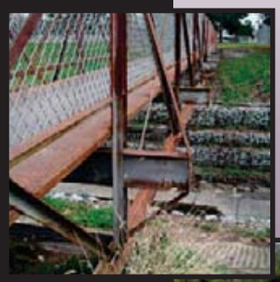

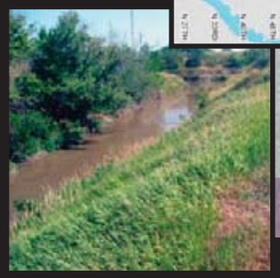

City of Lincoln, NE

Deadmans Run Watershed
MASTER PLAN

December 2007

Study Report

CDM

In association with:

Kirkham Michael
Applied Ecological Services
Mead & Hunt
Heartland Center

CDM

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Acronyms

AES	Applied Ecological Services
BCA	benefit-cost analysis
BCR	benefit-cost ration
BMP	best management practice
C	coefficient
CDM	Camp Dresser & McKee Inc.
CFU	colony forming units
CIPs	capital improvement projects
City	City of Lincoln
CMP	corrugated metal pipe
CN	curve number
CTP	cooperating technical partnership
CUP	Community Unit Plan
CWA	Clean Water Act
DEM	digital elevation model
DFIRM	Digital Flood Insurance Rate Map
E. coli	*Escherichia coli*
EGL	energy grade line
EPA	U. S. Environmental Protection Agency
FEMA	Federal Emergency Management Agency
FIS	flood insurance study
GIS	geographic information system
GPS	global positioning system
HC	Heartland Center for Leadership Development
HEC-HMS	Hydrologic Engineering Center's Hydrologic Modeling System
HEC-RAS	Hydrologic Engineering Center's River Analysis System
HSG	hydrologic soil group
K&M	Kirkham Michael Consulting Engineers
lb/ft^2	pounds per square foot
LOMA	Letter of Map Amendment
M&H	Mead & Hunt
Master Plan	Deadmans Run Watershed Master Plan
ml	milliliter
NDEQ	Nebraska Department of Environmental Quality
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
NRD	Natural Resources District
PER	preliminary engineering report
QMP-1	Quality Management Process Manual - 1
SCS	Soil Conservation Service
TIN	triangular irregular network
TMDL	total maximum daily load
TRC	technical review committee
TRM	turf-reinforced matrix
UDS	urban drainage study
USACE	U. S. Army Corps of Engineers
WQCV	water quality control volume

Executive Summary

Introduction

The City of Lincoln (City) and the Lower Platte South Natural Resources District (NRD) are in the process of developing a *Comprehensive Watershed Management Plan for the City of Lincoln* and its future growth areas. This comprehensive watershed plan is being developed basin by basin, through the completion of watershed master plans for individual basins. Watershed master plans are used as planning tools to be referenced in conjunction with future development and to serve as a guide in the preparation of capital improvement projects (CIPs). The City and NRD have previously adopted watershed master plans for the Beal Slough, Southeast Upper Salt Creek, and Stevens Creek basins (Figure ES-1 on the following page) and are now working on master plans for Cardwell Branch and Little Salt Creek watersheds.

To continue with the planning process, the City and NRD sponsored the Deadmans Run Watershed Master Plan (Master Plan) study. The primary goal of the study was to develop planning tools and comprehensive improvement projects that reduce the potential for street and building flooding, address existing erosion problems, and improve water quality. A diverse public participation program was implemented to gather input from the public and address citizen concerns, including the establishment of an 18-member Citizens Advisory Committee.

The Deadmans Run watershed study area is approximately 9 square miles located in the northeast portion of the City, as indicated on Figure ES-2. Deadmans Run, a right-bank tributary of Salt Creek, begins in the eastern part of the City. The Deadmans Run main channel flows northwest, ultimately draining into Salt Creek just downstream of Cornhusker Highway. The entire watershed is located within Lincoln's city limits and includes residential neighborhoods, the University of Nebraska East Campus, and commercial areas such as Westfield Shopping Center.

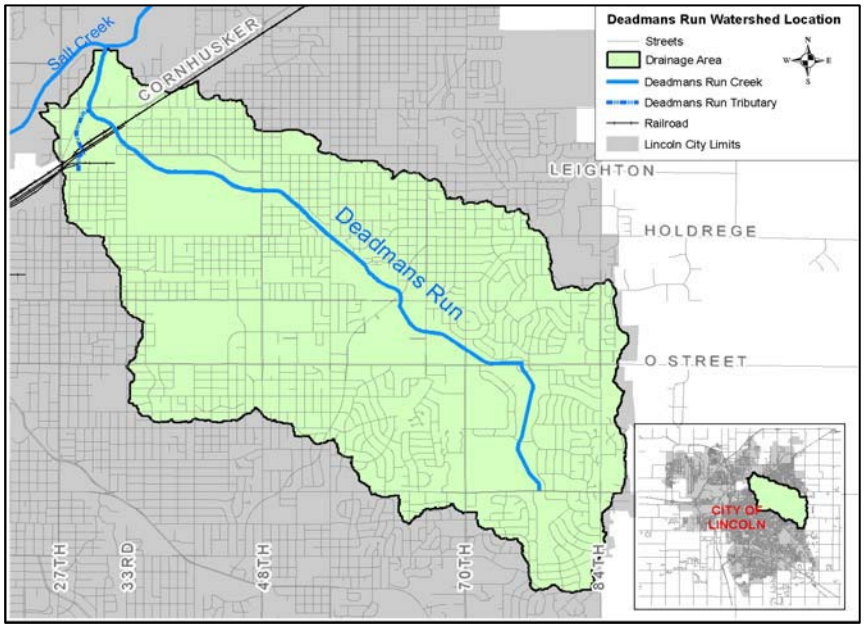


Figure ES-2
Deadmans Run Watershed Area Map

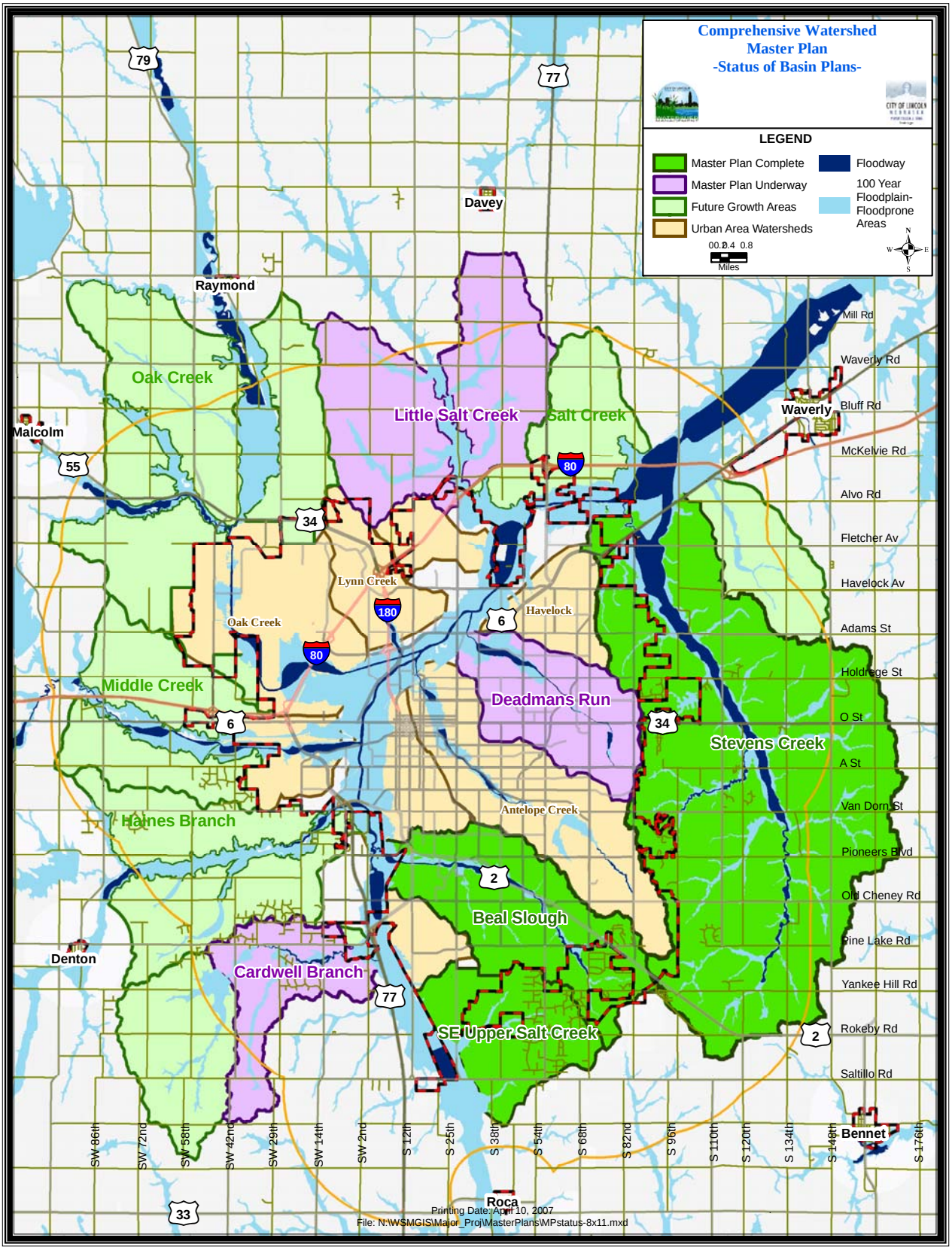


Figure ES-1
City of Lincoln Comprehensive Watershed Management Plan

Like many watersheds throughout the country, the Deadmans Run watershed is fully urbanized and contains a limited amount of open green space. As a result, the process of developing solutions to mitigate flooding becomes very challenging because of the physical limitations that significantly reduce the number of suitable locations for flood control projects. However, the improvement alternatives analysis used for this study focused on utilizing existing open space where available with the goal of minimizing stakeholder disruption.

The project team was led by the City and NRD. The City and NRD retained the consultant team of Camp Dresser & McKee Inc. (CDM), in association with Mead & Hunt (M&H), Applied Ecological Services (AES), Heartland Center for Leadership Development (HC), and Kirkham Michael to provide assistance with the planning effort.

Public Participation Process

As part of the master planning process, a comprehensive public participation process was used to solicit input from a broad range of stakeholder groups. The stakeholder groups included property owners, business community and environmental groups, and neighborhood representatives. The public participation process included the following:

- The involvement and input of an 18-member Citizen Advisory Committee representing a broad cross section of interests in the watershed, who met with the project team during a series of four meetings that began in November 2006 and ended in September 2007.
- A series of three open houses in June 2006, November 2006, and October 2007 that attracted over 200 people.
- A series of 10 information sessions with property owners and interested citizens regarding potential CIPs.
- A series of three newsletters mailed to over 4,200 individual residents and organizations. In addition, a project website was used to post alternatives under consideration, upcoming events, and materials distributed to the advisory committee.

The public input and feedback received during this process was used by the project team to formulate and refine its Master Plan recommendations. Section 1 of the Master Plan provides further details regarding the public participation process.

Master Plan Elements

The Master Plan consists of three major elements: (1) floodplain management tools, (2) capital improvement projects, and (3) benefit-cost analysis. A brief summary of each major element follows:

Floodplain Management Tools

One of the major elements of the Master Plan is updated 100-year floodplain and floodway boundary maps. This information will provide a planning tool to protect existing homes and businesses from potential flood hazards in the future. The Master Plan recommends the adoption of this information for local regulatory purposes. The Master Plan recognizes that these floodprone areas will be reflected on the Federal Emergency Management

Agency (FEMA) floodplain maps at some time in the future when FEMA finalizes the Flood Insurance Rate Map Physical Map Revision.

The study floodplain map is shown on Figure ES-3, which encompasses approximately 982 buildings within the floodplain limits. In the lower reach of the watershed along Huntington Avenue, the depth of potential flooding is 5 to 7 feet in many areas, which could result in significant property damage and potential loss of life if the 100-year storm occurred.

Capital Improvement Projects

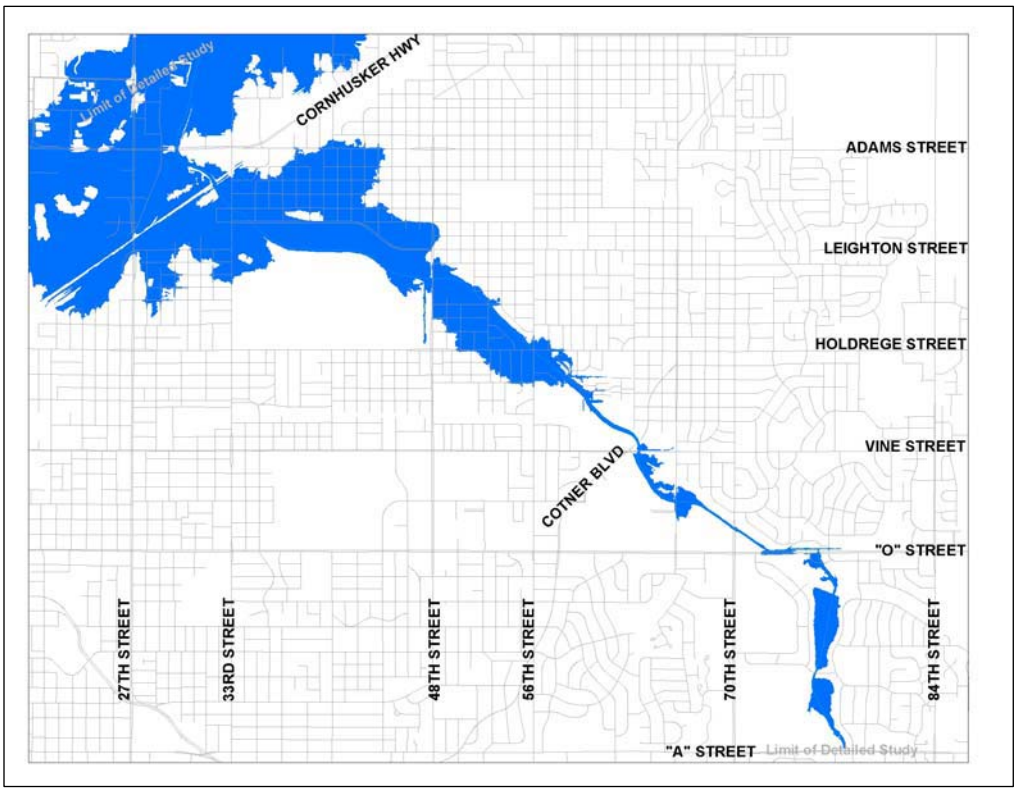
A comprehensive set of CIPs were developed to address flooding problems, severe stream erosion, and water quality issues. Problem areas were identified along the main channel of Deadmans Run that pose a serious public safety concern with respect to potential building flooding, street flooding, or stream instabilities. In addition, the study evaluated potential management strategies and projects to improve the quality of stormwater runoff. The overall goal was focused on utilizing existing open space to minimize stakeholder disruption.

As part of the project formulation process, improvement alternatives were evaluated based on physical limitations, design considerations, economic feasibility, stakeholder disruption, and the overall public benefit. The projects that were determined to provide measurable benefits were included as recommended projects.

The primary objective of the CIP development was to reduce future flood damages based on the 10-, 50-, and 100-year storm events. This resulted in a series of recommended projects that involve channel widening and bridge/culvert upgrades, which will significantly reduce the flood hazards along the main channel extending from the Salt Creek confluence to Vine Street. However, improving the channel and drainage structures will increase the peak flows along the main channel by eliminating overbank storage, which can cause adverse impacts downstream. Therefore, stormwater detention basin projects, which are designed to temporarily store and attenuate flood waters, are recommended to minimize the increases in peak flow rates.

The improvement projects to address stream erosion in the watershed focused on resolving critical stream instability issues along unlined portions of the main channel that have the potential to adversely impact buildings and public infrastructure. Regarding water quality, new structural best management practices (BMPs), retrofitting existing ponds with water quality features, end of pipe treatments, and stream stability measures were the primary focus (Section 6). The new structural BMPs were identified based on available open space in the watershed, while existing detention ponds were considered based upon opportunities for enhancements and proper location.

The evaluation process resulted in 13 capital improvement projects. The general location and the types of improvements are illustrated on Figure ES-4. The total conceptual level cost estimate for the 13 CIPs is approximately $50 million. Section 8 of the Master Plan provides further detail regarding the improvement projects.



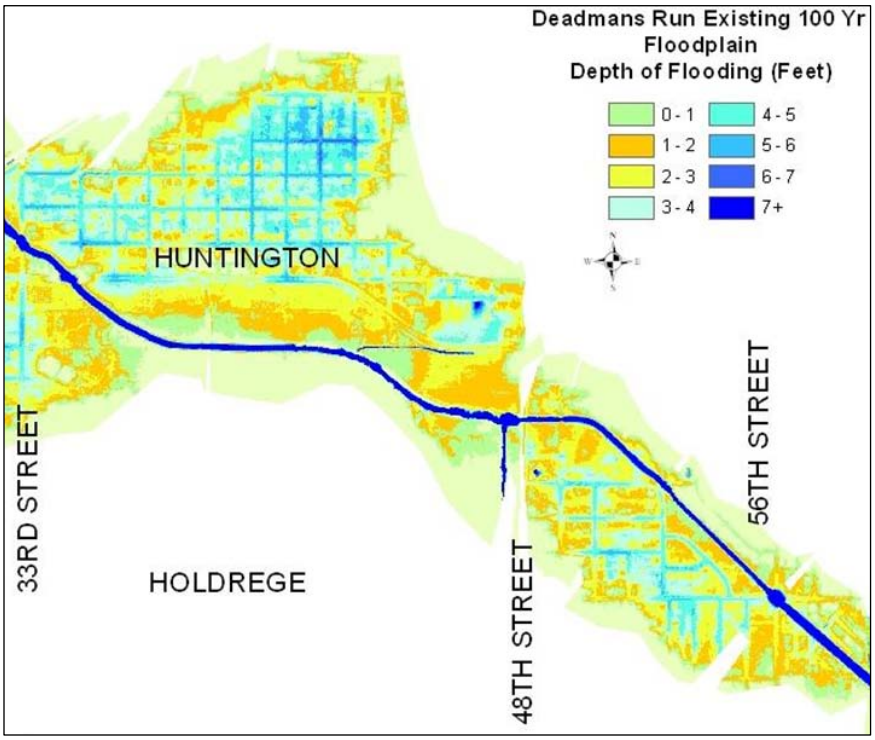


Figure ES-3
Floodplain Map and Depth of Potential Flooding

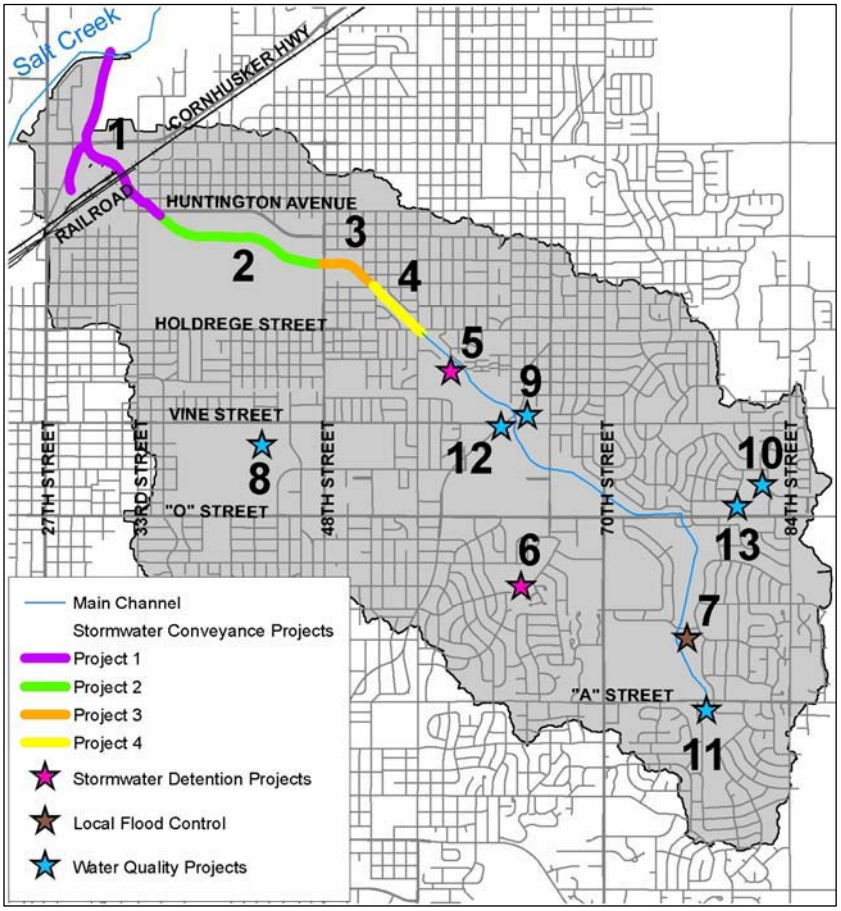


Figure ES-4
Conceptual Level Improvement Projects

The 13 CIPs are grouped into stormwater conveyance, stormwater detention, local flood control, and water quality based on their primary function. A brief description of each project is provided in Table ES-1.

The recommended projects accomplish the goals of reducing the potential for future flood damages, achieving stream stabilization, and improving water quality. The local flood control project (project 7) and water quality projects (projects 8 through 13) can be constructed independently of the other recommended projects. However, projects 1 through 6 are dependent on each other to ensure the net benefit of flood reduction is realized throughout the project area and that no adverse impacts occur downstream. Therefore, projects 1 through 6 are considered a watershed-based solution, which will require an implementation plan using construction sequencing. Section 10 of the Master Plan provides further details on CIP implementation.

In the portion of the watershed where the majority of the buildings are located within the floodplain, Figure ES-5 compares the study 100-year floodplain (existing conditions) with the potential 100-year floodplain after implementing projects 1 through 6. The total number of buildings taken out of the FEMA floodplain is 807 buildings, and another 175 buildings receive flood protection benefits.

Table ES-1
Deadmans Run Watershed CIP Summary

Project No.	Improvement Description	Estimated Project Cost
	Stormwater Conveyance	
1	Widening and reshaping the main channel from the Salt Creek confluence to Huntington Street. In addition, a portion of a west tributary near State Fair Park Drive will be improved. The improvements also include significant upgrades to several stream and railroad crossings. The implementation of this project will require close coordination with the Antelope Valley project to optimize community benefits.	$25,234,000
2	Widening and reshaping the main channel from Huntington Street to 48th Street. A combination of structural retaining walls and natural features will be used to minimize property impacts.	$9,198,000
3	Widening and reshaping the main channel from 48th Street to 52nd Street, using flood bench terraces. The improvements also include upgrading the 48th Street bridge and replacing the pedestrian crossing.	$2,474,000
4	Widening and reshaping the main channel from 52nd to 56th Street and upgrading stream crossings at both roadway locations.	$7,764,000
	Stormwater Detention Basins	
5	Constructing an off-line dry stormwater detention basin next to the main channel, to reduce the magnitude of floodwaters downstream.	$2,932,000
6	Constructing an in-line dry stormwater detention basin in Taylor Park to reduce the magnitude of floodwaters downstream.	$1,440,000
	Local Flood Control	
7	Installing an earth berm to mitigate a localized flooding problem.	$19,000
	Water Quality	
8	Modifying an existing pond located near Wyuka Cemetery to integrate water quality features.	$47,000
9	Installing a water quality stormwater facility within Bethany Park to improve water quality.	$113,000
10	Modifying two existing ponds located near Russwood Boulevard to integrate water quality features.	$35,000
11	Installing a water quality stormwater facility located immediately north of Trendwood Park to improve water quality.	$142,000
12	Installing a below ground hydrodynamic separator structure to remove trash and debris from stormwater runoff.	$237,000
13	Implementing stream stability measures to control erosion with Herbert Park.	$211,000
	Estimated Cost	**$49,846,000**

Benefit-Cost Analysis

Due to the magnitude of the recommended CIP program, specifically the watershed solution that consist of projects 1 through 6, a benefit-cost analysis was conducted to evaluate the economic feasibility of implementing these projects. The economic evaluation was conducted using a benefit-cost ratio (BCR) approach based on FEMA procedures.

The FEMA BCR procedure consists of determining whether the cost of the mitigation project today will result in sufficient flood damage reduction in the future to justify the capital investment of the project. If the benefit is determined to be greater than the estimated project cost, then the project is considered justified. However, if the benefit is less than the project cost, then the project is not considered cost-effective. Thus, the BCR, which is calculated by dividing the benefits by the costs, should have a value of 1.0 or greater to justify the economic feasibility of constructing large-scale improvement projects.

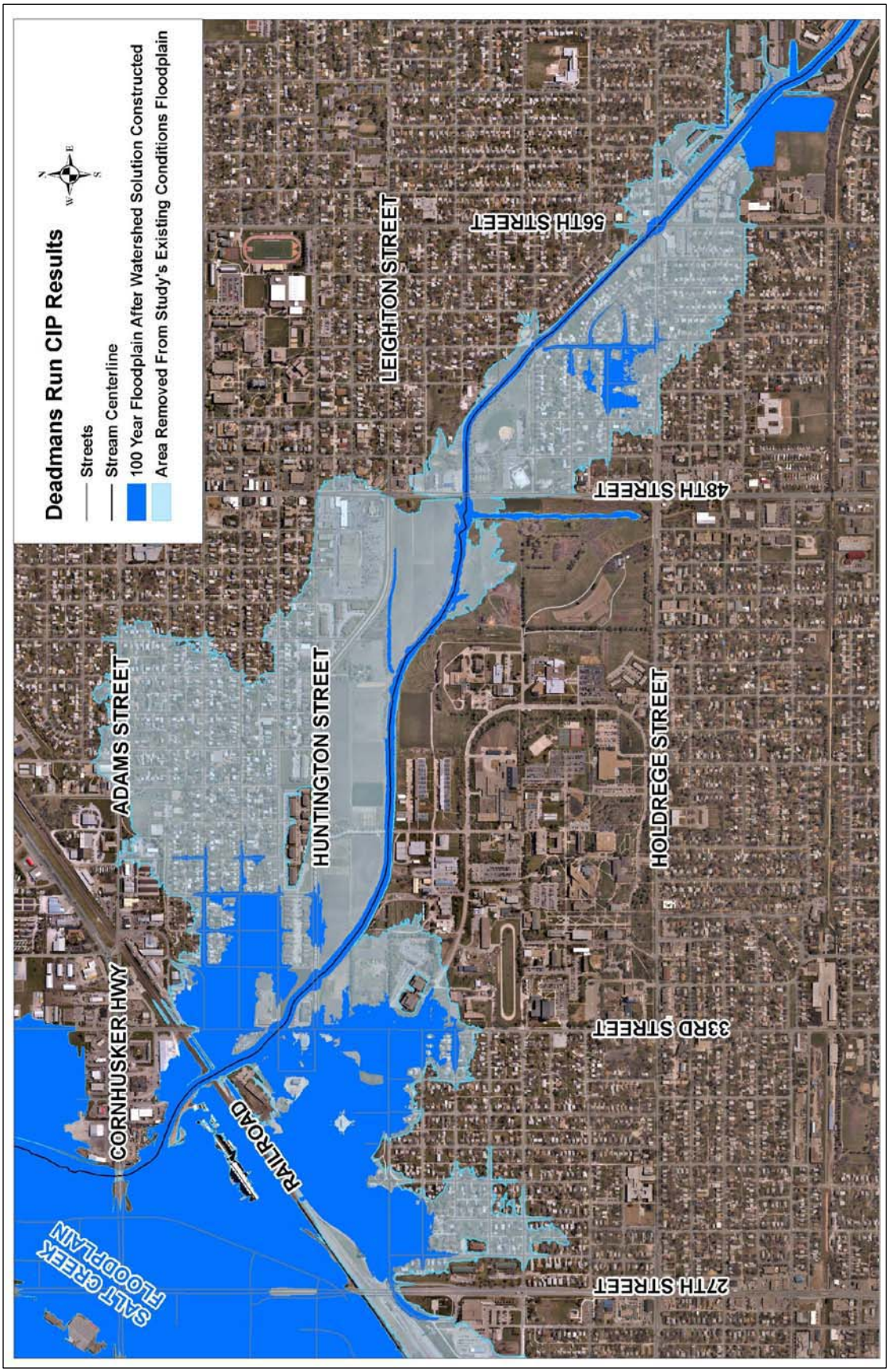


Figure ES-5
100-Year Floodplain Comparison

Significant losses suffered during a severe flood can be attributed to physical damages to building structures and their associated interior contents. The process of estimating physical damages is fairly straightforward using automated geographic information system (GIS) tools to estimate the severity of flooding associated with the various flood return intervals (i.e., 10-, 50-, and 100-year design storms). Conversely, the process of estimating economic and casualty losses, and emergency management costs, requires significant research, analysis, and assumptions. For this study, the goal was to develop a preliminary BCR based solely on physical damages since the data for this category was readily available, and because the projects are still conceptual and detailed economic information is not available.

For the Deadmans Run watershed solution (projects 1 through 6) a preliminary BCR value of 0.79 was estimated based solely on physical damages. Typically, if the BCR ratio is above 0.75 when only assuming physical damages, then the BCR will exceed 1.0 when the economic, casualty losses, and emergency management costs are factored into the calculations. Therefore, at this conceptual stage of the project formulation process, projects 1 through 6 appear to be economically viable.

Summary

The Deadmans Run Watershed Master Plan provides the necessary planning tools and CIPs to address flood management, stream stability, and water quality. The City and NRD should use this Master Plan as a reference and guide for the implementation of improvement projects in the Deadmans Run Watershed through the City Capital Improvement Programs and NRD's Long Range Implementation Plan. The agencies should use cooperative efforts to address project timing, prioritization between basins, and the sharing of responsibility.

By using the detailed study information and applying the Master Plan elements described above, multiple goals will be achieved including:

- Protection of future homes and businesses from flood hazards
- Reduction of potential future flood damages
- Long-term stream stability that protects public infrastructure
- Improvements to stream stability and water quality
- Improvements to aquatic and riparian habitat
- Opportunities for multiple benefits through an integrated approach to watershed planning
- Compliance with city, state, and federal regulatory requirements to protect and preserve water quality

Section 1
Introduction and Purpose

1.1 Introduction

The City of Lincoln, Nebraska (City) and the Lower Platte South Natural Resources District (NRD) are in the process of developing a *Comprehensive Watershed Management Plan for the City of Lincoln* and its future growth areas. This comprehensive watershed plan is being developed basin by basin, through the completion of watershed master plans for individual basins. Watershed master plans are used as planning tools and serve as a guide in the preparation of future capital improvement projects (CIPs). The City and NRD have previously adopted watershed master plans for the Beal Slough, Southeast Upper Salt Creek, and Stevens Creek basins (Figure 1-2 on the following page) and are now working on master plans for Cardwell Branch and Little Salt Creek watersheds.

To continue with the planning process, the City and NRD sponsored the Deadmans Run Watershed Master Plan (Master Plan) study. The primary goal of the study was to develop planning tools and comprehensive improvement projects that reduce the potential for street and building flooding, address existing erosion problems, and improve water quality. A diverse public participation program was implemented to gather input from the public and address citizen concerns, including the establishment of an 18-member Citizens Advisory Committee.

The Deadmans Run watershed study area is approximately 9 square miles located in the northeast portion of the City, as indicated on Figure 1-1. Deadmans Run, a right-bank tributary of Salt Creek, begins in the eastern part of the City. The Deadmans Run main channel flows northwest, ultimately draining into Salt Creek just downstream of Cornhusker Highway. The entire watershed is located within Lincoln's city limits and includes residential neighborhoods, the University of Nebraska East Campus, and commercial areas such as Westfield Shopping Center.

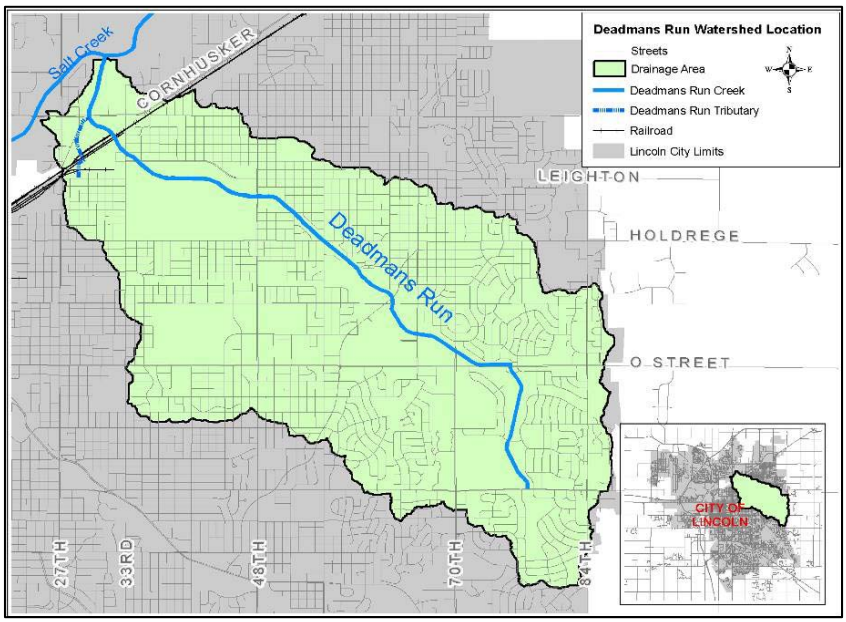


Figure 1-1
Deadmans Run Watershed Area Map

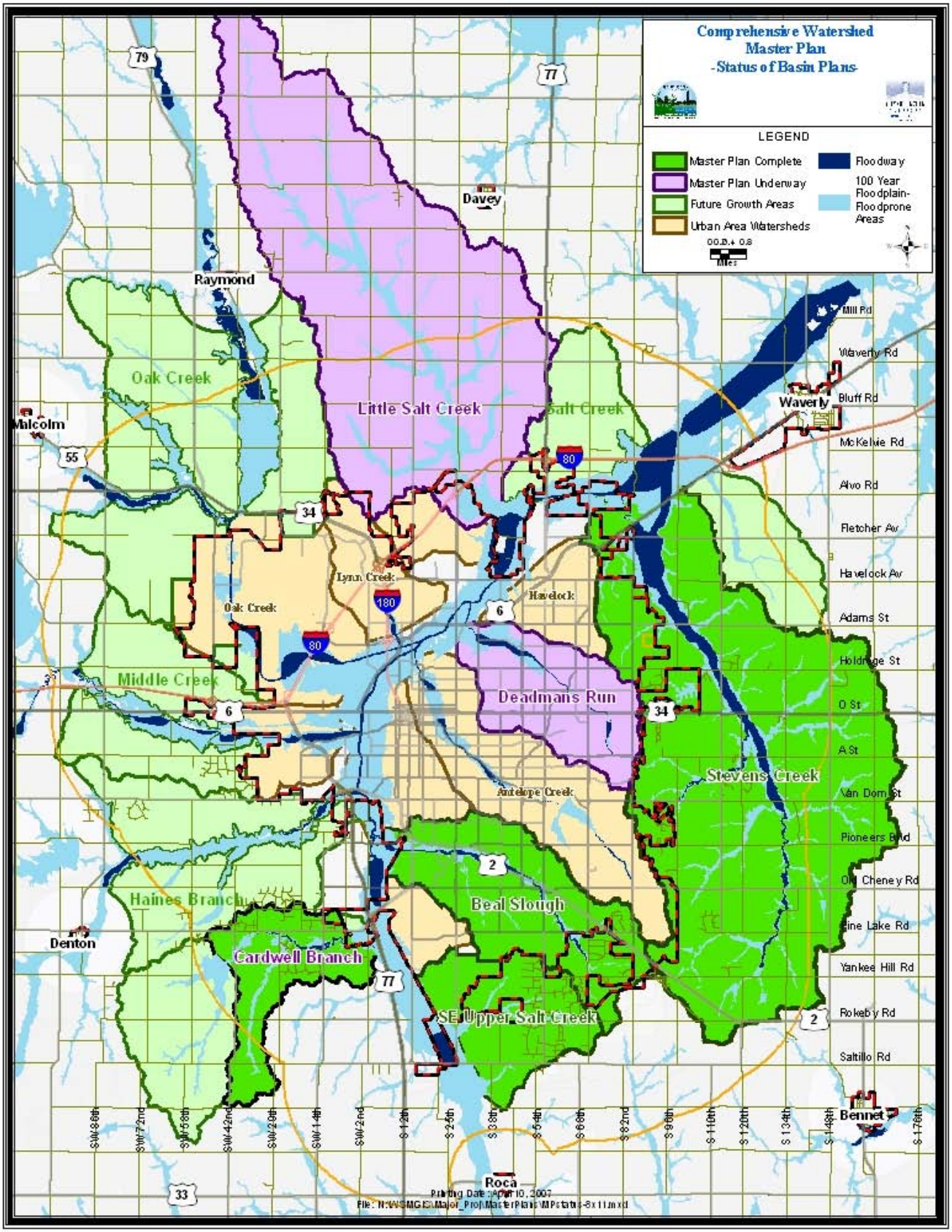


Figure 1-2
City of Lincoln Comprehensive Watershed Management Plan

Like many watersheds throughout the country, the Deadmans Run watershed is fully urbanized and contains a limited amount of open green space. As a result, the process of developing solutions to mitigate flooding becomes very challenging because of the physical limitations that significantly reduce the number of suitable locations for flood control projects. However, the improvement alternatives analysis used for this study focused on utilizing existing open space where available with the goal of minimizing stakeholder disruption.

The project team was lead by the City and NRD. The City and NRD retained the consultant team of Camp Dresser & McKee Inc. (CDM), in association with Heartland Center for Leadership Development (HC), Mead & Hunt (M&H), Applied Ecological Services (AES), and Kirkham Michael Consulting Engineers (KM).

1.2 Goals and Objectives

The goal of the Master Plan was to develop planning tools and improvement projects to address flood management, water quality, and existing erosion problems. While developing the improvement projects, the project team incorporated community input, developed cost-effective improvement solutions, integrated recreation and water quality components, protected infrastructure, minimized stakeholder impacts, and avoided any recommendations that would cause adverse impacts elsewhere in the watershed. The study included a wide range of services organized into the following major components.

Data Collection

- Watershed inventory to collect existing information applicable to the watershed
- Field survey to collect data describing the physical aspects of the drainage system

Hydrology and Hydraulics

- Computer models simulating the hydrologic and hydraulic aspects of the watershed, using subareas no larger than 150 acres at the upper reaches of the drainage system. The models included the U. S. Army Corps of Engineer's (USACE) Hydrologic Engineering Center's Hydrologic Modeling System program (HEC-HMS) and Hydrologic Engineering Center's River Analysis System program (HEC-RAS).
- Floodplain boundaries using HEC-GeoRAS that represent existing land use conditions. In addition, floodway boundaries were developed.
- Federal Emergency Management Agency (FEMA) submittal documents necessary for Digital Flood Insurance Rate Map (DFIRM) application.

Water Quality

- Reviewing previous water quality sampling performed by the University of Nebraska, Nebraska Department of Environmental Quality (NDEQ), and the City of Lincoln.
- Evaluating the Environmental Protection Agency (EPA) stormwater standards.
- Water quality assessment for the watershed including collecting and testing stormwater samples at two locations during two separate storm events.

Stream Stability

- Reviewing available aerial photographs, determination of meander geometry, initial analysis of allowable shear, and preparation of data collection reduction and analysis methodology.

- Geomorphic field investigation to document the condition of the stream.
- Geomorphic analysis to diagnose the stability of the stream.

Capital Improvement Projects

- Conceptual improvement projects to alleviate flooding and stream instability problems.
- Conceptual improvement projects to improve water quality, including structural best management practices (BMPs).

Public Participation

- Open houses and information sessions to disseminate information and solicit feedback from the public.
- Citizen advisory committee meetings to receive input from various interest groups and elected officials.
- Newsletters mailed to over 4,200 individual residents and study website designed to inform the public about the study and to post preliminary results.

Geographic Information System Services

- GIS products designed to enhance the usability of key study products.

1.3 Public Participation Process

Citizens and stakeholders were offered a variety of ways to provide input to the study and to contribute to the development of alternative concepts and solutions. Each public involvement activity provided the project team with ideas for presenting and refining its recommendation. A summary of the various components of the public participation process follows.

1.3.1 Open House Events

Information stations were used to ask questions

Three open house events were held during the study to present preliminary results and solicit input from the public. The events were advertised by sending postcards, displaying electronic digital billboards at several locations, announcements in the Sunday issue of the Lincoln Journal Star, broadcasting on the City's TV channel, and advertising on the City's watershed website. All three events followed the same general format consisting of formal presentations to discuss overall goals and preliminary results of the study. Following the formal presentations, participants were encouraged to visit information stations and to discuss their concerns with representatives from the project team. The first event was held at the Riley Elementary School, the second at Culler Middle School, and the third event at the Warren United Methodist Church. A summary of each open house event is provided below.

Approximately 107 citizens participated in the first open house held on June 29, 2006. The first open house was designed to discuss the overall goals and objectives of the study, timeline, as well as the public participation process to be conducted throughout the study effort. Following the formal presentations, participants were encouraged to visit four information stations set up around the room that provided watershed-specific information and the history of the watershed.

A total of 67 people attended the second open house held on November 16, 2006. The open house provided updated floodplain information that would subsequently be submitted to FEMA. In addition, the project team presented potential approaches to solving flooding issues in the watershed. Following the formal presentations, participants were encouraged to visit two information stations with hardboard maps that contained the updated floodplain information, as well as a kiosk with digital GIS information that allowed zooming into a specific area.

Nearly 50 people attended the third open house held on October 24, 2007. The third open house focused on presenting the Master Plan recommendations, including the CIPs that addressed flooding problems, stream instability, and water quality issues. The draft Executive Summary covering the various components of the study was available as a handout for all participants. Following the formal presentations, participants were encouraged to visit information stations covering the major Master Plan elements. In addition, participants were encouraged to fill out comment cards regarding the Master Plan recommendations. A copy of the submitted comment cards is provided in Appendix B of this report.

1.3.2 Citizen Advisory Committee

An important part of the study was the participation and review process of the Citizen Advisory Committee. At the first open house event, a nomination form was made available for those citizens interested in serving on the committee. The form was also made available on the study website.

Balancing interests, perspectives, and geography resulted in an 18-member group with City and NRD representatives. Roughly one-half of the group represented homeowners from the watershed, one-third represented the business community, and the remainder showed interests in environmental issues. The committee members included Mark Arter, Phil Bohl, Pam Brunke, Jennifer Dam, Joan Darling, Doug Emery, Scott Ernstmeyer, Luann Finke, Marleen Gordon, Russell Irwin, Russell Miller, Patte Newman, George Olson, Darryl Pederson, Barbara Standley, Dan Steinkruger, Richard Sutton, Erica Williams, and Ginny Wright. During the first meeting, the mission statement was provided to the group and is included below:

> *The Deadmans Run Advisory Committee represents neighborhood and community interests, and serves as a resource for the project team in the development of long-term planning tools and improvement projects to address flooding, stream stability, and stormwater quality in the Deadmans Run watershed. The Committee will serve on behalf of the citizens who live or work in the watershed, or are in any way impacted by the findings of this study, now and in the future. In an effort to build*

> *understanding, members are expected to share information among their constituencies and to act as a liaison between public interest and public policy.*
>
> *Committee members are charged with the careful review of existing data and new findings as study results are compiled by the project team. The Committee will provide input regarding recommendations forwarded by the project team. They will listen, ask questions, raise issues, and openly share information among one another, the public they represent, and the project team. As representatives of the community, they are asked to make every attempt to fully participate on a regular basis.*

The project team held a series of four committee meetings that began in November 2006 and ended in August 2007. The meetings were scheduled before other public events to disseminate the information to the committee before presenting it to the broader public. This allowed committee members to act as a liaison between the project team and the community they represented. Presentations and handouts were provided to the group that illustrated study findings, methodologies, and recommendations. A copy of the presentations, handouts, meeting minutes, and attendance records are provided in Appendix B.

1.3.3 Information Sessions

Ten separate information sessions were conducted to discuss special issues and impacts regarding potential capital improvement projects. The first eight sessions were held on April 16 and 17, 2007, with the goal of presenting specific CIP information to property owners that may be impacted by the projects. Each of the eight sessions was organized based on the location and type of potential CIPs. All eight meetings were held at the NRD building located at 3125 Portia Street in Lincoln. The meetings were conducted and facilitated by members of the project team with the goal of gathering feedback, answering questions, and addressing concerns. The feedback was then integrated into final Master Plan recommendations. The feedback summaries are provided in Appendix B of this report.

Two additional meetings were scheduled following the April information sessions to discuss CIP Project 5 (Section 8.4.2) and to gather input and concerns from the landowners including Lincoln Lutheran Schools and Chateau Properties, LLC. The meetings were of particular importance because of the necessity of the project and its impact on the implementation of other projects in the watershed. Members of the project team met with Lincoln Lutheran Middle/High School representatives on May 11, 2007. The meeting was conducted as a field visit to further understand concerns of the proposed dry detention facility within the school's existing open space. As a follow up to the field visit, additional information was provided, including examples of similar existing dry stormwater facilities throughout the region. In addition, a meeting with the Chateau Properties, LLC, who were unable to attend the April 2007 information session, was held on June 21, 2007, at the Chateau Apartments Leasing Office, 1025 N. 63rd Street.

The last information meeting was held on July 12, 2007, to further discuss the study's FEMA floodplain update process and results. Invitations were sent specifically to landowners whose properties were included in the study's updated floodplain but were not previously in the current effective FEMA floodplain. Similar to the second open house, a formal presentation provided an overview of the study while two information stations

provided hardboards with the floodplain results. In addition, a third station allowed zooming into a specific area using digital GIS information. The stations allowed property owners to determine if any structures on their property were included in the updated floodplain and to discuss next steps with the project team.

1.3.4 Newsletter and Website

CITY OF LINCOLN
NEBRASKA
MAYOR COLEEN J. SENG

WATERSHED NEWS
October 2006

A Publication Sponsored by
the City of Lincoln and the Lower Plate South Natural Resource District (LPSNRD)

DEADMANS RUN WATERSHED MASTER PLAN

The Deadmans Run Watershed, located in the heart of the City of Lincoln (City), has historically experienced flooding and erosion problems. During the past several years, the City and the Lower Plate South Natural Resources District (LPSNRD) have completed several channel stabilization and neighborhood drainage projects to mitigate these problems, while performing regular maintenance activities. To continue to build upon these past efforts, the City and the LPSNRD have embarked on a planning process to further evaluate the flooding and erosion problems while addressing water quality and integrating recreational opportunities.

The planning process involves the development of the Deadmans Run Watershed Master Plan. The Master Plan will identify improvement projects and other strategies to address street and building flooding, stream stability, and stormwater quality issues along the main channel of Deadmans Run (Figure 1). In addition, a diverse public participation program will be implemented to gather input from the public and address citizen concerns. The major components of the study include the following:

Update FEMA Floodplain Map. The Deadmans Run FEMA floodplain map was last updated in 1997. To properly evaluate potential solutions to reduce flooding hazards, the FEMA floodplain map will be updated using the latest computer modeling technology and topographic data.

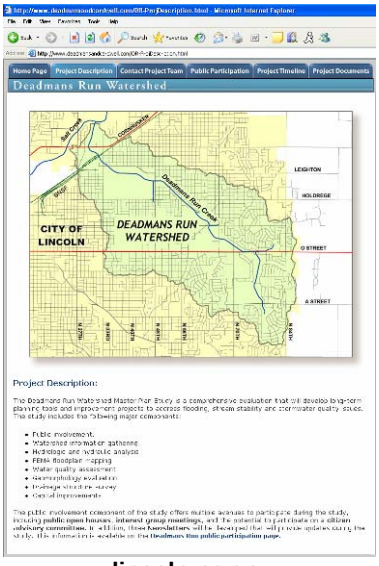
Address Stream Stability Issues. A stream stability assessment will be conducted for the natural channels within the watershed, with particular emphasis placed downstream of Cornhusker Highway, where significant erosion problems are present.

Figure 1

WATERSHED NEWS OCTOBER 2006

October 2006 Issue

Three newsletters (*Watershed News*) and a project website were used to disseminate information about the study process and Master Plan recommendations. Each newsletter edition was mailed to over 1,400 people and provided an effective means of informing the public about key aspects of the project. See Appendix B for a copy of each newsletter.



lincoln.ne.gov

The project website was another mechanism used to inform the public about the progress of the study. The website can be accessed by going to the City of Lincoln's website at lincoln.ne.gov, keyword "watershed." The website contains general background information, preliminary study results, and handout materials that were distributed at the open houses. The website was regularly updated throughout the study process and was used to advertise upcoming events.

Section 2
Data Collection and Development

2.1 Watershed Inventory

The watershed inventory consisted of reviewing existing information, developing digital datasets specific to the Master Plan development, and a drainage structure survey to fill data gaps. Known existing information was identified based on previous master plan studies and data collected by the City. The existing information collected during the study included:

- Existing land use and street network
- Existing floodway and flood fringe boundaries
- Existing hydrologic and hydraulic models
- Land ownership information
- Stream gage and precipitation data
- As-built plans for ponds and drainage structures/bridges
- City water quality data
- City of Lincoln Flood Insurance Study
- Historical photographs
- Color aerial photography
- U. S. Geological Survey LiDAR data (non-bare earth points)
- Corps of Engineers Section 22 Feasibility Study
- Corps of Engineers Hydrology/Hydraulics/Geomorphology Study for East Campus
- East Campus Geomorphology Study by Schemmer/Intuition & Logic
- Taylor and Herbert Park Geomorphology Study by Intuition & Logic
- City Drainage Manual
- Past public involvement correspondence
- Lancaster County soil map

Numerous new datasets were developed using GIS technology to organize the technical evaluations during the study and are included in Appendix A under GIS datasets. A description of each GIS dataset created during the study is provided below.

- **Bridge and Culverts/Detention Facilities** - This dataset includes shapefiles with the identification number, type, size, length, flow capacity, top of road profile, and invert elevation as well as the survey information gathered during the project. Also included in this folder are the scanned hardcopies of the design drawing data used in the hydraulic model analysis.

- **Known Problem Areas** - These datasets identify the location of CIPs and other areas evaluated that address issues for street and building flooding, existing erosion problems, and promoting water quality. The information was obtained by the project team during the CIP analysis.

- **Geomorphology Information** - These datasets summarize field information gathered by the project team to analyze the geomorphic processes within the natural stream reaches. Datasets include channel bar type and condition, bed and bank material, type and bed consolidation, channel profile and cross section information, erosion and mass wasting,

vegetative bank protection and condition of riparian corridor, outfalls, infrastructure crossings, location of stream reach photographs, shear values, location of knickpoints, debris jams, and fluvial process layers depicting meander adjustment, incising, widening, and stable channel.

- **Hydrologic Evaluation** - These datasets include the HEC-HMS model input files used during the hydrologic evaluation process. The files include time of concentration flow paths, subbasins, detention ponds, merged land-use and soils curve number files, and location of divergence nodes.

- **Hydraulic and Floodplain Information** - These datasets relate to the hydraulic model output and include the stream centerlines, the 100-year floodplain and floodway merged shapefile, floodplain shapefile for the 500-year floodplain, and the cross sections from the hydraulic models.

- **Benefit-Cost Analysis** - These datasets were used to develop the benefit-cost analysis described in Section 9. Shapefiles include structures impacted by the existing conditions floodplain as well as those impacted by the recommended CIP (Section 8). Also included are the depth grids used in the estimation of damages.

- **Water Quality Evaluation** - These datasets include the study's wet-weather evaluation sites as well as the City's NPDES program dry monitoring sites in shapefile format.

- **Fieldwork Photographs** - This dataset includes location of photographs taken throughout the watershed with a reference to the photo identification number.

Electronic Files

The electronic files associated with the study have been organized according to the following folder structure:

- Study Report and Appendix Information
- Public Participation, Field Work, and Survey Photographs
- GIS Datasets (as described above; can be accessed using ArcGIS)
- Hydrologic and Hydraulic Models

2.2 Drainage Structure Field Survey

A drainage structure field survey was conducted to obtain the necessary hydraulic data along the study reaches. The information was collected using global positioning system (GPS) to obtain the required elevations for each drainage structure. The drainage structures were categorized based on three types: bridges, culverts, and detention facilities.

52nd and Francis Street Bridge Crossing

- **Bridges** - The types of information collected for each bridge included a stream cross section to define the upstream face of the bridge opening, centerline profile of the bridge decking, low chord elevation of the bridge, physical characteristics of the support system, and photographs of the upstream face, downstream face, looking downstream, looking upstream, and piers.

Culvert extending beneath MoPac Trail just north of "O" Street

- **Culverts** - The types of information collected included a stream cross section immediately upstream of the culvert, centerline profile of the roadway crossing, upstream and downstream invert locations, opening dimensions, material type, wing-wall configuration, and photographs of the upstream face, downstream face, looking downstream, and looking upstream.

Carriage Hill Detention Facility near "A" Street and 84th Street

- **Detention Facilities** - Information was collected for detention facilities located within the watershed that provided watershed storage. The types of information collected included the location and dimensions of the inlet and outlet structures, dimensions of the emergency spillway, centerline profile of the detention embankment, a cross section of the emergency spillway at the embankment toe and crest, and representative photographs.

Table 2-1 summarizes each drainage structure surveyed, as well as those that contained useable design drawing information. Appendix A contains a CD-ROM that includes the electronically recorded survey data and photographs for each drainage structure.

