.3-inch, 24-hour, Type II Distribution	5 pumps starting at 870-ft	This is the base model which is updated to reflect the Existing Conditions (8/07) land use for the NWS. This model run establishes the response of the watershed for the design event with no pumping controls at the lift station.
NWS 3	NWS Proposed Land use	6.3-inch, 24-hour, Type II Distribution	5 pumps starting at 870-ft	The base model is further updated to reflect the proposed development as described in the comprehensive plan and the storm water infrastructure reflected in the City of Woodbury SWMP for the Bailey Lake watershed. This model does not have pump controls at the lift station
NWS 4	NWS- Proposed Land use with High School	6.3-inch, 24-hour, Type II Distribution	5 pumps starting at 870-ft	The proposed conditions model is refined to reflect the proposed change in land use from the Woodbury SWMP due to adding the high school. This will be used as the future conditions model.
NWS 5	NWS Existing Conditions, 7.8-inch storm	7.8-inch, 24-hour, Type II Distribution	5 pumps starting at 870-ft	Looking at the upper limit of the 95 percent confidence interval event for the watershed. Establish the upper margin of the volume of water being pumped and the expected elevation at Bailey Lake for the BASE model
NWS 6	NWS Proposed Land use, 7.8-inch storm	7.8-inch, 24-hour, Type II Distribution	5 pumps starting at 870-ft	Looking at the upper limit of the 95 percent confidence interval event for the watershed. Establish the upper margin of the volume of water being pumped and the expected elevation at Bailey Lake for the proposed model
NWS 7	NWS- Existing Conditions with Controlled pumps	6.3-inch, 24-hour, Type II Distribution	3 pumps staggered at 875, 876, 877-ft starting points and shut down at 265 hrs (receded to 877-ft)	Model used to develop an optimized pumping plan to utilize the storage available at Bailey Lake. The base model with uncontrolled pumping from Bailey keeps the stage at Bailey well below the 878-ft peak elevation presented as the highwater level for the design event
NWS 8	NWS- Proposed Land use with High School and Bailey Ridge pond diversion	6.3-inch, 24-hour, Type II Distribution	5 pumps starting at 870-ft	The proposed conditions model is refined to reflect the proposed change in land use from the Woodbury SWMP due to adding the high school and also a diversion from Bailey Ridge pond.

The majority of the above scenarios were evaluated based on the 6.3-inch, 24-hour rainfall with a Type II Distribution (Design Event). Select scenarios were also evaluated for the 100-year storm at the 90 percentile, represented by the 7.8-inch, 24-hour Type II Distribution.

The modeling assumes that no infiltration into the ground will occur within the storage basins. For planning and design, this assumption provides a conservative estimate of the maximum water surface elevations and storm water handling capabilities for the basins. It also compensates for continuity losses that occur during the model solutions process.

For the Central Draw Modeling, the Cottage Grove Storm Water Management Plan (CGSWMP) Scenarios represent proposed infrastructure conditions and the intended design condition for the project. The local flow condition looks at the storm water management aspect of the CDSF just to handle the local runoff, while the no outlet condition evaluates the need for the overflow to the East Ravine.

When evaluating the performance of the CDSF for regional storm water management purposes, three primary concerns must be addressed:

1) Confirmation of a need for an overflow from the CDSF system to the East Ravine or Central Ravine
2) When does the overflow need to be constructed
3) What is the minimum required capacity

To answer these questions, multiple modeling scenario were executed as listed in the above tables. Until such time that the overflow is constructed, the following requires careful analysis to help with interim management of storm runoff: volume allocation, volume optimization, and pumping rules. Several modeling scenarios were constructed according to the following:

- The revised CDSF storage volume within the SWWD property boundary is 1350 ac-ft
- The total permitted volume that can be pumped from Bailey Lake is approximately 1500 ac-ft
- The Bailey Lake pump station permit document lists elevation 878-ft as the peak stage at Bailey Lake for the design event
- The pump station is flood proofed to an elevation of 885-ft
- Available storage volume within the CDSF is 1810 ac-ft when CDP-86 is allowed to bounce to an elevation of 906
- The storage volume within Bailey Lake between elevation 873 and 878 is approximately 500 ac-ft
- The storage volume within Bailey Lake between elevation 878 and 880 is approximately 750 ac-ft

- The anticipated land use and infrastructure for future development is represented by the SWMPs for their respective cities

The Bailey Lake pump station has a critical influence on the ability of the CDSF to manage stormwater with or without a constructed overflow. In order to evaluate interim stormwater management scenarios for the CDSF (before the outlet is built), several pump station operation scenarios for Bailey Lake were formulated to use in the analysis. These pumping scenarios were used to evaluate the timing and required capacity for construction of the proposed CDSF overflow. Based on the above factors, interim pumping plans were evaluated to optimize the storage within Bailey Lake (thereby reducing pumping rates) and the CDSF basins. The interim pumping plans were looked at as options to managing storm water until the planned overflow is constructed.

6.0 RESULTS ANALYSIS AND DISCUSSION

Table 4 and Table 5 list the water surface elevations calculated for each model scenario listed in Table 2 and Table 3. It is important to note that these elevations are based on the current model update and level of detail (as of October 2007). The model results are subject to change based on geodatabase updates and detail added at later dates. All elevations are referenced to the NGVD 88 vertical datum. Relevant comments regarding the model results are also presented in Table 4 and Table 5.

The 70th Street low point, located at the south end of CDP-86S, is at elevation 906.25-ft and the CSAH 19 low point is at 908-ft. These elevations are important when considering the potential for uncontrolled overflows from the CDP-85/86 subsystems within the CDSF. As discussed in Section 2.1, the 902 elevation contour line was used as the target water surface elevation for the proposed grading plan for the CDP-86 flood storage area to maintain the flood storage pool within the SWWD property limits and to also provide freeboard for flood storage.

Table 4
Model Scenario Results for CDSF (Peak Elevations-ft NGVD 88)

Scenario ID	Scenario Name	Peak Elevation CDSF-85, ft	Peak Elevation CDP-86N, ft	Peak Elevation CDP-86S, ft	Total Volume pumped from Bailey Lake (ac-ft)	Comments
CDP 1	Central Draw Existing Conditions-No outlet	912.3	905.2	905.2	1500	The CDP-86 basin acts as a level pool at stages over 904 ft. Total Volume stored within the CDSF is 1700 ac-ft
CDP 2	Central Draw Existing Conditions- With outlet	912.3	905	898.2	1500	With an outlet available, the CDP-85/86 flood pool elevations would be maintained near or below the target pool elevations.
CDP 3	Central Draw Existing Conditions-Local flow only, No outlet	893	884.7	895	0	The total volume used up by the local runoff is 300 ac-ft, 42 ac-ft of which is used up within CDP-85. The weir between CDP-86N and CDP-86S is at elevation 904; hence the south lobe can have a higher flood pool than the north lobe.
CDP 4	Central Draw CGSWMP- Local flow only, No outlet	897	887.4	898.3	0	Total volume used for this scenario is 350 ac-ft. The total increase in runoff volume contributed only from Cottage Grove is 130 ac-ft. The weir between CDP-86N and CDP-86S is at elevation 904; hence the south lobe can have a higher flood pool than the north lobe.
CDP 5	Central Draw CGSWMP-150 cfs from Bailey, no outlet	912	906.4	906.4	1500	There is **NO** overflow to Gables Lake (low point on CSAH 19 is at elevation 908). **There is potential to overflow over 70th Street to Cottage Grove** (70th Street low point is at elevation 906.25).
CDP 6	Central Draw CGSWMP-150 cfs from Bailey, With outlet	912	904.8	901	1500	With an outlet available, the CDP-85/85 flood pool elevations would be maintained near or below the target pool elevations. Outlet pipe size is at 48-inches in diameter.
CDP 7	Central Draw CGSWMP Uncontrolled pumping, No outlet	912	907.8	907.8		**There is potential to overflow to Gables Lake** (low point on CSAH 19 is at elevation 908). **There is overflow 70th street to Cottage Grove** (70th street low point is at elevation 906.25).
CDP 8	Central Draw CGSWMP Uncontrolled pumping, With outlet	912	904.8	904.6		There is **NO** over flow to Gables Lake (low point on CSAH 19 is at elevation 908). There is also **NO** overflow across 70th street. **Flood stage contained within CDSF system but exceeds flood easements at 902-ft.**
CDP 9	Central Draw CGSWMP Controlled	911.4	904.6	904.3	1,422	There is **NO** over flow to Gables Lake (low point on CSAH 19 is at elevation 908). There is also **NO** overflow across 70th street. **Flood stage contained**

Scenario ID	Scenario Name	Peak Elevation CDSF-85, ft	Peak Elevation CDP-86N, ft	Peak Elevation CDP-86S, ft	Total Volume pumped from Bailey Lake (ac-ft)	Comments
	pumping, No outlet					**within CDSF system but exceeds flood easements at 902-ft**
CDP 10	Central Draw CGSWMP Controlled pumping, No outlet	911.1	904.5	903.2	1,300	There is **NO** over flow to Gables Lake (low point on CSAH 19 is at elevation 908). There is also **NO** overflow across 70th street. **Flood stage contained within CDSF system but exceeds flood easements at 902-ft**

Table 5
Model Scenario Results for Bailey Lake (Peak Elevations-ft NGVD 88)

Scenario ID	Scenario Name	Peak Elevations Bailey Lake Main Lobe	Total Volume pumped from Bailey Lake (ac-ft)	Comments
NWS 1	NWS Pre-update	872.4	1,951	
NWS 2	NWS- Existing Conditions	872.3	2,043	
NWS 3	NWS Proposed Land use	872.5	2,206	This is a comparison point
NWS 4	NWS- Proposed Land use with High School	872.5	2,.216	
NWS 5	NWS Existing Conditions, 7.8-inch storm	872.7	2,817	
NWS 6	NWS Proposed Land use, 7.8-inch storm	872.8	2,971	
NWS 7	NWS- Existing Conditions with Controlled pumps	878.6	1,422	
NWS 8	NWS- Proposed Land use with High School and Bailey Ridge pond diversion	872.09	2,041	

6.1 Local Storm Water Management (No Water Pumped from Bailey Lake)

The model results indicate that the CDSF, when graded as proposed, will function as a local storm water management system. It will have the capacity to handle a large rain event under existing conditions with no pumping from Bailey Lake (Scenario ID: CDP 3). The flood stage for this existing conditions scenario is around elevation 885 at CDP-86N and 895 at CDP-86S (Table 4). The maximum stage with the SWMP infrastructure in place and no pumping from Bailey Lake for the 6.3-inch, 24-hour event is about elevation 887 at CDP-86N and 898 at CDP-86S (Table 4, Scenario ID: CDP 4). The runoff volume in the CDSF is contained within the 902 limit. With the CDSF, there is no threat of overflowing into Gables Lake or through the Central Ravine (across 70th Street). It can accommodate local storm water volumes and maintain maximum ponding elevations without the need for an overflow. However, the flood stage during the design storm does increase over 3 feet within the system when compared to existing conditions. This rise in stage translates to a 180 ac-ft increase in stored volume. Woodbury accounts for 50 ac-ft of this volume, while the remaining 130 ac-ft increase in storm water volume can be directly attributed to the developments and storm water infrastructure in Cottage Grove's SWMP.

