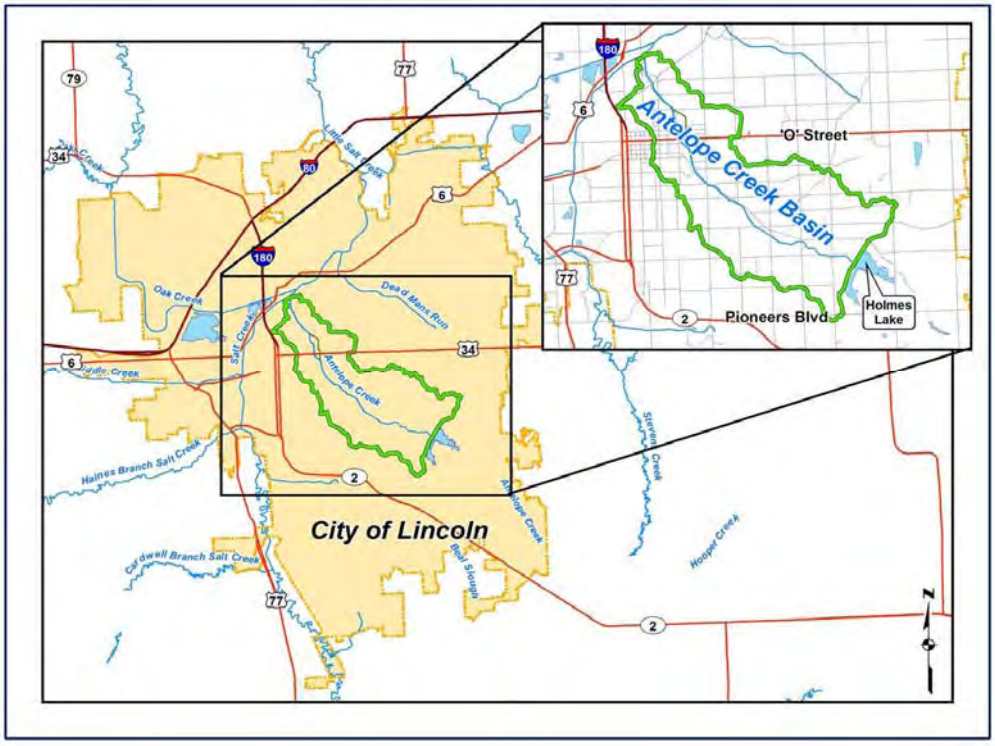
# EXECUTIVE SUMMARY

## Introduction

The City of Lincoln (City) and Lower Platte South Natural Resources District (LPSNRD) have continued efforts towards developing Comprehensive Watershed Management Plans for the City of Lincoln and future growth areas with the establishment of the Antelope Creek Watershed Basin Management Plan (Basin Plan). The focus of the Basin Plan is improving water quality as compared to past Basin Plans that provided information primarily for flood control and stream degradation projects. The Basin Plan addresses improvement of water quality in a stretch of Antelope Creek that is highly urbanized in the center of Lincoln, Nebraska. The Basin Plan only includes the portion of the Antelope Creek watershed downstream of Holmes Lake (see Figure ES-1).

**Figure ES-1: Antelope Creek Location Map**




Previously adopted Watershed Master Plans include:

- Beal Slough (2000)
- Southeast Upper Salt Creek (2003)
- Stevens Creek (2005)
- Cardwell Branch (2007)
- Deadmans Run (2007)
- Little Salt Creek (2009)

The Basin Plan boundary totals 4,932 acres, from Antelope Creek's confluence with Salt Creek near the Devaney Sports Center, southeast to Holmes Lake. The watershed includes approximately 7.7 square miles— 5.7 miles of stream with a maximum width of 2 miles, and maximum length of 5 miles.

The City and LPSNRD worked with a team of scientists and engineers during plan development from May 2010 through March 2012. The team was led by EA Engineering, Science, and Technology, Inc. (EA) located in Lincoln, NE. EA worked in cooperation with JEO Consulting Group (JEO) of Lincoln, NE, Wright Water Engineers (WWE) of Denver, CO, and a nationally recognized water quality expert, Dr. Robert Pitt, from the University of Alabama.