2.3 Base Mapping

Two sources of topography data were used for the base mapping for this project. The City's 1997 2-foot contour information was used during the hydrologic evaluation. To use the contour information, it was converted to a digital elevation model (DEM) using ArcInfo technology. The base map used for the hydraulic model and floodplain mapping was created using ArcInfo technology by converting the City's 2003 bare earth LiDAR data into a triangular irregular network (TIN). The DEM and TIN are three-dimensional

Table 2-1
Drainage Structure Survey Data

Reach	Location	River Station	Structure Type	Topography Source
Main Channel	Cornhusker Highway	2709.360	Bridge	Design Drawing
Main Channel	Burlington Northern Railroad	4126.170	Bridge	Survey
Main Channel	Abandoned Railroad	4197.290	Bridge	Survey
Main Channel	33rd and Baldwin	4952.940	Culvert	Survey
Main Channel	Huntington Avenue	5589.235	Bridge	Survey
Main Channel	38th Street at UNL East	7270.680	Bridge	Survey
Main Channel	48th Street	10837.900	Bridge	Survey
Main Channel	University Place Park Pedestrian Crossing	11265.400	Bridge	Survey
Main Channel	52nd and Francis	12558.700	Bridge	Survey
Main Channel	56th and Holdrege	14241.100	Culvert	Design Drawing
Main Channel	Chateau Footbridge	16640.700	Bridge	Survey
Main Channel	Chateau Bridge	17220.000	Bridge	Survey
Main Channel	North Cotner	17987.720	Bridge	Design Drawing
Main Channel	Vine Street	18233.060	Bridge	Design Drawing
Main Channel	MoPac Bridge	18350.800	Bridge	Survey
Main Channel	66th Street	20033.400	Bridge	Design Drawing
Main Channel	70th Street	21766.300	Culvert	Survey
Main Channel	MoPac Bridge/NDOR Culvert	23300.600	Culvert	Survey
Main Channel	O Street	24232.900	Culvert	Survey
Main Channel	Corporate Drive	24530.000	Culvert	Survey
Main Channel	Bike Trail downstream of Wedgewood Lake	25322.800	Bridge	Survey
Main Channel	Englewood Drive	27591.500	Culvert	Survey
Main Channel	Bike Trail upstream of Englewood Drive	27815.300	Culvert	Survey
Main Channel	Bike Trail extended off Hickory Lane	28733.400	Culvert	Survey
Main Channel	Bike Trail downstream of Vine Street	18139.000	Bridge	Survey
Tributary	DMR West Trib Culvert into DMR Main Channel	100.548	Culvert	Survey
Tributary	Cargill RR Spur	1812.705	Bridge	Survey
Tributary	Burlington Northern Railroad	1953.561	Bridge	Survey
Tributary	OLB Railroad	2022.994	Bridge	Survey
Tributary	Lincoln Elevator and Feed Old Road owned by JAVA	2613.568	Culvert	Survey

representations of the ground topography. The 2003 LiDAR data are the more recent information and were assumed to represent existing conditions more accurately than the 1997 data. Because of the size of the watershed, the LiDAR data were not used in the hydrologic evaluation. The 1997 data were assumed to provide the required accuracy for the hydrologic evaluation. The creation of the hydrologic and hydraulic models is discussed in greater detail in Sections 3 and 4, respectively.

The quality control results, which evaluated the accuracy of the LiDAR TIN, were presented to the City and NRD under separate cover. In summary, the quality control analysis indicated that the data met the National Mapping Accuracy Standards criteria for vertical accuracy as a function of horizontal accuracy, as required in *Appendix A of the FEMA Guidelines and Specifications for Flood Hazard Mapping Partners*. Therefore, the LiDAR data were used for the Deadmans Run hydraulics evaluation and mapping process.

2.4 Water Quality Evaluation

The water quality evaluation consisted of reviewing previous water quality studies in the watershed and performing a limited water quality assessment on the main channel. The purpose of the review process was to become familiar with existing data, with the goal of building on past efforts. Two previous water quality documents were available, including the University of Nebraska's *Dry Weather Stormwater Monitoring* study published in September 2005 and a Masters of Science thesis, *The Storm Water Quality Evaluation of Livestock Runoff From East Campus Site.* Both studies are summarized in Section 6.4.

The purpose of the Master Plan's water quality assessment was to gather additional wet weather data along the main channel of Deadmans Run. Samples were collected in two locations, the 33rd Street crossing at Baldwin Street and the 70th Street crossing of Deadmans Run, as shown on Figure 2-1. Wet weather sampling was conducted during two separate storm events, the first on July 13, 2006, and the second on September 21, 2006. Grab samples were collected to quantify runoff pollutant concentrations. The results were used to evaluate various structural and nonstructural BMPs to address pollutants at their source and to provide treatment at regional locations.

2.5 Geomorphic Investigation

The geomorphic evaluation included a background analysis, field investigation, and geomorphic analysis for the stream reaches identified on Figure 2-1. The background analysis was performed using existing datasets, while the field investigation was used to gather the geomorphic information datasets summarized in Section 2.1. The purpose of the background analysis and field investigation was to characterize the natural stream segments with the goal of using the data to evaluate potential stream improvements to address erosive or excess sediment conditions.

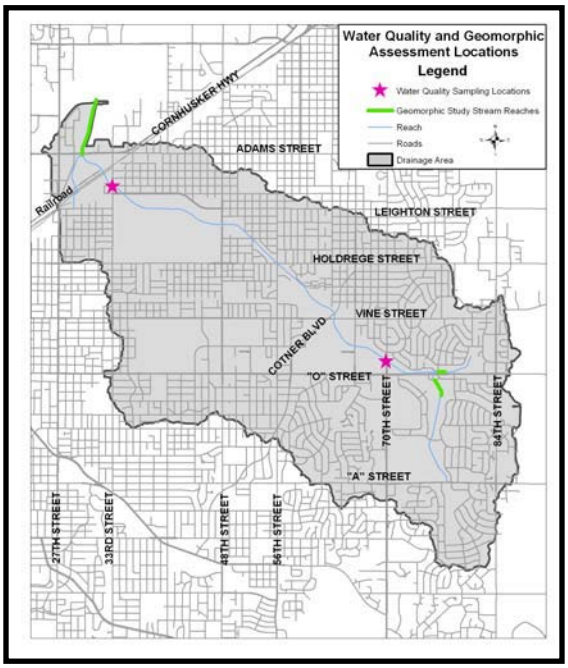


Figure 2-1
Water Quality and Geomorphic Assessment Locations

Section 3
Hydrologic Model Development

3.1 Introduction

This section provides a detailed description of the methodology used to develop the existing conditions hydrologic model for the Deadmans Run Watershed Study. The modeling was performed using USACE's HEC-HMS Version 3.0.

3.2 Hydrology Methodology

The HEC-HMS model was used to simulate runoff volumes and hydrographs resulting from design storms for 2-, 10-, 50-, 100- and 500-year return periods using the design storms outlined in the City's *Drainage Criteria Manual*. The hydrology methodology contains six primary components: subarea delineation, rainfall, runoff volume, runoff hydrographs, routing and storage.

3.2.1 Subarea Delineation

The Deadmans Run Watershed was delineated into approximately 40 subareas with an average area of 150 acres. Subarea delineation was initially performed using ArcView, HEC-GeoHMS, and DEM developed from the 1997 contour data provided by the City. The HEC-GeoHMS tool runs within ArcView and uses DEM to delineate subareas and to determine the overland flow path for each subarea. Another major advantage of using the HEC-GeoHMS tool was that it automates the HEC-HMS model development.

Using the HEC-GeoHMS tool, the approximate locations for subarea outlets, such as stream crossings, tributaries, and major lakes/ponds, were located using ArcView and available GIS data. The HEC-GeoHMS tool used these points to automatically delineate the subarea boundaries based on DEM. The preliminary HEC-HMS model was created based on the automated subbasin delineations.

The subarea boundaries were manually checked against contours, drainage structure locations, and the City's Urban Drainage Study (UDS) to accurately define the subareas based on the enclosed systems. The preliminary HEC-HMS model was manually modified to reflect updated subarea boundaries.

Subareas draining to Deadmans Run were given a unique alphanumeric name with the format DR-BB. "DR" is the two-letter code for the Deadmans Run Watershed. "BB" is a two-digit subarea number. Subarea names from the City's UDS were used to maintain consistency between the studies.

3.2.2 Rainfall

The Soil Conservation Service (SCS), now called the Natural Resources Conservation Service (NRCS), design storm with a Type II distribution was used to simulate rainfall events for each return interval. This method requires the rainfall depth for a storm duration of 24 hours. Table 3-1 summarizes the design rainfall depths for 24-hour events from the *City of Lincoln Drainage Criteria Manual* (*Manual*) dated February 22, 2000 (revised May 10, 2004) that were used in the HEC-HMS model. The peak intensity was derived by distributing the rainfall depth over a 24-

hour period using the Type II distribution and 6-minute increments. The peak intensity in inches per hour was calculated by multiplying ten 6-minute increments together. Extrapolations to the 500-year storm were conducted using the Gumbel distribution.

Table 3-1
Rainfall Duration Depths

Return Interval	Rainfall Depth (inches)	Peak Intensity (in/hr)
2-Year	3.00	3.31
10-Year	4.69	5.18
50-Year	6.00	6.62
100-Year	6.68	7.37
500-Year	8.05	8.89

3.2.3 Runoff Volume

The SCS curve number (CN) loss rate option in the HEC-HMS model was used to generate runoff volumes for each subarea. The SCS option uses an initial abstraction value and composite CN to estimate runoff volumes from each subarea for a particular design rainfall event.

Initial abstraction is defined as losses from rainfall before runoff begins. Initial abstraction is a function of the composite CN and is commonly calculated using Equation 1.

$$Ia = 0.2(1000/CN - 10) \qquad \text{Equation 1}$$

The CN is a function of the land use condition and hydrologic soil group (HSG). For each subarea, a composite CN was developed using GIS by overlaying the soils and land use coverages and spatially analyzing the percent of each surface type and soil condition in each subarea. Runoff CN tables from the *Manual* were used to assign a CN to each soil and land use combination. The CNs listed are for average antecedent runoff conditions.

Existing Land Use

For existing land use conditions, the digital land use data supplied by the City were used to determine a runoff CN. Figure 3-1 shows the existing land uses and Table 3-2 lists the percentage for each category. Table 3-3 shows the land use categories and the assigned CN value from the *Manual*. Several land use categories do not correspond directly with cover types located in the *Manual*. CNs for these land uses were assigned by determining an average percent impervious and calculating a composite CN.

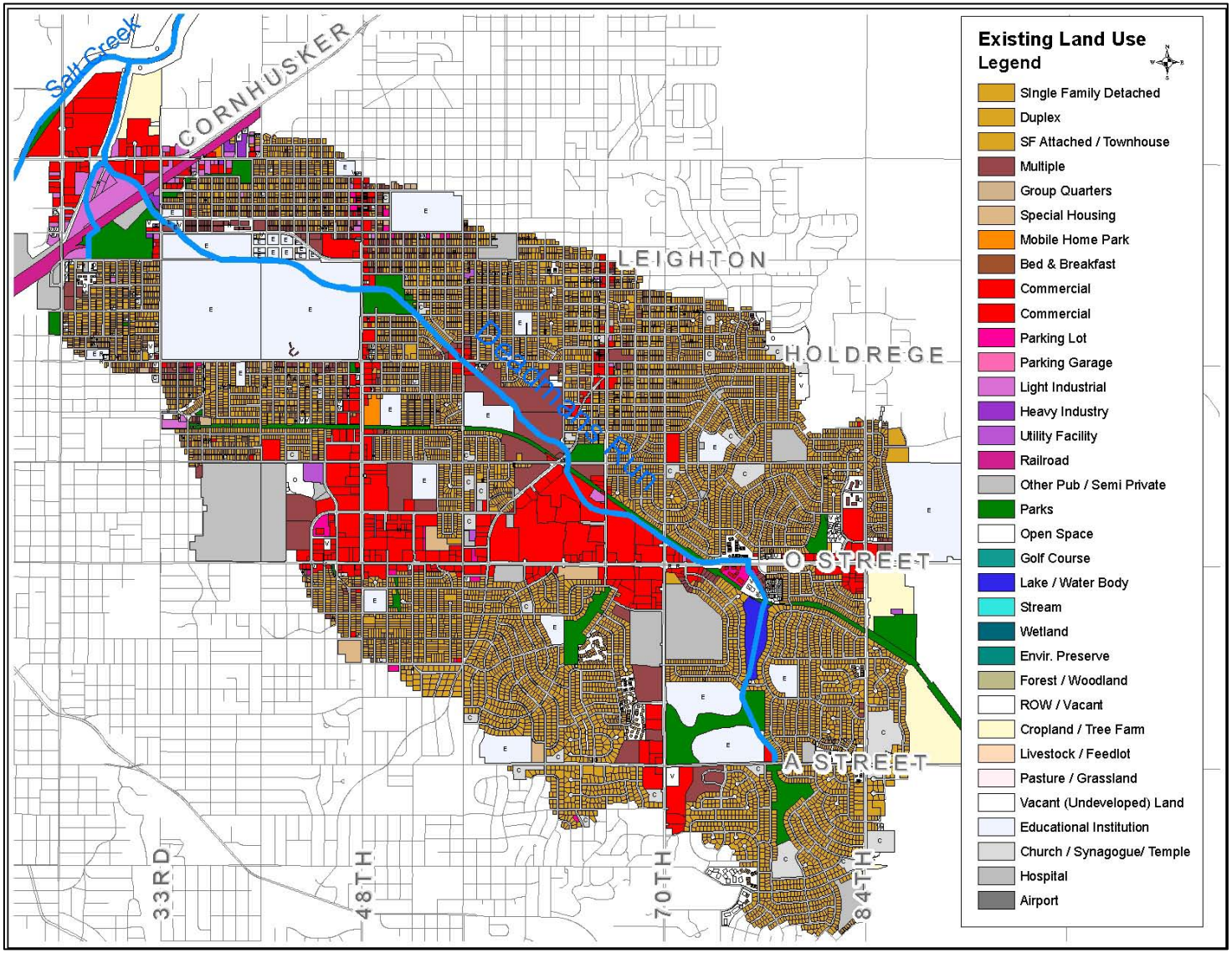


Figure 3-1
Deadmans Run Existing Conditions Land Use

Table 3-2
Existing Land Use Percentages

Land Use Category	*Percentage of Watershed Area*
Single Family (detached)	40.9
Educational Institution	12.9
Commercial NEC	12.0
Public and Semi	7.7
Apartments (w/number of units)	4.9
Park Land	4.8
Open Space	3.2
Agricultural Production: Crops/Tree Farm	2.2
Church, Synagogue, or Temple	2.1
Hospital	1.5
Railroad	1.4
Light Industrial	1.3
Vacant (Undeveloped) Land	1.1
Duplex	1.0
Stream/Creek	0.5
Attached Single Family (Townhouses)	0.5
Special Housing	0.5
Lake	0.4
Parking Lot (PL)	0.4
Utility Facility (e.g., communication tower)	0.2
Vacated ROW (retained by public entity)	0.1
Mobile Home including parks, courts (w/number of units)	0.1
Group Quarters	0.1
Heavy Industrial	0.1
Commercial w/Residential Unit(s) above	<0.1

As shown in Table 3-3, all agricultural land uses were designated a cover description of straight row crops in good hydrologic condition. Streams/Creeks, Lakes, and Wetlands were given a CN of 98. Land uses that do not correspond directly with a cover type were assigned a CN based on approximate average percent impervious and generally accepted engineering practice.

The category Single Family (detached) includes residential lots of varying sizes; however, the *Manual* CN tables have lot sizes broken into 1/8 acre, 1/4 acre, 1/3 acre, 1/2 acre, 1 acre and 2 acres. Single Family (detached) land use was assigned to one of these six land use CN categories based on the actual lot size. The lot size was calculated using GIS. For example, if a single-family (detached) land use parcel has an area of 1 acre, it was assigned a CN for 1- acre residential.

Table 3-3
Curve Numbers for Deadmans Run Watershed

Lincoln/Lancaster County Land Use	*Cover Type (% Imp)*	*HSG*			
		A	*B*	*C*	*D*
Agricultural Production: Crops/Tree Farm	Row Crops - Straight Row Good Condition	67	78	85	89
Airport	Compacted Soil	72	82	87	89
Apartments (w/number of units)	Residential 1/8 acre or less (65%)	77	85	90	92
Attached Single Family (Townhouses)	Residential 1/8 acre or less (65%)	77	85	90	92
Church, Synagogue, or Temple	Churches/Schools (75%)	84	89	92	94
Commercial NEC or w/residential above	Commercial and business (85%)	89	92	94	95
Duplex	Residential 1/8 acre or less (65%)	77	85	90	92
Educational Institution	Churches/Schools (75%)	84	89	92	94
Forest/Woodland	Woods - Fair Condition	36	60	73	79
Golf Course	Open Space - Good Condition	39	61	74	80
Group Quarters	Residential 1/8 acre or less (65%)	77	85	90	92
Heavy Industrial	Industrial (72%)	81	88	91	93
Hospitals	Churches/Schools (75%)	84	89	92	94
Lake and Wetlands	Water	98	98	98	98
Light Industrial	Industrial (72%)	81	88	91	93
Mobile Home including parks, courts (w/number of unit)	Residential 1/8 acre or less (65%)	77	85	90	92
Open Space	Open Space - Fair Condition	49	69	79	84
Park Land	Open Space - Fair Condition	49	69	79	84
Parking Lot (PL)/Street	Impervious (100%)	98	98	98	98
Pasture/Grassland	Pasture - Fair Condition	49	69	79	84
Public & Semi-Public NEC (e.g., cemetery)	Open Space - Fair Condition	49	69	79	84
Railroad	Gravel Covered Surface	76	85	89	91
Single Family (detached)	Residential 1/8 acre or less (65%)	77	85	90	92
	Residential 1/4 acre (38%)	61	75	83	87
	Residential 1/3 acre (30%)	57	72	81	86
	Residential 1/2 acre (25%)	54	70	80	85
	Residential 1 acre (20%)	51	68	79	84
	Residential 2 acres (12%)	51	68	79	84
Special Housing	Residential 1/8 acre or less (65%)	77	85	90	92
Stream/Creek	Water	98	98	98	98
Urban Residential	Residential 1/3 acre (30%)	57	72	81	86
Utility Facility (e.g., communication tower)	Commercial and business (85%)	89	92	94	95
VACANT (UNDEVELOPED) LAND	Open Space - Fair Condition	49	69	79	84
Vacated ROW (retained by public entity)	Open Space - Fair Condition	49	69	79	84

Hydrologic Soil Groups

HSGs by soil types were determined from the NRCS Lancaster County Soil Survey. Figure 3-2 shows the HSGs for the Deadmans Run Watershed. The HSG was used to assign a composite CN based on land cover for each subarea. Table 3-4 shows the soil types and their associated HSG for soils in Lancaster County, Nebraska. For soil types where HSGs are provided for drained and undrained conditions, the drained HSG was used to provide stormwater runoff values. For example, Colo soil type has an HSG designation of B/D where B is for drained conditions and D is for undrained. All Colo soils were categorized as having a HSG of B. Urban land complexes with mixed soil types used the more poorly drained complex. For example, the Crete-Sharpsburg (HSGs C-B) complex used an HSG of C.

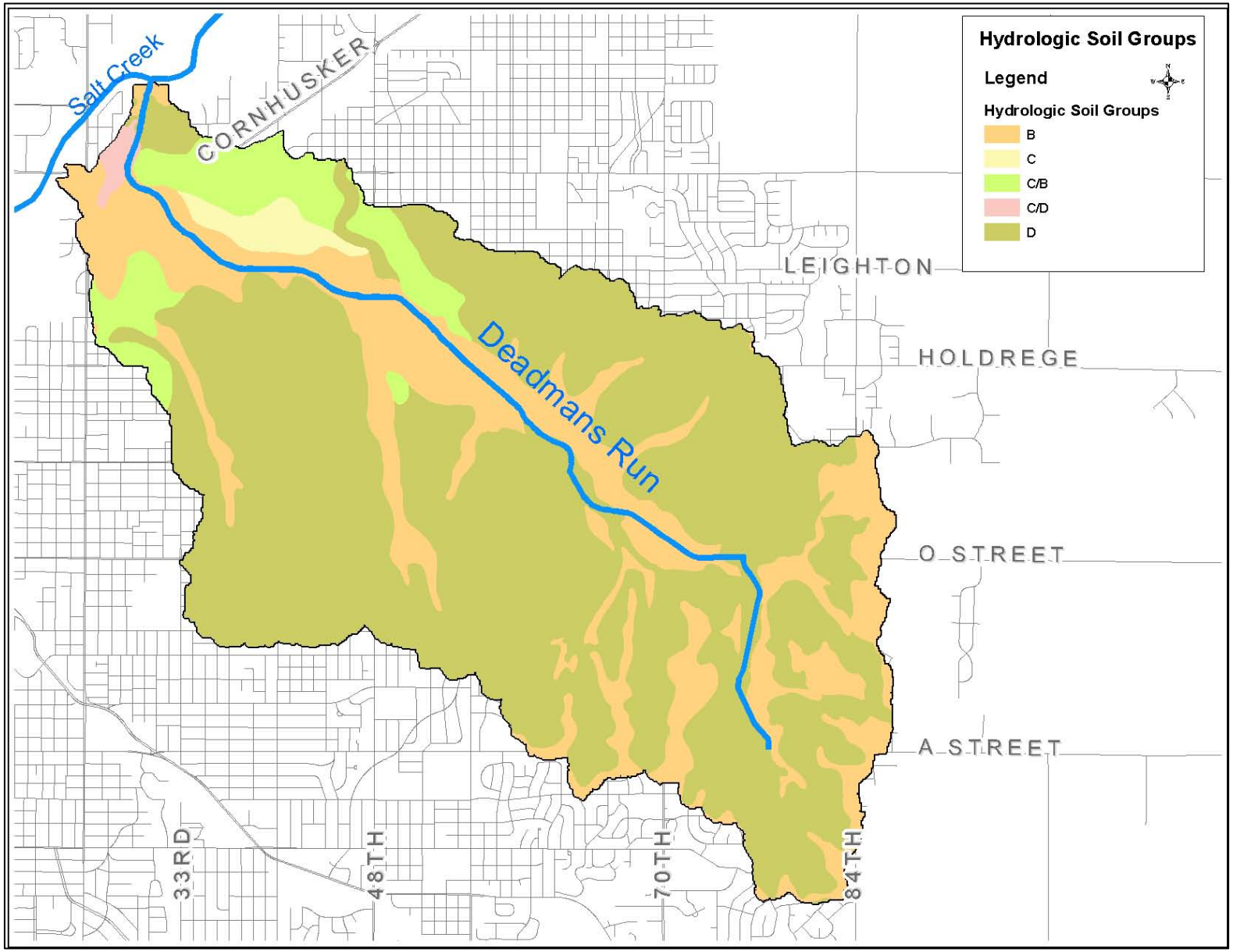


Figure 3-2
Deadmans Run Hydrologic Soil Groups

Table 3-4
Lancaster County Hydrologic Soil Groups

Soil Type	HSG	Soil Type	HSG	Soil Type	HSG	Soil Type	HSG
Aksarben	B	Fillmore	D	Nodaway	B	Wabash	D
Burchard	B	Geary	B	Pawnee	D	Water	D
Butler	D	Judson	B	Salmo	C/D	Wymore	D
Colo	B/D	Kennebec	B	Sharpsburg	B	Yutan	B
Crete	C	Malmo	D	Shelby	B	Zook	C/D
Crete-Sharpsburg	C/B	Mayberry	D	Steinauer	B		
Dickinson	B	Morrill	B	Urban Land	D		
Aksarben	B	Fillmore	D	Nodaway	B		

3.2.4 Runoff Hydrographs (Lag Time)

The SCS Dimensionless Unit Graph was used to distribute the runoff volume to a unit hydrograph. The determination of an SCS lag time was required for this method. Consistent with the methodology of TR-55, the lag time for a subarea was assumed to equal 0.6 times the time of concentration. The time of concentration, in turn, is defined as the time required for water to travel to the subarea outlet from the most hydraulically distant point in the subarea.

The time of concentration for each subarea was calculated using the methodology outlined in TR-55. For each subarea, the longest flow path to the subarea outlet was determined using DEM and ArcView/ArcInfo tools that divided the flow path into four elements:

- Sheet flow
- Shallow concentrated flow
- Secondary channel
- Primary channel

The travel times associated with each of the four elements were added to calculate the time of concentration for the subarea. The methodology described below was used to evaluate the existing surface conditions in the watershed.

Sheet Flow

Sheet flow is assumed to occur at the most hydraulically distant portion of the flow path. Using aerial photographs and contour data, the engineer estimated the sheet flow length. Physical data are required to calculate the travel time associated with sheet flow using the TR-55 methodology, including flow length, slope, and overland flow roughness coefficient. The sheet flow length was calculated using GIS. A composite overland flow roughness value was estimated by calculating a weighted roughness value using typical literature values for each surface condition and the length of sheet flow associated with each surface condition. The surface condition was determined from the aerial photos. Typical literature values are listed in Table 3-5. The engineer used Equation 2 to calculate whether the sheet flow length is acceptable. If the sheet flow length estimated using GIS does not conform to Equation 2, the engineer redigitized the sheet flow length until the equation was satisfied.

$$L <= (100*S^{0.5})/N \qquad \text{Equation 2}$$

Source: *Hydrologic Analysis and Design*, R.H. McCuen 2004

Table 3-5
Sheet Flow and Shallow Concentrated Flow Values

Surface Conditions	*Overland Flow Roughness Coefficient*	*Shallow Flow Paved/Unpaved*
Business-Heavy Commercial	0.06	Paved
Business-Light Commercial	0.08	Paved
Single Family I	0.23	Unpaved
Single Family II	0.17	Paved
Multi-Family Areas	0.13	Paved
Churches and Schools	0.10	Paved
Industrial-Light Areas	0.13	Paved
Industrial-Heavy Areas	0.09	Paved
Industrial-Parks, Cemeteries	0.22	Unpaved
Industrial-Railroad Yard	0.19	Paved
Undeveloped Areas (Permanent)	0.40	Unpaved
Impervious: Asphalt, Concrete, Roofs, etc.	0.011	Paved
Turfed	0.24	Unpaved
Wet Detention Basins	0.05	NA
Unknown Developed	0.17	Paved

Shallow Concentrated Flow

Shallow concentrated flow occurs between the areas of sheet flow and open channel flow. Shallow concentrated flow for urban areas may include gutters, swales, and sometimes small ditches. Open channels are assumed to begin where channels are visible on aerial photographs and include major conveyances, including creeks and rivers. To calculate the travel time associated with shallow concentrated flow by the TR-55 methodology, physical data including the shallow concentrated flow length, slope, and surface conditions along the path are required. Table 3-5 was used to derive a paved/unpaved coefficient (C) based on land use. Equation 3 was used to estimate the average velocity.

$$V = C*(Slope^{0.5}) \qquad \text{Equation 3}$$

The process for calculating the time of concentration for shallow concentrated flow was the same as performed for sheet flow.

Secondary Channel Flow and Primary Channel Flow

Secondary channel flow occurs between the end of shallow concentrated flow and the flow path intersection with the primary stream network, while primary channel flow occurs along the primary stream network to the subarea outlet. The primary stream network is the main channel of Deadmans Run and its tributaries that receive runoff from areas approximately 150 acres in size and greater. Depending upon location, a subarea may have one or both of these channel flow features. For example, a headwater subarea will probably include only flow length associated with the secondary stream network and none associated with the primary stream network.

Secondary channel flow in Deadmans Run Watershed includes storm sewers that convey only a small portion of large storm events. The rest of the peak flow travels by streets, lawns, and so on, to the outlet. Therefore, careful consideration of the hydraulic flow path and subsequent travel time were made. A pilot study within the watershed was analyzed to determine the impact of identifying secondary channel flow using the pipe network versus using overland flow of street grades. The pilot study results revealed negligible differences

between the subbasin times of concentration for each secondary channel flow. Therefore, the flow path for secondary channel flow was delineated based on overland topography and the pipe network.

For both primary and secondary channel flow, travel time was calculated based on flow path length and velocity. Manning's equation was used to estimate average flow velocity in open channels and pipe flow. Average flow velocity in open channels was determined for bank-full elevation, channel slope, and the cross-sectional geometry developed from the GIS. Average flow velocity in pipes was determined assuming pipes at full capacity. Slope data were calculated by using the upstream and downstream elevations of the stream or pipe segment length in GIS.

3.2.5 Routing (Muskingum-Cunge)

The Muskingum-Cunge Routing method was used to route runoff through the watershed. An 8-point channel cross section was developed for each routed reach using the ArcView profiler tool and the elevation contours. The channel length and slope were also determined using ArcView and DEM.

3.2.6 Storage

The following stormwater detention facilities that provide significant flood control storage, identified on Figure 3-3, were included in the HEC-HMS model as a reservoir hydrologic element:

- Wyuka Cemetery including the ponds at 46th and "R" Street, and 42nd and Vine Street
- Taylor Park attenuation near Taylor Park Drive and 66th Street
- Dialysis Center of Lincoln, Inc. detention facility at Sycamore Drive north of "O" Street
- Russwood Park north and south detention facilities near Russwood Boulevard and Trail Ridge Court
- Saint Elizabeth's detention facility at 70th Street and "L" Street
- Wedgewood Lake
- Carriage Hill near Coachmens Drive and Carriage Hill Court

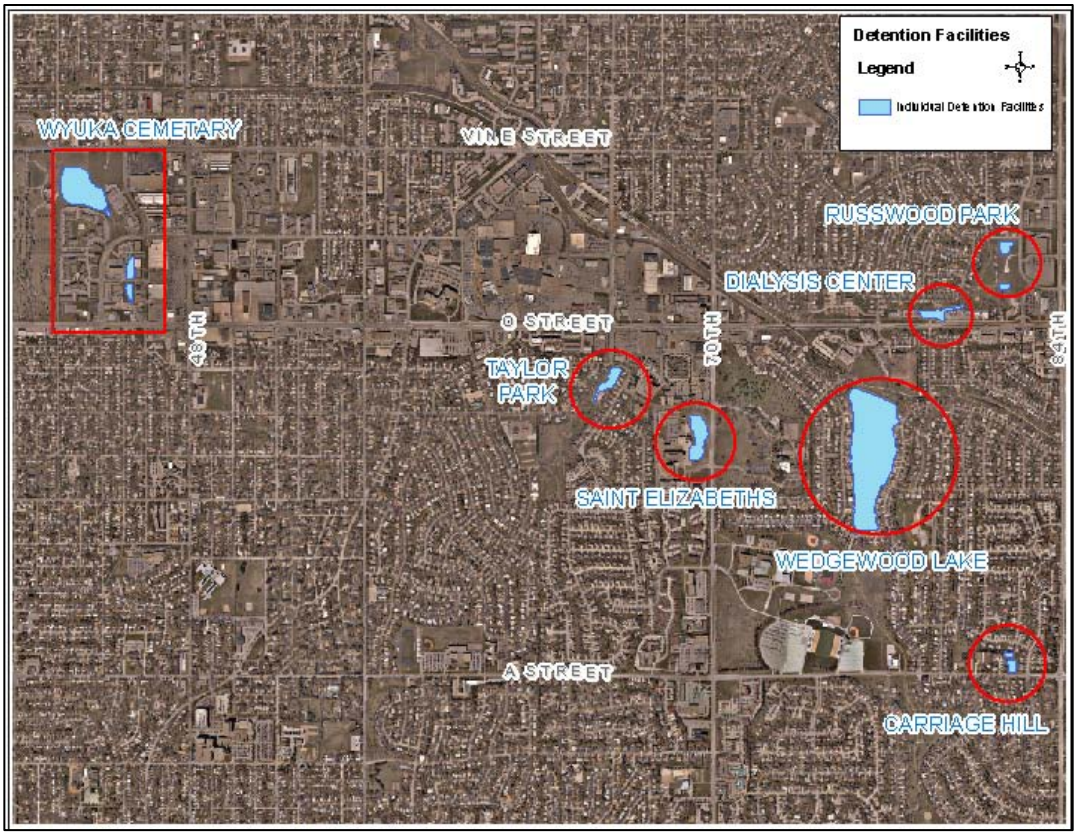


Figure 3-3
Stormwater Detention Facilities

3.2.7 Deadmans Run West Tributary

Available topographic data indicate the main channel may overflow the left overbank near 33rd and Leighton during high flows. The overflow is routed into a tributary that receives additional flow from contributing drainage. The tributary begins at 29th Street and Leighton Street and flows north draining under the railroad via a series of culverts approximately 1,500 feet to the southwest of the main channel. The tributary channel is routed approximately 2,000 feet downstream of the railroad culverts running parallel to State Fair Park Drive and ultimately discharging into Deadmans Run via a culvert just south of Cornhusker Highway. This tributary is referred to as the Deadmans Run West Tributary. Figure 3-4 depicts the tributary location, sources, and direction of flow.

The tributary receives two sources of inflow, contributing drainage and overflow from the main channel. The Deadmans Run West Tributary was included in both the hydrologic and hydraulic models to accurately represent the physical characteristics of the area. The hydrologic model routed the main channel without consideration of the overflow during high events (i.e., divergence nodes were not used in HEC-HMS). The hydraulic model incorporated the flow diversion from the main channel to the tributary by using an iterative process to balance stages between the two areas and is discussed in greater detail in Section 4.

Figure 3-4
Deadmans Run West Tributary

3.2.8 Flow Diversions

A total of five flow diversions were included in the HEC-HMS model where pipe networks crossed subbasin ridge lines. All pipe networks were considered, but only those that crossed ridge lines carrying more than 10 percent of the total peak flow from the drainage area were included in the hydrologic model. Rating curves for the pipe flow were calculated using Mannings equation for various flow depths within the pipe. Upon reaching maximum flow capacity within the pipe, the HEC-HMS model routed any additional flow based on overland flow topography.

3.3 Model Calibration and Verification

Precipitation information is available from the University of Nebraska's Institute of Agriculture and Natural Resources for a period of record spanning August 1986 to the present. However, because of insufficient stream flow data for the main channel, the HEC-HMS model was not calibrated using historical data. For verification purposes, the HEC-HMS model results were compared to the Lancaster County Flood Insurance Study (FIS), the City of Lincoln's UDS peak flows, the Army Corps of Engineers Section 22 report, Nebraska USGS regression equations, and rational method flows for the individual subbasins. Historical photos and eyewitness accounts of flooding during storm events were used in the verification process. The public open house meetings were used to facilitate the gathering of this information. Table 3-6 provides a comparison of the HEC-HMS results compared to effective FIS flow information at various locations along the main channel of Deadmans Run.

Table 3-6
100-Year Flow Comparisons

Location No.	Description	FEMA	HMS Model[1]	Percent Change
1	At mouth	9,660	9,078	-7
2	At 38th Street	8,410	8,193	-6
3	Below 48th Street	8,530	8,628	2
4	Above 48th Street	7,210	7,426	3
5	At Cotner	5,780	6,350	11
6	Below 66th Street	4,980	5,764	20
7	Above 66th Street	3,330	5,534	73
8	Below "O" Street	2,790	3,066	9
9	Above "O" Street	1,760	1,876	5
10	At "A" Street	1,360	1,007	-29

1 - Peak flow rates based on existing land use conditions

Table 3-6 reveals peak flows matching the previous FEMA FIS within 10 percent in many locations. Larger differences in peak flows, specifically at "A" Street and above 66th Street, can be attributed to the difference in drainage area delineations between the previous FEMA study and the HEC-HMS model, as shown in Table 3-7. Other discrepancies in peak flow were attributed to the use of updated FEMA tools and methods as well as a more detailed hydrologic analysis during this study.

Table 3-7
Drainage Area Comparisons

Location No.	Description	FEMA	HMS Model[1]	Percent Change
1	At mouth	9.3	9.6	3
2	At 38th Street	9.3	6.9	-25
3	Below 48th Street	6.9	6.6	-5
4	Above 48th Street	5.7	5.7	0
5	At Cotner	4.8	4.3	-11
6	Below 66th Street	4.0	3.6	-10
7	Above 66th Street	2.3	3.4	47
8	Below "O" Street	2.3	1.9	-17
9	Above "O" Street	1.2	1.2	3
10	At "A" Street	1.1	0.4	-61

1 - Peak flow rates based on existing land use conditions

3.4 Model Results

Table 3-8 presents the HEC-HMS modeling results under existing land use conditions. The stormwater peak flow rates are provided at the same major locations as reported in the Lancaster County FIS. The electronic copy of the final hydrologic model is included in Appendix A under the Computer Models, Hydrology folder. The peak flow rates under existing conditions were used as hydraulic model input as described in the following section.

Table 3-8
HEC-HMS Modeling Results

Location No.	Description	2-year	10-year	50-year	100-year	500-year
1	At mouth	3,127	5,853	7,933	9,078	11,823
2	At 38th Street	2,529	4,686	6,954	8,193	10,738
3	Below 48th Street	3,052	4,917	7,280	8,628	11,325
4	Above 48th Street	2,390	4,405	6,349	7,426	9,663
5	At Cotner	2,080	3,993	5,541	6,350	8,308
6	Below 66th Street	1,985	3,684	5,053	5,764	7,748
7	Above 66th Street	1,897	3,503	4,825	5,534	7,487
8	Below "O" Street	1,031	1,940	2,671	3,066	3,943
9	Above "O" Street	689	1,202	1,619	1,876	2,400
10	At "A" Street	330	637	880	1,007	1,261

Section 4
Hydraulic Model Development

4.1 Introduction

This section provides a description of the methodology used to develop the hydraulic model for the Deadmans Run Watershed study. The objective was to produce an accurate hydraulic model for both the floodway and floodplain that reflects the inherent complexities in local topography and provides an effective tool for the City to use while addressing flood issues. The hydraulic model was used to simulate the watershed's primary stream network based on existing land use conditions and estimate water surface elevations for the design storms described in Section 3. The hydraulic modeling was performed using USACE's HEC-RAS Version 3.1.3 steady state option.

The following paragraphs present guidelines for developing the watershed HEC-RAS model and include:

- HEC-RAS model parameters
- Procedures for developing HEC-RAS model parameters and creating the Deadmans Run HEC-RAS model
- Procedures for modeling the Deadmans Run overflow
- Procedures for modeling hydraulic structures
- Procedures for using steady state flow option
- Procedures for defining the floodway
- Procedures and data used for model calibration
- Procedures for technical review and quality control of the hydraulic model
- Procedures for mapping the hydraulic model results
- Procedures for submitting results to FEMA

4.2 HEC-RAS Model Development

HEC-RAS model data requirements can be summarized into nine model parameters. Table 4-1 lists the nine parameters and the methods used to develop the data requirements. As shown in Table 4-1, the model parameters were developed using a combination of manual procedures and automation tools using ARC/INFO, ArcView GIS, and HEC-GeoRAS in conjunction with GIS data.

Table 4-1
HEC-RAS Parameter Development

HEC-RAS Model Parameter	*Development Method*	*Data Requirements*
Stream network	ArcView GIS	Stream centerline coverage with unique stream reach names
Cross sections (river station and geometry data)	ARC/INFO and HEC-GeoRAS	Triangular irregular network (TIN), cross section cut line coverage
Downstream reach lengths (channel and overbanks)	ARC/INFO and HEC-GeoRAS	Stream centerline and overbank (left and right) flow path coverage
Manning's n-values	ARC/INFO	Mannings n-value assigned using orthophotos and field observations
Roadway crossings	Manual input using field survey data and as-built information	Roadway profile and bridge or culvert opening
Expansion and contraction coefficients	Manual input using standard values and engineering judgment	Contours and cross section cut line coverage
Normal depth boundary conditions	ArcView GIS	Contours, stream centerline, and cross section cut line coverage
Ineffective flow areas	Manual input using standard procedures and engineering judgment	Contours and cross section cut line coverage
Channel bank stations	Manual input using standard procedures and engineering judgment	Cross section geometries (station and elevation data)

The paragraphs below describe the HEC-RAS model development procedures.

4.2.1 Stream Network, Cross Sections, and Reach Lengths

The first step in developing the HEC-RAS model was to create a HEC-RAS geometry file containing the stream network, cross section river stations and geometries, and channel and overbank downstream reach lengths. The stream network defines the extent of the model and can be defined as the main channel extending from "A" Street to the confluence with Salt Creek. Cross section river stations define the location of the cross section along the stream in feet measured from the Salt Creek confluence while cross section geometry includes station and elevation data. Downstream reach lengths define the distance to the next downstream cross section along the stream reach and along the left and right overbanks.

This study used HEC-GeoRAS in conjunction with ArcView GIS to prepare an ASCII text file that is directly imported by HEC-RAS, creating a geospatially referenced HEC-RAS geometry file. HEC-GeoRAS is a free software program developed by USACE HEC.

HEC-GeoRAS uses the following data to create the ASCII text import file:

Triangular Irregular Network

The TIN was created from the Lincoln/Lancaster County LiDAR information (2003) using ARC/INFO. The TIN is a surface representing the ground topography and is used in conjunction with the cross section cut line coverage to develop station and elevation information for cross section geometry data. A ground surface elevation was recorded at each station along the cross section cut line that crosses the TIN edge.

Stream Centerline Coverage

The stream centerline coverage was manually digitized in ArcView GIS to represent the thalweg of the main channel. HEC-GeoRAS requires a river name and reach name be

assigned to each line segment. For the purpose of this study, the river name was assigned "Deadmans Run" and the reach name was assigned "main channel."

Cross Section Cut Line Coverage

The cross section cut line coverage is a GIS line coverage that identifies the location and extent of each cross section. The cross section cut line coverage was generated in ArcView GIS. Cut lines were placed in the same location as the effective FIS cross sections if the placement was deemed correct. Additional cut lines were located along the stream centerline at points that represent the average geometry of the stream reach and at changes in geometry, slope, channel, overbank roughness, and discharge. Available aerial photographs and contour information were used to lay out the cross section cut lines. The FEMA 500-year floodplain boundary was used as a guide in determining the extent of the cross sections. The average distance between cross sections was approximately 400 feet, with less distance between cross sections in the vicinity of structures and abrupt changes in channel geometry. The cross section cut lines are oriented from left to right looking downstream. Each cross section was identified by the stream name, reach name, and river station. The river station for each cross section is the cumulative distance from the model outfall in feet.

Overbank Flow Path Coverage

The overbank flow path coverage is a GIS line coverage that represents the average left and right overbank flow paths between each cross section. The overbank flow path coverage was used to determine the downstream reach lengths for the left and right overbanks. The FEMA 500-year floodplain boundary and the contour information were used as a guide to locate the overbank flow paths. In general, the overbank flow path was located on each side of the stream halfway between the 500-year floodplain boundary and the channel bank. In areas where the 500-year floodplain is contained within the channel, the location of the overbank flow path was following the top of the channel bank.

4.2.2 Manning's n-Values

The Manning's n-values at each cross section were estimated using digital aerial and field photographs. Manning's n-values are assigned with the purpose to represent land surface characteristics identified in Table 4-2. The initial n-values were used as a model starting point and were adjusted within the provided ranges during calibration. Horizontally varied Manning's n-values were input in the HEC-RAS model to capture changes in land use spanning the cross section.

Table 4-2
Land Surface Characteristics and Associated Manning's n-Values[1]

Land Surface Type	*Initial n-Value*	*Range of n-Value*
Grass, urban and maintained	0.030	0.025 to 0.035
Trees and brush	0.090	0.035 to 0.160
Brush	0.060	0.035 to 0.160
Residential areas[2]	0.150	0.035 to 10
University of Nebraska East Campus (developed area)[2]	0.100	0.035 to 10
Agricultural, Pasture	0.035	0.025 to 0.050
Agricultural, Cultivated Areas	0.040	0.020 to 0.050
Pavement	0.020	0.013 to 0.025
Lake	0.025	0.0160 to 0.033

1. Source: *Open Channel Hydraulics*, Chow 1959.
2. These n-values will be used in developed areas to account for the loss of conveyance caused by buildings.

The overbank n-values were increased where buildings are located within the floodplain to account for conveyance loss. The n-values in these areas may range

from 0.030 for areas with few buildings to 0.15 for fully developed areas. If significant blockage is caused by buildings in the flood fringe, the developed areas were modeled as ineffective flow.

Channel n-values were manually adjusted using the HEC-RAS cross section data editor. A combination of digital aerial photos, field photographs, and site visits was used to select an appropriate n-value. Table 4-3 lists channel descriptions and associated ranges of n-values used for Deadmans Run.

Table 4-3
Channel Descriptions and Associated Manning's n-Values[1]

Channel Description	*Initial n-Value*	*Range of n-Value*
Fabriform Mattress[2] - clean channel and sidewalls	0.025	0.020 to 0.030
Fabriform Mattress - rock gabion, grass sidewalls	0.030	0.025 to 0.035
Fabriform Mattress - brush in channel, sidewalls	0.040	0.030 to 0.500
Natural, clean, straight	0.030	0.025 to 0.033
Natural, straight channels, weeds	0.035	0.030 to 0.040
Natural, clean, meandering	0.040	0.033 to 0.045
Natural, meandering, weedy	0.045	0.045 to 0.050
Natural, sluggish, weedy	0.070	0.050 to 0.080
Natural, very weedy, floodways with heavy timber and underbrush	0.100	0.075 to 0.150

1. Source: *Open Channel Hydraulics*, Chow 1959
2. Source: Construction Techniques, Incorporated (CONTECH)

4.2.3 Roadway Crossings and Dams

Bridge and culvert openings and roadway profiles were developed from data collected during field surveys. Field data were collected based on monument and GPS controls using standard field survey collection forms. These data were manually entered into the HEC-RAS model that was created using HEC-GeoRAS.

HEC-RAS requires four cross sections to be entered to define each hydraulic structure. The four cross sections include a downstream cross section where flow is fully expanded, a cross section at the downstream face of the structure, a cross section at the upstream face of the structure, and an upstream cross section before flow contraction. All four cross sections were cut from the LiDAR TIN. Where available, survey information was used to supplement the LiDAR topography at the upstream and downstream face cross sections.

The flow lengths between the bridge cross sections and the upstream and downstream cross sections were determined using ArcView GIS. The drainage structure location in river feet was estimated by intersecting the stream network coverage with structure cut lines.

Table 4-4
Expansion and Contraction Coefficients[1]

Transition Type	*Expansion Coefficient*	*Contraction Coefficient*
Gradual	0.3	0.1
Roadway Crossing	0.5	0.3
Abrupt	0.8	0.6

1. Data from *HEC-RAS Hydraulic Manual*, Page 3-20

4.2.4 Expansion and Contraction Coefficients

The expansion and contraction coefficients were estimated based on the ratio of expansion and contraction of the effective flow area in the floodplain occurring at cross sections and at roadway crossings. Typical coefficients used in the model are listed in Table 4-4. The expansion and contraction coefficients were input manually using the HEC-RAS cross section data editor.

4.2.5 Boundary Conditions

Normal depth was used as the downstream boundary condition. This boundary condition requires the input of the energy grade line (EGL) slope at the downstream boundary. The downstream EGL slope can be approximated as the channel invert slope from the contour data. Therefore, the slope between the two most downstream cross sections was used to calculate the normal depth boundary condition for each reach. This slope was calculated in ArcView GIS using the elevation contour data, cross section cut line coverage, and stream centerline coverage.

4.2.6 Ineffective Flow Areas

Ineffective flow areas were determined using the cross section plots and contour information. The following situations required the use of the ineffective flow area option:

- Floodplain areas significantly below the top of the channel bank that are not hydraulically connected to the channel downstream.
- Floodplain areas within the hydraulic shadow of roadway encroachments caused by contraction and expansion of flow through the bridge or culvert openings. These will be estimated using 4:1 expansion and 1:1 contraction ratios.
- Floodplain areas within the hydraulic shadow of other obstructions or irregularities in the stream valley floodplain.
- Floodplain areas that are significantly blocked by buildings.

Ineffective flow areas were input manually using the HEC-RAS cross section data editor.

4.2.7 Channel Bank Stations

The bank stations were located and entered manually by graphically editing the cross sections within HEC-RAS. The bank stations were verified by comparing samples of channel bank stations from the field survey, the GIS-generated cross section geometries, and conditions during field reconnaissance.

4.3 Modeling Deadmans Run West Tributary

The Deadmans Run West Tributary discussed in Section 3.2.7 used the same procedure described above to develop the a separate hydraulic model for this area; however, at cross sections where flow has overtopped the main channel, each reach's cross sections were clipped to avoid double accounting conveyance. The hydraulic model incorporated the flow diversion from the main channel to the West Tributary by using an iterative process to balance stages between the two models. Flows along the main channel were systematically modified along with the West Tributary flows, keeping the total flow constant, until the flood stage is equal on both reaches. The Deadmans Run West Tributary model was created to refine the main channel flood stages and was not mapped as a separate tributary.

4.4 Steady Flow Water Surface Profiles

Stream profiles were developed depicting the 2-, 10-, 50-, 100-, and 500-year water surface elevations. With the exception of the area near the West Tributary discussed on the previous page, flow change locations were coordinated with HEC-HMS junctions and input into HEC-RAS at geographically correct load points.

4.5 Floodway Determination

A floodway was modeled for the Deadmans Run main channel. The floodway is determined from the floodplain model by encroaching the left and right overbanks of each cross section to produce a target rise in water surface elevation. The encroachments simulate fill within the floodplain that reduces conveyance of flood flows.

A 1-foot rise criterion was used to determine the encroachment stations at each cross section. Initially, Encroachment Method 4 was used to estimate encroachment stations at each cross section. Encroachment Method 4 automates the floodway modeling process by computing the encroachment station so that conveyance within the encroached cross section (with a target water level) is equal to the conveyance of the natural cross section at the natural water level. The higher water level for the encroached cross section was specified as a fixed amount above the natural profile. A target increase of 1.0 foot was used for this analysis. Once the encroachment stations were determined by HEC-RAS using Encroachment Method 4, each cross section was reviewed and adjusted if necessary to meet the target 1-foot rise.

The downstream boundary condition for the floodway model was the same normal depth that was used to calculate the 1-percent-annual-chance natural flood profile. In addition, the main channel floodway determination adjacent to the Deadmans Run West Tributary used the clipped cross sections and the final flow (after the iterative analysis) described in Section 4.3.

4.6 Model Calibration and Verification

Precipitation information is available from the University of Nebraska's Institute of Agriculture and Natural Resources for a period of record from August 1986 to the present. However, because of the lack of any stream gauge information along the main channel, the HEC-RAS model was not calibrated using historical water surface elevation data.

The HEC-RAS model results were verified by comparing the results to any available high water marks or historical aerial photos. In addition, information obtained from public meetings was used to verify the model results.

4.7 Quality Control

After the HEC-RAS model was developed, a computer program called CHECK-RAS was used to check the reasonableness of the HEC-RAS data to verify that the model assumptions and results meet FEMA requirements and the limitations of the HEC-RAS program.

CHECK-RAS consists of five checking routines:

- NT (Manning's roughness coefficients and transition loss coefficients)
- XS (cross sections)
- Structures
- Floodways
- Profiles

The HEC-RAS model was checked using each of the five routines. All warnings and errors that occurred were evaluated by the engineer to determine if modifications were warranted.

4.8 HEC-RAS Product

Two separate HEC-RAS models were created, one for the main channel and the other for the West Tributary. Both models and the resulting output water surface elevations are included in Appendix A under the Computer Models, Hydraulics folder. In addition, the design data for each modeled drainage structure are provided in Appendix C. The CHECK-RAS review comments and flow loading discussed in Section 4.4, as well as the flow iterations used to develop flow inputs to the HEC-RAS model near the West Tributary, are included in tabular format in Appendix A under the same folder.

Section 5
Floodplain Management Tools

5.1 Floodprone Areas

One of the major elements of the Master Plan is the updated 100-year floodplain and floodway boundary maps. This information provided the most up-to-date tools to protect homes and businesses from flood hazards and provide guidance for any additional development in the watershed. In addition, this component of the Master Plan reflects the conclusions of the Mayor's Floodplain Task Force, which recommended that the City continue to develop a comprehensive watershed approach to floodplain mapping using the latest technology and data available to keep the City's FEMA floodplain maps as accurate and reliable as possible.

The current FEMA Deadmans Run floodplain maps were based on a study completed by USACE and officially adopted for regulatory purposes in 1997. Through the City's Cooperating Technical Partnership (CTP) program with FEMA, the floodplain maps were updated as part of the Master Plan study process. The Master Plan study required the most recent modeling tools to update the floodplain boundary and to evaluate flooding issues. The floodplain boundary is delineated along the main stem of Deadmans Run and includes stream reaches that were previously mapped by FEMA. The study floodplains are referred to as "floodprone areas." These floodprone areas will be reflected on the FEMA floodplain maps at some time in the future when FEMA finalizes the Flood Insurance Rate Map Physical Map Revision and it is adopted by the City.

The study floodplain maps were submitted to FEMA in April 2007 for preliminary review and comment. The FEMA review process could potentially take several months to more than a year following the final submittal to FEMA and will include a public comment period. The comment period typically includes a FEMA-hosted public meeting before the maps become officially adopted. In the interim, the City intends to use study floodplains for the purposes of regulating the floodprone areas until the FEMA approval adoption process is finalized.

5.1.1 Flood Insurance Certificates

The study's updated floodplain map encompasses approximately 982 buildings within the floodplain limits. Flood elevation certificates were offered to individuals whose properties were located near the outer edge of the flood fringe to verify whether the buildings were in fact located within the study's updated floodplain. Notification letters were sent to property owners to notify them of this one-time offer. The completed flood elevation certificate will be submitted as needed to FEMA. A community-wide Letter of Map Amendment (LOMA) will be completed by FEMA after the maps have been adopted.

5.1.2 Floodplain Delineation Process

The 100- and 500-year floodplain were mapped for the Deadmans Run main channel using HEC-GeoRAS, which is a set of procedures, tools, and utilities for processing geospatial data in ArcView GIS. The HEC-GeoRAS post-processing was used to generate spatially accurate floodplain boundaries. The floodplain boundaries were delineated based on the

GIS data and HEC-RAS results. A manual quality control review was conducted to verify the accuracy of the automated process.

The confluence of Deadmans Run with Salt Creek was not simulated with the HEC-RAS computer model. Per FEMA requirements, stream confluences are to be simulated with HEC-RAS only if coincident peaks occur, which is not the case within this watershed. To accurately map the Deadmans Run floodplain at the confluence of Salt Creek, a level pool process was performed. A comparison of the draft updated Salt Creek DFIRM, which is currently under FEMA review, was made with the Deadmans Run model results and the higher controlling flood stage was mapped. In general, the 100-year floodplain north of the railroad near Cornhusker Highway is controlled by Salt Creek.

5.1.3 Study Floodplain and Floodway Maps

Figure 5-1 represents an overview map depicting the entire watershed divided into two floodplain maps. The study floodplain maps are based on existing land use and infrastructure as described in Section 3. Figure 5-2 and Figure 5-3 provide additional detail and a comparison of the extents of the current effective FEMA floodplain with the study's updated 100-year floodplain. In addition to the floodplain extents, Figure 5-4 provides illustration of the depth of flooding in the lower reach of the watershed along Huntington Avenue. The depth of potential flooding is 5 to 7 feet in many areas, which could result in significant property damage and potential loss of life if the 100-year storm occurred.

