ENGINEER'S REPORT

CENTRAL DRAW PROJECT AND FLOOD STORAGE AREA MAPS

FINAL – JUNE 2002

HDR

ENGINEERS REPORT

CENTRAL DRAW PROJECT AND EXISTING FLOOD STORAGE AREA IDENTIFICATION

SOUTH WASHINGTON WATERSHED DISTRICT

June 2002

FINAL

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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Introduction

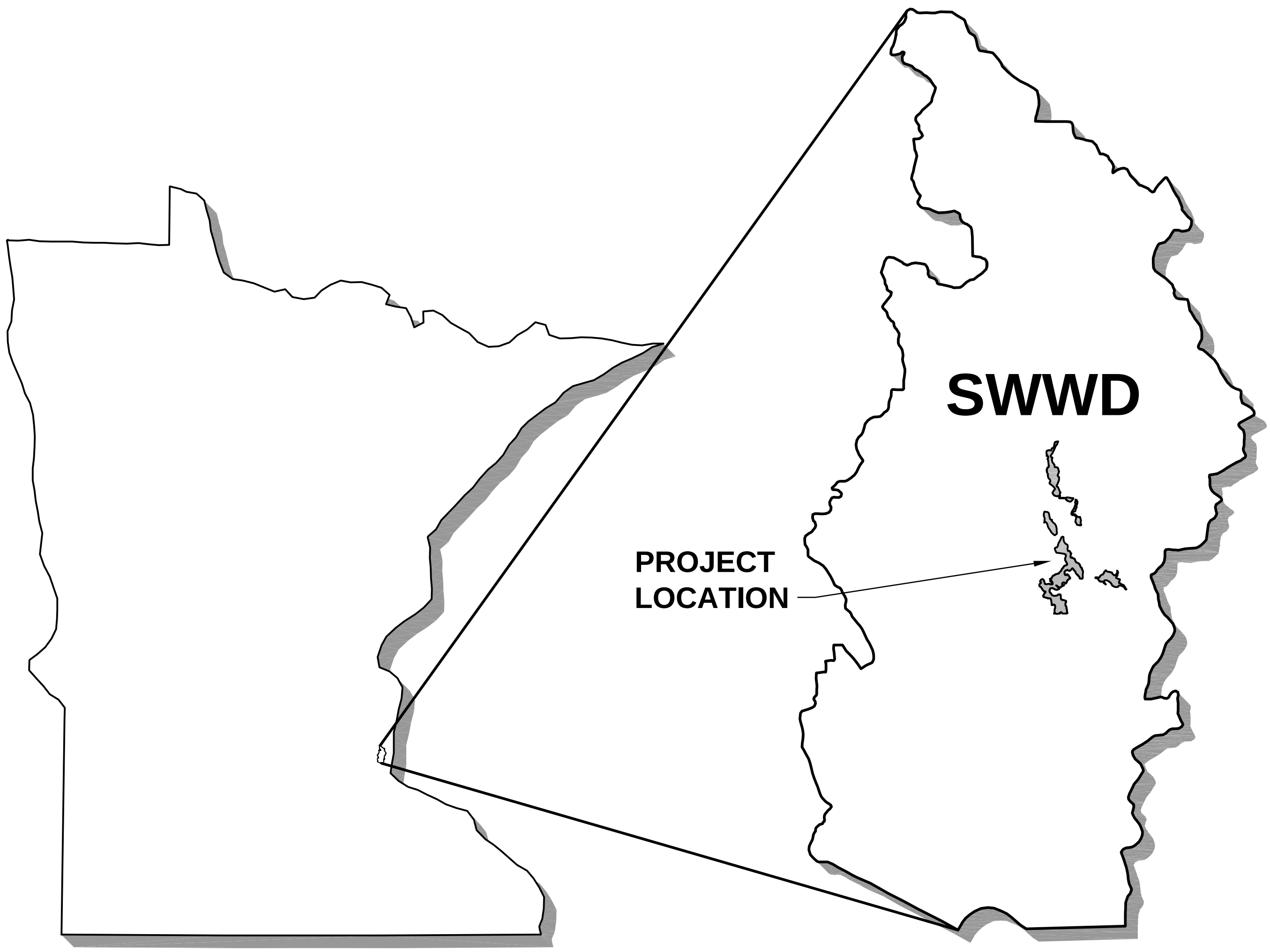
1.0 Purpose of Report

The South Washington Watershed District (SWWD) is preparing a minor plan amendment for the South Washington Watershed District Watershed Management Plan. The purpose of the minor plan amendment is to provide for construction of a flood control project (Project) to reduce existing flooding potential within the watershed and identify existing flood storage areas. At the request of the City of Woodbury, the proposed Project has been designed to also accommodate drainage modifications resulting from Woodbury's Phase I AUAR (Alternative Urban-wide Area Review) area. Figure 1 presents a map showing the location of the proposed Project and site vicinity map. In September of 2000, the SWWD Board was presented with a draft "Preliminary Engineers Report for Plan Amendment" prepared by HDR Engineering, Inc. (HDR) and SWWD staff. Following review of the report, the SWWD Board determined that there were still several unanswered questions and additional information was required. Items included:

- Producing comparable results between consultants and engineers working on the project through use of Washington County 2-foot topographic maps.
- Identification and mapping of existing flood storage areas.
- Impact of the overflow on the City of Cottage Grove's Central Ravine drainage system.
- Documentation surrounding the basis of the 7.2-inch, 100-year, 10-day runoff event and whether it should be used for design.
- Estimation of flood damage costs to residential structures versus project implementation costs for various flow rates and project phases.
- Provide for continued discussions with impacted communities to gain a better understanding of issues associated with an outlet.

The SWWD conducted additional studies, analyses and planning to address these concerns and has now requested HDR to prepare this Engineers Report and present a project to correct existing flooding conditions with associated flood storage areas identified. This information will be used to amend the SWWD plan to allow for project implementation.

SOUTH WASHINGTON WATERSHED DISTRICT



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HDR

SITE VICINITY MAP

Date
6/06/02

Figure
1

HDR Engineering, Inc.

2.0 Summary of Activities

The SWWD conducted hydrologic and hydraulic modeling in order to assess existing conditions of the storm water system of the watershed. Where available, the hydrologic and hydraulic modeling incorporated information provided by the cities. In addition, Washington County 2-foot topographic maps, aerial photos, and field surveys were used to verify drainage divides and hydraulic features. The various sources of information available for the hydrologic and hydraulic models were:

- Lake Elmo's 1986 Cottage Grove Ravine WMO Local Water Management Plan
- Oakdale's March 1995 Draft Annexation Area Drainage Study
- Woodbury's 1979 Storm Drainage Plan
- Woodbury's 1994 Surface Water Management Plan (Tri-Lakes & Meadow View Areas)
- Cottage Grove's 1984 Comprehensive Storm Drainage Plan
- Cottage Grove Ravine WMO's 1988 Draft Watershed Management Plan
- Woodbury's Hydrologic Analysis for the Design of the Bailey Lake Lift Station
- I-94 Study
- Northern Watershed Model and its Variations
- Southeast Model
- Wilmes Lake Watershed Model
- Cottage Grove Central Ravine Model
- Infiltration Studies conducted by the SWWD
- City of Woodbury's January 2002 XP-SWMM Model of the Proposed Phase I AUAR area.

The SWWD has conducted a number of engineering, scientific and inventory studies as part of the Central Draw Project evaluation. These efforts are ongoing and have included:

- Lake water quality assessment
- Wetland inventory and classification
- Analysis of biological surveys and reconnaissance studies
- Infiltration documentation and studies
- Field surveys
- Greenway Plan

- County Road 19 Environmental Assessment
- Ravine Stabilization Study

3.0 Purpose of the Proposed Project and Existing Flood Storage Area Identification

According to Webster's 9th New Collegiate Dictionary, a flood is "a rising and overflowing of a body of water especially onto normally dry land" and a floodplain is "level land that may be submerged by floodwaters". The SWWD definition of a floodplain is more specific, "a floodplain is the area along channels and waterways, including the area around lakes, marshes, lowlands, and ponding areas, which would become inundated as the result of a flood occurring once every 100 years". The process of developing the project for existing conditions results in mimicking a flood event and identifying its associated floodplain. Because floodplains may be altered as part of development, this report has adopted terminology consistent with Minnesota Rules. Therefore, the term flood storage area has been used rather than floodplain. According to Minnesota Rules 8410.0060 Subp. 4, Surface Water Resources, Watershed Districts must identify the following information in regards to surface water data:

- maps showing the areas served by each existing stormwater system that identify existing stormwater ponds and the location of all stormwater outfalls (see Figures 3 and 4);

- a table summarizing available information on the 100-year flood levels and peak discharges of existing and proposed stormwater ponds and flood profile information that corresponds to the peak discharges of channelizing flow passing through the watershed. The plan shall determine the need for additional data and recommend a schedule for that data. A discussion must also be provided relative to the consistency of the flood profile information developed as part of the stormwater management plan to that of any information published in a Federal Emergency Management Agency flood insurance study (There is no FEMA information published for this watershed);

- a general discussion of, or a map showing areas of, known flooding problems not identified as flood-prone in a published flood insurance study (Addressed in Section 6.3 of this report);

- a listing of the existing flood insurance studies and a location of where they can be viewed. - No studies exist for this area.

The proposed Project is intended 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 under existing conditions. An event of this return period and duration is generally considered the maximum level of service provided by previously constructed drainage systems in the watershed. Also, additional overflow capacity is provided to manage higher volume and longer duration events. Therefore, the design is intended to provide principal and emergency outlet capacity for this land locked watershed up through completion of Woodbury's Phase I AUAR development area. The proposed Project is located in Washington County, Minnesota and is illustrated in Figure 2.

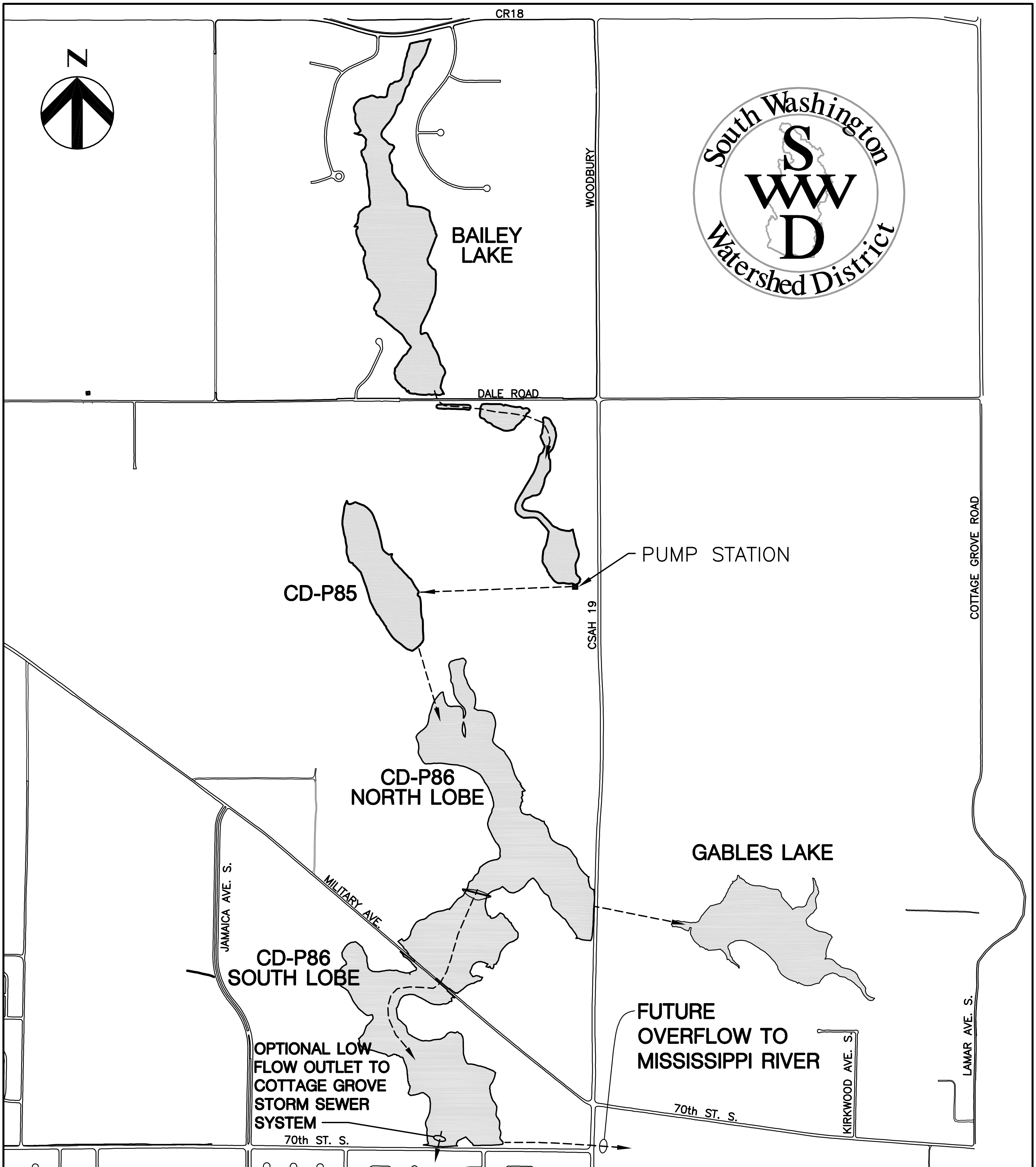
At the request of the City of Woodbury, the proposed Project has also been designed to accommodate additional drainage from the Phase I AUAR area through the existing drainage system. The design does not take into account other city drainage proposals presented to the

SWWD Board by the City of Woodbury at the February SWWD meeting. The other proposed drainage improvements will be addressed as part of a major amendment to the SWWD plan.

Woodbury also intends to apply for a permit to alter the rate, volume and location of storm water discharge from the Bailey Lake Pump Station. The current permit limits flow rate to 75 cfs and water can not discharge beyond CD-P86 North lobe. The Project is designed to accommodate flows up to 150 cfs and discharge stormwater to CD-P86 South Lobe and Gables Lake. Earlier proposals included release of stormwater into the City of Cottage Grove's stormwater system. However, engineering analysis of the Cottage Grove drainage system has shown it is susceptible to flooding for certain storm events. Therefore no regional water will be discharged into this system until flood damage reduction projects are completed.

The project minimizes flooding potential on upstream residential and commercial properties. The conveyance and storage of water along the proposed route will provide additional opportunities for infiltration and recharge of the aquifer system, creation of greenways along the project route and also provide the opportunity for the City of Cottage Grove to utilize portions of the system for their own local drainage.

There has been considerable discussion whether the proposed project should be developed based upon existing or ultimate land use conditions. For the purposes of this plan, HDR has utilized the land use and topographic conditions that are documented in the year 2000 Washington County 2-foot topographic maps and aerial photos and the stormwater modeling results provided to the SWWD by the City of Woodbury for the Phase I AUAR area. The design for this project is based upon reducing the existing flood risk within the upstream communities. It also accommodates Woodbury's expansion into its Phase I AUAR area. The outlet capacity provided by the project exceeds the discharge capacity of the northern watershed under existing conditions. The project design does not consider any additional development beyond the Phase I AUAR area.



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PROJECT LAYOUT MAP

Date
6/06/02

Figure
2

HDR Engineering, Inc.

4.0 Project Overview

HDR has prepared preliminary design drawings depicting a 150 cfs design for the Project. These drawings are provided in Appendix A. The drawings indicate the proposed SWWD improvements to transfer water between the basins, CSAH 19, Military Road and 70th Street. The major construction elements of the Project Implementation Plan include:

- An overflow pipe from CD-P85 to CD-P86N

- Upgrade of CSAH 19 to act as a dam and construction of a fixed crest overflow into a gated culvert structure to direct flows towards Gables Lake. Channel improvements are likely needed downstream of CSAH 19 to safely convey water to Gables Lake.

- Construction of a small spillway structure to convey water from CD-P86N to CD-P86S

- A road raise and culvert improvement at Military Road

- Construction of the necessary pilot channels for water conveyance.

- Upgrade 70th Street to act as a dam, with optional low flow outlet to Cottage Grove storm sewer system.

- Optional improvements to CD-P86 South Lobe to increase the efficiency of the storage and land use.

- Optional connection pipe between CD-P85 and CD-P86N to facilitate water management between the basins.

In regards to proposed improvements to the Bailey Lake Lift Station, HDR understands that the City of Woodbury will be responsible for making these improvements. The following items are suggested for the City's consideration.

- Adding Additional Pump Capacity
- Flood proofing the Lift Station
- Adding Redundant Power Supply

The existing flood storage area maps associated with this report provide several uses. These include:

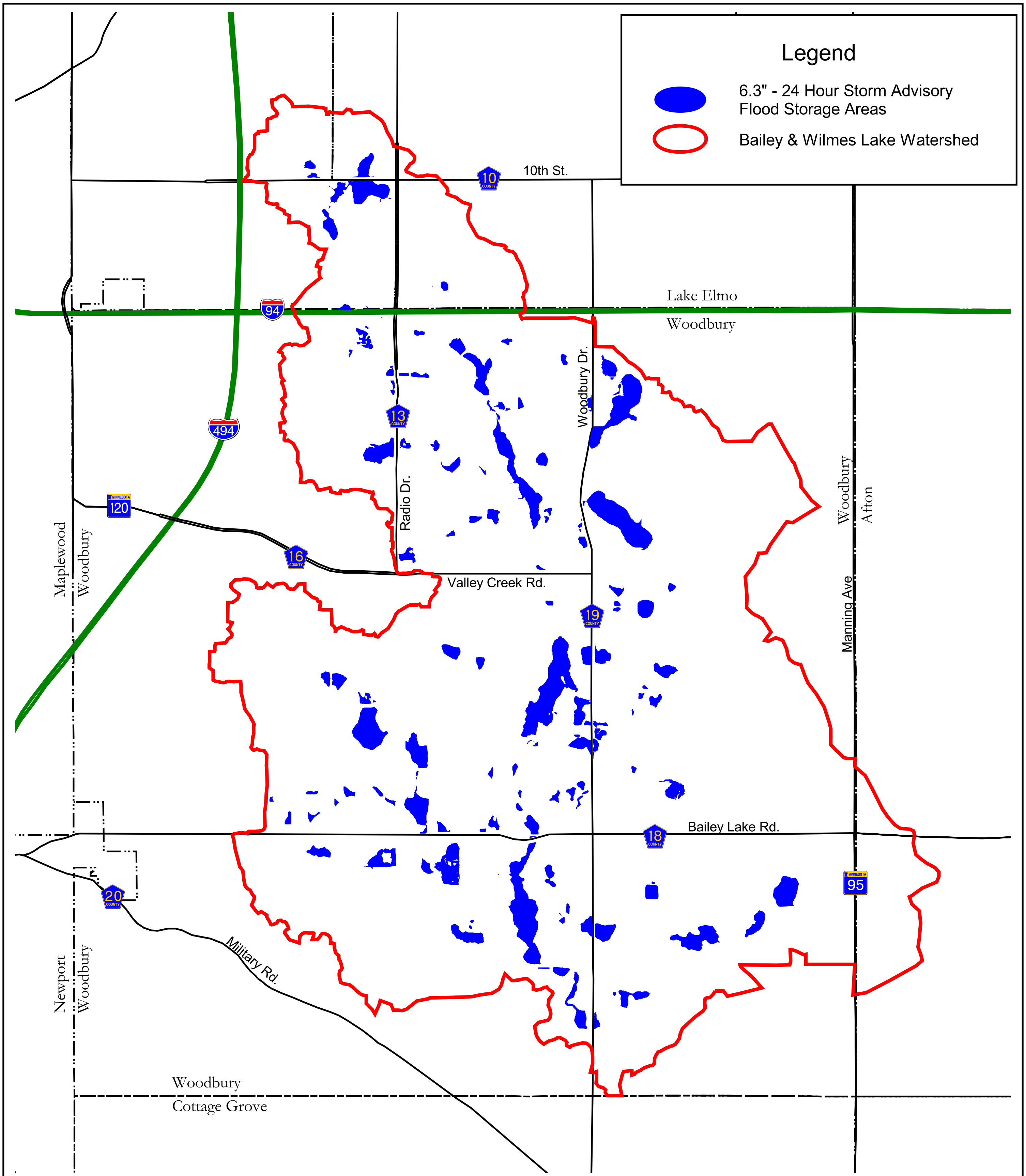
- Documenting the location and volume of water storage under existing conditions.
- Providing advisory maps to guide land use decisions and planning.
- Assist in emergency planning to identify critical infrastructure and structures in harm's way.

5.0 Project Need

There is currently a flood risk within the City of Woodbury and especially areas under the hydraulic influence of Bailey Lake because of MNDNR permit conditions, development, and lack of a defined overflow route. The existing Bailey Lake Lift Station was designed under the assumptions that water levels would be maintained at or below a pool elevation of 877. However, there is limited ability to discharge storm water beyond CD-P85. The existing Department of Natural Resources permit does not allow the discharge of storm water past CD-P86 North Lobe and engineering analysis indicates that the CSAH-19 road embankment would not be a suitable dam unless modified. Therefore, the hydraulic calculations predict that the lift station and other properties are inundated during certain flood events upstream of the lift station. There is not an emergency outlet for this watershed. If the existing lift station is to be utilized, then it is critical that sufficient pump and outlet capacity is provided. The City of Woodbury has objected to raising the lift station and increasing the flood elevation on Bailey Lake based upon their environmental concerns. However, additional operational flexibility and flood storage capacity could be achieved through increasing flood levels at Bailey Lake. Due to the limited flood storage capacity in CD-P85 and CD-P86 North Lobe as constrained by the DNR permit, the lift station can only be operated for 6½ days before storage capacity is used up during the 100-year 24-hour conditions. For the purposes of this report, it is assumed that the existing lift station remains in place and is flood proofed to an elevation of 883.

Significant area upstream of Bailey Lake is within the Metropolitan Council's 2020 growth area. The only areas that are not within the 2020 growth area are small portions of Afton, Lake Elmo and Cottage Grove. The City of Woodbury has the largest landmass within the project watershed and has a comprehensive plan that results in significant development opportunities. Portions of the watershed have developed under the assumption that the outlet contemplated in the City of Woodbury's 1979 drainage plan and the 1984 Cottage Grove drainage plan would be provided. However, that outlet was never constructed. The project is intended to provide sufficient outlet capacity for development under existing conditions and includes Woodbury's Phase I AUAR area. A major plan amendment is being developed to address ultimate development conditions. It is important for the minor and major plan amendments to proceed in a timely manner so the communities can know the specific operating parameters of the Project in order to design their local drainage systems accordingly.

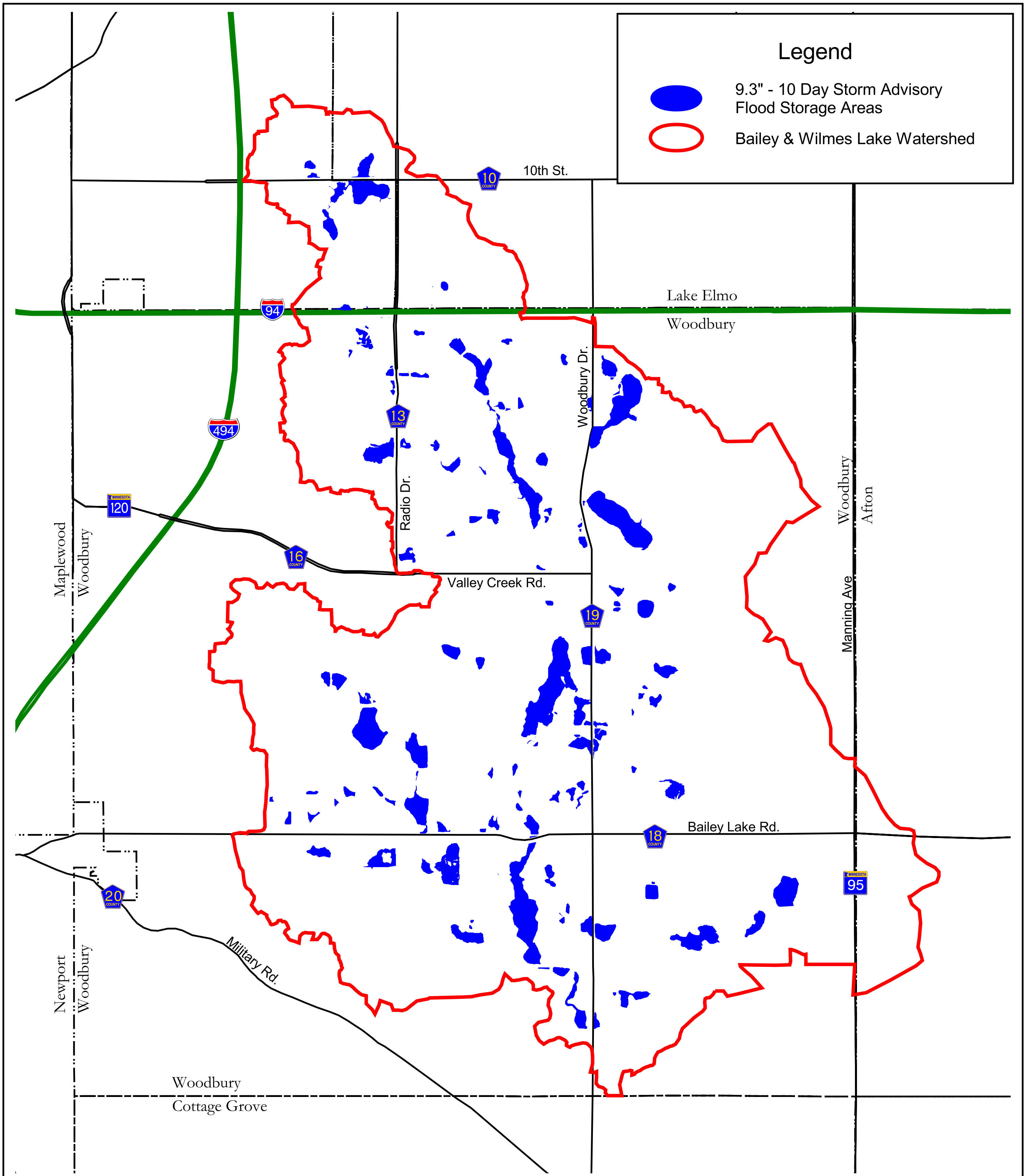
To date, there has not been wide spread residential flooding within the watershed. However, modeling of design storms indicates that the threat is very real. Figure 3 and Figure 4 present the existing condition flood storage areas for this watershed for the 100-year 24-hour and 100-year 10-day precipitation events respectively. It is important to recognize that much of the flooding is local in nature and related to issues with the Municipal drainage systems. The maps presented illustrate the storage area water levels with a functioning Bailey Lake outlet as proposed in this project. They also document the locations of storage assumed in the project design.



0 0.5 1 1.5 Miles

6.3" - 24 Hour Rainfall Event
Advisory Flood Storage Areas
South Washington Watershed District
Washington County, Minnesota

GIS: DPS	Date: 06/06/02
PM: DJ	
Proj No.: 10550-009-164	
File: bailey_y.apr	
Figure No. 3	



0 0.5 1 1.5 Miles

9.3" - 10 Day Rainfall Event
Advisory Flood Storage Areas
South Washington Watershed District
Washington County, Minnesota

GIS: DPS	Date: 06/06/02
PM: DJ	
Proj No.: 10550-009-164	
File: bailey_y.apr	
Figure No. 4	

6.0 Project Alternatives, Design Goals and Design Criteria

6.1 General Project Alternatives

Numerous flood management alternatives have been considered by the SWWD. These have included complete storage concepts to various drainage concepts. The SWWD has considered several overflow routes and options for storm water conveyance. A listing of the various reports and memorandums that address these considerations is provided in Appendix B. These reports are on file with the SWWD.

Any number of the proposed alternatives may be considered feasible, but are not considered practical due to political, cost, environmental or other considerations given the complex regulatory and political climate that exists regarding this project. The alternative that satisfies the flood storage management objectives, maximizes the use of natural storage areas and storm water conveyance systems, creates greenway opportunities, coordinates to the extent practical with proposed land use development projects, minimizes project costs, accommodates future growth and minimizes overall environmental impacts will result in most attractive project alternative. The selected alternative may not be the least expensive alternative, but the one that results in addressing the most concerns and maximizing overall public benefits.

After careful consideration of the various alternatives and review of the relevant facts, HDR is presenting a Project that is a variation of the one presented in the September 20, 2001 memorandum to the SWWD Board. This Project results in an outlet for the City of Woodbury that meets the intent of their 1979 Storm Drainage Plan to provide an overflow outlet to satisfy the 100-year 6-inch 24-hour rainfall event, plus provides additional capacity for larger volume 24-hour events and longer duration 10-day precipitation events.

The City of Woodbury indicated that designing for existing conditions does not address their concerns regarding future development. The City of Cottage Grove is concerned about completing a project ahead of its need and prior to Cottage Grove developing areas along the route. In particular, there appears to be a disagreement regarding the mapping and use of existing flood storage areas for the purposes of the Project development.

The Project and flood storage areas identified in this report are utilized to establish the rate, volume and timing of overflows that can be accommodated from the upstream watershed for the storm events analyzed under existing conditions. Therefore, this plan becomes a point of reference to compare the impact of future development on the design of overflow systems. In regards to Woodbury's Phase I AUAR area, the design of the project assumes Woodbury will commit to the rate, volume and timing of flows as predicted by HDR in our modeling. The city has been provided copies of our model files. Specific areas where rate, volume and timing are assumed include:

- PL1-1 Powers Lake
- CL1E10-1 Wetland area south of Golden Eagle Circle in the Eagle Valley Golf Course/Home Development (Outlot K)

- CL1E5-1 Wetland area on Margaret M. Bailey property SE of the intersection of Dorset Lane and Raleigh Road.

- CL1N4-1 Klaus Becker property SE of the intersection of St. John's Drive and Valley Creek Road.

- CL1N6-1 Pond south of Grand Valley Lane within the Eagle Valley Golf Course/Home Development (Outlot B)

- CL1E9-1 Wetland area east of Eagle Valley Drive and west of White Eagle Drive within the Eagle Valley Golf Course/Home Development (Outlot C)

These inflow points are illustrated in Figure 5.

6.2 Design Criteria

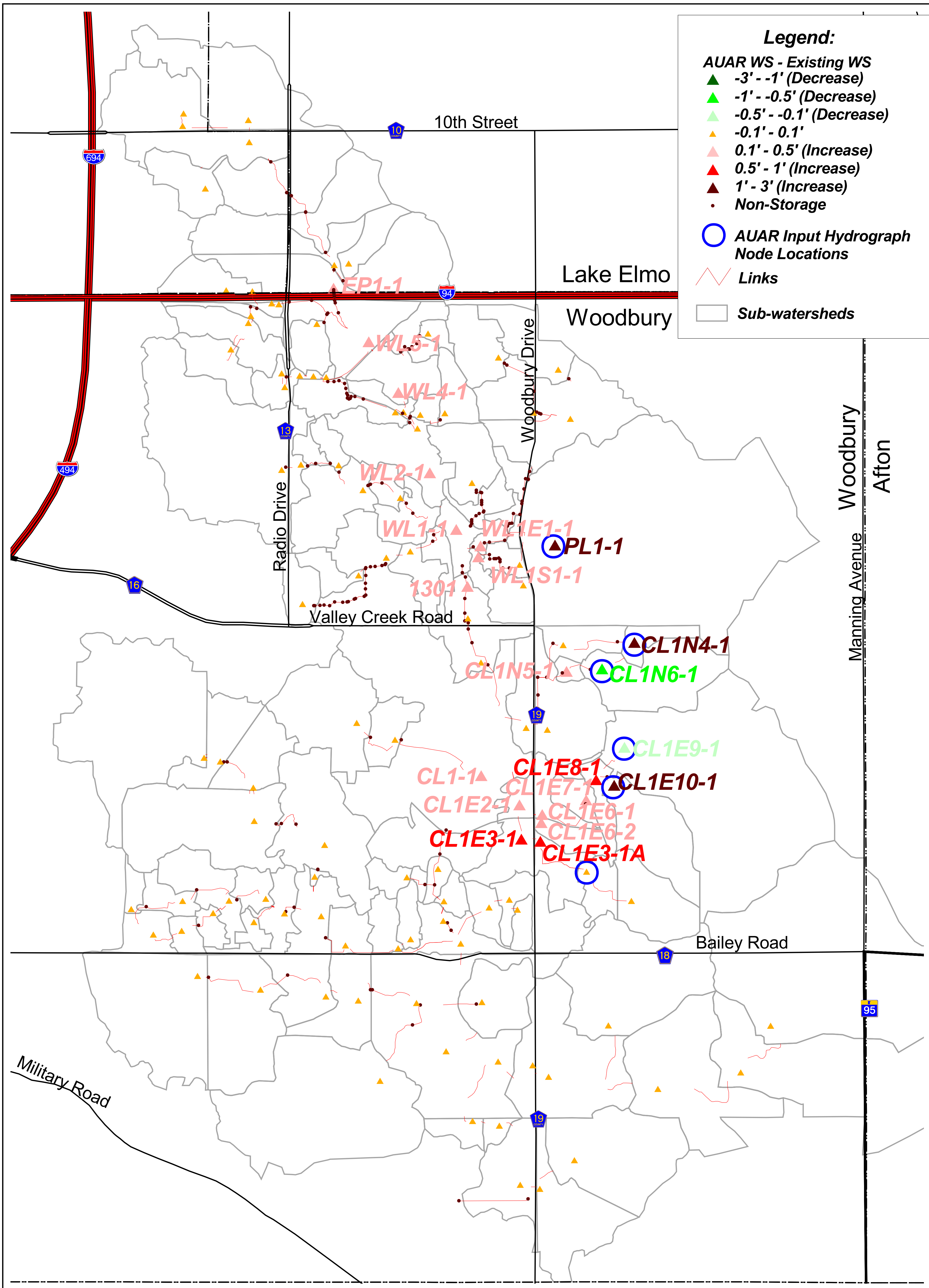
Before actual hydrologic and hydraulic design can begin, criteria must be established for system design. These criteria establish the framework under which hydrologic and hydraulic analysis and design of the system are conducted. The following criteria were utilized in the hydrologic and hydraulic analysis and design of the proposed Project and advisory flood storage area mapping.

6.2.1 Maximum Water Surface Elevation

A controlling factor in design of the project and mapping of flood storage areas within the watershed is the proposed operation of the Bailey Lake lift station within the City of Woodbury. An elevation of 877 was established in the 1979 Storm Drainage Plan for Bailey Lake and the lift station was constructed based upon this elevation. A planned operational curve describing the operation of the lift station under ultimate conditions was used. This operational curve was developed by Woodbury's consultant. Other high water elevations in the overflow system were determined based upon the site specific design considerations and are presented elsewhere in this report.

6.2.2 Flood Storage Areas

Flood storage areas, discharge rates, high water elevations and storage volumes are based upon existing conditions as determined in the year 2000 Washington County topographic maps. The effect of adding the Woodbury Phase I AUAR area into the system has been documented through the use of tables and Figure 5. It will be the responsibility of the communities to resolve problems identified in the local drainage systems and modify theflood storage areas consistent with the project provided by the SWWD.



1:36000	**Figure 5** 6.3-inch 24-Hour Rainfall Event AUAR Phase I Impact Summary Wilmes/Bailey/Colby Lake Watersheds South Washington Watershed District	GIS: RWG	Date: 05/06/02
		PM: DJ	
HDR		Proj No.: 10550-009-164	
		File: bailey_d.apr	
		Figure No. 5	

6.2.3 Design Storm Data

The SWWD advisory flood storage area maps and project design utilized information presented in the National Weather Service Technical Paper Number 40 (TP 40), Soil Conservation Service National Engineering Handbook Number 4 and Soil Conservation Service Technical Release Number 60 (TR 60). The source data for this published information was researched to determine its age and data record. This data has been considered the standard in the Minnesota engineering community for more than 30 years, however, more recent and statistically significant data was also considered in development of a precipitation event for the purposes of the design and floodplain mapping purposes.

The SWWD had been utilizing a 7.2-inch, 100-year, 10-day runoff event for the purposes of analysis and conceptual design of storm water systems in the SWWD. The 7.2-inch runoff event has its origins in the TR-60 design guides for small dams produced by the Soil Conservation Service. The delivery rate of the runoff to the watershed is modeled as a Type II distribution in accordance with recommendations of the TR-60 design guides.

HDR has researched the basis for establishing the 7.2-inch runoff amount and assigning it a 100-year return interval. It appears that researchers utilized a limited period of record and estimated the return intervals by regression equations that considered a number of factors to produce the 7.2-inch, 100-year runoff amount. Other data that is similar in nature to the 7.2-inch runoff are data contained in the Minnesota Hydrologic Guide (10-day precipitation amounts) and U.S. Weather Bureau Technical Paper 50 (TP 50) (March Snow Water Equivalents). These data sources have the same limited period of record problem as TR-60. The limited period of record creates concerns regarding the statistical reliability of the data contained in these reports.

Recently, researchers have utilized a longer period of record that creates a more statistically sound data analysis. The new analysis includes updated snow water equivalent and precipitation frequency maps. There is not an updated analysis of 10-day runoff events as included in TR-60; however, it can be concluded that the same data problems exist for the runoff event data. Given the capital investment in land and infrastructure proposed by the SWWD, it would be prudent to develop a design event and method that is statistically sound and defensible. The following paragraphs describe new data sources and a proposed analysis method that capitalizes on the new, higher quality data.

Proposed Design Flood for the SWWD

The 7.2-inch runoff event cannot be directly tied to a particular meteorological occurrence. It is a reflection of runoff amount or yield produced by some unknown event. It could be a large snow pack that had a high snow water equivalent, or a rain on snow event or a long duration rainfall event. Given the critical nature and expense associated with the Central Draw Project, the SWWD is justified in considering the updated March 1-15 Snow Water Equivalents, an updated 100-year 24-hour event and the updated 100-year, 10-day precipitation data in the design of the Project.