To summarize the model results for Scenarios CDP 3 and CDP 4, which compare the existing and proposed (as shown in the Cottage Grove SWMP) conditions in the CDSF in absence of flow from Bailey Lake:

1) The CDSF can contain the 6.3-inch, 24-hour local runoff under existing conditions.
2) The CDSF does see an additional 130 ac-ft of volume under proposed conditions in the Cottage Grove SWMP
3) The CDSF does see an additional 50 ac-ft of volume from Local drainage from Woodbury.
4) The total volume addition from Woodbury and Cottage Grove is 180 ac-ft.

6.2 Regional Storm Water Management (Water Pumped from Bailey Lake)

The response analysis of the CDSF for the scenarios in Table 2 and Table 4 is primarily focused on the CDP-86 basin flood stage elevations. Table 3 and Table 5 discuss the modeling completed using the Northern Watershed model with primary attention to the Bailey Lake sub-watershed. The CDP-86 basin is critical, since it represents the elevations at which uncontrolled overflows can occur to the Central Ravine in Cottage Grove. Also, the south lobes (SN, S1, and S2) of basin CDP-86 is where property restrictions occur, limiting the bounce under fully developed conditions to the approximate elevation of 902.

The CDSF model was analyzed for both the maximum pumping rate of 150 cfs from the Bailey Lake pump station (Scenarios: CDP 1, CDP 2, CDP 5 and CDP 6) and the pump flow hydrograph developed by the Northern Watershed model under existing conditions (Scenario: CDP 7). The Northern Watershed model run allowed 5 pumps to operate when the Bailey Lake

elevation of 870-ft was attained, with no restriction on the length of time the pumps operated (maximum unrestricted pumping; Scenarios: NWS 1, NWS 2, NWS 3, NWS 4, NWS 5, and NWS 6). A maximum stage of 906.4 for Scenario CDP 5 and 907.8 for Scenario CDP 7 was calculated at CDP 86. As shown in Figure 6, the stage at the main lobe of Bailey Lake reaches an elevation of 872.3 under existing conditions with maximum unrestricted pumping from Bailey Lake (Scenario: NWS 2).

Figure 5
Stage Hydrograph in the Main Lobe of Bailey Lake, 5 Pumps Operating, Design Event, Existing Conditions Model (Scenario: NWS 2)

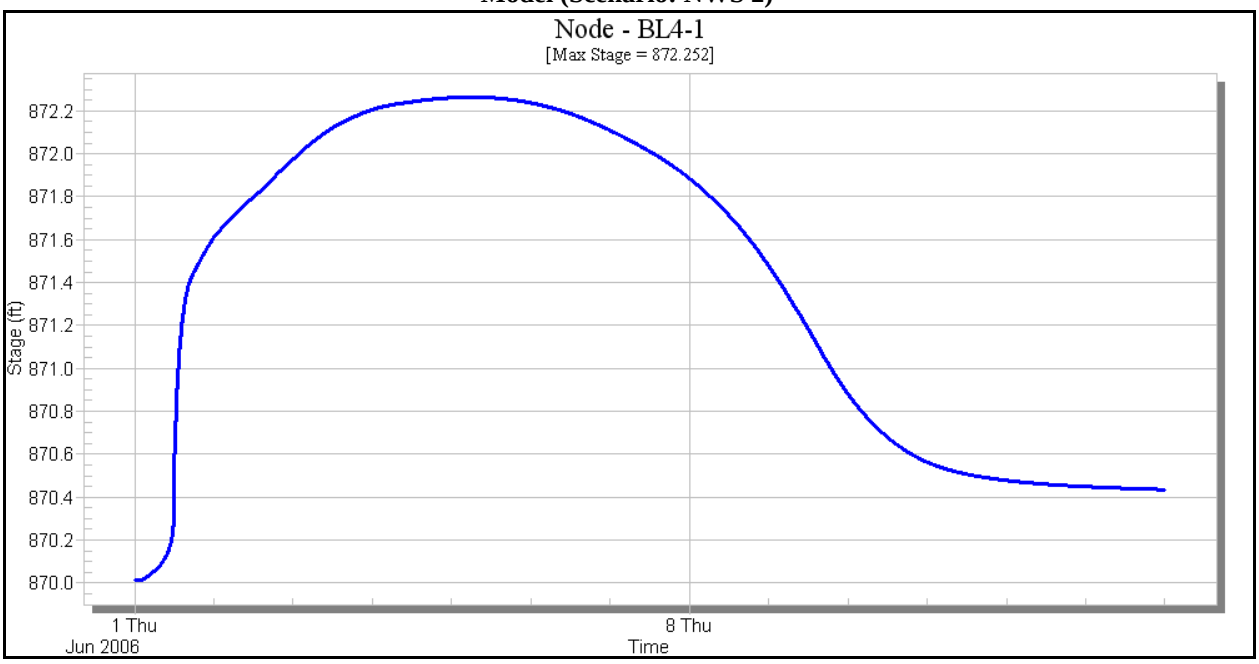
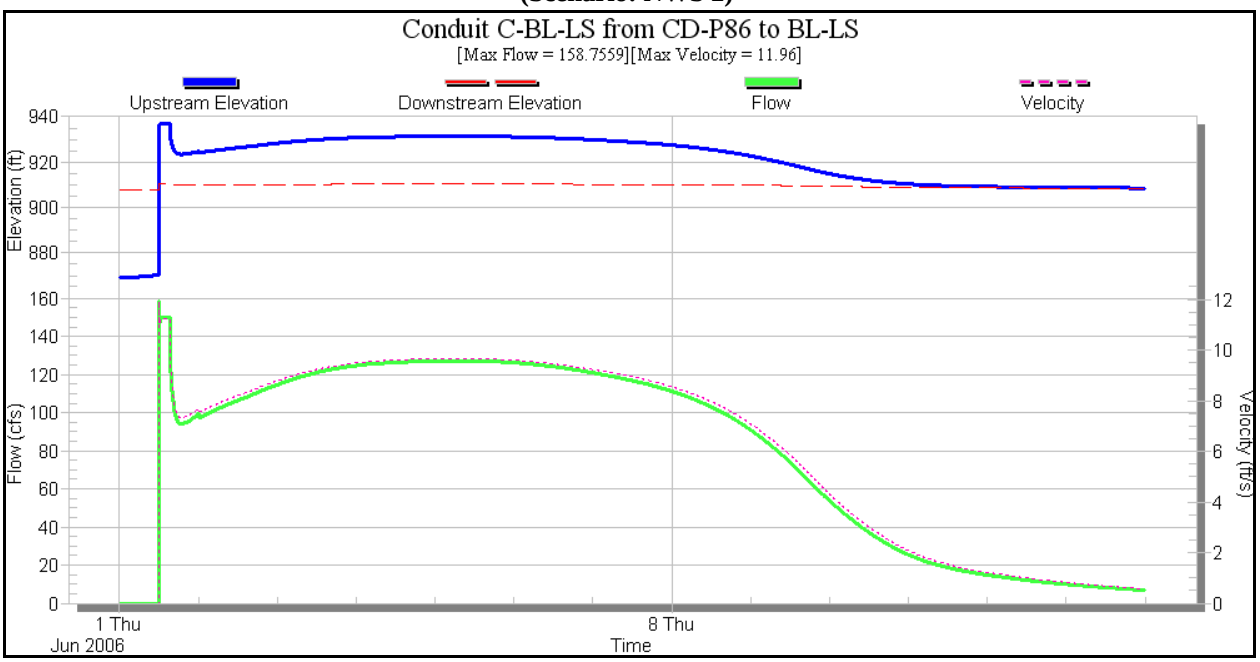


Figure 6 shows the pump hydrograph for this unrestricted pumping condition. There is 500 ac-ft of storage remaining within Bailey Lake that can improve storage allocation and manage the regional storm water, based on the allowable bounce within Bailey Lake. The allowable sustained bounce is elevation 877-ft and was set based on City of Woodbury easements, flood proof elevations on properties surrounding Bailey Lake, and at the pump station.