In 2007, the Nebraska Department of Environmental Quality (NDEQ) and the United States Environmental Protection Agency (EPA) listed this stretch of Antelope Creek as being impaired due to elevated levels of ammonia and the bacterium *Escherichia coli (E. coli)*. *E. coli* bacteria are commonly found in the intestines of animals and

humans and serve as an indicator of fecal contamination. Antelope Creek was determined to be a Category 5 water body and was listed on EPA's Clean Water Act Section 303(d) list of impaired waters. In response, NDEQ developed a Total Maximum Daily Load (TMDL) in 2007 for Antelope Creek, in order to set goals for pollution reduction levels necessary to remove Antelope Creek from the 303(d) list.

The primary goal of this Basin Plan is to identify sources of pollution, provide alternatives to reduce pollutant loads below EPA criteria, and to provide information to aid in removing this segment from the 303(d) list. Secondary goals include educating the public about water quality, and applying lessons learned from the Basin Plan to other basins within Lincoln, NE and future growth areas.

Although reducing concentrations of *E. coli* in Antelope Creek is a primary focus, the Basin Plan was written comprehensively to address both non-point and point sources and other contaminants found in the Creek. A community-based planning process was used which emphasized public involvement. In addition, the Basin Plan was written with a focus on EPA's Nine Elements of watershed planning.

## Public Involvement

The City and LPSNRD emphasized public participation and education as key aspects of the Basin Plan. A public involvement strategy was established so that citizens could participate in public decisions that might affect them, their property, and their interests. Public involvement was also included due to the importance of educating the public on stormwater best management practices (BMPs) and their use by the City as well as by residential landowners. The public involvement process included the following:

- **Advisory Council** – A 12-member group was appointed by the Mayor and is displayed in Table ES-1. The group members' roles and responsibilities included reviewing elements of the Basin Plan, asking questions, raising issues, and sharing information with one another, the public, and the team. The team facilitated three Advisory Council meetings.
- **Core Work Group** – An eight member, technically-based group, including the City of Lincoln Parks and Recreation, Planning, and Public Works, the LPSNRD, and the NDEQ, was established at the beginning of the project to provide technical direction for Basin Plan development. The project team facilitated 11 core work group meetings.
- **Open Houses** – Two open houses were conducted, one in September 2010 and a second in December 2011. Post card invites were sent to 11,000 landowners in the Basin Plan area.
- **Stakeholder Meetings** – Presentations were conducted for multiple stakeholders, including the University of Nebraska–Lincoln (UNL), Witherbee Neighborhood Association (NA), Colonial Hills NA, Homebuilders Association of Lincoln, 40th and A Street NA, and the Lincoln Children's Zoo.
- **Watershed News** – Four newsletters providing information on the Basin Plan development and public education were distributed through mailing to 1,100 key stakeholders in Lincoln.


**Picture 1: JB Dixon answers questions at Open House #1**

- **City Website** – The City's website provided plan information and announcements, and made materials such as the newsletter available to the public.

Public involvement and input from the Advisory Council, open houses, Core Work Group, and stakeholder meetings were used by the project team during establishment of strategies in the Basin Plan.

**Table ES-1. Basin Plan Advisory Council**

| Representing | Name |
|---|---|
| Non-profit | Mike Renken, NeighborWorks |
| Lincoln Public Schools | Scott Wieskamp, Facilities & Management |
| Business Group | Andrew Campbell, Campbell's Nursery |
| Business Group | Steve Hill, Assurity |
| University of Nebraska – Lincoln | Jennifer Dam, Campus Planning |
| Lincoln Golf Courses | Dale Hardy, Administrator |
| Lincoln Children's Zoo | John Chapo, President |
| Neighborhood Group | Tracy Corr, 40th and A Street |
| Neighborhood Group | Bob Kuzelka, Near South |
| University of Nebraska – Lincoln | Rachel Herpel, Water Center |
| LPSNRD | Karen Amen, Board Director |
| City of Lincoln | Adam Hornung, City Council |

## Basin Plan Elements

The Basin Plan preparation included several key elements that enabled the project team to review existing information, collect field data, model the watershed, screen potential project locations, conceptualize and prioritize projects, and formulate an implementation strategy. Summaries of each significant Basin Plan element are provided below:

**Picture 2: Antelope Creek Open House #1**

### Basin Inventory

- Completed an inventory to identify critical areas within the watershed with potential to be pollutant sources.
- Completed a bridge inventory to identify locations where animals can directly contribute to pollutant loads within Antelope Creek.