March 1-15 Snow Water Equivalents

HDR reviewed three documents in regards to Snow Water Equivalents for the March 1-15 time period. These include:

- Technical Paper 50, Frequency of Maximum Water Equivalent of March Snow Cover in the North Central United States, U.S. Department of Commerce Weather Bureau, 1964.
- A Critique of the Climatic Record of “Water Equivalent Snow on the Ground” in the United States, Journal of Applied Meteorology, Thomas W. Schmidlin, 1990.
- Frequency Mapping of Maximum Water Equivalent of March Snow Cover over Minnesota and eastern Dakotas, Steve Buan, University of Minnesota, 1995.

Technical Paper 50 estimated a 100-year, March 1-15 water equivalent in the snow pack of 11-inches of water for South Washington County. This estimate was based upon an average length of record of nine years. In 1990, Mr. Schmidlin conducted a review of the quality of this and other snow water equivalent data. He concluded that the data had not been subjected to rigorous quality control during the measurement process or during analysis by researchers. He cautioned that users of the snow water equivalent data should proceed with caution and be wary of any large snow water equivalent values encountered. Mr. Buan, as part of fulfillment of his Degree of Masters of Science, conducted quality control of the snow water equivalent data using a calibrated model and re-calculated the March 1-15 water equivalent in the snow pack using a much longer period of record. The new quality controlled and calibrated data analysis yielded a 100-year, March 1-15 water equivalent in the snow pack of 7.2-inches of water for South Washington County. This is a 3.8-inch reduction in the 100-year snow water equivalent. The snow water equivalent data does not provide information on the rate of melt. It is used primarily as a qualitative indicator, along with other factors, to predict potential flood risk.

10-Day Precipitation Data

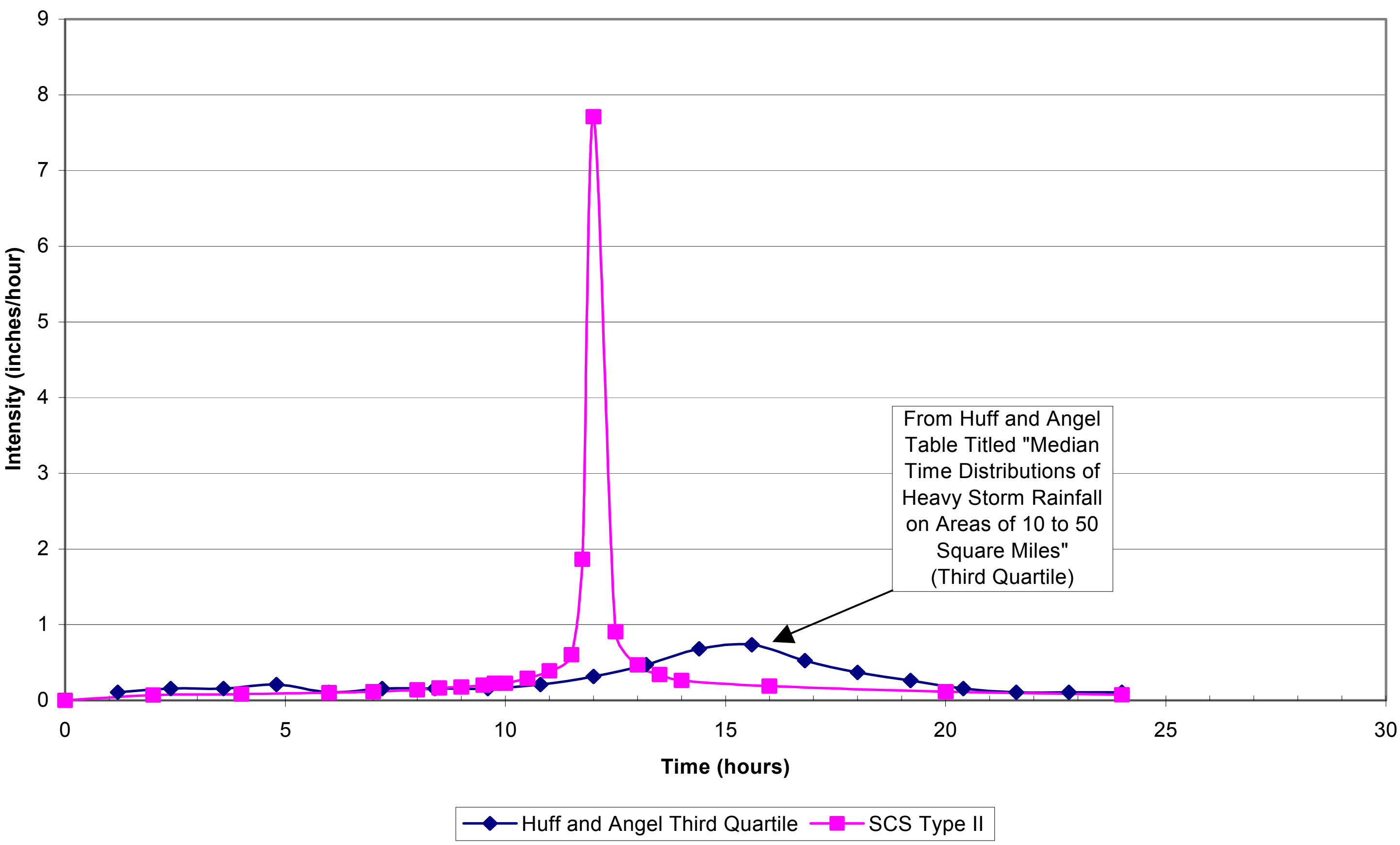
HDR reviewed two documents in regards to 10-day precipitation amounts. These include:

- Hydrology Guide for Minnesota, U.S. Department of Agriculture, Soil Conservation Service, 1975.
- Rainfall Frequency Atlas of the Midwest, Floyd A. Huff and James R. Angel, Midwestern Climate Center and Illinois State Water Survey, 1992.

The Minnesota Hydrology Guide contains 10-day precipitation data for the 100-year event. The data source is referenced as U.S. Weather Bureau Technical Paper 49 published in 1966. This document indicates for South Washington County that the total 100-year, 10-day precipitation is 10.9-inches. Huff and Angel in 1992 analyzed an extensive rain gauge network in the upper Midwest and developed revised 100-year, 10-day precipitation amounts. The new data indicates the 100-year, 10-day rainfall amount for South Washington County to be 9.3-inches. This is 1.6-inch reduction in the 10-day precipitation amount based upon a more extensive data set.

Huff and Angel also analyzed seasonal distribution of heavy rainfall in the upper Midwest. They analyzed the distribution of total precipitation in each of the four seasons and the seasonal distribution of heavy rainstorms. They determined that heavy rainfall events are most likely to occur in Minnesota during the summer months. In fact, the greatest 10-day precipitation event in Minnesota occurred during the warm weather season. They also proposed rainfall distributions based upon seasonal patterns, with the summer distribution being the most intense. Figure 5 compares the third quartile Huff distribution to the Type II distribution currently being used by the SWWD. They also provided sufficient data such that the design precipitation event can be evaluated statistically and 95% confidence intervals established. Therefore, it is possible to quantify the uncertainty in the hydrologic design and analysis.

Figure 6. Comparison of Huff and Angel Distribution to SCS Type II Distribution



Design Storm Selection

The SWWD has evaluated the 7.2-inch, 100-year runoff event as presented in TR-60 for the purposes of planning the Central Draw Project. HDR has not been able to produce a specific updated study that refutes this amount of runoff as statistically incorrect. The time distribution of the runoff follows generally accepted engineering practices for design of small dams. However, studies of comparable weather statistics that have been updated show the TR-60 era reports are fraught with data quality and analysis problems. In addition, the source data for the 7.2-inch event could not be located.

After careful consideration of the data and its quality, it was decided to design the project based upon two events:

- 24-hour 100-year precipitation event – HDR utilized rainfall data from Huff and Angel to estimate the mean 100-year 24-hour rainfall event for the South Washington Watershed District. It was determined that this amount was 6.3 –inches. HDR then utilized the techniques presented by Huff and Angel to determine the upper 95% confidence interval for that event which corresponds to 1.5 inches or a 7.8-inch event. The 100-year 24-hour storm evaluated for the purposes of flood storage area mapping and system design is 6.3 inches in 24-hours. The 7.8-inch event was used to determine the adequacy of the proposed design to provide capacity to manage a larger emergency overflow for a 100-year 24-hour event.

- 10-day 100-year precipitation event- HDR utilized rainfall data from Huff and Angel to estimate the mean 100-year 10-day rainfall event for the South Washington Watershed District. It was determined that this amount was 9.3 inches. HDR then utilized the techniques presented by Huff and Angel to determine the upper 95% confidence interval for that event which corresponds to 1.3 inches or 10.6-inches. The 100-year 10-day storm evaluated for the purposes of flood storage are mapping and system design is 9.3 inches in 10-days. The 10.6-inch event was used to determine the adequacy of the proposed design to provide capacity to manage a larger emergency overflow for a 100-year 10-day event.

The SWWD in previous work had considered the 6.0-inch 100-year 24-hour event as determined from NWS TP 40 and the 7.2-inch 10-day 100-year runoff value from SCS TR-60. However, after research into the source data and locating recent, statistically sound precipitation information, HDR recommends that the SWWD base its design decision on the more recent precipitation data. In addition, no area reduction factors were applied to the rainfall data to reduce the point rainfall totals. This was done to accommodate the estimation of 100-year floodplains at regional basins throughout the watershed and to provide a level of conservatism to the proposed plan due to the volume sensitive nature of this essentially land locked watershed.

6.2.4 Design Event Rainfall Distribution

Previous modeling conducted by the SWWD utilized a SCS Type II rainfall and runoff distribution. The SCS Type II distribution is a synthetic storm hyetograph for use in the United States for storms of 24-hours in duration. This same distribution is also recommended in the SCS TR-60 document for developing 10-day precipitation events for the design of small dams. HDR continued to utilize this distribution for both the 24-hour and 10-day precipitation events in the SWWD. These distributions are more intense than those recommended by Huff and Angel for precipitation events and produce higher volumes and rates of runoff. These intense rainfall distributions also provide a degree of conservatism to the design.

6.2.5 Model Development

The base model used for most of the subwatersheds was taken from previous work done by the SWWD and their consultants Emmons and Olivier Resources and Bonestroo Rosene and Anderlik as presented in the various other reports listed in Appendix B. These base models were updated using 2000 aerial photos and topography collected by Washington County and supplemented with field surveys. A completed Arcview database was generated to track source data quality. A complete copy of all source data used in the analysis is available from the SWWD.

The SWWD chose to utilize the hydrologic and hydraulic model XP-SWMM to develop the floodplain mapping and alternatives analysis. The non-linear reservoir method in XP-SWMM was used to estimate the runoff hydrographs from the land surface. These resultant hydrographs were then routed through the drainage systems network of ponds, pipes and channels using the EXTRAN block of SWMM. A complete list of modeling parameters is provided in Tables 1A through 1I.

The Woodbury Phase I AUAR area hydrological hydraulics involved modification of a January 2002 XP-SWMM model prepared by the City's consultant, Bonestroo Rosene and Anderlik. Inflow hydrographs were developed for six (6) input areas into the HDR existing condition model, and the following parameters were modified in the Woodbury Phase I AUAR model. All other parameters remained as provide by the city.

Table 1
XP-SWMM Modeling Parameters
Summer Storm
4/1/02

Table 1A: Land Use Percent Impervious Values
South Washington Watershed District
XP-SWMM Model

Land-use Percent Impervious Values Used for the Bailey/Colby/Powers Models	
Land-use Type	*% Impervious[1]*
Multi-Family Residential	38
Public & Semi-Public Vacant	7
Open Water Bodies	100
Single Family Residential	35
Extractive	7
Public Semi-Public	24
Commercial	65
Vacant/Agricultural	7
Farmsteads	8
Major Four Lane Highways	50
Industrial	56
Parks & Recreation Areas	6

Land-use Percent Impervious Values Used for Cottage Grove Central Ravine	
Land-use Type	*% Impervious[1]*
Multi-Family Residential	46
Public & Semi-Public Vacant	N/A
Open Water Bodies	100
Single Family Residential	35
Extractive	N/A
Public Semi-Public	49
Commercial	93
Vacant/Agricultural	0
Farmsteads	7
Major Four Lane Highways	50
Industrial	100
Parks & Recreation Areas	3

[1] All values based on representative sample sites within each study area

Table 1B: Monthly Evaporation Values (in/mo)
South Washington Watershed District
XP-SWMM Model

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
0.35	0.38	0.86	1.75	3.00	4.00	5.50	5.50	4.30	3.00	1.30	0.40

Table 1C: Summer Infiltration Parameters
South Washington Watershed District
XP-SWMM Model

Parameter	Summer Infiltration
Horton Infiltration	
Maximum Rate (in/hr)	4.0
Minimum Rate (in/hr)	0.35
Decay Rate (1/sec)	0.0008
Impervious Areas	
Depression Storage (in)	0.20
Manning's "n"	0.014
Zero Detention (%)	0
Pervious Areas	
Depression Storage (in)	0.10
Manning's "n"	0.30

Table 1D: Type II Rainfall Distribution Values
South Washington Watershed District
XP-SWMM Model

10 day Runoff Event		24 hour Rainfall Event		Rainfall Cumulative Multiplier
Time (hrs)	Duration (hrs)	Time (hr)	Duration (hr)	$Runoff_t/Runoff_{10day}$ $Rain_t/Rain_{24hr}$
0	20	0	2	0.022
20	20	2	2	0.048
40	20	4	2	0.08
60	10	6	1	0.098
70	10	7	1	0.12
80	5	8	0.5	0.133
85	5	8.5	0.5	0.147
90	5	9	0.5	0.163
95	2.5	9.5	0.25	0.172
97.5	2.5	9.75	0.25	0.181
100	5	10	0.5	0.204
105	5	10.5	0.5	0.235
110	5	11	0.5	0.283
115	2.5	11.5	0.25	0.357
117.5	2.5	11.75	0.25	0.663
120	5	12	0.5	0.735
125	5	12.5	0.5	0.772
130	5	13	0.5	0.799
135	5	13.5	0.5	0.82
140	20	14	2	0.88
160	40	16	4	0.952
200	40	20	4	1.0

Table 1E: XP-SWMM Simulation Tolerances and Routing Control
South Washington Watershed District
XP-SWMM Model

Parameter	**Value**
Simulation Tolerances	
Flow Tolerance	0.0005
Head Tolerance	0.000005
Minimum Orifice Length	1000 (default)
Default Head Loss	0.0 (default)
Default Contraction Loss	0.0 (default)
Routing Control	
Under Relaxation Parameter	0.85
Time Weighting Factor	0.85
Conduit Roughness Factor	1.0 (default)
Flow Adjustment Factor	1.0 (default)
Initial Conduit Smoothing	0 (default)
Minimum Courant Time Step Factor	1.0 (default)
Maximum Time Step Iterations	500 (default)
Routing Method	Dynamic Wave

Table 1F: Powers Lake Pump Data
South Washington Watershed District
XP-SWMM Model

Pump Flow Rate (cfs)	Water Surface Elevation
0	890.0
5	891.0
5.3	895.0
6	900.0

Table 1G: West Tributary to Bailey Lake Pump
South Washington Watershed District
XP-SWMM Model

Pump Flow Rate (cfs)	Water Surface Elevation
0	954.0
0.01	955.0
1	955.1
2.5	956.0
3	962.0

Table 1H: East Tributary to Colby Lake Pump
South Washington Watershed District
XP-SWMM Model

Pump Flow Rate (cfs)	Water Surface Elevation
0	892.0
0.001	896.9
1	897.0
6	897.1
12.5	898.0
14	920.0

Table 1I: Bailey Lake Lift Station Pumps
South Washington Watershed District
XP-SWMM Model

Pump Flow Rate (cfs)	Pump #1 Water Surface Elevation	Pump #2 Water Surface Elevation	Pump #3 Water Surface Elevation
0	863.0	863.0	863.0
0.001*	869.4	869.9	870.4
30	869.5	870.0	870.5
32.5	883.0	883.0	883.0

* Model requires a non-zero value here

- The project design presumes automated operation of the Bailey Lake lift station as shown in Table 1I. In order for the City of Woodbury to realize the flood damage reduction benefit of this project it should consider automation of the pump station, or develop an alternative operation plan. The implication of the pump curves presented in this report is that Bailey Lake would be maintained at an elevation around 869.4 to 869.5. The pump station would operate more frequently than under existing conditions because of automated controls.

- Infiltration over the watershed pervious landscape is modeled for both the 24-hour and 10-day precipitation events. The infiltration parameters are listed in Table 1.

- Watershed Width, Slope and Manning's "n" – The watershed width and slope were calculated as indicated in Table 1. HDR modified the Watershed Manning's "n" utilized for pervious areas in previous model runs. It was discovered that the Watershed Manning's "n" value used in previous runs was taken from the XP-SWMM help screen. The value listed in the help screen is a typographical error and the correct values can be found in textbooks by Huber and in the EPA-SWMM documentation. The corrected values are indicated in Table 1C. The modification of this parameter has the influence of reducing the peak flow rates from individual subwatersheds. If infiltration is allowed, it also has a modest impact on runoff volume by predicting that runoff will remain on the land surface for a longer period of time, thereby increasing the infiltration amount.

- Watershed Connectivity – Overflow routes from various basins were modeled utilizing the Washington County 2-foot topographic information. HDR utilized the topographic maps, site surveys and professional judgment to model and predict the overflow routes for basins that exceeded their principle outlet capacity. Floodplain areas were mapped based upon these determinations.

6.2.6 Infiltration Assumptions

The South Washington Watershed District has conducted a series of infiltration management studies in the watershed. In storm water basins located upstream of Bailey Lake, no infiltration losses have been incorporated into the modeling or design. Basins downstream of Bailey Lake include CD-P85, CD-P86 North Lobe and CD-P86 South Lobe. The SWWD has constructed infiltration devices in CD-P85 and the monitoring in that basin indicates that a firm loss of 15 cfs could be accounted for in this basin. In developing the project design, HDR is accounting for a 15 cfs loss in the CD-P85 basin. However, an infiltration loss has not been accounted for in the CD-P86 North and South Lobes, although the geologic data indicates that its occurrence is highly likely.

6.2.7. Accuracy of the model

The modeling effort completed is part of the framework to ultimately produce a decision support system for the South Washington Watershed District by integrating the storm water models with a GIS database. XP-SWMM is a complex unsteady state hydraulic model optimized for use with sewer systems. The present application utilizes the capabilities of this model by including storage nodes to model lakes, ponds, and overland open channel flow. But, XP-SWMM is the most suitable modeling package available to achieve the project goal of developing an integrated watershed wide storm water model linked to a GIS database.

To maintain an accurate link between the model and the GIS database, a modeling approach was set to match the physical characteristics of existing hydraulics structures to structures being modeled in XP-SWMM. The limitations that are inherent in XP-SWMM necessitate adjustments to the structures within the model in order to accurately simulate the hydraulic characteristics of the system. The modeling approach imposed restrictions on possible adjustments to the model. Hence, it is important to note that the overall accuracy of the results reflect a trade-off in order to accurately model the physical attributes of the in place structures.

This is evident at certain weir structures that serve as outlets to ponds and lakes. The options available to model a weir in XP-SWMM are limited to a diversion weir in a manhole. Non-convergence errors occur at these weir structures associated with ponds when the downstream conduit flow does not match the weir flow or if the weir is submerged. The new convergence error could be corrected if the weirs were represented as open channels or pipes with equivalent hydraulic characteristics. However, the weirs were kept as the outlet structures to maintain an accurate link with the GIS database.

Though this modeling approach results in an overall continuity error of approximately 7% (197 ac-ft) for the model, which is classified as 'fair' in XP-SWMM, the results are acceptable based on the purpose of the modeling effort. Accepting this error is further reinforced by the fact that 50% of the inflow is stored within the Wilmes and Bailey Lakes system and by the additional storage available at Bailey Lake. Thus, it is reasonable to assume that a sizable portion of this volume of water will be stored within the system and the remaining volume can be stored in Bailey Lake. Hence, the modeled system can accommodate the margin of error in the volume of water if the need arises.

Based on information provided by the technical support staff at XP-Software, XP-SWMM will extend vertical walls at nodes that surcharge above the defined spill crest elevation, which results in inaccurate maximum water surface elevations. Ideally, the model should include overflow routes from nodes that the water surcharges above spillcrest elevation to model overland flow. The present models include overland flow routes as best possible to account for the over flow during the 6.3-inch 24-hour event within the scope of the project, but does not accommodate all the surcharge nodes. This issue is more pronounced for the larger storm events (7.8-inch/24-hr, 10.6-inch/10-day). As the present work is focused on the 6.3-inch 24-hour storm event, the water surface elevations from models run for the larger storm events are presented for comparison purposed to aid in the planning process.

6.3 Project Design Development

The project has been designed to accommodate the excess storm water generated from the upstream watershed and discharged from Bailey Lake through a modified Bailey Lake pump station. The City of Woodbury has indicated that their 1979 Drainage Plan was intended to accommodate that 100-year, 6-inch 24-hour event. For the purposes of designing an overflow, HDR is utilizing a 6.3-inch 24-hour event as a principal outlet event. In other words, the design goal is to provide an adequate outlet for storm water from Bailey Lake into order to accommodate a 100-year, 6.3-inch, 24-hour event and maintain Bailey Lake within its current flood easement of 877. The required downstream infrastructure to accommodate that design goal was established as the first implementation priority for the purposes of the Project design.

The second design goal was to accommodate the upper 95% confidence interval 100-year, 24-hour event of 7.8-inches. The drainage goal for Bailey Lake was to allow a rise to an elevation of 879 in this event. However, the modeling indicates that Bailey Lake will not reach this elevation. The required downstream infrastructure to accommodate that design goal was established as the second implementation priority for the purposes of the Project design. Additional pump capacity was also considered.

HDR then evaluated the 10-day, 100-year rainfall event of 9.3 inches. A pumping rate was determined that would maintain Bailey Lake within its 877 flood storage easement and the required downstream infrastructure to accommodate that design goal was established. This was established as the third design goal for this project.

The final design evaluation involved analysis of the upper 95% confidence interval 100-year, 10-day event of 10.6 inches. The design goal for Bailey Lake was to allow a rise to an elevation of 879 in this event. Again, the modeling indicates that Bailey Lake will not reach this elevation. The required pumping rate and downstream infrastructure to accommodate that design goal was established as the fourth implementation priority for the purposes of the Project design.

6.3.1 Flood Storage Area Maps

Maps have been produced to illustrate high water elevations for the flood storage areas used in project design. Appendix D contains tables D1, D2 and D3 that summarize flood levels in key basins for all rainfall events.

The Cities of Woodbury and Cottage Grove have expressed concerns regarding the publication of flood storage maps, especially in undeveloped areas. It is anticipated that significant alterations to existing flood storage areas will occur once development progresses into these basins.

The purpose of the flood storage area maps is not to limit development but to document and account for existing water storage locations within the watershed in order to design the project. Future changes that affect the rate, volume or timing of runoff from these basins will affect the operation and reliability of the project. It is important to document existing conditions in order to understand how future development will impact the built and natural environment and make necessary modifications to proposed watershed management plans for these areas.

6.4 Impact of Woodbury Phase I AUAR Area

The addition of the Phase I AUAR area to the model has a modest impact on the hydrology and hydraulics of the system. Figure 5 illustrates the relative impact of the Phase I AUAR water on the local drainage system. Table D3 in Appendix D provides a summary of the impact of the of the AUAR water on existing flood storage areas. It is assumed that Woodbury will review the data provided and address any local concerns. Tables 2 and 3 summarize the impact of the Phase I AUAR area on the project. An additional 292 ac-ft of water for the 6.3-inch 24-hour event is routed into the project and can be accommodated as part of the project design.

6.5 Estimated Damage From Flooding

HDR prepared a memorandum on May 25, 2001 that estimated damages to residential structures in Woodbury resulting from flooding associated a 7.2-inch 10-day runoff event. If the project was not constructed and the MnDNR permit was enforced, one-time damages would be on the order of 9.3 million dollars. Current damage estimates in Woodbury for the 6.3-inch 24-hour precipitation event with the project in place are on the order of 0.5 million dollars mostly due to localized flooding. While not directly comparable, HDR’s damage estimates indicate that the project reduces damages in the Woodbury area by providing an outlet.

HDR also conducted a one-time damage estimate for structures on the Cottage Grove central ravine drainage system. A total of $1.5 million dollars in one-time damages were estimated for the 6.3-inch 24-hour event. There are several flood storage areas that experience flooding for this event. The SWWD will address these areas as a flood damage reduction project as part of the major plan amendment.

Table 2
Project Design Model Results-Existing Conditions
CD-P85/CD-P86 System

	Total Drainage Area	**acres**	**16365**			
			6.3 inch 24 hr	**7.8 inch 24 hr**	**9.3 inch 10 day**	**10.6 inch 10 day**
CD-P85	***Inflow from Bailey Lake***	inches	1.03	1.40	0.95	1.18
	Local Runoff	inches	0.03	0.06	0.02	0.03
	Stored	inches	0.12	0.13	0.00	0.00
	Outflow to CD-P86	inches	0.55	0.93	0.42	0.64
	Volume Infiltrated	inches	0.41	0.41	0.55	0.58
	Final Elevation	ft	901.00	902.00	884.00	884.00
	Time to Overflow	days	3.3	2.2	8.3	7.6
CD-P86N	***Inflow from CD-P85***	inches	0.55	0.93	0.42	0.64
	Local Runoff	inches	0.02	0.04	0.02	0.02
	Stored	inches	0.44	0.49	0.44	0.46
	Outflow to CD-P86S	inches	0.13	0.18	0.00	0.20
	Over flow into Gables lake	inches	0.00	0.29	0.00	0.00
	Final Elevation	ft	904.00	905.00	903.88	904.40
	Time to overflow into Gables lake	days	N/O	7.4	N/O	N/O
	Time to Overflow into CD-P86S	days	7.6	5.5	N/O	11.5
CD-P86 S	***Inflow from CD-P86N***	inches	0.13	0.18	0.00	0.20
(combined)	***Local Runoff***	inches	0.07	0.11	0.05	0.07
	Stored	inches	0.19	0.30	0.05	0.27
	Overflow over 70th Street	inches	0.00	0.00	0.00	0.00
	Final Elevation	ft	903.20	905.00	899.31	904.40
	Time to Overflow	days	N/O	N/O	N/O	N/O
Gables Lake	***Inflow from CD-P86N***	inches	0.00	0.29	0.00	0.00
	Stored	inches	0.00	0.29	0.00	0.00
	Final Elevation	ft	n/a	874.00	n/a	n/a
	Model Run Period	days	20	20	40	40

Table 3
Project Design Model Results-AUAR Conditions
CD-P85/CD-P86 System

	Total Drainage Area	**acres**	**16365**			
			6.3 inch 24 hr	**7.8 inch 24 hr**	**9.3 inch 10 day**	**10.6 inch 10 day**
CD-P85	***Inflow from Bailey Lake***	inches	1.11	1.56	1.07	1.33
	Local Runoff	inches	0.03	0.06	0.02	0.03
	Stored	inches	0.14	0.17	0.00	0.01
	Outflow to CD-P86	inches	0.61	1.03	0.49	0.72
	Volume Infiltrated	inches	0.41	0.41	0.61	0.63
	Final Elevation	ft	902.00	904.00	884.00	884.00
	Time to Overflow	days	3.3	2.1	8.2	7.6
CD-P86N	***Inflow from CD-P85***	inches	0.61	1.03	0.49	0.72
	Local Runoff	inches	0.02	0.04	0.02	0.02
	Stored	inches	0.45	0.49	0.44	0.50
	Over flow to CD-P86S	inches	0.18	0.18	0.07	0.21
	Over flow into Gables lake	inches	0.00	0.40	0.00	0.04
	Final Elevation	ft	904.00	905.10	904.00	905.00
	Time to overflow to Gables Lake	days	N/O	7.1	N/O	16.5
	Time to Overflow to CD-P86S	days	7.2	5.3	14.5	11.3
CD-P86 S	***Inflow from CD-P86N***	inches	0.18	0.18	0.07	0.21
(combined)	***Local Runoff***	inches	0.07	0.11	0.05	0.07
	Stored	inches	0.25	0.29	0.12	0.28
	Overflow over 70th Street	inches	0.00	0.00	0.00	0.00
	Final Elevation	ft	904.15	905.10	901.50	905.00
	Time to Overflow	days	N/O	N/O	N/O	N/O
Gables Lake	***Inflow from CD-P86N***	inches	0.00	0.40	0.00	0.04
	Stored	inches	0.00	0.40	0.00	0.04
	Final Elevation	ft	n/a	879.50	n/a	857.00
	Model Run Period	days	20	20	40	40

7.0 Project Features

The following sections describe the components of the Project. The system is described in a downstream to upstream fashion, starting with the suggested modifications to the Bailey Lake Lift station.

7.1 Project Layout

The project is proposed to be constructed in two phases. The initial phase encompasses the following major components:

- Bailey Lake Lift Station Improvements implemented by the City of Woodbury
- CD-P85 Structure
- CD-P86 North Lobe Improvements
- CD-P86 South Lobe Improvements
- Gables Lake Overflow

The second phase will require a major amendment to the SWWD plan and will provide for construction of a permanent overflow route to Mississippi River in order to accommodate larger volume emergency overflow events. The proposed route, commonly referred to as the cross-country route, is planned to also service the City of Cottage Grove's local trunk storm sewer needs.

7.2 Bailey Lake Lift Station

The Bailey Lake lift station is the lowest flood prone structure surrounding Bailey Lake other than the substation that serves it. The City of Woodbury's 1979 Storm Drainage plan calls for a 100-year, 24-hour flood elevation for Bailey Lake of 877. Based upon this plan, the City constructed the floor of the lift station at approximately elevation 880, providing 3-feet of freeboard. However, modeling of larger volume events has shown that the lift station is vulnerable to failure should water levels utilize the available freeboard.

The Lift station will continue to be owned and operated by the City of Woodbury. Given the freeboard available compared to the size of the tributary watershed, it is critical that the pump station continue to operate throughout a flood event. In addition, the City of Woodbury has applied to participate in FEMA programs under emergency rules. Should Woodbury continue to participate in the FEMA program then permanent floodplain maps may be prepared for the City. Preparation of these maps will require that the lift station serve as a recognized flood control system and need to meet federal certification requirements for such systems. HDR conducted a preliminary review in May of 2001 to estimate the potential improvements. Table 4 contains recommendations that should be considered by the City of Woodbury in modifying the pump station to ensure its secure operation.

Table 4
South Washington Watershed District
Recommended Bailey Lake Pump Station Improvements

Bailey Lake Elevation ft (msl)	Electrical Improvements	Structural Improvements
872	Remove Dry Well Receptacles Move Sump Pump Receptacles	No improvements necessary
878	All the above plus Raise Xcel Energy transformer and metering cabinet Remove dry well lights Remove dry well gas-fired unit heater and thermostat	No improvements necessary
880.5	All the above plus Raise motor control center and variable frequency drive Raise Autocon Control Cabinet Raise wet well sump pump receptacle	Need to begin to consider flooding dry well or adding ballast to prevent structure from floating
883	All of the above plus Raise generator connection receptacles Raise three valve position switches Raise lighting panels and upper level receptacles Raise telephone network interface	Requires flooding drywell or adding ballast to prevent structure from floating

The proposed pumping system will also require the addition of force main from the pump station to CD-P85 and associated infrastructure. The mechanical, electrical and structural systems will have to be enhanced to manage the additional pumping capacity.

7.3 CD-P85

HDR is proposing a controlled overflow structure for CD-P85 at elevation 910 that will convey storm water into CD-P86 North Lobe in a controlled fashion. The area contains poorly graded sands that are susceptible to erosion. Given these soil conditions, it will be necessary to construct a culvert, energy dissipator and protected waterway down to the bottom elevation of CD-P86 North Lobe in order to avoid back cutting and scour. Appendix A: Drawing P-1 illustrates the proposed design.

7.4 CD-P86 North Lobe

CD-P86 North Lobe contains 637 ac-ft of effective flood storage in excess of local runoff and offers the potential for additional storm water infiltration capacity. Much of the storage capacity of the basin was created by fill placed across a topographic low area to create Washington County Road 19. The layout and proposed improvements to the basin are provided in Appendix A: Drawing P-1. The following activities are proposed:

- Modifications and enhancement to the County Road 19 embankment in order to create a stable dam embankment.
- Construction of a gated by-pass culvert/structure to allow emergency release of storm water to Gables Lake.
- Creation of an earthen berm between CD-P86 North and South Lobes, a lined spillway and channels to direct water flow towards CD-P86 South Lobe.

7.5 CD-P86 South Lobe

CD-P86 South Lobe contains 317 ac-ft of effective flood storage in excess of local runoff and offers the potential for additional storm water infiltration capacity. The damming of the topographic low by 70th Street in Cottage Grove created the flood storage capacity of the basin. In order for storm water to reach CD-P86 South Lobe modifications are required to Military Road (See Appendix A: Drawing P-2). It is recommended that Military Road be raised approximately 3.5 feet to elevation 908.5 to provide cover over the box culvert. This raise will also provide adequate freeboard for wave runup. A 10-foot wide by 9-foot high box culvert, or similar structure, will be installed through the road to convey floodwater as well as serve as a bike path underpass. Grading and scour protection will be required along route to ensure a consistent transfer of water from CD-P86 North Lobe to CD-P86 South Lobe. Some improvements will also be required to the 70^{th} Street embankment to prevent seepage and create a stable dam embankment. The road should be raised 1.15 feet to elevation 907.4 to provide adequate freeboard for wave runup.

To preserve developable land around CD-P86 South Lobe, HDR recommends excavating the basin and using the material to fill outer areas as shown in Appendix A; Drawing P-3. This will increase usable land, above elevation 905, by 20 acres.

7.6 Gables Lake Overflow

As referenced in the CD-P86 North Lobe discussion, the plans for this project call for placement of a bypass structure through the County Road 19 embankment to allow for the emergency discharge of storm water into Gables Lake. The topographic and environmental conditions surrounding Gables Lake are presented in Appendix A: Drawing PP-4. The normal elevation of the lake is in the range of 850 feet msl. The proposal calls for releasing up to 700 ac-ft of storm water into Gables Lake under emergency conditions or up to elevation 884. This elevation is close to a ring of water sensitive hardwood trees that surround the lake. The trees should be surveyed to determine if any are located below the emergency flood storage elevation. Grading a channel from County Road 19 to the lake and lining scour prone sections will be required to transport flow to Gables Lake.

7.7 Cottage Grove System

The earlier proposals called for creation of a low capacity outlet to the Mississippi River through the City of Cottage Grove's existing storm drainage system. With modest upgrades to the storm drainage system downstream of 70th Street, a discharge of 6 - 8 cfs could be generated to provide outlet capacity for the project. However, detailed modeling of the Cottage Grove system indicates that it is also prone to flooding. Therefore, this feature has been dropped from consideration until such time that flood damage reduction activities in the Cottage Grove system render it feasible.

7.8 Cross Country Pipe Alignment

The major amendment will include a pipe alignment that conveys storm water through currently agricultural lands. The exact alignment depends upon coordination with the Metropolitan Council and the City of Cottage Grove's Phasing Plan. A more detailed alignment will be further developed in the major plan amendment.

7.9 Existing Ravine to Mississippi River

The major amendment calls for discharge of regional and local storm water flows through the existing ravine. Several potential diversion concepts have been developed by the SWWD to protect natural resources within the ravine. More details will be provided in the major amendment.

8.0 Evaluation of 6.0–inch 24-hour and 7.2-inch 10-day Runoff Events

HDR reviewed previous work conducted by the SWWD in regards to the 6.0-inch 24-hour rainfall and 7.2-inch 10-day runoff event. The principal outlet event analysis conducted for this report demonstrates the ability of the proposed project to effectively manage a 6-inch 24-hour rainfall event.

This project has sufficient storage volume to manage a 10- to 25-year 10-day runoff event of 4.8 to 5.8 inches as shown in the Minnesota Hydrology Guide without infiltration and a 50-year runoff event of 6.5 inches with infiltration. Previous work conducted by HDR estimated that this project could accommodate 45% of the 100-year 10-day runoff volume of 7.2-inches without infiltration at CD-P85 and 86 and 90% of the runoff volume with a conservative infiltration estimate. Therefore, project implementation moves the SWWD closer to providing the ability to manage a large volume event.

9.0 Other Considerations

9.1 Geotechnical

The primary geotechnical engineering considerations regarding the project design include:

- Structural stability of the Bailey Lake Lift Station
- Erosion and scour potential along overflow routes and channels
- Road and embankment design considerations in regards to dam safety and overall embankment stability.

The structural stability of the Bailey Lake Lift Station is a concern should Bailey Lake exceed certain flood elevations. There is a large dry well associated with the facility, that when surrounded by water a buoyant force is created that could compromise the structural integrity of the facility. The City of Woodbury should address this issue when modifying the lift station for this project.

The design has considered the transient conditions during the filling and draining of the project and transfer of water between basins. The sandy soils in the project area are erodible and therefore provisions have been made to minimize adverse erosion of the site soils.

Provisions have also been made to create stable embankments at CR-19, Military Road and 70th Street. The designs consider seepage, slope stability, wave runup and required freeboard. These designs are based upon general soils information. HDR recommends that soil borings and testing be conducted of site soils prior to final designs.

9.2 Roadway

The proposed project impacts roadways in four locations. This includes two locations along County Road 19, Military Road and 70th Street. County Road 19 at CD-P86 North Lobe will require modifications of the embankment to create a stable dam. In addition, the road will either need to be tunneled or open cut to install the proposed emergency overflow pipe. The roadway will also have to be crossed when the major amendment Project is constructed near the vicinity of 70th Street.