Figure 6
Bailey Lake Pump Hydrograph, 5 Pumps Operating, Design Event Existing Conditions Model (Scenario: NWS 2)



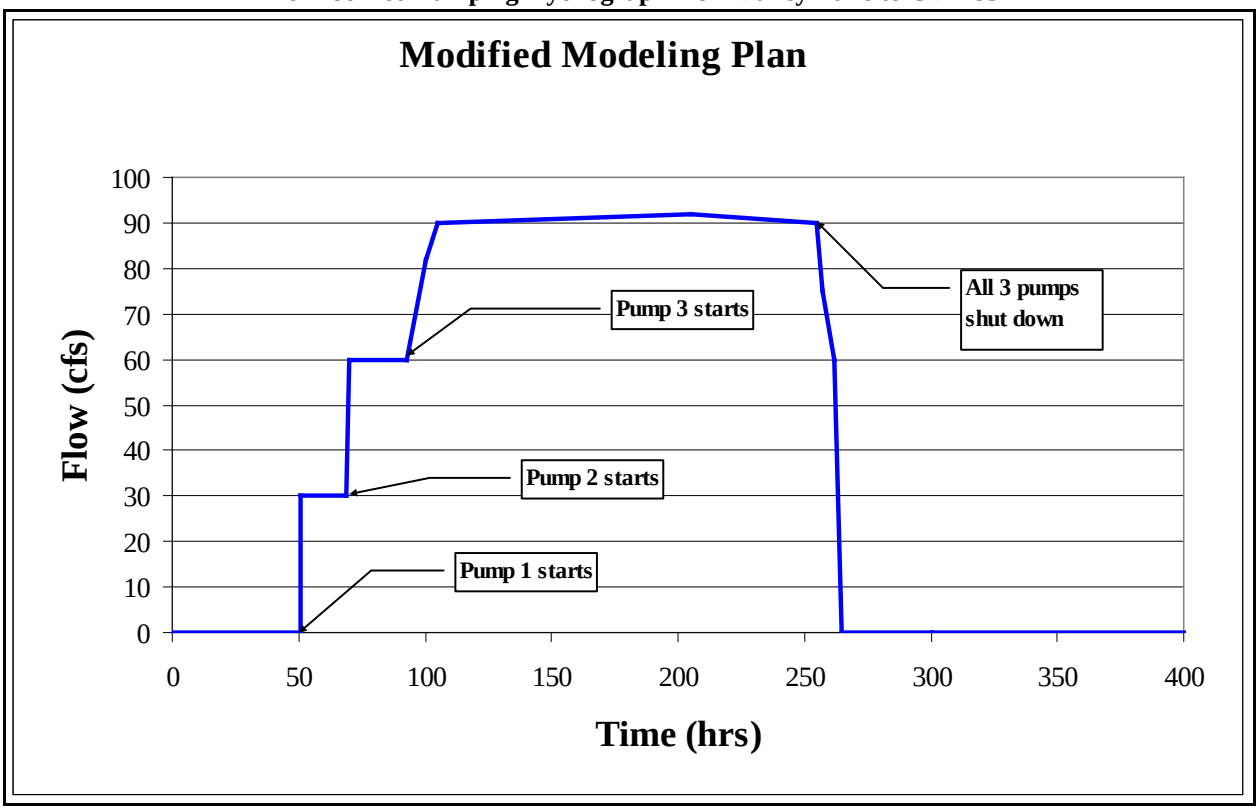
One approach to manage storage allocation is to take advantage of the 500 ac-ft remaining in Bailey Lake by allowing only 1300 ac-ft of water to be pumped from Bailey Lake to the CDSF (Model scenario: CDP 10). In addition, the pumps can be controlled to a rate of 60 cfs (two pumps operating) for a period of 250 hours. If this scenario is used, basin CDP-86N only reaches an elevation 904.5 ft, providing over 2-feet of freeboard to the uncontrolled overflow elevation during the 6.3-inch, 24-hour event (Table 4). However, at the 904 elevation the flood pool would encroach onto current flowage easements outside the SWWD property limits.

A representative pumping plan was compiled from the various plans presented in Appendix A and the response at Bailey Lake was examined using the Existing Conditions Northern Watershed model. The representative pumping plan is based on using only three of the existing 30-cfs rated pumps within the Bailey Lake lift station (Figure 5):

- First pump activated when Bailey Lake reaches elevation 875
- Second pump activated when Bailey Lake reaches elevation 876
- Third pump activated when Bailey Lake reaches elevation 877
- All three pumps turned off when the Bailey lake stage recedes below 877

The 3 step pumping plan is highlighted in scenarios CDP 9 and NWS 7 in Table 4 and Table 5.

Figure 7
The Modified Pumping Hydrograph from Bailey Lake to CDP-85



The pumping plan shown in Figure 9 was developed by modifying the pumping scenarios until Bailey Lake's stage peaked at elevation 878 (Figure 8). The resulting peak stage in CDP-86S is elevation 904.3 (Scenario: CDP 9), which is over two feet above the elevation limits that are within the SWWD property and causes an encroachment on available flood easements. This option also reduces the threat of an uncontrolled overflow in the City of Cottage Grove. This pumping plan (Figure 9) demonstrates that optimizing storage and controlling the pumping rate from Bailey Lake can ease the storage requirement and uncontrolled overflow from the CDSF. **This is especially valuable for interim flood management within the CDSF until the overflow is constructed.**

Based on the above modeling results, there is a need for the overflow when considering a maximum pump rate of 150 cfs. To summarize, the CDSF function for regional storm water management:

1) The CDSF needs an outlet
2) An interim pumping plan can allow the CDSF to function as both, a local and regional storm water management facility without an outlet for a single, 6.3-inch, 24-hour event. A deviation from this event (greater than a 6.3-inch, 24-hour event; back-to-back events, etc) will cause the CDSF to overflow

3) The CDSF can contain local storm water, without an overflow, if there is no pumping from Bailey Lake.

Figure 8
Bailey Lake Stage Curve with Modified Interim Pumping Plan (Scenario: NWS 7)

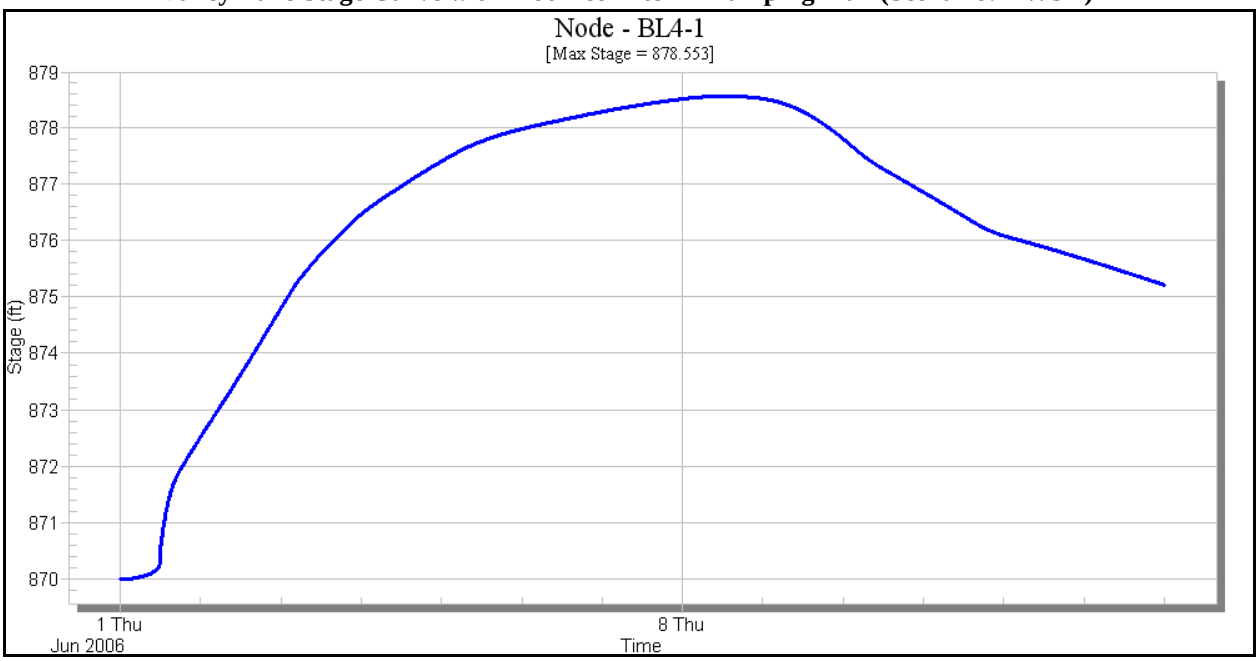


Figure 9
Bailey Lake Pump Hydrograph with Modified Interim Pumping Plan (Scenario: NWS 7)

