Section 3
Water Quality Assessment

3.1 Introduction

A water quality assessment was conducted to document and evaluate the natural resources within the study area, with the goal of developing a watershed management strategy that protects and enhances the natural stream system as development continues in the watershed. The water quality assessment included four major components:

- Review of the draft study, *An Assessment of the Hydrology, Fluvial Geomorphology, and Stream Ecology in the Cardwell Branch Watershed, Nebraska,* completed by USGS in April 2006.
- A natural resource assessment to identify critical, unique, endangered, sensitive, or the best available natural resources worthy of protection or preservation
- A stream asset inventory (SAI) to record and categorize the relative condition of the streams
- Identification of connections of habitat corridors with the stream corridor and the opportunity to preserve nodes of habitat along the connections
- Recommendation of watershed management practices to protect or enhance the natural resources, preserve water quality, and maintain or improve stream stability

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

3.2 USGS Stream-Ecology Assessment

The draft study completed by USGS in April 2006 was reviewed before conducting the natural resource assessment of the main stem and south tributary. The USGS study included a stream ecology assessment to characterize the stream chemistry, aquatic habitat, and aquatic biota. Nine water quality samples were collected between August 2003 and November 2004 at the selected monitoring site located at the South 1st Street bridge. In addition, specific aquatic data were collected on August 26, 2003. The monitoring site extended across the main stem of Cardwell Branch. The key conclusions presented in the draft USGS report with regards to the stream-ecology, included:

- Degraded aquatic communities were observed at the monitoring site. In general, the USGS report indicated that fish species were under-nourished, and a lack of species diversity, water quality (particularly low dissolved oxygen [DO] concentrations), and generally low streamflow at the time of the sampling event characterize the degraded condition of the stream.
- Fish specimens collected during the sampling period were generally under-nourished and unhealthy, indicating a lack of nutrient availability and poor water quality (warm temperature and low DO).

- Aquatic invertebrates (insects) demonstrated a general lack of diversity richness, particularly sensitive species such as stoneflies, mayflies, and caddisflies. The majority of insects present were of the order Diptera, including midges, mosquitoes, gnats, and flies. The majority of aquatic invertebrates sampled are typically pollution tolerant.

- Assessment of the algal community present in Caldwell Branch indicated that primarily pollution-tolerant diatom and nondiatom species were dominant. One factor affecting the algal community is a lack of available light, which is limited by a preponderance of overhanging woody debris and vegetation.

- Generally, a lack of available habitat may be contributing to the unhealthy aquatic community structure observed at the monitoring site. The report indicates that low streamflows and DO levels may be reducing the amount of habitat available to aquatic communities, even with the presence of ample substrate.

- Changes in the stream morphology including incising, naturally developing grade controls from log jams and beaver dams, and aggradation of sediments could return the stream to pre-disturbed conditions.

3.3 Methodology

The methodology used for the natural resource assessment and SAI analysis, and the rationale for stream protection and enhancement recommendations are summarized below. For additional details regarding the natural resource assessment and SAI analysis, refer to *Technical Memorandum Summarizing Results of the Natural Resource Assessment at Cardwell Branch*, August 8, 2006, completed by AES, which was submitted under separate cover.

3.3.1 Natural Resource Assessment

The natural resource assessment included classification, grading, and mapping of the plant communities; selection of habitat corridors; and identification of green spaces.

Classification

During field work conducted in May 2006, the plant communities and land uses were documented and characterized by vegetative type, species composition, and quality. Characterization of the plant communities involved noting the dominants in each stratum, general species composition, presence of invasive species, and any other pertinent information that may prove helpful in the natural resource assessment. Percent cover and composition of each plant community varies depending on such factors as type of disturbance, time since last disturbance, management history, hydrologic regime, and topography. The vegetative survey was restricted to land adjacent to the main channel of Cardwell Branch and its major south tributary and associated riparian corridors.

Grading

Plant communities were assigned an ecological condition rank of higher quality, moderate quality, or lower quality according to degree of degradation. Cultural land cover types and open water features were not ranked. The grading of plant communities is described on the following page:

- **Higher Quality** - Dominants are native species, trees are older in age, species composition is diverse, and riparian buffers are wide.

- **Moderate Quality** - Dominants are mostly composed of native species, trees are varied in age, species composition is less diverse than higher quality, and buffers are moderate in width.

- **Lower Quality** - Dominants are typically a mix of native and non-native species, trees are younger in age, species composition has limited diversity, and corridors are narrow.