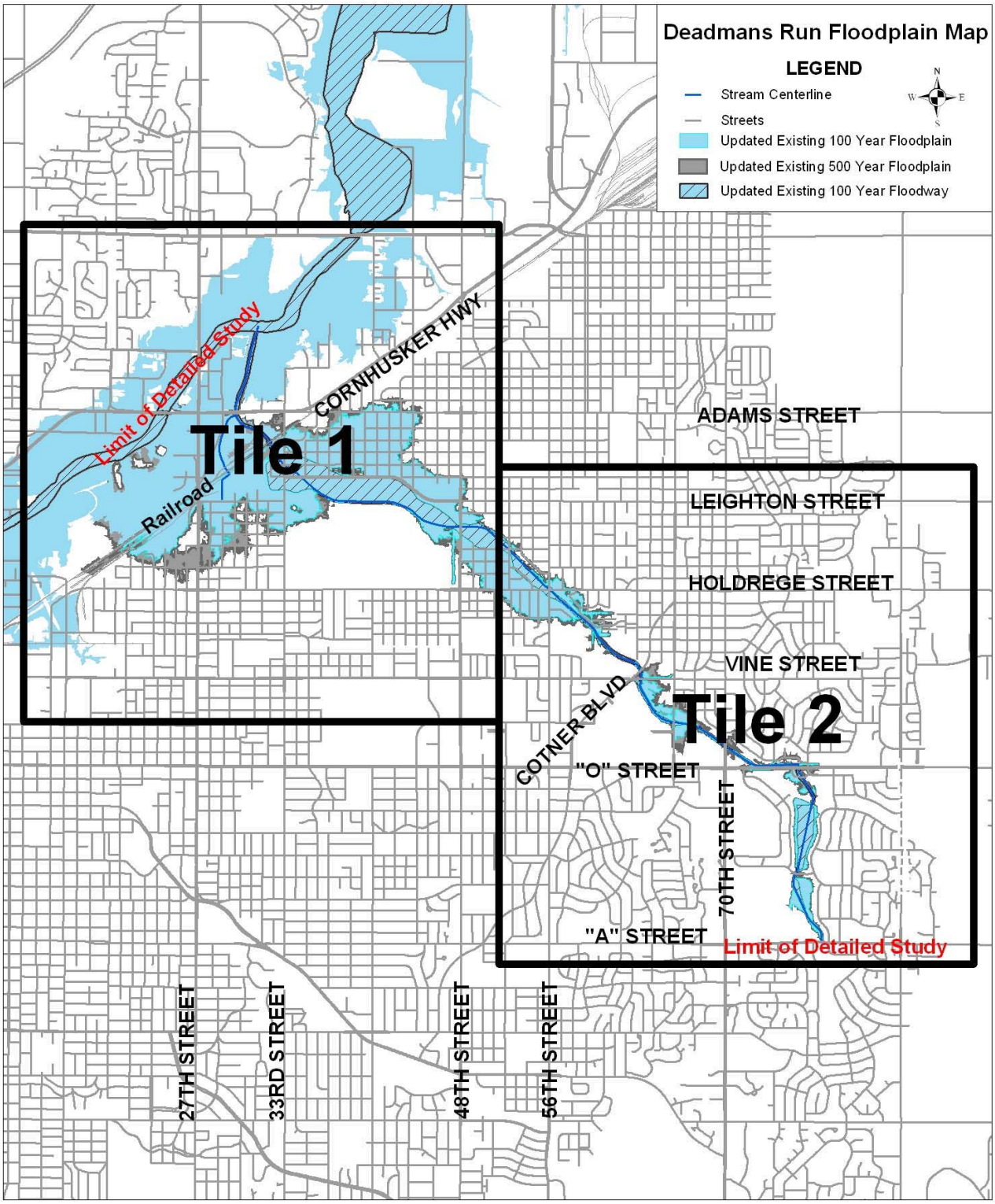


Figure 5-1
Floodplain Map Tiles

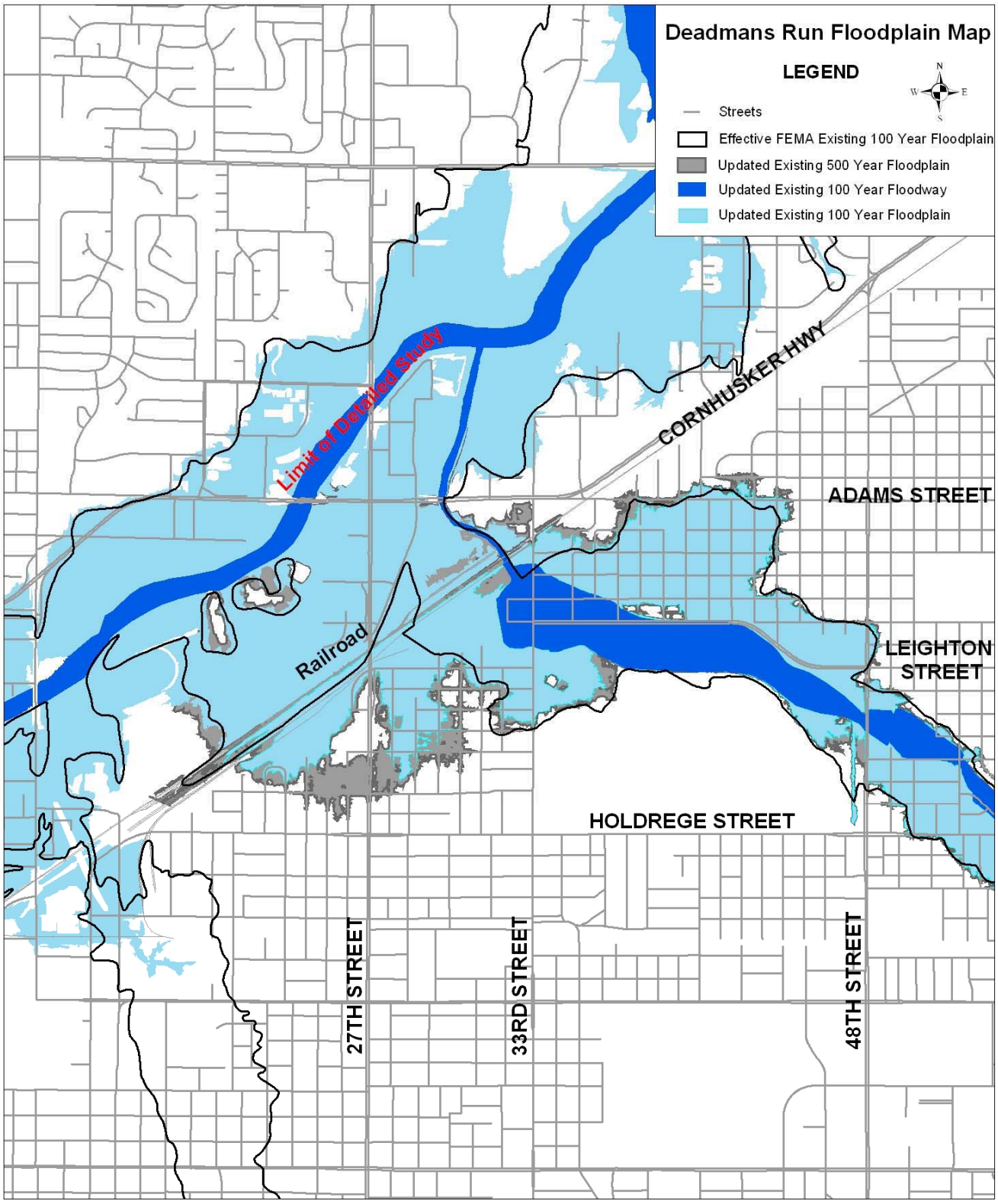


Figure 5-2
Tile 1 Floodplain Map

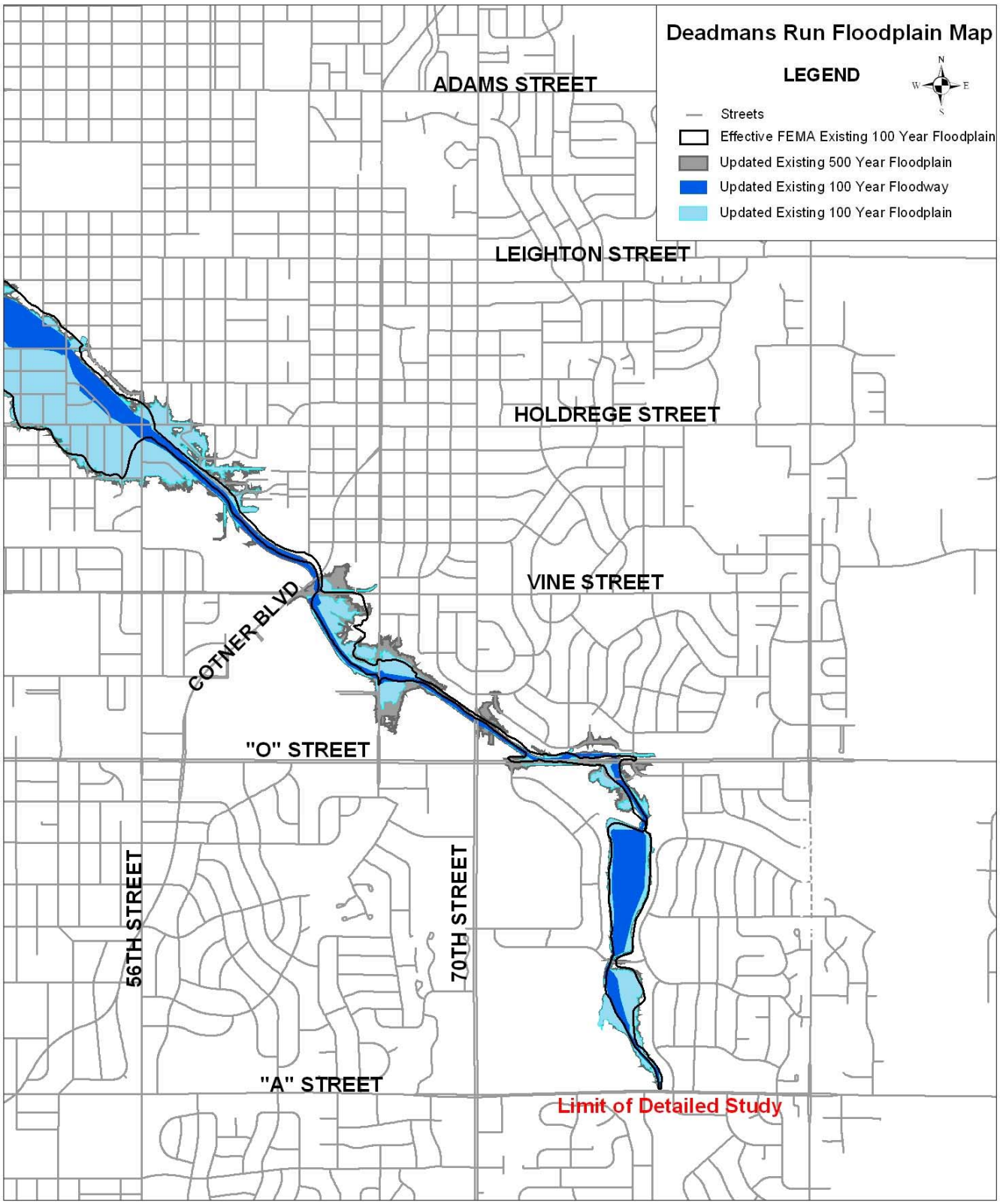


Figure 5-3
Tile 2 Floodplain Map

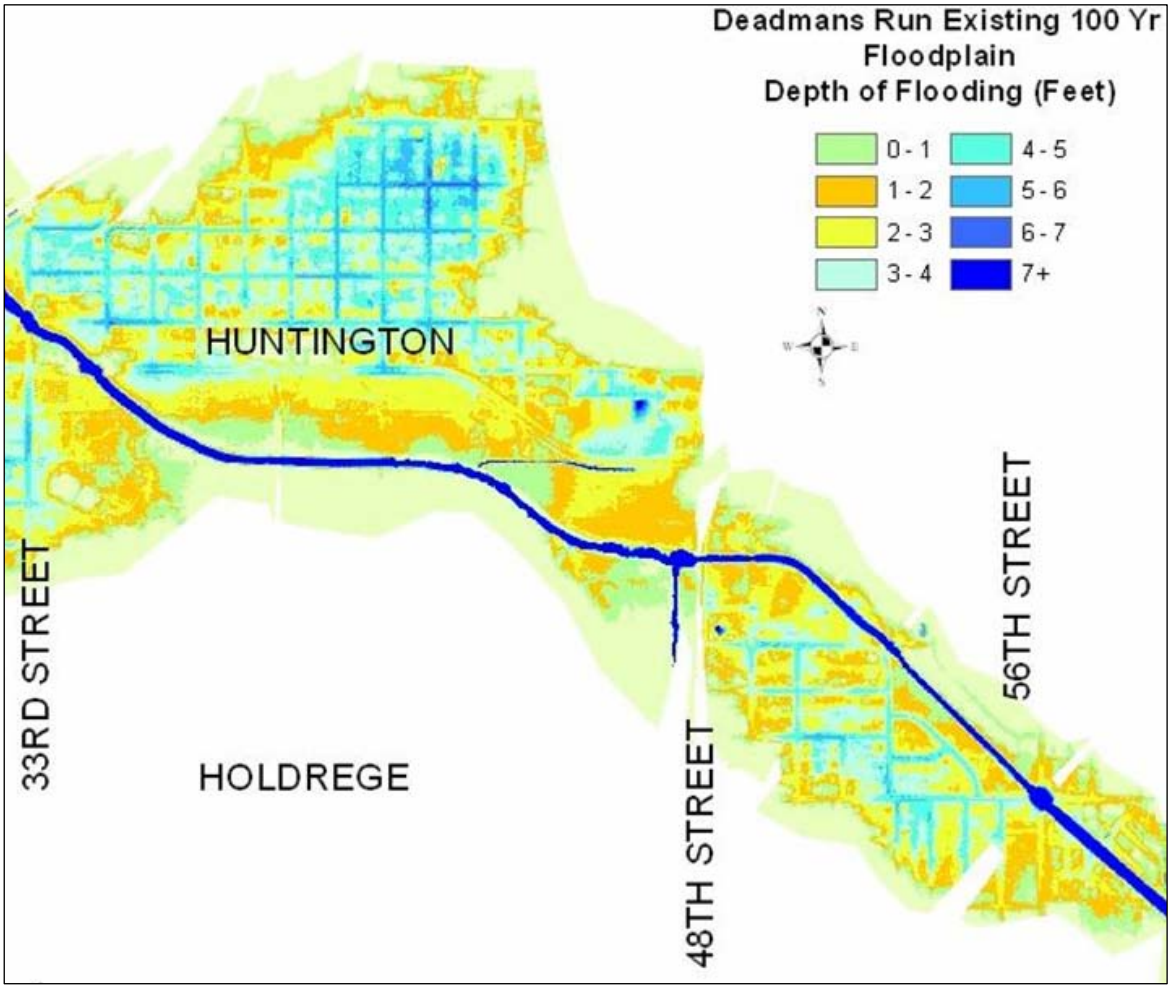


Figure 5-4
Depth of 100-Year Storm

Section 6
Water Quality

6.1 Introduction

The Deadmans Run watershed is considered fully urbanized. As such, the land is covered with impervious surfaces such as roads, parking lots, roofs, driveways, and sidewalks that prevent rainfall from infiltrating into the ground. Even the remaining green space, (pervious surfaces) such as parkland, cannot infiltrate rainfall into the ground as rapidly as it did before development because during construction the topsoil is removed, compacted, and/or mixed with the underlying less permeable soil. The combined result is that infiltration is greatly reduced or halted by urbanization, and 40 to 90 percent of the rainfall (depending upon land use) is directly converted to stormwater runoff. This causes an increase in stormwater runoff flow rate, volume, and velocity. If the proper stormwater controls are not installed as urbanization occurs, these hydrologic changes will cause erosion and sediment deposition within the natural stream network.

Over the years, the majority of open channels within the Deadmans Run watershed have been channelized with hard armoring materials. The armoring has mitigated the erosion problems caused by urbanization but at the same time minimized aquatic habitat, limited natural filtration for water quality, and may be contributing to increased velocities that cause erosion in unlined portions of the main channel. Several natural stream segments still remain, including the segment extending from Cornhusker Highway to the confluence with Salt Creek, which is experiencing bed and bank failures. Section 7 of this report discusses fluvial geomorphology, or the science of how moving water shapes the land, and the geomorphic processes that are causing the stream instability problems that are affecting the natural stream segments.

In addition to the adverse impacts caused by increased erosion and sediment deposition, aquatic habitat is also affected by pollutants transported by stormwater runoff. During dry weather, impervious surfaces collect pollutants such as oil and grease that leak from automobiles and sand and salt deposits along roadways. Other pollutants include nutrients and bacteria from pesticides and fertilizer usage, leaves, grass clippings, and animal wastes. The pollutants have the potential to directly impact water quality in the Deadmans Run main channel as well as adversely impact water quality in downstream water bodies.

6.2 Regulatory Compliance

The Deadmans Run drainage system is subject to regulatory requirements that are designed to improve the stormwater runoff quality with the goal of maintaining an acceptable surface water quality within the channel system. A brief overview of these regulations is provided below.

6.2.1 Stormwater Regulations

Stormwater runoff quality is regulated under the National Pollutant Discharge Elimination System (NPDES) Program. Specifically, the 1987 amendment to the Clean Water Act (CWA) introduced regulations pertaining to stormwater, which are enforced by EPA and individual

states and tribes. Because the State of Nebraska is a delegated state, the stormwater program is implemented by the Nebraska Department of Environmental Quality (NDEQ). To comply with the NPDES program, the City is required to develop, implement, and enforce a program to address the quality of stormwater runoff. The program must involve the implementation of BMPs, which are actions and practices designed to preserve the quality and integrity of streams and lakes. In general, BMPs can be classified as nonstructural and structural.

Nonstructural BMPs consist of pollution prevention techniques designed to prevent the pollutants from entering the drainage system rather than trying to control pollutants with constructed facilities (structural BMPs). Structural BMPs are constructed facilities such as designed to remove pollutants and slow down the runoff before the stormwater enters the receiving stream. Structural BMPs are designed to address the smaller more frequent rainstorms that carry the majority of pollutants. In designing structural BMPs, the smaller rainstorms are defined by the water quality control volume (WQCV), which is the initial amount of stormwater runoff from a development site. The use of specific structural BMPs depends on the site conditions and objectives such as pollutant removal, stream stability, and flood control.

6.2.2 Surface Water Regulations

The CWA also requires that each state establish water quality standards to protect public health or welfare and enhance the quality of surface waters. The water quality standards applied to surface waters consist of two primary parts: (1) designated or beneficial uses, and (2) the water quality criteria necessary to protect those uses. These two elements, which are applicable to any surface water, provide the basis for evaluating water quality data and identifying water quality concerns.

NDEQ is the regulatory agency responsible for establishing and implementing water quality standards in the State of Nebraska. NDEQ has established the following beneficial uses for Deadmans Run (Nebraska Administrative Code, Title 117, Chapter 5, Section 004):

- Primary Contact Recreation - waters where there is a high potential for prolonged or intimate contact with the water, including swimming
- Aquatic Life Warmwater Class B - waters where the resident biota is presently limited by water volume or flow, water quality (natural or irretrievable human-induced conditions), substrate composition, or other habitat conditions
- Agricultural Water Supply Class A - waters used for general agricultural purposes (e.g., livestock watering and irrigation) without treatment
- Aesthetics - waters that are aesthetically acceptable and free from human-induced pollution such as noxious odors, floatable materials, refuse, and algal blooms

As required by CWA regulations, NDEQ periodically assesses available water quality data to identify water quality concerns. If the concern is sufficiently high, a surface water may be classified as impaired, i.e., water quality data indicate that one or more beneficial uses are not protected. Waters classified as impaired are placed on the 303(d) list and require the development of a total maximum daily load (TMDL). A TMDL establishes the

pollutant control requirements deemed necessary to resolve the impairment and bring the water body into compliance with water quality standards.

The most recent assessment published by NDEQ (2006 Nebraska Surface Water Quality Integrated Report) indicated the following water quality conditions in Deadmans Run:

- Primary Contact Recreation - beneficial use is not supported; water body is impaired based on a finding of elevated concentrations of *Escherichia coli* (*E. coli*) bacteria
- Aquatic Life Warmwater Class B - beneficial use is supported; no water quality concerns identified that impair aquatic life
- Agricultural Water Supply Class A - beneficial use is supported; no water quality concerns identified that impair agricultural water supply
- Aesthetics - insufficient data available in 2006 assessment to evaluate this beneficial use

Based on the above assessment findings, NDEQ identified only one water quality pollutant at a level that resulted in pollutant control requirements in Deadmans Run: elevated bacteria that impair the primary contact recreation beneficial use. Accordingly, in June 2007 NDEQ published a TMDL for *E. coli*. The TMDL establishes allowable pollutant loadings for the Deadmans Run main channel. Per the TMDL, a 92 percent reduction in bacteria loading is required to achieve the bacteria water quality standard.

Implementation of the TMDL in Deadmans Run is targeted at control of nonpoint sources, including urban runoff. NDEQ plans to rely on the implementation of BMPs under stormwater discharge permits to improve water quality. If water quality improvements are not achieved, then, as noted in the TMDL, NDEQ may apply wasteload allocations to individual stormwater outfalls. If this occurs, additional treatment controls may be necessary at these outfalls.

6.3 Evaluation Approach

For this study, a water quality evaluation was conducted to evaluate various nonstructural and structural BMPs to address pollutants at their source and to provide treatment at regional locations. The water quality evaluation included three major components:

- Review of previous Deadmans Runs water quality studies, with the goal of building on past efforts.
- A limited wet weather sampling program to characterize the quality of the receiving waters
- Recommendation of watershed management practices to improve water quality, while addressing the regulatory issues

The following sections summarize the methodology, results, conclusions, and recommendations.

6.4 Previous Water Quality Studies

The University of Nebraska has published two studies addressing water quality issues in the Deadmans Run watershed. These studies are discussed below.

6.4.1 Stormwater Quality Evaluation of Livestock Runoff

A Masters of Science thesis, *The Storm Water Quality Evaluation of Livestock Runoff From East Campus Site* (written by Rabab Shamayleh under the supervision of Dr. Bruce Dvorak, December 2004), examined runoff from a transient livestock facility at the University's east campus, which was suspected to contribute surface water pollution in the Deadmans Run main channel. The thesis focused on one specific area in the watershed - immediately upstream of 38th Street adjacent to the main channel. During seven rainfall events, the quantity and quality of water discharged from upstream of the livestock facility and along the main channel of Deadmans Run were investigated. The test results showed a median fecal coliform count of 2,500 colony forming units (CFU)/100 milliliters (ml) at the upstream site and 21,000 CFU/100 ml along the main channel. The thesis concluded that the livestock facility is a source of bacterial loads to the Deadmans Run main channel. The thesis provided recommendations including additional sampling and implementation of BMPs to reduce the amount of bacterial contamination delivered to Deadmans Run main channel. The University is currently regulated through the NPDES program and is investigating options to address the bacteria issues.

6.4.2 Dry Weather Stormwater Monitoring

The University of Nebraska submitted the study Dry Weather Stormwater Monitoring to the City of Lincoln Public Works and Utilities Department, Engineering Services, in September 2005. The purpose of the study was to conduct dry weather sampling to characterize instream water quality and to identify areas contributing pollutants to the main channel during dry weather conditions. The University's report did not identify any linkage between water quality conditions and land use activities occurring at sample sites but did provide data within the watershed for temperature, pH, chloride, total chlorine, copper, fluoride, nitrate, sulfate, anionic surfactants, and phenols. The study recommended further investigation of six sites based on high concentrations of total chlorine, fluoride, surfactants, sulfates, or nitrates.

6.5 Wet Weather Water Quality Assessment

The objective of wet weather sampling is to characterize the quality of stormwater runoff and evaluate potential impacts to receiving waters. For this study, wet weather stormwater runoff data were collected and evaluated to assess stormwater quality in the main channel of Deadmans Run.

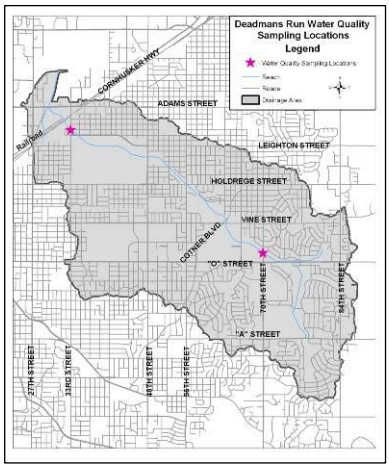


Figure 6-1
Water Quality Sampling Locations

6.5.1 Water Quality Sampling Program

Samples were collected from two locations, the 33rd Street crossing at Baldwin Street and the 70th Street crossing of Deadmans Run (Figure 6-1). The sites were chosen based on

the location in the watershed as well as accessibility to the stream. The 70th Street sampling site includes flow from the headwater tributaries, multiple parks, and Wedgewood Lake. The 33rd Street site was the best location to collect samples from the majority of the watershed while limiting safety concerns. Wet weather sampling was conducted during two separate storm events, the first on July 13, 2006, and the second on September 21, 2006. To capture the first flush, the team tracked weather conditions and prepared for a sampling event if the forecast called for a greater than 70 percent chance of rain. Grab samples were analyzed by Midwest Laboratories Inc. in Omaha, Nebraska. Constituents measured included biochemical oxygen demand, copper (total), cyanide, fecal coliform, fecal streptococcus, hexane extractable materials, kjeldahl nitrogen, lead (total), phenols, phosphorus (total), residual chlorine, total dissolved solids, total suspended solids, and zinc (total). The constituent analysis data sheets and comparison graphs are included in Appendix D.

6.5.2 Water Quality Sampling Results

Similar to previous NDEQ assessments, the water quality samples demonstrated compliance with the minimum requirements established for aquatic life protection but failed to comply with the primary contact recreation requirements for bacteria. In 2002, NDEQ opted to convert from fecal coliform to *E. coli* bacteria as the indicator for primary contact recreation assessment. The study sampling included fecal coliform rather than *E. coli* but still provides relevant results for analyzing bacteria concentrations. Comparing the results from the two sampling sites on July 13, 2006, the fecal coliform counts were higher at the 70th Street site (60,000 CFU/100 ml) than at the 33rd Street sampling site (55,000 CFU/100 ml). In contrast, the fecal coliform counts for the September 21, 2006 event were lower at the 70th Street site (6,000 CFU/100 ml) than at the 33rd Street site (60,000 CFU/100 ml). Such variability in bacteria results is common in stormwater runoff.

Although it is difficult to draw any location-specific conclusions from these data, the sample results support previous NDEQ findings regarding impairment. In addition, the wet weather results coupled with the dry weather data suggest that bacteria sources are widespread in the watershed. Identifying specific sources of bacteria can be difficult. Fecal coliform bacteria are microscopic organisms that live in the intestines of warm-blooded animals. Accordingly, potential sources range from livestock and wild animals to illicit sanitary sewer connections and pet waste.

6.6 Water Quality Recommendations

A series of watershed management recommendations are provided below that are designed to improve the water quality of Deadmans Run, with the primary goal of addressing the regulatory requirements. In addition to regulatory requirements, the recommendations address a wide variety of urban pollutants with the overall goal of water quality enhancement. The recommendations include enforcing existing nonstructural BMP programs, integrating structural BMPs using both retrofit techniques and installing new facilities, private sector BMP demonstration projects, and additional studies to better understand the pollutant sources.

6.6.1 Nonstructural BMPs

Nonstructural BMPs, if correctly implemented, can be the most efficient method of reducing stormwater pollution and improving water quality. The more nonstructural BMPs that are implemented in a watershed, the fewer burdens are placed on structural BMPs to remove pollutants from the stormwater runoff. For the Deadmans Run watershed the recommendation includes enforcing existing City programs that are designed to provide education, reducing pollutant sources, and using natural systems for stormwater management. These programs include:

- Outlot education program
- Low nonphosphorus fertilizer program
- Contractor/developer/realtor education
- Household hazardous waste collection program
- Earth Wellness Festival
- Waterfest
- Pet waste management education
- Rain to Recreation Program

6.6.2 Structural BMPs

The Deadmans Run watershed is fully urbanized and contains limited open space that is suitable for new structural BMPs. Because of this limitation, the recommended management strategy includes a combination of new structural BMPs located on public property and the retrofit of existing ponds to integrate water quality features. Once retrofitted, the existing ponds will perform like "extended wet detention basins," or "extended dry detention basins," which are types of structural BMPs designed to remove a variety of different pollutants. Table 6-1 lists the structural BMP CIP projects for the Deadmans Run watershed.

Table 6-1
Structural BMP CIP Projects

CIP No.	Project Name	Structural BMP Type
8	Wyuka Cemetery	Wet pond retrofit
9	Bethany Park	New extended dry detention basin
10	Russwood	Dry pond retrofit
11	Trendwood Park	New extended wet detention basin
12	Cotner Boulevard	New hydrodynamic separator

Section 8.3.4 of this report provides additional details for each of the projects listed above. In addition, the following paragraphs provide a general description of the structural BMPs being recommended for the Deadmans Run watershed.

Targeted Constituents

Sediment	◗
Nutrients	○
Trash	●
Metals	◗
Bacteria	◗
Oil and Grease	◗
Organics	◗

Legend *(Removal Effectiveness)*
○ Low ◗ Medium ● High

Extended Dry Detention Basins

Extended dry detention basins are well suited for removing a variety of constituents including bacteria, which has been identified by NDEQ as a pollutant of concern for this watershed (Section 6.2.1). Therefore, this type of BMP is a good application for this watershed. In addition, these types of BMPs can be easily configured to become an integral part of the urban landscape by supplementing landscape features, park amenities, and passive and active recreation facilities. These types of detention facilities can be situated in a variety

of locations including residential developments, commercial property, open space lots, and adjacent to stream corridors.

The vegetation within the basin provides erosion control and sediment entrapment. The basin can be planted with native grasses or with turf grasses depending on the design intent and its other intended uses, such as recreation. Sediment deposition, along with frequent and prolonged periods of inundation, makes it difficult to maintain healthy grass cover on the bottom of the basin. Other alternatives are available, including marshy wetland bottoms, riparian shrub, or other types of vegetation that can survive conditions found at the bottom of the basin.

Extended Wet Detention Basins

Extended wet detention basins are similar to extended dry detention basins, except they are designed to have a permanent pool of water that is surrounded by emergent wetland vegetation. The permanent pool provides a mechanism for the settling of solids between storms and the removal of nutrients and dissolved pollutants. The wetland vegetation bench is called the littoral zone and provides aquatic habitat and enhances pollutant removal. Wet basins are superior to extended dry detention basins in their ability to remove a variety of pollutants including sediment, nutrients, and dissolved pollutants. Like Extended Dry Detention Ponds, Extended Wet Detention Basins remove bacteria, which is a pollutant of concern identified by the NDEQ (Section 6.2.1). The City's *Drainage Criteria Manual* refers to this type of BMP as retention (wet) ponds.

Targeted Constituents

Sediment	●
Nutrients	◗
Trash	●
Metals	◗
Bacteria	◗
Oil and Grease	●
Organics	◗

Legend *(Removal Effectiveness)*
○ Low ◗ Medium ● High

Extended wet detention basins offer a number of aesthetic advantages. Typically, wet basins are more attractive than dry detention basins and are considered property value amenities in many areas. This is primarily because the sediment and debris accumulate within the permanent pool, hiding it from public view.

Hydrodynamic Separator

Hydrodynamic separators are an effective means of removing heavy particulates that can be settled out or floatables that can be captured. The units come in a wide variety of sizes, some small enough to fit in manholes. This makes hydrodynamic separators ideal for urban watersheds or areas where available open space is limited. There are many separation systems available. One example is the Continuous Deflective Separation system, which uses the natural

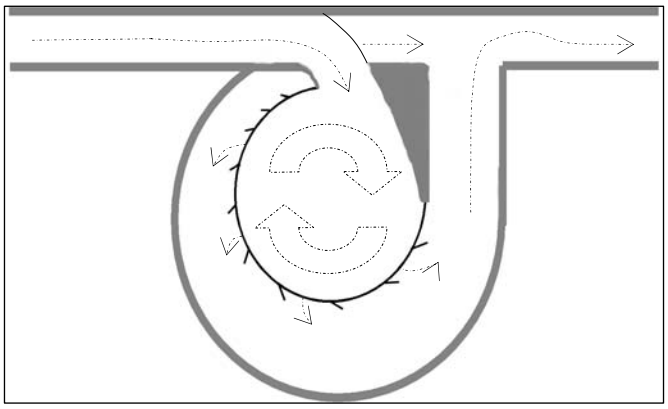


Figure 6-2
Continuous Deflection Plan View

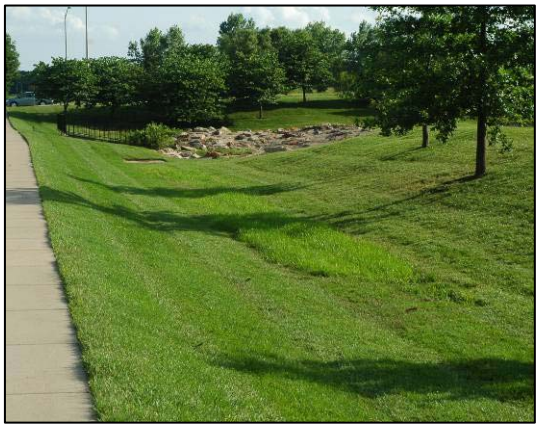
motion of water to separate and trap sediments by indirect filtration, as depicted on Figure 6-2. As the stormwater flows through the system, a very fine screen deflects the pollutants, which are captured in a litter sump in the center of the system. Floatables are retained separately. Maintenance of the hydrodynamic separator unit is site specific but typically requires inspection at least once every 30 days during the wet season. During these inspections, the floatables should be removed and the sump cleaned out (if it is more than 85 percent full). It is also recommended that the unit be pumped out and the screen inspected for damage at least once per year.

6.6.3 Private Development Demonstration Projects

One of the major sources of pollutants in urbanized watersheds is the large parking lots located within commercial and industrial areas. As discussed previously, these impervious surfaces collect pollutants such as oil, grease, sand, and salt, which are then transported by stormwater runoff into streams. To address this issue, the recommended management strategy is to partner with the private development community to implement parking lot structural BMPs to promote the benefits of these facilities.

The types of structural BMPs could include landscaped bioretention islands or grass swales located along the perimeter of parking lots. Examples of these techniques are provided below.

Example of bioretention cell



Example of a grass swale along a parking lot

6.6.4 Additional Studies

As discussed in Section 6.5.2, it is difficult to pinpoint site-specific sources of bacteria in the watershed, with the potential sources ranging from livestock, wild animals, pet waste, illicit sanitary sewer connections, and leaky sanitary sewer collection systems. In an effort to better understand potential human sources of bacteria, the following additional studies are recommended, which are beyond the scope of this Master Plan study:

- Conduct a comprehensive dry weather illicit sanitary sewer connection field investigation to identify potential bacteria sources.
- Conduct an inflow and infiltration study of the sanitary sewer system to identify areas where the collection system (manholes and pipelines) may contain maintenance issues, such as breaks and cracks, that may be contributing to the bacteria issues.

- Implement a comprehensive monitoring program. Monitoring is essential to all TMDLs to assess the future beneficial use status and to determine if the water quality is improving based on the implementation of the recommended BMPs. The monitoring program should include *E. coli* sampling along the main channel of Deadmans Run as well as localized sampling at the structural BMP sites. Sampling along the main channel is necessary to determine the overall effectiveness of implemented BMPs, whereas localized sampling provides necessary information to evaluate the effectiveness of specific BMPs.

Section 7
Fluvial Geomorphic Evaluation

7.1 Introduction

Fluvial geomorphology is the process of how moving water shapes the land. Fluvial relates to flowing water and geomorphology refers to the systematic examination of land forms. Combined, fluvial geomorphology is the systematic examination of land formed by flowing water either through erosion or deposition. Correspondingly, the fluvial geomorphic processes are examined in relation to dynamic equilibrium. This equilibrium is the balanced movement of water and sediment under dynamic (variable) flow conditions typically inherent in a natural environment.

The purpose of the Deadmans Run geomorphic investigation was to determine the geomorphic conditions of three stream segments, including two unlined stream segments of the main stem and one unlined tributary segment. By understanding the geomorphic conditions of the watershed, the locations and prioritizations of interventions can be determined for managing the main stem and tributary. Primary elements of this investigation included a field reconnaissance and classification of the current condition of the waterways along the following segments of the Deadmans Run Watershed (Figure 7-1):

- Segment 1: Tributary upstream of Sycamore Drive Extension to Skyway Road
- Segment 2: Main channel downstream of Wedgewood Lake to Corporate Drive
- Segment 3: Main channel extending from Cornhusker Highway to the confluence with Salt Creek

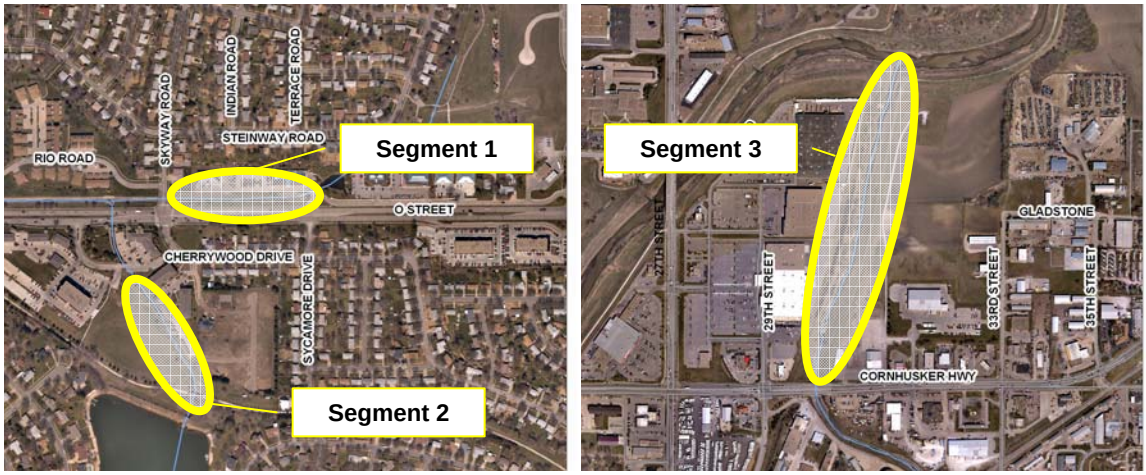


Figure 7-1
Geomorphic Evaluation Stream Segments

7.2 Geomorphic Field Reconnaissance

Detailed field reconnaissance was conducted in June 2006. The approach to the field reconnaissance for the Deadmans Run Watershed was to observe geomorphic conditions and indicators currently present in the watershed. Each of the identified waterways was walked and pertinent geomorphic observations were recorded with a Pocket PC equipped with ArcPad Version 7.0 and a GPS unit. The City provided topographic contour, street, and stream alignment shapefile layers to locate features.

The data recorded in the field were grouped into suites including:

- Bars
- Channel dimensions
- Crossings
- Erosion and mass wasting
- Material
- Notes (miscellaneous)
- Outfalls
- Photographs
- Profile features
- Vegetation

The shapefiles for these field notes, as well as photographs taken during field reconnaissance, are included in the electronic files of Appendix A. Typically, at a minimum, two photographs, one looking upstream and the other looking downstream, were taken at each chosen location.

7.3 Evaluation Results

Reach description summaries for the stream sections evaluated by the project team are provided in Appendix E. These reach summaries include an interpretation of historical data reviewed and the conclusions from the geomorphic assessment completed by the project team.

7.3.1 Historical Background

The archived aerial photographs for Segments 1 and 2 are presented on Figure 7-1 while Figure 7-2 shows the historical photos for Segment 3. The following descriptions are based on a review of available aerial photographs and historic maps provided by the City/NRD or obtained by the project team.

Segment 1: Sycamore Drive Extension to Skyway Road: In 1959, the alignment along the north side of O Street was straight, indicating channelization with only a few isolated trees along the channel in a rural setting. The channel remained relatively unchanged through 1965 and nearby areas did not show signs of urbanization until 1999. By 1999, the Dialysis Center detention pond at the Sycamore Drive extension was present and the channel was lined with concrete upstream and downstream of this reach. Further, more trees are seen along the channel and signs of active meandering were visible along the upstream half of the channel. By 2002, many of the trees appear removed and the signs of remeandering along the channel are more pronounced, encroaching on O Street, especially along the east portion. By 2005, the channel meanders were essentially graded out of the channel and the channel is reasonably straight. The banks are essentially turf grass with isolated trees and brush as seen today.

Segment 2: Wedgewood Lake to Corporate Drive: As depicted on Figure 7-1, the main channel shows meanders in 1959 with a single row of isolated trees along the banks in a rural setting. The present day trail is a railroad alignment. By 1965, Wedgewood Lake and its dam are present and the channel has been straightened. Residential development is beginning to appear at a distance away from the main channel.

The railroad alignment was changed to a pedestrian/biking trail by 1999. Residential and commercial developments have fully encroached around the channel to the east and plans have recently been submitted to the City for development on the west (left descending) bank.

The channel shows some deviation along its straight alignment seen in 1965, but the overall alignment is straight. A scour pool, as seen today, is downstream of the spillway. Field investigations revealed current conditions are similar to the 1999 photograph.

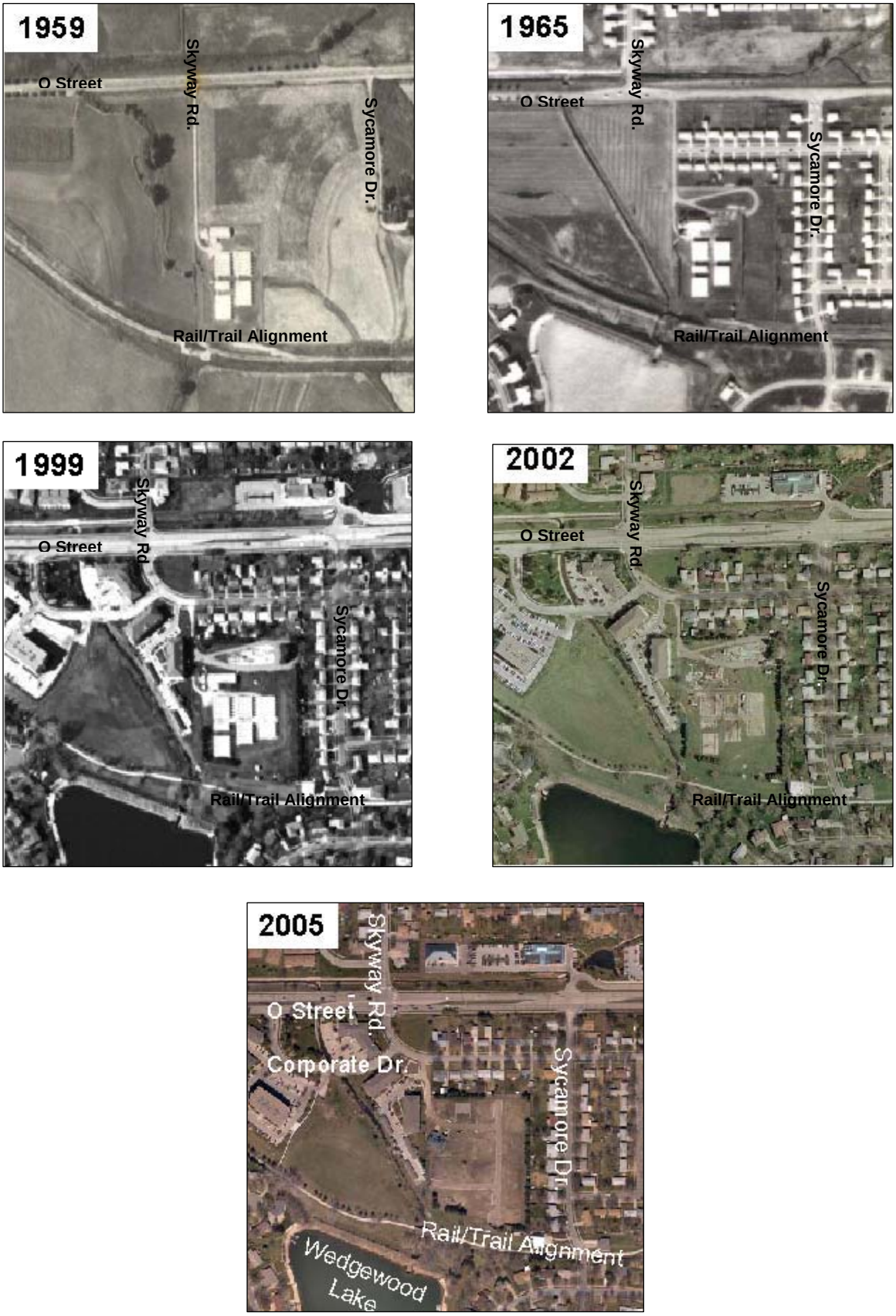


Figure 7-2
Segments 1 and 2 - Historical Photographs

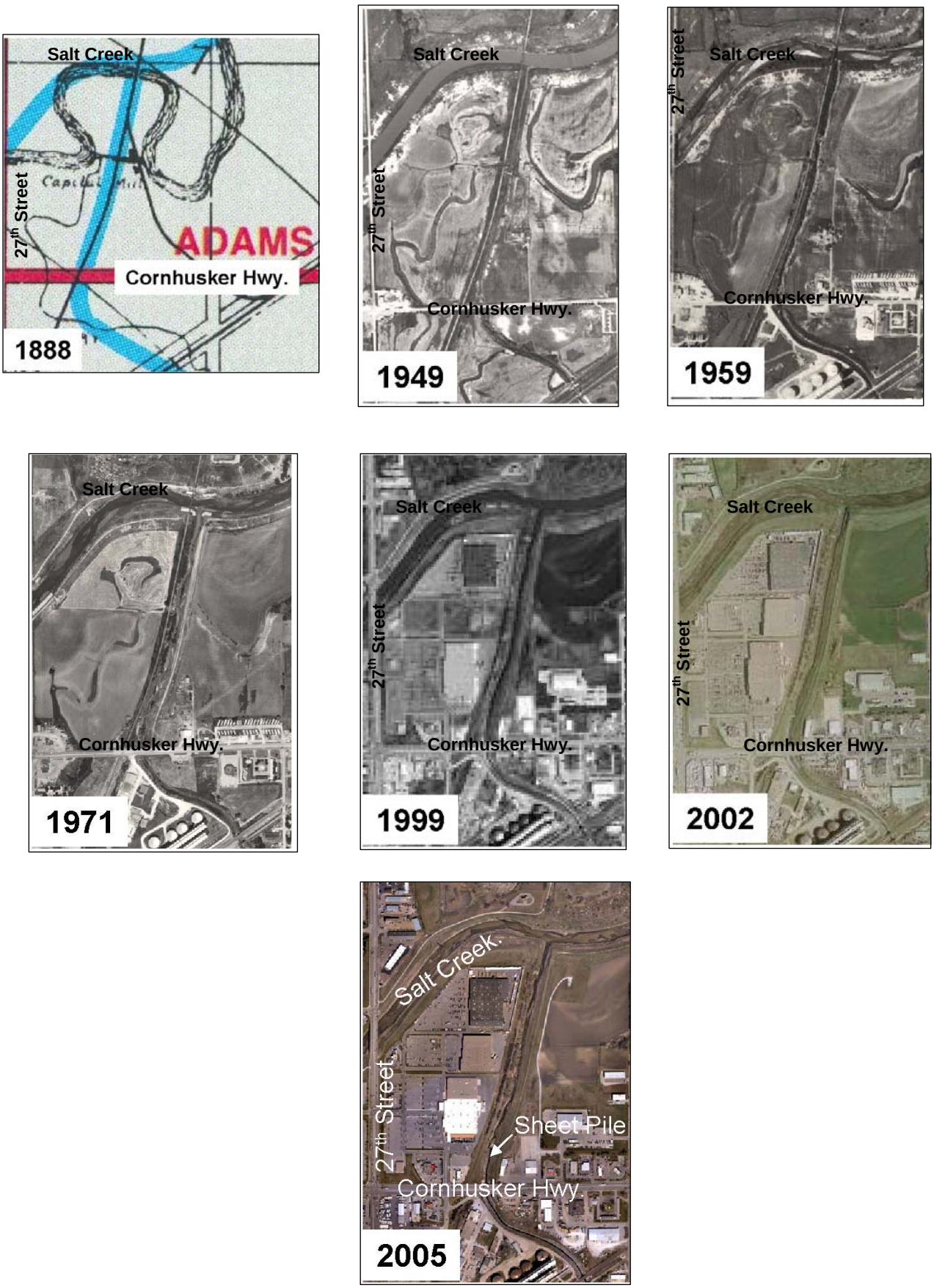


Figure 7-3
Segment 3 - Historical Photographs

Segment 3: Cornhusker Highway to Salt Creek Confluence Main Stem: Since 1888, the Deadmans Run and Salt Creek channels have been straightened and shortened. Deadmans Run, downstream of Cornhusker Highway, was shortened by approximately 15 percent (Figure 7-2). More importantly, the channel was straightened. Scroll marks, seen in the aerial photographs dating to 1949, indicate meandering radii for Deadmans Run in the order of 75 to 150 feet. As seen in 1949, the railroad had been aligned along the west side of the channel. Land use around the channel was rural. In 1971, the channel exhibited some meandering, but by 1999 the channel was again straightened. Between 1971 and 1999, the channel upstream was lined with concrete and the sheet pile wall was placed at the upstream end of the study reach. By 1999, the railroad was gone and commercial development encroached the channel along the west side and near the channel along the east upstream half. Further, by 1999, bank erosion is evident along the 650 feet of the upstream portion of the left bank, and becomes prominent by 2002, and even more prominent through 2005. It was not until 2005 that the erosion downstream of the storm sewer acting as a flow vane appeared. In 2007, corrective action is planned by the City's Wastewater Division to mitigate the erosion at the flow vane, as well as upstream of the area. Sheet pile walls are planned to be constructed in two sections to armor the low flow banks on each side of the stream with the intention of avoiding additional erosion in the area.

7.3.2 Stream Stage Classification

As summarized above, one of the key objectives of the evaluation was to evaluate the current conditions of the stream system. Schumm (1984) and Simon (1989) have classified the process of how streams reestablish equilibrium after a disturbance to the channel or the watershed. Simon classifies this reestablishment into six stages: I) Pre-Disturbance, II) Disturbance, III) Incision, IV) Widening, V) Deposition, and VI) Recovery and Reconstruction. Figure 7-4 schematically depicts each of these stream stages.

Segment 1: Sycamore Drive Extension to Skyway Road: The creek along this reach is primarily a trapezoidal channel with turf-grass-covered banks. Medium-sized trees are located along the left descending bank crest and more brushy-type woody vegetation is near the crest along the right descending bank crest. The nominal flow at the bottom of the channel is from flow overtopping and leaking through the stoplog weir located immediately upstream of the Sycamore Drive crossing and potentially from groundwater base flow. Rushes line the edges and are growing in the bottom channel at several locations, indicating a typical low energy waterway.

Evidence of incision and active meandering as seen in the historical aerial photographs was not observed. The 6- to 8-inch diameter pieces of crushed limestone in the channel have apparently abated incision since repairs to the banks and channel. However, current practices of mowing the shallow-rooted grass as close as possible to the waters edge (including rushes) and close to the ground have seriously reduced the potential of filtering surface water before it reaches the channel and of the roots reinforcing the banks. Several areas of the banks were scalped to bare ground, thus eliminating the potential for the turf grasses from reinforcing the near surface and providing a stormwater buffer. The combination of shallow-rooted grasses along the banks and current mowing practice may have initiated the bank instabilities in the past. Using Simon's Classification for urban channel evolution as seen on Figure 7-4, this reach is classified as Stage V/VI.

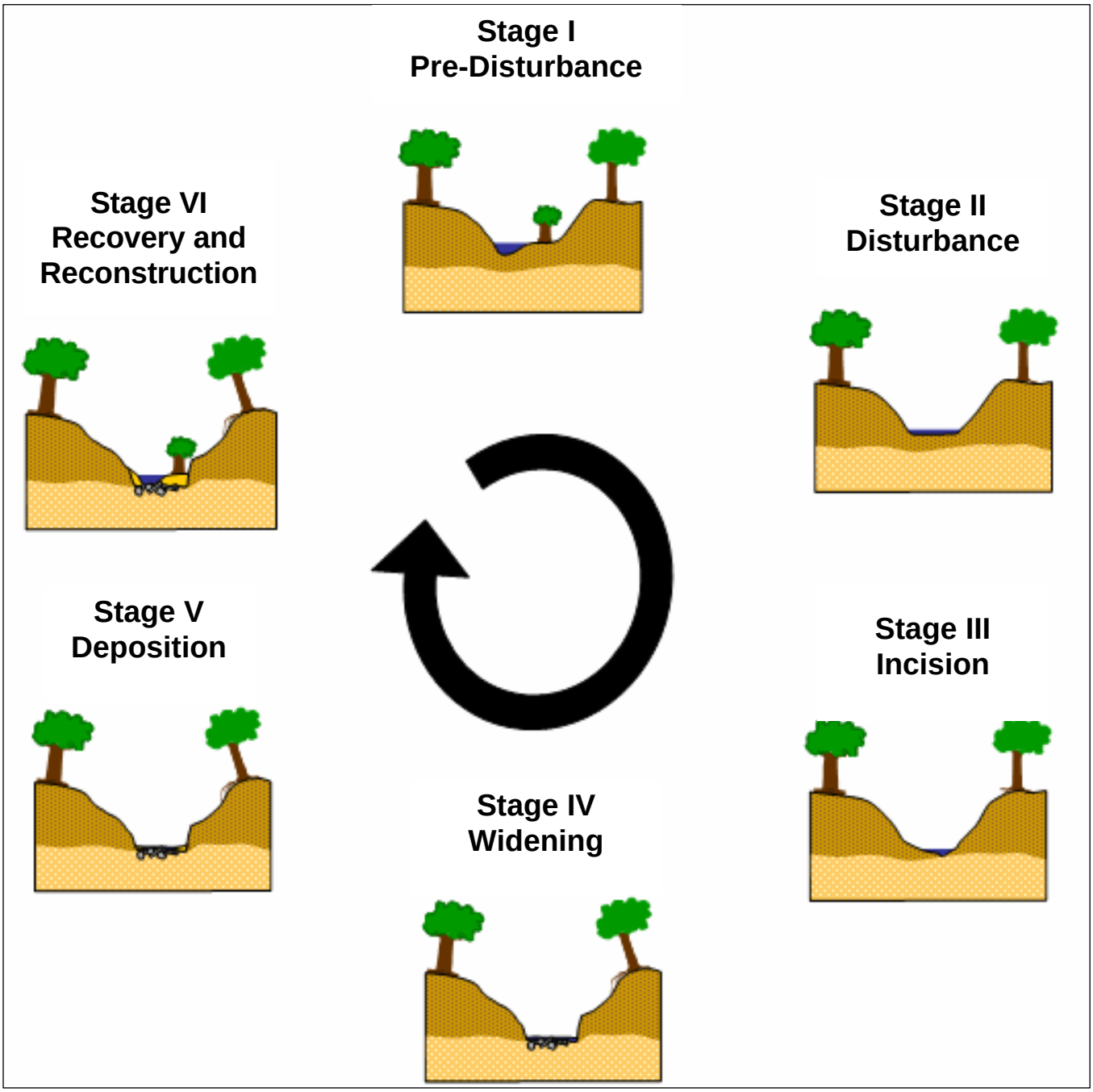


Figure 7-4
Channel Evolution Model (Simon 1989)

Segment 2: Wedgewood Lake to Corporate Drive: From the spillway of Wedgewood Lake to the pedestrian trail bridge, this tributary is reasonably stable with a two-stage channel and good bank reinforcement from existing woody vegetation. There is a knickpoint at the end of the concrete slab leading from the spillway, but the channel appears to have adjusted to the grade change and large broken slabs of concrete armor the bottom.