### TMDL Assessment

- Assessed the TMDL requirements for Antelope Creek and the data set used to develop the TMDL.

### Water Quality Monitoring

- Conducted a visual inspection of dry weather flows contributing to Antelope Creek to identify potential point sources by walking the creek bed and observing more than 220 outfalls.
- Developed and implemented a water quality monitoring program to characterize pollutant distribution in the surface water and sediments.

**Source Loading and Management Model for Windows (WinSLAMM)**

- Utilized WinSLAMM to evaluate stormwater pollutant loadings specific to storm hydrology and land use conditions in the Basin Plan area.
- Completed a detailed land use inventory of specific locations in the watershed to calibrate WinSLAMM.
- Utilized WinSLAMM to evaluate alternative Best Management Plans (BMPs) throughout the watershed to analyze the effectiveness of different combinations of BMPs.

**Best Management Practices (BMPs)**

- Conducted a field screening and desktop review of more than 50 sites throughout the watershed to identify potential sites for water quality BMPs.
- Ranked and selected sites in the watershed based upon watershed specific selection criteria to identify the most feasible project locations.
- Conceptualized 13 structural BMP projects, including description, cost, water quality benefits, and pollutant loading estimates.
- Established more than 20 non-structural recommendations including expansion of existing programs and consideration of new programs.

**Implementation Strategy**

- Developed a long-term implementation strategy to improve water quality in Antelope Creek.

## Summary of Findings

The TMDL regulatory driver set by NDEQ, as mandated by the EPA, requires that Antelope Creek attain water quality standards of a full body contact recreational stream during the months of May through September. The two regulated pollutants listed in the 2007 TMDL are ammonia and *E. coli* bacteria. The TMDL also identifies other "pollutants of concern" for the stream, including conductivity, selenium, and chloride. Currently, no TMDL has been developed for these pollutants for Antelope Creek. The activities conducted in preparation of this Basin Plan allowed the Project Team to successfully identify sources of the pollutants, define the magnitude of the problem, and develop Basin Plan recommendations to address the problem. Below is a summary of the Basin Plan findings.

1. **Antelope Creek does not attain the TMDL standard for *E. coli* bacteria.** The *E. coli* standard for the stream established by the EPA is 126 colony-forming units per 100 milliliters (cfu/100 mL) during both dry and wet weather conditions. The recreation season geometric mean concentration of *E. coli* at the confluence with Salt Creek measured by NDEQ in 2004 used to develop the TMDL was 3,433 cfu/100 mL. The 2007 TMDL lists 113 cfu/100 mL as the reduction goal for Antelope Creek. The recreation season geometric mean concentration of *E. coli* at the confluence with Salt Creek measured during the 2010-2011 sampling activities as part of the Basin Plan was 1,511 cfu/100 mL. The project team used the 1,511 cfu/100 mL level in development of the Basin Plan recommendations. This means that a 93% reduction in the *E. coli* pollutant load to Antelope Creek will be necessary to meet the recreational stream standards and TMDL goal at the confluence with Salt Creek.
2. **Other pollutants found in Antelope Creek are not as great of a concern as *E. coli*.** With the exceptions of *E. coli*, conductivity, chloride and selenium, Antelope Creek currently attains all other stream standards assigned to the stream by NDEQ. Based on sampling activities conducted as part of this Plan, ammonia is no longer present in the stream at levels exceeding the current TMDL. Conductivity, selenium, and chloride are currently only listed as pollutants of concern and do not have TMDLs. Groundwater inflows to the stream are expected to be the source of chloride, conductivity, and selenium in the lower portion of Antelope Creek, and are most likely naturally occurring.
3. ***E. coli* bacteria are likely from a diffuse source such as urban wildlife and potentially also from domestic pets.** Pollution sources within a watershed