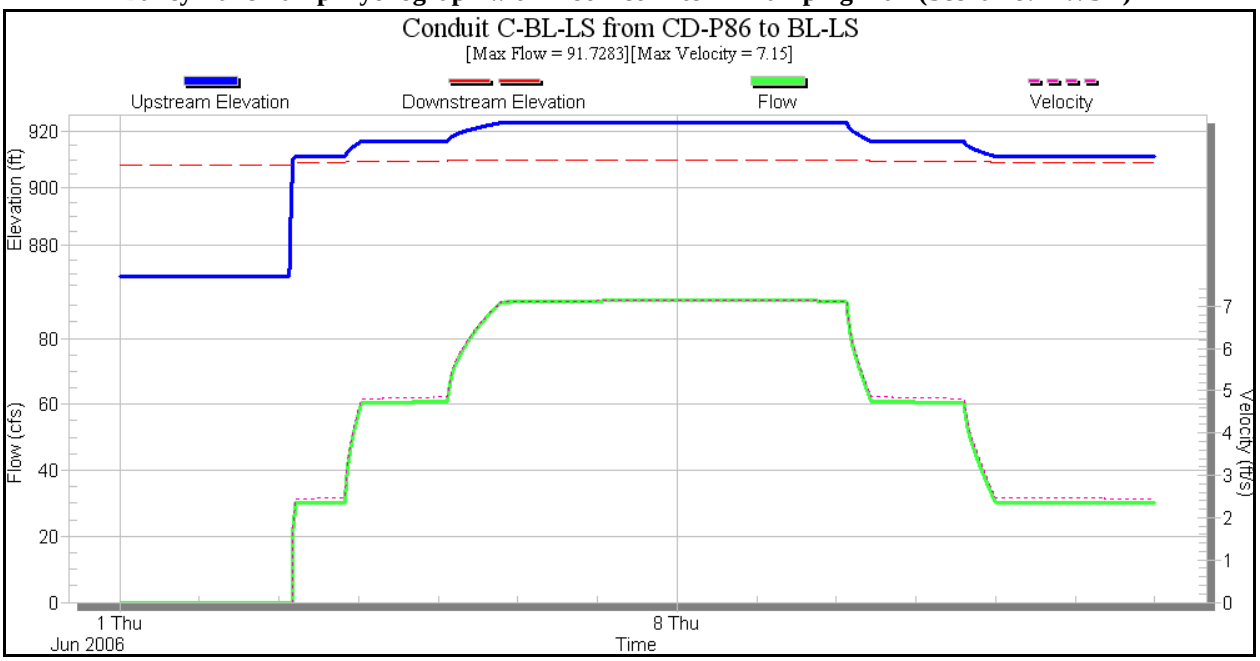
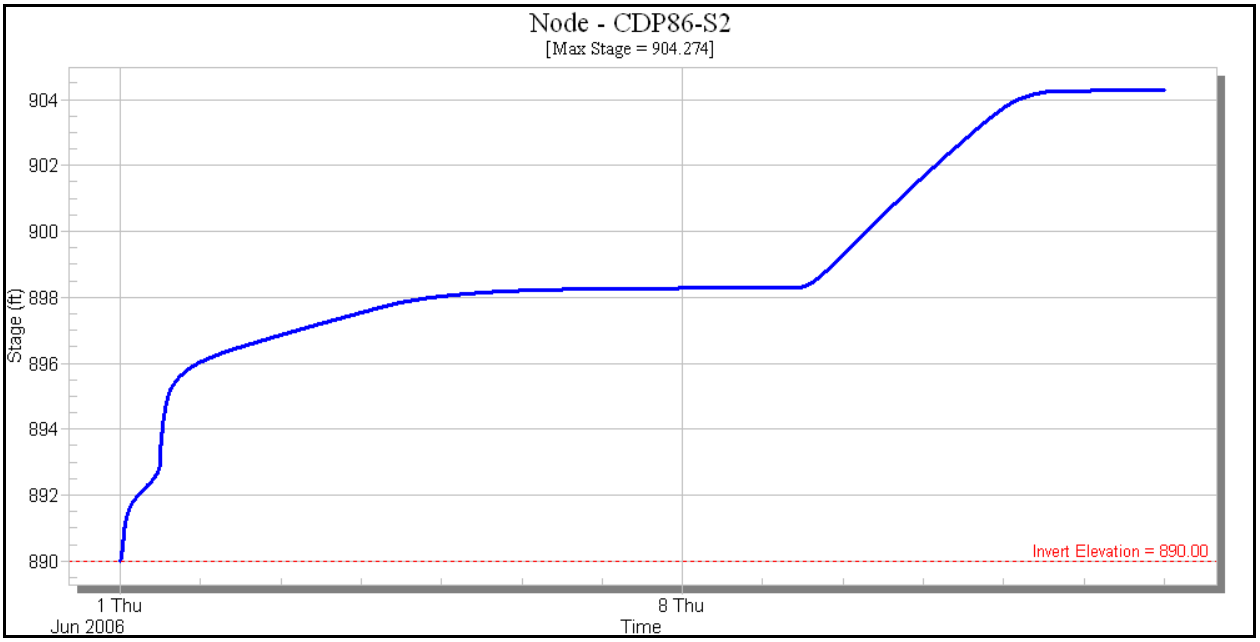


Figure 10
CD-P86S Stage Curve When the Modified Pumping Plan is Used at the Bailey Lake Lift Station (Scenario: CDP 9)



6.3 Overflow Sizing Analysis

The modeling analysis confirms the need for an overflow outlet for the CDSF. The size and alignment, based on initial concepts developed after the Engineer's Report of 2002, was a 72-inch pipe that will run east and then south to outlet to the East Ravine. The current modeling efforts included analysis of a reduced pipe size to convey the overflow safely to the East Ravine. Modeling (Scenario: CDP 6) indicates a 48-inch pipe size will have adequate capacity to provide the overflow for the CDSF system while maintaining the runoff volume for a design event within the allocated easements.

Adding an outlet to the CDSF system will promote the use of the CDP-86 basin for local storm water management by the City of Cottage Grove. The watershed is keen to provide local storm water management combined with the regional facility. Based on size and capacity requirements for the overflow, the outlet design for the CDSF system can include a pipe through the Central Ravine or a multiple stage outlet. Further analysis of these potential options will follow prior to design and construction of the outlet.

7.0 SUMMARY

A complex matrix of modeling scenarios was completed and the results analyzed to answer the following primary questions:

- What is the capacity needed for the overflow from the CDSF
- When does it need to be constructed
- What are the impacts the surface water management plans for Cities of Woodbury and Cottage Grove on the CDSF
- Can the CDSF function as a local storm water management facility

The pertinent models were updated to reflect the storm water infrastructure and landuse changes anticipated in the surface water management plans for the respective cities. The results of this effort are summarized as follows:

- The rate and volume of runoff from the Bailey Lake watershed moderately increased for the proposed conditions reflected in the surface water management plan. The outlet structure planned for the Danner gravel pit in the surface water management plan leaves excess, unused storage that can be maximized by installing a revised outlet structure design
- The Bailey Lake pump station, when operated without any flow restrictions, forces approximately 2200-acft of volume into CDP-85, spread over a fourteen day period during a 6.3-inch 24-hour design rain event. This volume results in uncontrolled overflows across 70th Street in Cottage Grove
- The available storage volume at Bailey Lake can be utilized by optimizing the operations at the pump station during a 6.3-inch, 24-hour event. When pumping is controlled, the water surface elevations in the CDSF system would stay below the maximum overflow elevations without uncontrolled overflows. However, the water surface elevations would exceed target elevations and ponded areas would encroach onto current flowage easements. The current configuration and the proposed grading plan configuration for the CDP-86 basins can accommodate a 6.3-inch, 24-hour event with no expected uncontrolled overflows if the Bailey Lake pump station has optimized operating rules
- Storm runoff volumes for the 6.3- and 7.8-inch, 24-hour events from the direct drainage areas affecting the CDSF, without pumping from Bailey Lake, is contain within the CDSF without uncontrolled overflows. In this scenario, the basins work to manage the local runoff. Base flood elevations are contained below the target elevations for the basins under the proposed grading plan
- Uncontrolled overflows across 70th Street would result under a 7.8-inch, 24-hour event or back to back 100-year 6.3-inch, 24-hour events even when pumping is controlled at Bailey Lake. In light of the probabilities of these events occurring, the construction of an overflow does not present an immediate or emergency need. However, it is strongly recommended that an implementation plan for an overflow be compiled so that one can be funded, planned, designed, and constructed within a reasonable time span such as the next 3 to 5 years

- The proposed concept plan for the Ravine Parkway will have significant impacts to all the discussion points above. These impacts were discussed in a separate memorandum and are attached as Appendix B

8.0 CONCLUSIONS

This document discusses the complex and challenging issues of managing storm water runoff and rate within the Bailey Lake and CDSF watersheds. The CDSF is critical to the overall watershed functioning both as the primary outlet to the Northern Watershed and as a local storm water facility within the City of Cottage Grove. The following conclusions are based on the analysis completed and discussed in this document:

- The Central Draw Storage Facility needs an overflow pipe to provide an adequate level of protection for the watershed. Present modeling indicates a 48-inch diameter pipe capacity, at a minimum, is required to adequately convey the overflow
- It is recommended that an implementation plan for an overflow be compiled so that one can be funded, planned, designed, and constructed within the next 3 to 5 years
- The surface water management plans for both Cities of Woodbury and Cottage Grove maintain peak flow rates within the exiting values but, result in moderate increases in runoff volume from the contributing watersheds. Controlled and managed pumping from Bailey Lake can increase the functionality of the Central Draw Storage Facility
- The Central Draw Storage Facility can contain the 100-year runoff from the immediate watershed. Hence, the CDSF can function as a local storm water management facility within the immediate CDSF contribution drainage areas

Appendix A
Bailey Lake Pump Station Permit Letter

Appendix B
Review Letter for the Ravine Parkway

Bailey Lake Discharge Facility Operating Plan

March 1, 2004 Draft

The Bailey Lake Discharge Facility Operating Plan follows from detailed hydrologic and hydraulic modeling conducted by the City of Woodbury and the South Washington Watershed District (SWWD). The intent of this modeling is to determine the design requirements for Woodbury's full-development stormwater system and how this design affects the Bailey Lake improvements proposed for 2004 construction. The preliminary report titled Bailey Lake Lift Station Expansion Improvements (September 30, 2003) details aspects of the regional stormwater system that are assumed in the design of the Bailey Lake facility.

Also important in determining the operating plan is consideration of interim plans for discharge downstream of CD-P85. In this interim period, until a permanent outlet to the Mississippi River is constructed, the ability to discharge may be limited by the storage and infiltration capacities within CD-P85 and the several basins that are collectively known as CD-P86. The operating routines described in this report are based upon full-development conditions. To some extent the more aggressive pumping routinges should be measured against the ability of the downstream system to accommodate the Bailey Lake discharge.

This operating plan is organized into the following sections:
Introduction

- Standard Operating Routines for Flood Control
- Operating Routines for 10-day Rainfall Events
- Operating Routines for Runoff Events
- Interim Flood Control Operations
- Drawdown

Introduction

For multiple pump operation, proper pump sequencing allows each of the two 48-inch forcemains to carry, as much as possible, the same flow. This reduces overall system losses and allows optimum pump operation. The prescribed operation groups and their respective rating curves are provided in table 2. One of the six pumps provides redundant pump capacity and is thus not a component of the rating curves. Figure 4 provides locations for existing and proposed pumps within the lift station.

The elevations at which one pump transitions to two, two to three, and so on result from analyses of a multitude of storm and runoff events used by both the South Washington Watershed District and the City of Woodbury. In some cases particular events have a unique operating routine. In other cases an operating routine covers several events. The operating routines outlined below relate to full-development of the watershed.

The following is a summary of the rainfall and runoff events for which the operating routines are developed:

24-hour events of magnitude less than the 100-year:

As utilized in developing the operating plan and routines these events include:

- 2.8-inch, 2-year event
- 3.6-inch, 5-year event
- 4.2-inch, 10-year event
- 5.4-inch, 50-year event

24-hour 6.0 inch rainfall event:

Historically, the City of Woodbury's 100-year design event and the event for which the majority of City's stormwater infrastructure has been designed.