Plant communities located outside of the study area but within the Cardwell Branch watershed (e.g., minor tributaries to Cardwell Branch) were assigned a low quality ranking given their small size and likelihood of being affected by invasive species. Based on the project team's experience and as documented in the literature, smaller plant communities in an agricultural context are going to be very disturbed and lack the diversity and native species composition to be ranked higher in quality. In addition, the smaller the plant community, the larger the perimeter is to actual size, which greatly increases the chance for invasive species proliferation – native and otherwise. The grading of the plant communities was conducted in conjunction with the terrestrial habitat scoring of the SAI analysis (Sampling Protocol, Section 3.3.2) for comparison and quality control purposes since the natural resource assessment methods are qualitative in nature, while those of the SAI are more quantitative in nature.

This grading system is only applicable to this watershed since the plant communities are ranked relative to other plant communities observed in the two stream channels in the study area. Even though plant communities outside of the Cardwell Branch watershed may be, in general, similar to the plant communities in the study area, these communities within the Cardwell Branch watershed are "unique" to this watershed given its land use history and hydrology. Consequently, comparing plant communities within the Cardwell Branch watershed to those outside of the watershed would be misleading for the purposes of this study.

Mapping

Plant communities observed in the field were mapped based on field notes, hand-drawn boundaries, and vegetative signatures on aerial photographs. Natural features located outside of the study area were mapped by vegetative signatures. Those areas that were difficult to determine by composition or type were grouped based on local knowledge of the region and best professional judgment. Boundaries were digitized to create a GIS shapefile representing vegetation community boundaries.

3.3.2 Stream Asset Inventory

The SAI procedure used for the study area was developed by AES and other firms for use in the Kansas City region (Tetra Tech et al. 2001). The protocol incorporates the best components of a number of widely used stream and habitat assessments. The SAI methodology provides quick and scientifically defensible indicators of water quality, stream stability, and habitat conditions at any given location selected as representative of a stream reach. Assessment parameters include bed and bank composition, erosion indicators, aquatic habitat and quality, and canopy and understory composition and cover. These parameters are assigned weighted scores used to generate an overall score of stream quality at each survey point and a relative ranking of stream quality throughout the watershed. Numerous steps are involved in the SAI as explained on the following page.

Sample Locations. Stream reaches were defined by stream size and changes in stream condition, either through natural or manmade means. A reach began where conditions changed from a previous condition upstream or downstream (e.g., riparian vegetative cover, adjacent land use, confluence with another stream, or a road crossing). Survey locations were selected on most segments or "reaches" to ensure that the baseline conditions within the watershed were accurately characterized and sufficiently sampled. Twenty sample locations were selected after review of existing watershed data including aerial photography, topographic maps, and the USGS watershed assessment study (Section 2.2).

Sampling Protocol. An SAI data sheet was completed at each sampling location. Each data sheet has four categories—stream stability, aquatic habitat quality, terrestrial habitat quality, and water quality—each having five scoring components (e.g., terrestrial habitat quality is composed of vegetation width, adjacent land uses, woodland richness, grassland richness, and undesirable vegetation). Each component has a potential maximum score of 10 points for a possible total score of 200 points. By dividing the total score by 20 (or by the number of sampled components), the assessment provides a numerical score ranging from 0 to 10. A score of 10 would be optimal stream conditions, while a score of 0 would mean poor stream conditions. In the northern Midwest, the stream with optimal conditions or the so-called "perfect stream" would be the swale-like stream meandering through a landscape of tall grass prairie where out-of-bank flooding is commonplace and erosion and incision are rare.

Stream Classification. The stream reaches were classified according to five categories ranging from high quality (Type I) through low quality (Type V) based on a statistical distribution of all stream scores for water quality, terrestrial habitat, and stream stability. The definition of each stream type is provided below.

Type I: Highest quality stream typified by nondegraded stream condition (stable banks, pools, and riffles) with higher quality aquatic habitat such as streamflow, biological diversity, and water quality (clarity and temperature).
Type II: Good stream quality with some bank and/or bed degradation, generally good biodiversity and vegetative substrate, good streamflow.
Type III: Generally average stream quality. This would include streambank and/or bed degradation, lower streamflow, poorer water quality, and less diverse biological diversity.
Type IV: Significantly impaired stream quality, low streamflow, generally poor vegetative substrate, and biodiversity.
Type V: Poor stream quality, typified by drastically altered stream conditions such as concrete channels, poor vegetation and/or biological diversity and habitat, little to no streamflow.

These rankings are used to determine which stream reaches are worth preserving (typically Type I and II), those reaches worth restoring (Type III), and those in the worst condition (Type IV and V).