Downstream of the pedestrian bridge, the tributary is wider and appears to form a backwater condition upstream of the Corporate Drive crossing. Erosion is not a factor for this portion of the stream reach and sedimentation is less of a concern because of the limited sediment source along the banks and the upstream sediment sink of Wedgewood Lake. The main limiting factor for this portion of the reach is the narrow vegetative buffers along either side of the tributary. Algae and duckweed were of limited presence, but the potential for both species thriving following the loading of nutrient-rich surface waters flowing to the channel was apparent. Using Simon's Classification for urban channel evolution, this reach is classified as Stage V/VI.

Segment 3: Cornhusker Highway to Salt Creek Confluence: The sheet pile wall located near the Cornhusker Highway crossing and at the end of the lined trapezoidal channel remains an effective grade control, abating migration of the headcut upstream. The scour pool downstream of the sheet pile wall appears to have sized itself accordingly to the drop and flow from the sheet pile wall. Immediately downstream of the sheet pile wall is a 48-inch corrugated metal pipe (CMP) along the left descending bank, labeled Outfall 1 in Figure 7-5. The flow during rainfall events from this outfall appears to direct the flow of the main stem over to the right descending bank, resulting in localized scour along this bank. This directing of flow also appears to set up the meandering front, such that the left descending bank shows erosion downstream.

The erosion continues along the left descending bank for approximately half the distance between the sheet pile wall and the confluence with Salt Creek. The right descending bank may not show as much scour because it was regraded. The creek is undergoing active re-meandering from Outfall 1 and Outfall 3. Outfall 3 is a destroyed 36-inch CMP along the left descending bank, approximately 1,000 feet downstream of Cornhusker Highway.

When Outfall 3 was installed, the outside bend of the meander was likely along the right descending bank. During higher flows, which overtopped the CMP outlet frame, the bank behind the frame scoured, exposing the fine glacial outwash sand that underlies the loess. The overtopped pipe became a flow vane, directing the flow perpendicular to the pipe alignment. Water flows over the pipe until the sand is eroded under the pipe and the undermined pipe collapses. This sequence is repeated along the inclined pipe and the erosion migrates to the left bank.

Between Outfall 3 and Outfall 6, localized bank degradation is observed, where the flows have acted as turning vanes. Sedimentation through bar deposition is prevalent along the entire unlined portion of this reach. The bars within the remeandering segment are irregular, which would be expected. Downstream of Outfall 6, the bars become somewhat more regular-shaped. Closer to the confluence with Salt Creek, submerged ripples and megaripples of sand along the channel bottom are prevalent. Using Simon's Classification for urban channel evolution, this reach is classified as Stage IV/V.

Figure 7-5
Segment 3 - Existing Outfalls

7.3.3 Summary Discussion

Segments 1 and 2 appear reasonably stable. The knickpoint downstream of the Wedgewood Lake's spillway (Figure 7-6) appears abated by the armoring in the channel. Segment 3 is undergoing a combination of widening and remeandering with mobile bar deposition. The knickpoint and zones in this area are depicted on Figure 7-6.

Figure 7-6 also presents the shear in the channel at the bankfull height (depth), which should be the stage of the channel-forming flow. These figures depict shear along the channel, which was calculated using the slopes from topographic contours provided by the City. Although Segments 1 and 2 are reasonably stable, higher shear values were calculated in these areas ranging from 0.9 to 1.7 pounds per square foot (lb/ft^2). This is an indication that these reaches show a significant potential for erosion should the flows scour under the shallow-rooted and stressed bank vegetation or if current channel armoring such as the 6- to 8-inch diameter rocks are removed. This mechanism of scour became evident in the 2002 aerial photograph of the upstream reaches. Although the shear values (0.3 to 0.6 lb/ft^2) in Segment 3 are less than those of the upstream reaches, the threshold shear of the silty/sandy bank

material (shear less than 0.1 lb/ft^2) is less than the calculated shear. Thus, when scour is concentrated around structures such as the culvert outfalls, the underlying bank material provides little resistance to erosion under the back cover.

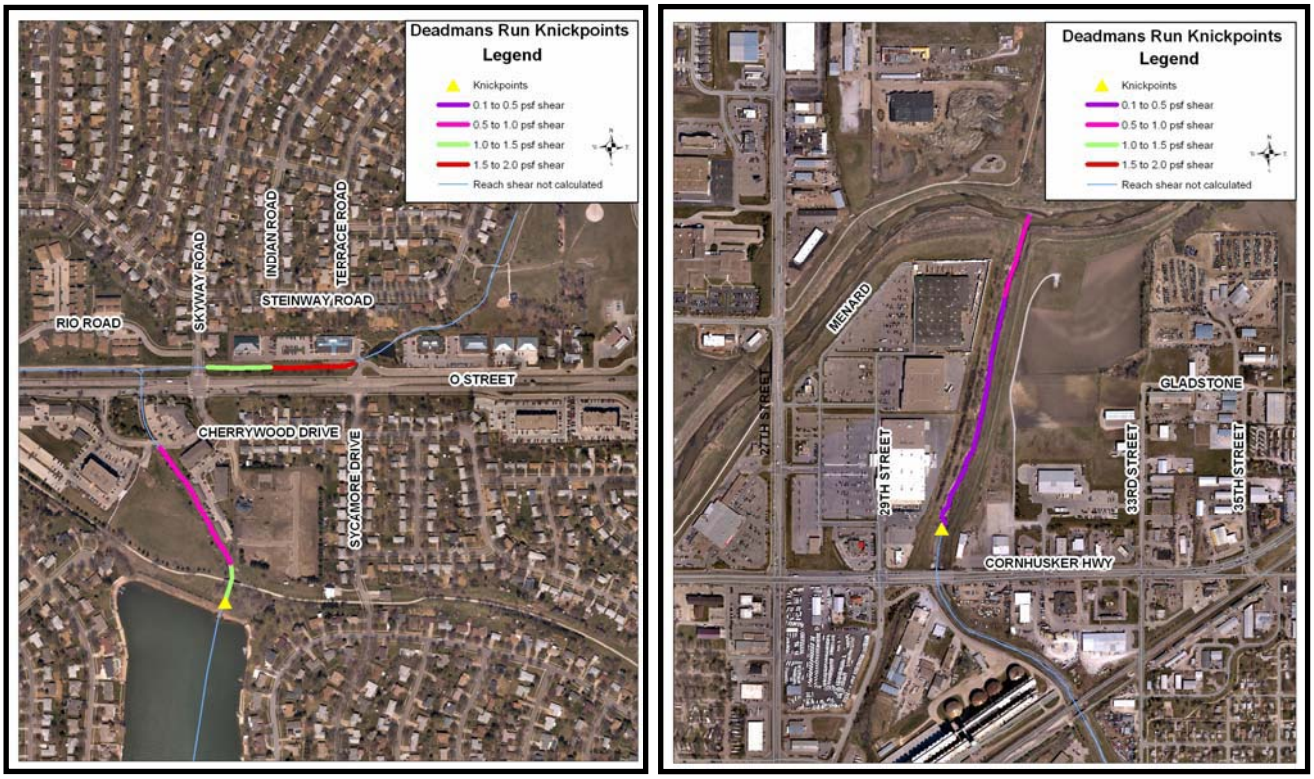


Figure 7-6
Deadmans Run Knickpoints

7.4 Stream Improvements

Segment 1 appears reasonably stable at this time; however, enhancements to the stability of the channel can be achieved by planting deeper-rooted woody and mesic prairie vegetation along the banks and placing several grade controls to maintain the channel slope. For Segment 2, establishing a wider vegetative buffer downstream of the pedestrian bridge will provide stormwater quality filtering. Each reach is encountering localized issues that should be addressed during routine maintenance activities. The severities of these issues are not critical and do not warrant inclusion in the recommended Master Plan improvement projects.

For Segment 3, current conditions are endangering utility and building infrastructure along the left (west) bank, requiring stream improvements focused at abating the extensive active meandering. To assist the creek in its attempt to reach dynamic equilibrium, the following is recommended:

- Remeandering the entire reach with a two-stage channel that will also facilitate flood conveyance
- Reconfiguring the left descending bank and right descending bank
- Raising the channel bed downstream of the sheet pile wall with grade controls

Further details regarding the recommended Segment 3 stream improvements are provided in Section 8 of this report.

Section 8
Capital Improvement Projects

8.1 Introduction

The results of the hydrologic, hydraulic, geomorphic, and water quality evaluations discussed in the previous sections of this report formed the foundation for identifying problem areas in the watershed. Potential improvement projects addressing each problem area were evaluated based on design considerations, economic feasibility, and overall efficiency. The following pages describe the process used to identify problem areas, evaluation approach, and formulation of the recommended CIP.

8.2 Problem Identification

The process for identifying flooding and erosion problems was focused on areas along Deadmans Run main channel that pose a serious public safety concern with respect to potential building flooding, street flooding, or stream instabilities. Drainage problems related to the enclosed pipeline systems that discharge to the main channel was not part of this study evaluation.

Hydraulic deficiencies including undersized bridges and culverts, as well as channel overbank flooding, were identified along the main channel. Table 8-1 lists street flooding at major roadway stream crossings. The overbank flooding is illustrated by the extent of the 100-year existing conditions floodplain, as shown on Figure 8-1. Approximately 982 buildings are located within the Deadmans Run existing conditions floodplain.

Table 8-1
Stream Crossing Overtopping Flood Depths

Location	*2 Year Storm Event Overtopping (Feet)*	*10 Year Storm Event Overtopping (Feet)*	*50 Year Storm Event Overtopping (Feet)*	*100 Year Storm Event Overtopping (Feet)*
52nd Street	0.0	0.0	0.0	1.0
56th Street	0.0	0.8	1.8	2.1
66th Street	0.0	0.0	0.0	2.0
“O” Street	0.5	1.8	2.7	3.1

The geomorphic evaluation discussed in Section 7 was used to identify stream instability problems. In addition to flooding and stream erosion projects, the study evaluated structural BMPs that focus on improving the water quality throughout the watershed.

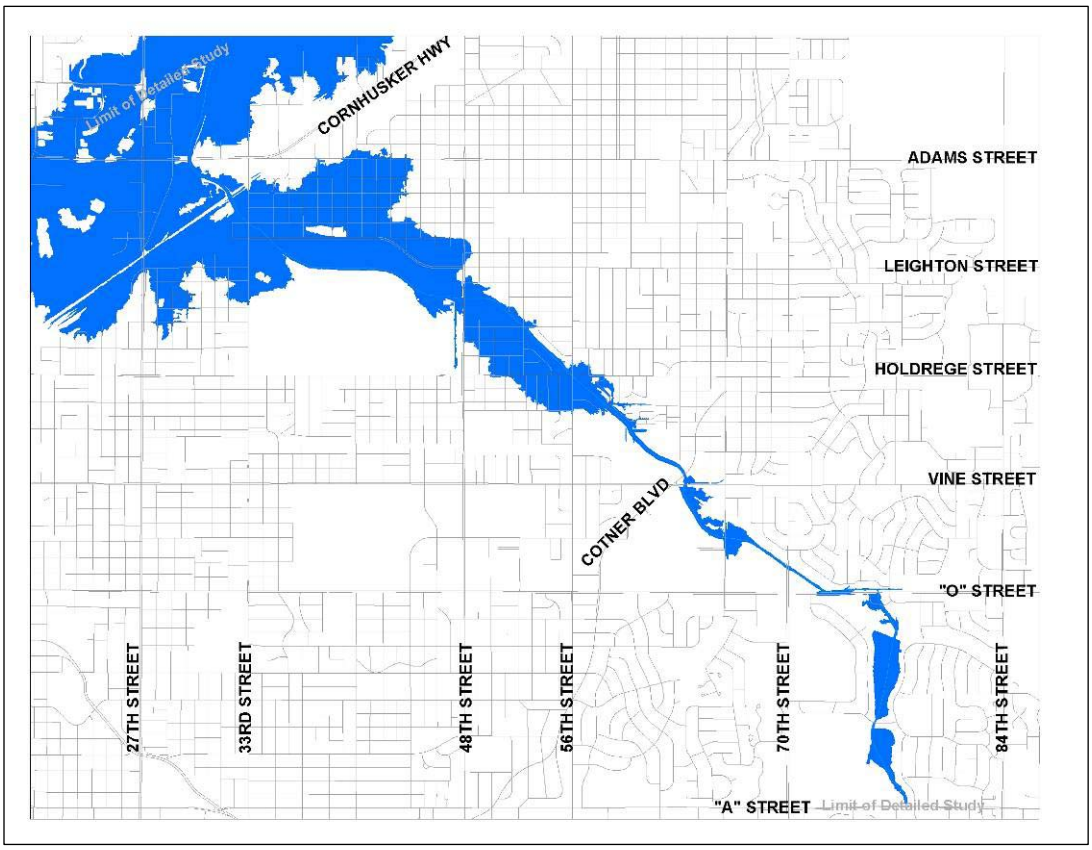


Figure 8-1
Master Plan Existing Conditions 100-Year Floodplain

8.3 Evaluation Approach

Potential improvement projects were evaluated based on design considerations, economic feasibility, and overall efficiency. This evaluation approach varied based on the intent of the project, including flood mitigation, stream stability measures, and water quality improvements. Projects that were determined to provide measurable benefits are included as recommended projects in Section 8.4. Projects that were considered but were not included as part of CIP did not meet the evaluation criteria and are summarized in Section 8.7.

8.3.1 Flooding Evaluation

The majority of the Deadmans Run main channel has been channelized using a variety of hard armoring components to increase channel conveyance and mitigate erosion problems. In addition, a limited amount of open space exists adjacent to the channel which makes it difficult to identify suitable locations for flood control projects. However, all of the evaluated alternatives utilize existing open space where available with the goal of minimizing stakeholder disruption.

The main goal of the flooding evaluation approach was to develop flood improvement projects that reduce future flood damages based on the 10-, 50-, and 100-year storm events. The flooding evaluation approach identified channel, bridge, and culvert conveyance improvements that effectively reduce the floodplain width in the respective area. Conveyance improvements that reduce overbank flooding also increase peak flows along

the main channel. Therefore, the project team evaluated multiple combinations of detention projects to avoid an increase in downstream flood water surface elevations. Finally, the improvement projects integrated water quality and stream stability features. While investigating bridge constrictions, the bridge ratings were reviewed to determine if the stream crossing was structurally sufficient to remain in service. Table 8-2 provides the summary of bridge ratings and their respective status.

Table 8-2
Bridge Ratings and Status

Location	*Rating*	*Status*
Cornhusker Highway	86.8	Not Deficient
33rd Street and Baldwin Street	97.0	Not Deficient
Huntington Boulevard near 33rd Street	86.2	Not Deficient
48th Street near Leighton Street	75.1	Functionally obsolete because of roadway width
52nd Street and Francis	96.9	Not Deficient
56th Street and Holdrege Street	96.2	Not Deficient

Table 8-2 denotes the 48th Street Bridge status as functionally obsolete. A functionally obsolete bridge has older design features and, while it is not unsafe for all vehicles, it cannot safely accommodate current traffic volumes and vehicle sizes. The priority for improving a functionally obsolete bridge may be higher than bridges that are not deficient. Therefore, an opportunity exists to coordinate the recommended improvement for 48th Street conveyance (Section 8.4.1.3) with future transportation improvements.

In summary, an iterative process was used to balance the design and overall efficiency of the flood improvement projects with the economic considerations. The economic feasibility is further discussed in Section 9.

8.3.2 Stream Erosion/Water Quality Evaluation

The improvement projects to address stream erosion in the watershed focused on resolving critical stream stability issues that have the potential to adversely impact buildings and infrastructure. Improvement projects to improve water quality in the watershed included the consideration of new structural BMPs, retrofitting existing detention basins with water quality features, and end of pipe treatments (Section 6). The new structural BMPs were identified based on available open space in the watershed. Existing detention facilities eligible for retrofit included wet and dry detention ponds located in the proper location with opportunities for enhancements.

8.4 Recommended Improvement Projects

Like many watersheds throughout the country, the Deadmans Run watershed is fully urbanized and contains a limited amount of open green space. As a result, the process of developing solutions to mitigate flooding was very challenging because of the physical limitations that significantly reduce the number of suitable locations for flood control projects. However, the improvement alternatives analysis used for this study focused on utilizing existing open space where available with the goal of minimizing stakeholder disruption.

The evaluation process resulted in 13 total conceptual level improvement projects. The general location of each project is shown on Figure 8-2. The total conceptual level cost estimate for the 13 CIPs is approximately $50 million. Detailed cost information for each project is presented in Appendix F. All costs are in 2007 dollars. The cost estimates do not include costs for easements or land rights, hazardous waste remediation, utility relocation, or rehabilitation. The costs also do not include potential cost-sharing opportunities with NRD's Antelope Valley or other City street improvement projects within the area.

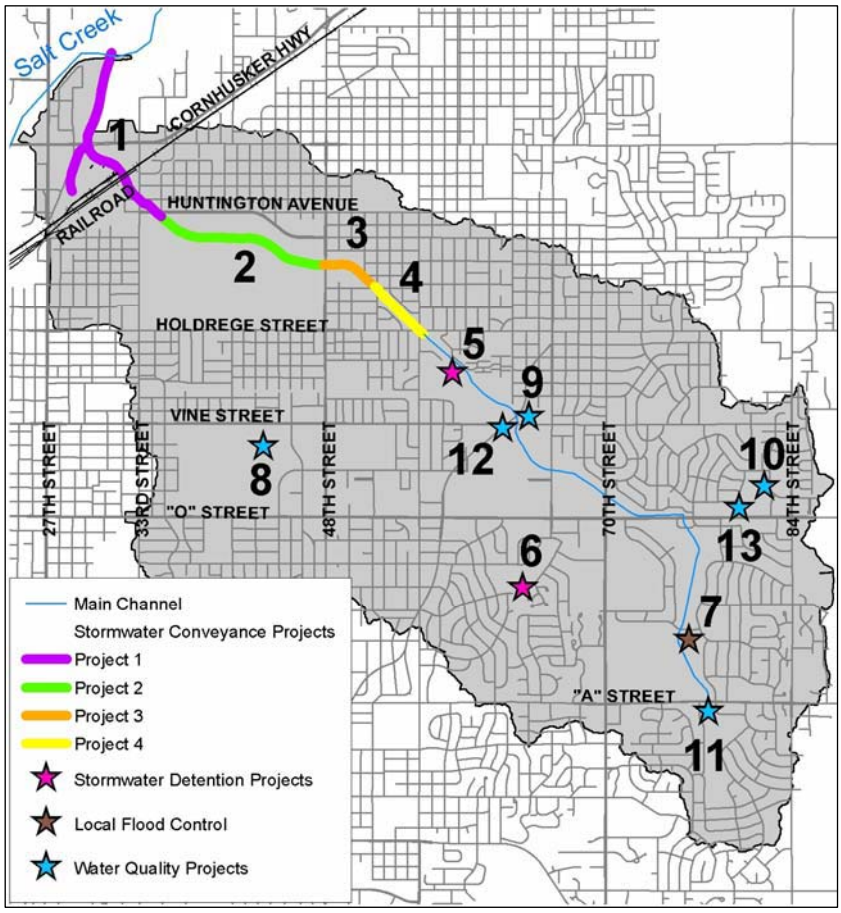


Figure 8-2
Conceptual Level Improvement Projects

The 13 CIPs are grouped into stormwater conveyance improvements, dry detention basins, local flood control, or water quality projects based on their main function. The projects are discussed on the following pages.

8.4.1 Stormwater Conveyance Projects

The stormwater conveyance projects extend from the Salt Creek confluence to 56th Street. The channel improvements were organized into four projects based on their geographic location. All four project improvements were evaluated using the HEC-RAS computer model which provided the ability to modify the hydraulic conveyance properties of the drainage system to determine the net effect on flood elevations.

8.4.1.1 Project 1: Downstream Conveyance System

Project 1 was divided into three locations, two along the main channel and one along the Deadmans Run West Tributary. Location 1 includes flooding improvements and geomorphic interventions to alleviate erosion problems downstream of Cornhusker Highway. Location 2 includes a portion of the downstream section of Deadmans Run West Tributary. Location 3 includes the portion of the main channel that extends from Cornhusker Highway to Huntington Street.

Project 1, Location 1: Main Channel, Station 0+00 to 23+66

Problem Description: The Salt Creek levee system ties into existing grade using the right and left bank of Deadmans Run. The levee isolates conveyance of the Deadmans Run main channel to a width of approximately 200 feet. Although the channel has adequate capacity to convey the 100-year storm flow, the area creates a constriction that increases water surface elevations upstream of Cornhusker Highway. This stream segment has undergone straightening but has not been improved with hard armoring, which has made this segment susceptible to erosion.

Further contributing to erosion in this area are several storm sewer outfalls that are acting as turning vanes which direct flow of the main channel to the bank opposite the storm sewer outfall. This mechanism has caused accelerated widening and meander migration throughout this unlined reach, especially along the upstream half of the reach and along the left (west) bank. The storm sewer outfall pictured to the right has been flanked which caused a collapse and is directing flow to the opposite bank and causing erosion. The exposed soils along the left bank are silty and sandy. These soils are easily eroded once flows scour under the root zones of bank vegetation. Side and channel bars are present in the channel which indicate that the channel bottom is stable downstream of the sheet pile and scour pool, which have abated the headcut from migrating upstream.

Storm sewer outfall contributing to erosion

The erosion and bank instability along the left bank will continue, if left unattended. In turn, the failing banks could expose and endanger the sanitary sewer that runs parallel to the channel along the west side. Continued bank failure could endanger the commercial properties farther to the west. Continued scouring and erosion of the banks will generate significant sediment and, to a lesser extent, woody debris. This generation of sediment and woody debris could affect the stability of Salt Creek, particularly at the confluence with Deadmans Run, where the material would initially accumulate downstream of Deadmans Run.

Recommended Improvements*:* The constriction of flow will be alleviated by increasing the width of the stream channel. Widening the channel by shifting the right levee tie-in approximately 80 feet to the east allows space for a two-stage channel in which the smaller stream forming flow will meander within the larger flood channel, as depicted on Figure 8-3. The low-flow channel is designed to handle flows up to bankfull discharge. The purpose of

the two-stage channel is to honor this channel geometry found in naturally formed creeks. The regularly occurring storms are transported by the low-flow channel, while the larger flood events are handled with the expanded portion of the channel. The channel modifications will involve shifting the left bank to the east. The channel widening will also move the right bank farther to the east to facilitate the meander within the 110-foot wide channel at the base, while containing a smaller 25-foot low-flow channel. The banks will be sloped at 2 horizontal to 1 vertical.

As shown on Figure 8-4, the low-flow channel will consist of toe stone along its banks up to the bankfull shelf. The bankfull shelf, which forms the base for the majority of the channel, will be covered with a bioengineered system design of erosion fabric and plants. The banks, which extend up to the crest, will be covered with a combination of composite revetment and fabric and plants, depending upon the depth and frequency of inundation and tractive shear. To replace the sheet pile and scour pool, a series of grade controls will be placed along the channel to facilitate a stable grade change from the sheet pile wall to the confluence with Salt Creek. The grade controls should be Newbury-type rock structures with gently sloping tailwater ramps. The grade controls should extend through the low-flow channel and bankfull shelf and tie into the composite revetment along the banks.

Estimated Project Cost: $8,304,000

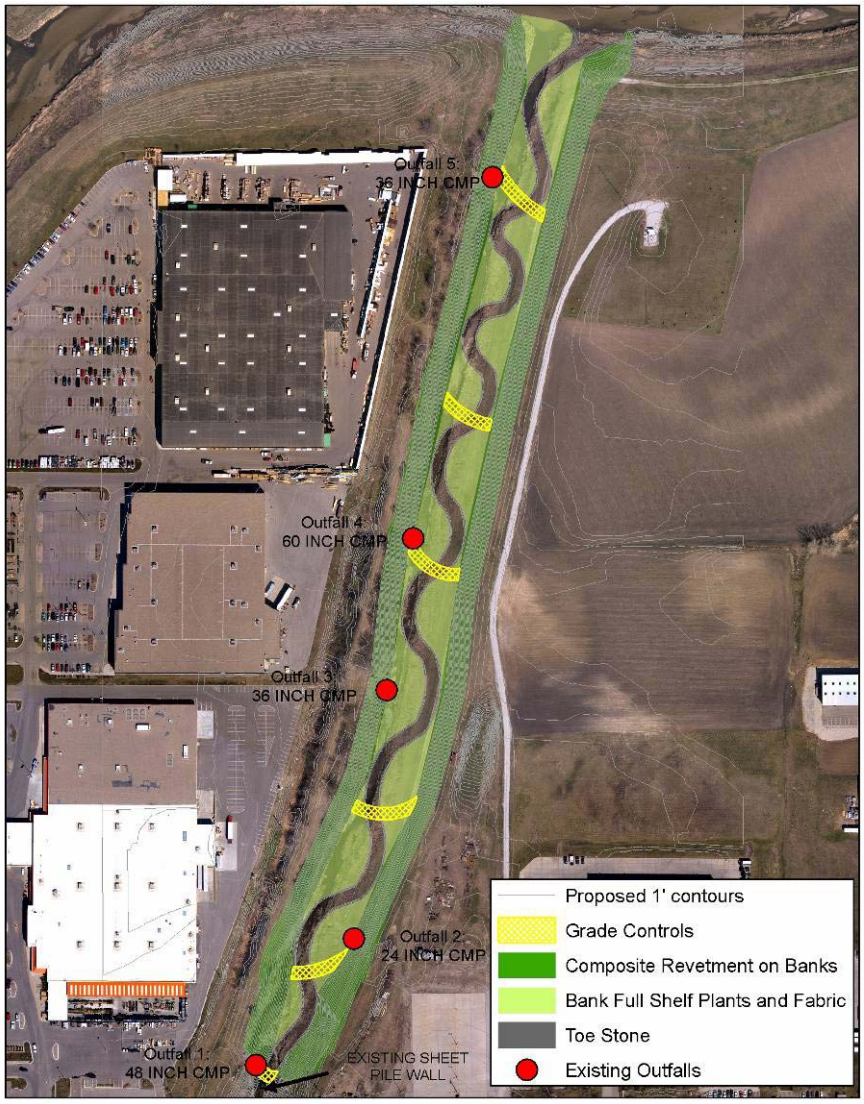


Figure 8-3
Project 1, Location 1 Channel Improvements

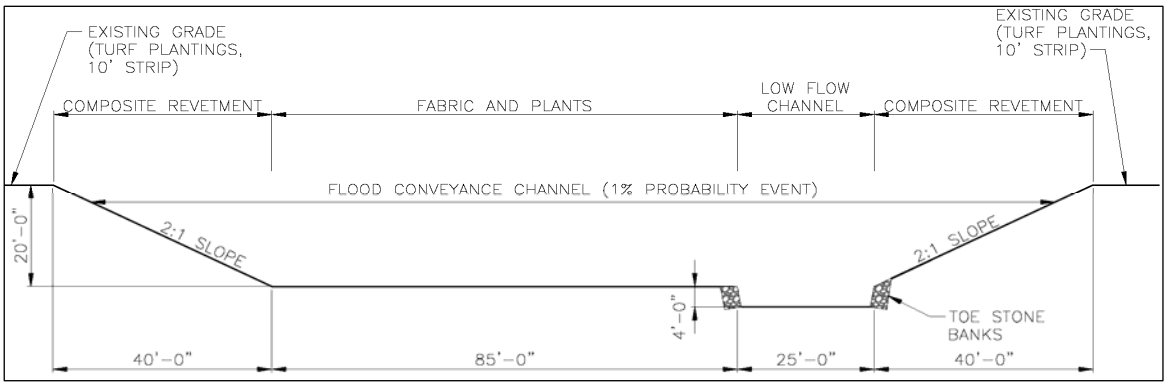


Figure 8-4
Project 1, Location 1 Typical Channel Cross Section

Project 1, Location 2: Deadmans Run West Tributary, Station 0+00 to 13+44

Problem Description: The West Tributary receives approximately 1 square mile of upstream drainage as well as overbank flooding from the main channel. During the 100-year storm event, the railroad culverts and bridges constrict flood flows causing flooding upstream. Downstream of the railroad crossings, the channel conveyance is undersized which causes overbank flooding across State Fair Park Drive to the west. In addition, the twin 6-foot diameter CMPs just upstream of the confluence with the main channel, do not have adequate capacity which creates backwater effects and upstream flooding.

Recommended Improvements*:* The Deadmans Run main channel floodplain in this area is controlled by Salt Creek; therefore, improvements along the West Tributary will not significantly reduce the extent of the floodplain. However, the flooding caused by Deadmans Run West Tributary can be greatly reduced by focusing on reducing backwater and increasing channel capacity. To avoid adversely impacting stakeholders, no buildings in this area are proposed to be removed.

The recommended improvements include utilizing open space to widen the channel. In areas that have been encroached by development and widening is not possible, an increase in channel conveyance can be achieved by flood benching (Figure 8-5). To further promote increased capacity, the tributary invert should be gradually lowered to achieve a constant slope over the project extents. The constriction in flow at the confluence with the main channel will be eliminated by replacing the twin 6-foot CMPs with a 24-foot span, 12-foot rise, ConSpan culvert.

Estimated Project Cost: $1,207,000

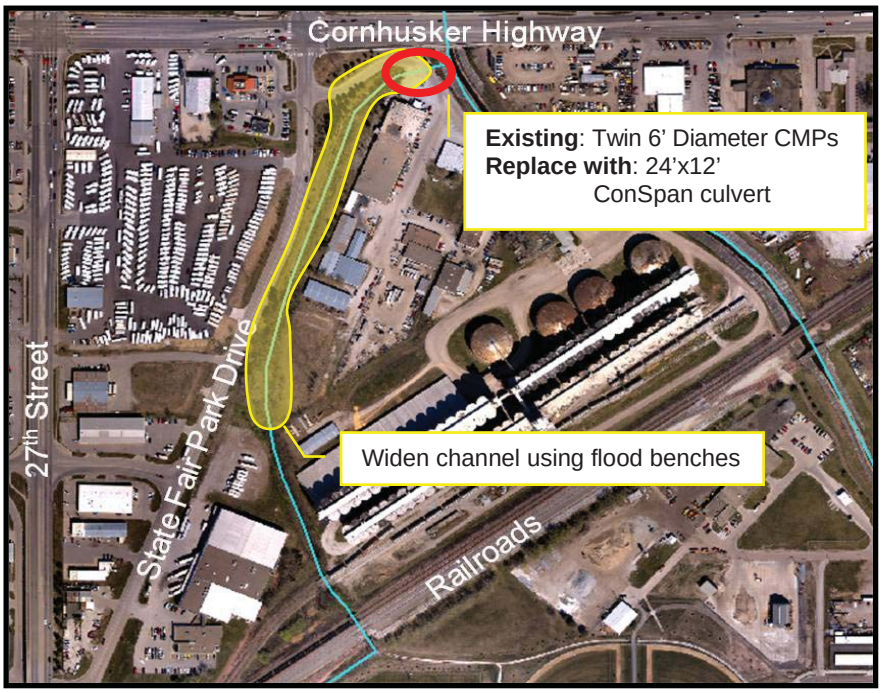


Figure 8-5
Project 1, Location 2 Channel Improvements

Project 1, Location 3: Main Channel, Station 23+66 to 58+00

Problem Description: The main channel from the railroad crossings to downstream of Cornhusker Highway conveys the 100-year storm event. However, the channel creates a constriction that increases water surface elevations upstream of the railroad crossings. In addition, the railroad bridges, 33rd Street culvert, and the Huntington Street bridge openings are too small to accommodate the design flood flows, resulting in overbank flooding throughout this channel segment.

33rd Street Culvert

Recommended Improvements*:* The stream crossings in this location are undersized and require increased capacity. Figure 8-6 provides the recommended modifications to the drainage structures as well as construction limits for channel widening. A typical flood bench channel (Figure 8-7), including a low-flow natural channel, will balance aquatic habitat and water quality with a flood conveyance channel for larger storm events. The existing lined channel will be removed and replaced with a rock grade control base to encourage aquatic habitat, limit hydraulic movement of the surface, and provide a stable lining for the creek streambed. The rock lining is necessary to protect the native soils from erosion during stream forming flow. The widened flood channel bottom ties into gradual side slopes to complete the hydraulic section. The proposed channel must be widened by 100 feet on the right bank to accommodate the flood bench. As a result, one building and various roads and parking lots will be permanently removed.

Estimated Project Cost: $15,723,000

Figure 8-6
Project 1, Location 3 Channel Improvements

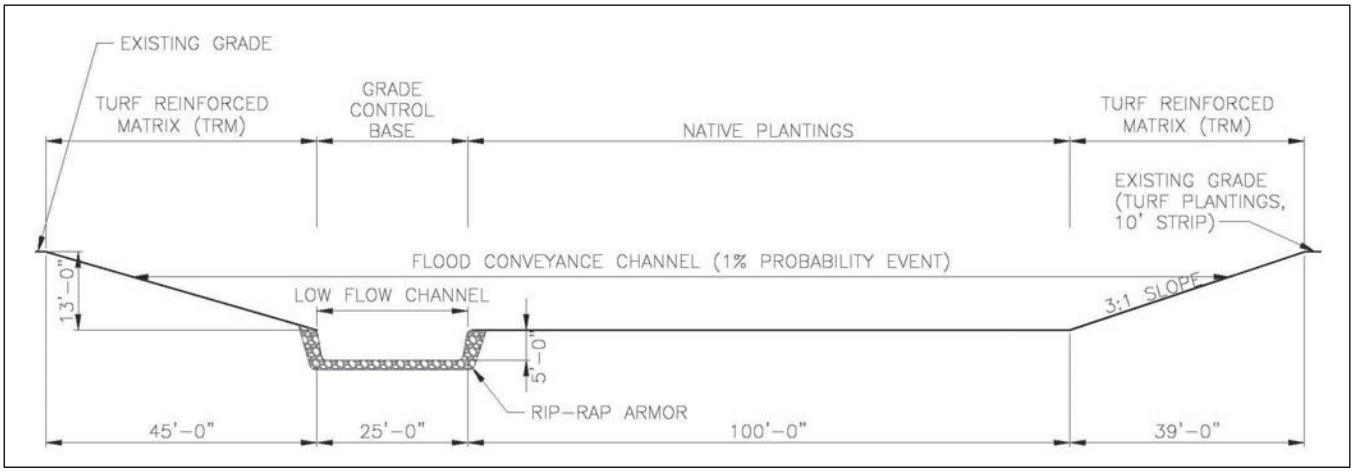


Figure 8-7
Project 1, Location 3 Typical Channel Cross Section

8.4.1.2 Project 2: University of Nebraska – East Campus

Project 2 is divided into two locations based on the physical characteristics of each stream segment (Figure 8-8). Location 1, outlined in orange, includes the engineered, lined section of channel, which is bordered by several buildings owned and operated by the University of Nebraska. Location 2, shown in yellow, spans the natural channel section upstream of 38th Street to downstream of 48th Street.

Project 2, Location 1: Main Channel, Station 58+00 to 81+78

Problem Description: The channel does not have adequate capacity for larger storm events. During the 100-year storm event, the channel capacity is exceeded resulting in overbank flooding.

Recommended Improvements*:* The University buildings to the south and research fields to the north limit design alternatives to improve the capacity of the channel in this area. The channel conveyance will be increased by implementing a terraced section, as depicted on Figure 8-9. The channel accommodates stream forming flows in the low-flow channel and limits erosion with a grade control base made of natural stone. Native plantings on the horizontal terraces will promote infiltration and improve wildlife habitat. Structural retaining walls increase channel capacity without widening the channel, which is needed in this stream segment to avoid impacting adjacent buildings or the research fields. The retaining walls could be constructed using various materials. For the purpose of this study, a retaining wall system was assumed.

Project 2, Location 2: Main Channel, Station 81+78 to 107+80

Problem Description: The steep banks and a narrow channel characteristic of this segment constrict flow during larger storm events. During the 100-year storm event, the channel capacity is exceeded, resulting in overbank flooding to the north. The University's research fields to the north limit the amount of channel widening in this area.

Recommended Improvements*:* Using available open space to reshape the channel banks back at a more gradual side slope will limit bank sloughing and also increase the flow capacity of the channel. The City and NRD recently performed stream stabilization improvements at multiple locations along this segment. Therefore, the recommendation is to continue with similar stream improvements in areas that were not addressed previously, using a typical cross section as depicted on Figure 8-10. A grade control base should be used to minimize erosion during stream forming flows. Velocities on the flood portion of the section are low enough to use native plantings, which will further promote water quality and improve wildlife habitat. The channel banks are tied back into existing grade, resulting in approximately 30 to 40 feet of widening to the south and up to 20 feet of widening to the north. Widening the channel will provide opportunity for stream meanders and riffles and pools, which will stabilize the stream channel.

Estimated Project Cost: $9,198,000

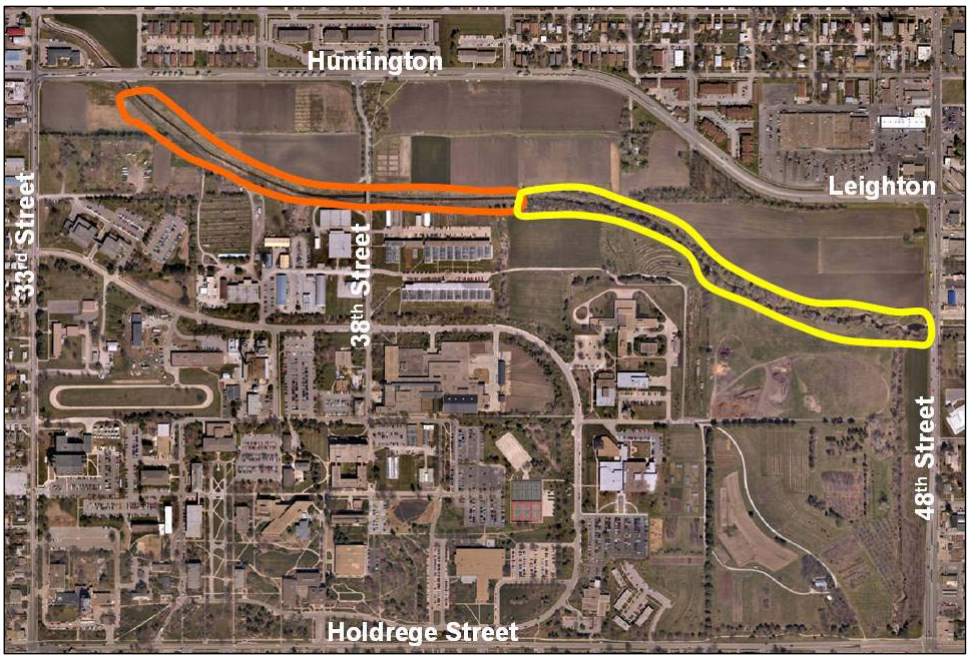


Figure 8-8
Project 2 Improvement Locations

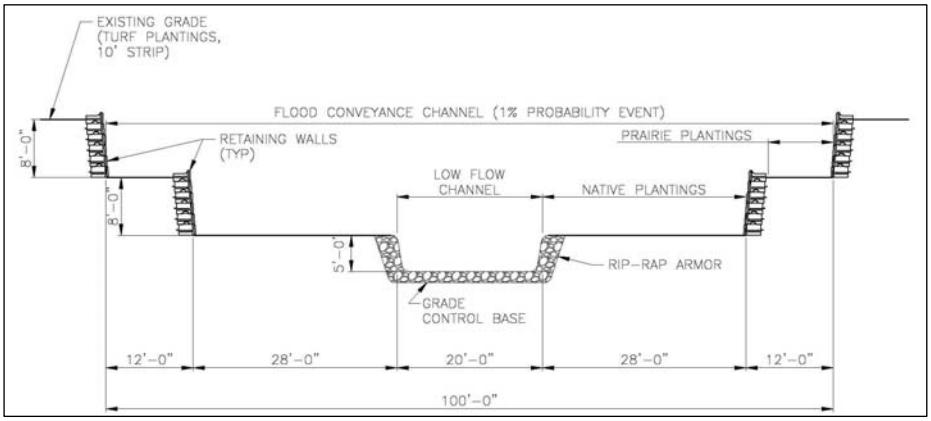


Figure 8-9
Project 2, Location 1 Typical Channel Cross Section

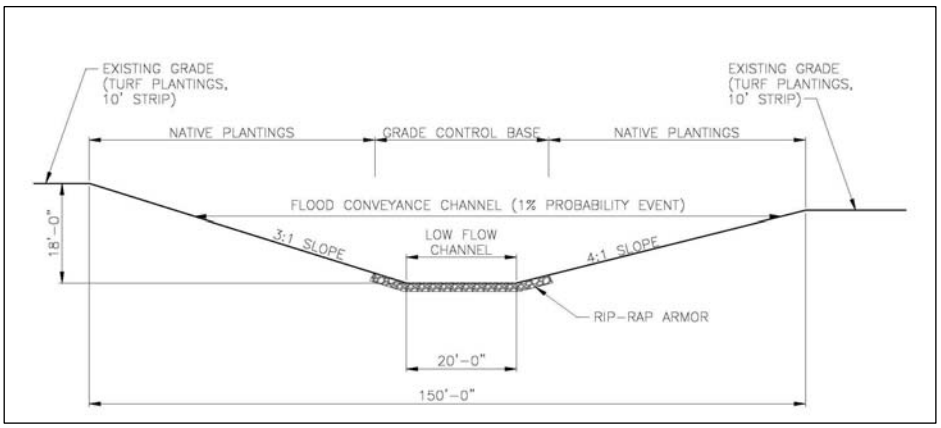


Figure 8-10
Project 2, Location 2 Typical Channel Cross Section

8.4.1.3 Project 3: University Place Park, Main Channel, Station 107+80 to 124+40

Problem Description: The narrow channel constricts flow during larger storm events, causing overbank flooding to the south. In addition, the 48th Street culvert and the pedestrian bridge near the park are undersized to convey the 100-year storm event.

Recommended Improvements*:* The recommended improvement consists of widening the channel using flood benches to reduce the overbank flooding, as well as replacing the pedestrian crossing and the bridge that extends beneath 48th Street. Figure 8-11 depicts the channel widening and project construction limit extents. Flood benching the channel by an average of 50 feet to the south, with the process shown on Figure 8-12 will provide an opportunity to replace the existing main channel with stream meanders, riffles, and pools. Flood bench terraces will be vegetated with native grasses similar to the vegetation found in the park. Trees that are impacted during channel widening will be mitigated by replanting riparian trees adjacent to the stream corridor.

Estimated Project Cost: $2,474,000

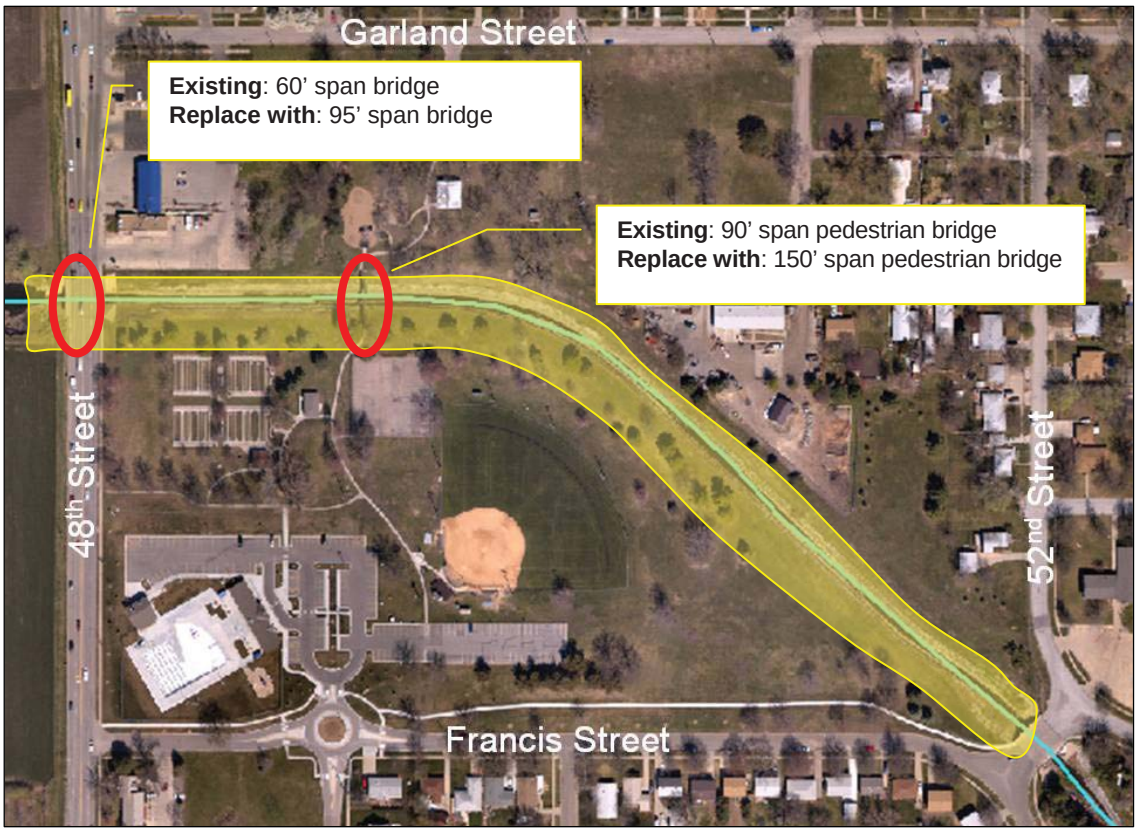


Figure 8-11
Project 3 Channel Improvements

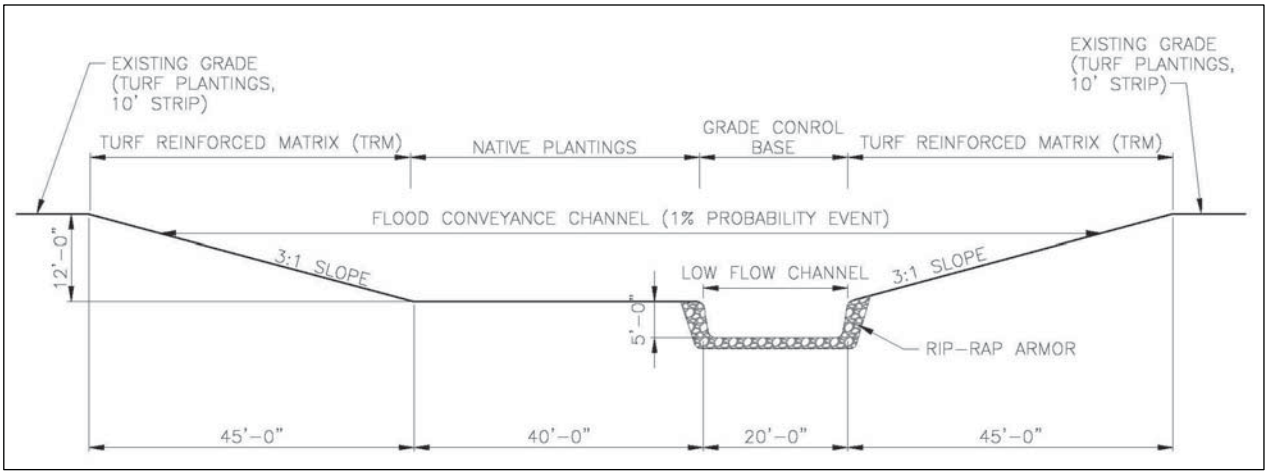


Figure 8-12
Project 3 Typical Channel Cross Section

8.4.1.4 Project 4: 52nd Street to 56th Street, Main Channel, Station 124+40 to 143+90

Problem Description: Through previous channelization projects, this section of the creek has been improved using hard armoring components. The channel consists of a Fabriform mattress liner with gabion basket retaining walls to support vertical banks. In addition, a limited amount of open space exists near the channel because of the close proximity of residential homes. The narrow channel does not have adequate capacity to support larger storm events, causing overbank flooding to the south. The culverts at 52nd Street and 56th Street are undersized for the 100-year storm event, which causes backwater flooding immediately upstream of the area.

Recommended Improvements*:* The recommended improvements include widening the channel by approximately 20 feet on each side of the banks as shown on Figure 8-13. To maximize the capacity of the channel without impacting the backyards of the adjacent residential homes, vertical structural retaining walls using a terraced approach is recommended, as depicted on Figure 8-14. Native planting the terraces will provide water quality benefits and improve wildlife habitat.

The 60-foot-wide bridge at 52nd Street should be modified to incorporate vertical walls rather than sloping abutments. The existing sloping abutments of the bridge are causing the bottleneck of flows as well as reported debris jams. The 56th Street culvert should be replaced with an 80-foot span bridge to adequately convey the upstream flood flows.

Estimated Project Cost: $7,764,000

Figure 8-13
Project 4 Channel Improvements

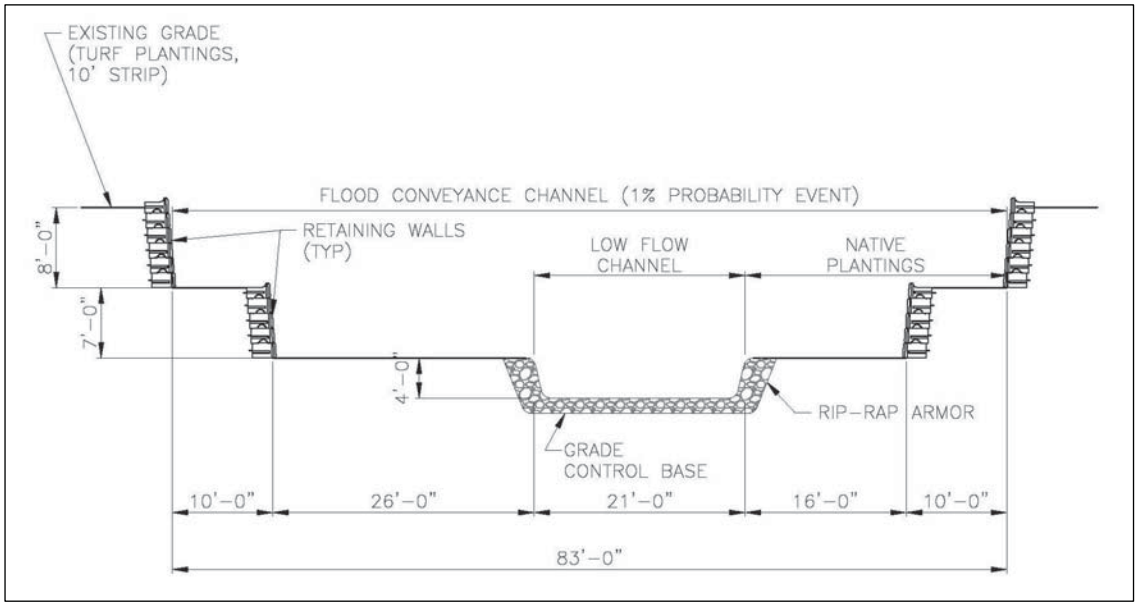


Figure 8-14
Project 4 Typical Channel Cross Section

8.4.2 Stormwater Detention Projects

Multiple stormwater detention project locations were evaluated with the goal of reducing flood flows along Deadmans Run main channel. A detailed hydrologic model was developed for each alternative to determine the effectiveness of the proposed sites. Based on the detailed evaluation, two dry detention projects are recommended. The first dry detention basin is located upstream of 56th Street and Holdrege Street along the main channel, while the second basin is located within Taylor Park.

8.4.2.1 Project 5: Offline Dry Detention Upstream of 56th Street, Main Channel, Station 152+93 to 159+78

Problem Description: Projects 1 through 4 include channel improvement projects that lower the floodplain elevation by increasing conveyance in the channel. This process eliminates existing flood storage in the overbanks and results in higher flood flows. To mitigate this increase in flow and potential adverse impacts downstream, stormwater detention basins must be constructed upstream of the channel conveyance projects.

Recommended Improvements*:* The goal of stormwater detention projects is to reduce flood flows by temporarily storing flood waters during severe rain storms and then slowly releasing the stormwater back into the channel after the storm has ended. Multiple alternatives were evaluated in this area, including variations of in-line storage with a wet bottom and variations of off-line storage with a dry bottom. The offline dry detention option was selected based on its efficiency of reducing flood flows for a given volume and project cost. The risk of adversely impacting adjacent buildings is also greatly reduced with the offline storage facility.

Available open space was targeted for the offline storage facility based on the size and geographic location within the watershed. The configuration of the basin consists of two cells, as depicted on Figure 8-15. Cell A encompasses land owned by an apartment complex and is designated as open space on their Community Unit Plan, which was approved by the City of Lincoln's Planning Department. The apartment complex has built a trail on the north side of the area that provides a connection from the west apartments to the leasing office and recreational facilities approximately a half mile to the east. The area south of the trail includes varying topography, mature trees, and a maintenance road currently used as a disposal site for construction fill and debris. Cell B encompasses land owned by a private school. The school has recently improved the area by regrading and seeding the field to create improved recreational playing surfaces.

The construction of Cell A will involve excavating approximately 16 feet of soil material using gradual 4:1 side slopes. The construction of Cell B will involve excavating approximately 13 feet of soil material using the same side slopes. A side channel weir will be constructed along the left bank of Deadmans Run main channel. The left bank and weir will separate the excavated storage facility from the channel. The weir elevation will be positioned at approximately the 5-year design storm stage. When the Deadmans Run main channel water level reaches the crest elevation of the weir, stormwater will be diverted into Cell A. As the main channel continues to rise, the bottom of Cell A will fill. During approximately the 10-year design storm, Cell B will begin to inundate, storing stormwater

for larger, less frequent storms. After the storms end, the storage facilities will drain water back into the main channel within a 24-hour period.

Other supplemental features of Cell A will include environmental enhancement by replanting with native grasses and trees. In addition, the connection trail can be replaced along the existing alignment, or through the detention facility providing access to passive recreation activities. Cell B will include a sand bed, underdrain system, and turf grass that can be used for recreational purposes. The area will gravity drain to Cell A and be available for recreational use within 24 hours of the storm subsiding.