Washington County is in the planning and preliminary design phase for improvements to Military Road. The County intends to reconstruct this road in 2002 or 2003. This project requires raising this road and installing a large culvert. It is likely that given the counties plans to work on the road this year that the SWWD will cost share with the County to make the recommended changes to the road design.

A small road raise and embankment improvement is also required at 70th street to accommodate the project. This improvement will also provide the City of Cottage Grove greater storage and flexibility in managing their future storm water needs.

9.3 Metropolitan Council Coordination

The proposed work at County Road 19 must be coordinated with the Metropolitan Council's plans for a sanitary sewer main along the road alignment. The details of this coordination have yet to be worked out and will be addressed during final design of the Project.

9.4 Timing of Flows

Assuming that the 100-year 24-hour 6.3-inch rainfall event starts at a reference time of 0.0-hours, the sequence of flow and flood events are as follows:

0.0-hours	Event starts (6.3-inch 24-hour)
12-hours	Rainfall intensity peaks. Due to modeling assumptions, the peak rainfall intensity occurs at all nodes through the watershed at this time.
13-hours	Pumps at Bailey Lake turn on with Bailey at a standing water level of approximately 869.0 feet and water from the northern watershed flows into the project area.
66-hours	Bailey Lake reaches 870-ft and stabilizes for the duration of the event.
79-hours	CD-P85 starts to overflow to CD-P86N. The maximum elevation at CD-P85 is 911.2-ft.
183-hours	CD-P86N starts to flow over the spillway into CD-P86S.

336-hours CD-P86S fills to elevation 903.2-ft

Tables 2 and 3 present a summary of the water yield from the watershed flowing into the project area at CD-P85 and CD-P86.

9.5 Potential Groundwater Impacts

There are several areas of potential impact of the infiltration on the groundwater resources in the area. These potential impacts include

- Elevating the groundwater levels to cause adverse impacts to underground structures or unintended surface effects

- Degrading the quality of the water in the aquifer(s) by potentially introducing pollutants via the infiltrated storm water;

- Interference with groundwater pumping systems, in terms of either water quality or hydraulic impacts.

These issues have been previously addressed in the Environmental Assessment Worksheet (EAW) prepared in 1994, the Infiltration Management Study (IMS) in 2000, or subsequent or on-going investigations. This report presents updated information about these issues and re-evaluates the questions in light of the more recent data.

Elevated Groundwater Levels

The issue of elevated groundwater levels and mounding of the groundwater beneath the infiltration areas was previously addressed in the Infiltration Management Study (IMS) (EOR, 2000). A theoretical, transient model (Hantush, 1967) was used to calculate peak heights of the groundwater mounds beneath the infiltration basins. While the height of the peak of the mound is useful information, the shape of the mound is also of concern, particularly how far the mound extends laterally. Although the infiltration basins are generally removed from the developed areas, there are some areas where development is or will be near the basin. In these areas, the mound could impact basements, sewers or other underground structures.

In the 2001 Infiltration Monitoring Report, information about groundwater levels and infiltration rates are included for several infiltration events. The most extensive information is for CD-P85. Based on that report and previous reports, infiltration rates have been calculated as a function of head (water level) in the infiltration basin. Based on a review of this report, it appears that the infiltration rates achieved are also a function of antecedent moisture conditions above the water table. Higher rates are observed when the soils are less than fully saturated. Due to these variations, the rates of infiltration have been reported as ‘envelopes’. The reported envelope of infiltration rates for 2001 ranged from 0.41 to 1.21 in/hr (0.8 to 1.4 ft/day) for the fully saturated periods to 0.72 to 2.76 in/hr (1.4 to 5.5 ft/day) for the less saturated conditions.

The design infiltration will require higher heads in the infiltration basins and probably for longer durations than has previously been experienced. In order to evaluate the height and shape of the groundwater mounds under these conditions, HDR created a transient, two-dimensional model using the MODFLOW computer program. For this modeling exercise, the aquifer was assumed to have a flat base elevation, a constant saturated thickness of 45 feet and a hydraulic conductivity of 100 ft/day. These values are similar to those used in EOR modeling for this site. The infiltration was modeled as a specified flux from the model cells representing the infiltration basins. Infiltration rates were initially estimated by extrapolating the rate curves in the 2001 Infiltration Monitoring Report to the proposed weir elevations on CD-P85 and CD-P86. This led to an initial peak estimate for the rate of 4 ft/day (2 in/hr) in CD-P85. However, at this rate, a mound formed that rapidly exceeded the base of the basin and also the elevation of the surrounding uplands.

At this point, the conceptual model for the infiltration was changed. Once the head in the aquifer exceeds the elevation of the bottom of the infiltration basin, the head in the basin and that of the groundwater must be equal. By continuity of mass, the rate of infiltration will then be equal to the rate at which the groundwater mound can be laterally dissipated through the aquifer. The modeling attempted to duplicate this natural control by reducing the infiltration rate so that heads at the infiltration nodes remained at or just below the weir elevation in CD-P85. The resulting infiltration rate in CD-P85 was approximately 2 ft/day (1 in/hr). Below this rate, the mound beneath CD-P85 subsided.

The general shape of the mound was consistent throughout all modeling performed during this evaluation. Although the height of the mound exceeds the elevation of the basin bottom, the side slopes of the mound are extremely steep. As a result, the area where the groundwater is high enough to cause significant impacts does not appear to extend more than a few hundred feet beyond the boundaries of the basin.

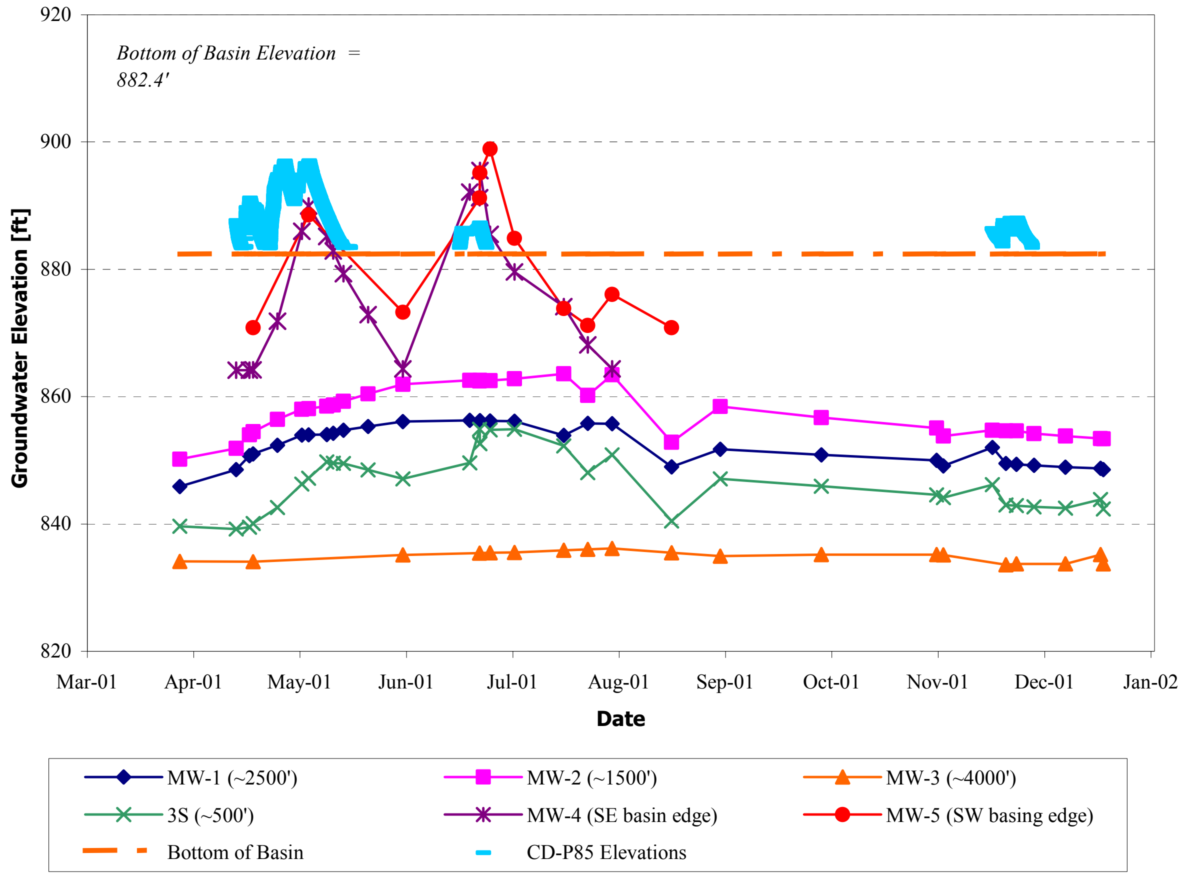
The modeled behavior of CD-P86 was significantly different than CD-P85. Except for a couple of deep 'holes', the depth of the surface water in CD-P86 will be significantly less than in CD-P85, which should cause lower rates of infiltration. The peak rate for the majority of CD-P86 in the MODFLOW model was approximately 1 ft/day (0.5 in/hr). However, the mound height still increased at this rate. We have not explored this phenomenon, but expect that it may be caused by the relatively large area of CD-P86.

The model indicates the mound height beneath CD-P86 will coincide with the water surface elevation over much of the area. This includes the area of the culvert beneath Military Road. On the fringes of the infiltration area, the height of the mound to declines rapidly as at CD-P85. The model indicates groundwater water levels will rise to near or above the elevation of the sanitary sewer interceptor along Woodbury Road. The dissipation of the extreme southern end of the mound will likely be sufficient so that the homes across 70th St from CD-P86 will not be adversely affected.

Figure 6 is a hydrograph of surface and groundwater elevations measured in 2001 at points in and near CD-P85. Based on these data, the maximum change in groundwater levels over the period from April to August is about 15.7 ft in 3s (approximately 400 feet from CD-P85), 10.4 ft in MW-1 (approximately 1,500 feet from CD-P85), 13.4 ft in MW-2 (approximately 2,500 feet from CD-P85), and 2.1 ft in MW-3 (approximately 4,000 feet from CD-P85). It should be noted that there is about 40 to 45 feet of available height between the static water level and the bottom of CD-P85.

The 2001 water level data suggests the mound extends further away from the infiltration area (particularly at MW-1 and MW-2) than is predicted by either the Hantush or the MODFLOW models. In addition, the water level exceeded the basin bottom elevation in MW-4 and MW-5 on two occasions. On one occasion the water level in MW-4 and MW-5 was actually higher than that of the basin, which is impossible assuming flow from the basin to the groundwater where MW-4 and MW-5 are completed. The causes of these phenomena are not known, but may be related to lateral flow caused by the low permeability layer observed beneath the basin or other undocumented inhomogeneities.

Figure 7
South Washington Watershed District
Surfaced Groundwater Elevations



Based on our evaluations, we have reached the following conclusions regarding the groundwater mounding:

- Theoretical calculations of the mound height indicate the height of the mound will dissipate rapidly beyond the bounds of the infiltration basins. It does not appear there will be adverse impacts due to the groundwater mounding.

- The actual infiltration rate could be less than has been achieved thus far with smaller volumes of water and pumping durations. However, the storage requirements for CD-P85 and CD-P86 have been established using an infiltration loss of 15 cfs (~1 ft/day) from CD-P85 and no infiltration losses from CD-P86. The modeling indicates these rates will be exceeded, confirming the storage design is conservative.

- Field data contain some unexplained results that indicate the actual conditions could be somewhat different that the theoretical predictions.

Effects on Water Quality

The degradation of groundwater quality by the potential introduction of pollutants via the infiltrated storm water was previously discussed in the original Bailey Lake EAW and the IMS (EOR, 2000). Ranges and averages of contaminant concentrations in storm water runoff of U.S. urban areas, including the Twin Cities, were evaluated against state and federal drinking water standards. These studies concluded that, based on these typical values, storm water runoff is potable.

Surface water chemistry data have since been collected from the infiltration basins. Table 5 summarizes chemistry monitoring results from basins CD-P82 and CD-P85 from September 2000 to June 2001. Table 6 is a summary of median concentrations of various chemicals in groundwater sampled from four aquifers in Cottage Grove. These data were collected in 1999 by the Minnesota Pollution Control Agency (MPCA) as part of a groundwater quality study in Cottage Grove and can be regarded as representative of ambient groundwater conditions in the area ("Ground Water Quality in Cottage Grove, Minnesota", Ground Water Monitoring and Assessment Program, Minnesota Pollution Control Agency, Ground Water and Toxics Monitoring Unit, Environmental Monitoring and Analysis Section, Environmental Outcomes Division, St. Paul, MN, June 2000). Minnesota Department of Health (MDH) Health Risk Limits (HRLs) for the analyzed compounds are included when they exist.

The following inferences can be drawn from these tables.

- None of the chemical concentrations in the surface water samples exceed the MDH HRLs, confirming the infiltrated water is chemically potable.
- The infiltration basin water generally has a higher chloride concentration than the ambient groundwater. This may be attributable to road salts.
- The infiltration basin water is higher in phosphorous than the groundwater. This could be related to fertilizer use.
- The groundwater has a greater nitrate concentration than the surface water. The MPCA water quality study documents a groundwater nitrate problem in Cottage Grove. The cause of the elevated nitrated concentrations has not been identified.
- There is no consistent evidence of organic constituents in the infiltration basin water.

The infiltration basin chemistry data supports the previous studies' conclusions that the storm water runoff is potable.

Table 5
Surface Water Chemistry of Infiltration Basins CD-P82 and CD-P85

Parameter	Units	MDH HRL	9/19/2000	9/25/2000	10/2/2000	4/16/2001			6/26/2001	
			CD-P85	CD-P85	CD-P85	CD-P85 #1	CD-P85 #2	CD-P82	CD-P85 #1	CD-P85 #2
Lead, total	µg/L	15	<2	<2	<2	<2	<2	<2	<2	<2
Cadmium, total	µg/L	4	NA	NA	NA	<1	<1	<1	<1	<1
Manganese, total	µg/L	100	NA	NA	NA	90	89	81	17	16
Nickel, total	µg/L	100	NA	NA	NA	<9	<9	<9	<9	<9
Copper, total	µg/L	--	NA	NA	NA	<12	<12	<12	<4	<4
Zinc, total	µg/L	2000	NA	NA	NA	26	11	19	25	42
Zinc, dissolved	µg/L	2000	NA	NA	NA	NA	NA	NA	18	16
Total Suspended Solids	mg/L	--	12	6	8	60	8	58	11	10
Phosphorus, total	µg/L	--	141	116	121	146	130	476	95	124
Phosphorus, ortho	µg/L	--	NA	NA	NA	27	17	359	88	89
Total Kjeldahl Nitrogen	mg/L	--	19.2	1.97	1.71	1.63	1.5	2.49	5.91	1.45
Nitrate + Nitrite	mg/L	10	<0.08	<0.08	<0.08	0.36	<0.08	1.64	<0.08	<0.08
Chloride	mg/L	250	30.2	28.4	30	34.8	34.6	7.11	4.87	5.05
Volatile Organic Compounds	µg/L	varies	NA	NA	NA	BRL	BRL	BRL	BRL	BRL
Polynuclear Aromatic Hydrocarbons	µg/L	varies	NA	NA	NA	BRL	BRL	BRL	BRL	BRL

Notes:

MDH HRL is the Minnesota Department of Health Health Risk Limit

µg/L = micrograms per liter, or parts per billion; mg/L = milligrams per liter, or parts per million

NA = not analyzed

BRL = below detection limit for all compounds

'<' indicates the result was less than the indicated reporting limit.

Table 6

Median Chemical Concentrations in Groundwater of Four Aquifers, Cottage Grove

Parameter	Units	MDH HRL	Surficial Sand	Prairie du Chien	Jordan	Franconia
Lead, total	µg/L	15	<24	<24	<24	<24
Cadmium, total	µg/L	4	<1.9	<1.9	<1.9	<1.9
Manganese, total	µg/L	100	23	<0.7	<0.7	32
Nickel, total	µg/L	100	<6.1	<6.1	<6.1	<6.1
Copper, total	µg/L	--	<5.5	<5.5	<5.5	<5.5
Zinc, total	µg/L	2000	8.5	43	41	19
Zinc, dissolved	µg/L	2000	NA	NA	NA	NA
Total Suspended Solids	mg/L	--	NA	NA	NA	NA
Phosphorus, total	µg/L	--	<20	20	<20	<20
Phosphorus, ortho	µg/L	--	NA	NA	NA	NA
Total Kjeldahl Nitrogen	mg/L	--	NA	NA	NA	NA
Nitrate	mg/L	10	4	6.1	5.4	3.6
Chloride	mg/L	250	10	14.1	8.9	2.3
Volatile Organic Compounds	µg/L	varies	NR	NR	NR	NR
Polynuclear Aromatic Hydrocarbons	µg/L	varies	NR	NR	NR	NR

Notes:

MDH HRL is the Minnesota Department of Health Health Risk Limit

µg/L = micrograms per liter, or parts per billion; mg/L = milligrams per liter, or parts per million

NR = not reported

'<' indicates the result was less than the indicated reporting limit.

Interference with Other Groundwater Pumping Systems

There are local groundwater pumping features that could potentially be impacted by the infiltration basins. One is a containment system at the 3M Woodbury Landfill that consists of a series of pump-out wells. The other concern is the presence of Cottage Grove and St. Paul municipal wells located west and southwest of the infiltration basins.

The EAW used the computer model SLAEM (Single Layer Analytical Element Model) to evaluate the potential impacts to the area. This model only allows simulation of infiltration to and pumping from a single aquifer. In reality, the infiltration basins will recharge to the water table aquifer, while the 3M wells are pumping from a deeper bedrock aquifer (the Prairie du Chien). Using the single-layer model would exaggerate the amount of infiltrated water that would reach the 3M wells. The results of the EAW SLAEM modeling indicated that a large amount of infiltrated water would reach the 3M wells, but that the containment area of the system was maintained.

A second model, MLAEM (Multi-Layer Analytical Element Model) was used by EOR during the Infiltration Management Study. This model allows for the input of more than one aquifer, as actually exist. The results of this modeling indicated that there was essentially no impact from the infiltration basins on the 3M containment system due to the amount of vertical separation between the infiltration to the water table aquifer and the pumping in the deeper bedrock aquifer.

These modeling scenarios represent two extreme cases. In the single-layer case, the nature of the model dictates an assumption that there is no vertical separation between the infiltration and the pumping. In this model, while infiltrated water was directed to the 3M wells, the area of capture was maintained. In the multi-layer case, there is no predicted impact because of the vertical separation between the infiltrated and pumped aquifers. However, based on chemical data, the MPCA Cottage Grove study concluded that there is vertical mixing of groundwater between the aquifers, indicating groundwater movement between aquifers. Thus, the actual impact of the infiltration basins would be between these extremes. However, neither scenario predicts that the infiltration basins would compromise the 3M containment system.

HDR reviewed the potentiometric surface of Washington County and the 10-year capture zones for City of Cottage Grove and City of St. Paul Park municipal wells, as modeled by EOR for the Minnesota Department of Health. Given groundwater flow patterns, lateral distance between the infiltration basins and municipal wells and the evidence of vertical mixing, it is distinctly possible that the infiltrated water could be captured by municipal wells.

This issue has not been previously identified. It should not be considered a critical issue because the quality of the infiltrated water has been documented as potable. In addition the quality of the water could be different by the time it is captured by the municipal wells due to vertical mixing. Nonetheless, it is important to further evaluate this observation, with the goals of 1) narrowing the likelihood that the infiltrated water is actually captured, and 2) assessing what percentage of the water supply is affected. Depending on these results, we can ascertain appropriate levels of monitoring and/or pollution prevention measures (e.g., BMPs) that are warranted in the watershed to protect the water supplies.

10.0 Opinion of Most Probable Cost

The SWWD estimates that the land purchase costs for the Project will be $7,000,000 for CD-P86 North and South lobes and does not include cost for Gables Lake. Construction costs of this project's required improvements are estimated to be slightly over $2,000,0000, excluding improvements to the Bailey Lake Lift Station which are the responsibility of the City of Woodbury. A summary of the cost assumptions is provided in Table 7.

Table 7
Engineer's Estimate of Probable Cost
Central Draw Project
Preliminary Design

ITEM	ITEM DESCRIPTION	UNIT	QUANTITY	UNIT COST	AMOUNT
CD-P85 Weir and Discharge Pipe					
1	Mobilization	LS.	1	$11,286	$11,286
2	Topsoil Stripping and Stockpile	SY.	5200	$0.30	$1,560
3	Construct Cast-in-Place Concrete Inlet & Weir	CY.	12	$300.00	$3,600
4	Furnish and Install Pre-cast 6' x 6' Box Culvert	LF.	620	$250.00	$155,000
5	Excavation/Backfill	CY.	9200	$5.00	$46,000
6	Furnish and Install Safety Grate	EA.	1	$1,000.00	$1,000
7	Furnish and Install Pre-cast 6' x 6' Apron	EA.	1	$3,000.00	$3,000
8	6" Riprap with Geotextile	CY.	21	$50.00	$1,050
9	Finish Grading and Topsoiling	SY.	4800	$2.00	$9,600
10	Turf Establishment (seed and mulch, native plantings)	SY.	4800	$0.50	$2,400
11	Erosion Control (silt fence)	LF.	1250	$2.00	$2,500
	Subtotal				**$236,996**
CD-P86 North Lobe Pilot Channel					
12	Mobilization	LS.	1	$8,090	$8,090
13	Topsoil Stripping and Stockpile	SY.	10650	$0.30	$3,195
14	Excavation	CY.	3600	$5.00	$18,000
15	Furnish and Install Permanent RECP	SY.	7600	$16.00	$121,600
16	Finish Grading and Topsoiling	SY.	7600	$2.00	$15,200
17	Turf Establishment (seed and mulch, native plantings)	SY.	7600	$0.50	$3,800
	Subtotal				**$169,885**
CD-P86 Berm					
18	Mobilization	LS.	1	$2,498	$2,498
19	Topsoil Stripping and Stockpile	SY.	6000	$0.30	$1,800
20	Common Excavation to Embankment	CY.	4550	$5.00	$22,750
21	Soil Liner Borrow	CY.	1100	$8.00	$8,800
22	Finish Grading and Topsoiling	SY.	6000	$2.00	$12,000
23	Turf Establishment (seed and mulch, native plantings)	SY.	6000	$0.50	$3,000
24	Erosion Control (silt fence)	LF.	800	$2.00	$1,600
	Subtotal				**$52,448**

ITEM	ITEM DESCRIPTION	UNIT	QUANTITY	UNIT COST	AMOUNT
CD-P86 South Lobe Pilot Channel and Berm Spillway					
25	Mobilization	LS.	1	$10,721	$10,721
26	Topsoil Stripping and Stockpile	SY.	11400	$0.30	$3,420
27	Excavation	CY.	9800	$5.00	$49,000
28	Furnish and Install Wood Fiber RECP	SY.	7680	$13.00	$99,840
29	Finish Grading and Topsoiling	SY.	7680	$2.00	$15,360
30	Turf Establishment (seed and mulch, native plantings)	SY.	7680	$0.50	$3,840
31	Spillway Excavation	CY.	940	$5.00	$4,700
32	Spillway - 9" Riprap with Geotextile	CY.	510	$75.00	$38,250
	Subtotal				**$225,131**
Military Road Raise and Culvert					
33	Mobilization	LS.	1	$11,849	$11,849
34	Topsoil Stripping and Stockpile	SY.	8200	$0.30	$2,460
35	6" Riprap with Geomembrane	CY.	10	$50.00	$500
36	Finish Grading and Topsoiling	SY.	8700	$2.00	$17,400
37	Turf Establishment (seed and mulch, native plantings)	SY.	8700	$0.50	$4,350
38	Erosion Control (silt fence)	LF.	2250	$2.00	$4,500
39	Underpass Structure	LS.	1	$40,000.00	$40,000
40	Road Embankment	CY.	7300	$9.00	$65,700
41	Pavement Removal	SY.	2990	$6.00	$17,940
42	Pavement Replacement	SY.	2990	$33.00	$98,670
	Subtotal				**$263,369**
CSAH 19 Stormwater Retention Structure and Outlet Structure					
43	Mobilization	LS.	1	$3,842	$3,842
44	Topsoil Stripping and Stockpile	SY.	4300	$0.30	$1,290
45	Road Embankment	CY.	0	$5.00	$0
46	Soil Liner Borrow	CY.	4080	$8.00	$32,640
47	9" Riprap with Geotextile - Channel to Gables Lake	CY.	18	$75.00	$1,350
48	Finish Grading and Topsoiling	SY.	4300	$2.00	$8,600
49	Turf Establishment (seed and mulch, native plantings)	SY.	4300	$0.50	$2,150
50	Erosion Control (silt fence)	LF.	800	$2.00	$1,600
51	Outlet Pipe and Structure	LS.	1	$29,205.00	$29,205
	Subtotal				**$80,677**

ITEM	ITEM DESCRIPTION	UNIT	QUANTITY	UNIT COST	AMOUNT
70th Street Stormwater Retention Structure and Outlet Structure					
52	Mobilization	LS.	1	$6,683	$6,683
53	Topsoil Stripping and Stockpile	SY.	5900	$0.30	$1,770
54	Common Excavation to Embankment	CY.	535	$5.00	$2,675
55	Soil Liner Borrow	CY.	6200	$8.00	$49,600
56	Pavement Removal	SY.	830	$6.00	$4,980
57	Pavement Replacement	SY.	830	$33.00	$27,390
58	6" Riprap with Geotextile	CY.	2	$50.00	$100
59	Finish Grading and Topsoiling	SY.	4600	$2.00	$9,200
60	Turf Establishment (seed and mulch, native plantings)	SY.	4600	$0.50	$2,300
61	Erosion Control (silt fence)	LF.	1100	$2.00	$2,200
62	Outlet Pipe and Structure (Optional)	LS.	1	$33,438.00	$33,438
	Subtotal				**$140,335**
Cottage Grove Storm Sewer Upgrade (Optional)					
63	Mobilization	LS.	1	$579.00	$579
64	Excavation/Backfill	CY.	390	$5.00	$1,950
65	Remove and Reposition 12" RCP	LF.	210	$26.00	$5,460
66	Connect to Existing Manhole	EA.	2	$2,000.00	$4,000
67	Turf Establishment (seed and mulch, native plantings)	SY.	140	$0.50	$70
68	Erosion Control (silt fence)	LF.	50	$2.00	$100
	Subtotal				**$12,159**
Channel to Gables Lake					
69	Mobilization	LS.	1	$9,732.75	$9,733
70	Clear and Grub - Channel to Gables Lake	SY.	8600	$1.00	$8,600
71	Topsoil Stripping and Stockpile	SY.	8600	$0.30	$2,580
72	Common Excavation to Spoil	CY.	6400	$3.00	$19,200
73	Furnish and Install Permanent RECP	SY.	6000	$16.00	$96,000
74	9" Riprap with Geotextile	CY.	667	$75.00	$50,025
75	Finish Grading and Topsoiling	SY.	7300	$2.00	$14,600
76	Turf Establishment (seed and mulch, native plantings)	SY.	7300	$0.50	$3,650
	Subtotal				**$204,388**
Subtotal					**$1,385,386**
Contingencies (25%)					$346,347
Engineering (12%)					$166,246
Surveying and Geotechnical (10%)					$138,539
Permitting (3%)					$41,562
Total					**$2,078,080**

11.0 Compatibility with Existing Plans, Statutes, Rules and Permit Needs

11.1 South Washington Watershed District Plan

The current SWWD plan was adopted in November 1997. The plan was prepared in accordance with Minnesota Rules Chapter 8410 "Metropolitan Area Local Water Management" and the applicable sections of Minnesota Statutes Sections 103B and 103D.

In addition, the SWWD has developed goals for managing the natural resources within the watershed. There are several overall watershed goals applicable to accomplishing the minor and major plan amendments being proposed in this Engineer's Report:

Goal 1 Protect the watershed's water resources and natural resources to benefit recreation, wildlife and future needs.

Goal 2 Protect the water quality and quantity of surface waters and groundwater.

Goal 3 Manage the flow of water within the watershed to prevent damage to property and water resources by planning for future growth.

Goal 4 Encourage cities to use appropriate development practices to balance growth with environmental protection.

Goal 5 Maintain a high level of public awareness on water quality and water quantity issues through education.

Goal 6 Utilize long-term planning to minimize public capital expenditures to address water quality and quantity problems.

Goal 7 Prevent soil erosion and control sediment leaving construction sites.

Goal 8 Maintain an effective Watershed Management Plan that addresses short- and long-term goals of the watershed and ensure that the Plan is workable, viable and enforceable.

The Plan contains nine identified projects to be implemented during the timeframe of the Plan. This includes the Central Draw Outlet Study and the West Draw Drainage Improvements. It also includes the acquisition of the CD-P86 detention area and associated construction improvements necessary to convey and manage storm water. Finally, the activities proposed in the minor and major amendments are consistent with the creation of multipurpose corridors identified in the SWWD Natural Resources Management Plan. The implementation of the minor plan amendment and subsequent major plan amendment is fully consistent with the existing SWWD watershed management plan.

11.2 Local Municipal Plans

Woodbury's 1979 Storm Drainage and 1994 Surface Water Management Plans

The SWWD watershed plan was approved and adopted pursuant to Minnesota Statutes 103B.231. However, the City of Woodbury is not required to update and prepared a local water management plan, capital improvement program, and official controls as necessary to bring local water management into conformance with the SWWD watershed plan because other WMOs which Woodbury is a part of have not adopted plans. Therefore, the SWWD plan takes precedence in local water management. The draft plans are consistent with the SWWD plan in that all plans recognize the need for flood damage reduction and a planned drainage system. The plans are inconsistent with the SWWD plan in the selection of a design event and how high water elevations and freeboard are treated in landlocked basins. Finally, the plans are different from the SWWD plan in that there is no approved overflow to the Mississippi River. The current regulatory constraints do not allow Woodbury to discharge water past CD-P85.

Cottage Grove's 1997 Draft Comprehensive Storm Drainage Plan

The SWWD watershed plan was approved and adopted pursuant to Minnesota Statutes 103B.231. However, the City of Cottage Grove is not required to update and prepared a local water management plan, capital improvement program, and official controls as necessary to bring local water management into conformance with the SWWD watershed plan. The 1997 draft plan has not been approved by the SWWD as being compliant; therefore, the SWWD plan takes precedence in local water management. The draft plans are consistent with the SWWD plan in that all plans recognize the need for flood damage reduction and a planned drainage system. The plans are inconsistent with the SWWD plan in the treatment of undeveloped land. New information developed by the SWWD in recent studies should be evaluated by the City of Cottage Grove and be considered for incorporation into the updated City plan.

11.3 Minnesota Statutes and Rules

Minnesota Rules Chapter 8410

Minnesota Rules Chapter 8410 governs the plan content and actions of metropolitan watershed districts. The rules require that each plan must contain an assessment of existing and potential water resource related problems using a combination of analysis of land and water resource data and through the identification of existing or potential problems by residents or local, regional, or state agencies. To address problems, the rules also require that each plan describe an implementation program consisting of nonstructural, structural, and programmatic solutions to the problems, issues, and goals. The SWWD plan was developed in compliance with Minnesota Rules Chapter 8410 and lays out a phased plan to address the flooding problems identified in Woodbury and Cottage Grove. The SWWD has developed minimum standards and provided for appropriate controls for the design of new storm water conveyance, ponding, and treatment systems. This Engineer's Report lays out a phased amendment process in accordance with the requirements of Minnesota Rules 8410.0140, which governs the watershed plan amendment process.

Minnesota Statutes Chapter 103B

Minnesota Statutes Chapter 103B is the Metropolitan Surface Water Use Management Act which defines the purposes of watershed districts in the metropolitan area. The SWWD watershed Plan was prepared in accordance with the requirements of M.S. §103B. The plan describes the existing physical environment, presents information on the hydrologic system and existing and potential problems and establishes the management plan that will be followed for watershed improvements.

In addition, M.S. § 103B allows the SWWD managers to initiate an amendment of a watershed management plan or revised watershed management plan by submitting a petition with the proposed amendment to the Board of Water and Soil Resources. The proposed minor and major amendments to the SWWD watershed management plan proposed in this Engineer's Report are consistent with the statutorily defined mission of watershed districts as described in this section of Minnesota Statutes. The implementation of the minor and major amendments detailed in this Engineer's Report is consistent with the SWWD plan and M.S. §103B.

Minnesota Statutes Chapter 103D

Minnesota Statutes Chapter 103D is the state's watershed law. The law defines the purpose of a watershed district as to conserve the natural resources of the state by land use planning, flood control, and other conservation projects by using sound scientific principles for the protection of the public health and welfare and the provident use of the natural resources. One of the primary purposes of watershed districts under this chapter is to control or alleviate damage from floodwaters. The projects being proposed by the SWWD are flood damage reduction projects. The proposed minor and major amendments to the SWWD watershed management plan proposed in this Engineer's Report are consistent with the statutorily defined mission of watershed districts as described in this section of Minnesota Statutes.

11.4 State Environmental Review

Minnesota Statutes 116D and Minnesota Rules Chapter 4410 govern environmental review in Minnesota. In April 1994, the City of Woodbury completed a mandatory Environmental Assessment Worksheet (EAW) for the creation of Bailey Lake and the Bailey Lake lift station. The scope of the EAW covered the Bailey Lake lift station, CD-P85 and CD-P89 (now CD-P86). The EAW did not examine any downstream impacts of future storm water management infrastructure.

The minor plan amendment is intended to allow the SWWD to complete the implementation of the CD-P85 and CD-P89 detention/infiltration areas and associated infrastructure. Therefore, consistent with environmental review laws, the Project will not require additional environmental review.

In accordance with Minnesota Rules Chapter 4410, the major amendment plan will require additional environmental review as a phased and connected action to the Project. The SWWD intends to complete the required environmental review at the appropriate time.

11.5 Section 404 or Section 10

The Corps of Engineers' Regulatory Programs include Section 10 of the Rivers and Harbors Act of 1899 and Section 404 of the Clean Water Act. The St. Paul District's regulatory jurisdiction covers the states of Minnesota and Wisconsin.

Under Section 10, a Corps' permit is required to do any work in, over or under a Navigable Water of the U.S. Waterbodies have been designated as Navigable Waters of the U.S. based on their past, present, or potential use for transportation for interstate commerce. These waters include many of the larger rivers and lakes, such as the St. Croix and Mississippi rivers.

Under Section 404, a Corps' permit is required for the discharge of dredged or fill material into waters of the U.S. Many waterbodies and wetlands in the nation are waters of the U.S. and are subject to the Corps' Section 404 regulatory authority. The SWWD intends to complete the Minnesota State-Federal water resources permit application and submit it for review prior to undertaking any construction activities.

11.6 Minnesota Department of Natural Resources

The Minnesota Department of Natural Resources (DNR) is charged with managing the state’s land and water resources through various programs. The Waters Division manages protected waters, wetlands and watercourses and requires permits for any project that will alter the course, current or cross-section of a protected water. The Wildlife and Ecological Services Divisions regulate Wildlife Management Areas and Scientific and Natural Areas. It is recommended that the DNR Area Managers for Fisheries, Wildlife be contacted prior to initiation of the minor and major amendments to determine any permit requirements of the DNR for the Project.

The DNR also regulates the appropriation of waters of the state. The City of Woodbury has an existing DNR Permit, number 94-6178, that allows for the appropriation of water from Bailey Lake to CD-P85 at a rate not to exceed 75 cfs.

11.7 Wetland Conservation Act

Minnesota Statutes Section 103G.221 through 103G.2373 and Minnesota Rules Chapter 8420 are referred to as the Wetland Conservation Act (WCA). Under WCA, wetlands must not be drained or filled unless (a) drain or fill activity is exempt or (b) wetlands are replaced by restoring or creating wetland areas of at least equal public value. The overall goal is no net loss of wetlands.

The local government unit (LGU) has the primarily responsibility for administration of the WCA and for making key determinations. Generally, the LGU is the city or county, but may be another entity such as a watershed district or soil and water conservation district. The cities of

Woodbury and Cottage Grove are the WCA LGUs in the SWWD. The state agency is the LGU for a project by that state agency or activity on state land. The SWWD intends to complete the Minnesota State-Federal water resources permit application and submit it for review prior to undertaking any construction activities.

11.8 NPDES Requirements

There are two areas under National Pollutant Discharge Elimination System (NPDES) Phase II program that will have to be considered when implementing minor and major plan amendments construction. The 1987 Amendments to the Clean Water Act required the U.S. Environmental Protection Agency (EPA) to develop regulations for storm water discharges associated with construction and industrial activity. NPDES permitting authority was given to the Minnesota Pollution Control Agency (MPCA) to administer this federal program. Anyone conducting a construction activity, including clearing, grading and excavating, which results in the disturbance of five or more acres of land, is required to apply for coverage under the General Storm-Water Permit for Construction Activity. Such activities may include (but are not limited to): road building and construction of residential houses, office buildings, industrial or commercial buildings, landfills, airports and feedlots. If the construction activities in the minor and major plan amendments expose more than five acres of land, an NPDES permit will be applied for by the SWWD.

The Storm Water NPDES Phase II Final Rule is EPA's next step in an effort to preserve, protect and improve the Nation's water resources from polluted storm water runoff. The NPDES Phase II program expands the NPDES Phase I Storm Water program by requiring additional operators of MS4s in urbanized areas and operators of small construction sites (1 to 5 acres), through the use of NPDES permits, to implement programs and practices to control polluted storm water runoff. NPDES Phase II is intended to further reduce adverse impacts to water quality and aquatic habitat by instituting the use of controls on the unregulated sources of storm water discharges that have the greatest likelihood of causing continued environmental degradation. Both the cities of Woodbury and Cottage Grove will be required to be compliant with NPDES Phase II storm water permit conditions. The SWWD recommends that the cities work with the SWWD on the implementation of the Project to ensure that storm water permit requirements are met.