24-hour 6.3-inch rainfall event (SWWD design)

Based on a closer look at historic rainfall data and work by Huff and Angel, the SWWD has developed this event as the replacement for the 6.0-inch rainfall event.

24-hour 7.8-inch rainfall event (SWWD 95% confidence interval)

This is the 95% confidence interval rainfall depth for the 6.3-inch event.

10-day 9.3-inch rainfall event (SWWD design)

Again, based on work by the SWWD and relying on work by Huff and Angel this is considered by the SWWD as the 100-year, 10-day rainfall.

10-day 10.6-inch rainfall event (SWWD 95% confidence interval)

95% confidence interval rainfall depth for the 9.3-inch event.

10-day 7.2-inch runoff/snowmelt event

Historically used by the City and the SWWD as a design event.

10-day 6.0-inch runoff/snowmelt event

Another commonly used runoff event used elsewhere in the Twin Cities Metropolitan Area.

Table 1
Rating Curve Summary

One Pump Rating Curve — Any single pump

Elevation (MSL - F	Discharge (CFS)
869.0	28.7
870.0	29.0
871.0	29.3
872.0	29.5
873.0	29.8
874.0	30.0
875.0	30.3
876.0	30.5
877.0	30.7
878.0	31.0

Two Pump Rating Curve — One pump from #6, #5, #4; One pump from #3, #2, #1

Elevation (MSL - F	Discharge (CFS)
869.0	58.5
870.0	59.0
871.0	59.5
872.0	60.0
873.0	60.5
874.0	61.0
875.0	61.4
876.0	61.9
877.0	62.3
878.0	62.8

One Pump Rating Curve — Any single pump

Elevation (MSL - F	Discharge (CFS)
869.0	28.7
870.0	29.0
871.0	29.3
872.0	29.5
873.0	29.8
874.0	30.0
875.0	30.3
876.0	30.5
877.0	30.7
878.0	31.0
879.0	31.2
880.0	31.4

Two Pump Rating Curve — One pump from #6, #5, #4; One pump from #3, #2, #1

Elevation (MSL - F	Discharge (CFS)
869.0	58.5
870.0	59.0
871.0	59.5
872.0	60.0
873.0	60.5
874.0	61.0
875.0	61.4
876.0	61.9
877.0	62.3
878.0	62.8
879.0	63.2
880.0	63.6

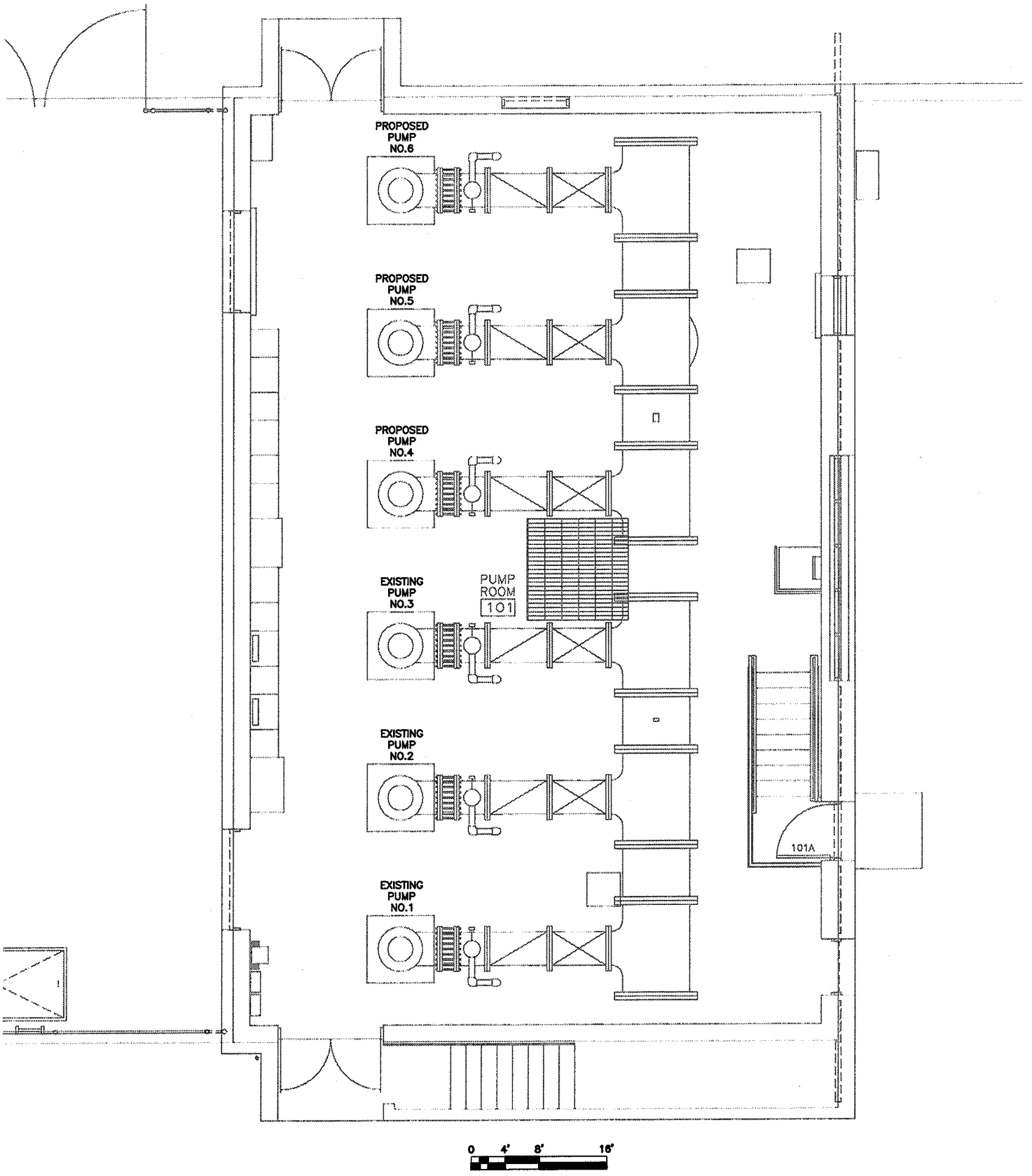
Three Pump Rating Curve — 2 pumps or 1 pump from #6, #5, #4; 1 pump or 2 pumps from #3, #2, #1

Elevation (MSL - F	Discharge (CFS)
869.0	85.5
870.0	86.3
871.0	87.1
872.0	87.8
873.0	88.5
874.0	89.3
875.0	90.0
876.0	90.7
877.0	91.3
878.0	92.0
879.0	92.7
880.0	93.4

Four Pump Rating Curve — Two pumps from #6, #5, #4; Two pumps from #3, #2, #1

Elevation (MSL - F	Discharge (CFS)
869.0	113.7
870.0	114.7
871.0	115.7
872.0	116.7
873.0	117.6
874.0	118.6
875.0	119.5
876.0	120.4
877.0	121.3
878.0	122.2
879.0	123.1
880.0	124.0

Five Pump Rating Curve — 3 pumps or 2 pumps from #6, #5, #4; 2 pumps or 3 pumps from #3, #2, #1



UPPER LEVEL PLAN

WOODBURY, MINNESOTA FIGURE 1

BAILEY LAKE LIFT STATION IMPROVEMENTS

3103222ZF01 DATE: 12-16-03 COMM: 3103222

Bonestroo Rosene Anderlik & Associates
Engineers & Architects

Standard Operating Routines for Flood Control

Operating Routine A

Condition	24-hour rainfall totals from 2.0 to 2.8 inches (2-year event)
Pumping	Single pump on at 870.0
Bailey Lake HWLs (2.8-inch event)	
Upper	873.4
Pool #1	873.4
Lower	873.4
Peak Discharge (2.8-inch event)	30 cfs
Time to Bailey Lake Peak Elevation	7 days

Operating Routine B

Condition	24-hour rainfall totals from 2.8 to 3.6 inches (2-year event)
Pumping	First pump on at 870.0
	Second pump on at 871.0
	Third pump on at 872.0
	Fourth pump on at 875.0
Bailey Lake HWLs (3.6-inch event)	
Upper	875.1
Pool #1	875.0
Lower	875.0
Peak Discharge (3.6-inch event)	120 cfs
Time to Bailey Lake Peak	10 days

Operating Routine C

Condition	24-hour rainfall totals from 3.6 to 6.0 inches (100-year event)
Pumping	First pump on at 870.0
	Second pump on at 871.0
	Third pump on at 872.0
	Fourth and fifth pumps on at 873.0
Bailey Lake HWLs (6.0-inch event)	
Upper	877.0
Pool #1	876.9
Lower	876.8
Peak Discharge (6.0-inch event)	150 cfs
Time to Bailey Lake Peak	9 days

Operating Routine D

Condition	24-hour rainfall totals above 6.0 inches
Pumping	All pumps on at 870.0
Bailey Lake HWLs (6.0-inch event)	
Upper	877.0
Pool #1	876.9
Lower	876.8
Peak Discharge (6.0-inch event)	150 cfs
Time to Bailey Lake Peak	9 days

Operating Routines for 10-day Rainfall Events

It is assumed for the purposes of developing operating routines that 80% of the SWWD 10-day design rainfalls occur in a two day period, so the response to these events, in terms of initiating an operating routine, can be based on two day rainfall totals. Table 2 shows 80% depths for the two 10-day design rainfalls.

Table 2
80% Depths for 10-day Rainfalls

SWWD 10-day Rainfall	80% Rainfall Depth
9.3 inches	8.4 inches
10.6 inches	9.5 inches

When two day rainfall totals exceed 8.4 inches Operating Routine D should be used. The initial day of a two day rainfall may trigger Operating Routine B or C. If, on the second day, additional rainfall occurs such that the two day total exceeds 8.4 inches Operating Routine D should be initiated. Modeling simulations calculate a 5 day travel time for flood hydrographs from Armstrong Lake to Bailey Lake so the system allows sufficient time to respond to changing conditions without increasing calculated HWLs.