Estimated Project Cost: $2,932,000

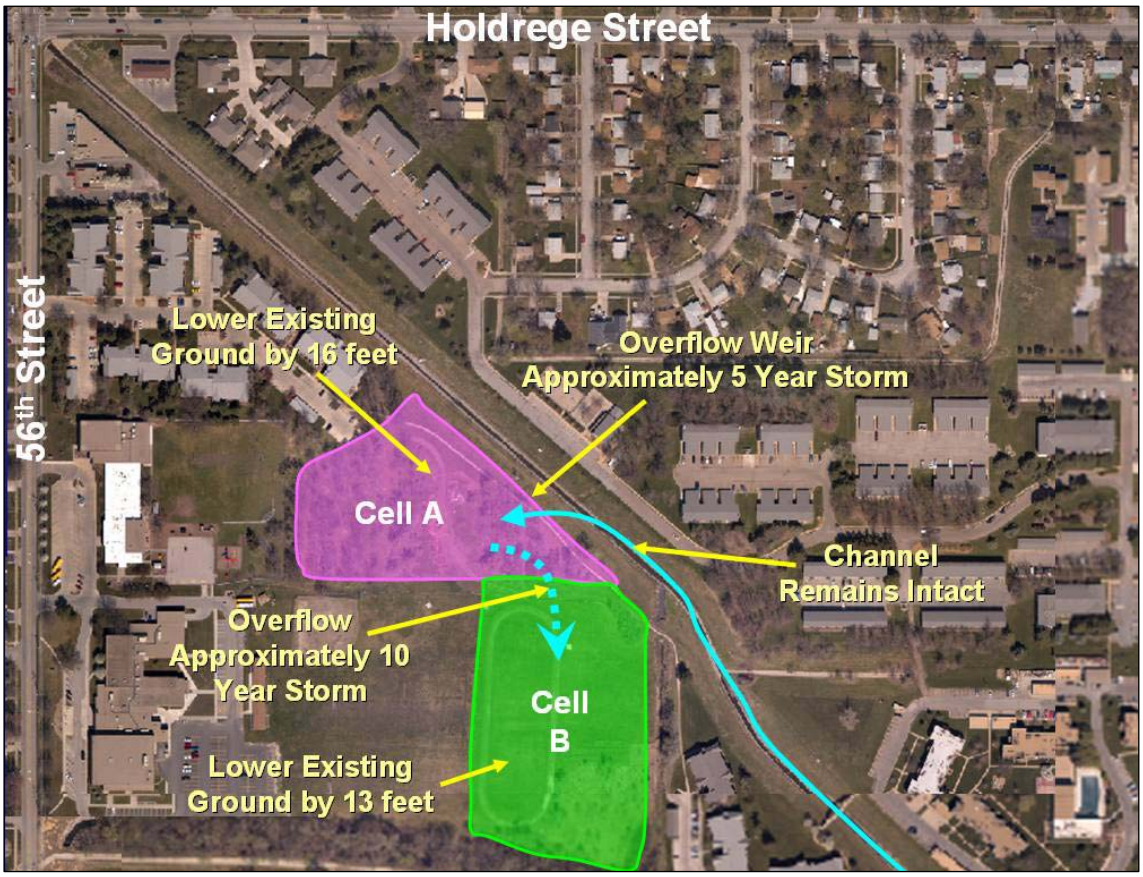


Figure 8-15
Project 5 Design Components

8.4.2.2 Project 6: Taylor Park Dry Detention

Problem Description: Projects 1 through 4 include channel improvement projects that lower the floodplain elevation by increasing conveyance in the channel. This process eliminates existing flood storage in the overbanks and results in higher flood flows. To mitigate this increase in flow and potential adverse impacts downstream, stormwater detention basins must be constructed upstream of the channel conveyance projects.

Recommended Improvements*:* Taylor Park, located near 66th Street and Taylor Park Drive (Figure 8-16), is a good candidate to implement stormwater detention. The south end of the park receives over 300 acres of upstream drainage which contributes to overbank flooding along Deadmans Run main channel. Available open space at the south end of the park includes a large hill to the west of the channel. The hill will be excavated almost 30 feet starting at the City's property line and using 4:1 side slopes. An earthen berm, approximately 12 feet in height, would be constructed across the channel and tie into existing grade. The berm would back up water into the basin during larger storm events, temporarily storing the water and releasing over an extended time.

Similar to Project 5, the existing functionality of the park will be enhanced as part of the project. The excavated portion of the basin would be replanted with native grasses and trees. In addition, the area is an excellent candidate for a walking trail system that would meander within the basin footprint. Planting additional trees to provide shade for the trail will also enhance the function of the park, which is currently a designated arboretum. The project will be integrated with the channel stabilization effort currently being constructed and managed through the City's Parks and Recreation Department. The construction includes stabilization measures located along the stream channel throughout Taylor Park.

Estimated Project Cost: $1,440,000

Figure 8-16
Project 6 Design Components

8.4.3 Local Flood Control

Local flood control projects are designed to prevent flood waters from impacting habitable buildings by redirecting existing drainage patterns. One local flood control project is recommended and discussed below.

Project 7: Seacrest Park Berm

Problem Description: Flooding at the north end of Seacrest Park has been reported to cause damages to the habitable buildings near Englewood Drive and Hazelwood Drive. An existing berm on the north end of the park becomes overtopped and does not provide adequate protection.

Recommended Improvements*:* The proposed recommended improvements include raising the existing earth berm height by approximately 2 feet. The improved berm would tie into existing grade further to the east. Project construction limits are indicated on Figure 8-17.

Estimated Project Cost: $19,000

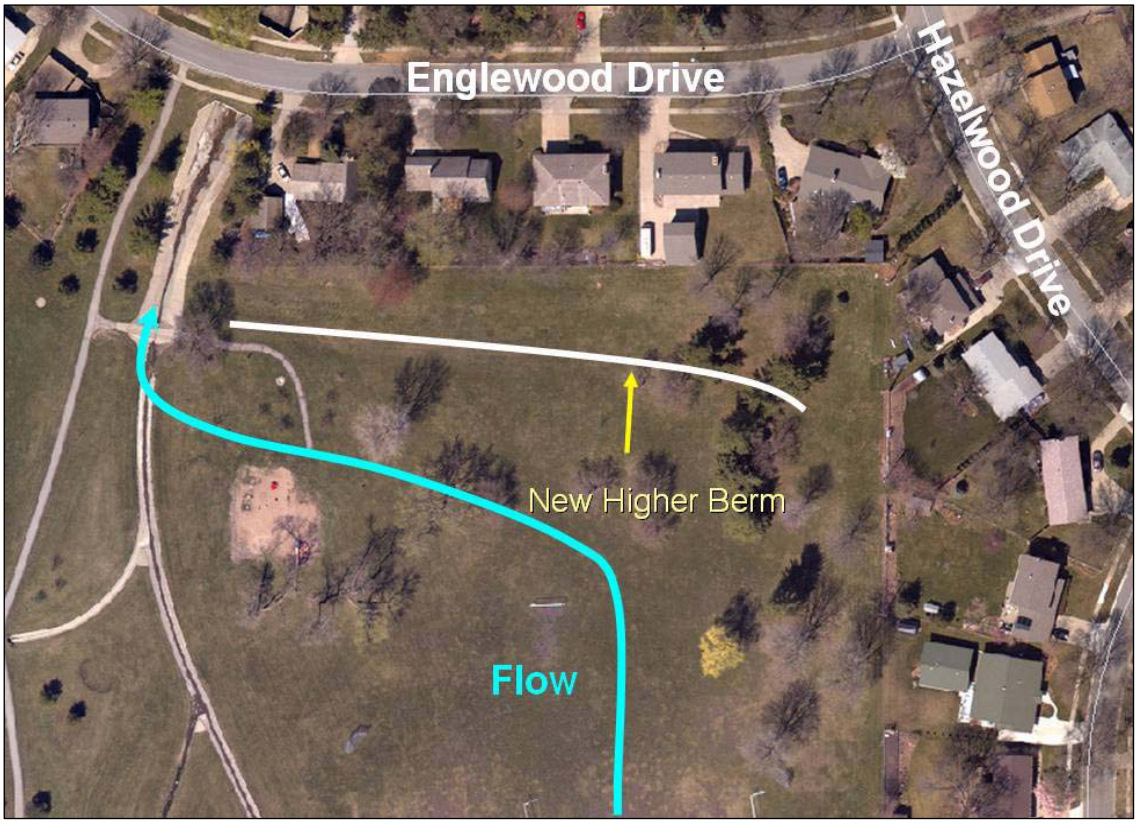


Figure 8-17
Project 7 Construction Limits

8.4.4 Water Quality Projects

Five water quality projects are recommended. The projects utilized open space where available and are strategically located to maximize pollutant removal efficiencies in Deadmans Run main channel (Figure 8-18). Improvement projects to address water quality in the watershed include new structural BMPs, retrofitting existing detention basins with water quality features, end of pipe treatments, and stream stabilization measures.

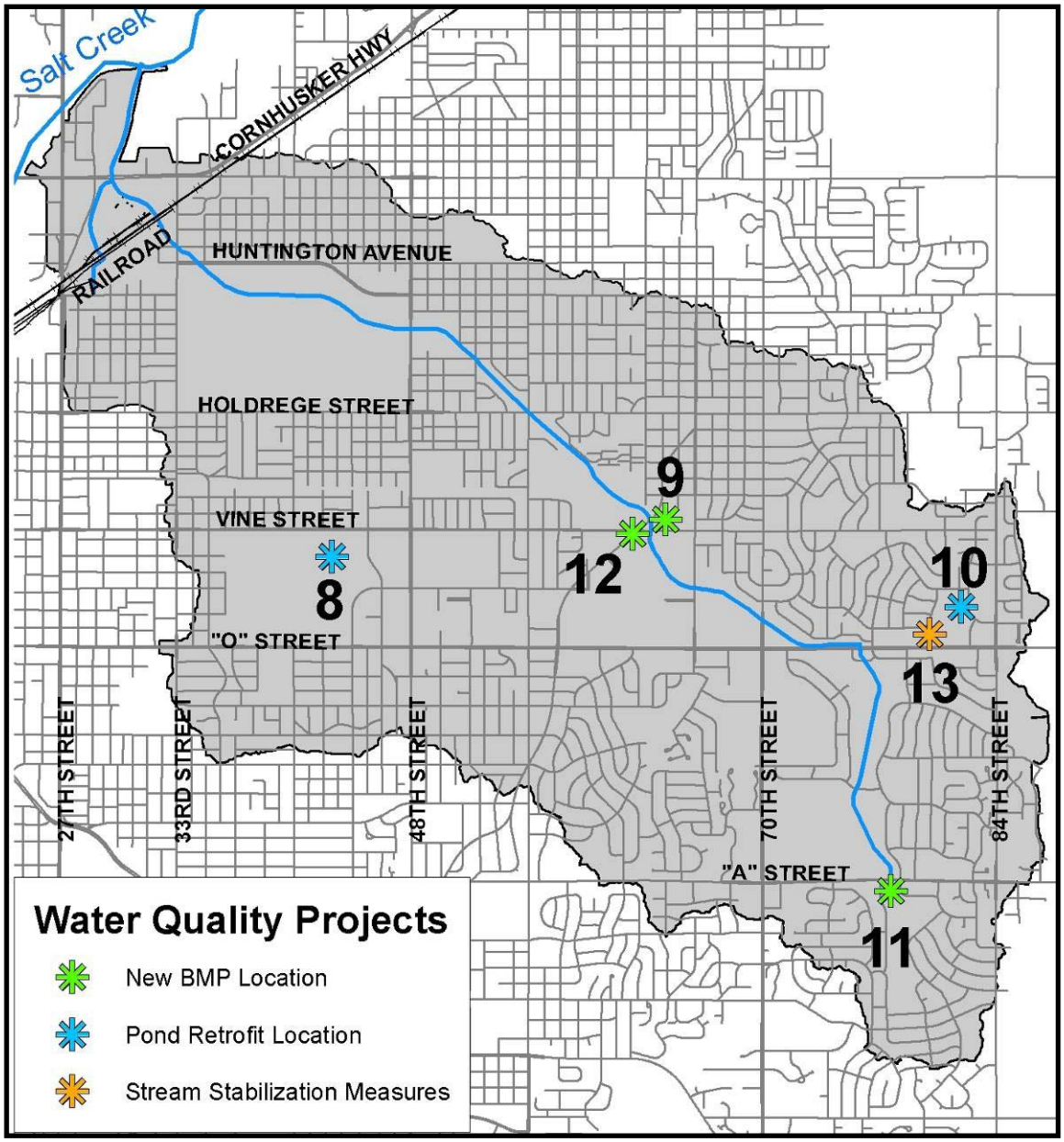


Figure 8-18
Recommended Water Quality Project Locations

8.4.4.1 Project 8: Wyuka Cemetery Existing Detention Pond Retrofit

Problem Description: The Wyuka Cemetery detention pond located near Vine Street and 45th Street was designed as a flood-control facility to reduce peak runoff rates. The basin is not appropriately configured to maximize the available storage to treat the water quality control volume. The existing outlet and sediment forebay is not efficiently flushing the system as indicated in the photo to the right.

Biological Growth in Wyuka Cemetery Pond

Recommended Improvements*:* The proposed recommended improvements for the detention pond include using a portion of the storage volume to treat runoff entering the facility as indicated on Figure 8-19. This would be accomplished by modifying the outlet of the facility to extend the drawdown time during smaller storm events. The basin has sufficient capacity to treat 100 percent of the water quality volume without adversely impacting flood control benefits. In addition to the outlet modifications, the existing sediment forebay volume can be increased by adding berm height to the existing grade that separates the basin from the forebay.

Estimated Project Cost: $47,000

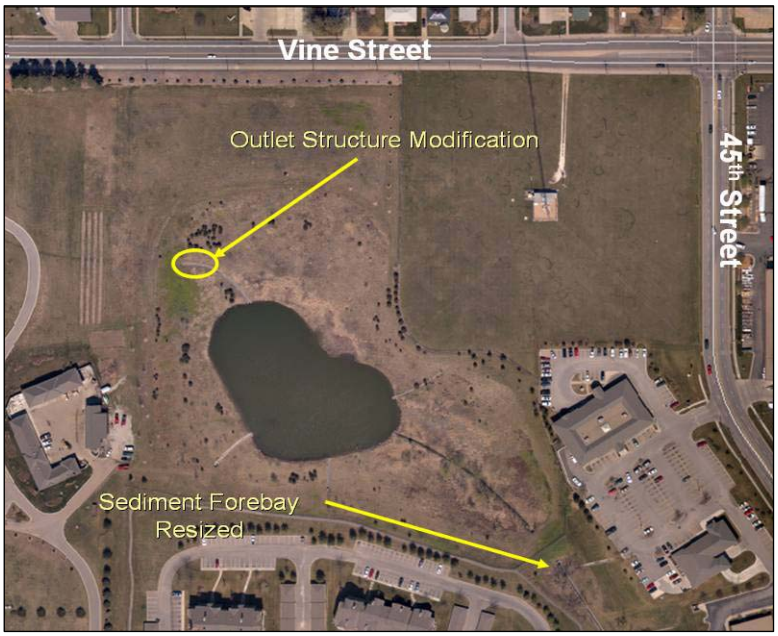


Figure 8-19
Project 8 Pond Retrofits

8.4.4.2 Project 9: Bethany Park New Water Quality BMP

Problem Description: The residential development located upstream of Bethany park (250 acres) is drained by a network of enclosed pipelines and concrete-lined channels. This type of traditional drainage system provides no water quality treatment benefits.

Recommended Improvements*:* The proposed recommended improvements include converting a portion of the west end of the park into a water quality feature that will treat the Vine Street tributary flow. The west end of the park will be excavated approximately 1 to 6 feet within the construction limits shown on Figure 8-20. A small culvert installed in the low-flow channel of the existing concrete-lined Vine Street tributary will divert the water quality storm flows and allow larger flood flows to continue to the main channel. The proposed grading would allow treatment of 45 percent of the WQCV.

Estimated Project Cost: $113,000

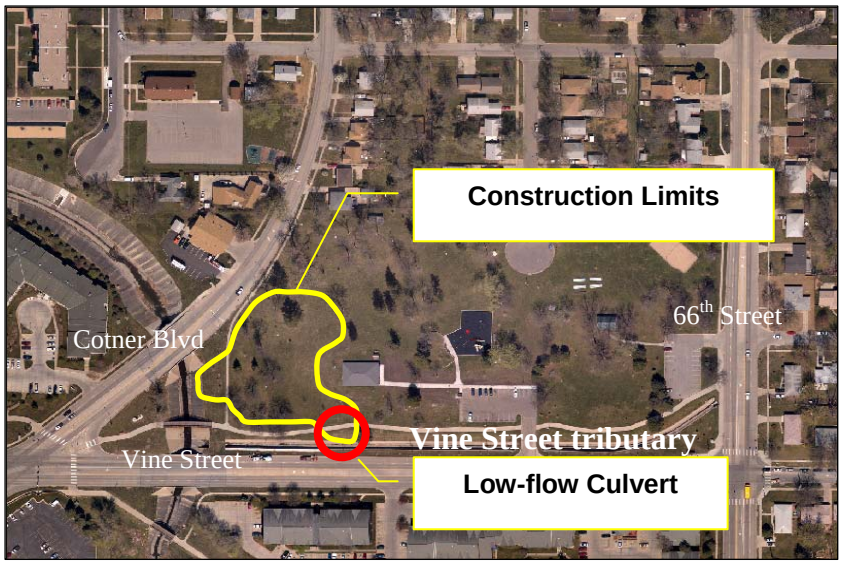


Figure 8-20
Bethany Park Recommended Water Quality Feature

8.4.4.3 Project 10: Russwood Dry Detention Pond Retrofit

Problem Description: The commercial development upstream of two existing dry detention basins is drained by a traditional drainage system that provides limited water quality benefits. The existing basin outlet structures are designed for flood control, which allows low flows to exit the facility without proper water quality treatment, as shown in the picture to the right.

Recommended Improvements*:* The proposed recommended improvements, as shown in Figure 8-21, include modifying each basin's outlet to achieve an appropriate drawdown of the water quality volume. The basins have adequate capacity to treat the entire water quality volume. In addition to the outlet modification, the construction of sediment forebays at the two east inlet locations is recommended to provide pretreatment measures.

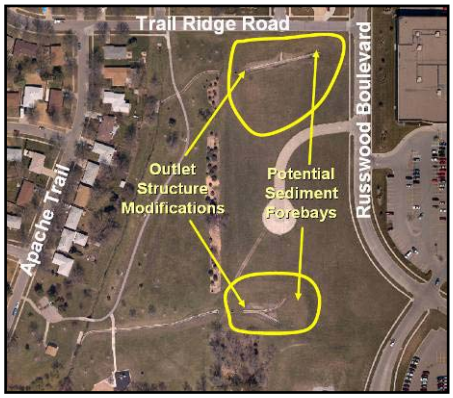


Figure 8-21
Russwood Basin Retrofits

Estimated Project Cost: $35,000

8.4.4.4 Project 11: Trendwood Park Water Quality BMP

Problem Description: Trendwood Park is located at the outlet of a 270-acre drainage area consisting primarily of residential development. The drainage area contributes large amounts of trash, sediment, and other urban pollutants.

Recommended Improvements*:* The proposed recommended improvements include the construction of a water quality feature near "A" Street along the Deadmans Run main channel as shown on Figure 8-22. The area immediately upstream of "A" Street would be excavated approximately 6 feet with gradual side slopes. Over-excavating the area to create a wet pond, if desired, is suitable in this area as baseflow will continually flush the basin avoiding stagnant water. The culvert at "A" Street would be retrofitted with a concrete box weir with a water quality orifice. The weir would back water into the BMP during small storm events and achieve a sufficient drawdown to treat approximately 20 percent of the water quality volume. During significant storm events, the weir is sized appropriately to overtop and not constrict larger flow volumes, effectively avoiding any adverse flooding impacts.

Figure 8-22
Project 11 Water Quality Features

Estimated Project Cost: $142,000

8.4.4.5 Project 12: Cotner Boulevard Storm Pipe

Problem Description: Significant amounts of trash and debris have been reported by City maintenance crews who maintain the main channel near Cotner Boulevard and Vine Street.

Recommended Improvements*:* The proposed recommended improvements include the implementation of a hydrodynamic separator. The separator would be installed within the existing 60-inch storm pipe located at the intersection of Vine Street and Cotner Street (Figure 8-23). Small storm events are diverted from the existing pipe into the hydrodynamic separator, which uses a vortex to settle out particulate matter. The separator allows larger flow volumes to bypass the treatment.

Estimated Project Cost: $237,000

Figure 8-23
Project 12 Location of Hydrodynamic Separator

8.4.4.6 Project 13: Herbert Park Stream Stabilization

Problem Description: As part of a study completed by Intuition & Logic for the City of Lincoln Parks and Recreation Department, stream stability issues were identified in Herbert Park. This problem description, recommended improvements, and cost estimate are based on Intuition & Logic's preliminary stream stability assessment report submitted to the City of Lincoln in December 2003. This tributary segment to Deadmans Run main channel receives approximately 180 acres drainage and is actively undergoing erosion, causing widening with minor right-descending bank scour and major left-descending bank scour endangering adjacent property.

Figure 8-24
Project 13 Location of Stream Stabilization Measures

Recommended Improvements*:* The recommended improvements include constructing grade controls near the pedestrian bridge, grade controls along the tributary length and within the concrete channels to manage energy, a riprap stilling basin by the second pedestrian bridge, a composite revetment downstream of the bridge, and

installing vegetated riprap by the concrete junctions. The cost estimate below has been calculated based on Intuition & Logic's 2003 estimate and adjusted to present value dollars using McGraw-Hill Construction's Engineering News Record cost index.

Estimated Project Cost: $211,000

8.5 Watershed Solution

The projects recommended in Section 8.4 accomplish the goals of reducing the potential for future flood damages, achieving stream stabilization, and improving water quality. The local flood control project (project 7) and water quality projects (projects 8 through 12) can be constructed independent of the other recommended projects. However, projects 1 through 6 are dependent on each other to ensure the net benefit of flood reduction is realized throughout the project area and that no adverse impacts occur downstream. Therefore, projects 1 through 6 are considered a watershed-based solution, which will require an implementation plan using construction sequencing. The implementation of the recommended projects is further discussed in Section 10.

8.6 Prioritization

The prioritization of Deadmans Run CIPs was completed according to the prioritization system that was developed for the City and NRD by a peer review committee to set priorities for the implementation of watershed master planning projects. The peer review committee consisted of local consultants along with City, state, and NRD staff who provided input and suggestions regarding the prioritization criteria and appropriate weighting of the selected criteria. The prioritization system was specifically developed for CIPs that are part of the ongoing watershed master planning efforts.

The prioritization system contains five major categories as summarized below:

- Flooding Impacts – This category identifies the impact of flood water encroachment on structures, public or private property, parking lots, public utilities, or other infrastructure. The flooding potential can be identified through hydrologic and hydraulic analysis, study of topographic maps, field investigation, and recorded historic problems. This category is further divided according to the frequency of the flooding – flooding that occurs at a more or less frequent rate than the 10-year storm event. Projects primarily intended to address structural or nonstructural flooding will usually incorporate a high or low risk safety factor and may, if applicable, incorporate stream stability or water quality benefits.

- Stream Stability – This category identifies the impacts of channel erosion – the transport and undermining of soil by stream flow or overland flow. Channel erosion can threaten structures, public property, parking lots, public utilities, or other public infrastructure. Channel erosion can also endanger streams, wetlands, lakes, conservation easements, buffer zones, or other natural resources. The stream stability and erosion threat may be identified through basic visual observation, not strictly using a fluvial geomorphic assessment. This category is further divided according to the nature of the erosion, aggressive channel downcutting as compared to gradual channel widening. Projects

primarily intended for stream stability typically will not incorporate flooding impact benefits, though will incorporate water quality benefits.

- Water Quality – This category identifies the impacts of water quality. A number of geomorphic mechanisms can adversely affect water quality through increased pollutant loading. The water quality benefits broken down in this category reflect the types of projects developed during watershed master planning efforts. This category is further divided according to the perceived scope of the project benefits, with greater emphasis placed upon projects with broad-based impacts. Projects primarily intended for water quality typically will not incorporate flooding impact benefits, though may incorporate stream stability benefits.

- Safety Factor – This category identifies benefits to the potential threat to public health and safety. The potential for loss of life or bodily injury may include individuals trapped in structures during flooding or vehicles being swept away by flood water. A safety factor is generally associated with projects addressing structural or nonstructural flooding, though may be associated with stream stability or water quality projects.

- Miscellaneous Factors – This category identifies various other miscellaneous factors and additional considerations that have not been addressed in the previous four categories. Examples of other factors include but are not limited to: project location, development status, adjacent projects, complaints, and outside funding opportunities.

Ranking worksheets were used to assign points under each category, with the goal of developing an overall score. The projects with the highest point score are considered a higher priority. Appendix G provides a copy of each ranking worksheet. Because projects 1 through 6 are dependent on each other, one ranking was provided for all six flood reduction projects. Table 8-3 lists the results of the ranking scores for the eight CIPs within the Deadmans Run study area. For projects with the same overall score, engineering judgment was used to finalize the ranking.

Table 8-3
Deadmans Run Priority Ranking Results

Project No.	*Overall Score*	*Project Ranking*
1 - 6	450	1
7	150	8
8	250	7
9	330	3
10	250	6
11	330	2
12	250	5
13	255	4

As implementation begins on the Deadmans Run CIPs, the priority of these projects will need to be reviewed and weighted against other projects included in adopted watershed master plans.

8.7 Summary

Table 8-4 provides a summary of the recommended improvement projects and the associated project costs.

Table 8-4
Recommended Improvement Project Costs

Project No.	Name	Project Cost
1	Downstream Conveyance Components	$ 25,234,000
2	University of Nebraska - East Campus Channel Conveyance	$ 9,198,000
3	University Place Park	$ 2,474,000
4	52nd Street to 56th Street	$ 7,764,000
5	Chateau Apartments/Lincoln Lutheran Schools	$ 2,932,000
6	Taylor Park	$ 1,440,000
7	Seacrest Park	$ 19,000
8	Wyuka Cemetery Existing Detention Pond Retrofit	$ 47,000
9	Bethany Park New Water Quality BMP	$ 113,000
10	Russwood Dry Detention Pond Retrofits	$ 35,000
11	Trendwood Park New Water Quality BMP	$ 142,000
12	Cotner Boulevard Storm Pipe	$ 237,000
13	Herbert Park Stream Stabilization Project	$ 211,000
	Total	**$ 49,846,000**

As shown in the table above, approximately 99 percent of the total CIP costs can be attributed to projects 1 through 6. Due to the magnitude of these projects, an economic evaluation was conducted using a benefit-cost approach to justify the feasibility of these improvements (Section 9).

Figure 8-24 compares the Master Plan existing conditions 100-year floodplain with the 100-year floodplain after implementation of the recommended watershed solution. The number of total buildings within the Deadmans Run existing 100-year floodplain will be reduced from 982 buildings to 58 total buildings after implementation of the recommended watershed alternative. Due to the Salt Creek backwater, the total number of buildings within the mapped FEMA floodplain would be reduced from 982 to 175 total buildings.

In the portion of the watershed where the majority of the buildings are located within the floodplain, Figure 8-25 compares the study 100-year floodplain (existing conditions) with the potential 100-year floodplain after implementing projects 1 through 6. The total number of buildings taken out of the FEMA floodplain is 807 buildings, and another 175 buildings receive flood protection benefits.

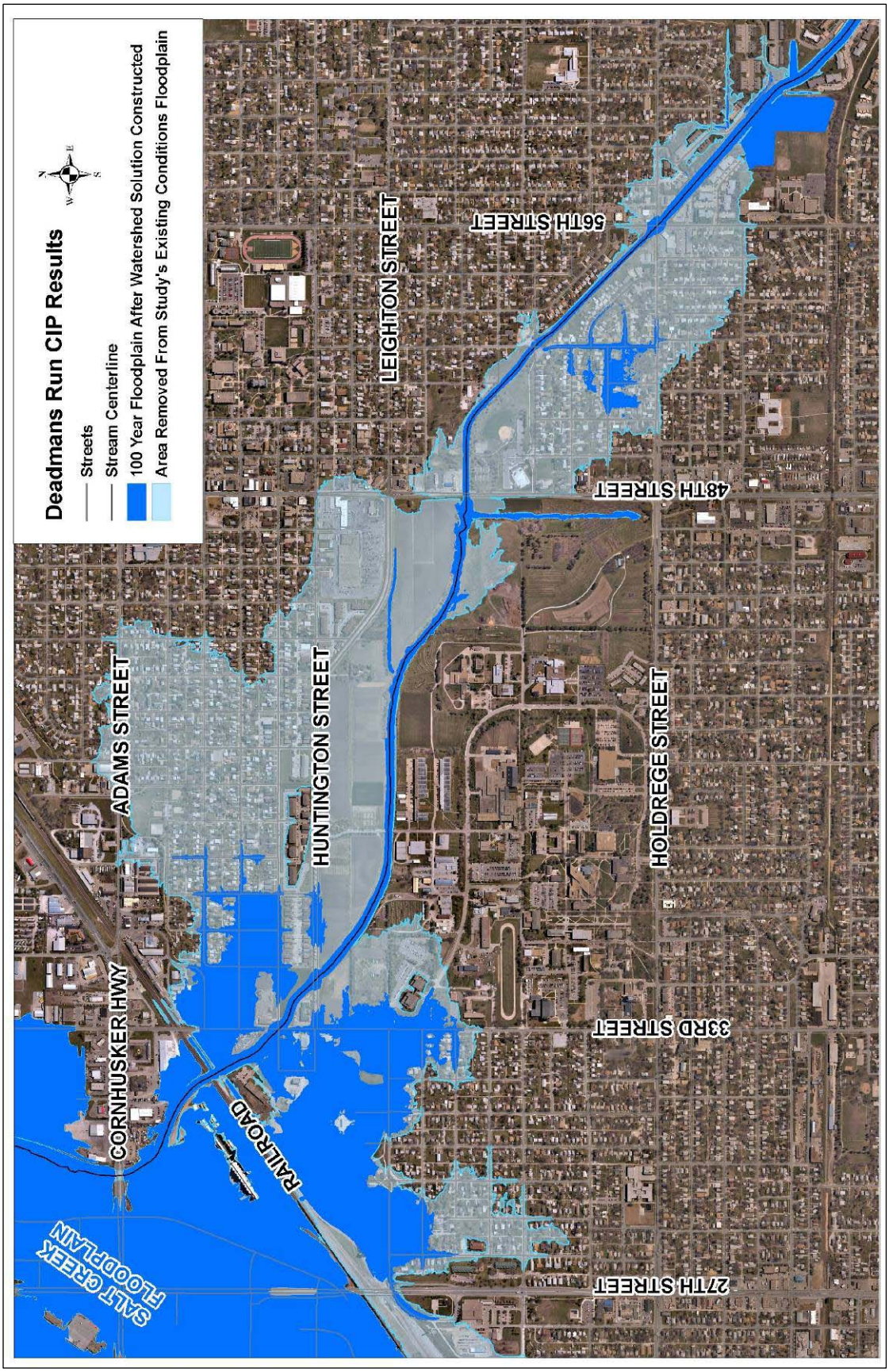


Figure 8-25
100-Year Floodplain Comparison

8.8 Other Projects Evaluated

Potential improvements that were not recommended but were thoroughly evaluated are depicted as "Other Projects Evaluated" and are shown on Figure 8-25. These projects were not included in the CIP because of the physical constraints, design issues, economic feasibility, or overall efficiency in reducing flooding or improving water quality. A summary of these projects is listed below.

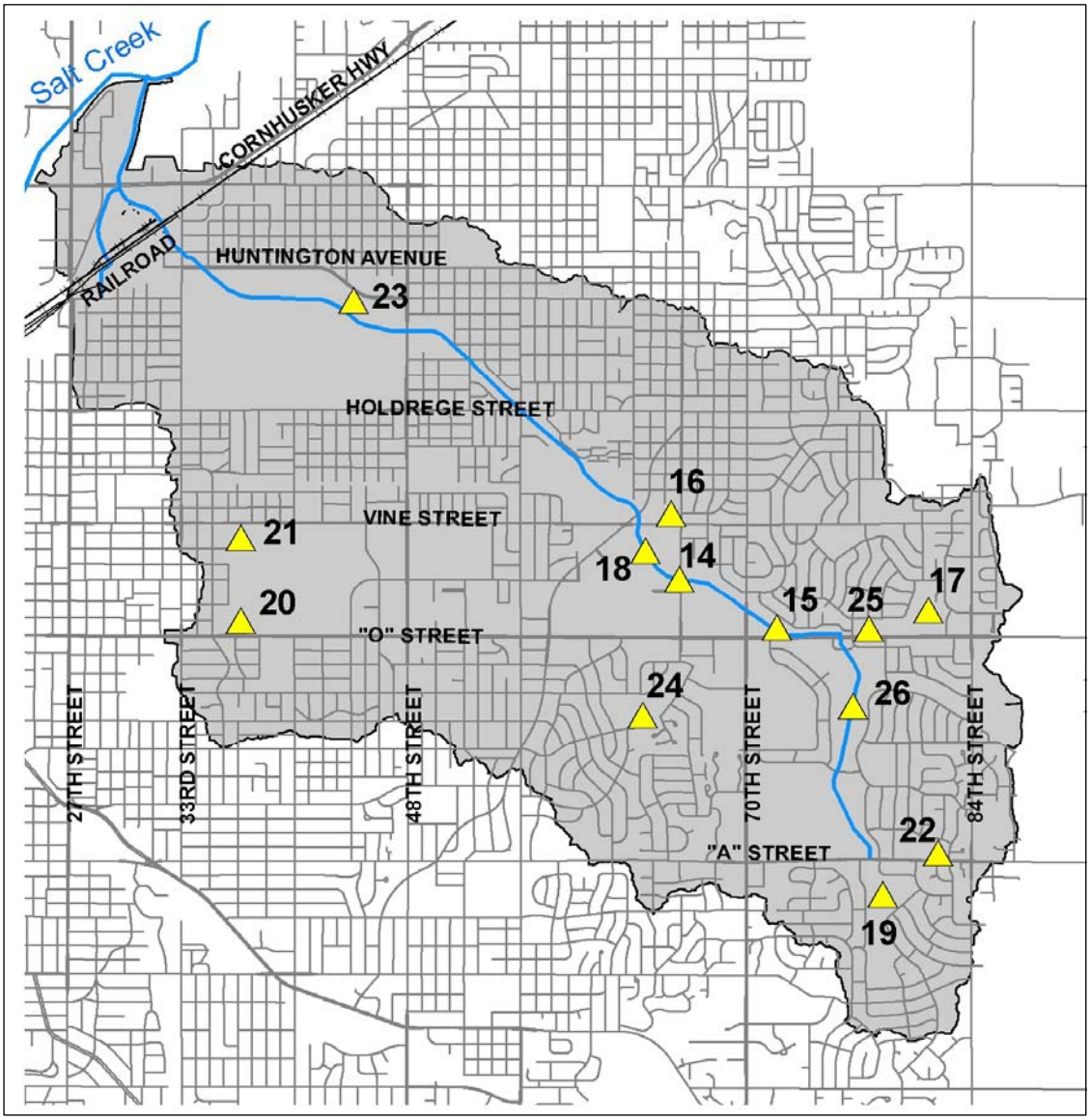


Figure 8-26
Other Projects Evaluated

8.8.1 Other Stormwater Conveyance Projects

Two additional channel projects were considered during the improvement project evaluation process. Both projects address street flooding and are discussed below.

8.8.1.1 Project 14: 66th Street Flooding

Problem Description: During the 100-year storm event, it is anticipated 2.6 feet of overtopping will be observed at the 66th Street stream crossing

Evaluated Improvements*:* Extensive flood benching of the channel upstream and downstream of the crossing, as well as expanding the length of the bridge by 60 feet would be necessary to reduce flooding across 66th Street to ½ foot of overtopping.

Issues*:* The project was not economically feasible based on the benefit-cost outlined in Section 9.

8.8.1.2 Project 15: "O" Street Flooding

Problem Description: During the 100-year storm event, it is anticipated "O" Street near the MoPac Trail overpass will encounter 3.1 feet of street flooding.

Evaluated Improvements*:* Lowering the existing trail to make room for flood benching of the channel, 70th Street crossing expansion, adding culverts to the MoPac Trail crossing, and lowering the invert adjacent to "O" Street would be necessary to eliminate flooding across "O" Street.

Issues*:* The project was not economically feasible based on the benefit-cost outlined in Section 9.

8.8.2 Other Stormwater Detention Projects

Additional stormwater detention was considered during the improvement project evaluation process, as discussed below. The problem description for each of these projects is similar to the previously recommended dry detention facilities, which minimize flows by temporarily storing stormwater and reduce the flooding potential in the downstream reaches of Deadmans Run watershed.

Project 16: Bethany Park Dry Detention

Evaluated Improvements*:* The park's playground, permanent air conditioned shelter, and open air shelter currently are used throughout the year. To minimize stakeholder impacts, a terraced detention facility was evaluated. Excavation to the west half of the park would provide flood storage volume. The playground was relocated within the 50-year flood storage to the east portion of the detention facility. The shelters were moved to the east, completely out of the detention facility.

Issues*:* The weir structure adjacent to the main channel is too short to efficiently divert flood flows. In addition, the topography of the site makes it difficult to maximize the available flood storage before submerging the weir. The project was not efficient at reducing flood flows.

Project 17: Russwood Dry Detention

Evaluated Improvements: Excavation between the north and south existing dry detention facilities at the Russwood development area would provide additional flood storage volume.

Issues: The drainage areas into the basins do not significantly contribute to flood flows. The expanded basin is not efficient in decreasing flood flows.

Project 18: Fusion Dry Detention

Evaluated Improvements: Demolish the buildings within the existing shopping area between 66th Street and the MoPac Trail and excavate the area to provide flood storage volume. Twin 10-feet by 15-feet box culverts would constrict flow and attenuate flood waters.

Issues: The cost of the improvement project was not justified based on the efficiency of the system at reducing flood flows.

Project 19: Trendwood Park Dry Detention

Evaluated Improvements*:* An earthen berm would be constructed across the channel and tie into existing grade. The berm would back up water into the basin during larger storm events, temporarily storing the water and releasing over an extended time.

Issues*:* The topography of the area was not suitable for efficiently reducing flood flows.

8.8.3 Other Water Quality Projects

Additional water quality projects were considered during the improvement project evaluation process, as discussed below.

8.8.3.1 Project 20: Wyuka Cemetery Swan Pond Retrofit

Problem Description: Approximately 240 acres drains to the Wyuka Cemetery through a culvert under "O" Street. The stormwater in the area may include urban pollutants. The pond is currently used by the cemetery visitors to view the wildlife in a calm setting.

Evaluated Improvements*:* Construct a berm across the outlet and tie into existing grade to the east and west of existing pond. Modify the outlet to obtain a longer drawdown and achieve approximately 25 percent of the water quality treatment. Construct a sediment forebay at the inlet to the pond.

Issues*:* The improvements would drastically change the aesthetics of the pond. In addition, the berm would be large enough to increase risk of flooding at "O" Street and the cemetery's offices to the east.

8.8.3.2 Project 21: Wyuka Cemetery New Water Quality BMP at Vine Street

Problem Description: Approximately 500 acres drains to the Vine Street Culvert near 36th Street. The stormwater in the area may include urban pollutants. The area currently has some open space available adjacent to the cemetery plots.

Evaluated Improvements*:* Construct a V-notch weir that would back water up into an excavated area to the east and west of the tributary flow. The project would treat 60 percent of the water quality volume in the area.

Issues*:* Drainage issues were brought to the attention of the project team during stakeholder meetings. When further investigated, the project was removed from consideration based on design concerns and the ability to achieve positive drainage.

8.8.3.3 Project 22: Carriage Hill Pond Retrofits

Problem Description: The Carriage Hill existing ponds were designed for flood control. Two ponds in sequence provide the desired flood attenuation for this area. The residential development may be impacting the water quality.

Evaluated Improvements*:* Redesign the facility with a sediment forebay and modified outlet. The berm separating the two facilities would be moved to the north to achieve the required detention volume.

Issues*:* Design issues and concern of increasing flood potential in the area caused the project team to remove this retrofit from consideration.

8.8.3.4 Project 23: Leighton Tributary Wetland

Problem Description: Approximately 100 acres drains via a storm pipe network into a tributary adjacent to Leighton Street. The tributary is located in the middle of the University's research fields and outlets to the main channel upstream of 38th Street. The urbanization of upstream drainage may contribute to adverse water quality in this area.

Evaluated Improvements*:* Construct an earthen flow spreader in available open space to slow velocities and settle particulates. Available open space would be excavated to maximize available treatment volumes. In-line structures that would backup the tributary flow were not feasible based on the surrounding topography.

Issues*:* Based on the flow velocities of the upstream pipe network, the tributary would reform the natural channel and bypass any water quality treatment. The conceptual design was removed from consideration based on the efficiency of the system.

8.8.3.5 Project 24: Taylor Park Water Quality Features

Problem Description: Over 400 acres drains via overland flow and storm pipe networks from residential neighborhoods into a tributary through Taylor Park. The urbanization of upstream drainage may contribute to adverse water quality in this area.

Evaluated Improvements*:* Construct multiple micro pools with small berms approximately 5 feet high to slow velocities, settle particulates, and allow plants to treat the water.

Issues*:* The current stream stabilization measures being constructed by the City's Parks and Recreation Department include similar water quality measures.

8.8.3.6 Project 25: Stream Stability Measures along Tributary Upstream of Sycamore Drive Extension to Skyway Road

Problem Description: Current practices of mowing the shallow-rooted grass as close as possible to the waters edge (including rushes) and close to the ground have seriously reduced the potential of filtering surface water before it reaches the channel and of the roots reinforcing the banks. Several areas of the banks were scalped to bare ground, thus eliminating the potential for the turf grasses to reinforce the near surface and provide a stormwater buffer. The combination of shallow-rooted grasses along the banks and the current mowing practice may have initiated the bank instabilities.

Evaluated Improvements: Enhancements to the stability of the channel can be achieved by planting deeper-rooted woody and mesic prairie vegetation along the banks and placing several grade controls to maintain the channel slope.

Issues: The stream segment is encountering localized issues that should be addressed during routine maintenance activities.

8.8.3.7 Project 26: Stream Stability Measures Along Main Channel from Wedgewood Lake to Corporate Drive

Problem Description: The main limiting factor for this portion of the reach is the narrow vegetative buffers along either side of the tributary. Algae and duckweed were of limited presence, but the potential for both species thriving following the loading of nutrient-rich surface waters flowing to the channel was apparent.

Evaluated Improvements*:* Establishing a wider vegetative buffer downstream of the pedestrian bridge will provide stormwater quality filtering.

Issues*:* The severities of these issues are not critical and do not warrant inclusion in the recommended Master Plan improvement projects. However, the stream segment is encountering localized issues that should be addressed during routine maintenance activities.

Section 9
Benefit-Cost Analysis

9.1 Introduction

Due to the magnitude of the recommended CIP program (Section 8), specifically projects 1 through 6, which include the stormwater conveyance and detention basin projects, a benefit-cost analysis (BCA) was conducted to evaluate the economic feasibility of implementing these projects. The economic evaluation was conducted using a benefit-cost ratio (BCR) approach based on FEMA procedures.

The FEMA BCR procedure consists of determining whether the cost of the mitigation project today will result in sufficient flood damage reduction in the future to justify the capital investment of the project. If the benefit is determined to be greater than the estimated project cost, then the project is considered justified. However, if the benefit is less than the project cost, then the project is not considered cost-effective. Thus, the BCR, which is calculated by dividing the benefits by the costs, should have a value of 1.0 or greater. The following section describes the process used to perform the FEMA BCR analysis.

9.2 Benefit-Cost Analysis Approach

The methods outlined in the FEMA BCA toolkit can be used for flood hazards by using frequency-damage relationships that are established from the hydraulic modeling, floodplain mapping, and application of GIS toolsets. The benefits for any project can be estimated by determining the amount of reduced damages as a result of constructing the project. The flood damage types are categorized into four main categories, as summarized in Table 9-1.

Table 9-1
Categories of Avoided Damages

Category	*Damage Types*	
Physical Damages	▪ Buildings ▪ Contents ▪ Infrastructure ▪ Landscaping	▪ Site Contamination ▪ Vehicles ▪ Equipment ▪ Streambank/bed erosion
Loss-of-Function Costs	▪ Displacement costs for temporary quarters ▪ Loss of rental income ▪ Loss of business income ▪ Lost wages	▪ Disruption time for residents ▪ Loss of public services ▪ Economic impact of loss of utility services ▪ Economic impact of road/bridge closures
Emergency Management Costs	▪ Flood insurance premiums ▪ Emergency operations center costs ▪ Evacuation or rescue costs ▪ Security costs	▪ Temporary protective measure costs ▪ Debris removal and cleanup costs ▪ Other management costs
Casualties	▪ Deaths ▪ Injuries	▪ Illnesses

The majority of losses suffered during a severe flood are physical damages to building structures and their associated interior contents. The process of estimating physical damages is fairly straightforward using automated GIS tools to estimate the severity of flooding associated with the various flood return intervals (i.e., 10-, 50-, and 100-year design storms). Conversely, the process of estimating loss of function, emergency costs, and casualties requires significant economic research, analysis, and assumptions. For this study, the goal

was to develop a preliminary BCR based solely on physical damages since the data for this category was readily available, and because the projects are still at conceptual level where detailed economic and emergency management information is not available. In general, for projects with a BCR above 0.75 when assuming only physical damages, it is likely that the final BCR will be above 1.0 after the damages from the other remaining categories (loss of function, emergency costs, and casualties) are estimated. For example, the reduction in flood insurance premiums (emergency management costs), which would occur if the buildings were removed from the floodplain, could be a substantial benefit to the property owners and contribute to an increase in the BCR.

The BCR was based on the total project cost and associated benefits from the watershed solution (Section 8.5), which combines projects 1 through 6. This was done because the benefits from these projects cannot be realized unless all of these projects are constructed. In addition, these projects cannot be constructed independently of each other to avoid downstream adverse impacts.

9.3 Benefit-Cost Ratio Calculation Process

In general, a five-step process is used to calculate the BCR, which is summarized in Table 9-2.

Table 9-2
Benefit-Cost Ratio Procedures

Step	Description
1	The total CIP cost at present value is estimated.
2	Damages under existing conditions are estimated. The total annualized cost at present value is calculated based on the different design storm event frequencies.
3	Damages after implementation of the recommended projects are estimated. The total annualized cost at present value is calculated based on different design storm event frequencies.
4	Benefits are defined as the damage before projects (Step 2) subtracted by the damages after projects (Step 3).
5	BCR is equal to the benefits divided by the project cost (Step 4/Step 5).

The BCR calculation process for the Deadmans Run watershed solution (projects 1, 2, 3, 4, 5, and 6) using the steps outlined above is discussed on the following pages.

Step 1: Total Capital Improvement Project Cost

The total conceptual cost for the recommended watershed solution, including projects 1 through 6, is approximately $49.0 million (Section 8.6).

Steps 2 and 3: Calculation of Flood Damages

The process of estimating flood damages before the project (existing conditions) and after the project is calculated using the same procedures. As discussed above, only physical damages were estimated for this analysis.

Physical damages to buildings, their contents, and streets were calculated as follows:

- The depth of flooding for each individual building structure and street segment was determined separately for the 10-, 50-, and 100-year storm events. The depths were calculated using ArcGIS by applying individual storm frequency depth grids to digitized building structures and street segments.

- A monetary value for the building was obtained based on Lancaster County assessor information, supplied by the City of Lincoln. The monetary value of contents was assumed to be 30 percent of the total building value. The street replacement monetary value was estimated using $60 per square yard.

- FEMA depth damage curves were applied for buildings (Figure 9-1), contents (Figure 9-2), and streets (Figure 9-3) to obtain a percentage of total value damaged for each respective storm event. The total monetary value was then multiplied by the percentage of damage to obtain a total damage for each individual building, contents, and street segment. The total physical damage for each storm event was calculated as the sum of all individual damages.

- The total annualized cost at present value for the 10-, 50-, and 100-year monetary damages for buildings, contents, and street repairs were calculated.

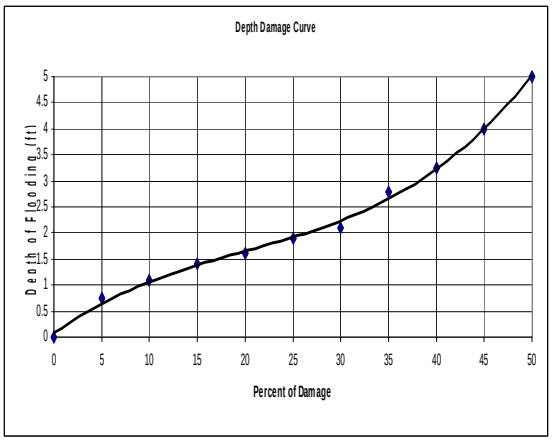


Figure 9-1
FEMA Building Depth-Damage Curve

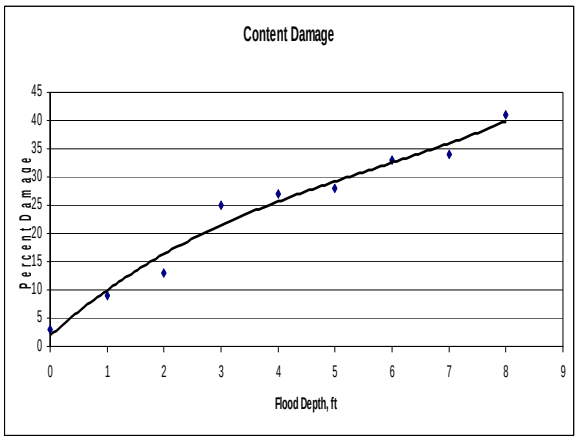


Figure 9-2
FEMA Contents Depth-Damage Curve

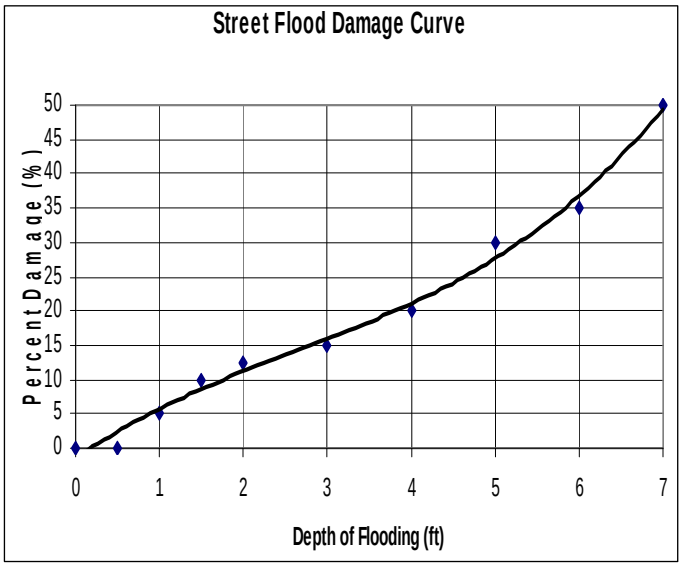


Figure 9-3
Street Flooding Depth-Damage Curve
(Based on previous Lincoln, NE flood damage replacements)

The estimated flood damages before the projects (existing conditions) and after the projects are summarized in Tables 9-3 and 9-4, respectively.

Table 9-3
Total Physical Damages *Before* Projects

Flood Frequency Events (Years)	*Buildings*	*Contents*	*Streets*	*Total Damages and Losses*
10	$4,490,280	$713,713	$944,600	$6,148,593
50	$31,233,266	$2,384,824	$5,097,344	$38,715,434
100	$50,019,320	$3,363,949	$6,538,511	$59,921,780
Total Annualized Damages				$2,219,193

Table 9-4
Total Physical Damages *After* Projects

Flood Frequency Events (Years)	*Buildings*	*Contents*	*Streets*	*Total Damages and Losses*
10	$157,963	$152,477	$58,296	$368,736
50	$1,514,629	$365,909	$399,233	$2,279,770
100	$2,285,128	$404,588	$547,819	$3,237,535
Total Annualized Damages				$127,043

Step 4: Calculation of Benefits

The benefit is defined as the avoided physical damages after project compared to that of existing conditions. Subtracting the total annualized damages of existing conditions from the total annualized damages after implementing projects 1 through 6, the total benefit equals approximately $2.09 million. Before calculating BCR, the benefit must be converted to present value dollars. Using the current Water Resources Institute discount rate of 4 7/8% and a project life of 50 years, the present value of $2.09 million equals $38.9 million.

Step 5: Calculation of Benefit-Cost Ratio

BCR is calculated by dividing the present value benefit ($38.9 million) with the present value cost ($49.0 million), which equals 0.79.

9.4 Conclusions

In summary, a BCR value of 1.0 or above is desirable to justify the economic feasibility of constructing large-scale improvement projects. For the Deadmans Run watershed solution (projects 1 through 6) a preliminary BCR value of 0.79 was estimated based solely on physical damages. Typically, if the BCR ratio is above 0.75 when only assuming physical damages, then the BCR will exceed 1.0 when the other three categories (loss of function, emergency management, and casualties) are factored into the calculations. Therefore, at this conceptual stage of the project formulation process, projects 1 through 6 appear to be economically viable.

The next step in the planning process is to move from a conceptual level (DMR Master Plan) to preliminary design. During the preliminary design stage, the engineering details and construction phasing issues will become better defined for projects 1 through 6, which will be the appropriate time to update the BCR using more refined data.

Section 10
Implementation

The successful implementation of the Master Plan recommendations will involve addressing multiple issues, including identifying physical constraints, avoiding downstream impacts, property owner and government agency coordination issues, maintenance agreements, funding, and education programs. The following paragraphs provide a discussion of these various issues.

10.1 Capital Improvement Project Implementation

The 12 improvement projects recommended in Section 8 were grouped into four categories: (1) stormwater conveyance improvements, (2) dry detention basins, (3) local flood control, and (4) water quality projects. The stormwater conveyance improvement projects (projects 1 through 4) and dry detention basins (projects 5 and 6) form the recommended watershed solution and are interrelated in their ability to maximize the effectiveness of each individual project. A watershed-based implementation approach for the construction of these recommended projects is critical in maximizing the benefits of each project, as well as avoiding adverse downstream impacts. The local flood control and water quality projects are independent of each other and can be implemented in a less rigid approach.

The implementation approaches for the recommended projects are included below.

10.1.1 Watershed Solution

The implementation of the watershed solution, which consists of projects 1 through 6, will involve additional engineering analysis, landowner coordination discussions, and a construction sequencing plan to avoid adverse downstream impacts.

Preliminary Engineering Report

The next step in the process is to develop a preliminary engineering report (PER) that further evaluates the details of each project, including identifying the physical constraints, exploring the subsurface conditions, evaluating various construction materials and aesthetics issues, agency coordination, environmental impacts, permitting, easement requirements, maintenance agreements, project costs, and construction limits. In addition, the BCR should be updated using modified project information, as well as integrating the damages caused by loss of function, emergency management, and casualties. The PER will establish the overall limitations of the watershed solution and provide a framework for approaching affected property owners with respect to acquiring temporary and/or permanent easements.