**Picture 3: Antelope Creek near Jim Ager Golf Course**

are generally divided into two categories; point sources and non-point sources. Point sources consist of a single site or location from which pollution occurs such as a sewer main break, or a facility discharging pollutants directly into the watershed. Non-point sources are background sources of pollutants that are spread throughout a watershed (*i.e*., wildlife, domestic pets, fertilizers, and urban stormwater runoff that collects bacteria from rooftops or gutters). Sampling of stormwater outfalls to the stream indicated the *E. coli* bacteria source is a non-point source mainly from urban wildlife (*e.g.,* pigeons, raccoons), and potentially from domestic pets. The background level of bacteria naturally occurring in the watershed is unknown. It should be noted that other local urban and rural streams also exhibit high levels of *E. coli*.

4. **Achieving the TMDL standard for *E. coli* will be difficult, costly, and require a long term systematic approach.** Due to the relatively ubiquitous and diffuse nature of such background level pollutants, it is impractical to remove all sources (wildlife and pets), and it is also impractical to treat the entire watershed at the lower end in a similar manner to how wastewater is treated. The diffuse nature of the sources of *E. coli*, will make meeting the standard difficult and costly, and will require a long-term, systematic approach. The estimate of total cost to implement best management practices (BMPs) and projects in the watershed that will achieve the EPA standard for *E. coli* will be approximately $57 million over the 40-year life of this plan. From a regulatory perspective, it is important for the City to proactively implement measures that may help to incrementally reduce *E. coli* loads to the stream.

5. **For the Antelope Creek Basin, the most effective pollution control strategies for diffuse sources of *E. coli* are source controls, stormwater surface runoff volume reduction, and infiltration BMPs.** Source controls, or non-structural BMPs, reduce the source of the pollutant rather than treating the pollutant through a structural BMP. Source controls are usually low-cost and are typically the responsibility of the resident or property owner to implement (*i.e.,* Low/No-phosphorus fertilizers and picking up pet waste). BMPs that achieve stormwater runoff volume reduction ultimately reduce the volume of surface water reaching Antelope Creek, thus reducing the pollutant load. Infiltration BMPs treat stormwater runoff and capture pollutants prior to reaching Antelope Creek.

6. **The levels of pollutants found in Antelope Creek are typical of other urban streams found throughout the United States.** In-stream monitoring of Antelope Creek in 2010 and 2011, and a review of existing water quality data have shown that the problems of Antelope Creek are not unique as compared to other urban streams.

## Summary of Recommendations

The ultimate goal of this Basin Plan is to remove Antelope Creek from the Clean Water Act Section 303(d) impaired waters list. Based on the most recent in-stream sampling, this equates to reducing the levels of *E. coli* bacteria in the stream by 93%. Due to the diffuse nature of the pollutant sources within the Antelope Creek watershed and the magnitude of the problem, the process used to achieve this goal could be challenging, costly, and long-term.

### Pollution Control Strategies

Two main types of pollution control strategies are recommended; source controls (non-structural programs) and pollutant treatment practices (structural BMPs).

1) Non-structural source control strategies involve controlling the pollutant source in the watershed as much as possible before it has the chance to be mixed with stormwater and enter Antelope Creek. These strategies might include pet waste removal, wildlife management strategies, and Low/No-phosphorus fertilizer programs.

2) Structural BMPs involve constructing projects throughout the watershed to treat the pollutants within the stormwater before reaching Antelope Creek, or within the creek. These include installation of grass swales using native vegetation, rain gardens, enhancing existing wetlands and small tributaries to increase ponding of stormwater (filtration, infiltration, and water retention), use of hydrodynamic separators, and others.