Operating Routines for Runoff Events

Runoff events occur with the spring thaw and result from rapid snowmelt or rainfall on top of rapid snowmelt. The water content of the snowpack can be determined. When snowpack water content approaches 3-inches the conditions for a runoff event may be in place. In March, public works staff should be aware, on an ongoing basis, of snowpack water content. When this water content plus a two day rainfall total exceeds six inches then Operating Routine D should be initiated.

Table 3 provides calculated rainfall and runoff event HWLs for automatic operation according to the routines described above.

Table 3
Calculated Full-Development HWLs

Event	HWL		
	Upper Bailey	Pool #1	Lower Bailey
24-hour Rainfall Events			
2-yr, 24-hr, 2.8-inch	873.4	873.4	873.4
5-yr, 24-hr, 3.6-inch	875.1	875.0	875.0
10-yr, 24-hr, 4.2-inch	876.5	876.4	876.4
50-yr, 24-hr, 5.4-inch	876.9	876.8	876.7
100-yr, 24-hr, 6.0-inch	877.0	876.9	876.8
100-yr, 24-hr, 6.3-inch (SWWD)	878.1	878.0	878.0
100-yr, 24-hr, 7.8-inch (SWWD 95% confidence)	880.3	880.1	880.1
10-day Rainfall Events			
100-yr, 10 day, 9.3-inch	877.5	877.3	877.3
100-yr, 10 day, 10.6-inch	879.3	879.1	879.1
10-day Runoff Events			
10-day, 6.0-inch	878.8	878.7	878.6
10-day, 7.2-inch	879.1	879.0	879.0

Interim Flood Control Operations

In the interim, until a permanent outlet to the Mississippi River is constructed, the Bailey Lake Discharge facility will be pumping into the CD-P85 and CD-P86 complex of infiltration areas. The P85/86 system does not have a permanent outlet. Limited discharge into Cottage Grove might be available for off-peak dewatering. Additionally, emergency discharge into Gables Lake has been accounted for in the SWWD plan amendment. Primarily, this system relies on infiltration as its only outlet.

Until a permanent outlet is constructed there are limitations to the 150-cfs pumping beyond which the CD-P85/86 complex is full and overflow occurs across County Road 19 toward Gables Lake.

According to the SWWD Engineers report that supports the watershed's 2003 Minor Plan Amendment, the following storage is available in the CD-P85/86 complex:

CD-P85	550 ac-ft
CD-P86 North	640 ac-ft
CD-P86 South	320 ac-ft
Total	1510 ac-ft

Table 4 shows for each 30-cfs pumping increment the time, in days, to fill the 1510 ac-ft of storage available.

Table 4
Pumping Times for 1510 ac-ft

Pumping rate	Time to Fill
(cfs)	(days)
30	25.4
60	12.7
90	8.5
120	6.4
150	5.1

Table 4 gives some indication of allowable run times, before cresting of County Road 19 and discharge to Gables Lake, for the interim condition with phase 2 improvements in place.

The SWWD monitors infiltration in CD-P85. Based on the results of this monitoring, the City of Woodbury has incorporated infiltration rating curves for both CD-P85 and CD-P86 into its stormwater modeling. Peak modeled infiltration rates for the two basins total approximately 120 cfs during flood event modeling. The average modeled infiltration rate is approximately 65 cfs. Assuming a 65-cfs steady state infiltration capacity leads to longer run time estimates for each of the pumping rate increments, as shown in table 5.

Table 5
Pumping Times for 1510 ac-ft with Infiltration

Pumping rate	Time to Fill
(cfs)	(days)
30	NA
60	NA
90	30.5
120	13.8
150	9.0

Taken together, tables 4 and 5 give some indication as to limits to pumping during the interim period.

All interim flood response pumping should be coordinated with the SWWD and modified according as upstream or downstream conditions warrant.

Drawdown

Periodic small rainfalls will generate runoff that does not trigger automatic pump operation (at 870.0'). Periodic drawdown to the proposed 868.0 Bailey Lake maintenance elevation will thus be necessary. Typically, these drawdowns will not move more than 100 to 150 ac-ft of water into CD-P85, unless the station is on manual operation and water levels in Bailey are allowed to build up beyond 870.0'.

The calculated full-development HWLs for Bailey Lake are based on an 870.0' starting elevation and not the 868.0' maintenance elevation. This allows for the possibility that a flood event might occur before a periodic drawdown has brought the basin back to the maintenance elevation. In the interim there is some flexibility to allow the basin to rise toward 871.0' or 871.5' and still maintain a 877.0' HWL for the 6.3-inch design event. As the Bailey Lake subwatershed develops, and the City gets closer to full development, the more important it becomes to begin drawdown before water levels rise above 870.0'.

Operational Responsibilities

To be determined by City staff?

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Memo

To:	Matt Moore, Administrator, South Washington Watershed District
From:	Suresh Hettiarachchi, Mike Johnson
Date:	04/30/2007
Job No:	42393-164

RE: Coordination of the Proposed Ravine Parkway with the Central Draw Overflow Project

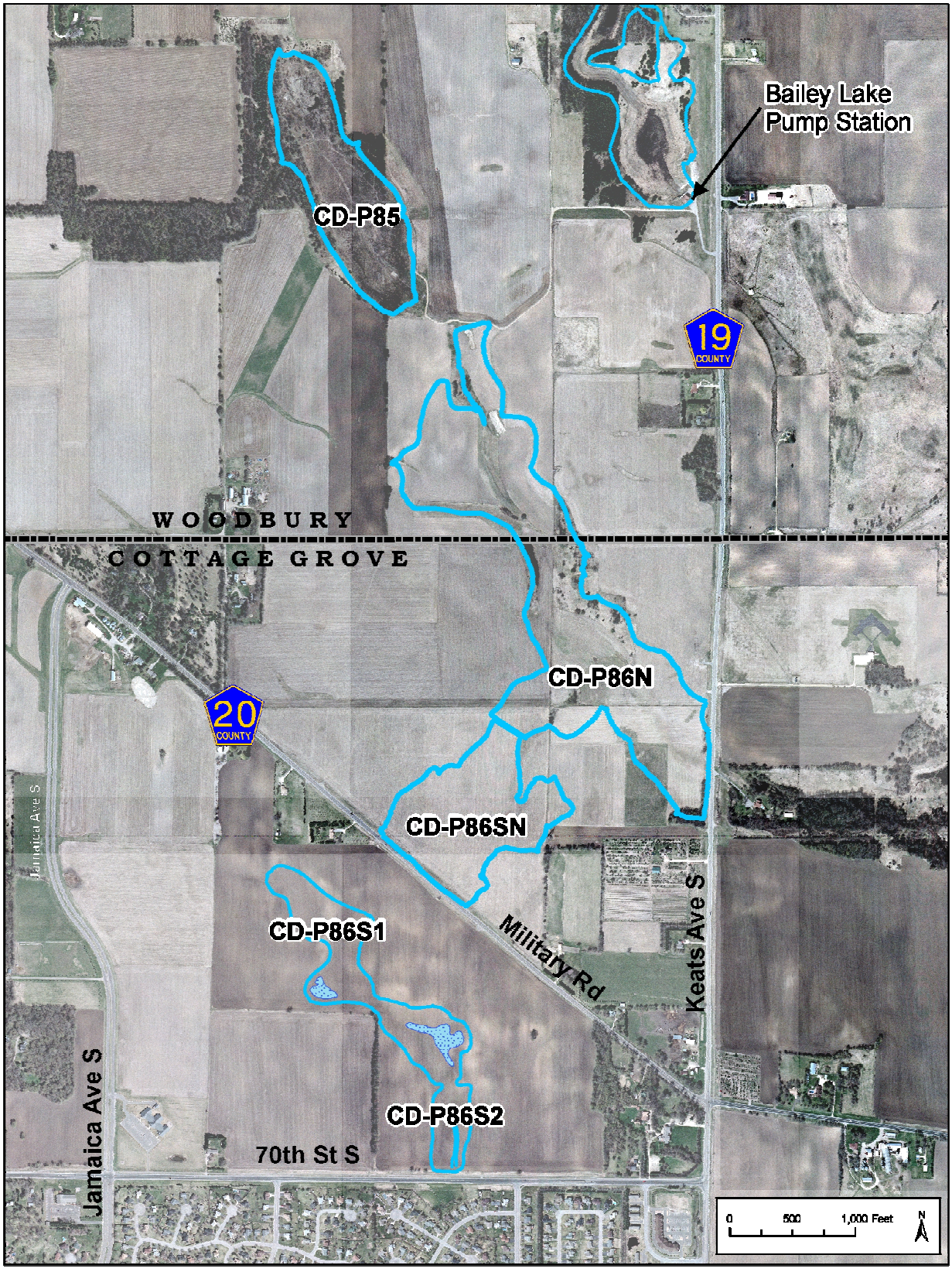
The following memorandum discusses comments on the proposed Ravine Parkway in the City of Cottage Grove and the present status of the Central Draw Overflow Project (Project) The context of the Project provides for regional storm water management, and promotes and encourages other municipal project uses of the storm water management features, such as the Ravine Parkway. The planned parkway has significant impacts on the overall form and function of the Project. These impacts require careful corporation and coordination between the City of Cottage Grove and the South Washington Watershed District (SWWD).

Background of the Central Draw Project

The SWWD, in coordination with the cities of Woodbury and Cottage Grove, is working on the Project that is part of the minor plan amendment presented by HDR Engineering, Inc. (HDR) in the year 2002. The Project purpose is to provide the communities upstream of Bailey Lake a principle outlet and a combined regional storm water service with the City of Cottage Grove. The layout is based on the management of excess runoff associated with a 100-year, 24-hour event. An event of this return period and duration is generally considered the maximum level of service provided by previously constructed and proposed drainage systems in the watershed.

Exhibit A presents a general overview of the Project, showing the layout of the detention/infiltration basins. The overflow from Bailey Lake is pumped into detention/infiltration location CDP-85, with the flow then following a southerly route that eventually ends in storage location CDP-86S. A future, large diameter outflow pipe will carry the excess storm water from the Project to the East Ravine, which will then eventually flow into the Mississippi River.