One of the key technical issues that must be further evaluated during the PER effort is determining the balance between increased channel conveyance and stormwater detention requirements. As discussed previously, the stormwater conveyance projects (projects 1 through 4) decrease flood water surface elevations but also increase flows to the downstream system. When the flows increase above a critical threshold, adverse flooding impacts could occur including increased water surface elevations or not realizing the net benefits of the downstream stormwater conveyance projects. To offset the increase in

flows, the Master Plan recommends stormwater detention basins at two locations, namely projects 5 and 6.

Once the final channel configuration of projects 1 through 4 is determined, the size and configuration of the detention basins can be optimized with the overall goal of avoiding downstream impacts. As part of the optimization process, the feasibility of constructing a single detention basin at the project 5 site location would be evaluated.

Once the PER is completed, preliminary and final design documents can be prepared, followed by construction. However, the construction process must follow a sequencing plan to avoid adverse downstream impacts as described below.

Construction Sequencing Plan

Two separate alternative construction sequencing plans can be implemented based on desired timeframes, budget, and results from the preliminary engineering report.

Construction Sequence Plan A

The first construction sequence plan is based on a three-phased approach as described below.

Phase I: Phase I includes the construction of projects 1 and 2, which can be completed without building either stormwater detention basin project (projects 5 and 6). The channel improvements throughout these areas provide enough conveyance to avoid overtopping, despite the additional flow increase. The construction must start with project 1, beginning with location 1, followed by locations 2 and 3. Once project 1 is completed, project 2 can be constructed.

Phase II: The continued construction of channel conveyance projects upstream of project 2, without building stormwater detention basins, will result in adverse downstream impacts. Therefore, either project 5 or project 6, or a combination of both projects, would need be constructed before moving forward with project 3. As discussed above, depending on the physical limitations at project site locations 5 and 6, one or both facilities may be required.

Phase III: Following the completion of the stormwater detention projects, projects 3 and 4 can be implemented. Similar to Phase I, the channel conveyance projects must progress moving upstream; therefore, project 3 must be completed before project 4.

Construction Sequence Plan B

Construction Sequence Plan B is based on a two-phased approach as described below.

Phase I: Phase I includes the construction of both stormwater detention basins (projects 5 and 6), which will provide flood benefit before construction of the channel conveyance improvements.

Phase II: Phase II includes the construction of the channel conveyance improvements (projects 1 through 4), which can be implemented with similar restrictions to Construction Sequence Plan A. The construction must start with project 1, beginning

with location 1, followed by locations 2 and 3. Once project 1 is completed, project 2, then project 3, and finally project 4 can be constructed.

10.1.2 Local Flood Control

The implementation of project 7, the Seacrest Park Berm, can occur at any point without adversely impacting downstream areas. The localized drainage patterns from adjacent property owners should be carefully evaluated when designing the berm to avoid localized adverse impacts. In addition, coordination with the City of Lincoln Parks and Recreation Department is recommended.

10.1.3 Water Quality Projects

The water quality projects, namely projects 8 through 12, are independent of each other, and can be constructed at any time. The water quality projects should be coordinated with the respective adjacent landowners to address their concerns, including aesthetics, recreational features, construction easements, and maintenance responsibilities.

10.2 Maintenance Agreements

The maintenance of Deadmans Run main channel is currently the responsibility of NRD and will likely continue after construction of the improvement projects. Regarding the water quality projects, the City will need to develop a maintenance plan to ensure the long-term functionality of these facilities. In addition, as part the PER process, the long-term maintenance of the stormwater detention projects, specifically project 5, which may involve the City and NRD, will need to be evaluated.

10.3 Coordination Efforts

A cooperative agreement between the various City departments and NRD needs to be established to guide the implementation of the Master Plan. For example, as roadways are upgraded, the Master Plan recommendations regarding bridge and culvert upgrades need to be followed. In addition, as future phases of the Antelope Valley project are completed in the downstream areas of the Deadmans Run watershed, coordination between the City and NRD will be required to achieve both improvements in transportation and stormwater conveyance.

The City of Lincoln Parks and Recreation Department will also need to be involved with several projects. Projects 3, 6, and 9 will be constructed either adjacent or within University Place Park, Taylor Park, and Bethany Park to achieve improvements in channel conveyance, stormwater detention, and water quality while maintaining the usability of these important City parks.

10.4 Project Funding

The traditional funding sources used to finance stormwater improvement projects will need to be supplemented with other funding options to finance the recommended improvement projects. The traditional funding options include City storm sewer bonds; general revenue appropriation; cost sharing between the City, NRD, and private entities; and City roadway project improvements.

Because of the magnitude of projects 1 through 6, other state and federal funding sources will need to be pursued, including appropriations through FEMA, USACE, and EPA.

Preliminary finance discussions have occurred at the federal and state level. Based on these discussions, USACE encouraged the City and NRD to pursue federal funding, probably as a General Investigation Project. USACE agreed that the project was similar to Antelope Valley and a similar funding approach could be considered. In addition to federal funding, the Deadmans Run flood control projects are currently on the State of Nebraska's list of potential projects for Nebraska Resources Development Funds.

10.5 Education Program

Water Quality Education – A proactive education program focusing on water quality issues should be developed to educate homeowners associations and private facility owners. The program may include a water quality seminar to address the primary sources of stormwater pollution and the methods for pollution reduction and removal, including both nonstructural and structural BMPs.

Demonstration Project – The City and NRD are in the process of constructing two demonstration projects that incorporate water quality BMPs into stormwater detention facilities through a partnership with the private sector. Once constructed, an evaluation should be completed to determine benefits and challenges of BMP incorporation into traditional stormwater detention facilities and to provide education on incorporating water quality features into private development in the future.

For the Deadmans Run watershed, this public-private partnership should be pursued to identify locations where structural BMPs within large parking lot areas can be incorporated, which have the potential to greatly improve water quality.

Structural BMP Design Workshop - A structural BMP design workshop could be held to educate engineers and business owners on designing and constructing structural BMPs. Providing this education will ensure proper BMP design, which will streamline the plan review process. The workshop would primarily focus on design guidance for BMPs such as grass swales and bioretention facilities, which can be used to treat stormwater runoff from parking lots.

10.6 Additional Studies

Additional studies should be conducted to identify source pollutants contributing to elevated bacteria that impair the primary contact recreation beneficial use within Deadmans Run. Dry weather illicit sanitary sewer connection investigations and inflow and infiltration studies of the sanitary sewer system will identify areas where the collection system (manholes and pipelines) may contain maintenance issues, such as breaks and cracks, which may be contributing to the bacteria issues. A comprehensive monitoring program is essential to the *E. coli* TMDL to assess the future beneficial use status and to determine if the water quality is improving based on the implementation of the recommended BMPs.

Section 11
Glossary of Terms and References

11.1 Glossary of Terms

The following terms and acronyms are used throughout the report.

- 2-year design storm - A rainfall event with a probability of occurrence of 50 percent in any given year.
- 5-year design storm - A rainfall event with a probability of occurrence of 20 percent in any given year.
- 10-year design storm - A rainfall event with a probability of occurrence of 10 percent in any given year.
- 50-year design storm - A rainfall event with a probability of occurrence of 2 percent in any given year.
- 100-year design storm - A rainfall event with a probability of occurrence of 1 percent in any given year.
- 500-year design storm - A rainfall event with a probability of occurrence of 0.2 percent in any given year.
- Bank angle - The angle measured from the horizontal between the base of the slope and the top of bank. For complex cross sections, it is the series of angles measured from the horizontal at each change in slope.
- Bankfull elevation - In classical terms, the elevation in the channel where water surface reaches the top of the streambanks, also referred to as "top-of-bank" elevation. When the water surface rises above the bankfull elevation, it crests the banks and spills over onto the bankfull floodplain. In urban streams, the bankfull elevation generally coincides with the dominant discharge elevation. This elevation corresponds to the stream forming flow, which creates bankfull floodplains.
- Bankfull floodplain - The bankfull floodplain is a low, vegetated terrace, formed by, and an indicator of, the bankfull discharge. In incised streams, bankfull floodplains form as internal shelves within the main channel. While not an absolute diagnostic, functioning bankfull floodplains indicate stable reaches. Bankfull floodplains fulfill the important function of reducing stress on the streambanks. When the flow crests the internal floodplain, the velocity and thereby the shear stress is reduced as the flow spreads across the internal shelf.
- Base flow - In a perennial stream, the low flow discharge attributable to groundwater flow.
- BFE - Base flood elevation.
- Bioengineering (also called biostabilization) - A scientific and ancient method of restoring the landscape of ecosystems using the physical properties of plants, such as their sheer resistance, tensile strength, and flexibility, to rebuild the terrestrial or aquatic foundation in a manner that is both physically and ecologically stable (see streambank stabilization, synonymous with bioengineering).

- BMP - Best management practice, a structural or nonstructural device designed to temporarily store and treat urban stormwater runoff in order to mitigate flooding, reduce pollution, and provide other amenities.
- cfs - Cubic feet per second, a unit of measurement for labeling flow of water.
- Channel bar - A streambed deposit of silt, clay, sand, or gravel, often exposed during low-water periods. An alluvial deposit composed of silt, clay, sand, gravel, or other material that obstructs flow and induces deposition or transport.
- Channel evolution - The progression of channel form (usually expressed as cross section) over time as a response to a disturbance. The model describes the progression of channel shapes as the stream accommodates the disturbance and eventually reacquires equilibrium. The stages of channel evolution in the most commonly used model are equilibrium, channel disturbance, incision, widening, deposition, and recovery.
- CMP - Corrugated metal pipe.
- Composite revetment - A bank strengthening method in which rock, geogrid, and plants form a composite material and increase resistance to scour and near-surface mass wasting. The revetment is built in layers comprised of durable rock interlaid with woody bare root plants. The thickness of the rock is controlled by geogrid layers wrapping the rock on three sides. The channel-facing side remains open. On steep slopes, a structural geogrid may also be used to increase slope stability.
- Contours - Lines of equal elevation that represent the land surface.
- Conveyance system - Natural channels and manmade structures that convey stormwater downstream.
- Cross section - A one-dimensional line that is drawn perpendicular to the contours to represent the open channel flow conveyance at that location.
- Detention basin - A stormwater facility that collects and temporarily stores runoff to reduce peak flow rates and alleviate downstream flooding and erosion problems.
- DFIRM - Digital Flood Insurance Rate Map
- Dominant discharge - The dominant stream-forming flow or recurring flow responsible for the majority of work and channel maintenance in a stream. It is the flow that over time has the greatest influence on stream form. The recurrence interval for the dominant discharge of most streams is roughly 1.5 years, as determined by flood frequency analysis. In urban areas with highly altered hydrology, this return interval may be much more frequent. The dominant discharge is sometimes referred to as the bankfull or stream-forming discharge.
- FEMA - Federal Emergency Management Agency.
- FIRM - Flood Insurance Rate Map
- FIS - Flood Insurance Study.

- Flood bench - A technique used in stormwater control, when horizontal space is available, that removes earth from one or both streambanks such that the result is a visible bench when the stream is viewed in cross section, and done to reduce water velocity, shear stresses, and water surface elevation.
- Floodplain - The area of land that is inundated with water during a given storm event.
- Fluvial geomorphology - The scientific discipline concerned with the study of how moving water shapes landforms.
- ft/sec - Feet per second, a unit of measurement for labeling velocity of water.
- ft^2 - Square foot or square feet, a unit of measurement for labeling area.
- Geomorphology - The study of surface land forms and the processes that develop those forms. Geomorphic processes are the primary mechanisms that produce these land forms, including drainage patterns, streams, floodplains, and other watershed features (see also fluvial geomorphology).
- GIS - Geographical information system.
- GPS - Global positioning system.
- HEC - Hydrologic Engineering Center of the U. S. Army Corps of Engineers.
- HEC-HMS - A computer model developed by the U. S. Army Corps of Engineers to simulate the hydrologic conditions of a drainage area.
- HEC-RAS - A computer model developed by the U. S. Army Corps of Engineers to simulate the hydraulic conditions of a conveyance system through a drainage area.
- Hydraulic analysis - The study of stormwater flow through the conveyance system that includes underground pipelines, culverts, improved open channels, and natural creeks.
- Hydraulic Profile - A plot of the water surface elevation along the flow line of a stream or pipe.
- Hydrograph - A plot of surface runoff or excess precipitation versus time.
- Hydrology analysis - The study of the occurrence, distribution, movement, and properties of waters of the earth and their environmental relations.
- Hyetograph - A plot of rainfall depth or intensity versus time.
- Impervious - The characteristic of a material that prevents the infiltration or passage of liquid through it. This may apply to roads, streets, parking lots, rooftops, and sidewalks.
- Incision - Vertical channel adjustment, or channel downcutting, generally in response to an alteration upstream or downstream of the incising reach. Incision occurs when sediment or transport material is more easily removed from the channel bed than it is from the streambanks. Bed material is liberated to “heal” a temporary disturbance in sediment transport equilibrium or channel shape.

- Knickpoint - An abrupt discontinuity in bed slope indicating the upward limit of channel incision. A knickpoint usually occurs at a resistant hard point in the channel bed, such as a geologic control, debris jams, de facto grade control, or manmade structure.

- Knickzone - Typically observed in loess or alluvial streams, a knickzone is an area of slope discontinuity similar to a knickpoint, but less pronounced and occurring over a greater length of channel. In bedrock streams, knickzones occur as a series of smaller knickpoints.

- Left (and right) descending bank - Refers to the either side of the channel in relation to the downstream flow of water. For example, left descending bank refers to the left-hand side of an in-channel observer facing downstream. This designation is the convention in river science and engineering.

- lf - Linear foot or linear feet, a unit of measurement for labeling length.

- Longitudinal profile - A profile survey down the thalweg of a stream. A thalweg profile is not a channel centerline profile and the two are not interchangeable. Longitudinal profiles are used both for diagnosis of dominant process and for design guidance. Longitudinal profiles are particularly helpful in identifying knickpoints and knickzones and for evaluating pool riffle sequences.

- Manning's formula - A formula used to predict the velocity of water flow in an open channel or pipeline: $V = 1.486/n * R^{2/3} * S^{1/2}$, where V is the mean velocity of flow in feet per second; R is the hydraulic radius; S is the slope of the channel, in feet per foot; and n is the roughness coefficient of the channel lining.

- Mass wasting - Landslide, a mass downward movement of material caused by gravity in contrast to surficial erosion, which is the movement of individual soil particles.

- Meander advance - The natural process by which the meander waveform migrates downstream. The movement is a consequence of the secondary flows occurring perpendicular to the primary downstream flow. These secondary flows alternately scour and deposit channel materials. The greatest stress and the greatest scour occur just downstream of the apex of a curve on the outside of the bend. Similarly, the peak deposition occurs just downstream of the apex on the inside of a bend. Over time, this pattern moves the waveform downstream.

- Meander amplitude - The linear distance between the apex of one meander and the apex of the next meander.

- Meander wavelength - The length of one complete waveform. Wavelength can be measured as the linear distance between two analogous points on a waveform.

- Normal depth - Depth of flow in an open conduit during uniform flow for the given conditions (see Manning's equation).

- NPDES - The National Pollutant Discharge Elimination System, established by Section 402 of the Clean Water Act, is a federally mandated system used for regulating point source and stormwater discharges.

- Open channels - Also known as swales, grass channels, streams, and biofilters. These systems are used for the conveyance, retention, infiltration, and filtration of stormwater runoff.
- Outfall - The point where water flows from a conduit, stream, or drain.
- Perennial stream - A stream channel that has running water throughout the year.
- Plan form analysis - Evaluation of the horizontal geometry of the shape and size of the channels. Plan form analysis provides insight on whether and how parts of the basin differ from one another and if the geometric relationships of meanders are within the expected norms.
- Pool-riffle sequences - In a streambed, the combination of topographical lows (pools) produced by scour and the topographical high areas (riffles) created by the accumulation of relatively coarse-grained sediment. A sequence is defined as the beginning point of one riffle to the beginning of the next.
- RCB - Reinforced concrete box.
- RCP - Reinforced concrete pipe.
- Riparian - Woody vegetation that is characteristic of an area bordering a stream or river.
- Riprap - A loose assemblage of broken stones built along streams or beaches for erosion protection.
- Runoff - The portion of precipitation that is discharged from a drainage area.
- Sediment transport - The movement of dislodged particles through a stream system. It is one of the driving forces (along with flow) of channel adjustment.
- Sediment transport competence - The condition in which the stream maintains sufficient stream power to transport the sediment supplied to it continuously through the system.
- Sedimentation - Soil particles suspended in stormwater that can settle in streambeds and disrupt the natural flow of the stream.
- Scour line elevation - The distance above a known datum (top of ground) to a persistent near-horizontal erosion feature at the peak depth of any given flow.
- Side slopes - The slope of the sides of a channel, dam or embankment, where customary naming is the horizontal distance first, as 1.5 to 1, or frequently, 1½:1, meaning a horizontal distance of 1.5 feet to 1 foot vertical.
- Sinuosity - The ratio of channel length to valley length. For example, a river 2,000 feet long, winding through a river valley that is 1,000 feet long has a sinuosity of 2.
- Slope - Defined by change in vertical elevation divided by horizontal distance and typically expressed as a percentage.

- Stabilization - Providing adequate measures, vegetative and/or structural that will prevent erosion from occurring.
- Streambank stabilization - The use of the structural properties of live plants to rebuild washed out streambanks and flood terraces, including live slope fascines, hedge brush layers, and live willow brush mattresses.
- Structural BMPs - Constructed facilities designed to remove pollutants and slow down the runoff from smaller rainstorms to preserve water quality and provide long-term stream stability. These facilities can be installed as development progresses (site-specific) or to address multiple developments (regional).
- Subarea - A portion of a watershed that drains and concentrates at point, typically at a catch basin, within a system of drainage pipes, or along a stream.
- Swale - An open drainage channel or depression explicitly designed to detain and promote the filtration of stormwater runoff.
- Tail water - Water, in a river or channel, immediately downstream from a structure.
- Thalweg - The deepest part of a channel cross section. The dominant thread of stream flow creates the thalweg.
- Time of concentration - Time required for water to flow from the most remote point of a watershed, in a hydraulic sense, to a point of concentration described within a subarea.
- Toe (of slope) - Where the slope stops or levels out. Bottom of the slope.
- TR-55 - Technical Release 55, a report compiled by the Natural Resources Conservation Service that presents procedures for stormwater calculations.
- Watershed - A region of land that drains to a river, creek, or body of water.
- WQCV - Water quality control volume.
- WSE - Water surface elevation.

11.2 References

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Appendix B

Public Participation Materials

Deadmans Run Stakeholder Meetings Summary

April 16 & 17, 2007
Lower Platte South NRD

25 people attended the sessions, which included five CAC members

Pre-session with Parks and Recreation. 2 people attended
Concerns about the project within the different parks included the following

- Replacement of the pet bridge and widening the bridge at 48th
- The shelter impact at Bethany because it is a four season shelter and heavily used, this may be a tough sale. Some solutions included moving the shelter to the western edge and expand the cul-de-sac to incorporate more parking. The playground could be relocated.
- Concerns about Seacrest Park included the trash collection.
- Taylor park is designated a state-wide arboretum, this may be a tough sale as well.

Session 1. (Projects 1 & 2) 5 people attended
Within project 1, location 1 concerns were raised regarding the proposed Antelope Valley roadway and how much property the project might acquire. No bridge improvement will be needed at Cornhusker.
Project 2, the new channel at UNL will remain a continuous slope and the time frame of the project were brought up. Main concern centered of the this session was the ability of some stakeholders to sell land.

Session 2 (Project 4) 5 people attended
The main concerns around this section included the drop off into the channel and kids playing in the area. A trail idea was brought up but met with some opposition due to privacy issues and ADA compliance. Runza was concerned about losing their drive-in but will remain in tact. Stakeholders understood the flooding issue and mentioned the amount of debris that gets trapped at the bridges on 52nd and 56th.

Session 3 (Project 5) 1 person attended
Discussion centered around the one stakeholder (CAC member) and the impact to their property.

Session 4 (Project 9) 2 people attended
Citizens were interested in maintaining open space, trails, and slopes for sledding. Concerns were also brought up about problems with water backing up into the residential areas. Additional concerns included

- Changes in property values
- Where would the playground be relocated
- What additional features such as
    - Outflow structure in many forms
    - Playground could go in the detention area
    - Blocks set in place to dissipate outflow

- Supervision of kids
- ADA compliance

Session 5 (Project 7) 5 people attended

Lincoln Lutheran has recently spent $37,000 for improvements to the east field and a proposed $10,000 for the track. Lincoln Lutheran may also add nine portable units and to keep growing to the west.
A benefit of this detention would be to walk the property and there is certainly some compatibility as it could potentially join two trails.
Others issues raised include

- What kind of clean-up will there be such as trash, sediment and muddy water
- Down-time on the fields as they are used year round for sporting events and recreation

Session 6 (Projects 3, 8, 10) 1 person attended
Individual discussion with lone stakeholder.

Session 7. (Project 6) 1 person attended
Discussion with Parks and Recreation Trails Supervisor. Discussed potential trail solutions within the project area.

Session 8. (Projects 11 & 12) three people attended.
No concerns or issues specifically with regard to the water quality issues along Wyuka. Stakeholder was mainly concerned with water draining from her property into creek and past back-up issues were raised because the pipe was too small to allow a larger volume of water to pass. Devin was going to check into this concern and could possibly be incorporated into the larger project.

CITY OF LINCOLN
NEBRASKA
MAYOR COLEEN J. SENG

Watershed News

October 2006

A Publication Sponsored by
the City of Lincoln and the Lower Platte South Natural Resource District (LPSNRD)

Deadmans Run Watershed Master Plan

The Deadmans Run Watershed, located in the heart of the City of Lincoln (City), has historically experienced flooding and erosion problems. During the past several years, the City and the Lower Platte South Natural Resources District (LPSNRD) have completed several channel stabilization and neighborhood drainage projects to mitigate these problems, while performing regular maintenance activities. To continue to build upon these past efforts, the City and the LPSNRD have embarked on a planning process to further evaluate the flooding and erosion problems while addressing water quality and integrating recreational opportunities.

The planning process involves the development of the Deadmans Run Watershed Master Plan. The Master Plan will identify improvement projects and other strategies to address street and building flooding, stream stability, and stormwater quality issues along the main channel of Deadmans Run (Figure 1). In addition, a diverse public participation program will be implemented to gather input from the public and address citizen concerns. The major components of the study include the following:

Figure 1

Update FEMA Floodplain Map. The Deadmans Run FEMA floodplain map was last updated in 1997. To properly evaluate potential solutions to reduce flooding hazards, the FEMA floodplain map will be updated using the latest computer modeling technology and topographic data.

Address Stream Stability Issues. A stream stability assessment will be conducted for the natural channels within the watershed, with particular emphasis placed downstream of Cornhusker Highway, where significant erosion problems are present.

Deadmans Run Master Plan (cont.)

This will involve evaluating the soils, vegetation, channel stability, and stormwater flow conditions.

Improve Water Quality.
In an effort to improve the water quality within the main channel, a variety of watershed management practices will be evaluated to reduce the flow rates and pollutant concentrations in the stormwater runoff.

Main Channel of Deadmans Run

Street Crossing at Cotner Blvd.

Deadmans Run Channel
downstream from Cornhusker Highway

Channel Modifications.
As part of the study process, potential channel modifications will be evaluated to reduce flood hazards, restore habitat and improve water quality.

Formulate Capital Projects.
The final Master Plan will include a comprehensive set of improvement projects that reduce the potential for future street and building flooding, address existing erosion problems, and improve water quality. As part of formulating the capital projects, a variety of solutions will be considered including flood storage, structural channel improvements and culvert and bridge modifications.

Meet the Team

Paul Zillig
Assistant Manager
Lower Plate South
Natural Resources District

Paul Zillig
along Deadmans Run, near
52nd & Francis

Q. What is your role in the project?

The Lower Platte South NRD and City of Lincoln jointly fund a number of natural resource type studies and projects. My role is to be the NRD's representative to make sure the study addresses the NRD's concerns, provide input on all phases of the study and provide some historical perspective that will help us jointly develop a successful study for the public.

(continued on next page)

Public Participation.
A diverse public participation program will be implemented to disseminate project information, gather public input, and address citizen concerns. The public process will include three open houses, landowner discussions, interest group meetings, a project web site, a citizen advisory committee and three project newsletters. The first open house was held on June 29, 2006, and is discussed further in the next section.

The project web site address can be accessed by going to the City of Lincoln's web site at *lincoln.ne.gov, keyword "watershed"*.

A citizen advisory committee will be appointed to work with the project team during the development of the improvement projects. At the first open house (see next page), nomination forms were made available for citizens interested in identifying potential members or serving on the committee. The form was also made available on the study web site. Advisory committee members will represent a broad cross-section of the community and will include a variety of interests, perspectives, and areas of the City.

June 29 Open House A Great Success

One method this project is using to get citizens involved is a series of open houses. The format used by the project team allows people to go on a "public tour" at their own pace when they visit various information stations set up at the event. This venue is also conducive to more one-on-one interaction with project staff and provides participants more of an opportunity to ask individualized questions. With project maps, staff can show participants the potential impact on an individual parcel of land.

The first of three open houses for the Deadmans Run Watershed project was held Thursday, June 29th at the Riley School Gym. The open house included short presentations by Pat O'Neill from CDM, Milan Wall from the Heartland Center for Leadership Development, Paul Zillig from the LPSNRD, and Devin Biesecker of the City Public Works and Utilities Department. In all, 86 people signed in at the registration table.

After the presentations, citizens were invited to attend one of four information stations. The stations included maps of the watershed and provided an opportunity for people to discuss the project one-on-one with project staff. An additional information station shared more historical information about the watershed and its neighborhoods. In addition, citizens also were invited to indicate interest in serving on the citizen advisory committee which will interact with the project team and provide community feedback.

Project comment cards were made available so that people could add their input about the project and drop the card off to project staff that night or mail it to the Heartland Center. You can still fill out a comment card by accessing the project web site (see page 2). Once on the web site, select Deadmans Run and locate the comment card under the Public Participation heading. The web site also contains a presentation from the first open house and provides access to this and future newsletters to help keep everyone informed.

Meet the Team (cont.)

Q. What got you interested in conservation and resource management?

Growing up, I enjoyed outdoor activities such as hiking with my family, hunting and fishing. I also worked for area farmers walking beans, putting up hay and about everything else, so I learned the importance of conservation and resource management. That interest led me to other conservation related part-time jobs, onto college to study natural resources and then working for the NRD.

Q. What are your day-to-day duties with LPSNRD?

I spend a lot of time working on projects and programs that the NRD Board of Directors has established to assist with conservation efforts and resource management. These projects, programs, and responsibilities bring me in touch with a lot of landowners, agencies and the general public. The NRD has a wide variety of responsibilities so it seems like there's always something new going on.

Q. How familiar are you with the Deadmans Run watershed?

I've lived in Lincoln over 30 years, including several in the East Campus area. My wife Janet grew up in the Meadowlane area, and her mom still lives there, so I'm pretty familiar with it. Add in the fact that the NRD is responsible for the main channel of Deadmans Run, so I have a good reason to keep up with what's going on.

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City of Lincoln and Lower Platte South Natural Resources District

The Project Team

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The consulting team is comprised of CDM in association with Mead & Hunt, Applied Ecological Services, Heartland Center for Leadership Development, and Kirkham Michael Consulting Engineers.

For more information, contact:
Devin Biesecker, P.E.
Lincoln Public Works/Utilities Department
Phone: (402) 441-4955
Fax: (402) 441-8609
Email: *dbiesecker@lincoln.ne.gov*

UPCOMING STUDY ACTIVITIES

During the remaining months of 2006, the project team will complete the draft floodplain map and begin to formulate the preliminary capital improvement projects and watershed management recommendations. The draft floodplain map will be presented to the public at the second open house. (See below.)

Deadmans Run 2nd Open House

Culler Middle School

5201 Vine Street
5:30 - 8:00 p.m.

November 16, 2006
Presentation at 5:30 p.m.
repeated at 7 p.m.

Citizens Advisory Committee Meetings

Meetings will be held at:

Warren United Methodist Church
1205 N. 45th Street
4:30 p.m.
November 14, 2006
December 12, 2006

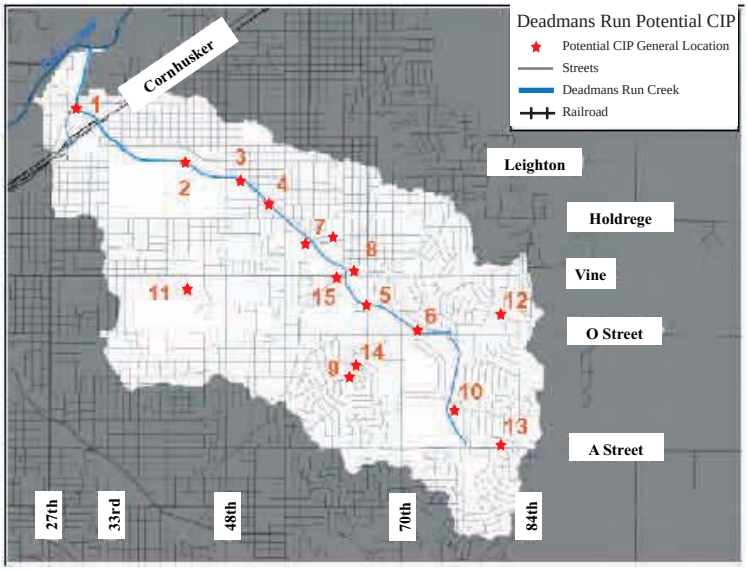
CITY OF LINCOLN
NEBRASKA
MAYOR CHRIS BEUTLER

WATERSHED NEWS

JUNE 2007

A Publication Sponsored by
the City of Lincoln and the Lower Platte South Natural Resources District (NRD)

DEADMANS RUN WATERSHED MASTER PLAN



The City of Lincoln and the Lower Platte South Natural Resources District (NRD) are sponsoring the Deadmans Run Watershed Master Plan study. As discussed in the October Newsletter, the primary goal of the study is to develop a comprehensive set of improvement projects that reduce the potential for future street and building flooding, address erosion problems, and improve water quality. In formulating the capital projects, various solutions were considered including channel modifications, culvert and bridge modifications, stormwater detention, and water quality measures.

Preliminary Capital Improvement Projects (CIPs)

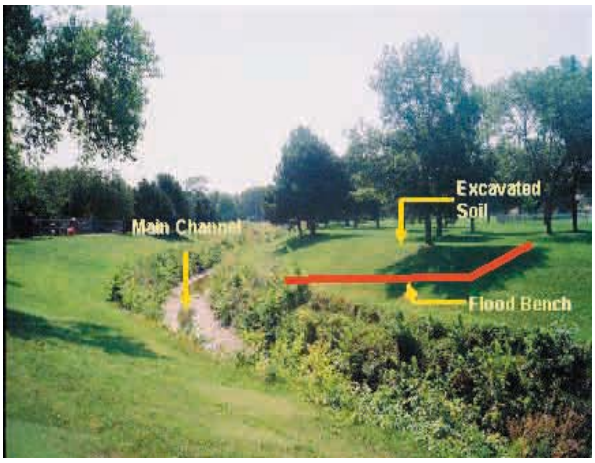
The project team has identified 15 conceptual CIPs. The general location of each CIP is shown as a star on the map above. The projects are categorized into four groups, including: 1) conveyance system components, 2) dry detention facilities, 3) local measures, and 4) structural best management practices (BMPs).

Conveyance System Components (Projects 1 through 6)

The primary goal of the conveyance system improvements is to increase the flow capacity of the channel and stream crossings (bridges and culverts) and minimize overbank and street flooding. A common technique used to increase the flow capacity is to install flood benches adjacent to the stream. This process involves the removal of soil adjacent to the channel while maintaining the integrity of the main channel. Flood benches can be installed on one or both sides of the channel. (continued on page 2)

UPCOMING STUDY ACTIVITIES

The study team will be updating the preliminary projects based on stakeholder and community input. Also, the project construction costs will be estimated to allow for a cost/benefit analysis. The study team will meet this summer with the Citizen Advisory Committee to review project recommendations. Final recommendations will be presented at an Open House in the fall.

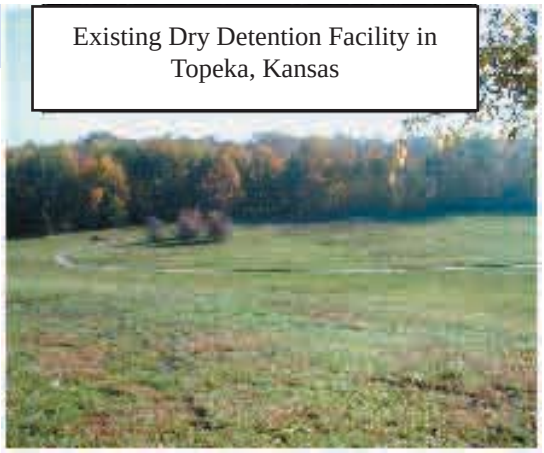


Example of the Flood Bench Concept

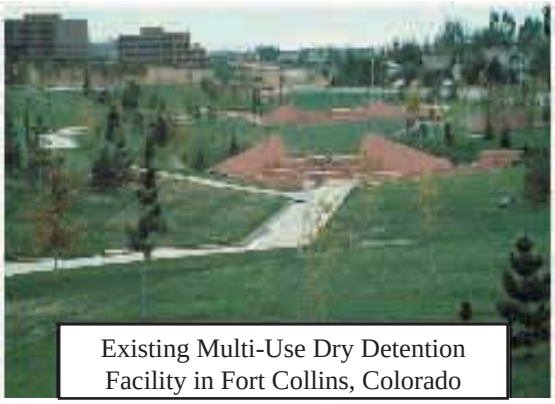
Deadmans Run Master Plan (cont.)

Dry Detention Facilities (Projects 7 through 9)

Dry detention facilities are designed to temporarily store flood waters with the goal of reducing downstream flooding. Typically, dry detention facilities include an engineered structure designed to temporarily store floodwaters within a depressed area. During dry weather, these facilities are used for multiple purposes, including walking trails, playground areas, and recreational fields. The facilities are designed using landscaped terraces to enhance the aesthetics and to minimize the frequency and duration of stored flood waters. In addition, the facilities are designed to drain dry within 12 hours after the rainfall has ended to maximize the usability of the facility.



Existing Dry Detention Facility in Topeka, Kansas



Existing Multi-Use Dry Detention Facility in Fort Collins, Colorado

Local Measures (Project 10)

Local measures include simple improvements to prevent floodwaters from reaching habitable buildings by redirecting overland flows. An earth berm is considered a local measure that provides flood protection. The study has identified one location where an earth berm project would provide local flood protection benefits for homes.

Structural Best Management Practices (Projects 11 through 15)

Structural Best Management Practices (BMPs) are constructed facilities designed to remove pollutants and slow down the runoff before the stormwater enters the receiving stream. Best Management Practices are designed to address the smaller rainstorms, which carry the majority of pollutants and are believed to cause the greatest amount of erosion. Structural BMPs can be designed to take many different forms, including dry and wet ponds, wetlands, and infiltration devices. In fully urbanized watersheds such as Deadmans Run where open space is limited, one of the most effective strategies is to integrate structural BMPs by retrofitting existing ponds to enhance their ability to remove pollutants and to more effectively slow down the runoff. Projects 11 through 14 include pond retrofits or building new ponds. Typical pond retrofits would include pretreatment measures such as the installation of sediment forebays, potential regrading, and slight modifications to the outlet structure.

Other strategies include installing more engineered devices, such as vortex separators, which are placed below ground as part of the pipeline system, and are designed to remove trash and debris from the stormwater. Project 15 has been identified as a location for this type of treatment.

Name Origins for Deadmans Run

Deadmans Run has many, many different supposed sources. All quite naturally have a dead man involved. Sometimes he runs away, perhaps playing possum, and, hence, Deadmans Run.

One story actually involves a couple of boys whose family was camping about where Gateway Shopping Center now sits. They find a dead man at the creek when they go down to get water and, when they return with their father, the body is gone — the dead man has "run."

The best guess is that there is a dead man involved who was on the creek bank and the word "run" simply comes from the less popular usage of a run as in a creek. In the East particularly, they have creeks called runs, chases and even kills.

Take your pick. No one knows or ever will know the exact derivation.

-Jim McKee
Lincoln Historian

Meet the Team

Nate Garrett

Water resources Engineer

CDM

Q. What is your role in the project?

I am a water resources engineer responsible for analyzing strategies to address stormwater flooding along the main channel of Deadmans Run as well as identifying potential solutions for water quality issues in the watershed. Much of my work involves modifying computer models to determine how effective a conceptual project would be at reducing flooding and improving water quality.

Q. How did you get interested in the field of water resources engineering?

My dad is a gifted mathematician and my mom has a passion for water recreation, so I think I was destined from birth. I began to gain direction when my high school chemistry teacher started an independent study that involved evaluating the water quality of a stream in western Nebraska. I quickly realized this type of work combined my love of the outdoors with my interest in math and science. I enrolled in Biological Systems Engineering at the University of Nebraska-Lincoln and learned a great deal about water resources and the environment. The rest, as they say, is history.

Q. Why does working on the Deadmans Run Watershed Study interest you?

I spent a great deal of time on East Campus and the surrounding area while attending college. I also have family members who live near the watershed. It is rewarding to investigate potential flood and water quality solutions that can improve an area special to me personally.

Deadmans Run Citizen Advisory Committee

Mark Arter
Phil Bohl
Pam Brunke
Jennifer Dam
Joan Darling
Scott Ernstmeyer
Luann Finke
Marleen Gordon
Russell Irwin
Russell Miller
Patte Newman
George Olson
Darryl Pederson
Barbara Standley
Dan Steinkruger
Richard Sutton
Erica Williams
Ginny Wright

Deadmans Run Preliminary Capital Improvement Projects

Project 1: Downstream Conveyance System
Stream Reach: Salt Creek confluence to upstream of Huntington Avenue

Project 2: UNL-East Campus
Stream Reach: Upstream of Huntington Avenue to downstream of 48th Street

Project 3: University Place Park
Stream Reach: Downstream of 48th Street to downstream of 52nd Street

Project 4: 52nd to 56th Street
Stream Reach: Downstream of 52nd Street to upstream of 56th Street

Project 5: 66th Street Expansion & Flood bench
Stream Reach: Downstream & Upstream of 66th Street

Project 6: O Street & MoPac Trail
Stream Reach: Downstream of 70th Street to upstream of trail culvert

Project 7: Chateau Apartments & Lincoln Lutheran School
Location: Upstream of 56th & Holdrege

Project 8: Bethany Park
Location: 66th & Vine

Project 9: Taylor Park
Location: Sunrise Road & Randolph Street

Project 10: Seacrest Park Berm
Location: North end of Seacrest Park near Englewood Drive & Hazelwood Drive.

Project 11: Wyuka Cemetery Pond Retrofits
Location: Vine Street & 35th Street

Project 12: Herbert Park Pond Retrofits
Location: Near “O” Street & 84th Street

Project 13: Carriage Hill Pond Retrofits
Location: Near “A” Street & 84th Street

Project 14: Taylor Park
Location: Near Sunrise Road & Randolph Street

Project 15: Cotner Boulevard Storm Pipe
Location: Near Cotner Boulevard & Vine Street

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Fax: (402) 441-8609
Email: *dbiesecker@lincoln.ne.gov*

Public Participation Process

The Deadmans Run Watershed Master Plan study process has featured a variety of public participation techniques designed to provide information on the approach to the study, gather input from stakeholders, and share preliminary recommendations for floodplain and floodway improvements.

These techniques have revolved around four major public participation strategies, including open houses, a citizen advisory committee, meetings with affected property owners, and this newsletter.

The first open house focused on the approach to the study. A second open house provided an update on the study's findings. A third, tentatively scheduled for July 2007, will present final project recommendations from the study team.

An 18-member citizen advisory committee, appointed by then-Mayor Colleen Seng, has met three times to hear project updates and provide advice on possible capital improvement projects. Similar information was provided to property owners most likely to be directly affected by the projects.

Three issues of the Watershed News round out the public participation aspects of the study.

CITY OF LINCOLN
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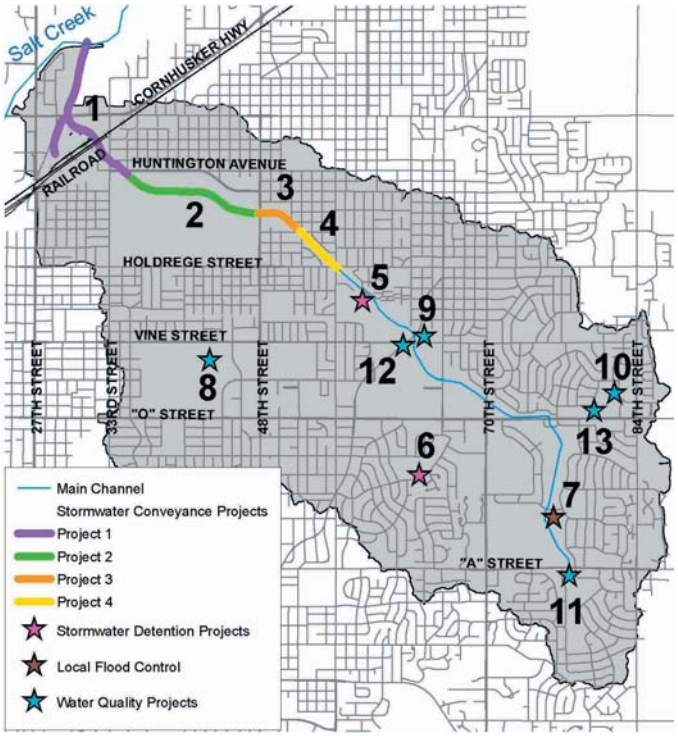
Watershed News

November 2007

A Publication Sponsored by
the City of Lincoln and the Lower Platte South Natural Resources District (NRD)

Deadmans Run Watershed Master Plan



Improvements Would Reduce Floodplain Significantly

Capital improvements recommended for the Deadmans Run watershed would significantly reduce the number of buildings located in the north central Lincoln floodplain, from 982 to 175. The total cost of the improvements, if all 13 of the recommended projects were built, is estimated at $49.6 million in today's dollars. The City of Lincoln and the Lower Platte South Natural Resources District (NRD) sponsored the Deadmans Run Watershed Master Plan study, and it is anticipated they will seek state and/or federal funding to assist in implementing the proposed projects. The primary goal of the study is to develop a comprehensive set of improvement projects that reduce the potential for flooding along the main channel of Deadmans Run, address existing erosion problems, and improve water quality.

Several preliminary improvement projects were presented in the last edition of Watershed News. Over the past few months the project team has been refining the preliminary projects based on stakeholder and community input. Stakeholder opinions were gathered during 10 information sessions held throughout the summer. Additional community input was solicited through a series of open houses and an 18-member Citizen Advisory Committee representing a broad cross-section of interests in the watershed.

Recommended Capital Improvement Projects (CIPs)

The recommended CIP projects significantly reduce the flood hazards along the main channel, address stream erosion issues, and enhance water quality. The 13 CIPs shown on the accompanying map include stormwater conveyance improvements, dry detention basins, local flood control and water quality projects.

Stormwater Conveyance

The stormwater conveyance projects (Projects 1-4) consist of widening and reshaping the main channel from the Salt Creek confluence to 56th Street. The improvements include significant upgrades to several street and railroad bridges. Critical stream erosion along unlined portions of the main channel that have the potential to adversely impact buildings and public infrastructure was addressed when evaluating solutions to improve the flood conveyance system.

Continued on Page 2

Dry Detention Basins

Improving the stormwater conveyance system cannot be done without stormwater detention upstream to prevent adverse impacts downstream caused by increasing the peak flows along the main channel to eliminate overbank flooding. Stormwater detention basin projects, which are designed to temporarily store and attenuate flood waters, are recommended to minimize the increases in peak flow rates.

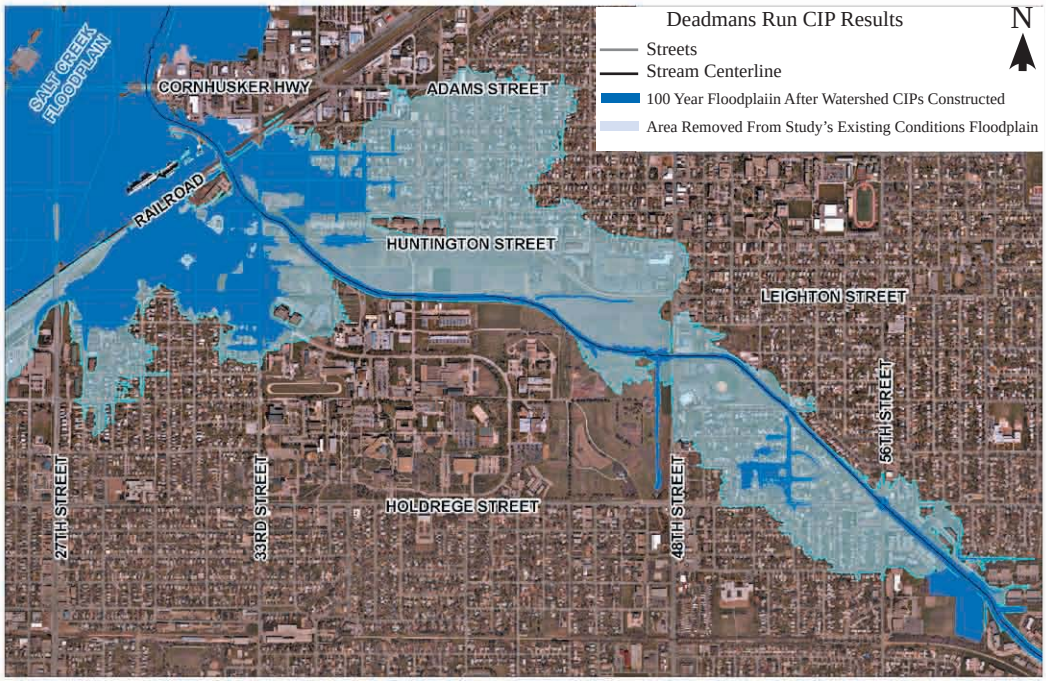
The two recommended dry detention basins (Projects 5-6) are proposed to be located within open space areas and would be constructed with the primary goal of reducing flood flows along the Deadmans Run main channel. The existing functionality of both project site locations would be replicated and enhanced after construction.

Local Flood Control

The local flood control measure is a smaller drainage project that includes installing an earth berm to mitigate a localized flooding problem (Project 7).

Water Quality

During dry weather, impervious surfaces throughout the watershed collect pollutants such as oil and grease that leak from automobiles and sand and salt deposits along roadways. Other pollutants include nutrients and bacteria from pesticides and fertilizer usage, leaves, grass clippings, and animal waste. The pollutants have the potential to directly impact water quality in the Deadmans Run main channel as well as adversely impact water quality in downstream water bodies. The recommended projects which address water quality include construction of new water quality treatment areas, retrofitting existing ponds with water quality features, end-of-pipe treatments, and stream stability measures (Projects 8-13). The new structural BMPs were identified based on available open space in the watershed, while existing detention ponds were considered for retrofit based upon opportunities for enhancements and proper location.



Benefit and Cost

The total conceptual level cost estimate for the 13 CIPs is about $49.6 million. Due to the magnitude of the recommended CIP program, specifically Projects 1 through 6 which comprise 99 percent of the cost, a benefit-cost analysis was conducted. The benefit-cost ratio determines whether the cost of the mitigation project today will result in sufficient flood damage reduction in the future to justify the capital investment of the project. The overall benefit was quantified as a monetary value using geographic information systems to relate estimated flood depths for various rain storms to the physical damages to buildings, building contents, and street damages. The overall benefit was compared to the cost of implementing Projects 1 through 6 using Federal Emergency Management Agency (FEMA) benefit-cost analysis guidelines. Based on the results of the FEMA benefit-cost analysis, projects 1 through 6 appear to be economically viable.

In the portion of the watershed where the majority of the buildings are located within the floodplain, the illustration above compares the 100-year floodplain (existing conditions) with the potential 100-year floodplain after implementing Projects 1 through 6. The total number of buildings taken out of the floodplain is 807, and another 175 receive flood protection benefits.

Meet the Team

Nicole Fleck-Tooze

Special Projects Administrator
City of Lincoln Public Works
& Utilities Department

Q. What is your role in the project?

My role is to provide overall direction for the development of the Deadman's Run master plan. I look at the goals and strategies for this plan and how it relates to the bigger picture, since it is intended to become part of a comprehensive watershed plan for Lincoln and its growth areas. I also provide guidance regarding the public process.

Q. What got you interested in conservation and resource management?

I grew up in the country, and lived on a farm for the first 11 years of my life. I spent a lot of time outdoors and horseback riding in the countryside. I guess this background really gave me an appreciation of the natural cycles of the environment and the value of natural resources.

Q. What are your day-to-day duties with the City?

I lead the Watershed Management Division of Public Works & Utilities, providing guidance for our major projects and programs and supervision for the division. I also coordinate legislative issues for Public Works & Utilities and provide support to the director on other projects within the department.

Q. What is your most unique hobby?

My husband and I have our private pilot's licenses and have recently taken up aerobatic flying. There's nothing quite like it!

Deadmans Run Watershed CIP Summary

Project No.	Improvement Description	Estimated Project Cost
Stormwater Conveyance		
1	Widening and reshaping the main channel from the Salt Creek confluence to Huntington Street. In addition, a portion of a west tributary near State Fair Park Drive will be improved. The improvements also include significant upgrades to several stream and railroad crossings. The implementation of this project will require close coordination with the Antelope Valley project to optimize community benefits.	$25,234,000
2	Widening and reshaping the main channel from Huntington Street to 48th Street. A combination of structural retaining walls and natural features will be used to minimize property impacts.	$9,198,000
3	Widening and reshaping the main channel from 48th Street to 52nd Street, using flood bench terraces. The improvements also include upgrading the 48th Street bridge and replacing the pedestrian crossing.	$2,474,000
4	Widening and reshaping the main channel from 52nd to 56th Street and upgrading stream crossings at both roadway locations.	$7,764,000
Stormwater Detention Basins		
5	Constructing an off-line dry stormwater detention basin next to the main channel, to reduce the magnitude of floodwaters downstream.	$2,932,000
6	Constructing an in-line dry stormwater detention basin in Taylor Park to reduce the magnitude of floodwaters downstream.	$1,440,000
Local Flood Control		
7	Installing an earth berm to mitigate a localized flooding problem.	$19,000
Water Quality		
8	Modifying an existing pond located near Wyuka Cemetery to integrate water quality features.	$47,000
9	Installing a water quality stormwater facility within Bethany Park to improve water quality.	$113,000
10	Modifying two existing ponds located near Russwood Boulevard to integrate water quality features.	$35,000
11	Installing a water quality stormwater facility located immediately north of Trendwood Park to improve water quality.	$142,000
12	Installing a below ground hydrodynamic separator structure to remove trash and debris from stormwater runoff.	$102,000
13	Implementing stream stability measures to control erosion with Herbert Park.	$211,000

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Email: *dbiesecker@lincoln.ne.gov*

Final Open House

The third and final Deadmans Run Open House was held November 8, 2007. Nearly 30 watershed residents and other interested people, plus LPSNRD Board members and project staff attended. This open house focused on presenting the Master Plan recommendations, including the CIPs discussed on previous pages. Following a formal presentation, participants were encouraged to visit information stations covering various plan elements. In addition, participants were encouraged to fill out comment cards regarding the Master Plan recommendations. The open house presentation materials as well as other project information can be accessed on the City of Lincoln's web site at lincoln.ne.gov, (keyword "watershed")

Next Steps

The project team will be submitting the Master Plan for approval through a series of public meetings including:

NRD Board Meeting: December 19, 2007

Planning Commission Hearing: January 2008 (tentative)

City Council and County Board Hearings:

January/February timeframe

Appendix C
Drainage Structure Design Data

Deadmans Run Watershed Basin Planning Study
STUDY CRITERIA

Performance Criteria Summary Table

Culverts	Condition 1	Condition 2
	1 ft freeboard measured from the min. top of road	0.5 ft overtopping measured at the min top of road
Code T	50 Year Peak	100 Year Peak
Code R	10 Year Peak	100 Year Peak
Code TR	10 Year Peak	100 Year Peak
Code D	N/A	N/A
Code RR	50 Year Peak	100 Year Peak

Bridges	Condition 1	Condition 2
	1 ft freeboard measured from the low cord	0.5 ft overtopping measured at the min top of road
Code T	100 Year Peak	100 Year Peak
Code R	100 Year Peak	100 Year Peak
Code TR	100 Year Peak	100 Year Peak
Code RR	100 Year Peak	100 Year Peak

Code T is defined as a Thoroughfare, Arterial, Collector, or Interstate trafficway.
Code R is defined as a Residential or Local trafficway.
Code TR is defined as a trail/non-automotive path
Code D is defined as a Dam/Spillway
Code RR is defined as a Railroad Crossing

Overtopping occurs if the upstream water surface elevation is greater than the min. top of road.
Bridge freeboard is measured from WSEL to Low Cord of bridge. Culvert freeboard is measured from WSEL to min. top of road. Positive freeboard means the WSEL is above the low cord (bridges) or min top of road (culverts).

Sizing Analysis (Undersized Column):
If first condition is true, structure is labeled "Y".
If first condition is false, second is true, structure is labeled "Y2".
If both are false, structure is labeled "N".