The State of Minnesota is currently developing an NPDES Phase II Storm Water program for Municipal Separate Storm Sewer Systems. The permit will be adopted by the State in March of 2003. The cities of Woodbury and Cottage Grove will be regulated by this permit. As it is currently drafted, the permit would not allow new discharges of stormwater to the Mississippi River without extensive justification.

For example, the draft permit does not cover the following existing, new or expanded discharges unless the requirements of Appendix C are met:

a) Discharges into waters with Prohibited Discharges as defined in Minn. R. 7050.0180, subp. 3.

b) Discharges into waters with Restricted Discharge as defined in Minn. R. 7050.0180, subp. 6.

c) Discharges into Wetlands as defined in Minn. R.7050.0130, subp. F.

d) Discharges with incomplete or unfinalized Environmental Review required by State or federal laws.

e) Discharges whose direct, indirect, interrelated, interconnected, or independent impacts would jeopardize a listed endangered or threatened species or adversely modify a designated critical habitat.

f) Discharges which adversely affect properties listed or eligible for listing in the National Register of Historic Places or affecting known or discovered archeological sites.

The section of the Mississippi River that would be receiving storm water has been designated as the Mississippi National River Recreation Area. A new discharge of storm water to this segment of river is restricted if prudent and feasible alternatives can be identified.

Finally, this section of the Mississippi River has a Total Maximum Daily Load (TMDL) Allocation. If a TMDL is approved by the USEPA, for any waterbody into which storm water will be discharged, the MS4s, you must review their Storm Water Pollution Prevention Program to determine whether the program meets the requirements of the TMDL implementation plan. If not, the Storm Water Pollution Prevention Program must be modified as appropriate, to meet the applicable requirements and schedules of the TMDL implementation plan.

The Storm Water Pollution Prevention Program must be designed and managed to reduce the discharge of pollutants from the storm sewer system to the Maximum Extent Practicable (MEP). The cities must manage their municipal storm sewer system in compliance with the Clean Water Act and with the terms and conditions of this permit. They also must manage, operate, and maintain the storm sewer system and areas they control that discharge to the storm sewer system in a manner to reduce the discharge of pollutants. The system management will consist of a combination of BMPs, including: education, maintenance, control techniques, system design and engineering methods, and such other provisions as you determined to be appropriate, as long as the BMPs meet the minimum requirements of this permit.

APPENDIX A

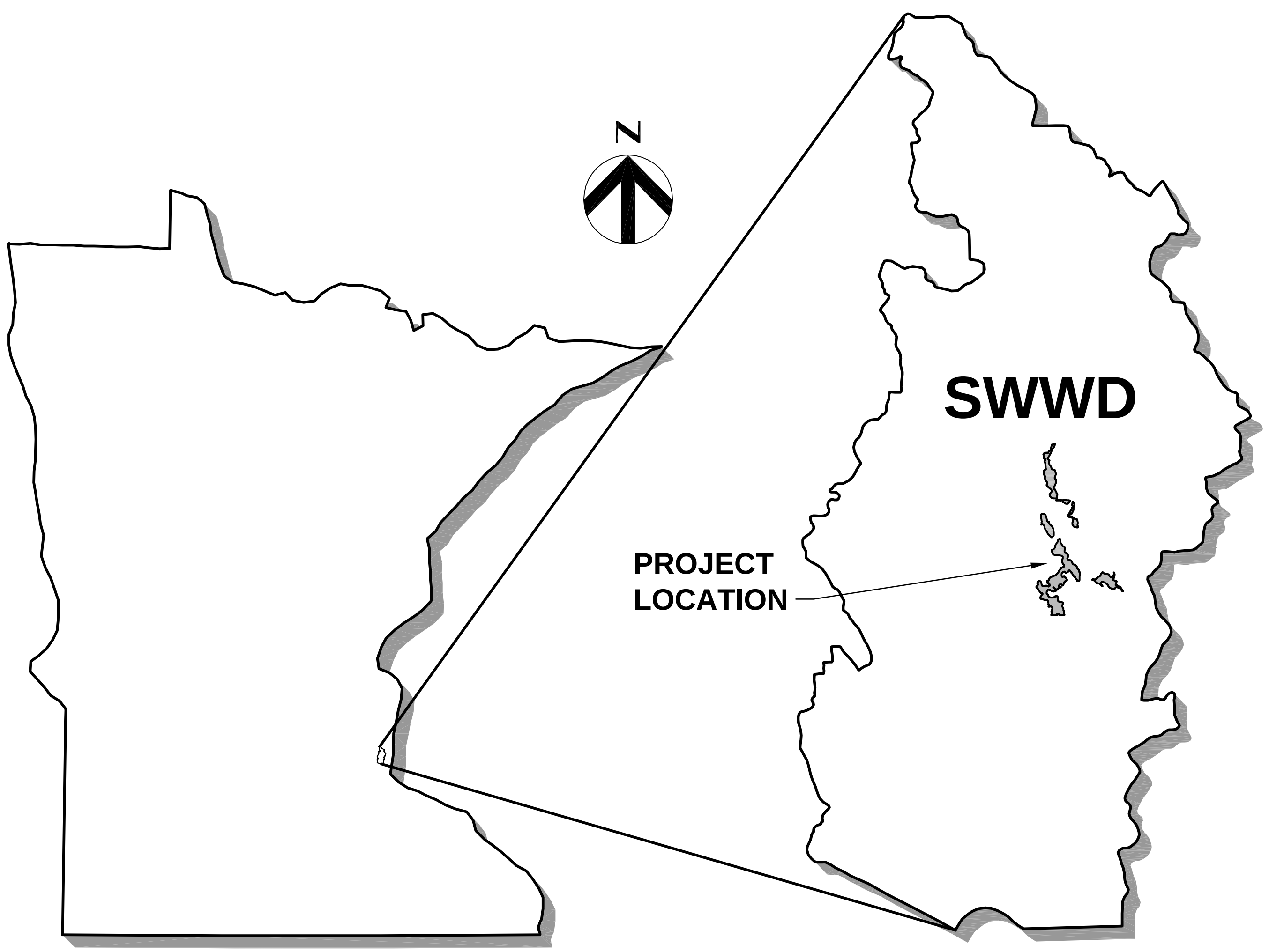
PROJECT DESIGN DRAWINGS

SOUTH WASHINGTON WATERSHED DISTRICT

IMPLEMENTATION OF CENTRAL DRAW OVERFLOW - PHASE I

CD-P86 OUTLETS AND EMBANKMENT IMPROVEMENTS

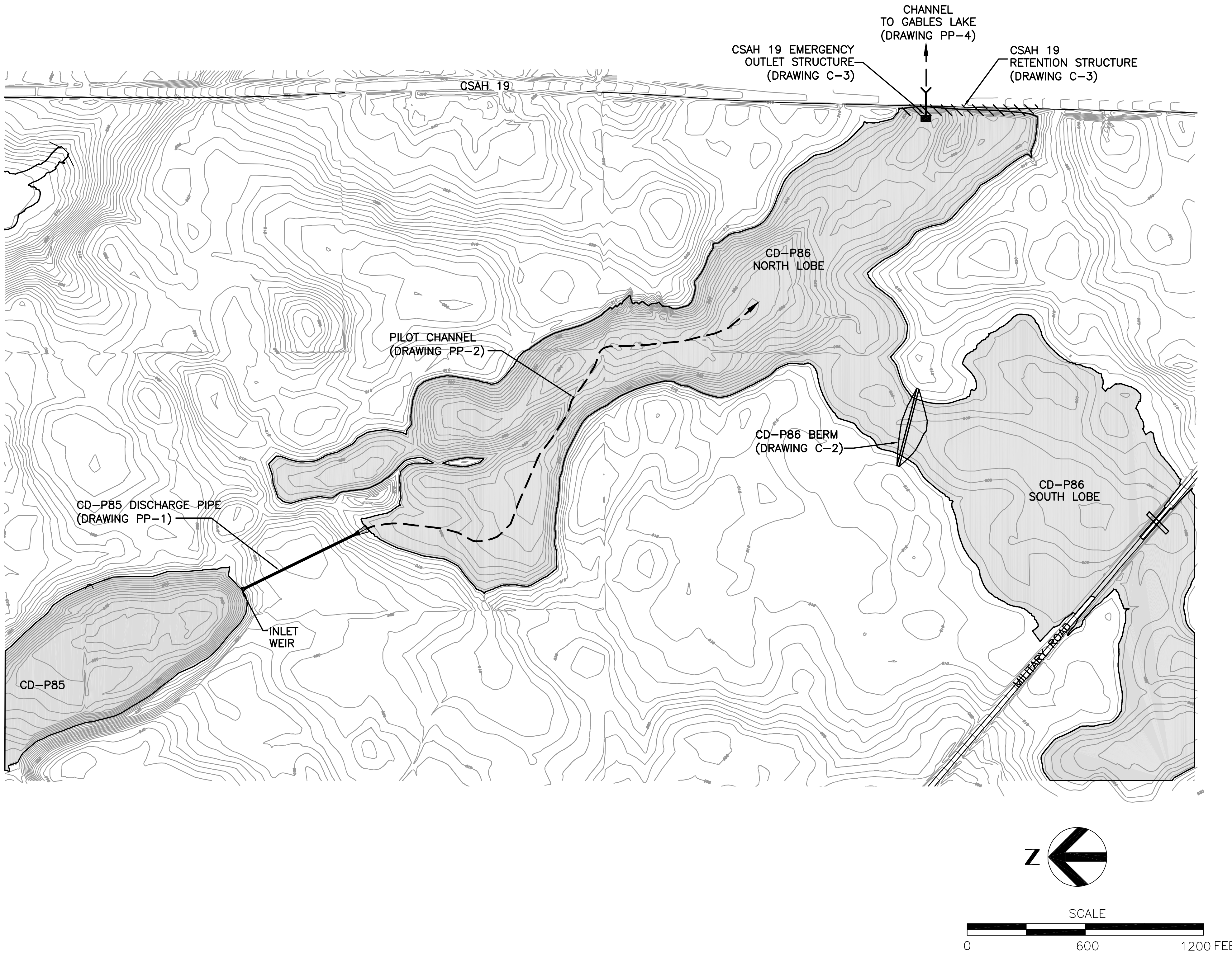
APRIL 2002



DRAWING LIST:

SHEET	TITLE
----	COVER
P-1	PLAN VIEW - NORTH AREA
P-2	PLAN VIEW - SOUTH AREA
P-3	PLAN VIEW - SOUTH AREA (REGRADED OPTION)
PP-1	PLAN AND PROFILE - CD-P85 DISCHARGE PIPE
PP-2	PLAN AND PROFILE - NORTH AREA PILOT CHANNEL
PP-3	PLAN AND PROFILE - SOUTH AREA PILOT CHANNEL
PP-4	PLAN AND PROFILE - CHANNEL TO GABLES LAKE
C-1	MILITARY ROAD CULVERT
C-2	CD-P86 BERM
C-3	CSAH 19 OUTLET AND EMBANKMENT IMPROVEMENT
C-4	70th STREET OUTLET AND EMBANKMENT IMPROVEMENT
C-5	COTTAGE GROVE STORM SEWER UPGRADE
D-1	DETAILS

HDR Engineering, Inc. HDR Project No. 105500-006-164



CD-P85

STORAGE CAPACITY BELOW 910 CONTOUR = 355 ACRE-FEET

CD-P86 NORTH LOBE

STORAGE CAPACITY BELOW 905 CONTOUR = 671 ACRE-FEET
STORAGE CAPACITY BELOW 906 CONTOUR = 734 ACRE-FEET

Issue No.	Description	Date	Drwn.	Chkd.	Resp. Engr.	Proj. Mgr.
A	PHASE I DESIGN	4/01/02	KAH	GW	AJL	DJ

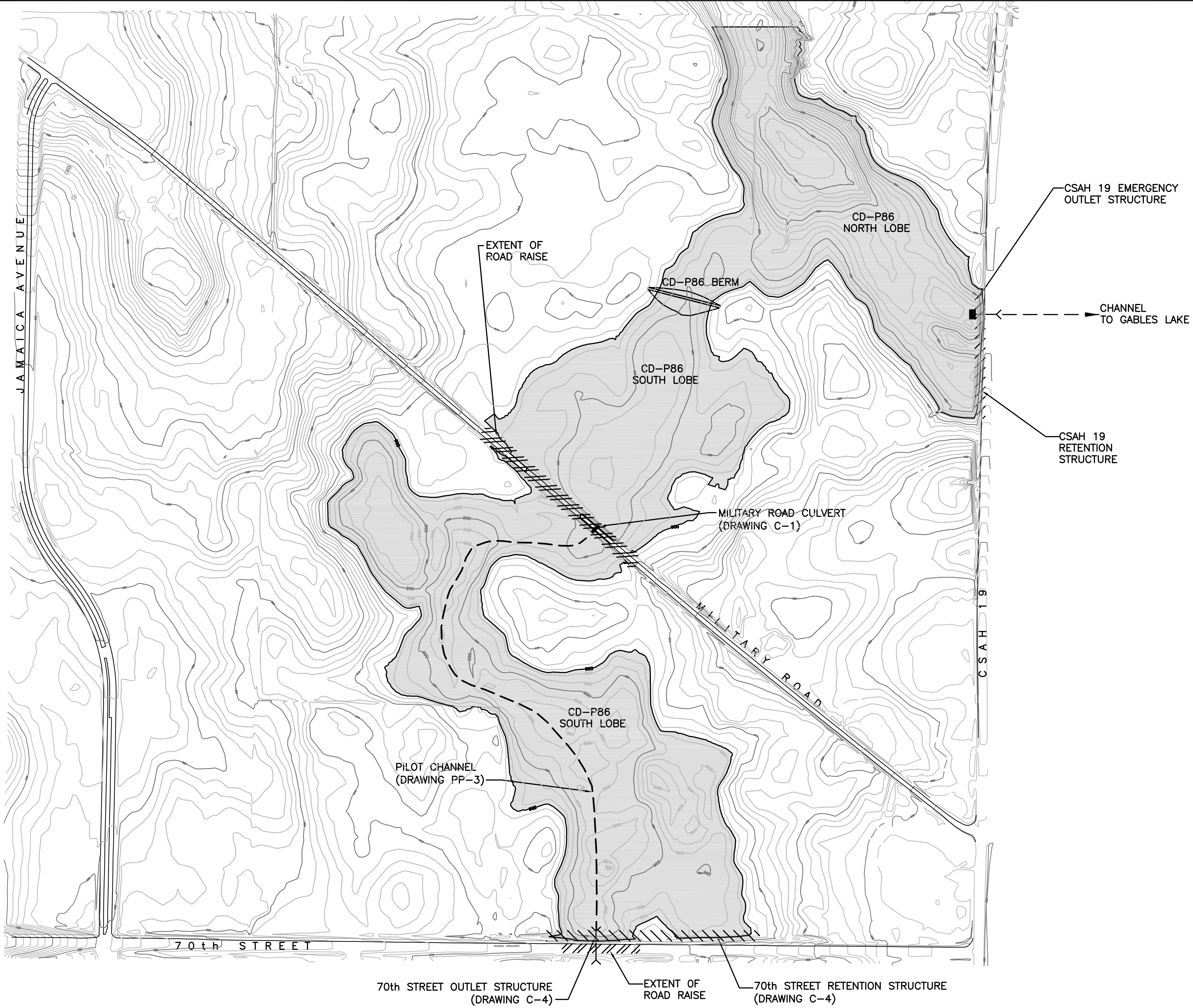
HDR
HDR Engineering, Inc.

Project Manager: D. JOHNSON
Designed: A. LUFT
Designed:
Checked:
Drawn: K. HODNE

South Washington Watershed District
SWWD

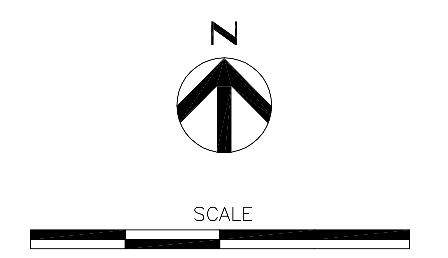
CENTRAL DRAW OVERFLOW - PHASE I
PLAN VIEW - NORTH AREA

Date: 4/01/02
Scale: 1"=600'
Project No.: 10550-006-164
File Name: 10550006-P1.DWG
Drawing No.: P-1
Issue: A



CD-P86 SOUTH LOBE

STORAGE CAPACITY BELOW 905 CONTOUR = 409 ACRE-FEET
STORAGE CAPACITY BELOW 906 CONTOUR = 495 ACRE-FEET



Issue No.	Description	Date	Drwn.	Chkd.	Resp. Engr.	Proj. Mgr.
A	PHASE I DESIGN	4/01/02	KAH	GW	AJL	DJ

HDR
HDR Engineering, Inc.

Project Manager: D. JOHNSON
Designed: A. LUFT
Designed:
Checked:
Drawn: K. HODNE

South Washington Watershed District
SWWD

CENTRAL DRAW OVERFLOW - PHASE I

PLAN VIEW - SOUTH AREA

Date	Project No.	Drawing No.	Issue
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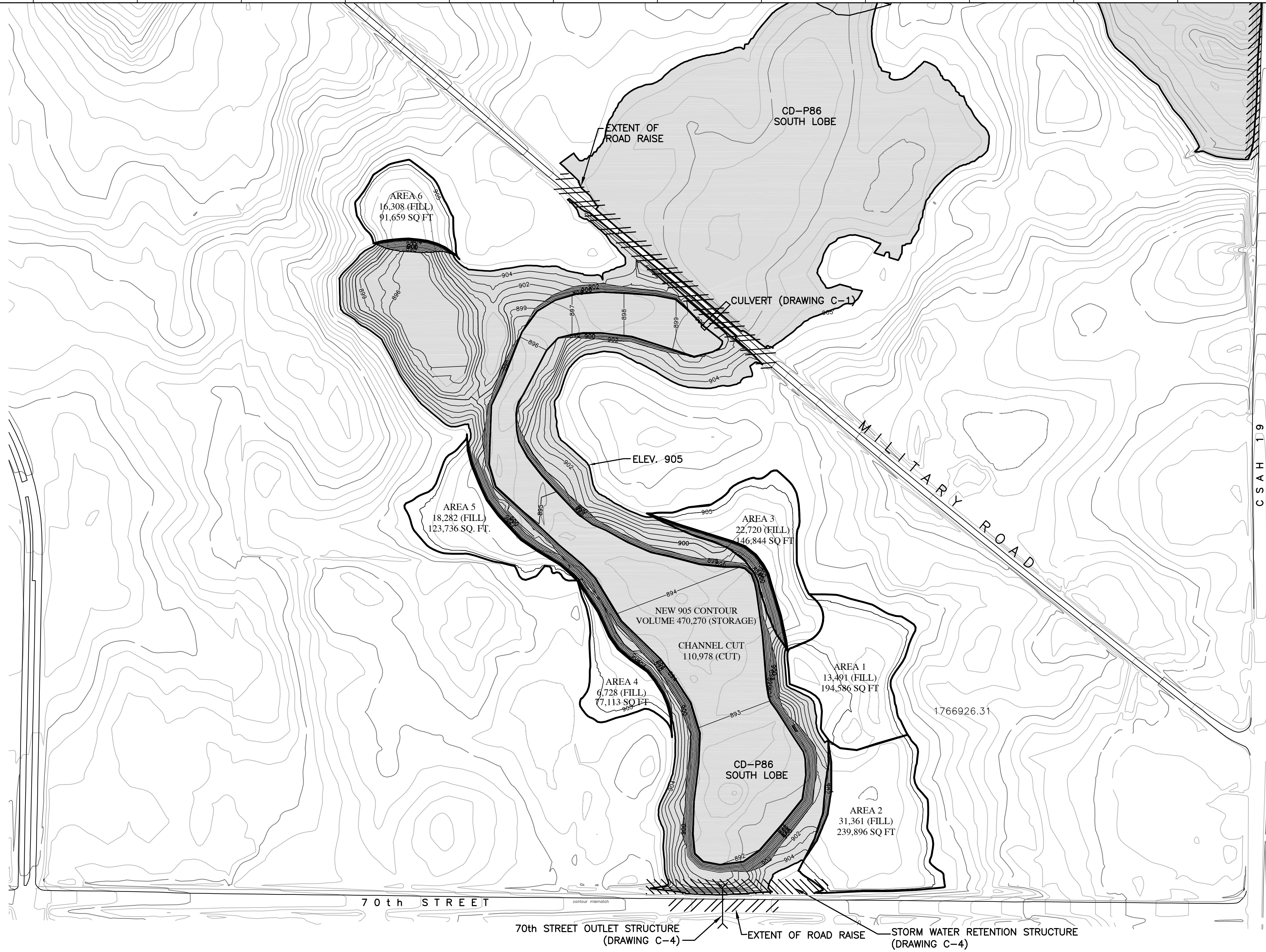


N

SCALE

0 400 800 FEET

REGRADED
CD-P86 SOUTH LOBE

STORAGE CAPACITY BELOW 905 CONTOUR = 291 ACRE-FEET

AREA	DEVELOPABLE LAND
1	4.5 ACRES
2	5.5 ACRES
3	3.4 ACRES
4	1.8 ACRES
5	2.8 ACRES
6	2.1 ACRES
TOTAL	20.1 ACRES

Issue No.	Description	Date	Drwn.	Chkd.	Resp. Engr.	Proj. Mgr.
A	PHASE I DESIGN	4/01/02	KAH	GW	AJL	DJ

HDR Engineering, Inc.

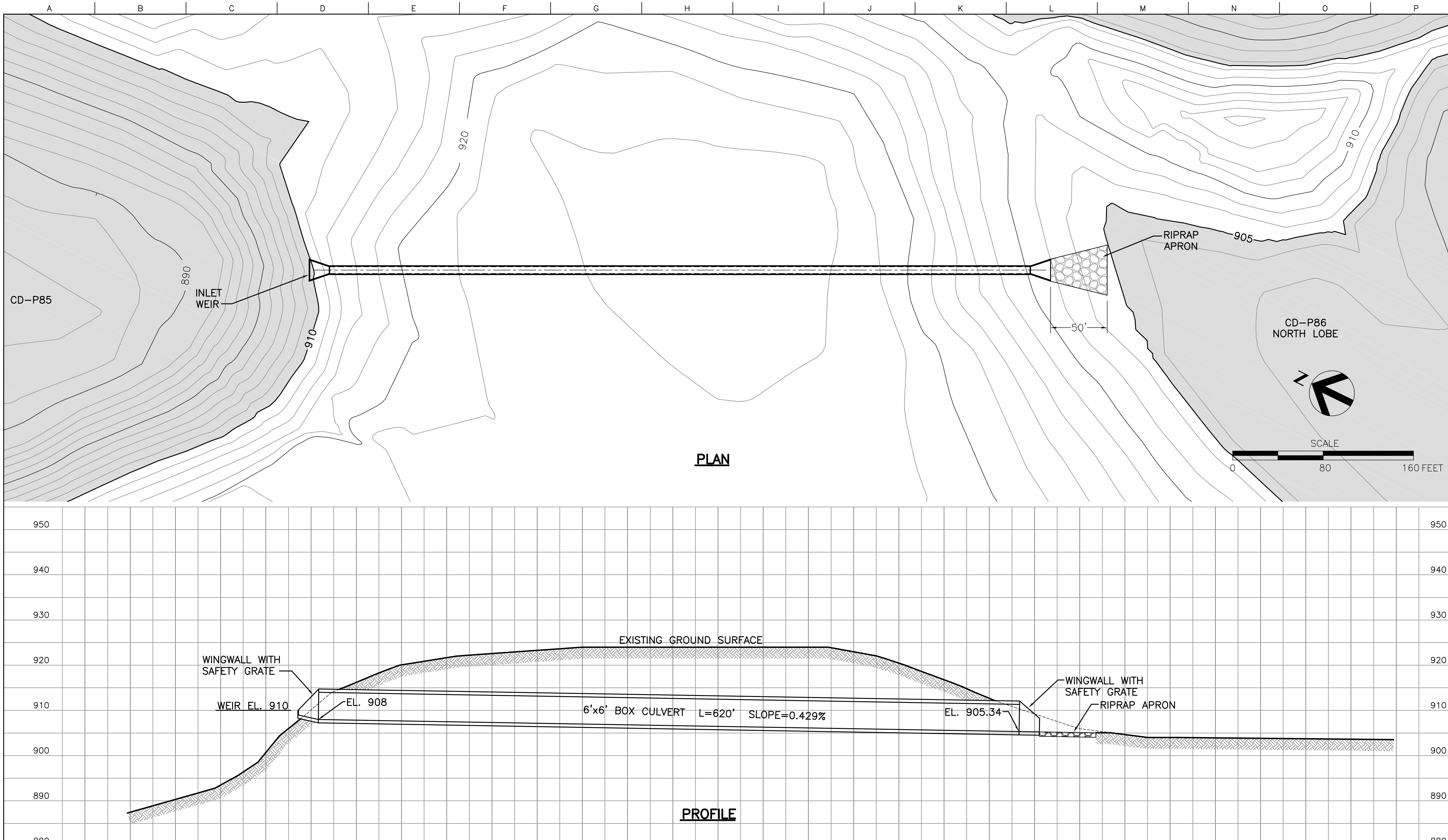
Project Manager: D. JOHNSON
Designed: A. LUFT
Designed:
Checked:
Drawn: K. HODNE

South Washington Watershed District

CENTRAL DRAW OVERFLOW - PHASE I

PLAN VIEW - SOUTH AREA (REGRADED OPTION)

Date: 4/01/02
Project No.: 10550-006-164
Drawing No.: P-3
Issue: A
Scale: 1"=400'
File Name: 10550006-P3.DWG



Issue No.	Description	Date	Drwn.	Chkd.	Resp. Engr.	Proj. Mgr.
A	PHASE I DESIGN	4/01/02	KAH	GW	AJL	DJ

HDR Engineering, Inc.

Project Manager: D. JOHNSON
Designed: A. LUFT
Designed:
Checked:
Drawn: K. HODNE

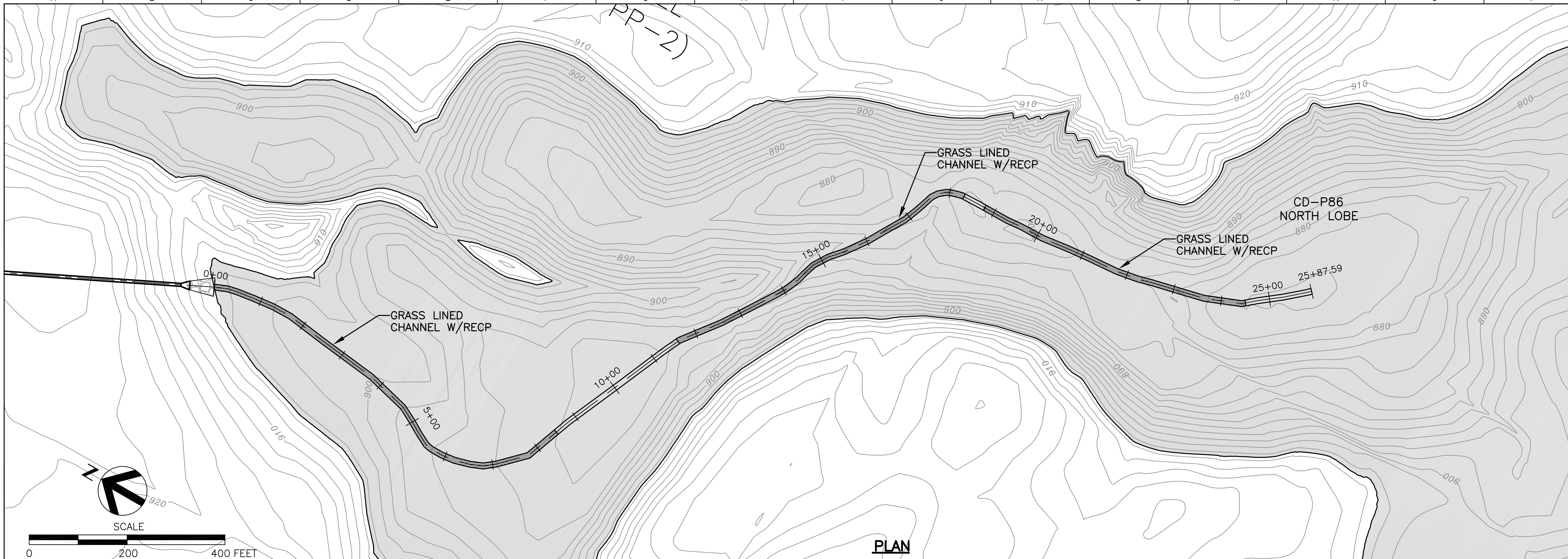
South Washington Watershed District (SWWD)

CENTRAL DRAW OVERFLOW - PHASE I

PLAN AND PROFILE
CD-P85 DISCHARGE PIPE

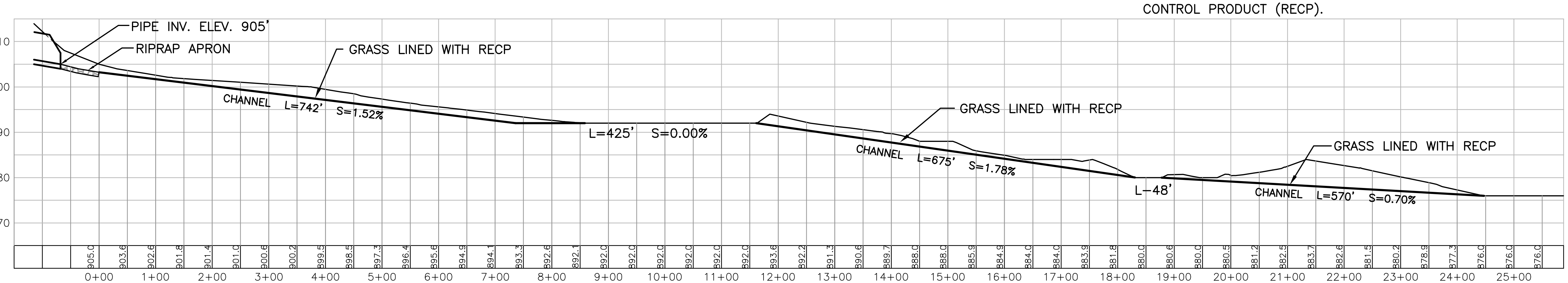
Date	Project No.	Drawing No.	Issue
4/01/02	10550-006-164	PP-1	A

Scale	File Name
1"=80'	10550006-PP1.DWG



PLAN

NOTE:
USE PERMANENT TYPE ROLLED EROSION CONTROL PRODUCT (RECP).



PROFILE

Issue No.	Description	Date	Drwn.	Chkd.	Resp. Engr.	Proj. Mgr.
A	PHASE I DESIGN	4/01/02	KAH	GW	AJL	DJ

HDR Engineering, Inc.

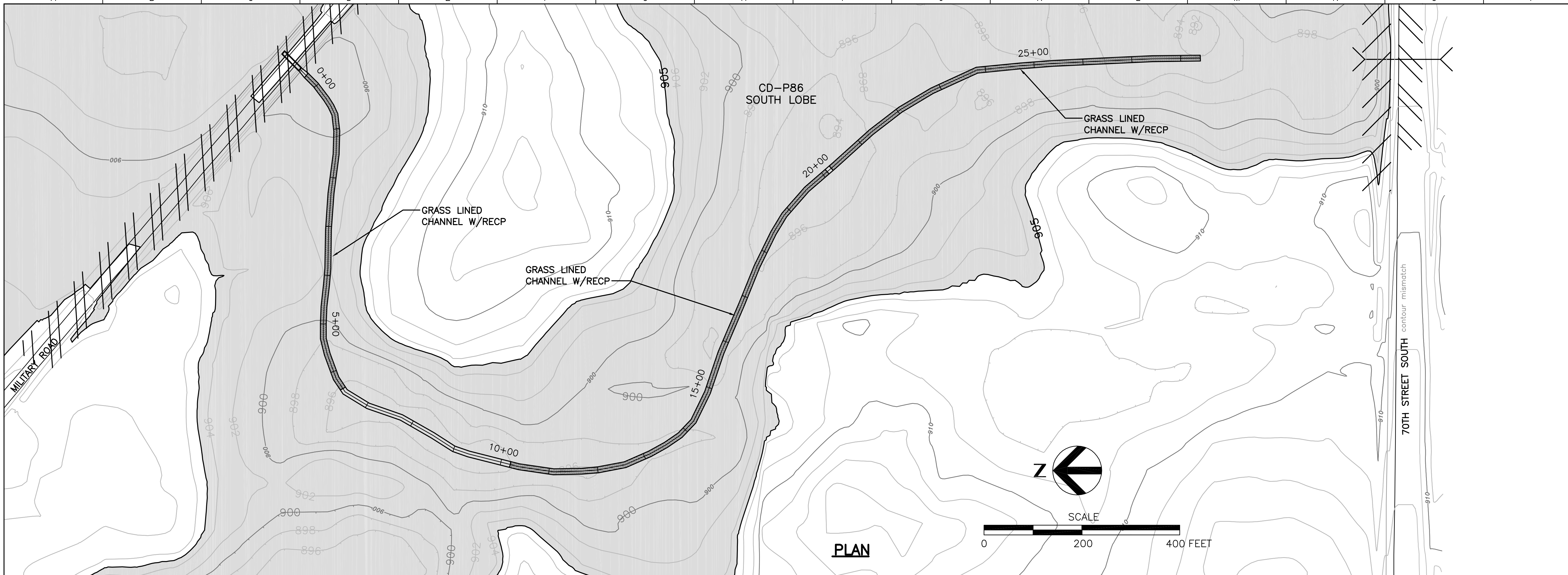
Project Manager: D. JOHNSON
Designed: A. LUFT
Designed:
Checked:
Drawn: K. HODNE

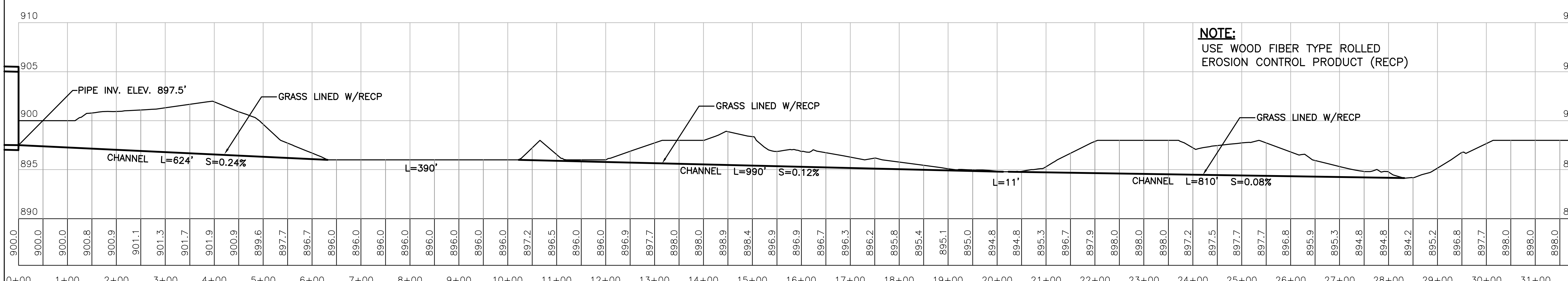
South Washington Watershed District (SWWD)

CENTRAL DRAW OVERFLOW - PHASE I

PLAN AND PROFILE
NORTH AREA PILOT CHANNEL

Date: 4/01/02
Scale: 1"=200'
Project No.: 10550-006-164
File Name: 10550006-P1.DWG
Drawing No.: PP-2
Issue: A





PROFILE

Issue No.	Description	Date	Drwn.	Chkd.	Resp. Engr.	Proj. Mgr.
A	PHASE I DESIGN	4/01/02	KAH	GW	AJL	DJ

HDR
HDR Engineering, Inc.