Exhibit A



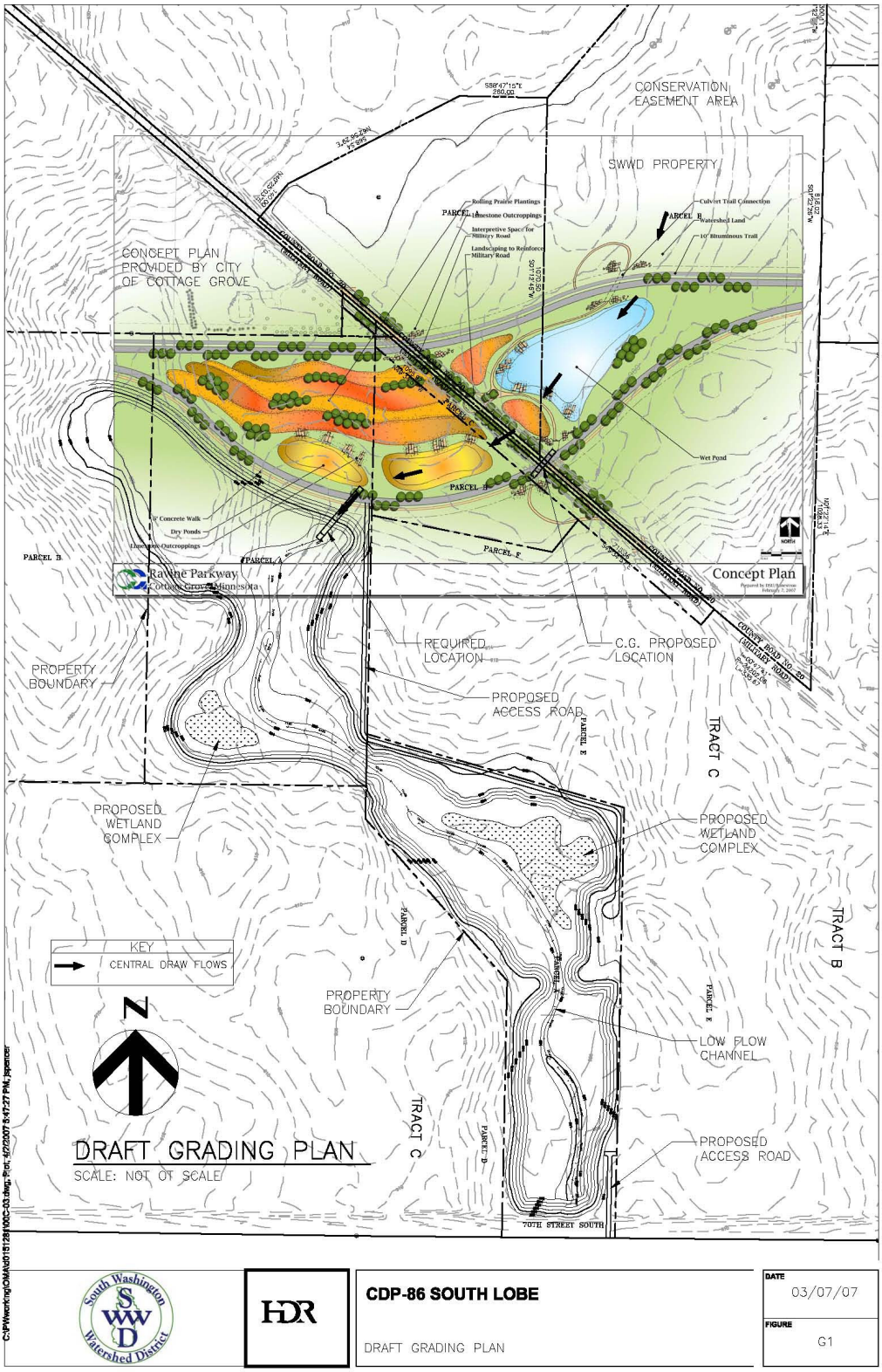
Map Document: (N:\GISProj\SWWD\42369\map_docs\MapsCentralDrawOverview2.mxd)
4/2/2007 – 4:19:09 PM

Comments and Discussion on the Ravine Parkway

The intent of the Project is to provide storm water management for the region in corporation with the cities of Woodbury and Cottage Grove. Hence, the following thoughts and comments are provided reflecting the efforts to update the grading for the CDP-86S basin and optimize the regional and local context of the Project. As the present layout of the proposed Ravine Parkway has a significant impact on the storage volume of the CDP-86S basin, resolution of the comments discussed below forms a critical path on completing the present update and planning for the overall Project. The points that need to be addressed are:

- Conveyence of flows through the Ravine Park
- Altering the alignment and layout to minimize impacts to the storage basin
- Profile and grading for the Ravine Parkway
- Volume impacts to the Project
- Storm sewer infrastructure
- High water lever impacts to the park
- Use of infiltration methods and native vegetation

Exhibit B
Grading Plan for CDP-86 S with the Layout for the Proposed Ravine Parkway



Conveyance system through the park

As presented in Exhibit B, the City of Cottage Grove is planning to construct a parkway through the present Military Road region. Military Road bisects the southern storage basin of the CDP-86 storage area. A 14-foot wide, 10-foot tall box culvert installed under Military Road provides the connection needed to allow proper conveyance of storm water through the Project. The proposed parkway will require installation of two similar culverts to connect the upstream and downstream basins of CDP-86S. The location of these culverts will need close coordination with the grading plans for CDP-86 and will also be based on the layout and grading for the parkway. Proper locations and alignment of these culverts with the internal conveyance system within the park is a crucial component of the overall Project, which needs careful consideration.

If the proposed plan is to convey the flows from the northern basin through the minor ponds within the loop area of the park, the hydraulic behavior of this section will need particular attention. Each of the ponds, and their associated hydraulic inlet and outlet structures, must have enough conveyance capacity to pass the required design storm (100-year, 24-hour, 6.3-inch event) from both offsite (form CDP 86N) and onsite storm water runoff. During a design event, the ponds may experience rapid increases or fluctuations in the pond water levels. Sufficient freeboard above the maximum water surface elevation (approximately 3 feet) should be considered to prevent unacceptable overland flow and erosion problems should an outlet become partially clogged or a larger than 100-year design storm occur.

A potential option to solve this issue is to design a meandering channel through the park area with sufficient conveyance capacity to accommodate the flows through the Project under design conditions. The minor ponds can have a connection to the channel, but will function as offset locations without being part of the main conveyance route. The parkway option will require installation of two box culverts, similar in size to the present culvert under Military Road. Two separate culverts are required for this option to connect the two halves of the CDP-86S basin.

Alternative layout

One option to consider for maintaining the form and function of the parkway and provide the storage volume needed for regional storm water management is and alternative layout through the CDP-86S basin for the parkway. Another option to consider would be for the parkway to remain along the south loop and have the adjacent park area as part of the Project area with park benches and such. This will minimize the grading required for the roadway and the impacts to the storage basin.

Profile and grading of the roadway area

When looking at the prevailing contours, it is evident that the proposed split in the parkway is at the low area along the alignment. Based on the profile for the road and the allowable slopes that meet traffic and roadway design requirements, the grading required for the road and the associated fill to achieve the proper roadway sections and grades can also alter the form and storage within the CDP-86S basin. Coordination will be essentail to develop a properly functioning layout for both the parkway and the basin that takes the effects of the proposed roadway embankments, and fill sections, into account.

Volume impacts to the Central Draw project area

The proposed Ravine Parkway consumes a significant fraction of area and volume from the CDP-86S basin. As indicated in Exhibit B through Exhibit D, the parkway removes significant portion of area and storage volume

from the basin. This volume impact will have to be mitigated in some way for the Project to provide an adequate level of service to the region. Any reduction in storage volume in the CDP will have ramifications in the volume of storm water pumped from Bailey Lake, and the volume of local storm water from the proposed development around the CDP-86S basin routed to the Project. Based on the prevailing contours, there is opportunity to trade some land between the SWWD and the City of Cottage Grove to achieve the optimum balance for the parkway and the Project. Alternatively, storing an equivalent volume of local storm runoff outside of the Project area can also mitigate the impact of the Ravine Parkway on the overall Project.

Storm sewer infrastructure and elevations

It is assumed that the proposed parkway will be an urban design with the storm sewer outleting to the CDP-86S basin. The profiles and outlet points for this infrastructure, as well as the locations and elevations of the outlets for the local sewer systems that connect to the Project, will also need to be coordinated.

High water level impacts to the park

The high water level for the CDP-86S basin is estimated to reach 902 feet. This high water level will have a significant impact on the profile of the proposed parkway, which will affect the grading and the overall impact to the Project. It is important to note that this 902-foot elevation is based on the present grading and storage volumes and can change based on design changes and adjustments as required through the combined efforts between the City of Cottage Grove and the SWWD.

Use of infiltration methods

Due to the advantages of the predominant soils within the watershed, the SWWD is focusing on infiltration as a preferred best management practice for storm water runoff control. In fact, the concept of the Project is based on detention/infiltration for regional storm water management. Hence, it is suggested that infiltration be used to the maximum extent possible for runoff control for the Ravine Parkway

Use of native vegetation in the park

The watershed is also striving to promote native vegetation when considering parkland and green spaces. Hence, the SWWD would encourage the use of native vegetation for the Ravine Parkway and the park area.

Current Status

In anticipation of development in and around the Project area, the SWWD is updating the storm water plan for this area and formulating grading plans that will represent the form of the storm water storage in the Project. The present effort is focused on working with the property limits owned by the SWWD to update the grading plan for the CDP-86 storage area. The land acquired by the SWWD for the Project is shown in both Exhibit B and Exhibit C. The storage areas follow the prevailing land contours in the area to minimize excavation, maximize storage, and reduce costs. The limits of the land acquired by the SWWD require a modification of the natural topography to maintain the storage area and volumes within the property limits.