Deadmans Run Drainage Structure Performance Table

Reach	Structure ID	County ID	Undersized	Location	Code	Structure	Station	Low Cord (ft)	Min. Top of Rd (ft)	Event	Q exist (cfs)	WS_US (ft)	Freeboard (ft)	Overtop (ft)	Tailwater Elev. (ft)
DMR Main Channel	DMR005	N/A	N	Cornhusker Highway	T	Bridge	2709.360	1143.880	1146.42	10yr	6108	1136.78	-7.10	-9.64	1136.60
										50yr	8154	1139.56	-4.32	-6.86	1139.59
										100yr	9460	1140.65	-3.23	-5.77	1140.76
DMR Main Channel	DMR010	N/A	Y	Burlington Northern Railroad	RR	Bridge	4126.170	1146.540	1149.45	10yr	5379	1142.39	-4.15	-7.06	1141.80
										50yr	6796	1144.86	-1.68	-4.59	1144.23
										100yr	7794	1147.75	1.21	-1.70	1145.38
DMR Main Channel	DMR015	N/A	Y	Abandoned Railroad	RR	Bridge	4197.290	1148.380	1147.93	10yr	5379	1142.74	-5.64	-5.19	1142.37
										50yr	6796	1145.17	-3.21	-2.76	1144.80
										100yr	7794	1147.98	-0.40	0.05	1147.68
DMR Main Channel	DMR025	N/A	Y2	Huntington Avenue	T	Bridge	5589.235	1151.040	1145.63	10yr	4746	1146.68	-4.36	1.05	1146.22
										50yr	6769	1148.33	-2.71	2.70	1147.87
										100yr	7997	1149.48	-1.56	3.85	1149.28
DMR Main Channel	DMR030	N/A	Y2	38th Street @ UNL East	T	Bridge	7270.680	1155.160	1147.88	10yr	4686	1150.15	-5.01	2.27	1149.62
										50yr	6954	1152.27	-2.89	4.39	1152.25
										100yr	8193	1152.46	-2.70	4.58	1152.44
DMR Main Channel	DMR035	N/A	Y	48th Street	T	Bridge	10837.900	1160.430	1161.07	10yr	4405	1159.22	-1.21	-1.85	1158.10
										50yr	6349	1162.32	1.89	1.25	1159.94
										100yr	7426	1164.34	3.91	3.27	1160.60
DMR Main Channel	DMR040	N/A	Y	Pedestrian Crossing East of 48th St	TR	Bridge	11265.400	1161.480	1162.37	10yr	4454	1162.98	1.50	0.61	1160.18
										50yr	6370	1163.50	2.02	1.13	1163.06
										100yr	7422	1164.79	3.31	2.42	1164.56
DMR Main Channel	DMR045	N/A	Y	52nd and Francis	T	Bridge	12558.700	1164.500	1164.23	10yr	4454	1165.95	1.45	1.72	1165.46
										50yr	6370	1166.92	2.42	2.69	1166.78
										100yr	7422	1168.32	3.82	4.09	1167.25
DMR Main Channel	DMR055	N/A	N	Pedestrian Crossing 1300ft Northw	TR	Bridge	16640.700	1179.450	1180.68	10yr	3993	1175.23	-4.22	-5.45	1175.18
										50yr	5541	1176.70	-2.75	-3.98	1176.61
										100yr	6350	1177.30	-2.15	-3.38	1177.18
DMR Main Channel	DMR060	N/A	N	Unknown bridge 700ft Northwest	R	Bridge	17220.000	1180.290	1180.09	10yr	3993	1175.86	-4.43	-4.23	1175.81
										50yr	5541	1177.45	-2.84	-2.64	1177.41
										100yr	6350	1178.12	-2.17	-1.97	1178.07
DMR Main Channel	DMR065	N/A	N	North Cotner	T	Bridge	17987.720	1184.460	1188.01	10yr	3993	1181.27	-3.19	-6.74	1179.84
										50yr	5541	1182.36	-2.10	-5.65	1181.53
										100yr	6350	1183.23	-1.23	-4.78	1182.23
DMR Main Channel	DMR070	N/A	Y	Vine Street	T	Bridge	18233.060	1186.000	1189.66	10yr	3428	1184.41	-1.59	-5.25	1184.28

Deadmans Run Drainage Structure Performance Table

Reach	Structure ID	County ID	Undersized	Location	Code	Structure	Station	Low Cord (ft)	Min. Top of Rd (ft)	Event	Q exist (cfs)	WS_US (ft)	Freeboard (ft)	Overtop (ft)	Tailwater Elev. (ft)
										50yr	4764	1188.28	2.28	-1.38	1186.31
										100yr	5486	1189.63	3.63	-0.03	1187.60
DMR Main Channel	DMR075	N/A	Y	Bike Trail upstream of Vine Street	TR	Bridge	18350.800	1187.750	1187.44	10yr	3684	1185.57	-2.18	-1.87	1185.16
										50yr	5053	1189.63	1.88	2.19	1189.23
										100yr	5764	1190.87	3.12	3.43	1190.79
DMR Main Channel	DMR080	N/A	Y	66th Street	T	Bridge	20033.400	1192.670	1194.48	10yr	3503	1192.65	-0.02	-1.83	1191.46
										50yr	4825	1195.90	3.23	1.42	1193.35
										100yr	5534	1196.68	4.01	2.20	1193.96
DMR Main Channel	DMR105	N/A	N	Bike Trail downstream of Wedgew	TR	Bridge	25322.800	1234.370	1232.64	10yr	1114	1224.85	-9.52	-7.79	1224.83
										50yr	1519	1225.59	-8.78	-7.05	1225.59
										100yr	1772	1225.97	-8.40	-6.67	1225.97
DMR Main Channel	DMR068	N/A	Y	Bike Trail downstream of Vine Stre	TR	Bridge	18139.000	1185.920	1187.10	10yr	3993	1184.38	-1.54	-2.72	1183.31
										50yr	5541	1186.43	0.51	-0.67	1185.70
										100yr	6350	1187.75	1.83	0.65	1187.08
DMR Tributary	DMRT_200	N/A	Y	RR spur entering Cargill	RR	Bridge	1812.705	1143.830	1146.74	10yr	800	1146.98	3.15	0.24	1146.76
										50yr	900	1147.06	3.23	0.32	1146.84
										100yr	1200	1147.25	3.42	0.51	1146.95
DMR Tributary	DMRT_205	N/A	Y	Burlington Northern Railroad	RR	Bridge	1953.561	1145.650	1148.39	10yr	800	1147.20	1.55	-1.19	1146.99
										50yr	900	1147.33	1.68	-1.06	1147.07
										100yr	1200	1147.76	2.11	-0.63	1147.26
DMR Tributary	DMRT_210	N/A	Y	Abandoned Railroad	RR	Bridge	2022.994	1146.230	1148.49	10yr	800	1147.72	1.49	-0.77	1147.19
										50yr	900	1148.16	1.93	-0.33	1147.33
										100yr	1200	1148.86	2.63	0.37	1147.87

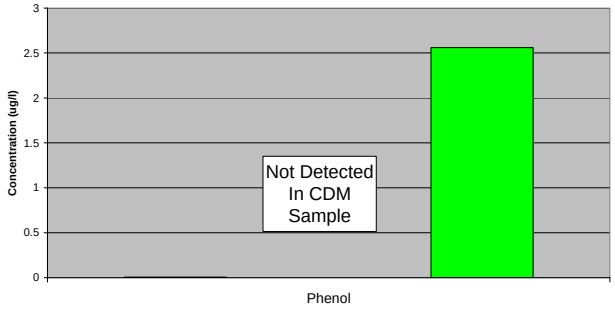
Deadmans Run Drainage Structure Performance Table

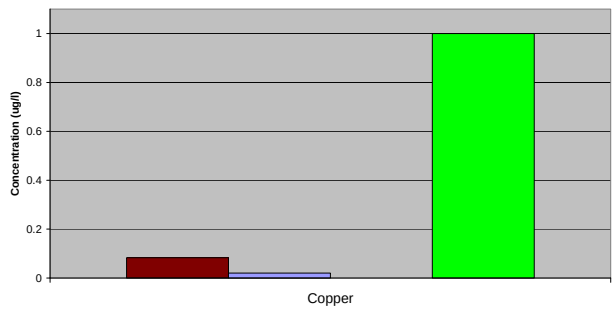
Reach	Structure ID	County ID	Undersized	Location	Code	Structure	Station	Min. Top of Rd (ft)	Event	Q exist (cfs)	WS_US (ft)	Overtop (ft)	Tailwater Elev. (ft)
DMR Main Channel	DMR020	N/A	Y	33rd and Baldwin	T	Culvert	4952.940	1145.20	10yr	5027	1145.35	0.15	1143.78
									50yr	7003	1146.6	1.40	1146.17
									100yr	8236	1148.88	3.68	1148.92
DMR Main Channel	DMR050	N/A	Y	56th and Holdrege	T	Culvert	14241.100	1171.77	10yr	4712	1173.56	1.79	1172
									50yr	6628	1174.58	2.81	1173.88
									100yr	7652	1174.88	3.11	1174.34
DMR Main Channel	DMR085	N/A	N	70th Street	T	Culvert	21766.300	1205.93	10yr	2528	1199.28	-6.65	1198.17
									50yr	3497	1202.58	-3.35	1200.46
									100yr	4014	1204.08	-1.85	1201.26
DMR Main Channel	DMR090	N/A	Y	Bike Trail upstream of 70th parallel to O Street	TR	Culvert	23300.600	1207.18	10yr	1940	1209.23	2.05	1201.7
									50yr	2671	1210.01	2.83	1204.03
									100yr	3066	1210.32	3.14	1205.19
DMR Main Channel	DMR095	N/A	Y	O Street	T	Culvert	24232.900	1220.73	10yr	1202	1221.77	1.04	1216.55
									50yr	1619	1222.29	1.56	1217.5
									100yr	1876	1222.51	1.78	1218.07
DMR Main Channel	DMR100	N/A	Y	Corporate Drive	R	Culvert	24530.000	1222.27	10yr	1167	1222.85	0.58	1221.91
									50yr	1570	1223.37	1.10	1222.39
									100yr	1818	1223.64	1.37	1222.7
DMR Main Channel	DMR110	N/A	N	Englewood Drive	R	Culvert	27591.500	1242.53	10yr	1072	1240.1	-2.43	1239.37
									50yr	1488	1241.6	-0.93	1240.47
									100yr	1717	1242.65	0.12	1241.01
DMR Main Channel	DMR115	N/A	Y	Bike Trail updstream of Englewood Drive	TR	Culvert	27815.300	1242.28	10yr	1072	1244.49	2.21	1244.35
									50yr	1488	1244.84	2.56	1244.67
									100yr	1717	1244.98	2.70	1244.82
DMR Main Channel	DMR120	N/A	Y	Bike Trail extended off Hickory Lane	TR	Culvert	28733.400	1249.29	10yr	675	1251.84	2.55	1251.44
									50yr	933	1251.98	2.69	1251.77
									100yr	1096	1252.1	2.81	1251.88
DMR Tributary	DMRT_200	N/A	Y	DMR West Trib Culvert into DMR Main Channel	T	Culvert	100.548	1146.26	10yr	800	1146.6	0.34	1136.77
									50yr	700	1146.67	0.41	1139.56
									100yr	650	1146.71	0.45	1140.65
DMR Tributary	DMRT_215	N/A	Y	Lincoln Elevator and Feed Old Road	R	Culvert	2613.568	1141.55	10yr	1090	1147.89	6.34	1147.89
									50yr	1200	1148.17	6.62	1148.17
									100yr	2200	1148.86	7.31	1148.86

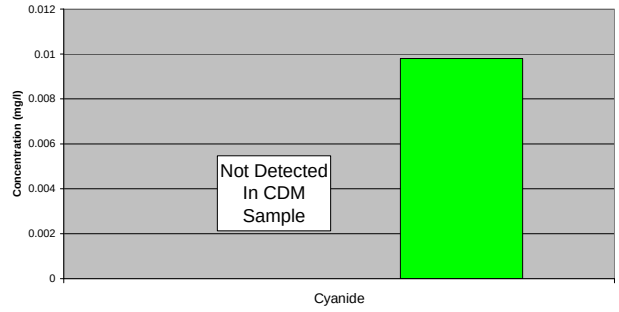
Appendix D

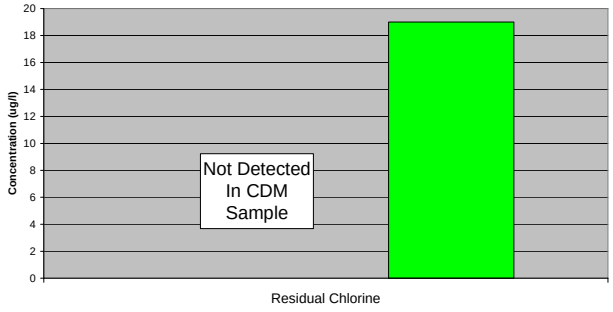
Water Quality

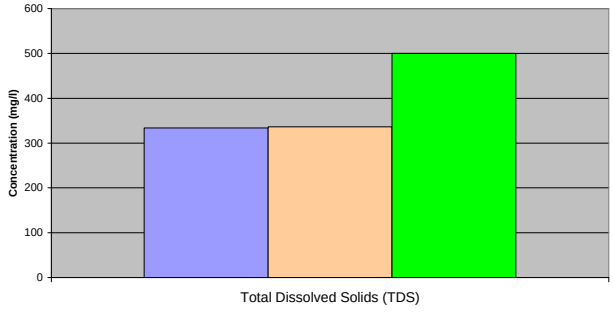
Deadmans Run Watershed Water Quality Testing Results at 70th Street
Event 1 Date Sampled - 7/13/2006
Event 2 Date Sampled - 9//21/2006

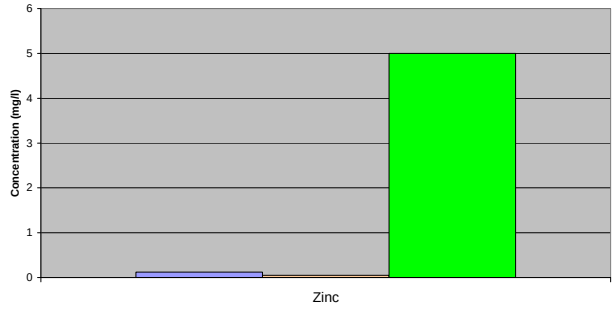












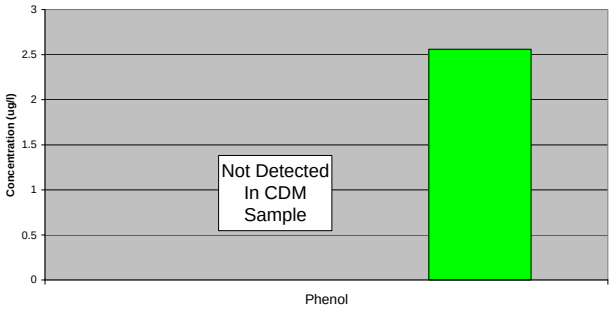
City of Lincoln 2005 Results (Copper and Phenol)

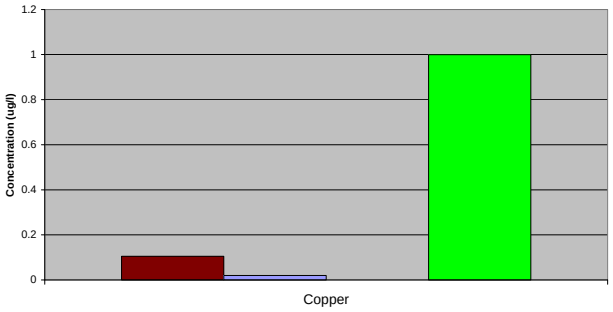
CDM Event 1 - 70th Street

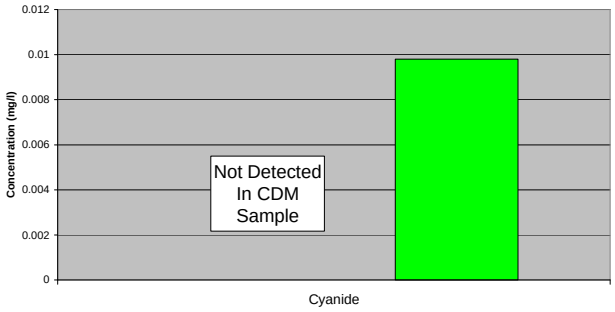
CDM Event 2 - 70th Street

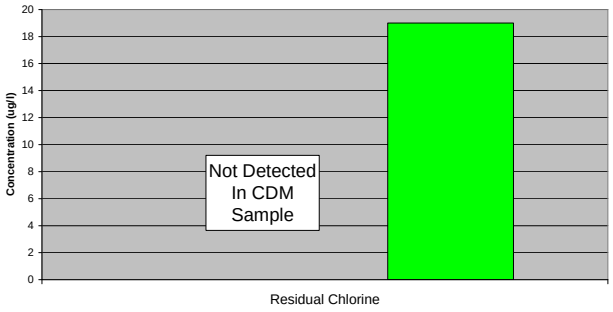
NDEQ Water Quality Standard

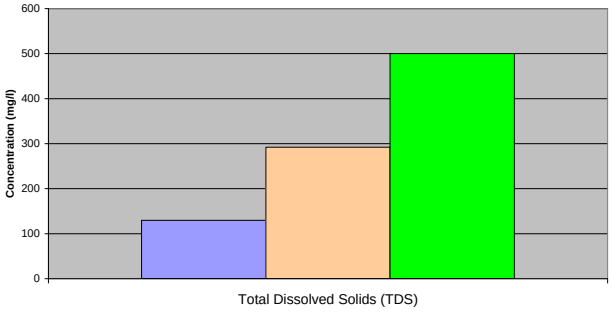
Deadmans Run Watershed Water Quality Testing Results at 33rd Street
Event 1 Date Sampled - 7/13/2006
Event 2 Date Sampled - 9//21/2006

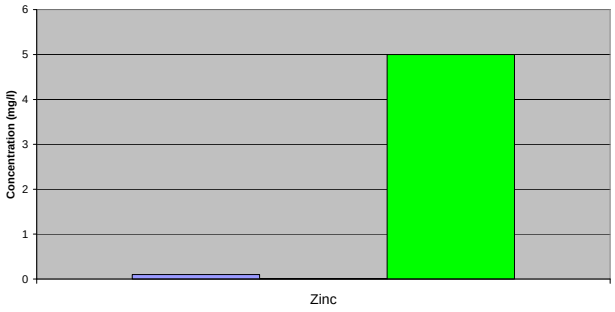










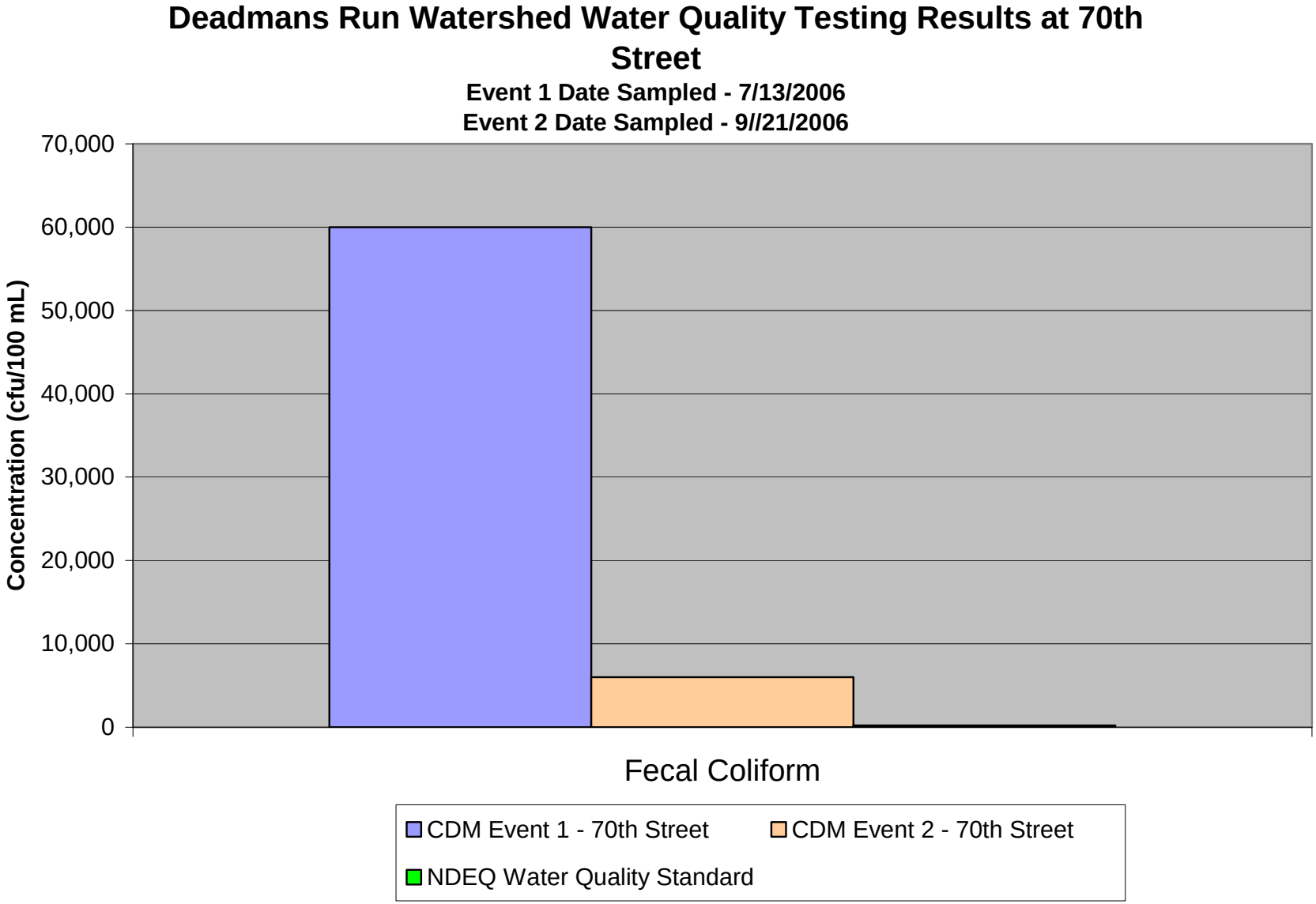


City of Lincoln 2005 Results (Copper and Phenol)

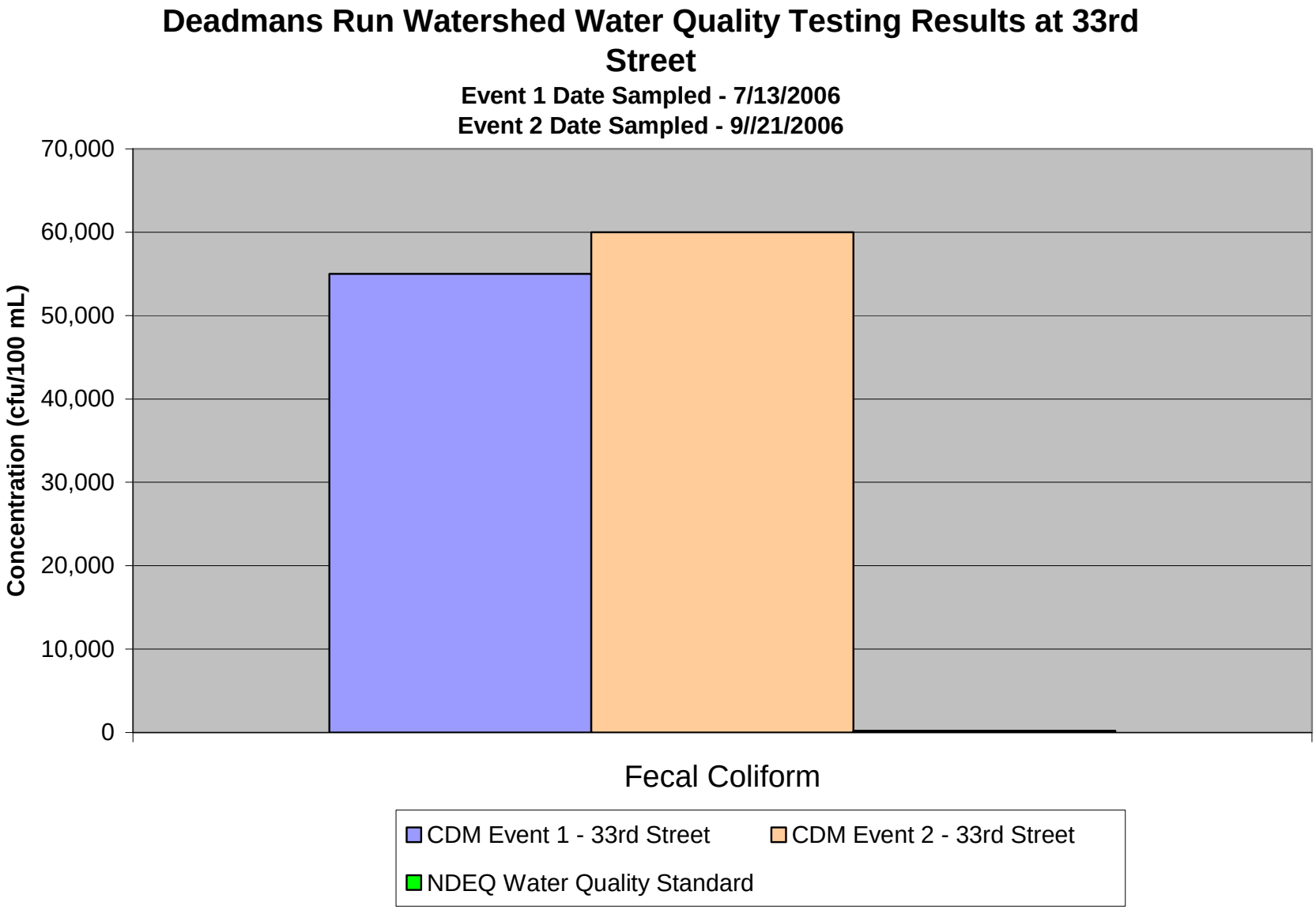
CDM Event 1 – 33rd Street

CDM Event 2 – 33rd Street

NDEQ Water Quality Standard



Note: UNL recorded two Fecal Coliform values during July 1 and July 5, 2004, at 48th Street. The values were 98,667 cfu/100ml and 18,333 cfu/100ml, respectively.


Deadmans Run Watershed Water Quality Testing Results at 33rd Street
Event 1 Date Sampled - 7/13/2006
Event 2 Date Sampled - 9//21/2006
Concentration (cfu/100 mL)
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
Fecal Coliform
CDM Event 1 - 33rd Street
CDM Event 2 - 33rd Street
NDEQ Water Quality Standard

Ref. Lab #: 152388
Report Number
06-201-2092

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REPORT OF ANALYSIS

For: (19493) CDM
(512)346-1100

Mail to: CDM
PATRICE MELANCON
12357-A RIATA TRACE PKWY #210
AUSTIN TX 78727-

Date Reported: 07/20/06
Date Received: 07/14/06
Date Sampled: 07/13/06

STORMWATER EVENT

Lab number: 1201291 Sample ID: 20060710#2001-2008

Analysis	Level Found	Units	Detection Limit	Method	Analyst-Date	Verified-Date
Biochemical oxygen demand	14	mg/L	2	SM 5210B	cch-07/14	jjd-07/20
Copper (total)	0.02	mg/L	0.01	EPA 200.7	emr-07/18	bab-07/18
Cyanide	n.d.	mg/L	0.02	SM 4500 CN-E	jlc-07/18	jjd-07/20
Fecal coliform	55,000	cfu/100mL	1	SM 9222D	arj-07/16	arj-07/16
Fecal streptococcus	> 2000	cfu/100mL	1	SM 9230C	arj-07/16	arj-07/16
Hexane extractable materials	n.d.	mg/L	5	EPA 1664A-SPE	hbm-07/20	jjd-07/20
Kjeldahl nitrogen	3.12	mg/L	0.50	EPA 351.3	mjb-07/18	jjd-07/18
Lead (total)	n.d.	mg/L	0.05	EPA 200.7	emr-07/18	bab-07/18
Phenols	n.d.	mg/L	0.05	EPA 420.1	jlc-07/19	jjd-07/20
Phenols	n.d.	mg/L	0.05	EPA 420.1	jlc-07/19	jjd-07/20
Phosphorus (total)	0.4	mg/L	0.1	EPA 200.7	emr-07/18	bab-07/18
Residual chlorine (ug/L)	n.d.	µg/L	50	SM 4500-CLF	cmw-07/14	dco-07/14
Total dissolved solids	130	mg/L	10	SM 2540C	mfo-07/17	jjd-07/20
Total suspended solids	426	mg/L	4	USGS I-3765-85/SM2540D	mfo-07/18	jjd-07/20
Zinc (total)	0.10	mg/L	0.01	EPA 200.7	emr-07/18	bab-07/18

Notes:
n.d. - Not Detected.
The solid analyses have been weighed to a constant weight by leaving the samples in the oven overnight. This protocol is an approved variation from the stated method.

Respectfully Submitted

Heather Ramig/Sue Ann Seitz/Rob Ferris
Client Services

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Ref. Lab #: 152422
Report Number
06-201-2060

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REPORT OF ANALYSIS

For: (19493) CDM
(512)346-1100

Mail to: CDM
PATRICE MELANCON
12357-A RIATA TRACE PKWY #210
AUSTIN TX 78727-

Date Reported: 07/20/06
Date Received: 07/14/06
Date Sampled: 07/13/06

XTRA BOTTLES

Lab number: 1201293

Analysis	Level Found	Units	Detection Limit	Method	Analyst-Date	Verified-Date
Sample ID: 20060710#2009						
Phenols	n.d.	mg/L	0.05	EPA 420.1	jlc-07/19	jjd-07/20
Sample ID: 20060710#1009						
Copper (total)	0.01	mg/L	0.01	EPA 200.7	emr-07/18	bab-07/18
Lead (total)	n.d.	mg/L	0.05	EPA 200.7	emr-07/18	bab-07/18
Zinc (total)	0.07	mg/L	0.01	EPA 200.7	emr-07/18	bab-07/18

Notes:
n.d. - Not Detected.

Respectfully Submitted

Heather Ramig/Sue Ann Seitz/Rob Ferris
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Report Number
06-202-2117

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REPORT OF ANALYSIS

For: (19493) CDM
(512)346-1100

Mail to: CDM
PATRICE MELANCON
12357-A RIATA TRACE PKWY #210
AUSTIN TX 78727-

Date Reported: 07/21/06
Date Received: 07/14/06
Date Sampled: 07/13/06

STORMWATER EVENT

Lab number: 1201292 Sample ID: 20060710#1001-1008

Analysis	Level Found	Units	Detection Limit	Method	Analyst-Date	Verified-Date
Biochemical oxygen demand	14	mg/L	2	SM 5210B	cch-07/14	jjd-07/21
Copper (total)	0.02	mg/L	0.01	EPA 200.7	emr-07/18	bab-07/18
Cyanide	n.d.	mg/L	0.02	SM 4500 CN-E	jlc-07/18	jjd-07/21
Fecal coliform	60,000	cfu/100mL	1	SM 9222D	arj-07/16	arj-07/16
Fecal streptococcus	> 2000	cfu/100mL	1	SM 9230C	arj-07/16	arj-07/16
Hexane extractable materials	n.d.	mg/L	5	EPA 1664A-SPE	hbm-07/20	jjd-07/21
Kjeldahl nitrogen	4.17	mg/L	0.50	EPA 351.3	mjb-07/18	jjd-07/18
Lead (total)	n.d.	mg/L	0.05	EPA 200.7	emr-07/18	bab-07/18
Phenols	n.d.	mg/L	0.05	EPA 420.1	jlc-07/19	jjd-07/21
Phosphorus (total)	0.5	mg/L	0.1	EPA 200.7	emr-07/18	bab-07/18
Residual chlorine (ug/L)	n.d.	µg/L	50	SM 4500-CLF	cmw-07/14	dco-07/14
Total dissolved solids	334	mg/L	10	SM 2540C	mfo-07/17	jjd-07/21
Total suspended solids	230	mg/L	4	USGS I-3765-85/SM2540D	mfo-07/18	jjd-07/21
Zinc (total)	0.12	mg/L	0.01	EPA 200.7	emr-07/18	bab-07/18

Notes:
n.d. - Not Detected.
The solid analyses have been weighed to a constant weight by leaving the samples in the oven overnight. This protocol is an approved variation from the stated method.

Respectfully Submitted

Heather Ramig/Sue Ann Seitz/Rob Ferris
Client Services

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Ref. Lab #: 152422
Report Number
06-270-2102

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www.midwestlabs.com

REPORT OF ANALYSIS

For: (19493) CDM
(512)346-1100

Mail to: CDM
PATRICE MELANCON
12357-A RIATA TRACE PKWY #210
AUSTIN TX 78727-

Date Reported: 09/27/06
Date Received: 09/21/06

XTRA BOTTLES

Lab number: 1223462 Sample ID: 1

Analysis	Level Found	Units	Detection Limit	Method	Analyst-Date	Verified-Date
Copper (total)	n.d.	mg/L	0.01	EPA 200.7	emr-09/25	bab-09/27
Lead (total)	n.d.	mg/L	0.05	EPA 200.7	emr-09/25	bab-09/27
Phenols	n.d.	mg/L	0.05	EPA 420.1	jlc-09/27	cmw-09/27
Zinc (total)	0.05	mg/L	0.01	EPA 200.7	emr-09/25	bab-09/27

Notes:
n.d. - Not Detected.

Respectfully Submitted

Heather Ramig/Sue Ann Seitz/Rob Ferris
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Ref. Lab #: 152388
Report Number
06-275-2014

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REPORT OF ANALYSIS

For: (19493) CDM
(512)346-1100

Mail to: CDM
PATRICE MELANCON
12357-A RIATA TRACE PKWY #210
AUSTIN TX 78727-

Date Reported: 10/02/06
Date Received: 09/21/06

STORMWATER EVENT

Lab number: 1223463

Analysis	Level Found	Units	Detection Limit	Method	Analyst-Date	Verified-Date
Sample ID: SITE 1						
Biochemical oxygen demand	33	mg/L	2	SM 5210B	aaa-09/21	cmw-10/02
Copper (total)	n.d.	mg/L	0.01	EPA 200.7	emr-09/25	bab-09/27
Cyanide	n.d.	mg/L	0.02	SM 4500 CN-E	jlc-09/26	cmw-10/02
Dissolved phosphorous	0.17	mg/L	0.05	SM 4500P F	lkm-09/22	cmw-10/02
Fecal coliform	6,000	cfu/100mL	1	SM 9222D	bjl-09/22	arj-09/24
Fecal streptococcus	9,000	cfu/100mL	1	SM 9230C	bjl-09/23	arj-09/24
Hexane extractable materials	n.d.	mg/L	5	EPA 1664A-SPE	hbm-09/29	cmw-10/02
Kjeldahl nitrogen	5.05	mg/L	0.50	EPA 351.3	his-09/25	cmw-09/26
Lead (total)	n.d.	mg/L	0.05	EPA 200.7	emr-09/25	bab-09/27
Phenols	n.d.	mg/L	0.05	EPA 420.1	jlc-09/27	cmw-10/02
Phosphorus (total)	0.4	mg/L	0.1	EPA 200.7	emr-09/25	bab-09/27
Residual chlorine (ug/L)	n.d.	µg/L	50	SM 4500-CLF	cmw-09/21	abd-09/21
Total dissolved solids	336	mg/L	10	SM 2540C	jeg-09/28	cmw-10/02
Total suspended solids	47	mg/L	4	USGS I-3765-85/SM2540D	jeg-09/28	cmw-10/02
Zinc (total)	0.05	mg/L	0.01	EPA 200.7	emr-09/25	bab-09/27

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REPORT OF ANALYSIS

Account: 19493 CDM
Report Number: 06-275-2014

Analysis	Level Found	Units	Detection Limit	Method	Analyst-Date	Verified-Date
Sample ID: SITE 2						
Biochemical oxygen demand	32	mg/L	2	SM 5210B	aaa-09/21	cmw-10/02
Copper (total)	n.d.	mg/L	0.01	EPA 200.7	emr-09/25	bab-09/27
Cyanide	n.d.	mg/L	0.02	SM 4500 CN-E	jlc-09/26	cmw-10/02
Dissolved phosphorous	0.06	mg/L	0.05	SM 4500P F	lkm-09/22	cmw-10/02
Fecal coliform	60,000	cfu/100mL	1	SM 9222D	bjl-09/22	arj-09/24
Fecal streptococcus	29,000	cfu/100mL	1	SM 9230C	bjl-09/23	arj-09/24
Hexane extractable materials	n.d.	mg/L	5	EPA 1664A-SPE	hbm-09/29	cmw-10/02
Kjeldahl nitrogen	10.2	mg/L	0.50	EPA 351.3	his-09/25	cmw-09/26
Lead (total)	n.d.	mg/L	0.05	EPA 200.7	emr-09/25	bab-09/27
Phenols	n.d.	mg/L	0.05	EPA 420.1	jlc-09/27	cmw-10/02
Phosphorus (total)	0.1	mg/L	0.1	EPA 200.7	emr-09/25	bab-09/27
Residual chlorine (ug/L)	n.d.	µg/L	50	SM 4500-CLF	cmw-09/21	abd-09/21
Total dissolved solids	292	mg/L	10	SM 2540C	jeg-09/28	cmw-10/02
Total suspended solids	77	mg/L	4	USGS I-3765-85/SM2540D	jeg-09/28	cmw-10/02
Zinc (total)	0.01	mg/L	0.01	EPA 200.7	emr-09/25	bab-09/27

Notes:
n.d. - Not Detected.
The solid analyses have been weighed to a constant weight by leaving the samples in the oven overnight. This protocol is an approved variation from the stated method.

Respectfully Submitted

Heather Ramig/Sue Ann Seitz/Rob Ferris
Client Services

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Appendix E

Stream Reach Descriptions

July 12, 2006

MEAD & HUNT

Designing the future

Mr. Nate Garrett
Camp Dresser & McKee, Inc.
9200 Ward Parkway, Suite 500
Kansas City, MO 64114

Subject: Deadmans Run Fluvial Geomorphology
July 13, 2006 Progress Meeting

In accordance with your request, Mead & Hunt, Inc. is pleased to present a summary of our fluvial geomorphic observations of Deadmans Run

This letter and the attached draft appendices will be reviewed during our project progress meeting with the city of Lincoln and the Lower Platte South Natural Resources District on July 13, 2006. Further, this letter, draft shapefiles, and photographs generated during my field work during the period of June 7 through June 12, 2006 and sent to your ftp site, will supplement our discussion on July 13.

Deadmans Run Geomorphic Observations

The approach for assessing the fluvial geomorphology of these unlined reaches was similar to that used for Steven's Creek. This included assessing the geomorphic indicators and processes and recording those observations using ArcPad Version 7.0. Our interpretations follow.

Sycamore Drive to Skyway Road Main Stem:

The creek along this reach is primarily a trapezoidal channel with turf grass-covered banks. Medium-sized trees are along the left descending bank crest and more brushy-type woody vegetation is near the crest along the right descending bank crest. The nominal flow at the bottom of the channel is from flow overtopping and leaking through the stoplog weir located immediately upstream of the Sycamore Drive crossing and potentially from groundwater base flow. Rushes line the edges of, and are growing in, the bottom channel at several locations, indicating a typical low energy waterway.

Evidence of incision and active meandering as seen in the historical aerial photographs were not observed. The 6- to 8-inch diameter pieces of crushed limestone in the channel have apparently abated incision since repairs to the banks and channel. However, current practices of mowing the shallow-rooted grass as close as possible to the waters edge (including rushes) and close to the ground have seriously reduced the potential of filtering surface water before it reaches the channel and of the roots reinforcing the banks. Several areas of the banks were scalloped to bare ground, thus eliminating the potential for the turf grasses from reinforcing the near surface and providing a stormwater buffer. The combination of shallow-rooted grasses along the banks and current mowing practice may have initiated the bank instabilities in the past.

Wedgewood Lake to Corporate Drive Tributary:
From the spillway for Wedgewood Lake to the pedestrian bridge for the trail, this tributary is reasonably stable with a two-stage channel and good bank reinforcement from existing woody vegetation. There is a knick point at the end of the concrete slab leading from the spillway but the tributary appears to have adjusted to the grade change and large broken slabs of concrete armor the bottom.

Downstream of the pedestrian bridge, the tributary is wider and appears to form a backwater condition upstream of the Corporate Drive crossing. Erosion is not a factor for this portion of this reach and sedimentation is less of a concern because of the limited sediment source along the banks and the upstream sediment sink of Wedgewood Lake. The main limiting factor for this portion of the reach is the narrow vegetative buffers along either side of the tributary. Algae and duckweed was of limited presence but the potential for both thriving following the loading of nutrient-rich surface waters flowing to the tributary was apparent.

Cornhusker Highway to Salt Creek Confluence Main Stem:
The sheetpile wall located near the Cornhusker Highway crossing and at the end of the lined trapezoidal channel remains an effective grade control, abating migration of the headcut upstream. The scour pool downstream of the sheetpile wall appears to have sized itself accordingly to the drop and flow from the sheetpile wall. Immediately downstream of the sheetpile wall is a 48-inch corrugated metal pipe (CMP) along the left descending bank. The flow during rainfall events from this outfall appears to direct the flow of the main stem over to the right descending bank resulting in localized scour along this bank. This directing of flow also appears to set up the meandering form, such that the left descending bank shows erosion downstream.

The erosion remains along the left descending bank for approximately half the distance between the sheetpile wall and the confluence with Salt Creek. Perhaps the right descending bank does not show as much scour because it was regraded. The creek is undergoing active re-meandering from the previously-mentioned 48-inch CMP and the destroyed 36-inch CMP along the left descending bank.

When the 36-inch CMP was installed, more than likely the outside bend of the meander was along the right descending bank. During higher flows which overtopped the CMP outlet frame, the bank behind the frame scoured, exposing the fine glacial outwash sand, which underlies the loess. The overtopped pipe became a flow vane, directing the flow perpendicular to the pipe alignment. Water flows over the pipe until the sand is eroded under the pipe and the undermined pipe collapses. This sequence is repeated along the inclined pipe and the erosion migrates to the left bank. The outside bend of the meander makes a phase change to the left bank and assists in setting up re-meandering process between the two CMP outfalls.

Downstream of the 36-inch CMP, localized bank degradation is observed opposite of two outfalls, where the flows of which have acted as turning vanes. Sedimentation through bar deposition is prevalent along the whole unlined portion of this reach. The bars within the re-meandering segment are irregular, which would be expected. Downstream of the 36-inch CMP, the bars become somewhat more regular-shaped. Closer to the confluence with Salt Creek, submerged ripples and megaripples of sand along the channel bottom are prevalent.

Appendix F

Opinion of Probable Construction Costs

Engineer's Opinion of Probable Construction Cost
Lincoln, Nebraska
Deadmans Run Watershed Study
Recommended Capital Improvement Project Totals

Project ID #	*Brief Description of Items*		*Total Conceptual Cost Estimate*
Project 1	**Downstream Conveyance Components**	$	25,234,000
Project 2	**University of Nebraska - East Campus Channel Conveyance**	$	9,198,000
Project 3	**University Place Park**	$	2,474,000
Project 4	**52nd Street to 56th Street**	$	7,764,000
Project 5	**Chateau Apartments / Lincoln Lutheran Schools**	$	2,932,000
Project 6	**Taylor Park**	$	1,440,000
Project 7	**Seacrest Park**	$	19,000
Project 8	**Wyuka Cemetary Existing Detention Pond Retrofit**	$	47,000
Project 9	**Bethany Park New Water Quality BMP**	$	113,000
Project 10	**Russwood Dry Detention Pond Retrofits**	$	35,000
Project 11	**Trendwood Park New Water Quality BMP**	$	142,000
Project 12	**Cotner Boulevard Storm Pipe**	$	237,000
Project 13	**Herbert Park Stream Stabilization**	$	211,000
	Total Conceptual Cost Estimate=		**$49,846,000**

Engineer's Opinion of Probable Construction Cost
Lincoln, Nebraska
Deadmans Run Watershed Study
Project 1
Downstream Conveyance Components

Project ID #	*Brief Description of Items*	*Unit*	*Estimated Quantity*	*Unit Price*	*Cost*
Project 1	**Downstream Conveyance Components**				
Location 1					
	Site Preperation				
	- Site Clearing and Grubbing	AC	15	$ 3,000.00	$45,000
	Site Earthwork				
	- Excavation	CY	138,000	$ 10.00	$1,380,000
	- Compaction of Fill	CY	43,813	$ 6.50	$284,785
	Channel Improvements				
	- Riprap Grade Control Base (D50=8")	CY	5,500	$ 65.00	$357,500
	- Composite Revetment	SY	33,000	$ 65.00	$2,145,000
	- Turf Reinforced Matrix	SY	25,000	$ 8.50	$212,500
	- Native Seeding	SY	10,000	$ 0.35	$3,500
Location 2					
	Site Preperation				
	- Site Clearing and Grubbing	AC	4	$ 3,000.00	$12,000
	- Demolition of Concrete/Asphalt/Gabion/Concrete Lining	SY	4,840	$ 5.00	$24,200
	- Demolition of Culverts (Mapes Pipes)	Each	1	$ 10,000.00	$10,000
	Site Earthwork				
	- Excavation	CY	30,700	$ 10.00	$307,000
	Channel Improvements				
	- Riprap Grade Control Base (D50=8")	CY	840	$ 65.00	$54,568
	- Composite Revetment	SY	1,032	$ 65.00	$67,080
	- Native Seeding	SY	7,195	$ 0.35	$2,518
	- Turf Planting	SY	1,999	$ 8.00	$15,992
	Stream Crossings				
	- Add 24' span x 12' rise ConSpan Culvert at Mapes	LF	75	$ 2,000.00	$150,000
Location 3					
	Site Preperation				
	- Demolition of Fabriform Mattress	SY	6,667	$ 5.00	$33,333
	- Demolition of Concrete/Asphalt/Gabion/Concrete Lining	SY	7,260	$ 5.00	$36,300
	- Demolition of Box Culverts (33rd Street)	Each	1	$ 50,000.00	$50,000
	- Demolition of Buildings	Each	1	$ 25,000.00	$25,000
	Site Earthwork				
	- Excavation	CY	198,743	$ 10.00	$1,987,430
	Channel Improvements				
	- Riprap Grade Control Base (D50=8")	CY	2,963	$ 65.00	$192,593

Engineer's Opinion of Probable Construction Cost
Lincoln, Nebraska
Deadmans Run Watershed Study
Project 1
Downstream Conveyance Components

Project ID #	*Brief Description of Items*	*Unit*	*Estimated Quantity*	*Unit Price*	*Cost*
Project 1	**Downstream Conveyance Components**				
	- Composite Revetment	SY	8,004	$ 65.00	$520,231
	- Turf Reinforced Matrix	SY	5,530	$ 8.50	$47,005
	- Native Seeding	SY	46,726	$ 0.35	$16,354
	- Turf Planting	SY	8,230	$ 8.00	$65,840
	Stream Crossings				
	- Expand Cornhusker from 100' to 200' Span Bridge	SF	10,000	$180.00	$1,800,000
	- Expand RR Mainline: 100' to 200 '	SF	2,800	$145.00	$406,000
	- Expand RR South Spur: 90' to 180 '	SF	1,620	$145.00	$234,900
	- Expand Huntington from 117' to 200' Span Bridge	SF	6,640	$180.00	$1,195,200
	- Build New 200' Span Bridge 33rd Street	SF	14,800	$120.00	$1,776,000
	Construction Subtotal=				$13,457,828
	Mobilization 5%				$672,891
	Utility Relocations 5%				$672,891
	Overhead Profit and Insurance@15%				$2,018,674
	Construction with Percent Allowances Subtotal=				$16,822,285
	Contingency 25%				$4,205,571
	Probable Cost Estimate=				**$21,027,857**
	Engineering / Permitting / Survey / Geotech (Contingency 20%)				$4,205,571
	Project Subtotal				$25,233,428
	Total Conceptual Cost Estimate=				**$25,234,000**
	(Rounded up to the nearest $1000)				

Engineer's Opinion of Probable Construction Cost
Lincoln, Nebraska
Deadmans Run Watershed Study
Project 2
University of Nebraska - East Campus Channel Conveyance

Project ID #	*Brief Description of Items*	*Unit*	*Estimated Quantity*	*Unit Price*	*Cost*
Project 2	**University of Nebraska - East Campus Channel Conveyance**				
	Site Preperation				
	- Site Clearing and Grubbing	AC	4	$ 3,000.00	$ 10,500
	- Demolition of Fabriform Mattress	SY	18,928	$ 5.00	$ 94,640
	- Demolition of Concrete/Asphalt/Gabion/Concrete Lining	SY	2,581	$ 5.00	$ 12,904
	Site Earthwork				
	- Excavation	CY	88,947	$ 10.00	$ 889,470
	Channel Improvements				
	- Riprap Grade Control Base (D50=8")	CY	5,642	$ 65.00	$ 366,730
	- Composite Revetment	SY	20,597	$ 65.00	$ 1,338,805
	- Turf Reinforced Matrix	SY	15,234	$ 8.50	$ 129,489
	- Native Seeding	SY	24,502	$ 0.35	$ 8,576
	- Retaining Wall	SY	8,889	$ 225.00	$ 2,000,025
	- Turf Planting	SY	6,760	$ 8.00	$ 54,080
	Construction Subtotal=				$4,905,219
	Mobilization 5%				$245,261
	Utility Relocations 5%				$245,261
	Overhead Profit and Insurance@15%				$735,783
	Construction with Percent Allowances Subtotal=				$6,131,523
	Contingency 25%				$1,532,881
	Probable Cost Estimate=				**$7,664,404**
	Engineering / Permitting / Survey / Geotech (Contingency 20%)				$1,532,881
	Project Subtotal				$9,197,285
	Total Conceptual Cost Estimate=				**$9,198,000**
	(Rounded up to the nearest $1000)				

Engineer's Opinion of Probable Construction Cost
Lincoln, Nebraska
Deadmans Run Watershed Study
Project 3
University Place Park

Project ID #	*Brief Description of Items*	*Unit*	*Estimated Quantity*	*Unit Price*	*Cost*
Project 3	**University Place Park**				
	Site Preperation				
	- Site Clearing and Grubbing	AC	3	$ 3,000.00	$7,500
	- Demolition of Fabriform Mattress	SY	1,067	$ 5.00	$5,333
	- Demolition of Concrete/Asphalt/Gabion/Concrete Lining	SY	593	$ 5.00	$2,963
	- Demolition of Bridges (Pedestrian Crossing)	Each	1	$ 6,300.00	$6,300
	Site Earthwork				
	- Excavation	CY	34,724	$ 10.00	$347,240
	Channel Improvements				
	- Riprap Grade Control Base (D50=8")	CY	1,975	$ 65.00	$128,395
	- Composite Revetment	SY	4,035	$ 65.00	$262,275
	- Turf Reinforced Matrix	SY	6,844	$ 8.50	$58,174
	- Native Seeding	SY	7,951	$ 0.35	$2,783
	- Turf Planting	SY	3,602	$ 8.00	$28,816
	Stream Crossings				
	- Expand 48th Street from 60' to 95' Span Bridge	SF	2,100	$180.00	$378,000
	- New 150' Pedestrian Bridge	LF	150	$ 610.00	$91,500
	Construction Subtotal=				$1,319,279
	Mobilization 5%				$65,964
	Utility Relocations 5%				$65,964
	Overhead Profit and Insurance@15%				$197,892
	Construction with Percent Allowances Subtotal=				$1,649,099
	Contingency 25%				$412,275
	Probable Cost Estimate=				**$2,061,374**
	Engineering / Permitting / Survey / Geotech (Contingency 20%)				$412,275
	Project Subtotal				$2,473,649
	Total Conceptual Cost Estimate=				**$2,474,000**
	(Rounded up to the nearest $1000)				

Engineer's Opinion of Probable Construction Cost
Lincoln, Nebraska
Deadmans Run Watershed Study
Project 4
52nd Street to 56th Street

Project ID #	*Brief Description of Items*	*Unit*	*Estimated Quantity*	*Unit Price*	*Cost*
Project 4	**52nd Street to 56th Street**				
	Site Preperation				
	- Demolition of Fabriform Mattress	SY	1,000	$ 5.00	$5,000
	- Demolition of Concrete/Asphalt/Gabion/Concrete Lining	SY	1,111	$ 5.00	$5,556
	- Demolition of Box Culverts (52nd and 56th Street)	Each	2	$ 50,000.00	$100,000
	Site Earthwork				
	- Excavation	CY	31,817	$ 10.00	$318,170
	Channel Improvements				
	- Riprap Grade Control Base (D50=8")	CY	494	$ 65.00	$32,099
	- Composite Revetment	SY	3,937	$ 65.00	$255,905
	- Retaining Wall	SY	5,636	$ 225.00	$1,268,100
	- Native Seeding	SY	10,742	$ 0.35	$3,760
	- Turf Planting	SY	1,111	$ 8.00	$8,889
	Stream Crossings				
	- Add 52nd Street 60' Span Bridge	SF	3,485	$120.00	$418,176
	- Add 56th Street 140' Span Bridge	SF	14,375	$120.00	$1,724,976
	Construction Subtotal=				$4,140,630
	Mobilization 5%				$207,031
	Utility Relocations 5%				$207,031
	Overhead Profit and Insurance@15%				$621,094
	Construction with Percent Allowances Subtotal=				$5,175,787
	Contingency 25%				$1,293,947
	Probable Cost Estimate=				**$6,469,734**
	Engineering / Permitting / Survey / Geotech (Contingency 20%)				$1,293,947
	Project Subtotal				$7,763,681
	Total Conceptual Cost Estimate=				**$7,764,000**
	(Rounded up to the nearest $1000)				

Engineer's Opinion of Probable Construction Cost
Lincoln, Nebraska
Deadmans Run Watershed Study
Project 5
Chateau Apartments / Lincoln Lutheran Schools

Project ID #	*Brief Description of Items*	*Unit*	*Estimated Quantity*	*Unit Price*	*Cost*
Project 5	**Chateau Apartments / Lincoln Lutheran Schools**				
Cell A	**Site Preperation**				
	- Site Clearing and Grubbing	AC	4	$ 3,000.00	$12,000
	Site Earthwork				
	- Excavation - Detention Facility	CY	84,421	$ 8.00	$675,372
	Detention Basin				
	- Native Seeding	SY	16,940	$ 0.35	$5,929
	- Native & Wetland Meadow Seeding	SY	2,420	$ 1.00	$2,420
	Earthen Embankment Outlet				
	- Install New RCP Outlet	LF	100	$ 325.00	$32,500
Cell B	**Site Earthwork**				
	- Excavation - Detention Facility	CY	90,429	$ 8.00	$723,429
	Channel Improvements				
	- Native Seeding	SY	4,840	$ 0.35	$1,694
	- Turf Planting	SY	16,940	$ 8.00	$135,520
	Construction Subtotal=				$1,588,864
	Mobilization 5%				$79,443
	Utility Relocations 3%				$47,666
	Overhead Profit and Insurance@15%				$238,330
	Construction with Percent Allowances Subtotal=				$1,954,303
	Contingency 25%				$488,576
	Probable Cost Estimate=				**$2,442,879**
	Engineering / Permitting / Survey / Geotech (Contingency 20%)				$488,576
	Project Subtotal				$2,931,454
	Total Conceptual Cost Estimate=				**$2,932,000**
	(Rounded up to the nearest $1000)				

Engineer's Opinion of Probable Construction Cost
Lincoln, Nebraska
Deadmans Run Watershed Study
Project 6
Taylor Park