Project Manager: D. JOHNSON
Designed: A. LUFT
Designed:
Checked:
Drawn: K. HODNE

South Washington Watershed District (SWWD)

CENTRAL DRAW OVERFLOW - PHASE I

PLAN AND PROFILE
SOUTH AREA PILOT CHANNEL

Date	Project No.	Drawing No.	Issue
4/01/02	10550-006-164	PP-3	A
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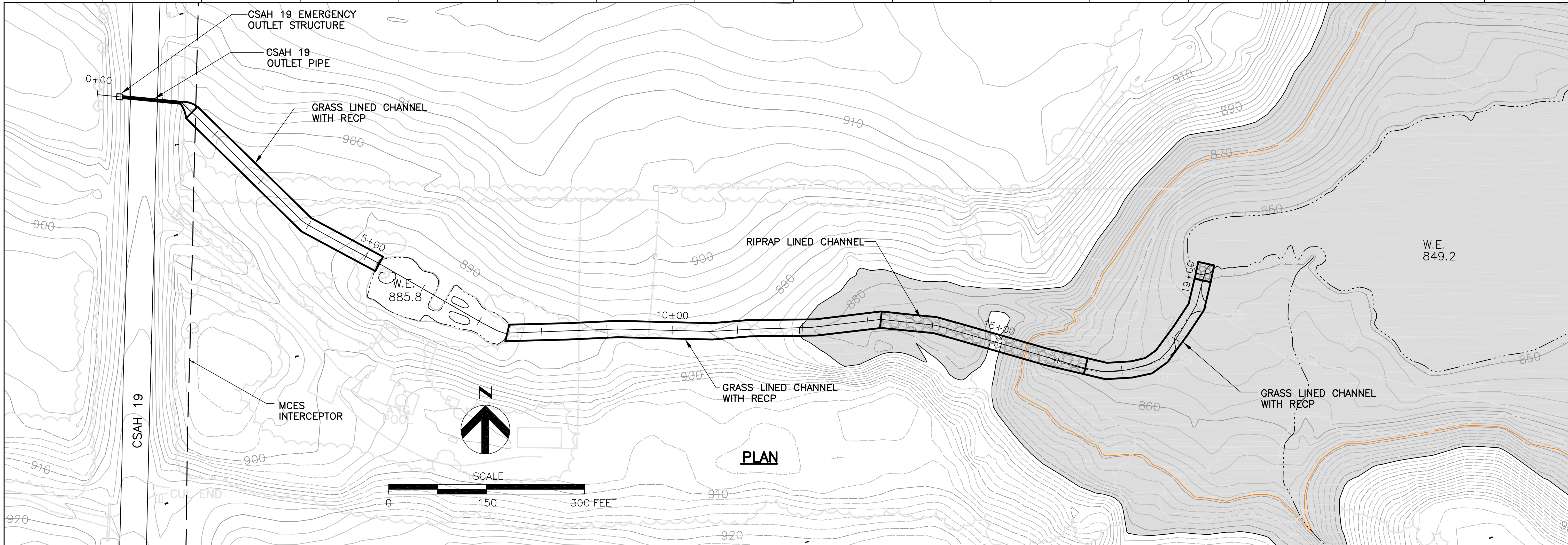
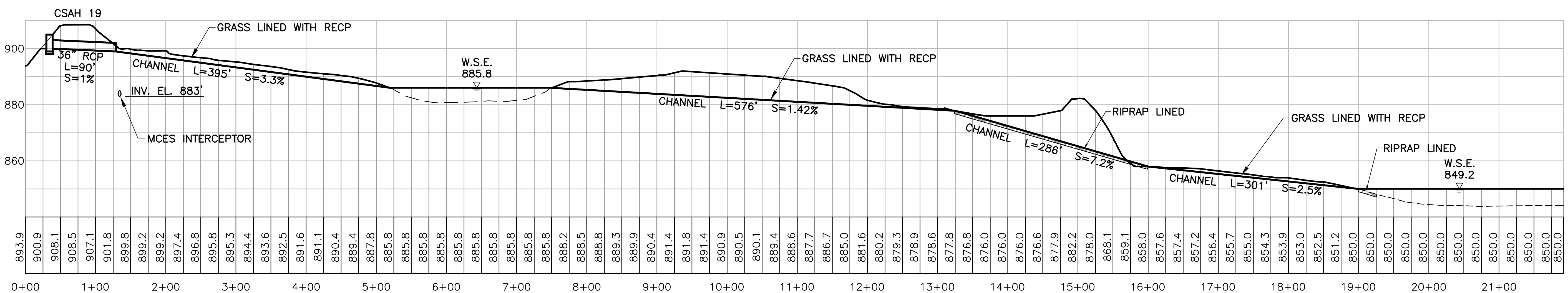


PLAN

NOTE

USE PERMANENT TYPE ROLLED EROSION CONTROL PRODUCT (RECP).



PROFILE

Issue No.	Description	Date	Drwn.	Chkd.	Resp. Engr.	Proj. Mgr.
A	PHASE I DESIGN	4/01/02	KAH	GW	AJL	DJ

HDR Engineering, Inc.

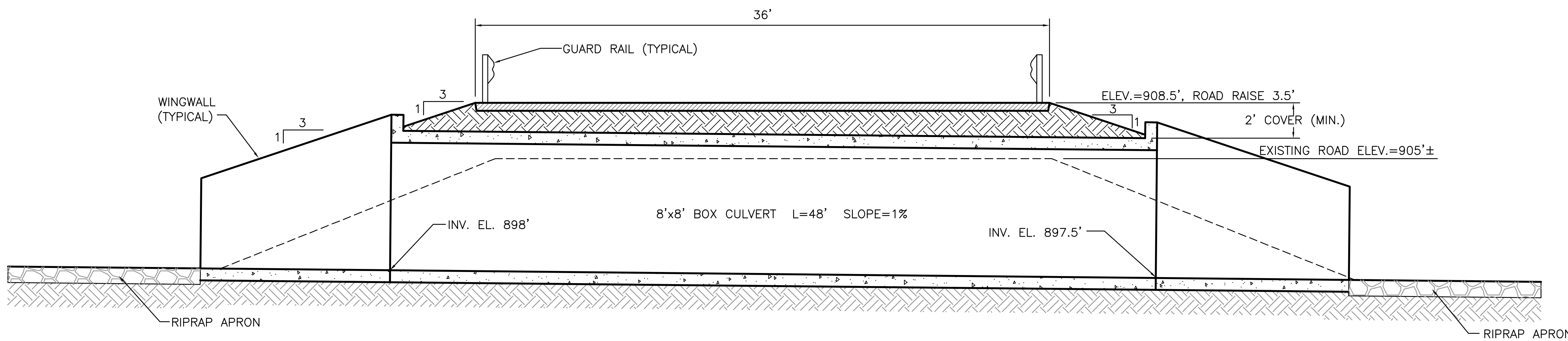
Project Manager: D. JOHNSON
Designed: A. LUFT
Designed:
Checked:
Drawn: K. HODNE

South Washington Watershed District (SWWD)

CENTRAL DRAW OVERFLOW - PHASE I

PLAN AND PROFILE
CHANNEL TO GABLES LAKE

Date	Project No.	Drawing No.	Issue
4/01/02	10550-006-164	PP-4	A
Scale: 1"=150'	File Name: 10550006-PP4.DWG		



MILITARY ROAD CULVERT

NOTE

LINEAR EXTENT OF ROAD RAISE IS 1,120 FEET.

Issue No.	Description	Date	Drwn.	Chkd.	Resp. Engr.	Proj. Mgr.
A	PHASE I DESIGN	3/28/02	KAH	GW	AJL	DJ

HDR Engineering, Inc.

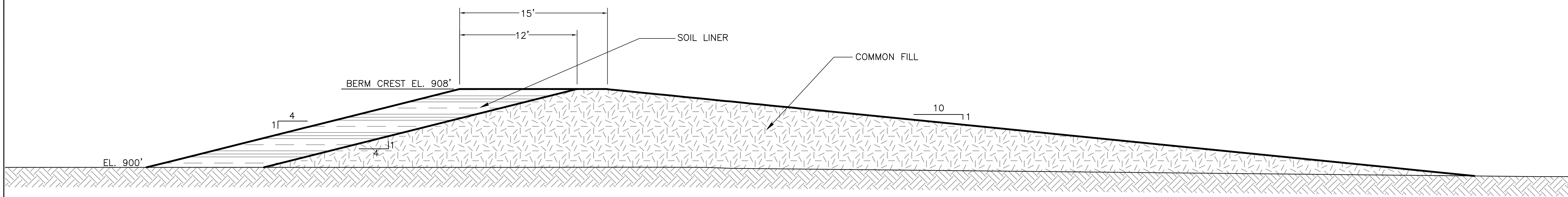
Project Manager: D. JOHNSON
Designed: A. LUFT
Designed:
Checked:
Drawn: K. HODNE

South Washington Watershed District (SWWD)

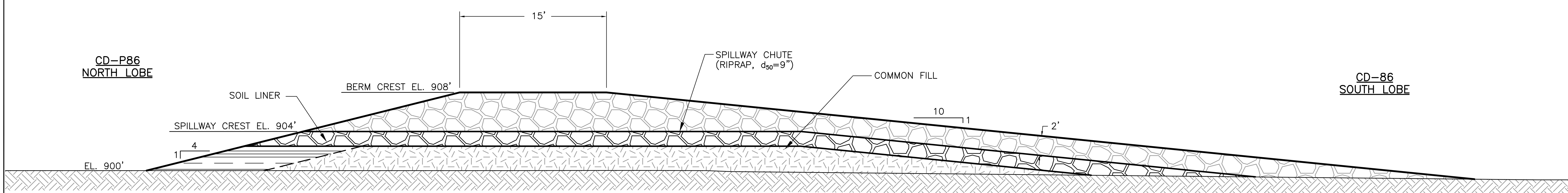
CENTRAL DRAW OVERFLOW - PHASE I

MILITARY ROAD CULVERT

Date	Project No.	Drawing No.	Issue
4/01/02	10550-006-164	C-1	A
Scale: 1"=8'	File Name: 10550006-C1		



BERM SECTION (TYPICAL)



BERM SECTION (FUTURE SPILLWAY)

CONDITION	SPILLWAY CREST ELEVATIONS	SPILLWAY WIDTH
CURRENT PERMIT CASE	NO SPILLWAY	–
NORTH LOBE WSE = 905	904	40'
NORTH LOBE WSE = 906	904	18'

Issue No.	Description	Date	Drwn.	Chkd.	Resp. Engr.	Proj. Mgr.
A	PHASE I DESIGN	4/01/02	KAH	GW	AJL	DJ

HDR Engineering, Inc.

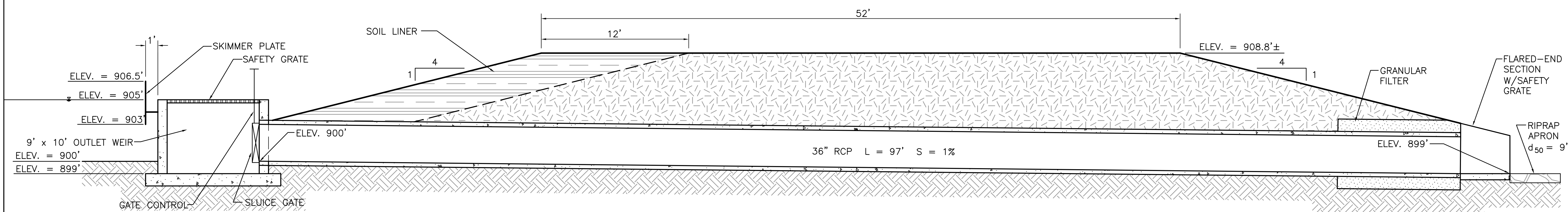
Project Manager: D. JOHNSON
Designed: A. LUFT
Designed:
Checked:
Drawn: K. HODNE

South Washington Watershed District (SWWD)

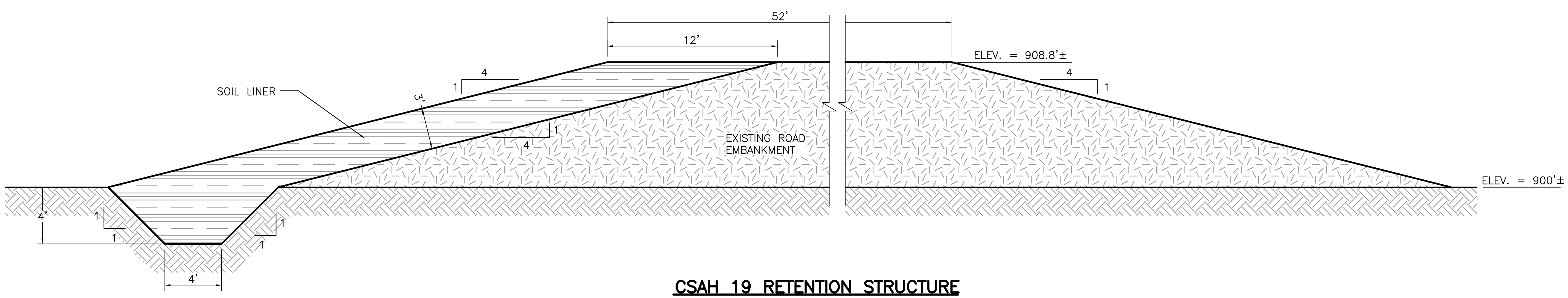
CENTRAL DRAW OVERFLOW - PHASE I

CD-P86 BERM

Date: 4/01/02
Scale: 1"=10'
Project No.: 10550-006-164
File Name: 10550006-C2
Drawing No.: C-2
Issue: A



CSAH 19 EMERGENCY OUTLET STRUCTURE



CSAH 19 RETENTION STRUCTURE

Issue No.	Description	Date	Drwn.	Chkd.	Resp. Engr.	Proj. Mgr.
A	PHASE I DESIGN	4/01/02	KAH	GW	AJL	DJ

HDR
HDR Engineering, Inc.

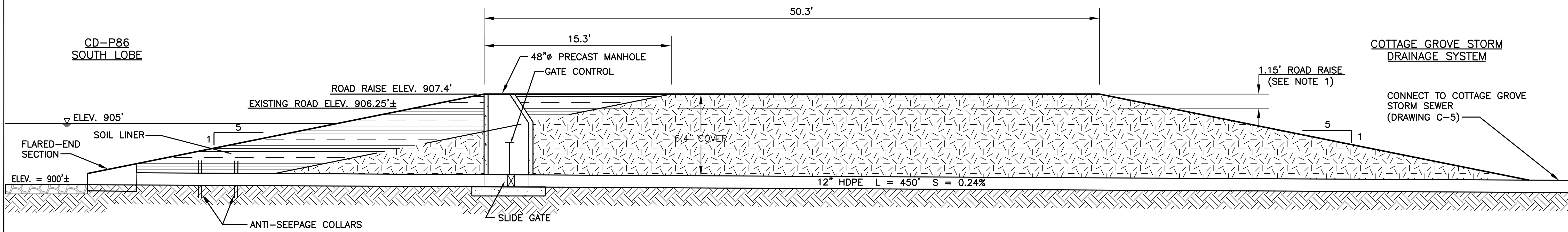
Project Manager: D. JOHNSON
Designed: A. LUFT
Designed:
Checked:
Drawn: K. HODNE

South Washington Watershed District (SWWD)

CENTRAL DRAW OVERFLOW - PHASE I

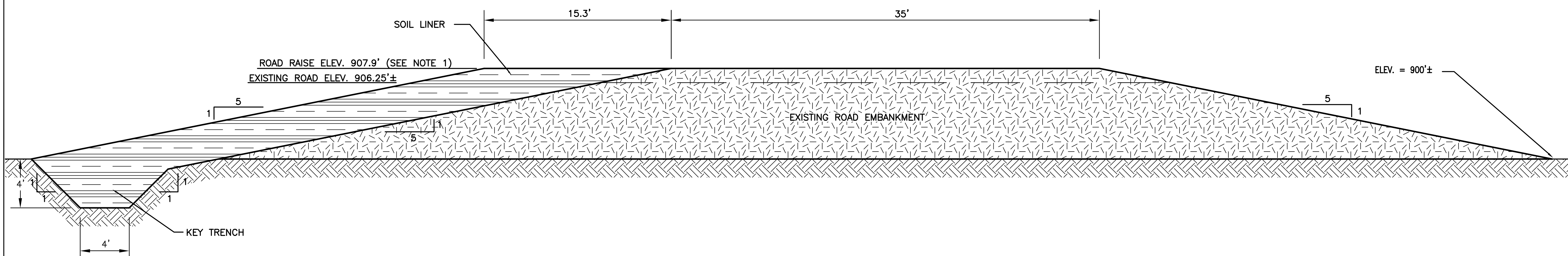
CSAH 19 OUTLET AND EMBANKMENT IMPROVEMENT

Date: 4/01/02
Scale: 1"=8'
Project No. 10550-006-164
File Name: 10550006-C3.DWG
Drawing No. C-3
Issue: A



70th STREET OUTLET STRUCTURE (OPTIONAL)

(SEE NOTE 2)



70th STREET RETENTION STRUCTURE

NOTE:

1. LINEAR EXTENT OF ROAD RAISE IS 310 FEET.
2. TO BE CONSIDERED AFTER OTHER CITY IMPROVEMENTS ARE COMPLETED, SEE DRAWING C–5.

Issue No.	Description	Date	Drwn.	Chkd.	Resp. Engr.	Proj. Mgr.
B	OPTIONAL OUTLET	5/07/02	KAH	GW	AJL	DJ
A	PHASE I DESIGN	4/01/02	KAH	GW	AJL	DJ

HDR
HDR Engineering, Inc.

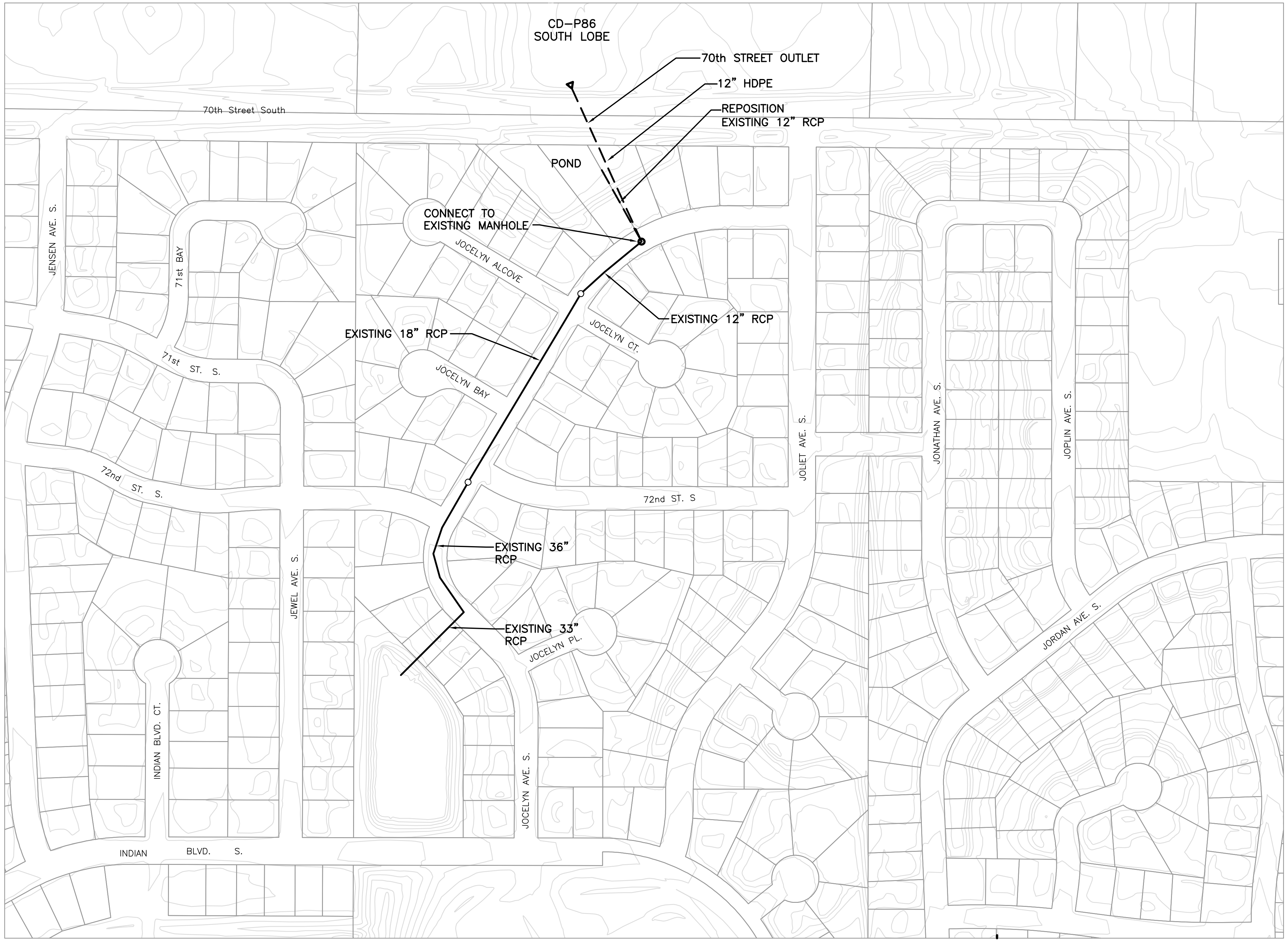
Project Manager: D. JOHNSON
Designed: A. LUFT
Designed:
Checked:
Drawn: K. HODNE

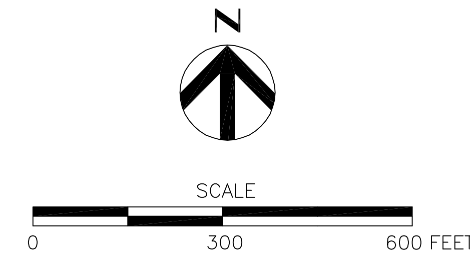
South Washington Watershed District (SWWD)

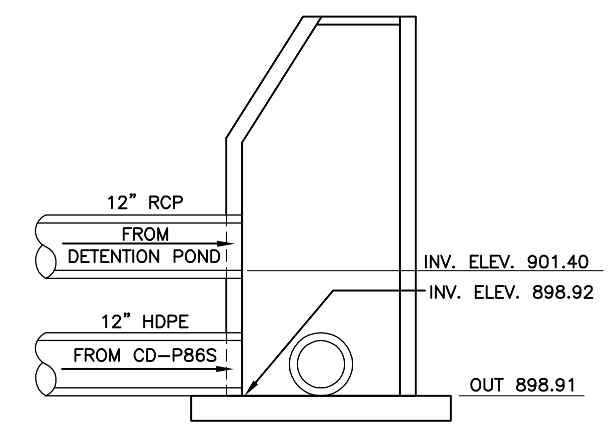
CENTRAL DRAW OVERFLOW - PHASE I

70TH STREET OUTLET AND EMBANKMENT IMPROVEMENT

Date: 5/07/02
Scale: 1"=8'
Project No.: 10550–006–164
File Name: 10550006–C4.DWG
Drawing No.: C-4
Issue: B







MANHOLE CONNECTION

NOTE:
TO BE CONSIDERED AFTER OTHER CITY IMPROVEMENTS ARE COMPLETED.

Issue No.	Description	Date	Drwn.	Chkd.	Resp. Engr.	Proj. Mgr.
B	OPTIONAL OUTLET	5/07/02	KAH	GW	AJL	DL
A	PHASE I DESIGN	4/01/02	KAH	GW	AJL	DJ

HDR Engineering, Inc.

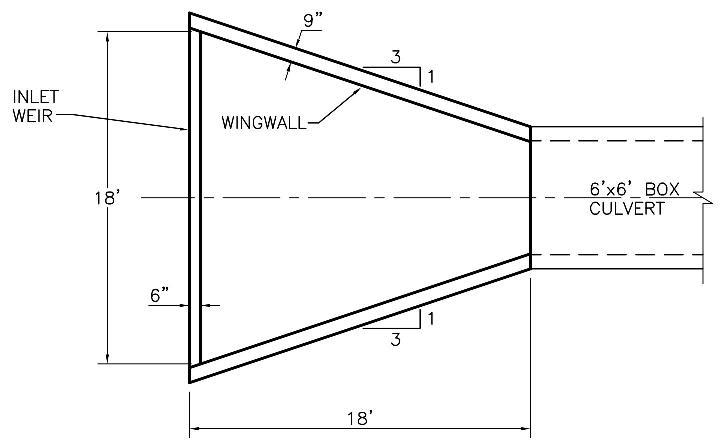
Project Manager: D. JOHNSON
Designed: A. LUFT
Designed:
Checked:
Drawn: K. HODNE

South Washington Watershed District (SWWD)

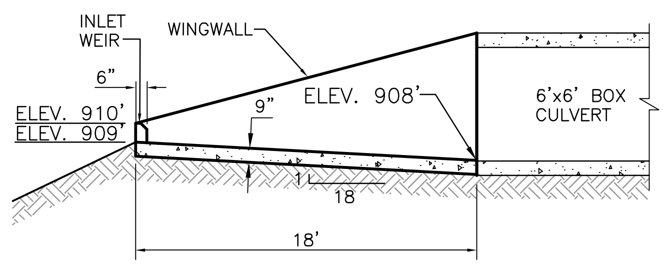
CENTRAL DRAW OVERFLOW - PHASE I

COTTAGE GROVE
STORM SEWER UPGRADE
(OPTIONAL)

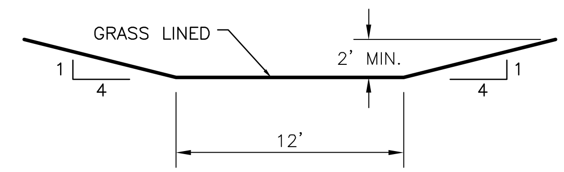
Date	Project No.	Drawing No.	Issue
5/07/02	10550–006.164	C-5	B
Scale: 1"=300'	File Name: 10550006–C5.DWG		



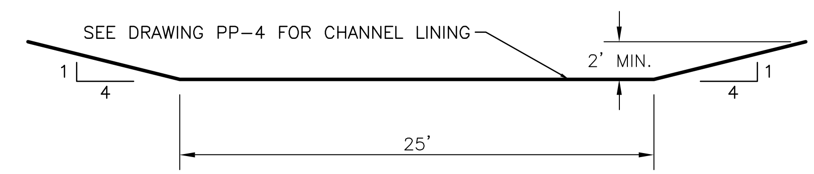
INLET WEIR PLAN
(CAST-IN-PLACE)



INLET WEIR SECTION



CD-P86 PILOT CHANNEL SECTION (TYP.)



CSAH 19 TO GABLES LAKE CHANNEL SECTION (TYP.)

Issue No.	Description	Date	Drwn.	Chkd.	Resp. Engr.	Proj. Mgr.
A	PHASE I DESIGN	4/01/02	KAH	GW	AJL	DJ

HDR Engineering, Inc.

Project Manager: D. JOHNSON
Designed: AJL
Designed:
Checked: GW
Drawn: K. HODNE

South Washington Watershed District (SWWD)

CENTRAL DRAW OVERFLOW - PHASE I

DETAILS

Date: 4/01/02
Scale: 1"=10'
Project No.: 10550-006-164
File Name: 10550006-D1.DWG
Drawing No.: D-1
Issue: A

APPENDIX B

LISTING OF REPORTS USED IN STUDY

3M Corporation, *Comments on Cottage Grove's Surface Water Management Plan*, October 8, 1999.

Bonestroo, Rosene, Anderlik & Associates, Inc., *Addendum to May 13, 1999 Storage Infiltration Memorandum*, May 19, 1999.

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Bonestroo, Rosene, Anderlik & Associates, Inc., *Fax from Bob Schumidt to Matt Moore regarding draft goals and questions stemming from the 04/27/99 Central Draw Workshop*, April 21, 1999.

Bonestroo, Rosene, Anderlik & Associates, Inc., *GIS Layers Including 10' Contours, 2' Contours, Ponds, Pipes and Land Cover*, August 9, 2000.

Bonestroo, Rosene, Anderlik & Associates, Inc., *Greenway and Natural Features Map*, June 1, 1997.

Bonestroo, Rosene, Anderlik & Associates, Inc., *Infiltration Management Map*, June 1, 1997.

Bonestroo, Rosene, Anderlik & Associates, Inc., *Memorandum to Matt Moore regarding corrections to the previous South Lobe outlet*, December 14, 1999.

Bonestroo, Rosene, Anderlik & Associates, Inc., *Memorandum to Matt Moore regarding the revised South Lobe outlet volumes*, December 13, 1999.

Bonestroo, Rosene, Anderlik & Associates, Inc., *Memorandum to South Washington Watershed District Board of Directors regarding the Ranking of Management Systems for Further Evaluation*, January 7, 1999.

Bonestroo, Rosene, Anderlik & Associates, Inc., *Memorandum to South Washington Watershed District Board of Managers Regarding Results of I-94 Ponding Study through Task 2*, August 5, 1998.

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Bonestroo, Rosene, Anderlik & Associates, Inc., *Report Detailing I-94 Ponding Study Analysis through Task 4*, November 18, 1998.

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Bonestroo, Rosene, Anderlik & Associates, Inc., *XP-SWMM models for the Upper Watershed Existing and Future Conditions Using the 6" Rainfall and 7.2" Snowmelt Conditions*, August 21, 2000.

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City of Cottage Grove, *Letter to Metropolitan Council Environmental Services Regarding Proposed Interceptor Alignment Alternatives*, December 22, 1999.

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City of Woodbury, *Comments Regarding Detention Basins Proposed April 19, 2000*, June 2, 2000.

City of Woodbury, *Letter Regarding Overflow Alternatives Council Workshop*, October 19, 1999.

City of Woodbury, *Letter to Jim Schug (Wash Co. Administrator) Regarding Tower Drive and Hinton Avenue Connection*, November 1, 1999.

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City of Woodbury, *Letter to Matt Moore Regarding Central Draw Flood Storage Contingency Plan Concerns*, May 6, 1999.

E.G. Rud & Sons Inc. - Land Surveyors, *Bailey Lake Ponding Plat Sheets*, November 17, 1993.

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Emmons & Oliver Resources, *75 cfs Floodplain Watershed Map (DRAFT)*, May 22, 2001.

Emmons & Oliver Resources, *90 cfs Floodplain Watershed Map (DRAFT)*, May 22, 2001.

Emmons & Oliver Resources, *Arcview Files Containing the 90 cfs Floodplain Scenario and Estimated Impacted Parcels (DRAFT)*, May 16, 2001.

Emmons & Oliver Resources, *Arcview Files Containing the Floodplain in Sections 22, 27, and 34 for the 120 cfs and 150 cfs Scenarios*, May 23, 2001.

Emmons & Oliver Resources, *Arcview Files Used to Create 75 cfs Floodplain Watershed Map (DRAFT)*, May 22, 2001.

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Emmons & Oliver Resources, *Clarification and Response to the Montgomery Watson Memorandums Dated February 3, 2002 Regarding the Infiltration Management Studies and the Central Draw Outlet*, February 8, 2000.

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Emmons & Oliver Resources, *CSAH 19 Corridor Evaluation of Erosion Potential for Different Flow Regimes Environmental Assessment*, February 7, 2001.

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Emmons & Oliver Resources, *Infiltration Management Map*, December 1, 1999.

Emmons & Oliver Resources, *Infiltration Management Study, Phase 1 Report*, October 14, 1998.

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Holler, Albert G., Ph.D., P.E., *Computation of Dam Freeboard for Wind Generated Waves*, Date Unknown.

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John Oliver and Associates, *Crystal Village Tollefson Development Construction Plans for Grading, Drainage, Sanitary Sewer, and Watermain-Cottage Grove*, December 18, 1998.

JRP Architects Inc., *Site & Landscape Plan, Country Inn and Suites-Cottage Grove*, July 7, 2000.

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Montgomery Watson, *Memorandum to Matt Moore Regarding Analysis of Bonestroo Bailey Lake Pumping Design*, March 9, 2000.

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Montgomery Watson, *Memorandum to Matt Moore Regarding Central Draw Outlet Design Flow and Alignment Alternatives for Spring Snowmelt*, February 3, 2000.

Montgomery Watson, *Memorandum to Matt Moore Regarding Review of Emmons and Oliver Infiltration Rates and Model*, January 18, 2000.

Montgomery Watson, *Response to the Bonestroo Model Agreement*, April 27, 2000.

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South Washington Watershed District, *05/30/00 South Washington Watershed District Meeting Agenda*, May 30, 2000.

South Washington Watershed District, *Consideration of Emmons and Oliver Overflow Route Environmental Assessment*, April 5, 2000.

South Washington Watershed District, *Fax to Emmons and Oliver Regarding Request for Cost Estimate for High Water Level Mapping*, May 18, 1999.

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South Washington Watershed District, *Letter to Woodbury City Engineer Regarding Follow-up to May 6, 1999 Letter Regarding Flood Storage Contingency Plan*, June 9, 1999.

South Washington Watershed District, *Memorandum to Board Indicating Need to Discuss Stormwater Utility Tool*, April 6, 2000.

South Washington Watershed District, *Memorandum to Board Managers Regarding 2000 Spring Infiltration Monitoring*, March 10, 2000.

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South Washington Watershed District, *Memorandum to Board of Managers Regarding Central Draw Overdraft Results*, January 7, 2000.

South Washington Watershed District, *Memorandum to Board of Managers Regarding Contributions of Runoff to Bailey Lake*, June 9, 2000.

South Washington Watershed District, *Memorandum to Board of Managers Regarding Current Technical Service Agreements*, April 6, 2000.

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South Washington Watershed District, *Memorandum to Board of Managers Regarding Frequency Analysis*, June 9, 2000.

South Washington Watershed District, *Memorandum to Board of Managers Regarding Montgomery Review of Stormwater Management Data*, February 4, 2000.

South Washington Watershed District, *Memorandum to Board of Managers Regarding Montgomery Watson Review of Northern Watershed Modeling*, June 9, 2000.

South Washington Watershed District, *Memorandum to Board of Managers Regarding the Available Proposals for Professional Services*, December 9, 1999.

South Washington Watershed District, *Memorandum to Board Regarding Surface Water Modeling, Cottage Grove Central Ravine Watershed*, January 4, 2001.

South Washington Watershed District, *Memorandum to Bonestroo Regarding the Revised Scope and Schedule for Central Draw Outlet Study Phase 1*, November 23, 1999.

South Washington Watershed District, *Memorandum to Emmons and Oliver Regarding the Revised Scope and Schedule for Critical Detention Plan*, November 23, 1999.

South Washington Watershed District, *Memorandum to Eric Thompson Regarding Workshop Meeting and Overflow Alternatives*, March 17, 2000.

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South Washington Watershed District, *Outline for South Washington Watershed District Presentation to the Cities*, August 18, 1998.

South Washington Watershed District, *Screen captures explaining the modeling of the Spring and Summer Infiltration Events*, March 21, 2000.

South Washington Watershed District, *Skyview School Wetland Project Memorandum*, June 8, 2000.

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South Washington Watershed District, *South Washington Watershed District Regular Meeting Agenda*, February 8, 2000.

South Washington Watershed District, *South Washington Watershed District Regular Meeting Agenda*, January 11, 2000.

South Washington Watershed District, *South Washington Watershed District Regular Meeting Agenda*, January 11, 2000.

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TKDA Engineers-Architects-Planners, *Review of I-94 Ponding Study*, March 29, 1999.

Ulteig Engineers Inc., *Country Inn and Suites-Cottage Grove Utility and Paving Plan*, July 17, 2000.

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Unknown, *Central Draw Outlet - Phase 1 Report (DRAFT)*, April 1, 1999.

Unknown, *Centrifugal Pumps and Applications*, Date Unknown.

Unknown, *Contour Map of Dorchester Drive Area*, Date Unknown.

Unknown, *Costs of various Central Draw Options*, April 1, 2001.

Unknown, *Design Drawings for the Bailey Lake Pump Station*, Date Unknown.

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Unknown, *Vertical Turbine Pump and Sump Design Data*, October 31, 1972.

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Washington County, *Washington Co. 2' Contours/Planimetric Data (Woodbury Area, T28R21 Sec 29)*, April 1, 2000.

Washington County, *Washington Co. 2' Contours/Planimetric Data (Woodbury Area, T28R21 Secs 2, 4, 11, 12 ,13, 14, 23, 24, 25 ,26, 35, 36)*, April 1, 2000.

Washington County, *Washington Co. 2' Contours/Planimetric Data (Woodbury Area, T28R21 Secs 3, 10, 15, 21, 22, 27, 28, 33, 34)*, April 1, 2000.

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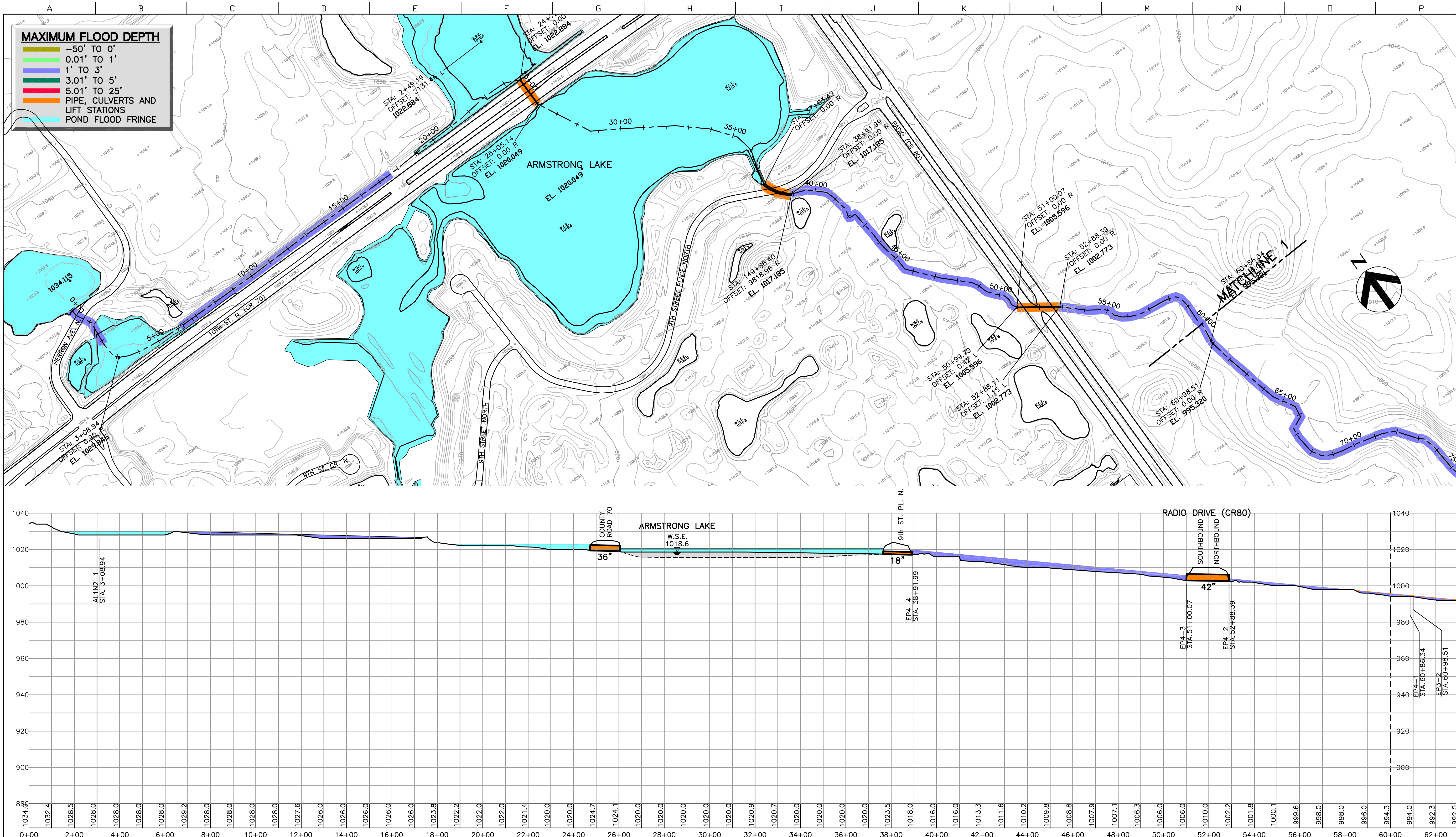
APPENDIX C

FLOOD PROFILE MAPS



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HDR Engineering, Inc.