On a watershed basis non-structural source control strategies are generally more cost-effective than structural controls for treating non-point sources of *E. coli* bacteria. However, non-structural source controls alone may not adequately reduce the *E. coli* levels in Antelope Creek by 93%. Structural BMPs may need to be constructed throughout the watershed to provide the additional pollutant removal capacity needed to meet the water quality goal.

### General Water Quality Recommendations

To improve water quality in the Antelope Creek Watershed the following actions are recommended:

1. Continue enforcing existing City ordinances to control pollutant sources within the Antelope Creek watershed, such as pet waste ordinances and sediment control.
2. Review existing ordinances and target the development of new ordinances based on the pollutants of concern.
3. Develop and implement wildlife control practices in the Antelope Creek watershed, such as retrofits to bridges to limit roosting/nesting, detour geese away from waterways using landscaping techniques (tall grass/shrubs), etc.
4. Continue and expand preventative maintenance and cleaning activities to minimize future pollutant sources, such as sanitary sewer inspections, street sweeping, and in-stream sediment removal.
5. Continue and expand pollution source control and runoff quantity reduction programs, such as public education programs, Low/No-phosphorus fertilizer program, and the rain garden/rain barrel programs.
6. Develop and implement additional pollution source and runoff volume control programs such as a downspout disconnection program and continue yard waste pickup programs.
7. Implement structural stormwater BMP ordinances for BMPs that would treat frequently occurring rainfall events and reduce surface runoff volumes. The BMPs should be designed to target 90% of all rainfall events (1.25 inches and under) if possible. Such stormwater BMPs could be implemented on new development projects and retrofit projects. There also could be opportunities for demonstration projects with the City and/or LPSNRD as funding is available.
8. Evaluate the feasibility of altering release patterns from Holmes Lake to determine whether more frequent "flushing flows" would benefit water quality in Antelope Creek.
9. Evaluate channel modifications throughout Antelope Creek to minimize sedimentation areas and reduce nuisance algae blooms.
10. Evaluate Lincoln's Storm Drainage Criteria Manual to ensure it is up to date. The evaluation can be compared to the 2010 version of the Urban Drainage and Flood Control District (UDFCD) manual, or another comparable national manual.
11. Consider concentration of resources into a priority sub-basin. A concentration of resources, such as developing several projects in a smaller sub-basin, would allow the City to more closely evaluate BMP performance. Focusing on a sub-basin is a more practical approach for a diffuse pollution source and is typical of EPA approved water quality plans.

## Summary of Implementation Plan and Projected Costs

Reducing the pollutant load into Antelope Creek is a complex and challenging effort that will require the City and LPSNRD to acquire outside financial and technical resources. A cost estimate was established in order to quantify potential financial resources necessary to remove Antelope Creek from the impaired waters list and does not reflect any type of commitment of resources by Basin Plan stakeholders.

### Implementation Strategy

The Basin Plan includes a strategy which describes practices to be implemented over the entire watershed for a 40-year period. A total of 8 sub-basins have been identified as a guide for step-by-step implementation to improve water quality overtime. This strategy assumes that projects will be implemented over a 5 year period for each sub-basin. During each phase projects should be evaluated further in regard to water quality, property owner interest, and cost. The implementation strategy includes a process for the City and NRD to follow in order to review progress towards improving water quality using evaluative criteria and monitoring.

### Phase One – Antelope Park Sub-Basin

Phase One of the Basin Plan includes implementation of several non-structural control strategies across the entire Antelope Creek watershed and several structural BMPs within a 630 acre sub-basin. The Phase One sub-basin includes Antelope Park from A Street south to Sheridan Boulevard and the Lincoln Children's Zoo as seen in Figure ES-2.

Although all non-structural BMPs listed in the Basin Plan may be considered, the nine listed below were given higher priority during the planning process and were viewed as being more effective in limiting *E. coli,* sediments, and

nutrient loadings from entering Antelope Creek. The following five non-structural BMP recommendations would be implemented by the City and/or LPSNRD:

1) Retrofitting older bridges and overpasses crossing Antelope Creek to limit bird activity
2) Sanitary Sewer Line Inspection Program Expansion
3) Dry Weather Storm Drainage Screening
4) Enforcement of existing pet waste ordinances
5) Supplying and maintaining additional pet waste containers

The following four non-structural BMPs listed below would be implemented by residents and property owners through programs offered by the City and/or LPSNRD.