Project ID #	*Brief Description of Items*	*Unit*	*Estimated Quantity*	*Unit Price*	*Cost*
Project 6	**Taylor Park**				
	Site Preperation				
	- Demolition of Concrete/Asphalt/Gabion/Concrete Lining	SY	556	$ 5.00	$ 2,777.78
	- Demolition of Bridges (Pedestrian Crossing)	Each	1	$ 6,300.00	$ 6,300.00
	Site Earthwork				
	- Excavation - Detention Facility	CY	86,077	$ 8.00	$ 688,612.47
	- Compaction of Fill	CY	5,310	$ 6.50	$ 34,515.59
	Channel Improvements				
	- Native Seeding	SY	21,622	$ 0.35	$ 7,567.62
	- Native & Wetland Meadow Seeding	SY	13,068	$ 1.00	$ 13,068.00
	Earthen Embankment Outlet				
	- Install New 48” RCP Plus 2’x2’, 8’ High Riser	LF	85	$ 325.00	$ 27,625.00
	Construction Subtotal=				$780,466
	Mobilization 5%				$39,023
	Utility Relocations 3%				$23,414
	Overhead Profit and Insurance@15%				$117,070
	Construction with Percent Allowances Subtotal=				$959,974
	Contingency 25%				$239,993
	Probable Cost Estimate=				**$1,199,967**
	Engineering / Permitting / Survey / Geotech (Contingency 20%)				$239,993
	Project Subtotal				$1,439,961
	Total Conceptual Cost Estimate=				**$1,440,000**
	(Rounded up to the nearest $1000)				

Engineer's Opinion of Probable Construction Cost
Lincoln, Nebraska
Deadmans Run Watershed Study
Project 7
Seacrest Park

Project ID #	*Brief Description of Items*	*Unit*	*Estimated Quantity*	*Unit Price*	*Cost*
Project 7	**Seacrest Park**				
	Site Preperation				
	- Site Clearing and Grubbing	AC	1	$ 3,000.00	$ 1,800.00
	Site Earthwork				
	- Compaction of Fill	CY	1,000	$ 6.50	$ 6,500.00
	Channel Improvements				
	- Native Seeding	SY	4,840	$ 0.35	$ 1,694.00
	Construction Subtotal=				$9,994
	Mobilization 5%				$500
	Utility Relocations 5%				$500
	Overhead Profit and Insurance@15%				$1,499
	Construction with Percent Allowances Subtotal=				$12,493
	Contingency 25%				$3,123
	Probable Cost Estimate=				**$15,616**
	Engineering / Permitting / Survey / Geotech (Contingency 20%)				$3,123
	Project Subtotal				$18,739
	Total Conceptual Cost Estimate=				**$19,000**
	(Rounded up to the nearest $1000)				

Engineer's Opinion of Probable Construction Cost
Lincoln, Nebraska
Deadmans Run Watershed Study
Project 8
Wyuka Cemetary Existing Detention Pond Retrofit

Project ID #	*Brief Description of Items*	*Unit*	*Estimated Quantity*	*Unit Price*	*Cost*
Project 8	**Wyuka Cemetary Existing Detention Pond Retrofit**				
	Site Earthwork				
	- Compaction and Fill (sedimentation Forbay)	CY	2,396	$ 6.50	$ 15,574
	Channel Improvements				
	- Riprap Grade Control Base (D50=8")	CY	42	$ 65.00	$ 2,730
	- Native & Wetland Meadow Seeding	SY	4,114	$ 1.00	$ 4,114
	- Outlet Structure (Standpipe, Trash Rack, and Orifice)	Ea	1	$ 3,500.00	$ 3,500
	Construction Subtotal=				$25,918
	Mobilization 5%				$1,296
	Overhead Profit and Insurance@15%				$3,888
	Construction with Percent Allowances Subtotal=				$31,102
	Contingency 25%				$7,775
	Probable Cost Estimate=				**$38,877**
	Engineering / Permitting / Survey / Geotech (Contingency 20%)				$7,775
	Project Subtotal				$46,652
	Total Conceptual Cost Estimate=				**$47,000**
	(Rounded up to the nearest $1000)				

Engineer's Opinion of Probable Construction Cost
Lincoln, Nebraska
Deadmans Run Watershed Study
Project 9
Bethany Park New Water Quality BMP

Project ID #	*Brief Description of Items*	*Unit*	*Estimated Quantity*	*Unit Price*	*Cost*
Project 9	**Bethany Park New Water Quality BMP**				
	Site Preperation				
	- Demolition of Concrete/Asphalt/Gabion/Concrete Lining	SY	100	$ 5.00	$500
	Site Earthwork				
	- Excavation	CY	10,886	$ 5.00	$ 54,432
	Channel Improvements				
	- Riprap Grade Control Base (D50=8")	CY	22	$ 65.00	$ 1,444
	- Native & Wetland Meadow Seeding	SY	871	$ 1.00	$ 871
	- Native Seeding	SY	6,389	$ 0.35	$ 2,236
	- Outlet Structure (Standpipe, Trash Rack, and Orifice)	Ea	1	$ 3,500.00	$ 3,500
	- Inlet Structure off Vine Street Drainage	Ea	1	$ 3,500.00	$ 3,500
	Replacement Work				
	- Trail System, Pavement Removal/Replacement	SY	100	$ 25.00	$2,500
	Construction Subtotal=				$62,484
	Mobilization 5%				$3,124
	Overhead Profit and Insurance@15%				$9,373
	Construction with Percent Allowances Subtotal=				$74,981
	Contingency 25%				$18,745
	Probable Cost Estimate=				**$93,726**
	Engineering / Permitting / Survey / Geotech (Contingency 20%)				$18,745
	Project Subtotal				$112,471
	Total Conceptual Cost Estimate=				**$113,000**
	(Rounded up to the nearest $1000)				

Engineer's Opinion of Probable Construction Cost
Lincoln, Nebraska
Deadmans Run Watershed Study
Project 10
Russwood Dry Detention Pond Retrofits

Project ID #	*Brief Description of Items*	*Unit*	*Estimated Quantity*	*Unit Price*	*Cost*
Project 10	**Russwood Dry Detention Pond Retrofits**				
	Russwood North				
	Site Earthwork				
	- Excavation	CY	388	$ 5.00	$ 1,940
	- Compaction and Fill	CY	30	$ 6.50	$ 195
	Channel Improvements				
	- Riprap Grade Control Base (D50=8")	CY	50	$ 65.00	$ 3,250
	- Native & Wetland Meadow Seeding	SY	1,113	$ 1.00	$ 1,113
	- Outlet Structure (Standpipe, Trash Rack, and Orifice)	Ea	1	$ 3,500.00	$ 3,500
	Russwood South				
	Site Earthwork				
	- Compaction and Fill	CY	260	$ 6.50	$ 1,687
	Channel Improvements				
	- Riprap Grade Control Base (D50=8")	CY	50	$ 65.00	$ 3,250
	- Native & Wetland Meadow Seeding	SY	532	$ 1.00	$ 532
	- Outlet Structure (Standpipe, Trash Rack, and Orifice)	Ea	1	$ 3,500.00	$ 3,500
	Construction Subtotal=				$18,967
	Mobilization 5%				$948
	Overhead Profit and Insurance@15%				$2,845
	Construction with Percent Allowances Subtotal=				$22,760
	Contingency 25%				$5,690
	Probable Cost Estimate=				**$28,450**
	Engineering / Permitting / Survey / Geotech (Contingency 20%)				$5,690
	Project Subtotal				$34,140
	Total Conceptual Cost Estimate=				**$35,000**
	(Rounded up to the nearest $1000)				

Engineer's Opinion of Probable Construction Cost
Lincoln, Nebraska
Deadmans Run Watershed Study
Project 11
Trendwood Park New Water Quality BMP

Project ID #	*Brief Description of Items*	*Unit*	*Estimated Quantity*	*Unit Price*	*Cost*
Project 11	**Trendwood Park New Water Quality BMP**				
	Site Earthwork				
	- Excavation	CY	5,786	$ 5.00	$ 28,930
	Channel Improvements				
	- Riprap Grade Control Base (D50=8")	CY	646	$ 65.00	$ 41,972
	- Native & Wetland Meadow Seeding	SY	2,420	$ 1.00	$ 2,420
	- Native Seeding	SY	4,356	$ 0.35	$ 1,525
	- Outlet Structure (Standpipe, Trash Rack, and Orifice)	Ea	1	$ 3,500.00	$ 3,500
	Construction Subtotal=				$78,346
	Mobilization 5%				$3,917
	Overhead Profit and Insurance@15%				$11,752
	Construction with Percent Allowances Subtotal=				$94,016
	Contingency 25%				$23,504
	Probable Cost Estimate=				**$117,519**
	Engineering / Permitting / Survey / Geotech (Contingency 20%)				$23,504
	Project Subtotal				$141,023
	Total Conceptual Cost Estimate=				**$142,000**
	(Rounded up to the nearest $1000)				

Engineer's Opinion of Probable Construction Cost
Lincoln, Nebraska
Deadmans Run Watershed Study
Project 12
Cotner Boulevard Storm Pipe

Project ID #	*Brief Description of Items*	*Unit*	*Estimated Quantity*	*Unit Price*	*Cost*
Project 12	**Cotner Boulevard Storm Pipe**				
	Site Earthwork				
	- Pavement Removal/Replacement	sf	400	$50.00	$ 20,000.00
	Hydro Dynamic Seperators				
	- Hydro Dynamic Seperator Implementation	cfs	44	$ 2,300.00	$ 101,200
	Construction Subtotal=				$121,200
	Mobilization 5%				$6,060
	Overhead Profit and Insurance@15%				$18,180
	Construction with Percent Allowances Subtotal=				$145,440
	Contingency 25%				$36,360
	Probable Cost Estimate=				**$181,800**
	Engineering / Permitting / Survey / Geotech (Contingency 30%)				$54,540
	Project Subtotal				$236,340
	Total Conceptual Cost Estimate=				**$237,000**
	(Rounded up to the nearest $1000)				

Engineer's Opinion of Probable Construction Cost
Lincoln, Nebraska
Deadmans Run Watershed Study
Project 13
Herbert Park Stream Stabilization

Project ID #	*Brief Description of Items*	*Unit*	*Estimated Quantity*	*Unit Price*	*Cost*
Project 13	**Herbert Park Stream Stabilization**				
	Site Preperation				
	- Site Clearing and Grubbing	AC	1	$ 3,000.00	$ 3,000
	Channel Improvements				
	- Riprap Grade Control Base (D50=8")	CY	289	$ 65.00	$ 18,785
	- Vegetated Riprap	SY	267	$ 65.00	$ 17,355
	- Composite Revetment	SY	694	$ 65.00	$ 45,110
	- Construction Access and Restoration	AC	1.5	$ 18,750.00	$ 28,125
	Construction Subtotal=				$112,375
	Mobilization 5%				$5,619
	Utility Relocations 5%				$5,619
	Overhead Profit and Insurance@15%				$16,856
	Construction with Percent Allowances Subtotal=				$140,469
	Contingency 25%				$35,117
	Probable Cost Estimate=				**$175,586**
	Engineering / Permitting / Survey / Geotech (Contingency 20%)				$35,117
	Project Subtotal				$210,703
	*** Total Conceptual Cost Estimate=**				**$211,000**
	(Rounded up to the nearest $1000)				

*** Cost estimate based on City of Lincoln's Preliminary Stream Stability Assessment Report for Herbert Park, 2003. Cost presented above is adjusted for inflation.**

Appendix G

Prioritization

Prioritization Ranking for Watershed Master Plan Projects - DRAFT

City of Lincoln, Nebraska

Prepared By:	CDM	Date:	12/6/07
Project ID:	Projects 1 through 6	Watershed	**Deadmans Run**
Project Location:	Deadmans Run main channel, 56th and Holdrege Street to Salt Creek confluence		
Project Description:	Stormwater conveyance projects including widening, floodbenching, and/or vertical retaining walls to increase conveyance within stream channel and lengthen bridges where overbank flooding or bottlenecks are occurring.		

Issues Addressed:

Flooding Impacts

Projects primarily intended to address structural or non-structural flooding will always incorporate a high or low risk safety factor; though typically will not incorporate stream stability or water quality benefits.

Flooding Benefits		Points, P_{FD}
Major Structural Flooding Damage		30
Minor Structural Flooding Damage		20
Non-Structural Flooding	Streets / ROW, Other	15
Conservation / Prevention	Easements / Acquisitions	10
None		0
	P_{FD}=	30

Flooding Frequency		Multiplier, C_{FF}
Frequent Flooding	More frequent than 10-year storm	4
Infrequent Flooding	Less frequent than 10-year storm	2
None		0
	C_{FF}=	2

	30
	2
A = P_{FD} * C_{FF}	60

Structural and Non-Structural Flooding

Stream Stability

Projects primarily intended for stream stability typically will not incorporate flooding impact benefits; though will incorporate water quality benefits.

Stream Stability Benefit	Points, P_{ET}
Channel Erosion Threatening to Structures	50
Channel Erosion Threatening to Public Infrastructure	40
Channel Erosion Threatening to Natural Resources	35
Conservation / Prevention	10
Stream Stability benefit due to Flood Control or Water Quality Project	10
None	0
P_{ET}=	50

Erosion Activity / Systemic Threat	Multiplier, C_{EA}
Aggressive Erosion	3
Non-Aggressive Erosion	2
None	0
C_{EA}=	3

	50
	3
B = P_{ET} * C_{EA}	150

Open Channel and Surface Erosion

Water Quality

Projects primarily intended for water quality typically will not incorporate flooding impact benefits; though may incorporate stream stability benefits.

Water Quality Benefits	Points, P_{WQ}
Enhance / Preserve Natural Resource Areas (Lake, Wetlands, etc.)	60
Regulatory Compliance / Stormwater Permit / NPDES	60
Create New Natural Resource Areas (Lakes, Wetlands, etc.)	50
Conservation / Prevention	30
Water Quality benefit due to Flood Control or Stream Stability Project	20
None	0
P_{WQ}=	20

Project Benefit		Multiplier, C_{WB}
Major Water Quality Benefit	Broad-Based Impacts	4
Minor Water Quality Benefit	Localized Impacts	3
None		0
	C_{WB}=	3

	20
	3
C = P_{WQ} * C_{WB}	60

Water Quality, Wetlands, Natural Habitat

Safety Factor

Public Health and Safety		Points, P_{SF}
High Risk	Potential Loss of Life or Bodily Injury	160
Low Risk	Public Nuisance	60
No Risk		0
	P_{SF}=	160

D = P_{SF} 160

Public Health and Safety

Prioritization Ranking Summary

X = A + B + C + D 430

Miscellaneous Factors may be used to adjust scoring:

P_{MISC} (See attached worksheet for description of miscellaneous items) 20

May Include: Project Location, Coincident Projects, Development Status, etc.

P_{AC}, Additional Considerations (may be used to add or subtract up to 60 points) 0

May Include: Legal Issues, Jurisdictional Coordination, Complaints, Outside Funding Sources, Wildlife Benefits, etc.

TOTAL = ***X*** + P_{MISC} + P_{AC} 450

TOTAL for PROJECT CB-1 ***450***

Project Location, Development Status, Coincident Projects, Condition / Maintenance, Downstream Impacts, Source Reduction, Additional Considerations

Comments or Description of Additional Considerations:

Widening channel will provide opportunity for stream meanders, riffles, and pools, as well as wetland nature areas, all of which stabilize the stream channel and promote water quality.

MISCELLANEOUS FACTORS - DRAFT

		Points Available	Points Assigned
Location	Public Property or willing owner of Private Property	up to 20	0
Coincident with Adjacent Projects	Public Projects (water, sanitary, roads, etc.)	up to 20	10
	Private Projects	up to 10	0
Development Status	Tier I, Priority A	20	
(Points available are fixed, and are not flexible)	Tier I, Priority B	15	
	Tier I, Priority C	10	
	Existing City Limits	10	10
Projects primarily intended to address structura	Tier II (development 25 - 50 years)	5	
	Tier III (development > 50 years)	0	

Tier I, Priority A - Areas designated for near term development are generally contiguous to existing development and should be provided first with basic infrastructure within 6 years of the adoption of the Plan. Some of the infrastructure required for development may already be in place. This area includes some land already annexed, with City commitments to fund infrastructure improvements, but the land is still undeveloped and without significant infrastructure in place yet. Some infrastructure improvements may be done in the near term while others, such as road improvements that are generally more costly, may take longer to complete.

Tier I, Priority B - The next areas for development, beyond Priority A, are those which currently lack almost all of the infrastructure required to support development. In areas with this designation, the community will maintain present uses until urban development can commence. Infrastructure improvements to serve this area will not initially be included in the City's CIP, but will be actively planned for in the longer term capital improvement planning of the various city and county departments.

Tier I, Priority C - This is the later phase of development areas and is intended to be served after Priority A and B. Given current growth rates and infrastructure financing, development would not begin in this area until after 2020 or 2025.

Total Miscellaneous Points, P_{MISC} = 20

Prioritization Ranking for Watershed Master Plan Projects - DRAFT

City of Lincoln, Nebraska

Prepared By:	CDM	Date:	12/6/07
Project ID:	Project 7	Watershed:	**Deadmans Run**
Project Location:	Seacrest Park, north end		
Project Description:	Modify existing earth berm to potentially avoid floodwaters from reaching habitable buildings by redirecting flow.		

Issues Addressed:

Flooding Impacts

Projects primarily intended to address structural or non-structural flooding will always incorporate a high or low risk safety factor; though typically will not incorporate stream stability or water quality benefits.

Flooding Benefits		Points, P_{FD}
Major Structural Flooding Damage		30
Minor Structural Flooding Damage		20
Non-Structural Flooding	Streets / ROW, Other	15
Conservation / Prevention	Easements / Acquisitions	10
None		0
	P_{FD}=	30

Flooding Frequency		Multiplier, C_{FF}
Frequent Flooding	More frequent than 10-year storm	4
Infrequent Flooding	Less frequent than 10-year storm	2
None		0
	C_{FF}=	2

	30
	2
A = P_{FD} * C_{FF}	60

Structural and Non-Structural Flooding

Stream Stability

Projects primarily intended for stream stability typically will not incorporate flooding impact benefits; though will incorporate water quality benefits.

Stream Stability Benefit	Points, P_{ET}
Channel Erosion Threatening to Structures	50
Channel Erosion Threatening to Public Infrastructure	40
Channel Erosion Threatening to Natural Resources	35
Conservation / Prevention	10
Stream Stability benefit due to Flood Control or Water Quality Project	10
None	0
P_{ET}=	0

Erosion Activity / Systemic Threat	Multiplier, C_{EA}
Aggressive Erosion	3
Non-Aggressive Erosion	2
None	0
C_{EA}=	0

	0
	0
B = P_{ET} * C_{EA}	0

Open Channel and Surface Erosion

Water Quality

Projects primarily intended for water quality typically will not incorporate flooding impact benefits; though may incorporate stream stability benefits.

Water Quality Benefits	Points, P_{WQ}
Enhance / Preserve Natural Resource Areas (Lake, Wetlands, etc.)	60
Regulatory Compliance / Stormwater Permit / NPDES	60
Create New Natural Resource Areas (Lakes, Wetlands, etc.)	50
Conservation / Prevention	30
Water Quality benefit due to Flood Control or Stream Stability Project	20
None	0
P_{WQ}=	0

Project Benefit		Multiplier, C_{WB}
Major Water Quality Benefit	Broad-Based Impacts	4
Minor Water Quality Benefit	Localized Impacts	3
None		0
	C_{WB}=	0

	0
	0
C = P_{WQ} * C_{WB}	0

Water Quality, Wetlands, Natural Habitat

Safety Factor

Public Health and Safety		Points, P_{SF}
High Risk	Potential Loss of Life or Bodily Injury	160
Low Risk	Public Nuisance	60
No Risk		0
	P_{SF}=	60

D = P_{SF} 60

Public Health and Safety

Prioritization Ranking Summary

X = A + B + C + D 120

Miscellaneous Factors may be used to adjust scoring:

P_{MISC} (See attached worksheet for description of miscellaneous items) 30

May Include: Project Location, Coincident Projects, Development Status, etc.

P_{AC}, Additional Considerations (may be used to add or subtract up to 60 points) 0

May Include: Legal Issues, Jurisdictional Coordination, Complaints, Outside Funding Sources, Wildlife Benefits, etc.

TOTAL = ***X*** + P_{MISC} + P_{AC} 150

TOTAL for PROJECT CB-1 ***150***

Project Location, Development Status, Coincident Projects, Condition / Maintenance, Downstream Impacts, Source Reduction, Additional Considerations

Comments or Description of Additional Considerations:

MISCELLANEOUS FACTORS - DRAFT

		Points Available	Points Assigned
Location	Public Property or willing owner of Private Property	up to 20	20
Coincident with Adjacent Projects	Public Projects (water, sanitary, roads, etc.)	up to 20	0
	Private Projects	up to 10	0
Development Status	Tier I, Priority A	20	
(Points available are fixed, and are not flexible)	Tier I, Priority B	15	
	Tier I, Priority C	10	
	Existing City Limits	10	10
Projects primarily intended to address structura	Tier II (development 25 - 50 years)	5	
	Tier III (development > 50 years)	0	

Tier I, Priority A - Areas designated for near term development are generally contiguous to existing development and should be provided first with basic infrastructure within 6 years of the adoption of the Plan. Some of the infrastructure required for development may already be in place. This area includes some land already annexed, with City commitments to fund infrastructure improvements, but the land is still undeveloped and without significant infrastructure in place yet. Some infrastructure improvements may be done in the near term while others, such as road improvements that are generally more costly, may take longer to complete.

Tier I, Priority B - The next areas for development, beyond Priority A, are those which currently lack almost all of the infrastructure required to support development. In areas with this designation, the community will maintain present uses until urban development can commence. Infrastructure improvements to serve this area will not initially be included in the City's CIP, but will be actively planned for in the longer term capital improvement planning of the various city and county departments.

Tier I, Priority C - This is the later phase of development areas and is intended to be served after Priority A and B. Given current growth rates and infrastructure financing, development would not begin in this area until after 2020 or 2025.

Total Miscellaneous Points, P_{MISC} = 30

Prioritization Ranking for Watershed Master Plan Projects - DRAFT

City of Lincoln, Nebraska

Prepared By:	CDM	Date:	12/6/07
Project ID:	Project 8	Watershed:	**Deadmans Run**
Project Location:	Wyuka Cemetery Existing Detention Pond Retrofit		
Project Description:	Modify existing outlet of the basin to extend the drawdown time during smaller storm events.		
	In addition to the outlet modifications, the existing sediment forebay volume can be increased by		
	adding berm height to the existing grade that separates the basin from the forebay.		

Issues Addressed:

Flooding Impacts

Projects primarily intended to address structural or non-structural flooding will always incorporate a high or low risk safety factor; though typically will not incorporate stream stability or water quality benefits.

Flooding Benefits		Points, P_{FD}
Major Structural Flooding Damage		30
Minor Structural Flooding Damage		20
Non-Structural Flooding	Streets / ROW, Other	15
Conservation / Prevention	Easements / Acquisitions	10
None		0
	P_{FD}=	0

Flooding Frequency		Multiplier, C_{FF}
Frequent Flooding	More frequent than 10-year storm	4
Infrequent Flooding	Less frequent than 10-year storm	2
None		0
	C_{FF}=	0

	0
	0
A = P_{FD} * C_{FF}	0

Structural and Non-Structural Flooding

Stream Stability

Projects primarily intended for stream stability typically will not incorporate flooding impact benefits; though will incorporate water quality benefits.

Stream Stability Benefit	Points, P_{ET}
Channel Erosion Threatening to Structures	50
Channel Erosion Threatening to Public Infrastructure	40
Channel Erosion Threatening to Natural Resources	35
Conservation / Prevention	10
Stream Stability benefit due to Flood Control or Water Quality Project	10
None	0
P_{ET}=	0

Erosion Activity / Systemic Threat	Multiplier, C_{EA}
Aggressive Erosion	3
Non-Aggressive Erosion	2
None	0
C_{EA}=	0

	0
	0
B = P_{ET} * C_{EA}	0

Open Channel and Surface Erosion

Water Quality

Projects primarily intended for water quality typically will not incorporate flooding impact benefits; though may incorporate stream stability benefits.

Water Quality Benefits	Points, P_{WQ}
Enhance / Preserve Natural Resource Areas (Lake, Wetlands, etc.)	60
Regulatory Compliance / Stormwater Permit / NPDES	60
Create New Natural Resource Areas (Lakes, Wetlands, etc.)	50
Conservation / Prevention	30
Water Quality benefit due to Flood Control or Stream Stability Project	20
None	0
P_{WQ}=	60

Project Benefit		Multiplier, C_{WB}
Major Water Quality Benefit	Broad-Based Impacts	4
Minor Water Quality Benefit	Localized Impacts	3
None		0
	C_{WB}=	3

	60
	3
C = P_{WQ} * C_{WB}	180

Water Quality, Wetlands, Natural Habitat

Safety Factor

Public Health and Safety		Points, P_{SF}
High Risk	Potential Loss of Life or Bodily Injury	160
Low Risk	Public Nuisance	60
No Risk		0
	P_{SF}=	60

D = P_{SF} 60

Public Health and Safety

Prioritization Ranking Summary

X = A + B + C + D 240

Miscellaneous Factors may be used to adjust scoring:

P_{MISC} (See attached worksheet for description of miscellaneous items) 10

May Include: Project Location, Coincident Projects, Development Status, etc.

P_{AC}, Additional Considerations (may be used to add or subtract up to 60 points) 0

May Include: Legal Issues, Jurisdictional Coordination, Complaints, Outside Funding Sources, Wildlife Benefits, etc.

TOTAL = ***X*** + P_{MISC} + P_{AC} 250

TOTAL for PROJECT CB-1 ***250***

Project Location, Development Status, Coincident Projects, Condition / Maintenance, Downstream Impacts, Source Reduction, Additional Considerations

Comments or Description of Additional Considerations:

MISCELLANEOUS FACTORS - DRAFT

		Points Available	Points Assigned
Location	Public Property or willing owner of Private Property	up to 20	0
Coincident with Adjacent Projects	Public Projects (water, sanitary, roads, etc.)	up to 20	0
	Private Projects	up to 10	0
Development Status	Tier I, Priority A	20	
(Points available are fixed, and are not flexible)	Tier I, Priority B	15	
	Tier I, Priority C	10	
	Existing City Limits	10	10
Projects primarily intended to address structura	Tier II (development 25 - 50 years)	5	
	Tier III (development > 50 years)	0	

Tier I, Priority A - Areas designated for near term development are generally contiguous to existing development and should be provided first with basic infrastructure within 6 years of the adoption of the Plan. Some of the infrastructure required for development may already be in place. This area includes some land already annexed, with City commitments to fund infrastructure improvements, but the land is still undeveloped and without significant infrastructure in place yet. Some infrastructure improvements may be done in the near term while others, such as road improvements that are generally more costly, may take longer to complete.

Tier I, Priority B - The next areas for development, beyond Priority A, are those which currently lack almost all of the infrastructure required to support development. In areas with this designation, the community will maintain present uses until urban development can commence. Infrastructure improvements to serve this area will not initially be included in the City's CIP, but will be actively planned for in the longer term capital improvement planning of the various city and county departments.

Tier I, Priority C - This is the later phase of development areas and is intended to be served after Priority A and B. Given current growth rates and infrastructure financing, development would not begin in this area until after 2020 or 2025.

Total Miscellaneous Points, P_{MISC} = 10

Prioritization Ranking for Watershed Master Plan Projects - DRAFT

City of Lincoln, Nebraska

Prepared By:	CDM	Date:	12/6/07
Project ID:	Project 9	Watershed:	**Deadmans Run**
Project Location:	Bethany Park New Water Quality BMP		
Project Description:	Convert a portion of the west end of the park into a water quality feature that will treat the Vine Street tributary flow.		

Issues Addressed:

Flooding Impacts

Projects primarily intended to address structural or non-structural flooding will always incorporate a high or low risk safety factor; though typically will not incorporate stream stability or water quality benefits.

Flooding Benefits		Points, P_{FD}
Major Structural Flooding Damage		30
Minor Structural Flooding Damage		20
Non-Structural Flooding	Streets / ROW, Other	15
Conservation / Prevention	Easements / Acquisitions	10
None		0
	P_{FD}=	0

Flooding Frequency		Multiplier, C_{FF}
Frequent Flooding	More frequent than 10-year storm	4
Infrequent Flooding	Less frequent than 10-year storm	2
None		0
	C_{FF}=	0

	0
	0
A = P_{FD} * C_{FF}	0

Structural and Non-Structural Flooding

Stream Stability

Projects primarily intended for stream stability typically will not incorporate flooding impact benefits; though will incorporate water quality benefits.

Stream Stability Benefit	Points, P_{ET}
Channel Erosion Threatening to Structures	50
Channel Erosion Threatening to Public Infrastructure	40
Channel Erosion Threatening to Natural Resources	35
Conservation / Prevention	10
Stream Stability benefit due to Flood Control or Water Quality Project	10
None	0
P_{ET}=	0

Erosion Activity / Systemic Threat	Multiplier, C_{EA}
Aggressive Erosion	3
Non-Aggressive Erosion	2
None	0
C_{EA}=	0

	0
	0
B = P_{ET} * C_{EA}	0

Open Channel and Surface Erosion

Water Quality

Projects primarily intended for water quality typically will not incorporate flooding impact benefits; though may incorporate stream stability benefits.

Water Quality Benefits	Points, P_{WQ}
Enhance / Preserve Natural Resource Areas (Lake, Wetlands, etc.)	60
Regulatory Compliance / Stormwater Permit / NPDES	60
Create New Natural Resource Areas (Lakes, Wetlands, etc.)	50
Conservation / Prevention	30
Water Quality benefit due to Flood Control or Stream Stability Project	20
None	0
P_{WQ}=	60

Project Benefit		Multiplier, C_{WB}
Major Water Quality Benefit	Broad-Based Impacts	4
Minor Water Quality Benefit	Localized Impacts	3
None		0
	C_{WB}=	4

	60
	4
C = P_{WQ} * C_{WB}	240

Water Quality, Wetlands, Natural Habitat

Safety Factor

Public Health and Safety		Points, P_{SF}
High Risk	Potential Loss of Life or Bodily Injury	160
Low Risk	Public Nuisance	60
No Risk		0
	P_{SF}=	60

D = P_{SF} 60

Public Health and Safety

Prioritization Ranking Summary

X = A + B + C + D 300

Miscellaneous Factors may be used to adjust scoring:

P_{MISC} (See attached worksheet for description of miscellaneous items) 30

May Include: Project Location, Coincident Projects, Development Status, etc.

P_{AC}, Additional Considerations (may be used to add or subtract up to 60 points) 0

May Include: Legal Issues, Jurisdictional Coordination, Complaints, Outside Funding Sources, Wildlife Benefits, etc.

TOTAL = ***X*** + P_{MISC} + P_{AC} 330

TOTAL for PROJECT CB-1 ***330***

Project Location, Development Status, Coincident Projects, Condition / Maintenance, Downstream Impacts, Source Reduction, Additional Considerations

Comments or Description of Additional Considerations:

The west end of the park will be excavated approximately 1 to 6 feet.
A small culvert installed in the low-flow channel of the existing concrete-lined Vine Street tributary will divert the water quality storm flows and allow larger flood flows to continue to the main channel. The proposed grading would allow treatment of 45 percent of the WQCV.

MISCELLANEOUS FACTORS - DRAFT

		Points Available	Points Assigned
Location	Public Property or willing owner of Private Property	up to 20	20
Coincident with Adjacent Projects	Public Projects (water, sanitary, roads, etc.)	up to 20	0
	Private Projects	up to 10	0
Development Status	Tier I, Priority A	20	
(Points available are fixed, and are not flexible)	Tier I, Priority B	15	
	Tier I, Priority C	10	
	Existing City Limits	10	10
Projects primarily intended to address structura	Tier II (development 25 - 50 years)	5	
	Tier III (development > 50 years)	0	

Tier I, Priority A - Areas designated for near term development are generally contiguous to existing development and should be provided first with basic infrastructure within 6 years of the adoption of the Plan. Some of the infrastructure required for development may already be in place. This area includes some land already annexed, with City commitments to fund infrastructure improvements, but the land is still undeveloped and without significant infrastructure in place yet. Some infrastructure improvements may be done in the near term while others, such as road improvements that are generally more costly, may take longer to complete.

Tier I, Priority B - The next areas for development, beyond Priority A, are those which currently lack almost all of the infrastructure required to support development. In areas with this designation, the community will maintain present uses until urban development can commence. Infrastructure improvements to serve this area will not initially be included in the City's CIP, but will be actively planned for in the longer term capital improvement planning of the various city and county departments.

Tier I, Priority C - This is the later phase of development areas and is intended to be served after Priority A and B. Given current growth rates and infrastructure financing, development would not begin in this area until after 2020 or 2025.

Total Miscellaneous Points, P_{MISC} = 30

Prioritization Ranking for Watershed Master Plan Projects - DRAFT

City of Lincoln, Nebraska

Prepared By:	CDM	Date:	12/6/07
Project ID:	Project 10	Watershed:	**Deadmans Run**
Project Location:	Russwood Dry Detention Pond Retrofit		
Project Description:	Modify the basins' outlet to achieve an appropriate drawdown of the water quality volume. In addition to the outlet modification, the construction of sediment forebays at the two east inlet locations is recommended to provide pretreatment measures.		

Issues Addressed:

Flooding Impacts

Projects primarily intended to address structural or non-structural flooding will always incorporate a high or low risk safety factor; though typically will not incorporate stream stability or water quality benefits.

Flooding Benefits		Points, P_{FD}
Major Structural Flooding Damage		30
Minor Structural Flooding Damage		20
Non-Structural Flooding	Streets / ROW, Other	15
Conservation / Prevention	Easements / Acquisitions	10
None		0
	P_{FD}=	0

Flooding Frequency		Multiplier, C_{FF}
Frequent Flooding	More frequent than 10-year storm	4
Infrequent Flooding	Less frequent than 10-year storm	2
None		0
	C_{FF}=	0

	0
	0
A = P_{FD} * C_{FF}	0

Structural and Non-Structural Flooding

Stream Stability

Projects primarily intended for stream stability typically will not incorporate flooding impact benefits; though will incorporate water quality benefits.

Stream Stability Benefit	Points, P_{ET}
Channel Erosion Threatening to Structures	50
Channel Erosion Threatening to Public Infrastructure	40
Channel Erosion Threatening to Natural Resources	35
Conservation / Prevention	10
Stream Stability benefit due to Flood Control or Water Quality Project	10
None	0
P_{ET}=	0

Erosion Activity / Systemic Threat	Multiplier, C_{EA}
Aggressive Erosion	3
Non-Aggressive Erosion	2
None	0
C_{EA}=	0

	0
	0
B = P_{ET} * C_{EA}	0

Open Channel and Surface Erosion

Water Quality

Projects primarily intended for water quality typically will not incorporate flooding impact benefits; though may incorporate stream stability benefits.

Water Quality Benefits	Points, P_{WQ}
Enhance / Preserve Natural Resource Areas (Lake, Wetlands, etc.)	60
Regulatory Compliance / Stormwater Permit / NPDES	60
Create New Natural Resource Areas (Lakes, Wetlands, etc.)	50
Conservation / Prevention	30
Water Quality benefit due to Flood Control or Stream Stability Project	20
None	0
P_{WQ}=	60

Project Benefit		Multiplier, C_{WB}
Major Water Quality Benefit	Broad-Based Impacts	4
Minor Water Quality Benefit	Localized Impacts	3
None		0
	C_{WB}=	3

	60
	3
C = P_{WQ} * C_{WB}	180

Water Quality, Wetlands, Natural Habitat

Safety Factor

Public Health and Safety		Points, P_{SF}
High Risk	Potential Loss of Life or Bodily Injury	160
Low Risk	Public Nuisance	60
No Risk		0
	P_{SF}=	60

D = P_{SF} 60

Public Health and Safety

Prioritization Ranking Summary

X = A + B + C + D 240

Miscellaneous Factors may be used to adjust scoring:

P_{MISC} (See attached worksheet for description of miscellaneous items) 10

May Include: Project Location, Coincident Projects, Development Status, etc.

P_{AC}, Additional Considerations (may be used to add or subtract up to 60 points) 0

May Include: Legal Issues, Jurisdictional Coordination, Complaints, Outside Funding Sources, Wildlife Benefits, etc.

TOTAL = ***X*** + P_{MISC} + P_{AC} 250

TOTAL for PROJECT CB-1 ***250***

Project Location, Development Status, Coincident Projects, Condition / Maintenance, Downstream Impacts, Source Reduction, Additional Considerations

Comments or Description of Additional Considerations:

The proposed recommended improvements include the construction of a water quality feature near "A" Street along the Deadmans Run main channel. The area immediately upstream of "A" Street would be excavated approximately 6 feet with gradual side slopes. Over-excavating the area to create a wet pond, if desired, is suitable in this area as baseflow will continually flush the basin avoiding stagnant water. The culvert at "A" Street would be retrofitted with a concrete box weir with a water quality orifice. The weir would back water into the BMP during small storm events and achieve a sufficient drawdown to treat 15 percent of the water quality volume.

MISCELLANEOUS FACTORS - DRAFT

		Points Available	Points Assigned
Location	Public Property or willing owner of Private Property	up to 20	0
Coincident with Adjacent Projects	Public Projects (water, sanitary, roads, etc.)	up to 20	0
	Private Projects	up to 10	0
Development Status	Tier I, Priority A	20	
(Points available are fixed, and are not flexible)	Tier I, Priority B	15	
	Tier I, Priority C	10	
	Existing City Limits	10	10
Projects primarily intended to address structura	Tier II (development 25 - 50 years)	5	
	Tier III (development > 50 years)	0	

Tier I, Priority A - Areas designated for near term development are generally contiguous to existing development and should be provided first with basic infrastructure within 6 years of the adoption of the Plan. Some of the infrastructure required for development may already be in place. This area includes some land already annexed, with City commitments to fund infrastructure improvements, but the land is still undeveloped and without significant infrastructure in place yet. Some infrastructure improvements may be done in the near term while others, such as road improvements that are generally more costly, may take longer to complete.

Tier I, Priority B - The next areas for development, beyond Priority A, are those which currently lack almost all of the infrastructure required to support development. In areas with this designation, the community will maintain present uses until urban development can commence. Infrastructure improvements to serve this area will not initially be included in the City's CIP, but will be actively planned for in the longer term capital improvement planning of the various city and county departments.

Tier I, Priority C - This is the later phase of development areas and is intended to be served after Priority A and B. Given current growth rates and infrastructure financing, development would not begin in this area until after 2020 or 2025.

Total Miscellaneous Points, P_{MISC} = 10

Prioritization Ranking for Watershed Master Plan Projects - DRAFT

City of Lincoln, Nebraska

Prepared By:	CDM	Date:	12/6/07
Project ID:	Project 11	Watershed:	**Deadmans Run**
Project Location:	Trendwood Park Water Quality BMP		
Project Description:	Convert a portion of the west end of the park into a water quality feature that will treat the Vine Street tributary flow.		

Issues Addressed:

Flooding Impacts

Projects primarily intended to address structural or non-structural flooding will always incorporate a high or low risk safety factor; though typically will not incorporate stream stability or water quality benefits.

Flooding Benefits		Points, P_{FD}
Major Structural Flooding Damage		30
Minor Structural Flooding Damage		20
Non-Structural Flooding	Streets / ROW, Other	15
Conservation / Prevention	Easements / Acquisitions	10
None		0
	P_{FD}=	0

Flooding Frequency		Multiplier, C_{FF}
Frequent Flooding	More frequent than 10-year storm	4
Infrequent Flooding	Less frequent than 10-year storm	2
None		0
	C_{FF}=	0

	0
	0
A = P_{FD} * C_{FF}	0

Structural and Non-Structural Flooding

Stream Stability

Projects primarily intended for stream stability typically will not incorporate flooding impact benefits; though will incorporate water quality benefits.

Stream Stability Benefit	Points, P_{ET}
Channel Erosion Threatening to Structures	50
Channel Erosion Threatening to Public Infrastructure	40
Channel Erosion Threatening to Natural Resources	35
Conservation / Prevention	10
Stream Stability benefit due to Flood Control or Water Quality Project	10
None	0
P_{ET}=	0

Erosion Activity / Systemic Threat	Multiplier, C_{EA}
Aggressive Erosion	3
Non-Aggressive Erosion	2
None	0
C_{EA}=	0

	0
	0
B = P_{ET} * C_{EA}	0

Open Channel and Surface Erosion

Water Quality

Projects primarily intended for water quality typically will not incorporate flooding impact benefits; though may incorporate stream stability benefits.

Water Quality Benefits	Points, P_{WQ}
Enhance / Preserve Natural Resource Areas (Lake, Wetlands, etc.)	60
Regulatory Compliance / Stormwater Permit / NPDES	60
Create New Natural Resource Areas (Lakes, Wetlands, etc.)	50
Conservation / Prevention	30
Water Quality benefit due to Flood Control or Stream Stability Project	20
None	0
P_{WQ}=	60

Project Benefit		Multiplier, C_{WB}
Major Water Quality Benefit	Broad-Based Impacts	4
Minor Water Quality Benefit	Localized Impacts	3
None		0
	C_{WB}=	4

	60
	4
C = P_{WQ} * C_{WB}	240

Water Quality, Wetlands, Natural Habitat

Safety Factor

Public Health and Safety		Points, P_{SF}
High Risk	Potential Loss of Life or Bodily Injury	160
Low Risk	Public Nuisance	60
No Risk		0
	P_{SF}=	60

D = P_{SF} 60

Public Health and Safety

Prioritization Ranking Summary

X = A + B + C + D 300

Miscellaneous Factors may be used to adjust scoring:

P_{MISC} (See attached worksheet for description of miscellaneous items) 30

May Include: Project Location, Coincident Projects, Development Status, etc.

P_{AC}, Additional Considerations (may be used to add or subtract up to 60 points) 0

May Include: Legal Issues, Jurisdictional Coordination, Complaints, Outside Funding Sources, Wildlife Benefits, etc.

TOTAL = ***X*** + P_{MISC} + P_{AC} 330

TOTAL for PROJECT CB-1 ***330***

Project Location, Development Status, Coincident Projects, Condition / Maintenance, Downstream Impacts, Source Reduction, Additional Considerations

Comments or Description of Additional Considerations:

The proposed recommended improvements include the construction of a water quality feature near "A" Street along the Deadmans Run main channel. The area immediately upstream of "A" Street would be excavated approximately 6 feet with gradual side slopes. Over-excavating the area to create a wet pond, if desired, is suitable in this area as baseflow will continually flush the basin avoiding stagnant water. The culvert at "A" Street would be retrofitted with a concrete box weir with a water quality orifice. The weir would back water into the BMP during small storm events and achieve a sufficient drawdown to treat 15 percent of the water quality volume.

MISCELLANEOUS FACTORS - DRAFT

		Points Available	Points Assigned
Location	Public Property or willing owner of Private Property	up to 20	20
Coincident with Adjacent Projects	Public Projects (water, sanitary, roads, etc.)	up to 20	0
	Private Projects	up to 10	0
Development Status	Tier I, Priority A	20	
(Points available are fixed, and are not flexible)	Tier I, Priority B	15	
	Tier I, Priority C	10	
	Existing City Limits	10	10
Projects primarily intended to address structura	Tier II (development 25 - 50 years)	5	
	Tier III (development > 50 years)	0	

Tier I, Priority A - Areas designated for near term development are generally contiguous to existing development and should be provided first with basic infrastructure within 6 years of the adoption of the Plan. Some of the infrastructure required for development may already be in place. This area includes some land already annexed, with City commitments to fund infrastructure improvements, but the land is still undeveloped and without significant infrastructure in place yet. Some infrastructure improvements may be done in the near term while others, such as road improvements that are generally more costly, may take longer to complete.

Tier I, Priority B - The next areas for development, beyond Priority A, are those which currently lack almost all of the infrastructure required to support development. In areas with this designation, the community will maintain present uses until urban development can commence. Infrastructure improvements to serve this area will not initially be included in the City's CIP, but will be actively planned for in the longer term capital improvement planning of the various city and county departments.

Tier I, Priority C - This is the later phase of development areas and is intended to be served after Priority A and B. Given current growth rates and infrastructure financing, development would not begin in this area until after 2020 or 2025.

Total Miscellaneous Points, P_{MISC} = 30

Prioritization Ranking for Watershed Master Plan Projects - DRAFT

City of Lincoln, Nebraska

Prepared By:	CDM	Date:	12/6/07
Project ID:	Project 12	Watershed:	**Deadmans Run**
Project Location:	Cotner Boulevard Storm Pipe		
Project Description:	Implementation of a hydrodynamic separator.		

Issues Addressed:

Flooding Impacts

Projects primarily intended to address structural or non-structural flooding will always incorporate a high or low risk safety factor; though typically will not incorporate stream stability or water quality benefits.

Flooding Benefits		Points, P_{FD}
Major Structural Flooding Damage		30
Minor Structural Flooding Damage		20
Non-Structural Flooding	Streets / ROW, Other	15
Conservation / Prevention	Easements / Acquisitions	10
None		0
	P_{FD}=	0

Flooding Frequency		Multiplier, C_{FF}
Frequent Flooding	More frequent than 10-year storm	4
Infrequent Flooding	Less frequent than 10-year storm	2
None		0
	C_{FF}=	0

	0
	0
A = P_{FD} * C_{FF}	0

Structural and Non-Structural Flooding

Stream Stability

Projects primarily intended for stream stability typically will not incorporate flooding impact benefits; though will incorporate water quality benefits.

Stream Stability Benefit	Points, P_{ET}
Channel Erosion Threatening to Structures	50
Channel Erosion Threatening to Public Infrastructure	40
Channel Erosion Threatening to Natural Resources	35
Conservation / Prevention	10
Stream Stability benefit due to Flood Control or Water Quality Project	10
None	0
P_{ET}=	0

Erosion Activity / Systemic Threat	Multiplier, C_{EA}
Aggressive Erosion	3
Non-Aggressive Erosion	2
None	0
C_{EA}=	0

	0
	0
B = P_{ET} * C_{EA}	0

Open Channel and Surface Erosion

Water Quality

Projects primarily intended for water quality typically will not incorporate flooding impact benefits; though may incorporate stream stability benefits.

Water Quality Benefits	Points, P_{WQ}
Enhance / Preserve Natural Resource Areas (Lake, Wetlands, etc.)	60
Regulatory Compliance / Stormwater Permit / NPDES	60
Create New Natural Resource Areas (Lakes, Wetlands, etc.)	50
Conservation / Prevention	30
Water Quality benefit due to Flood Control or Stream Stability Project	20
None	0
P_{WQ}=	60

Project Benefit		Multiplier, C_{WB}
Major Water Quality Benefit	Broad-Based Impacts	4
Minor Water Quality Benefit	Localized Impacts	3
None		0
	C_{WB}=	3

	60
	3
C = P_{WQ} * C_{WB}	180

Water Quality, Wetlands, Natural Habitat

Safety Factor

Public Health and Safety		Points, P_{SF}
High Risk	Potential Loss of Life or Bodily Injury	160
Low Risk	Public Nuisance	60
No Risk		0
	P_{SF}=	60

D = P_{SF} 60

Public Health and Safety

Prioritization Ranking Summary

X = A + B + C + D 240

Miscellaneous Factors may be used to adjust scoring:

P_{MISC} (See attached worksheet for description of miscellaneous items) 10

May Include: Project Location, Coincident Projects, Development Status, etc.

P_{AC}, Additional Considerations (may be used to add or subtract up to 60 points) 0

May Include: Legal Issues, Jurisdictional Coordination, Complaints, Outside Funding Sources, Wildlife Benefits, etc.

TOTAL = ***X*** + P_{MISC} + P_{AC} 250

TOTAL for PROJECT CB-1 ***250***

Project Location, Development Status, Coincident Projects, Condition / Maintenance, Downstream Impacts, Source Reduction, Additional Considerations

Comments or Description of Additional Considerations:

The separator would be installed within the existing 60-inch storm pipe located at the intersection of Vine Street and Cotner Street. Small storm events are diverted from the existing pipe into the hydrodynamic separator, which uses a vortex to settle out particulate matter. The separator allows larger flow volumes to bypass the treatment.

MISCELLANEOUS FACTORS - DRAFT

		Points Available	Points Assigned
Location	Public Property or willing owner of Private Property	up to 20	0
Coincident with Adjacent Projects	Public Projects (water, sanitary, roads, etc.)	up to 20	0
	Private Projects	up to 10	0
Development Status	Tier I, Priority A	20	
(Points available are fixed, and are not flexible)	Tier I, Priority B	15	
	Tier I, Priority C	10	
	Existing City Limits	10	10
Projects primarily intended to address structura	Tier II (development 25 - 50 years)	5	
	Tier III (development > 50 years)	0	

Tier I, Priority A - Areas designated for near term development are generally contiguous to existing development and should be provided first with basic infrastructure within 6 years of the adoption of the Plan. Some of the infrastructure required for development may already be in place. This area includes some land already annexed, with City commitments to fund infrastructure improvements, but the land is still undeveloped and without significant infrastructure in place yet. Some infrastructure improvements may be done in the near term while others, such as road improvements that are generally more costly, may take longer to complete.

Tier I, Priority B - The next areas for development, beyond Priority A, are those which currently lack almost all of the infrastructure required to support development. In areas with this designation, the community will maintain present uses until urban development can commence. Infrastructure improvements to serve this area will not initially be included in the City's CIP, but will be actively planned for in the longer term capital improvement planning of the various city and county departments.

Tier I, Priority C - This is the later phase of development areas and is intended to be served after Priority A and B. Given current growth rates and infrastructure financing, development would not begin in this area until after 2020 or 2025.

Total Miscellaneous Points, P_{MISC} = 10

Prioritization Ranking for Watershed Master Plan Projects - DRAFT

City of Lincoln, Nebraska

Prepared By:	CDM	Date:	12/6/07
Project ID:	Project 13	Watershed:	**Deadmans Run**
Project Location:	Herbert Park Stream Stabilization		
Project Description:	Construct grade controls near the pedestrian bridge, grade controls along the tributary length and within the concrete channels, a riprap stilling basin by the second pedestrian bridge, a composite revetment downstream of the bridge, and installing vegetated riprap by the concrete junctions.		

Issues Addressed:

Flooding Impacts

Projects primarily intended to address structural or non-structural flooding will always incorporate a high or low risk safety factor; though typically will not incorporate stream stability or water quality benefits.

Flooding Benefits		Points, P_{FD}
Major Structural Flooding Damage		30
Minor Structural Flooding Damage		20
Non-Structural Flooding	Streets / ROW, Other	15
Conservation / Prevention	Easements / Acquisitions	10
None		0
	P_{FD}=	0

Flooding Frequency		Multiplier, C_{FF}
Frequent Flooding	More frequent than 10-year storm	4
Infrequent Flooding	Less frequent than 10-year storm	2
None		0
	C_{FF}=	0

	0
	0
A = P_{FD} * C_{FF}	0

Structural and Non-Structural Flooding

Stream Stability

Projects primarily intended for stream stability typically will not incorporate flooding impact benefits; though will incorporate water quality benefits.

Stream Stability Benefit	Points, P_{ET}
Channel Erosion Threatening to Structures	50
Channel Erosion Threatening to Public Infrastructure	40
Channel Erosion Threatening to Natural Resources	35
Conservation / Prevention	10
Stream Stability benefit due to Flood Control or Water Quality Project	10
None	0
P_{ET}=	35

Erosion Activity / Systemic Threat	Multiplier, C_{EA}
Aggressive Erosion	3
Non-Aggressive Erosion	2
None	0
C_{EA}=	3

	35
	3
B = P_{ET} * C_{EA}	105

Open Channel and Surface Erosion

Water Quality

Projects primarily intended for water quality typically will not incorporate flooding impact benefits; though may incorporate stream stability benefits.

Water Quality Benefits	Points, P_{WQ}
Enhance / Preserve Natural Resource Areas (Lake, Wetlands, etc.)	60
Regulatory Compliance / Stormwater Permit / NPDES	60
Create New Natural Resource Areas (Lakes, Wetlands, etc.)	50
Conservation / Prevention	30
Water Quality benefit due to Flood Control or Stream Stability Project	20
None	0
P_{WQ}=	20

Project Benefit		Multiplier, C_{WB}
Major Water Quality Benefit	Broad-Based Impacts	4
Minor Water Quality Benefit	Localized Impacts	3
None		0
	C_{WB}=	3

	20
	3
C = P_{WQ} * C_{WB}	60

Water Quality, Wetlands, Natural Habitat

Safety Factor

Public Health and Safety		Points, P_{SF}
High Risk	Potential Loss of Life or Bodily Injury	160
Low Risk	Public Nuisance	60
No Risk		0
	P_{SF}=	60

D = P_{SF} 60

Public Health and Safety

Prioritization Ranking Summary

X = A + B + C + D 225

Miscellaneous Factors may be used to adjust scoring:

P_{MISC} (See attached worksheet for description of miscellaneous items) 30

May Include: Project Location, Coincident Projects, Development Status, etc.

P_{AC}, Additional Considerations (may be used to add or subtract up to 60 points) 0

May Include: Legal Issues, Jurisdictional Coordination, Complaints, Outside Funding Sources, Wildlife Benefits, etc.

TOTAL = ***X*** + P_{MISC} + P_{AC} 255

TOTAL for PROJECT CB-1 ***255***

Project Location, Development Status, Coincident Projects, Condition / Maintenance, Downstream Impacts, Source Reduction, Additional Considerations

Comments or Description of Additional Considerations:

MISCELLANEOUS FACTORS - DRAFT

		Points Available	Points Assigned
Location	Public Property or willing owner of Private Property	up to 20	20
Coincident with Adjacent Projects	Public Projects (water, sanitary, roads, etc.)	up to 20	0
	Private Projects	up to 10	0
Development Status	Tier I, Priority A	20	
(Points available are fixed, and are not flexible)	Tier I, Priority B	15	
	Tier I, Priority C	10	
	Existing City Limits	10	10
Projects primarily intended to address structura	Tier II (development 25 - 50 years)	5	
	Tier III (development > 50 years)	0	

Tier I, Priority A - Areas designated for near term development are generally contiguous to existing development and should be provided first with basic infrastructure within 6 years of the adoption of the Plan. Some of the infrastructure required for development may already be in place. This area includes some land already annexed, with City commitments to fund infrastructure improvements, but the land is still undeveloped and without significant infrastructure in place yet. Some infrastructure improvements may be done in the near term while others, such as road improvements that are generally more costly, may take longer to complete.

Tier I, Priority B - The next areas for development, beyond Priority A, are those which currently lack almost all of the infrastructure required to support development. In areas with this designation, the community will maintain present uses until urban development can commence. Infrastructure improvements to serve this area will not initially be included in the City's CIP, but will be actively planned for in the longer term capital improvement planning of the various city and county departments.

Tier I, Priority C - This is the later phase of development areas and is intended to be served after Priority A and B. Given current growth rates and infrastructure financing, development would not begin in this area until after 2020 or 2025.

Total Miscellaneous Points, P_{MISC} = 30