Exhibit B

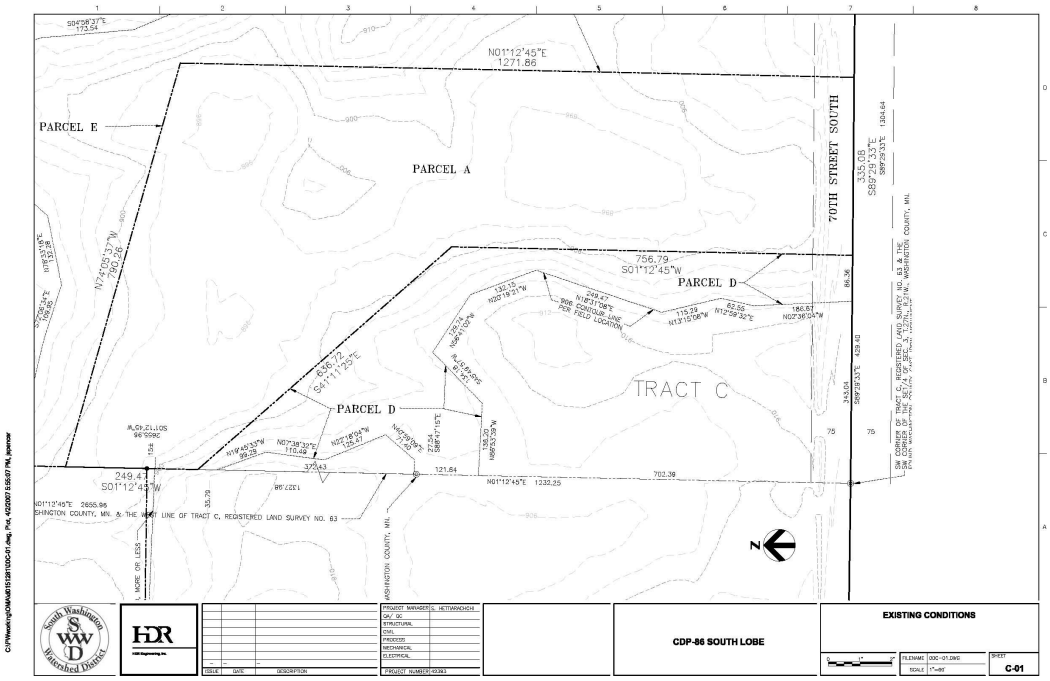
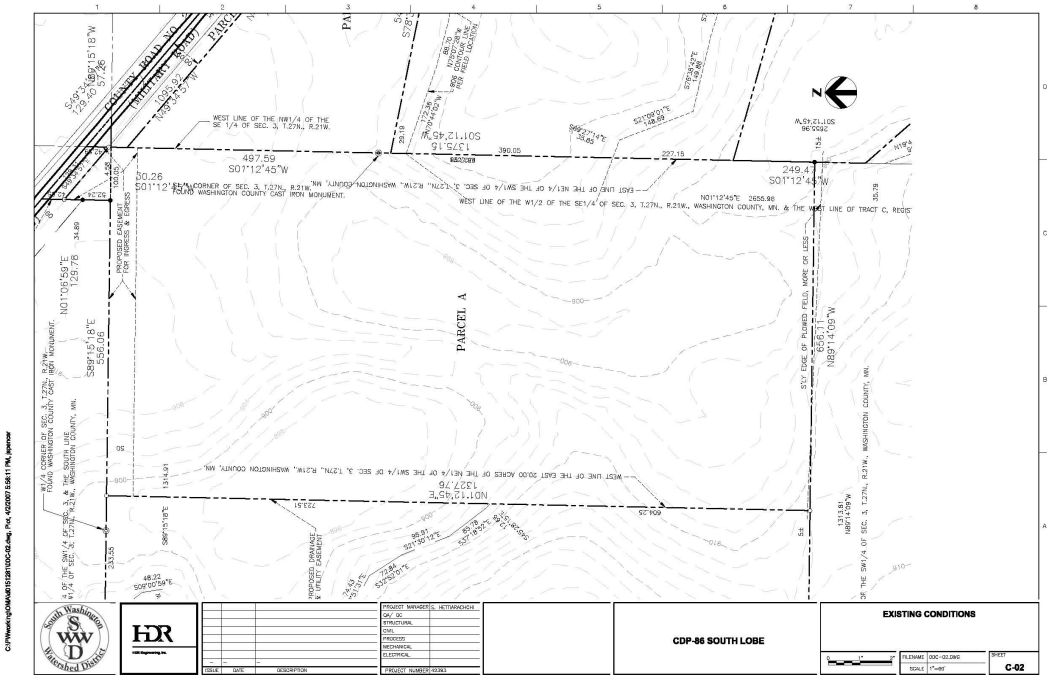
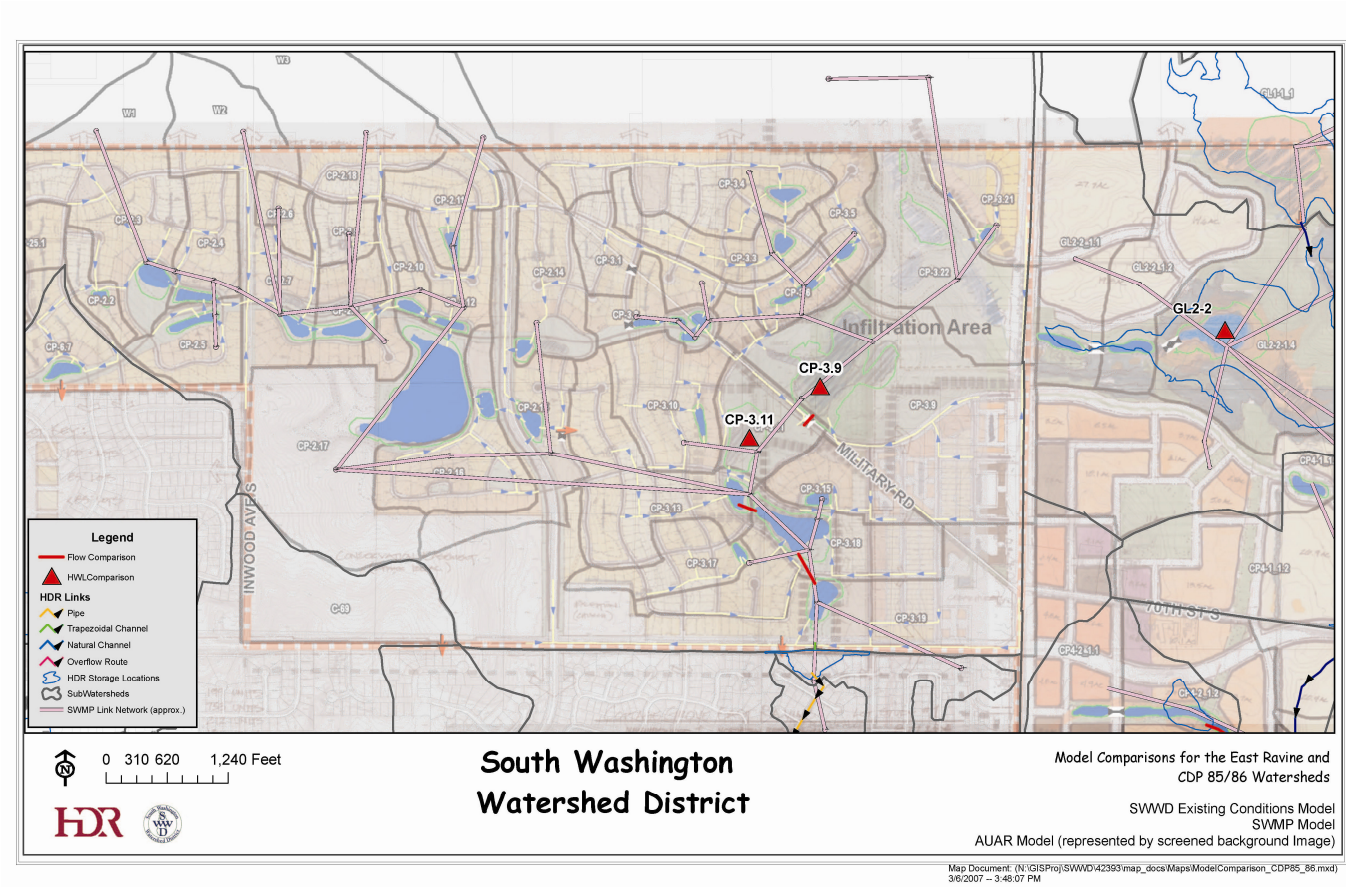


Exhibit C



The SWWD is working on incorporating the proposed development activity surrounding the Project with the proposed layout. The proposed development within the City of Cottage Grove includes residential developments and parkway systems with new storm sewer infrastructure and updated land use patterns. The proposed land use changes and storm sewer infrastructure, as provided in the Surface Water Management Plan (SWMP) by the City of Cottage Grove, is presented in Exhibit D. The proposed Ravine Parkway, as shown in Exhibit , has a direct impact on the Project and needs careful coordination to ensure that storm water functionality of the CDP 85 and 86 areas continue to provide tangible benefits and work cooperatively with the development planned for the surrounding areas. These aspects are further discussed following the modeling results.

Exhibit D
Proposed Storm Water Infrastructure Layout in the SWMP for the Central Draw Area



HDR updated the SWWD model for the Project based on the storm water management model provided by the City of Cottage Grove. This model incorporates the storm water infrastructure proposed in the SWMP and the updated and proposed grading for the CDP-86 storage area. Exhibit shows the updated grading plan for the CDP-86 south lobe with the proposed Ravine Parkway.

Conclusion

It appears that the overall concept for the Ravine Parkway can be accommodated, with some mutual coordination and adjustments, to fit in well with the overall SWWD watershed plan for the Project. Coordination of the Project design aspects to minimize volume impacts including sufficient conveyance and hydraulic performance capacity within the Ravine Parkway, will be required in order to make sure that the Project fits in with the overall storm water conveyance plan and that it is minimally susceptible to damage during low frequency storm events. As the SWWD is in the process of updating the layout for the CDP, looking at the need and timing of the overflow pipe, and evaluating the volume of water pumped from Bailey Lake, resolving the major volume and conveyance-related issues discussed above is critical and time sensitive.