BAR LENGTH ON ORIGINAL DRAWING EQUALS ONE INCH. ADJUST SCALE ACCORDINGLY.

Project Manager: R. Beduhn
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Drawn: KAH

South Washington Watershed District (SWWD)

9.3 INCH - 10 DAY FLOOD PLAN AND PROFILE STATION 0+00 TO 60+00

Date	Project No.	Drawing No.	Issue
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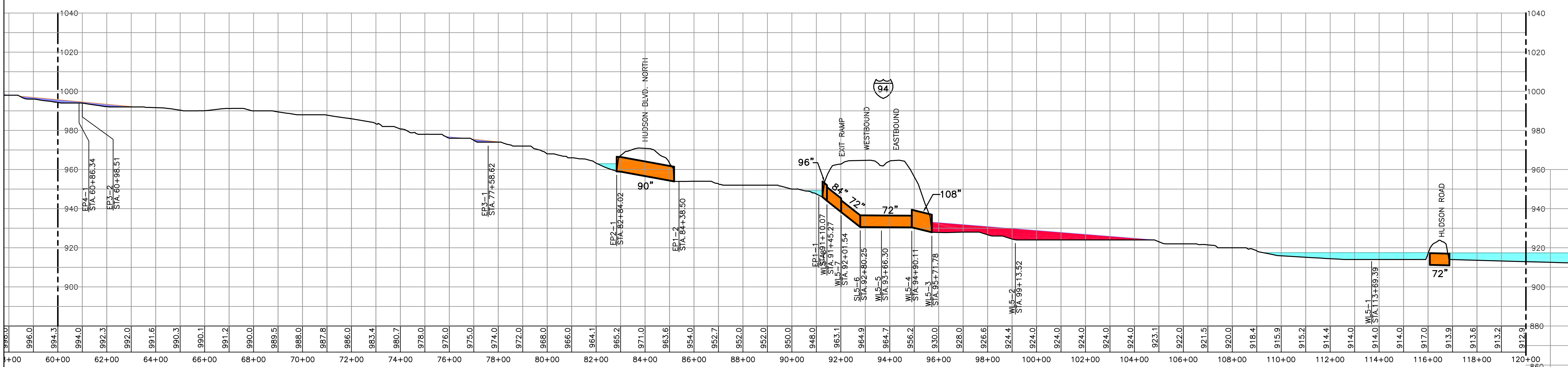

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HDR Engineering, Inc.

BAR LENGTH ON ORIGINAL DRAWING EQUALS ONE INCH. ADJUST SCALE ACCORDINGLY.

Project Manager: R. Beduhn
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Drawn: K. Hodne

South Washington Watershed District (SWWD)

9.3 INCH - 10 DAY FLOOD PLAN AND PROFILE STATION 60+00 TO 120+00

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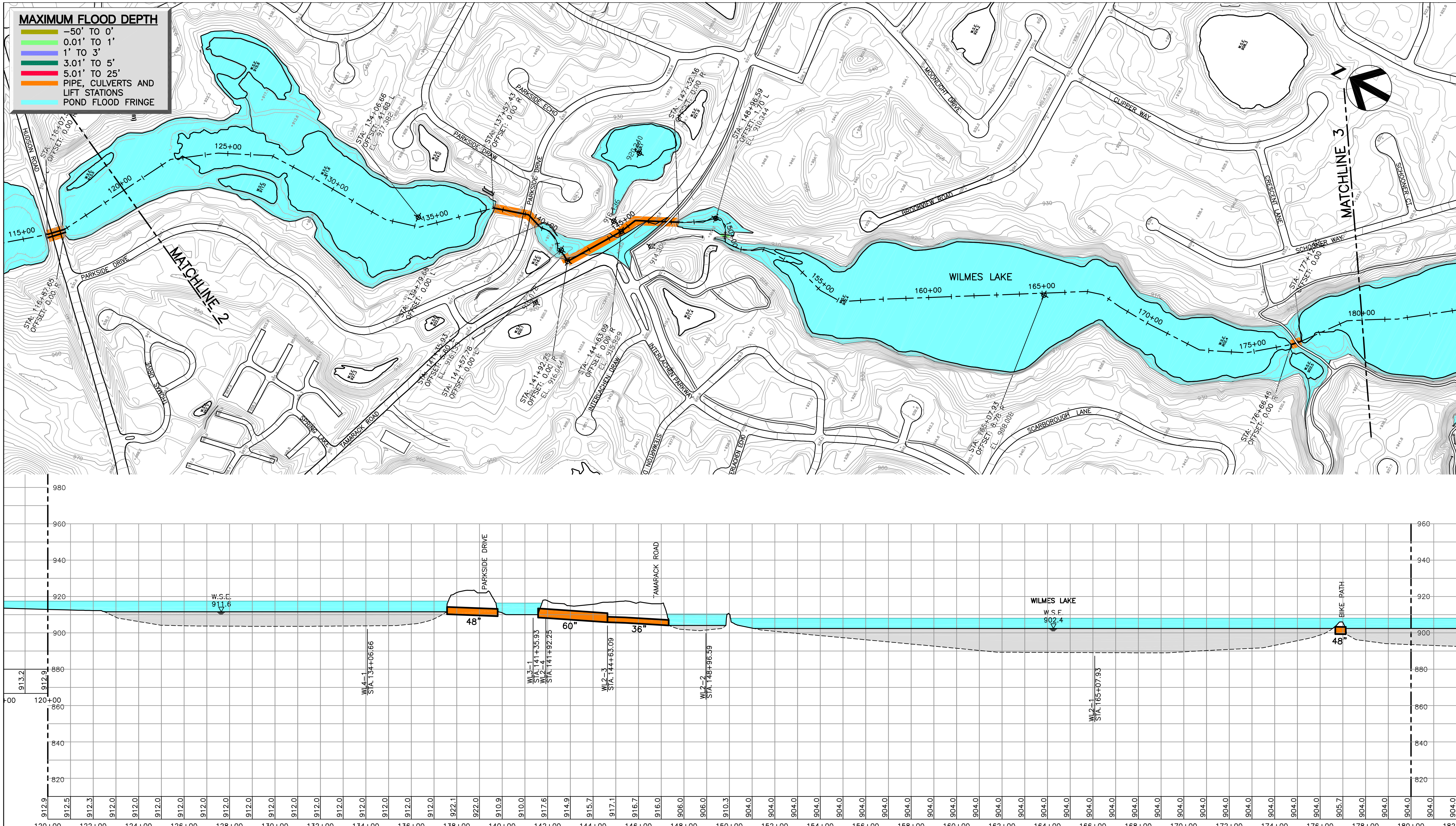

Issue No.	Description	Date	Drwn.	Chkd.	Resp. Engr.	Proj. Mgr.

HDR Engineering, Inc.

BAR LENGTH ON ORIGINAL DRAWING EQUALS ONE INCH. ADJUST SCALE ACCORDINGLY.

Project Manager: R. Beduhn
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Drawn: K. Hodne

South Washington Watershed District

9.3 INCH - 10 DAY FLOOD
PLAN AND PROFILE
STATION 120+00 TO 180+00

Date	Project No.	Drawing No.	Issue
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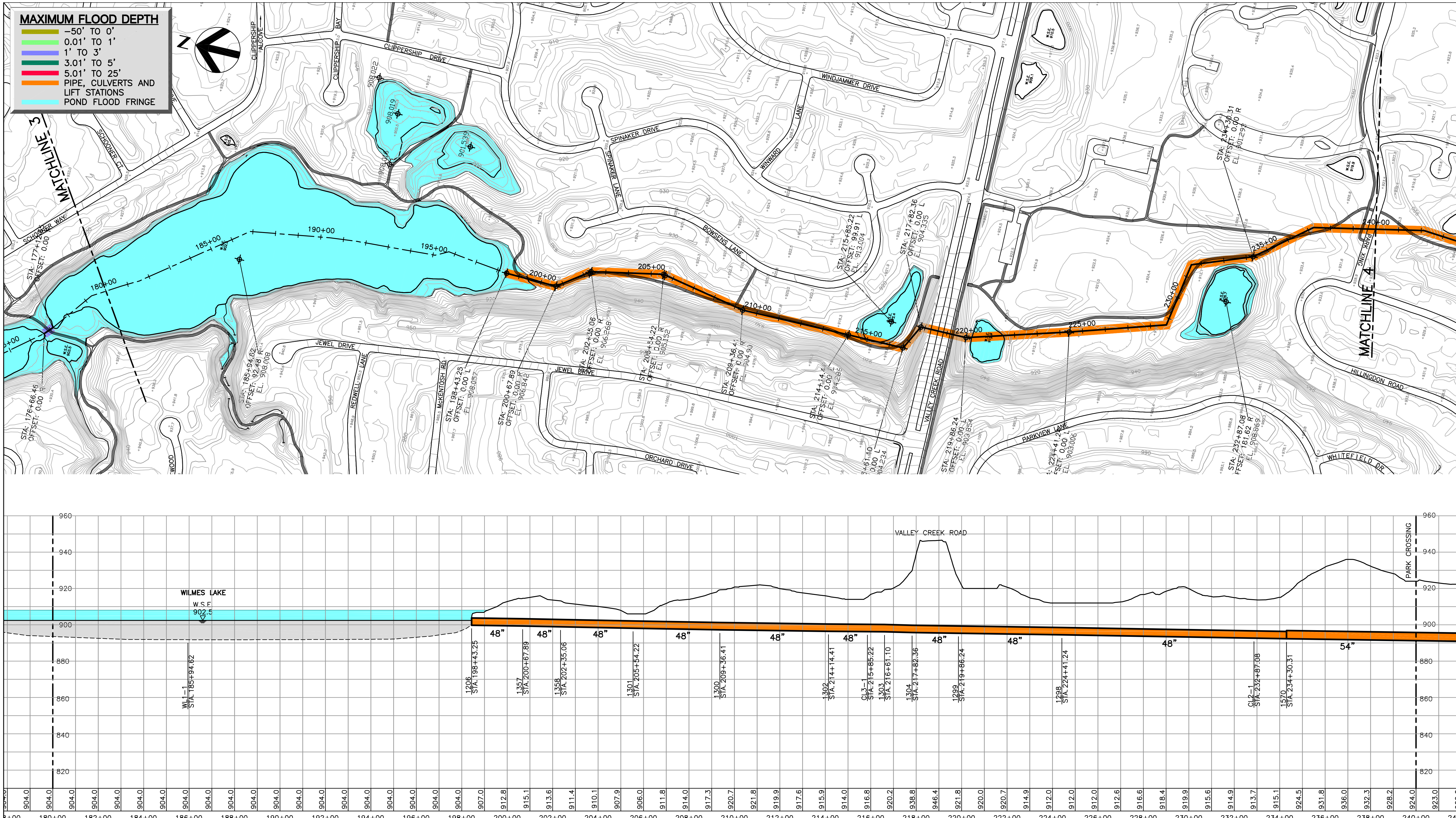

Issue No.	Description	Date	Drwn.	Chkd.	Resp. Engr.	Proj. Mgr.

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HDR Engineering, Inc.

BAR LENGTH ON ORIGINAL DRAWING EQUALS ONE INCH. ADJUST SCALE ACCORDINGLY.

Project Manager: R. Beduhn
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Drawn: K. Hodne

South Washington Watershed District

9.3 INCH - 10 DAY FLOOD PLAN AND PROFILE STATION 180+00 TO 240+00

Date	Project No.	Drawing No.	Issue
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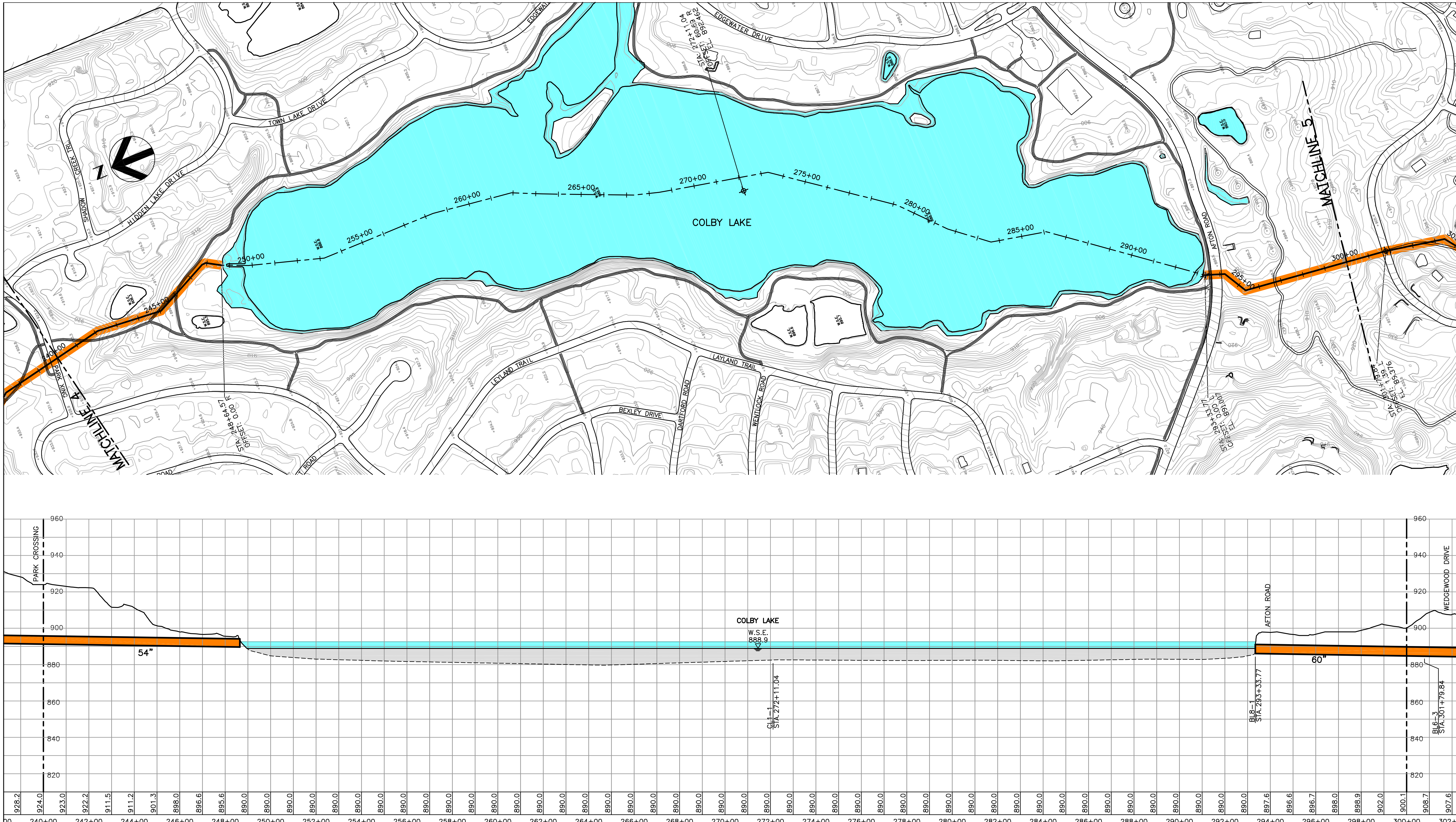

Issue No.	Description	Date	Drwn.	Chkd.	Resp. Engr.	Proj. Mgr.

HDR Engineering, Inc.

BAR LENGTH ON ORIGINAL DRAWING EQUALS ONE INCH. ADJUST SCALE ACCORDINGLY.

Project Manager: R. Beduhn
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Drawn: K. Hodne

South Washington Watershed District

9.3 INCH - 10 DAY FLOOD
PLAN AND PROFILE
STATION 240+00 TO 300+00

Date: APRIL 2002
Scale: 1=200
Project No.: 10550-010.164
File Name: 10550010-PP5
Drawing No.: PP-5
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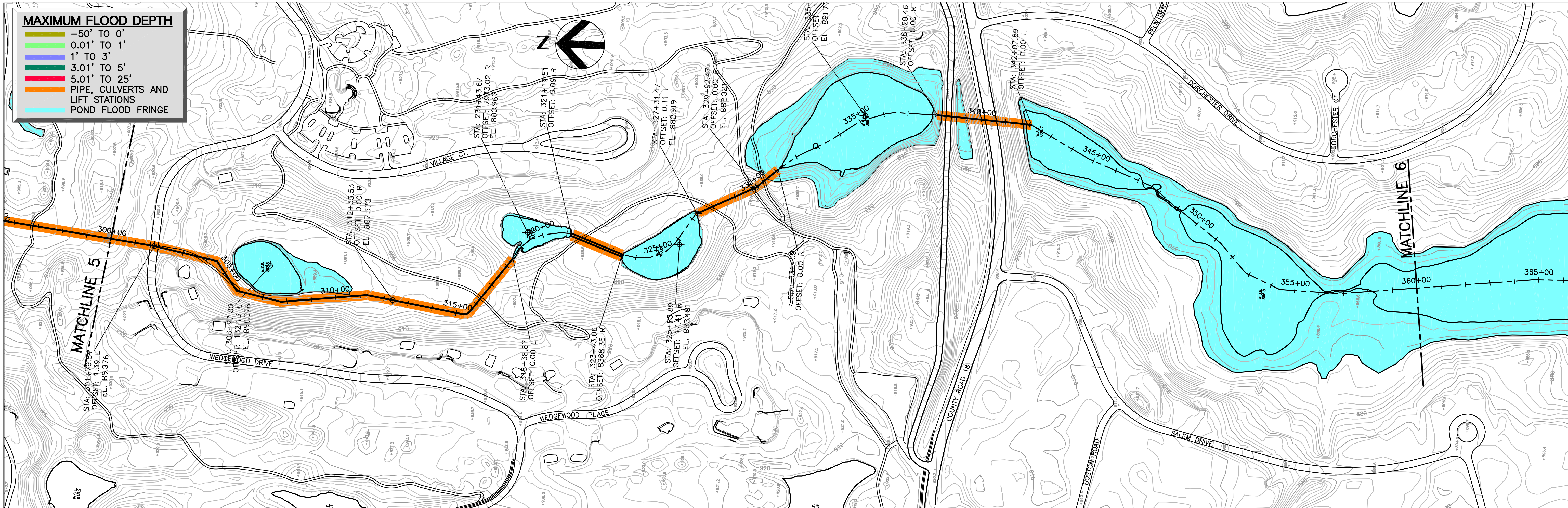
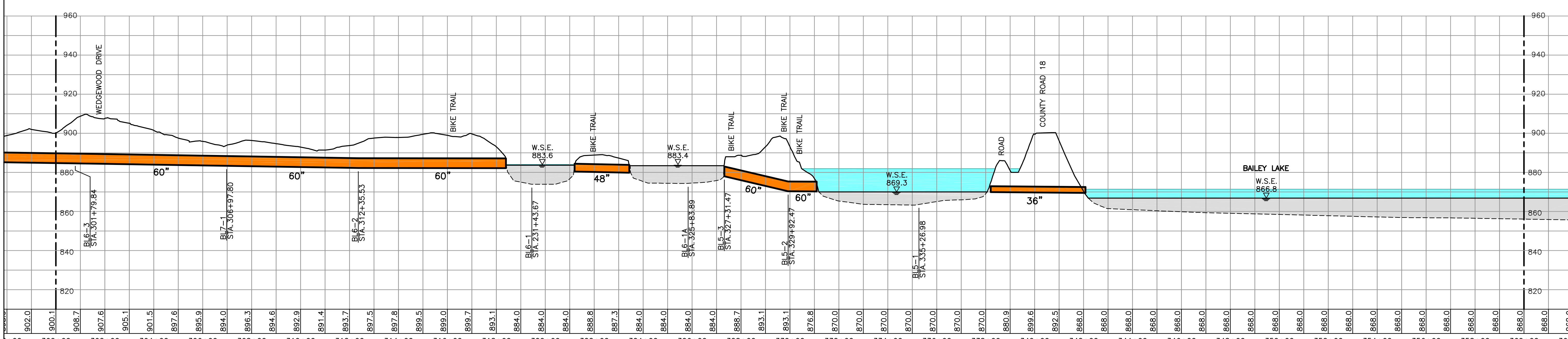




Issue No.	Description	Date	Drwn.	Chkd.	Resp. Engr.	Proj. Mgr.

HDR Engineering, Inc.

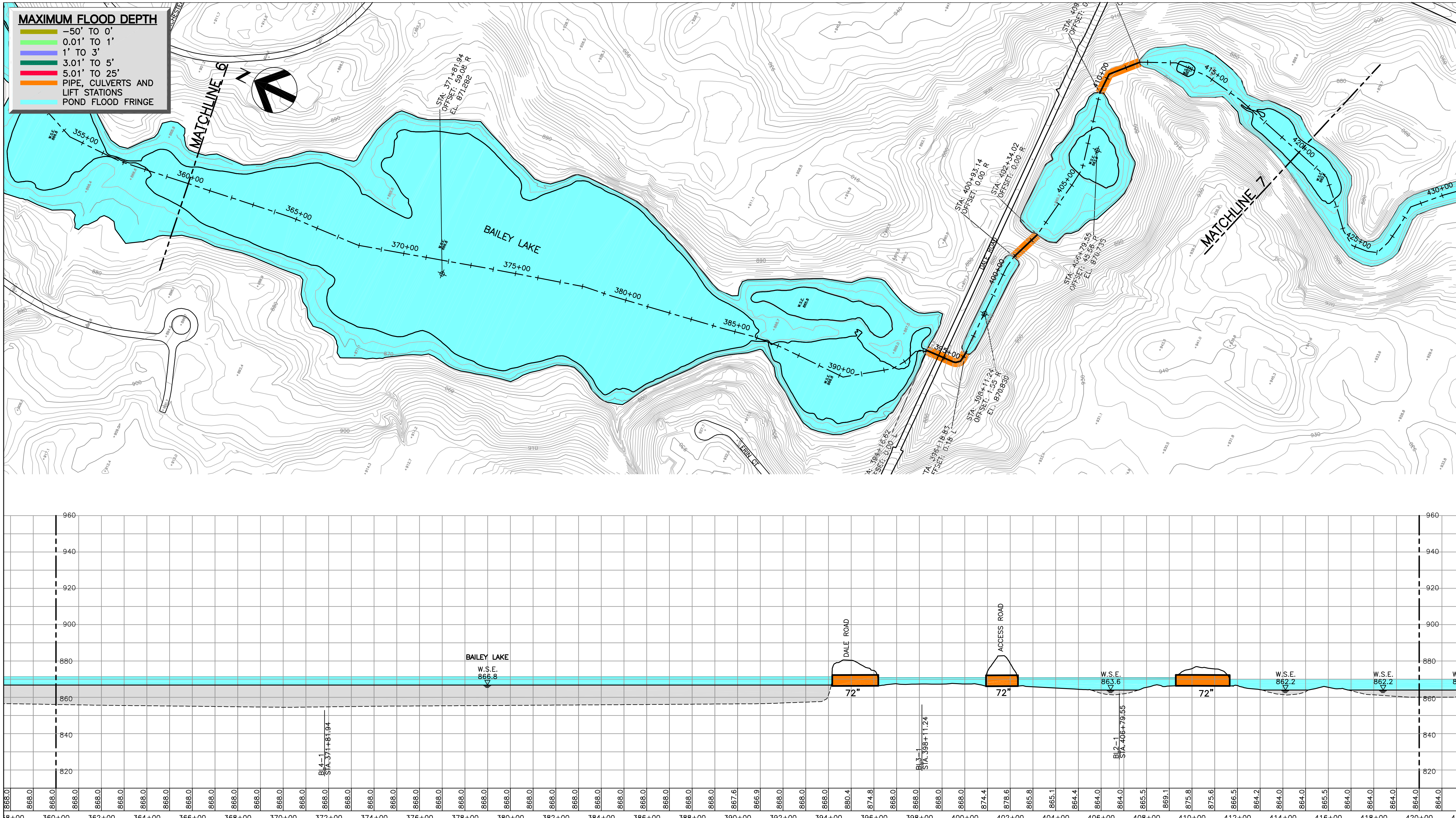
BAR LENGTH ON ORIGINAL DRAWING EQUALS ONE INCH. ADJUST SCALE ACCORDINGLY.

Project Manager: R. Beduhn
Designed:
Designed:
Checked:
Drawn: K. Hodne

South Washington Watershed District — SWWD

9.3 INCH - 10 DAY FLOOD PLAN AND PROFILE STATION 300+00 TO 360+00

Date	Project No.	Drawing No.	Issue
APRIL 2002	10550-010.164	PP-6	
Scale: 1=200	File Name: 10550010-PP6		



Issue No.	Description	Date	Drwn.	Chkd.	Resp. Engr.	Proj. Mgr.

HDR
HDR Engineering, Inc.

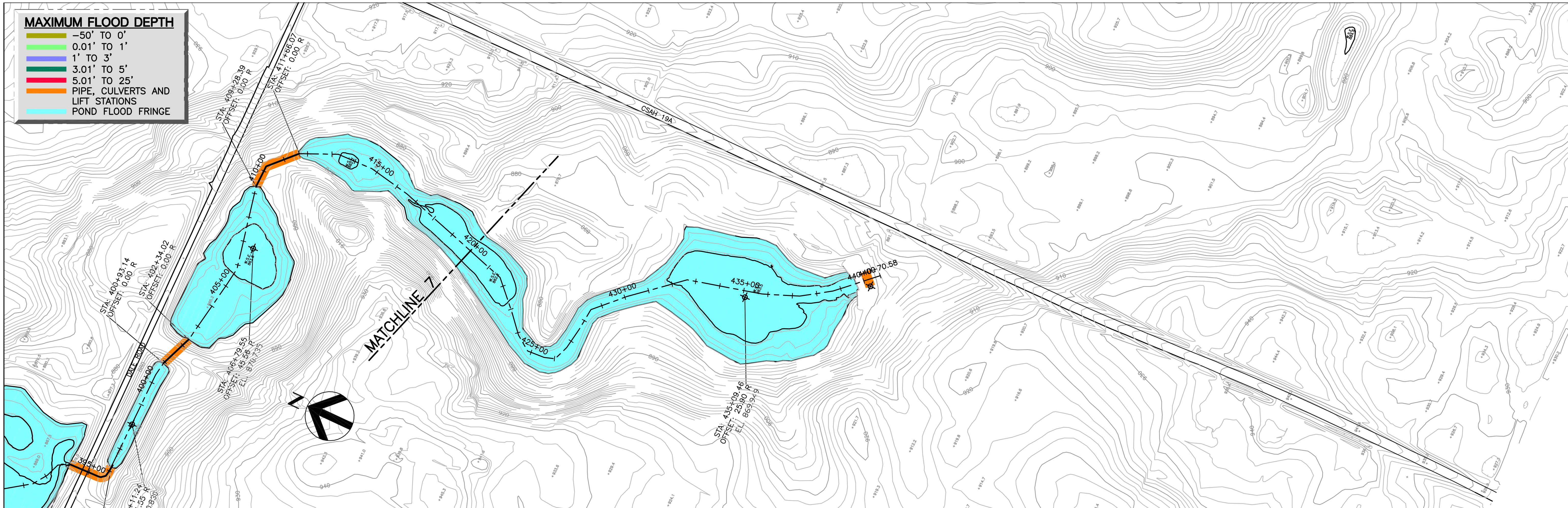
BAR LENGTH ON ORIGINAL DRAWING EQUALS ONE INCH. ADJUST SCALE ACCORDINGLY.

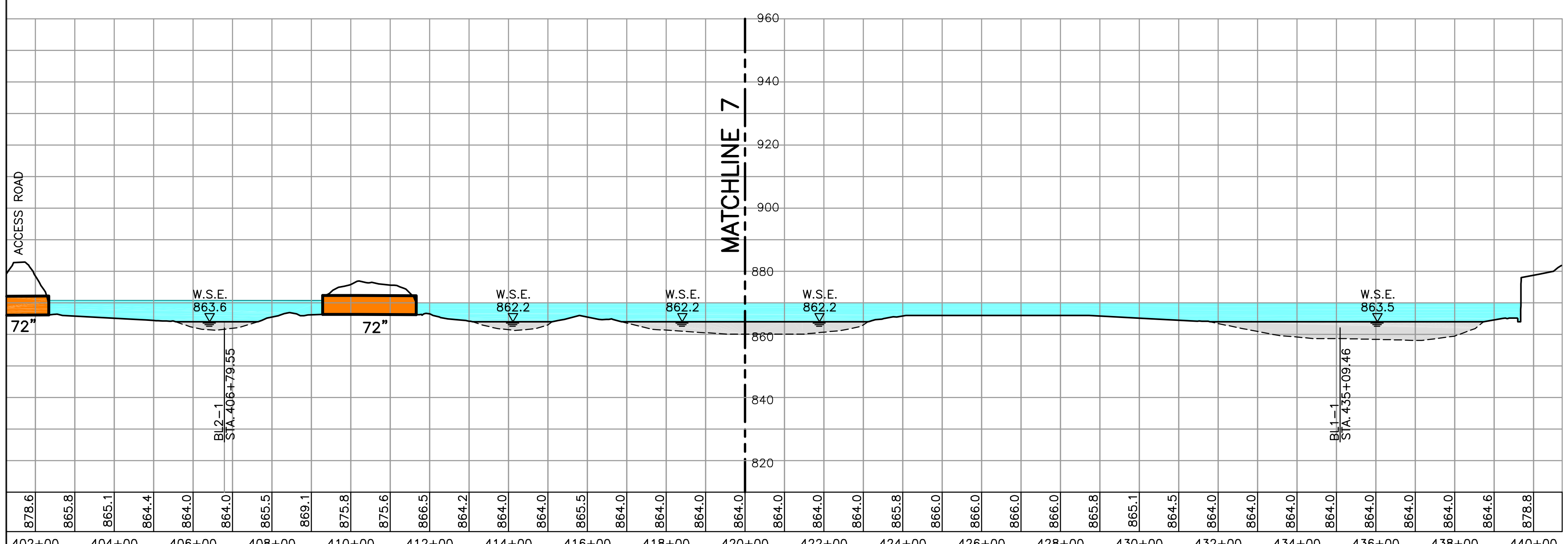
Project Manager: R. Beduhn
Designed:
Designed:
Checked:
Drawn: K. Hodne

South Washington Watershed District

9.3 INCH - 10 DAY FLOOD
PLAN AND PROFILE
STATION 360+00 TO 420+00

Date	Project No.	Drawing No.	Issue
APRIL 2002	10550-010.164	PP-7	
Scale: 1=200	File Name: 10550010-PP7		





Issue No.	Description	Date	Drwn.	Chkd.	Resp. Engr.	Proj. Mgr.

HDR Engineering, Inc.

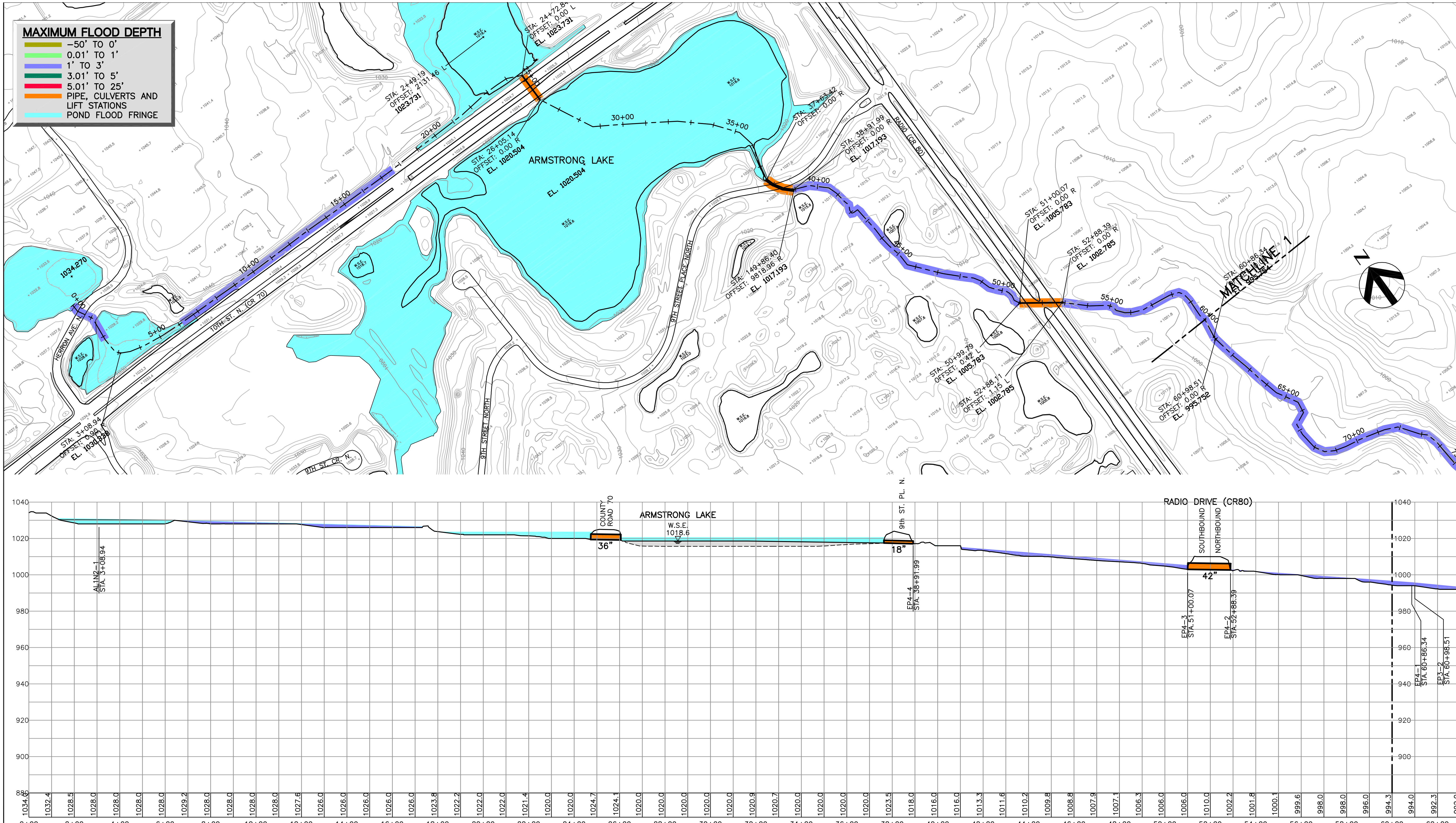
BAR LENGTH ON ORIGINAL DRAWING EQUALS ONE INCH. ADJUST SCALE ACCORDINGLY.

Project Manager: R. Beduhn
Designed:
Designed:
Checked:
Drawn: K. Hodne

South Washington Watershed District

9.3 INCH - 10 DAY FLOOD PLAN AND PROFILE STATION 420+00 TO END

Date	Project No.	Drawing No.	Issue
APRIL 2002	10550-010.164	PP-8	
Scale: 1=200	File Name: 10550010-PP8		



Issue No.	Description	Date	Drwn.	Chkd.	Resp. Engr.	Proj. Mgr.

HDR
HDR Engineering, Inc.

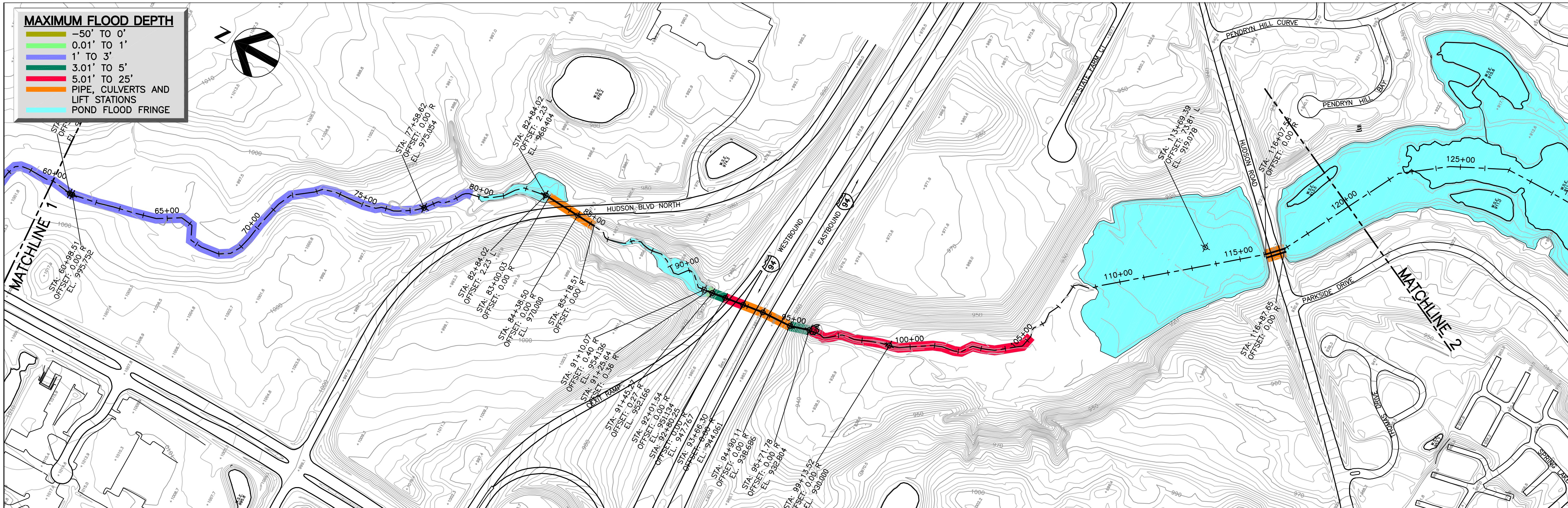
BAR LENGTH ON ORIGINAL DRAWING EQUALS ONE INCH. ADJUST SCALE ACCORDINGLY.