1) Low/No-phosphorus fertilizer program
2) Rooftop disconnection incentive program
3) Rain garden program
4) Rain barrel program

In total, 14 demonstrative structural BMPs have been identified to treat stormwater and remove pollutants from Antelope Creek. Five of these 14 structural water quality BMPs have been recommended as part of the Phase One implementation. The location of these proposed projects can be found in Figure ES-3.

To ensure success of both non-structural and structural BMPs, the City and LPSNRD could work together to provide educational opportunities and community outreach to residents and property owners throughout the Basin Plan area. Phase One would conclude with monitoring of water quality at the confluence with Salt Creek to assess the effectiveness of implemented strategies.

The total estimated cost of Phase One is $1.7 million over a 5-year period. Cost estimates are based upon preliminary engineering estimates, a review of City program cost, and several cost assumptions listed in the Basin Plan. Implementations of Phase One actions are dependent upon availability of funding resources and cost share from State/Federal resources and willingness of residents and property owners to participate in non-structural programs. Table ES-2 below displays cost estimates for the structural BMP projects as well as the estimated cost for implementation of non-structural programs as part of Phase One.

**Table ES-2. Phase One Antelope Creek Basin Implementation Plan**

| Basin Plan Watershed | Project Cost |
|---|---|
| **Phase One: Structural BMPs** | |
| P01: Antelope Park: Van Dorn St to Sheridan Blvd | $125,000 |
| P02: Antelope Park: South St to Van Dorn St | $125,000 |
| P03: Antelope Park: SW of 33rd and South St | $125,000 |
| P04: Antelope Park: A Street to South Street | $250,000 |
| P06: Lincoln Children's Zoo | $425,000 |
| **Sub-total** | **$1.1 million** |
| **Phase One: Non-Structural BMPs** | |
| Basin-wide Non-structural Programs | $550,000 |
| **Phase One: Review, Monitoring, plan revision** | $50,000 |
| **Grand Total** | **$1.7 million** |

**Additional Implementation Phases**

It is estimated that all phases would cost approximately $57 million which may be necessary to eventually meet existing regulatory criteria for *E. coli* in Antelope Creek. This cost estimate was established using information in the Source Loading and Management Model for Windows (WinSLAMM), Phase One cost estimates, and historical and current non-structural programs cost. This estimate far exceeds available funding, therefore it is recommended that the City and LPSNRD continue a phased approach, implementing the most cost effective practices in the early years and continuing to evaluate and implement additional practices over a 40-year period. In Phases 2-8 additional