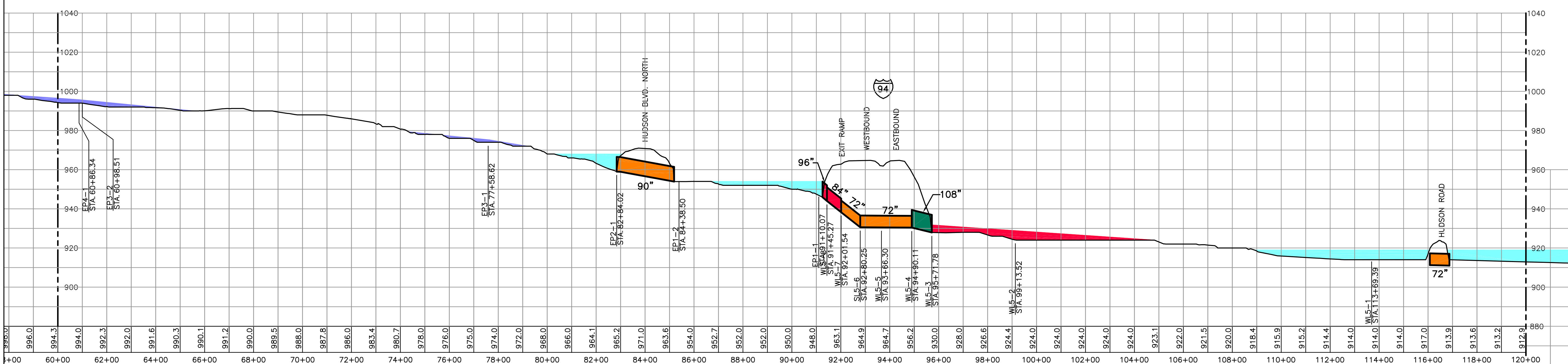
Project Manager: R. Beduhn
Designed:
Designed:
Checked:
Drawn: KAH

South Washington Watershed District

6.3 INCH IN 24 HOUR FLOOD
PLAN AND PROFILE
STATION 0+00 TO 60+00

Date	Project No.	Drawing No.	Issue
APRIL 2002	10550-010.164	PP-1	
Scale: 1=200	File Name: 10550010-PP1		





Issue No.	Description	Date	Drwn.	Chkd.	Resp. Engr.	Proj. Mgr.

HDR Engineering, Inc.

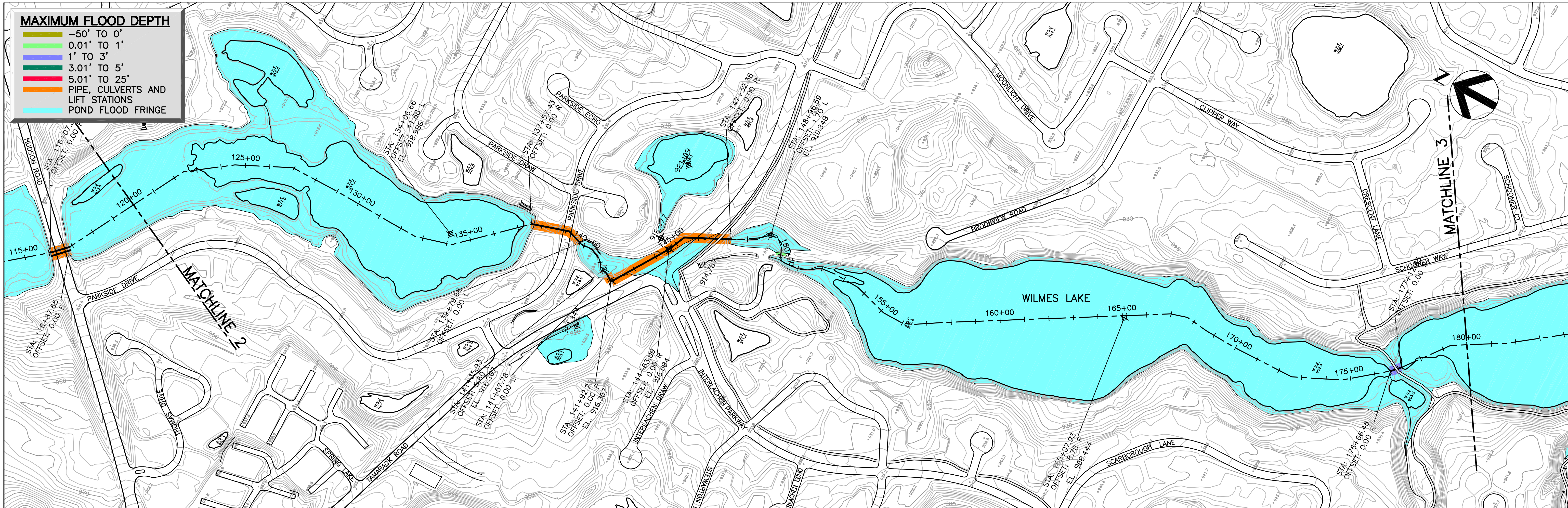
BAR LENGTH ON ORIGINAL DRAWING EQUALS ONE INCH. ADJUST SCALE ACCORDINGLY.

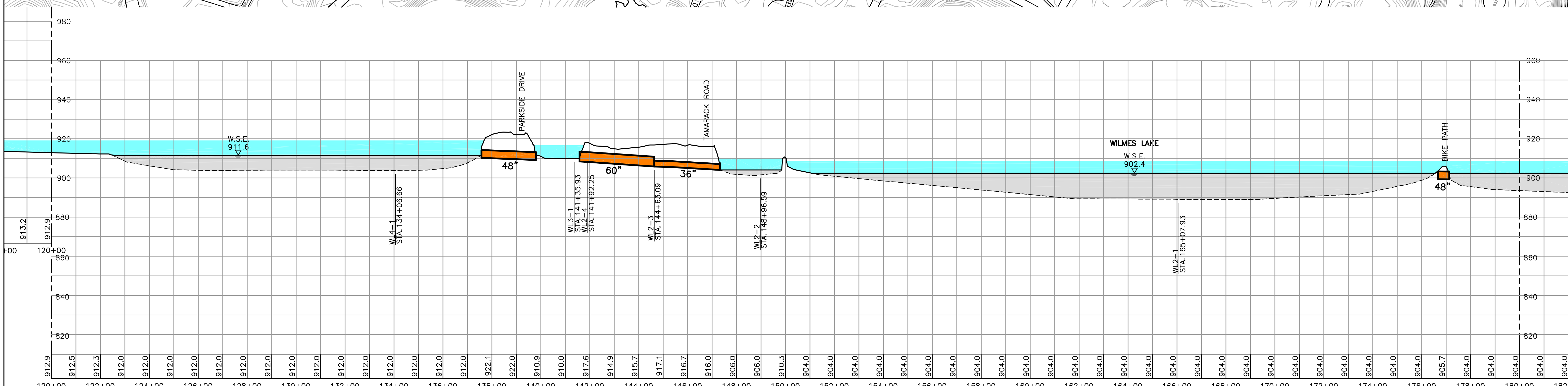
Project Manager: R. Beduhn
Designed:
Designed:
Checked:
Drawn: K. Hodne

South Washington Watershed District (SWWD)

6.3 INCH - 24 HOUR FLOOD PLAN AND PROFILE STATION 60+00 TO 120+00

Date	Project No.	Drawing No.	Issue
APRIL 2002	10550-010.164	PP-2	
Scale: 1=200	File Name: 10550010-PP2		





Issue No.	Description	Date	Drwn.	Chkd.	Resp. Engr.	Proj. Mgr.

HDR Engineering, Inc.

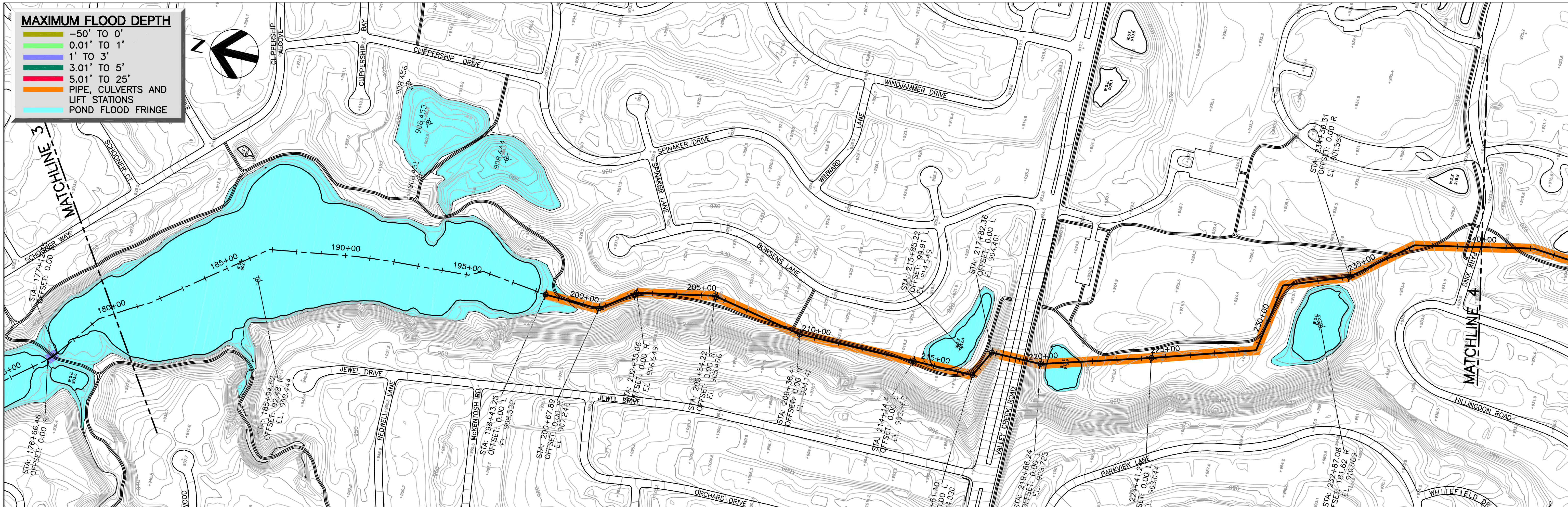
BAR LENGTH ON ORIGINAL DRAWING EQUALS ONE INCH. ADJUST SCALE ACCORDINGLY.

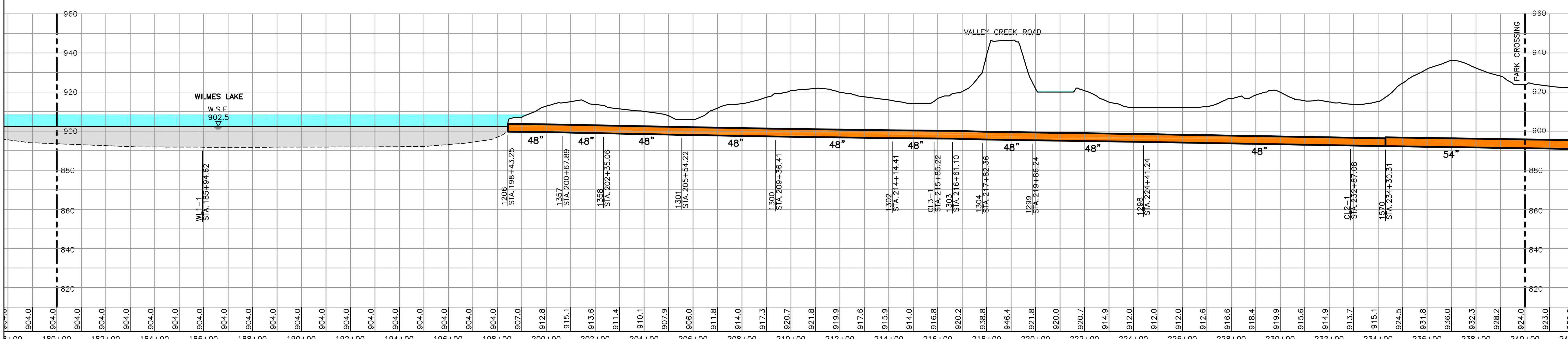
Project Manager: R. Beduhn
Designed:
Designed:
Checked:
Drawn: K. Hodne

South Washington Watershed District (SWWD)

6.3 INCH - 24 HOUR FLOOD PLAN AND PROFILE STATION 120+00 TO 180+00

Date: APRIL 2002
Scale: 1=200
Project No.: 10550-010.164
File Name: 10550010-PP3
Drawing No.: PP-3
Issue:





Issue No.	Description	Date	Drwn.	Chkd.	Resp. Engr.	Proj. Mgr.

HDR Engineering, Inc.

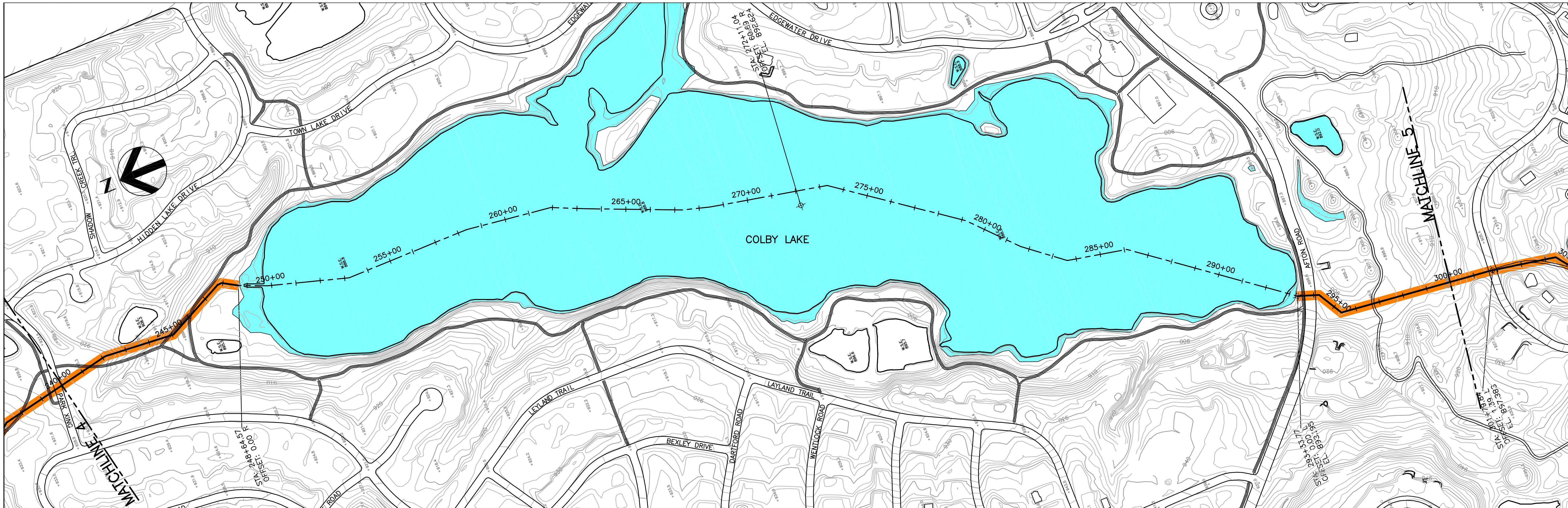
BAR LENGTH ON ORIGINAL DRAWING EQUALS ONE INCH. ADJUST SCALE ACCORDINGLY.

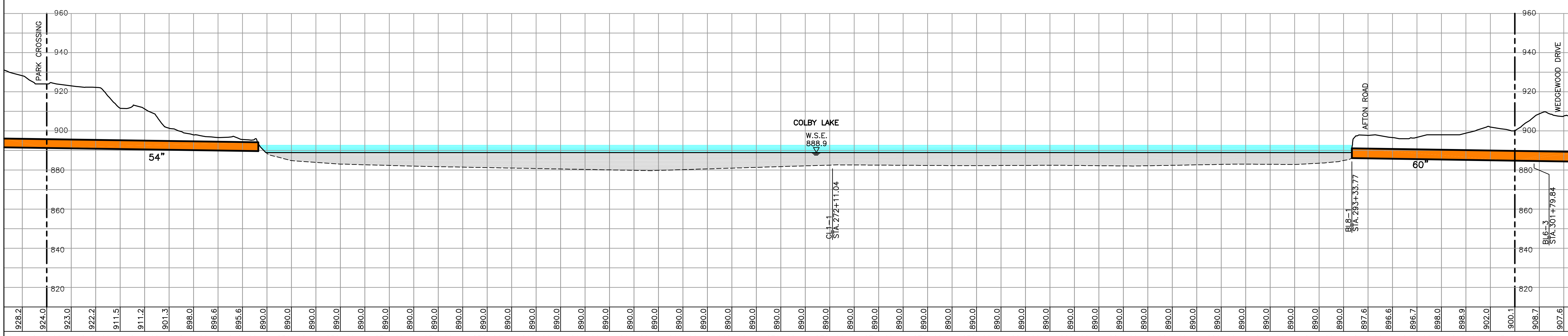
Project Manager: R. Beduhn
Designed:
Designed:
Checked:
Drawn: K. Hodne

South Washington Watershed District

6.3 INCH - 24 HOUR FLOOD PLAN AND PROFILE STATION 180+00 TO 240+00

Date	Project No.	Drawing No.	Issue
APRIL 2002	10550-010.164	PP-4	
Scale: 1=200	File Name: 10550010-PP4		





Issue No.	Description	Date	Drwn.	Chkd.	Resp. Engr.	Proj. Mgr.

HDR Engineering, Inc.

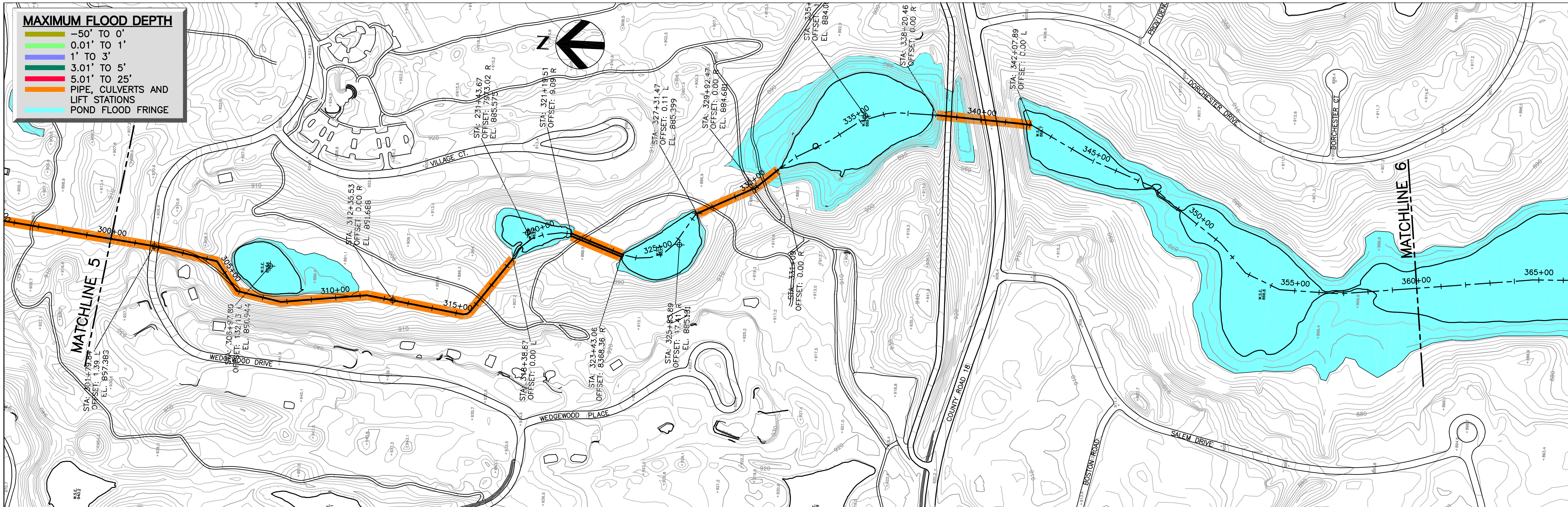
BAR LENGTH ON ORIGINAL DRAWING EQUALS ONE INCH. ADJUST SCALE ACCORDINGLY.

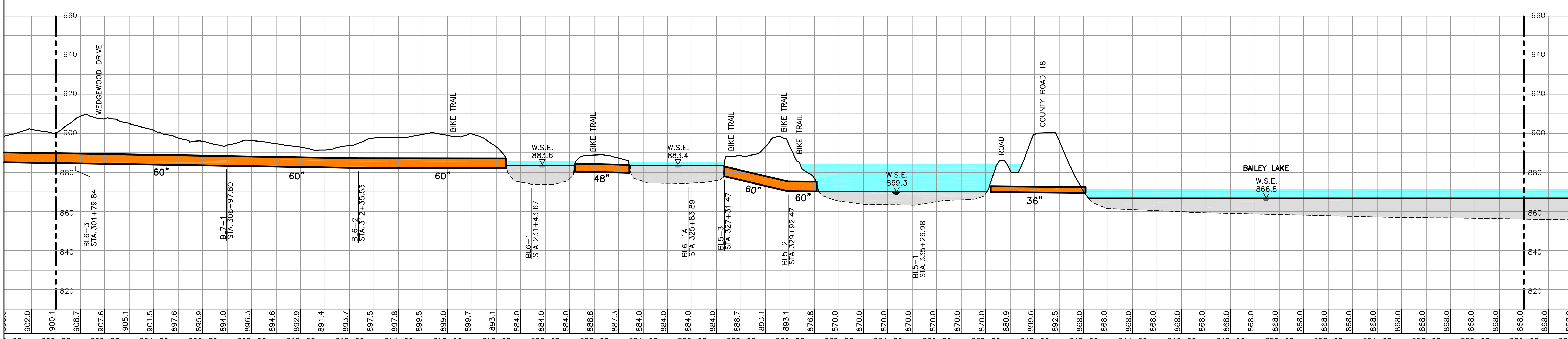
Project Manager: R. Beduhn
Designed:
Designed:
Checked:
Drawn: K. Hodne

South Washington Watershed District (SWWD)

6.3 INCH - 24 HOUR FLOOD PLAN AND PROFILE STATION 240+00 TO 300+00

Date	Project No.	Drawing No.	Issue
APRIL 2002	10550-010.164	PP-5	
Scale: 1=200	File Name: 10550010-PP5		





Issue No.	Description	Date	Drwn.	Chkd.	Resp. Engr.	Proj. Mgr.

HDR Engineering, Inc.

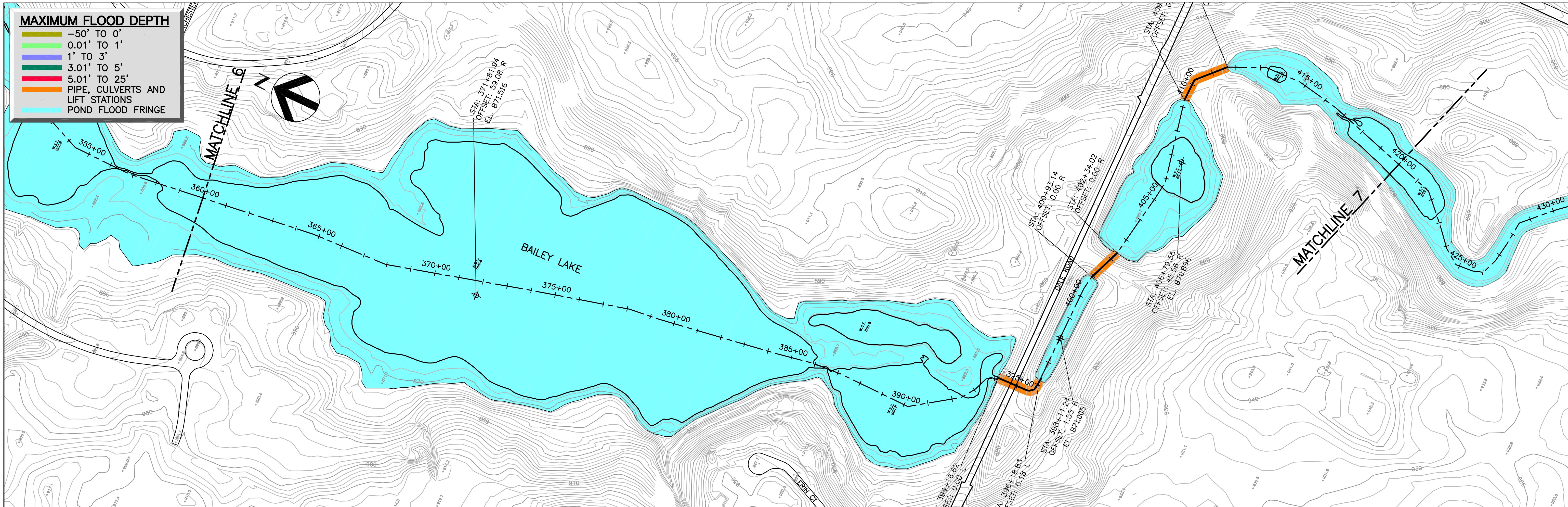
BAR LENGTH ON ORIGINAL DRAWING EQUALS ONE INCH. ADJUST SCALE ACCORDINGLY.

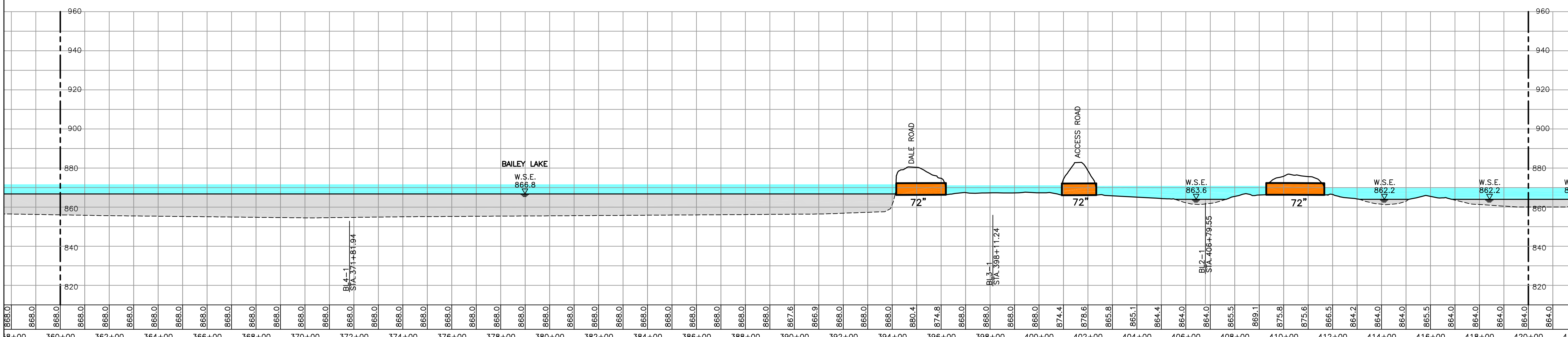
Project Manager: R. Beduhn
Designed:
Designed:
Checked:
Drawn: K. Hodne

South Washington Watershed District (SWWD)

6.3 INCH - 24 HOUR FLOOD PLAN AND PROFILE STATION 300+00 TO 360+00

Date	Project No.	Drawing No.	Issue
APRIL 2002	10550-010.164	PP-6	
Scale: 1=200	File Name: 10550010-PP6		





Issue No.	Description	Date	Drwn.	Chkd.	Resp. Engr.	Proj. Mgr.

HDR Engineering, Inc.

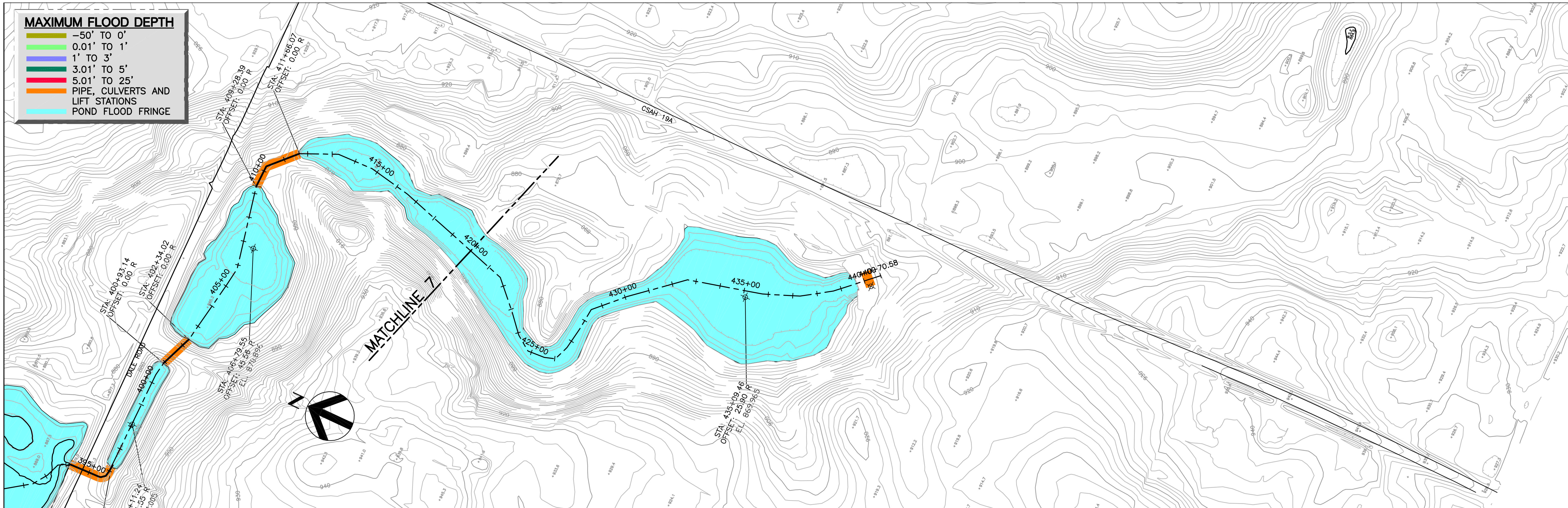
BAR LENGTH ON ORIGINAL DRAWING EQUALS ONE INCH. ADJUST SCALE ACCORDINGLY.

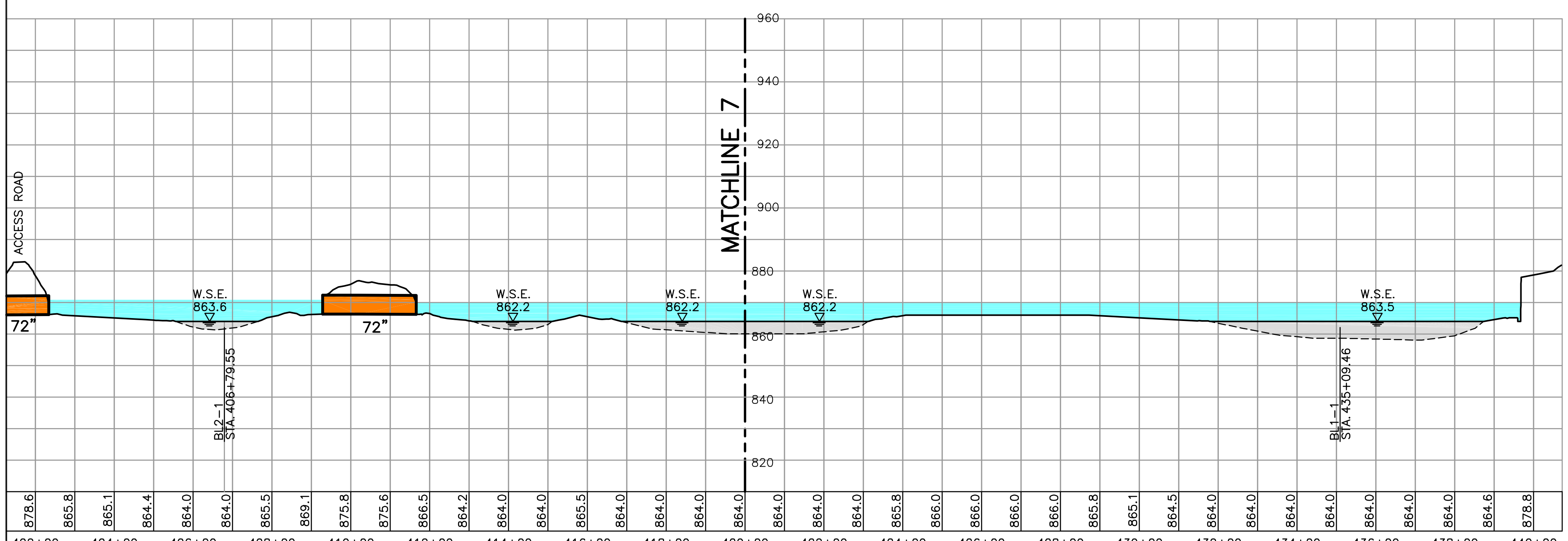
Project Manager: R. Beduhn
Designed:
Designed:
Checked:
Drawn: K. Hodne

South Washington Watershed District
SWWD

6.3 INCH - 24 HOUR FLOOD PLAN AND PROFILE STATION 360+00 TO 420+00

Date	Project No.	Drawing No.	Issue
APRIL 2002	10550-010.164	PP-7	
Scale: 1=200	File Name: 10550010-PP7		





Issue No.	Description	Date	Drwn.	Chkd.	Resp. Engr.	Proj. Mgr.

HDR Engineering, Inc.

BAR LENGTH ON ORIGINAL DRAWING EQUALS ONE INCH. ADJUST SCALE ACCORDINGLY.

Project Manager: R. Beduhn
Designed:
Designed:
Checked:
Drawn: K. Hodne

South Washington Watershed District

6.3 INCH - 24 HOUR FLOOD PLAN AND PROFILE STATION 420+00 TO END

Date	Project No.	Drawing No.	Issue
APRIL 2002	10550-010.164	PP-8	
Scale: 1=200	File Name: 10550010-PP8		

APPENDIX D

PEAK WATER SURFACE ELEVATION TABLES

Table D1. Peak Water Surface Elevations
100-Year Summer Rainfall and Runoff Events
South Washington Watershed District
Northern Watershed XP-SWMM Model

Junction Name[1]		6.0 inch 24-hour	6.3 inch 24-hour	7.8 inch 24-hour	9.3 inch 10 day	10.6 inch 10 day	6.3 inch 24-hour	7.8 inch 24-hour	9.3 inch 10-day	10.6 inch 10-day		6.3 inch 24-hour
	Pond Location	Modeled Peak Water Surface Elevation[2]	Modeled Peak Water Surface Elevation[2]	Modeled Peak Water Surface Elevation[3]	Modeled Peak Water Surface Elevation[3]	Modeled Peak Water Surface Elevation[3]	Modeled Peak Water Surface Elevation AUAR WSE[2]	Modeled Peak Water Surface Elevation AUAR WSE[3]	Modeled Peak Water Surface Elevation AUAR WSE[3]	Modeled Peak Water Surface Elevation AUAR WSE[3]	Woodbury 1979 Stormwater Plan High Water Elevation[4]	Peak Dishcharge[2] (cfs)
Armstrong Lake												
Mainstem												
AL1-1	Armstrong Lake	1020.3	1020.5	1021.3	1020.0	1020.4	1020.5	1021.3	1020.0	1020.4		12.5
North Tributary												
AL1N2-2	NW of County Highway 10 and Inwood Avenue North	1034.3	1034.3	1034.3	1034.1	1034.1	1034.3	1034.3	1034.1	1034.1		223
AL1N2-1	NW of County Highway 10 and Inwood Avenue North	1030.2	1030.3	1030.8	1029.8	1030.0	1030.3	1030.8	1029.8	1030.0		79
AL1N1-1	NW of County Highway 10 and Inwood Avenue North	1023.5	1023.7	1025.0	1022.9	1023.4	1023.7	1025.0	1022.9	1023.4		49
South Tributary												
AL1S1-1	NW of Hudson Boulevard and Inwood Avenue North	1020.2	1020.4	1021.3	1020.0	1020.3	1020.4	1021.3	1020.0	1020.3		0
Eagle Point												
Mainstem												
EP2-1	NE of I-94 and Inwood Avenue North	967.8	968.4	970.6	963.0	963.7	968.4	970.6	963.0	963.7		0
EP1-1	NE of I-94 and Inwood Avenue North	953.5	954.1	958.4	949.2	949.7	954.5	958.4	949.2	949.7		769
East Tributary												
EP2E1-1	NE of I-94 and Inwood Avenue North	981.2	981.5	983.2	980.5	981.2	981.5	983.2	980.5	981.2		
Guardian Angels												
GA1-2	NW of I-94 and Inwood Avenue North	1009.8	1010.1	1011.1	1009.5	1010.2	1010.1	1011.1	1009.5	1010.2		0
GA1-1	NW of I-94 and Inwood Avenue North	1006.0	1006.0	1006.8	1006.0	1006.1	1006.0	1006.8	1006.0	1006.1		0
Markgrafs Lake												
Mainstem												
ML2-1	NE of Woodbury Drive and Brookview Road	932.8	933.0	933.7	932.7	933.1	933.0	933.7	932.7	933.1	932.0	0
ML1-1	Markgrafs Lake	927.0	927.1	927.7	926.8	927.1	927.1	927.7	926.8	927.1		3
West Tributaries												
ML1W2-1	NW of Woodbury Drive and Brookview Road	950.9	950.9	951.0	950.4	950.5	950.9	951.0	950.4	950.5		310
ML1W1-1	NW of Woodbury Drive and Brookview Road	938.5	938.5	938.5	938.3	938.3	938.5	938.5	938.3	938.3		215

Table D1. Peak Water Surface Elevations
100-Year Summer Rainfall and Runoff Events
South Washington Watershed District
Northern Watershed XP-SWMM Model

Junction Name[1]	Pond Location	6.0 inch 24-hour Modeled Peak Water Surface Elevation[2]	6.3 inch 24-hour Modeled Peak Water Surface Elevation[2]	7.8 inch 24-hour Modeled Peak Water Surface Elevation[3]	9.3 inch 10 day Modeled Peak Water Surface Elevation[3]	10.6 inch 10 day Modeled Peak Water Surface Elevation[3]	6.3 inch 24-hour Modeled Peak Water Surface Elevation AUAR WSE[2]	7.8 inch 24-hour Modeled Peak Water Surface Elevation AUAR WSE[3]	9.3 inch 10-day Modeled Peak Water Surface Elevation AUAR WSE[3]	10.6 inch 10-day Modeled Peak Water Surface Elevation AUAR WSE[3]	Woodbury 1979 Stormwater Plan High Water Elevation[4]	6.3 inch 24-hour Peak Dishcharge[2] (cfs)
Powers Lake												
Mainstem												
PL1-1	Powers Lake	888.2	888.7	890.2	888.2	889.3	891.3	892.7	890.7	892.9		0
East Tributaries												
PL2E2-1	NW of Woodbury Drive and Valley Creek Road	897.0	897.3	898.8	896.6	897.6	897.3	898.8	896.6	897.6		0
PL2E1-1	NW of Woodbury Drive and Valley Creek Road	896.0	896.2	896.9	895.4	895.7	896.2	896.9	895.4	895.7		17
Wilmes Lake												
Mainstem												
WL5-1	SE of I-94 and Radio Drive	918.6	919.1	921.6	917.4	918.5	919.2	921.6	917.4	918.5	909*	510
WL4-1	SE of Hudson Road and Parkside Drive	918.6	919.0	921.4	917.4	918.4	919.1	921.4	917.4	918.4	909*	96
WL3-1	N of Interlachen Boulevard and Tamarack Road	916.3	916.4	916.5	916.1	916.3	916.4	916.5	916.1	916.3		105
WL2-2	SE of Interlachen Boulevard and Tamarack Road	910.3	910.3	910.8	910.3	910.3	910.3	910.9	910.3	910.3		72
WL2-1	N Wilmes Lake	908.2	908.4	910.8	908.0	909.0	908.7	910.9	908.0	909.7		114
WL1-1	S Wilmes Lake	908.2	908.4	910.8	908.0	909.0	908.7	910.9	908.0	909.7		85
East Tributaries												
WL1E1-1	NW of Woodbury Drive and Valley Creek Road	908.2	908.5	910.8	908.0	909.0	908.7	910.9	908.1	909.7		46
North Tributaries												
WL4N2-1		957.1	957.3	957.8	956.1	956.4	957.3	957.8	956.1	956.4	954.4	14
WL2N2-1	Woodbury Community Center (NE of Preserve Trail and Tamarack Road)	938.8	939.1	940.7	937.8	938.4	939.1	940.7	937.8	938.4		8
WL2N1-1	NE of Interlachen Boulevard and Tamarack Road	920.9	921.1	922.0	920.3	920.7	921.1	922.0	920.3	920.7	917.8*	7
WL1N2-1	SW of Woodbury Drive and Brookview Road	914.3	914.6	916.1	913.4	914.1	914.6	916.1	913.4	914.1	911.7	3
South Tributaries												
WL5S1-1	SE of I-94 and Radio Drive	978.1	978.2	978.6	977.6	977.7	978.2	978.6	977.6	977.7		94
WL1S1-1	NW of Woodbury Drive and Valley Creek Road	902.7	908.4	910.8	901.5	909.0	908.7	910.9	901.5	909.7		5
West Tributaries												
WL5W4-1	SW of Hudson Road and Radio Drive	1015.9	1016.0	1016.6	1015.6	1015.8	1016.0	1016.6	1015.6	1015.8		29

Table D1. Peak Water Surface Elevations
100-Year Summer Rainfall and Runoff Events
South Washington Watershed District
Northern Watershed XP-SWMM Model

Junction Name[1]	Pond Location	6.0 inch 24-hour Modeled Peak Water Surface Elevation[2]	6.3 inch 24-hour Modeled Peak Water Surface Elevation[2]	7.8 inch 24-hour Modeled Peak Water Surface Elevation[3]	9.3 inch 10 day Modeled Peak Water Surface Elevation[3]	10.6 inch 10 day Modeled Peak Water Surface Elevation[3]	6.3 inch 24-hour Modeled Peak Water Surface Elevation AUAR WSE[2]	7.8 inch 24-hour Modeled Peak Water Surface Elevation AUAR WSE[3]	9.3 inch 10-day Modeled Peak Water Surface Elevation AUAR WSE[3]	10.6 inch 10-day Modeled Peak Water Surface Elevation AUAR WSE[3]	Woodbury 1979 Stormwater Plan High Water Elevation[4]	6.3 inch 24-hour Peak Dishcharge[2] (cfs)
WL5W3-1	SW of Hudson Road and Radio Drive	999.5	999.8	1000.1	998.5	999.4	999.8	1000.1	998.5	999.4		10.5
WL5W2-1	NW of Hudson Road and Radio Drive	993.3	993.5	994.2	992.9	993.3	993.5	994.2	992.9	993.3		12
WL5W1-2	SW of I-94 and Radio Drive	981.8	981.9	982.5	979.3	979.5	981.9	982.5	979.3	979.5	994*	81
WL5W1-1	SW of I-94 and Radio Drive	975.9	975.9	976.2	974.3	974.5	975.9	976.2	974.3	974.5	994*	80
WL3W3-2	SW of Hudson Road and Radio Drive	1014.1	1014.1	1014.3	1013.7	1014.1	1014.1	1014.3	1013.7	1014.1		32
WL3W3-1	SW of Hudson Road and Radio Drive	1008.5	1008.8	1009.9	1008.0	1008.5	1008.8	1009.9	1008.0	1008.5	1012.6	8
WL3W2-3	NE of Hudson Road and Radio Drive	1006.8	1006.9	1007.5	1006.6	1006.8	1006.9	1007.5	1006.6	1006.8		8
WL3W2-2	NE of Hudson Road and Radio Drive	1006.0	1006.0	1006.0	1006.0	1006.0	1006.0	1006.0	1006.0	1006.0		18
WL3W2-1	NE of Hudson Road and Radio Drive	1004.1	1004.1	1004.1	1004.1	1004.1	1004.1	1004.1	1004.1	1004.1		9
WL3W1-1	NW of Interlachen Boulevard and Tamarack Road	921.1	921.3	922.6	916.1	916.9	921.3	922.6	916.1	916.9		145
WL2W7-1	SW of Tamarack Road and Radio Drive	995.8	996.0	996.9	995.3	995.8	996.0	996.9	995.3	995.8	996.0	15
WL2W6-1	SE of Tamarack Road and Radio Drive	985.1	985.1	985.1	985.1	985.1	985.1	985.1	985.1	985.1		131
WL2W4-1	SE of Tamarack Road and Radio Drive	977.6	977.6	977.8	977.1	977.2	977.6	977.8	977.1	977.2		156
WL2W3-1	SW of Interlachen Parkway and Tamarack Road	968.4	968.4	968.5	968.3	968.3	968.4	968.5	968.3	968.3	964.0	239
WL2W2-1	SW of Interlachen Parkway and Tamarack Road	950.3	950.3	950.4	950.2	950.3	950.3	950.4	950.3	950.3		278
WL1W4-1	NE of Valley Creek Road and Radio Drive	998.1	998.2	998.9	997.7	998.0	998.2	998.9	997.7	998.0	1000.0	7
WL1W3-2	NE of Valley Creek Road and Interlachen Parkway	970.4	970.4	970.5	970.2	970.2	970.4	970.5	970.2	970.2		98
WL1W3-1	N of Interlachen Parkway and Colby Lake Drive	945.1	945.5	947.3	943.7	944.8	945.5	947.3	943.7	944.8	952.2*	221
WL1W2-1	NE of Valley Creek Road and Interlachen Parkway	945.0	945.4	947.3	943.7	944.8	945.4	947.3	943.7	944.8	952.2*	25

Table D1. Peak Water Surface Elevations
100-Year Summer Rainfall and Runoff Events
South Washington Watershed District
Northern Watershed XP-SWMM Model

Junction Name[1]		6.0 inch 24-hour	6.3 inch 24-hour	7.8 inch 24-hour	9.3 inch 10 day	10.6 inch 10 day	6.3 inch 24-hour	7.8 inch 24-hour	9.3 inch 10-day	10.6 inch 10-day		6.3 inch 24-hour
	Pond Location	Modeled Peak Water Surface Elevation[2]	Modeled Peak Water Surface Elevation[2]	Modeled Peak Water Surface Elevation[3]	Modeled Peak Water Surface Elevation[3]	Modeled Peak Water Surface Elevation[3]	Modeled Peak Water Surface Elevation AUAR WSE[2]	Modeled Peak Water Surface Elevation AUAR WSE[3]	Modeled Peak Water Surface Elevation AUAR WSE[3]	Modeled Peak Water Surface Elevation AUAR WSE[3]	Woodbury 1979 Stormwater Plan High Water Elevation[4]	Peak Dishcharge[2] (cfs)
Colby Lake												
Mainstem												
CL3-1	NW of Woodbury Drive and Valley Creek Road	914.4	914.5	915.8	913.0	913.3	914.5	915.8	913.0	913.3	913.4	78
CL2-1	SW of Woodbury Drive and Valley Creek Road	910.6	911.0	912.5	908.9	909.7	911.0	912.5	908.9	909.7	912.1/909.4**	35
CL1-1	Colby Lake	892.5	892.6	893.6	892.5	892.7	892.7	893.7	892.6	892.7		101
East Tributaries												
CL1E10-1	NE of Lake Road and Woodbury Drive	918.4	918.8	920.6	917.3	918.1	921.4	922.2	920.7	920.9		11
CL1E9-1	SE of Valley Creek Road and Woodbury Drive	904.8	905.6	909.8	902.8	904.7	905.2	909.5	903.4	906.6	910.0	13
CL1E8-1	NE of Lake Road and Woodbury Drive	909.6	909.8	911.3	909.0	909.4	910.6	912.8	910.2	910.5	907.5	32
CL1E7-1	NE of Lake Road and Woodbury Drive	905.3	905.7	907.4	903.8	904.8	905.8	907.5	904.0	904.8	903.5	62
CL1E6-2	SE of Lake Road and Woodbury Drive	894.7	894.9	895.8	894.3	894.8	895.0	895.9	894.4	894.8		19
CL1E6-1	NE of Lake Road and Woodbury Drive	894.7	894.9	895.7	894.3	894.8	895.0	895.8	894.4	894.8		59
CL1E5-1	NW of Bailey Road and Cottage Road Drive	956.1	956.2	956.3	956.0	956.1	956.2	956.2	956.2	956.2		30
CL1E4-1	NE of Bailey Road and Woodbury Drive	934.4	934.6	938.7	933.4	933.5	934.6	935.8	933.6	934.2		55
CL1E3-1A	SE of Lake Road and Woodbury Drive	892.9	893.2	895.6	892.7	893.1	894.2	895.8	893.3	894.0		60
CL1E3-1	SW of Lake Road and Woodbury Drive	892.9	893.2	895.0	892.7	893.1	893.9	895.6	893.3	893.9	891.7	6
CL1E2-1	NW of Lake Road and Woodbury Drive	892.9	893.1	894.3	892.7	893.1	893.5	894.7	893.3	893.7	891.7	26
North Tributaries												
CL1N6-1	SE of Valley Creek Road and Woodbury Drive	925.0	925.2	926.4	924.4	924.7	924.5	924.6	924.5	924.5	922.0	16
CL1N5-1	SE of Valley Creek Road and Woodbury Drive	918.1	918.1	918.9	917.6	917.9	918.2	918.8	917.6	917.9		15
CL1N4-1	SW of Valley Creek Road and Cottage Grove Drive	921.8	922.1	923.3	921.2	922.1	924.0	924.7	924.2	924.7	923.2	0
CL1N3-1	SE of Valley Creek Road and Woodbury Drive	913.1	913.4	914.7	912.3	912.9	913.4	914.7	912.3	912.9	922.6	4
CL1N2-1	SE of Valley Creek Road and Woodbury Drive	894.3	894.6	895.9	893.5	894.2	894.5	895.8	893.6	894.1	891.7	13

Table D1. Peak Water Surface Elevations
100-Year Summer Rainfall and Runoff Events
South Washington Watershed District
Northern Watershed XP-SWMM Model

Junction Name[1]	Pond Location	6.0 inch 24-hour Modeled Peak Water Surface Elevation[2]	6.3 inch 24-hour Modeled Peak Water Surface Elevation[2]	7.8 inch 24-hour Modeled Peak Water Surface Elevation[3]	9.3 inch 10 day Modeled Peak Water Surface Elevation[3]	10.6 inch 10 day Modeled Peak Water Surface Elevation[3]	6.3 inch 24-hour Modeled Peak Water Surface Elevation AUAR WSE[2]	7.8 inch 24-hour Modeled Peak Water Surface Elevation AUAR WSE[3]	9.3 inch 10-day Modeled Peak Water Surface Elevation AUAR WSE[3]	10.6 inch 10-day Modeled Peak Water Surface Elevation AUAR WSE[3]	Woodbury 1979 Stormwater Plan High Water Elevation[4]	6.3 inch 24-hour Peak Dishcharge[2] (cfs)
CL1N1-1	SW of Valley Creek Road and Woodbury Drive	892.8	893.0	894.0	892.6	893.0	892.9	893.8	892.7	892.9	891.7	11
West Tributaries												
CL1W2-1	NE of Pioneer Drive and Lake Road	977.7	978.1	980.2	976.7	977.9	978.1	980.2	976.7	977.9	976.0	4
CL1W1-1	NE of Pioneer Drive and Lake Road	963.3	963.5	964.5	962.7	963.1	963.5	964.5	962.7	963.1	963.0	16
Bailey Lake												
Mainstem												
BL7-1	SW of Lake Road and Woodbury Drive	890.8	890.9	891.7	890.4	890.8	890.9	891.7	890.4	890.8		0
BL6-1A	NW of Bailey Road and Woodbury Drive	883.9	885.1	887.0	883.5	885.2	885.2	887.0	884.6	885.2	887*	259
BL6-1	NW of Bailey Road and Woodbury Drive	885.1	885.6	887.5	884.0	885.7	885.7	887.5	885.1	885.7	887*	167
BL5-1	NW of Bailey Road and Woodbury Drive	882.4	884.1	886.2	881.8	884.1	884.1	886.2	883.2	884.2	887*	101
BL4-1	Bailey Lake	871.4	871.5	871.8	871.3	871.6	871.5	871.8	871.4	871.6		99
BL3-1	SW of Dale Road and Woodbury Drive	870.9	871.0	871.2	870.8	871.0	871.0	871.2	870.9	871.0		99
BL2-1	SW of Dale Road and Woodbury Drive	870.8	870.9	871.1	870.7	870.9	870.9	871.1	870.8	870.9		99
BL1-4	NE of Mile Drive and Dale Road	934.1	934.5	936.1	933.4	934.4	934.5	936.1	933.5	934.4	938.0	0
BL1-1	SW of Dale Road and Woodbury Drive	870.0	870.0	870.5	869.9	870.0	870.0	870.5	870.0	870.0		99
East Tributaries												
BL5E3-1	NW of Bailey Road and Woodbury Drive	900.8	901.0	901.9	900.2	900.7	901.0	901.9	900.2	900.7	901.3*	3
BL5E2-1	NW of Bailey Road and Woodbury Drive	899.3	899.5	900.4	898.6	899.1	899.5	900.4	898.6	899.1	901.3*	19
BL5E1-1	NW of Bailey Road and Woodbury Drive	898.3	898.6	899.9	897.7	898.1	898.6	899.9	897.7	898.1	901.3*	29
BL4E8-1	SE of Bailey Road and Woodbury Drive	941.5	941.9	943.4	940.5	941.4	941.9	943.4	940.5	941.4	940.0	0
BL4E7-1	NE of Dale Road and Cottage Grove Drive	941.9	942.1	942.9	941.5	941.9	942.1	942.9	941.5	941.9	940*	85
BL4E6-1	NE of Dale Road and Cottage Grove Drive	933.3	933.4	933.9	933.1	933.3	933.4	933.9	933.1	933.3	940*	197
BL4E5-1	NW of Dale Road and Cottage Grove Drive	925.1	925.3	926.0	924.6	925.1	925.3	926.0	924.6	925.1	924.0	124

Table D1. Peak Water Surface Elevations
100-Year Summer Rainfall and Runoff Events
South Washington Watershed District
Northern Watershed XP-SWMM Model

Junction Name[1]		6.0 inch 24-hour	6.3 inch 24-hour	7.8 inch 24-hour	9.3 inch 10 day	10.6 inch 10 day	6.3 inch 24-hour	7.8 inch 24-hour	9.3 inch 10-day	10.6 inch 10-day		6.3 inch 24-hour
	Pond Location	Modeled Peak Water Surface Elevation[2]	Modeled Peak Water Surface Elevation[2]	Modeled Peak Water Surface Elevation[3]	Modeled Peak Water Surface Elevation[3]	Modeled Peak Water Surface Elevation[3]	Modeled Peak Water Surface Elevation AUAR WSE[2]	Modeled Peak Water Surface Elevation AUAR WSE[3]	Modeled Peak Water Surface Elevation AUAR WSE[3]	Modeled Peak Water Surface Elevation AUAR WSE[3]	Woodbury 1979 Stormwater Plan High Water Elevation[4]	Peak Dishcharge[2] (cfs)
BL4E4-1	NE of Dale Road and Woodbury Drive	907.1	908.8	914.9	903.7	908.3	908.9	915.0	903.9	908.3	909.0	0
BL4E3-1	NW of Dale Road and Woodbury Drive	916.4	916.5	916.7	916.2	916.4	916.5	916.7	916.2	916.4		0
Bailey Lake												
East Tributaries (continued)												
BL4E2-1	NW of Dale Road and Woodbury Drive	914.0	914.0	914.0	914.0	914.0	914.0	914.0	914.0	914.0		0
BL4E1-1	SW of Bailey Road and Woodbury Drive	870.1	870.4	871.9	869.4	870.1	870.4	871.9	869.4	870.1	877.0	0
BL1E1-2	SE of Dale Road and Woodbury Drive	915.1	915.3	916.5	914.6	915.2	915.3	916.5	914.6	915.2	920.0	0
BL1E1-1	SE of Dale Road and Woodbury Drive	892.2	892.2	892.3	892.1	892.2	892.2	892.3	892.1	892.2		167
West Tributaries												
BL6W1-1	NE of Pioneer Drive and Bailey Road	947.9	948.1	949.3	946.9	947.5	948.1	949.3	946.9	947.5		8
BL5W18-1	NW of Radio Drive and Lake Road	1001.1	1001.4	1002.1	999.4	1000.3	1001.4	1002.1	999.4	1000.3	1005.0	185
BL5W17-1	NW of Radio Drive and Lake Road	998.9	999.1	1000.4	998.2	998.7	999.1	1000.4	998.2	998.7		0
BL5W16-1	NE of Radio Drive and Lake Road	977.1	977.1	977.1	975.4	977.0	977.1	977.1	975.4	977.0		73
BL5W15-1	SE of Radio Drive and Lake Road	967.7	968.1	969.7	966.9	967.7	968.1	969.7	967.0	967.7	965.0	16
BL5W14-1	SW of Lake Road and Pioneer Drive	949.1	949.2	949.9	948.8	949.0	949.2	949.9	948.8	949.0		45
BL5W13-1	NW of Bailey Road and Pioneer Drive	937.6	937.9	939.4	936.8	937.5	938.0	939.4	936.9	937.5		45
BL5W12-1	NW of Bailey Road and Pioneer Drive	970.4	970.5	971.4	969.2	969.6	970.5	971.4	969.2	969.6		15
BL5W11-1	NW of Bailey Road and Radio Drive	992.1	992.4	993.8	991.0	991.7	992.4	993.8	991.0	991.7		3
BL5W10-1	NW of Bailey Road and Radio Drive	977.3	977.6	979.0	976.3	976.9	977.6	979.0	976.3	976.9		13
BL5W9-1	NW of Bailey Road and Radio Drive	957.1	957.4	959.0	956.2	956.8	957.4	959.0	956.2	956.8	974.4	2.6
BL5W8-1	NW of Bailey Road and Radio Drive	981.0	981.4	982.9	979.0	979.3	981.4	982.9	979.0	979.3		2
BL5W7-1	NE of Bailey Road and Radio Drive	978.2	978.5	979.8	977.1	977.5	978.5	979.8	977.1	977.5		16

Table D1. Peak Water Surface Elevations
100-Year Summer Rainfall and Runoff Events
South Washington Watershed District
Northern Watershed XP-SWMM Model

Junction Name[1]		6.0 inch 24-hour	6.3 inch 24-hour	7.8 inch 24-hour	9.3 inch 10 day	10.6 inch 10 day	6.3 inch 24-hour	7.8 inch 24-hour	9.3 inch 10-day	10.6 inch 10-day		6.3 inch 24-hour
	Pond Location	Modeled Peak Water Surface Elevation[2]	Modeled Peak Water Surface Elevation[2]	Modeled Peak Water Surface Elevation[3]	Modeled Peak Water Surface Elevation[3]	Modeled Peak Water Surface Elevation[3]	Modeled Peak Water Surface Elevation AUAR WSE[2]	Modeled Peak Water Surface Elevation AUAR WSE[3]	Modeled Peak Water Surface Elevation AUAR WSE[3]	Modeled Peak Water Surface Elevation AUAR WSE[3]	Woodbury 1979 Stormwater Plan High Water Elevation[4]	Peak Dishcharge[2] (cfs)
BL5W6-1	NE of Bailey Road and Radio Drive	966.7	967.4	969.9	964.8	966.1	967.4	969.9	964.8	966.1		28
BL5W5-1	NE of Bailey Road and Radio Drive	950.9	951.2	952.5	949.6	950.5	951.2	952.5	949.6	950.5		41
BL5W4-1	NW of Bailey Road and Pioneer Drive	950.7	951.0	952.6	949.4	950.3	951.0	952.6	949.4	950.3		59
BL5W3-1	NW of Bailey Road and Pioneer Drive	936.6	934.7	937.1	935.5	934.6	934.7	937.1	935.6	934.6	937.0	601
BL5W2-1	NE of Bailey Road and Pioneer Drive	936.6	933.7	933.2	935.5	933.6	933.9	933.5	935.6	934.1		32
BL5W1-1A	NE of Bailey Road and Pioneer Drive	919.6	919.7	920.1	919.4	919.6	919.7	920.1	919.4	919.6		0
BL5W1-1	NE of Bailey Road and Pioneer Drive	924.4	924.8	926.9	922.7	923.7	924.8	926.9	922.7	923.7	916.0	45
BL1W5-1	SW of Bailey Road and Tower Drive	971.4	971.7	973.1	970.8	971.4	971.7	973.1	970.8	971.4	970.0	26
BL1W4-1	SE of Bailey Road and Tower Drive	946.6	946.9	944.2	945.7	946.5	944.2	944.2	944.1	944.2	950.0	8
BL1W3-1	SW of Bailey Road and Mile Drive	926.1	926.1	926.6	926.1	926.1	926.4	926.6	926.2	926.3	926.0	9
BL1W2-1	SW of Bailey Road and Mile Drive	920.1	920.1	920.4	919.7	920.1	920.1	920.4	919.7	920.1	920.0	6
BL1W1-1	SE of Bailey Road and Mile Drive	889.8	891.1	890.2	882.0	890.5	889.3	890.2	882.0	888.1		5

[1]Listed from Upstream to Downstream
[2]Value taken from XP SWMM model
[3]Value taken from XP SWMM model. For Comparison only. Refer to section 6.2.7.
[4]Elevation taken from Drainage Study Report (1979).

* multiple HDR nodes correspond to one 79 plan node
** multiple 79 plan nodes correspond to one HDR node

Table D2: Peak Water Surface Elevation
100 Year Summer Rainfall and Runoff Events
South Washington Watershed District
Cottage Grove Central Ravine XP-SWMM Model

			6.3 inch 24-hour	7.8 inch 24-hour	9.3 inch 10-day	10.6 inch 10-day	6.0 inch 24-hour		6.3 inch 24-hour
Pond ID	Pond Location	Storage Basin Overflow Elevation	Modeled Peak Water Surface Elevation[1]	Modeled Peak Water Surface Elevation[2]	Modeled Peak Water Surface Elevation[2]	Modeled Peak Water Surface Elevation[2]	Modeled Peak Water Surface Elevation[2]	Cottage Grove Storm Water Plan High Water Elevation[3]	Modeled Peak Discharge[1]
81.02-2	70th Street and Jocelyn Avenue Storage Area	906	905.3	906.2	904	904.7	905.1	904	3.4
80.02-1	75th Street and Jocelyn Avenue Retention Pond	903	903.5	905.4	901.6	903.1	903.2	902	100
79.02-1	Kingston Park North (dry)	904	903.5	905.4	900.5	901.8	902.8	902	20.7
85.07-1	Kingston Park South	890	882.6	884.8	881.1	881.8	882.1	884	43.8
86.10-1	Jeffery/Jasmine Avenue Pond	838	835.9	837.9	835	836.1	835.5	830	35.6
88.17-7	Woodridge Park Pond	805	809.01	810.5	806.9	808.1	808.5	805	738.9
79.01-1	80th Street and Jenner Avenue S. Retention Pond	896	896.8	897.1	893	894.4	896.5	893	255.4
86.99-1	Jewel Avenue S.	874	875.4	875.7	874.9	874.9	875.2	879	566.2

86.09-1	Jenner Lane S. (1) Storage Area	868	868.6	869	868.4	868.5	868.5	N.A.	298.7
86.08-3	Jenner Lane S. (2) Storage Area	846	847.2	847.9	846.9	847	847.1	N.A.	294
86.08-5	Jenner Lane S. (3) Storage Area	840	841.3	842	841.1	841.2	841.3	N.A.	310.8
86.08-7	Hillside Drive/Jenner Lane S. (4) Storage Area	840	841.2	841.9	841	841	841.1	N.A.	333.6
68.01-1	Highlands Park Pond	908	907.4	908.4	905.9	906.8	907	N.A.	6.3
73.01-1	Summer Hills 1st Addition Pond	898	895.6	898.6	895.4	896	895.3	898	10.1
72.01-1	76th St. / Emmanual Ave. Storage Area	877	877.4	878.6	875.8	876.7	877.1	875	98.1
71.01-1	Pine Tree Valley North Pond	890	890.1	890.2	887.8	889.5	889.6	882	36
78.05-1	Pine Tree Valley South Pond	880	869.4	871	869.1	869.5	869.3	870	15.3
78.04-1	Pine Tree Pond	856	856.2	856.3	856	856.2	856.1	851	148.9

[1] Value taken from XP SWMM model

[2] Value taken from XP SWMM model. For Comparison only. Refer to section 6.2.7.

[3] Value taken from Cottage Grove Stormwater Management Plan (1984)

Table D3. Peak Water Surface Elevations at Pond Locations Affected by AUAR
100-Year Summer Rainfall and Runoff Events
South Washington Watershed District
Northern Watershed XP-SWMM Model

Junction Name[1]	Pond Location	6.0 inch 24-hour Modeled Peak Water Surface Elevation[2]	6.3 inch 24-hour Modeled Peak Water Surface Elevation[2]	7.8 inch 24-hour Modeled Peak Water Surface Elevation[3]	9.3 inch 10 day Modeled Peak Water Surface Elevation[3]	10.6 inch 10 day Modeled Peak Water Surface Elevation[3]	6.3 inch 24-hour Modeled Peak Water Surface Elevation AUAR WSE[2]	7.8 inch 24-hour Modeled Peak Water Surface Elevation AUAR WSE[3]	9.3 inch 10-day Modeled Peak Water Surface Elevation AUAR WSE[3]	10.6 inch 10-day Modeled Peak Water Surface Elevation AUAR WSE[3]	Woodbury 1979 Stormwater Plan High Water Elevation[4]	6.3 inch 24-hour Peak Dishcharge[2] (cfs)
Eagle Point												
Mainstem												
EP1-1	NE of I-94 and Inwood Avenue North	953.5	954.1	958.4	949.2	949.7	954.5	958.4	949.2	949.7		769
Powers Lake												
Mainstem												
PL1-1	Powers Lake	888.2	888.7	890.2	888.2	889.3	891.3	892.7	890.7	892.9		0
Wilmes Lake												
Mainstem												
WL5-1	SE of I-94 and Radio Drive	918.6	919.1	921.6	917.4	918.5	919.2	921.6	917.4	918.5	909*	510
WL4-1	SE of Hudson Road and Parkside Drive	918.6	919.0	921.4	917.4	918.4	919.1	921.4	917.4	918.4	909*	96
WL2-2	SE of Interlachen Boulevard and Tamarack Road	910.3	910.3	910.8	910.3	910.3	910.3	910.9	910.3	910.3		72
WL2-1	N Wilmes Lake	908.2	908.4	910.8	908.0	909.0	908.7	910.9	908.0	909.7		114
WL1-1	S Wilmes Lake	908.2	908.4	910.8	908.0	909.0	908.7	910.9	908.0	909.7		85
East Tributaries												
WL1E1-1	NW of Woodbury Drive and Valley Creek Road	908.2	908.5	910.8	908.0	909.0	908.7	910.9	908.1	909.7		46
South Tributaries												
WL1S1-1	NW of Woodbury Drive and Valley Creek Road	902.7	908.4	910.8	901.5	909.0	908.7	910.9	901.5	909.7		5
Colby Lake												
Mainstem												
CL1-1	Colby Lake	892.5	892.6	893.6	892.5	892.7	892.7	893.7	892.6	892.7		101
East Tributaries												
CL1E10-1	NE of Lake Road and Woodbury Drive	918.4	918.8	920.6	917.3	918.1	921.4	922.2	920.7	920.9		11
CL1E9-1	SE of Valley Creek Road and Woodbury Drive	904.8	905.6	909.8	902.8	904.7	905.2	909.5	903.4	906.6	910.0	13
CL1E8-1	NE of Lake Road and Woodbury Drive	909.6	909.8	911.3	909.0	909.4	910.6	912.8	910.2	910.5	907.5	32
CL1E7-1	NE of Lake Road and Woodbury Drive	905.3	905.7	907.4	903.8	904.8	905.8	907.5	904.0	904.8	903.5	62
CL1E6-2	SE of Lake Road and Woodbury Drive	894.7	894.9	895.8	894.3	894.8	895.0	895.9	894.4	894.8		19

Table D3. Peak Water Surface Elevations at Pond Locations Affected by AUAR
100-Year Summer Rainfall and Runoff Events
South Washington Watershed District
Northern Watershed XP-SWMM Model

Junction Name[1]		6.0 inch 24-hour	6.3 inch 24-hour	7.8 inch 24-hour	9.3 inch 10 day	10.6 inch 10 day	6.3 inch 24-hour	7.8 inch 24-hour	9.3 inch 10-day	10.6 inch 10-day		6.3 inch 24-hour
	Pond Location	Modeled Peak Water Surface Elevation[2]	Modeled Peak Water Surface Elevation[2]	Modeled Peak Water Surface Elevation[3]	Modeled Peak Water Surface Elevation[3]	Modeled Peak Water Surface Elevation[3]	Modeled Peak Water Surface Elevation AUAR WSE[2]	Modeled Peak Water Surface Elevation AUAR WSE[3]	Modeled Peak Water Surface Elevation AUAR WSE[3]	Modeled Peak Water Surface Elevation AUAR WSE[3]	Woodbury 1979 Stormwater Plan High Water Elevation[4]	Peak Dishcharge[2] (cfs)
CL1E6-1	NE of Lake Road and Woodbury Drive	894.7	894.9	895.7	894.3	894.8	895.0	895.8	894.4	894.8		59
CL1E5-1	NW of Bailey Road and Cottage Road Drive	956.1	956.2	956.3	956.0	956.1	956.2	956.2	956.2	956.2		30
CL1E4-1	NE of Bailey Road and Woodbury Drive	934.4	934.6	938.7	933.4	933.5	934.6	935.8	933.6	934.2		55
CL1E3-1A	SE of Lake Road and Woodbury Drive	892.9	893.2	895.6	892.7	893.1	894.2	895.8	893.3	894.0		60
CL1E3-1	SW of Lake Road and Woodbury Drive	892.9	893.2	895.0	892.7	893.1	893.9	895.6	893.3	893.9	891.7	6
CL1E2-1	NW of Lake Road and Woodbury Drive	892.9	893.1	894.3	892.7	893.1	893.5	894.7	893.3	893.7	891.7	26
North Tributaries												
CL1N6-1	SE of Valley Creek Road and Woodbury Drive	925.0	925.2	926.4	924.4	924.7	924.5	924.6	924.5	924.5	922.0	16
CL1N5-1	SE of Valley Creek Road and Woodbury Drive	918.1	918.1	918.9	917.6	917.9	918.2	918.8	917.6	917.9		15
CL1N4-1	SW of Valley Creek Road and Cottage Grove Drive	921.8	922.1	923.3	921.2	922.1	924.0	924.7	924.2	924.7	923.2	0
CL1N2-1	SE of Valley Creek Road and Woodbury Drive	894.3	894.6	895.9	893.5	894.2	894.5	895.8	893.6	894.1	891.7	13
CL1N1-1	SW of Valley Creek Road and Woodbury Drive	892.8	893.0	894.0	892.6	893.0	892.9	893.8	892.7	892.9	891.7	11
Bailey Lake												
Mainstem												
BL6-1A	NW of Bailey Road and Woodbury Drive	883.9	885.1	887.0	883.5	885.2	885.2	887.0	884.6	885.2	887*	259
BL6-1	NW of Bailey Road and Woodbury Drive	885.1	885.6	887.5	884.0	885.7	885.7	887.5	885.1	885.7	887*	167
BL5-1	NW of Bailey Road and Woodbury Drive	882.4	884.1	886.2	881.8	884.1	884.1	886.2	883.2	884.2	887*	101
BL4-1	Bailey Lake	871.4	871.5	871.8	871.3	871.6	871.5	871.8	871.4	871.6		99
BL3-1	SW of Dale Road and Woodbury Drive	870.9	871.0	871.2	870.8	871.0	871.0	871.2	870.9	871.0		99

Table D3. Peak Water Surface Elevations at Pond Locations Affected by AUAR
100-Year Summer Rainfall and Runoff Events
South Washington Watershed District
Northern Watershed XP-SWMM Model

Junction Name[1]	Pond Location	6.0 inch 24-hour Modeled Peak Water Surface Elevation[2]	6.3 inch 24-hour Modeled Peak Water Surface Elevation[2]	7.8 inch 24-hour Modeled Peak Water Surface Elevation[3]	9.3 inch 10 day Modeled Peak Water Surface Elevation[3]	10.6 inch 10 day Modeled Peak Water Surface Elevation[3]	6.3 inch 24-hour Modeled Peak Water Surface Elevation AUAR WSE[2]	7.8 inch 24-hour Modeled Peak Water Surface Elevation AUAR WSE[3]	9.3 inch 10-day Modeled Peak Water Surface Elevation AUAR WSE[3]	10.6 inch 10-day Modeled Peak Water Surface Elevation AUAR WSE[3]	Woodbury 1979 Stormwater Plan High Water Elevation[4]	6.3 inch 24-hour Peak Dishcharge[2] (cfs)
BL2-1	SW of Dale Road and Woodbury Drive	870.8	870.9	871.1	870.7	870.9	870.9	871.1	870.8	870.9		99
BL1-4	NE of Mile Drive and Dale Road	934.1	934.5	936.1	933.4	934.4	934.5	936.1	933.5	934.4	938.0	0
East Tributaries												
BL4E4-1	NE of Dale Road and Woodbury Drive	907.1	908.8	914.9	903.7	908.3	908.9	915.0	903.9	908.3	909.0	0
BL1E1-2	SE of Dale Road and Woodbury Drive	915.1	915.3	916.5	914.6	915.2	915.3	916.5	914.6	915.2	920.0	0
Bailey Lake												
West Tributaries												
BL5W3-1	NW of Bailey Road and Pioneer Drive	936.6	934.7	937.1	935.5	934.6	934.7	937.1	935.6	934.6	937.0	601
BL5W2-1	NE of Bailey Road and Pioneer Drive	936.6	933.7	933.2	935.5	933.6	933.9	933.5	935.6	934.1		32
BL1W4-1	SE of Bailey Road and Tower Drive	946.6	946.9	944.2	945.7	946.5	944.2	944.2	944.1	944.2	950.0	8
BL1W3-1	SW of Bailey Road and Mile Drive	926.1	926.1	926.6	926.1	926.1	926.4	926.6	926.2	926.3	926.0	9
BL1W1-1	SE of Bailey Road and Mile Drive	889.8	891.1	890.2	882.0	890.5	889.3	890.2	882.0	888.1		5

[1]Listed from Upstream to Downstream

[2]Value taken from XP SWMM model

[3]Value taken from XP SWMM model. For Comparison only. Refer to section 6.2.7.

[4]Elevation taken from Drainage Study Report (1979).

* multiple HDR nodes correspond to one 79 plan node

** multiple 79 plan nodes correspond to one HDR node