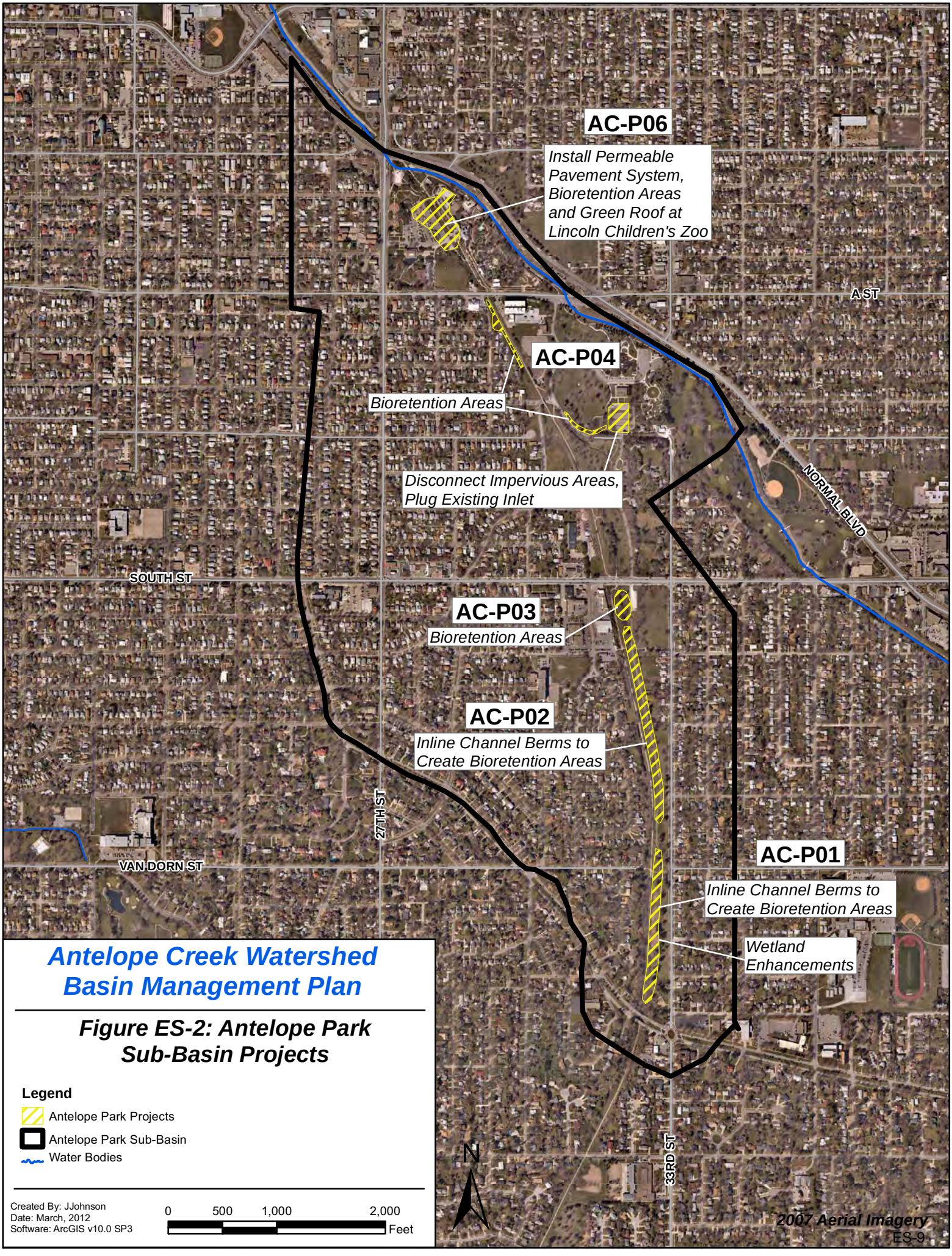
structural water quality improvement projects will be considered for construction within the Antelope Creek watershed.

**Conclusion**

The project team understands that financial expenditures of this magnitude, to consistently meet the EPA criteria in a recreational stream segment within an urbanized watershed, are somewhat impractical as compared to existing financial resources available. Plan reviews could potentially have large effects on the overall cost estimate based upon the effectiveness of the Phase One project and program implementation. Funding assistance from Federal, state, and local sources are anticipated to be available to provide assistance with funding during implementation of the Basin Plan.

Although the goal of this Basin Plan is to remove Antelope Creek from the impaired waters list, the structural and non-structural BMPs recommended have multiple benefits. These include, but are not limited to: reduction of a wide range of other pollutants, reduced stormwater runoff volume, reduced landscape maintenance, increased stream stability, reduced infrastructure cost downstream, recharging groundwater levels, aesthetics, educational opportunities, increasing the overall health of Antelope Creek, and improving public safety, health, and welfare for Lincoln citizens and visitors.

Together, the City, LPSNRD and Lincoln citizens can work proactively to reduce *E. coli* loads to the stream and implement strategies outlined in the Basin Plan. Successful implementation of strategies outlined in the Basin Plan will allow the City to begin working towards water quality improvements in Antelope Creek as well as other basins in the City.




# Antelope Creek Watershed Basin Management Plan

## Figure ES-2: Antelope Park Sub-Basin Projects

**Legend**

- Antelope Park Projects
- Antelope Park Sub-Basin
- Water Bodies

Created By: JJohnson
Date: March, 2012
Software: ArcGIS v10.0 SP3

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