3.3.3 Recommendation Rationale

The methodology and rationale used to generate recommendations for riparian corridor stream improvements, the selection of habitat corridors, and the identification of green space are summarized on the following page.

Riparian Corridor Stream Improvements. Results from the natural resource assessment and the SAI were examined to determine the conditions of the streams and other natural resources in the study area. With this information, recommendations were made on improving degraded reaches of stream due to factors such as stability issues, narrow buffers, poor quality habitat, and invasive species. The focus was on utilizing a suite of corrective measures throughout the riparian corridor for overall improvement of the ecosystem or in selected locations to provide more "bang for the buck" and connect high quality reaches of stream.

Selection of Habitat Corridors. Selection of potential habitat corridors connecting natural resources within and outside the Cardwell Branch watershed was based on the May 2006 field surveys and review of aerial photography of the surrounding region. Linear features (e.g., creeks, ditches, abandoned railroad beds, and utility corridors) and larger tracts of natural resources (i.e., woods, wildlife management areas [WMAs], and parks) were identified within and near the watershed boundaries as potential corridors and habitats to be connected. The utilization of corridors to be used for recreational purposes, such as hiking and biking trails, was also considered.

Identification of Green Space. Green space is set-aside land used for parks, ball fields, and stormwater management practices or areas that preserve woodland, prairie, and wetland habitats. The potential identification of green spaces to protect natural resources and provide recreational opportunities within the study area was the objective of this study.

3.4 Results and Conclusions

The results of the natural resource assessment and SAI analysis are summarized below, followed by the major conclusions of these combined efforts.

3.4.1 Natural Resource Assessment Results

The natural resource assessment did not identify any critical, unique, or endangered natural resources within the study area. The natural resources within the watershed have been severely depleted by the land use practices of the past several decades. Cropland dominates the landscape, and the effects of farming practices are evident throughout the watershed.

Virgin tall grass prairie is limited or nonexistent in the watershed and wooded communities, which have replaced the prairie, and consequently are not old growth, are small in size, and restricted to the riparian corridors in the watershed. Similarly, wetlands found in the study area (and most likely the rest of the watershed) are also restricted to the riparian corridors and are of poorer quality given the extensive impact of land use practices and dominance of invasive species like reed canary grass. Although the plant communities are poorer in quality relative to older, less impacted habitat, they are worth restoring and protecting. The alternative — clear-cutting the vegetation — is more costly and would likely result in further degradation of the Cardwell Branch watershed.

A description of the plant communities and land use, quality of plant communities, and other considerations are summarized on the following pages.

Plant Communities and Land Use

Ten types of plant communities and/or land uses were observed within or adjacent to the riparian corridors in the study area, which include three types of woodlands, reed canary grass wetland, smooth brome upland, weedy field, cropland, planted and virgin tall grass prairie, open water, and developed land. The planted tall grass prairie is often referred to as Conservation Reserve Program (CRP). The plant communities were observed within the riparian corridor while the cultural land covers were found outside of the riparian corridor, except for the native prairie (depicted on Figure 3-1). Canopy cover and composition of each plant community depends on such factors as type and time since last disturbance, management history, hydrologic regime, and topography.

High quality riparian woodland vegetation downstream of SW 12th Street

Quality of Plant Communities

The woodland communities generally had higher ratings given their wider buffers, older age woods, higher relative diversity, and limited prevalence of non-natives. The largest tracts of medium to high quality woodlands are located along the main branch of Cardwell Branch extending from approximately Folsom Road to SW 27th Street, immediately upstream and downstream of SW 27th Street along the south tributary, and a portion of the south tributary located just downstream of Saltillo Road. The approximate locations of the high and medium quality woodland communities are depicted on Figure 3-1.

Two tracts of native prairie were identified within the study area, as shown on Figure 3-1. The first area covers less than 10 acres and is located north of Rokeby Road, west of SW 27th Street, and adjacent to a grass swale that drains to the south tributary. The prairie contains a fairly diverse mix of native grasses and forbs, and is bordered by a hedgerow of wild plum and white mulberry. The native prairie is considered moderate quality (see adjacent photograph) because of its relative high diversity and should be preserved. A higher quality rating was not assigned to this area because of the abundance of smooth brome, the small size of the prairie, and the lack of close native buffers.

Native prairie located north of Rokeby Road

The second area is located south of the Ridgewood Boulevard housing development and east of SW 27th Street, and includes two small areas of land that total over 10 acres. Both native prairie areas have been impacted by the construction of a driveway and small outbuilding, and are currently being pastured to horses. Both native prairie areas contain a

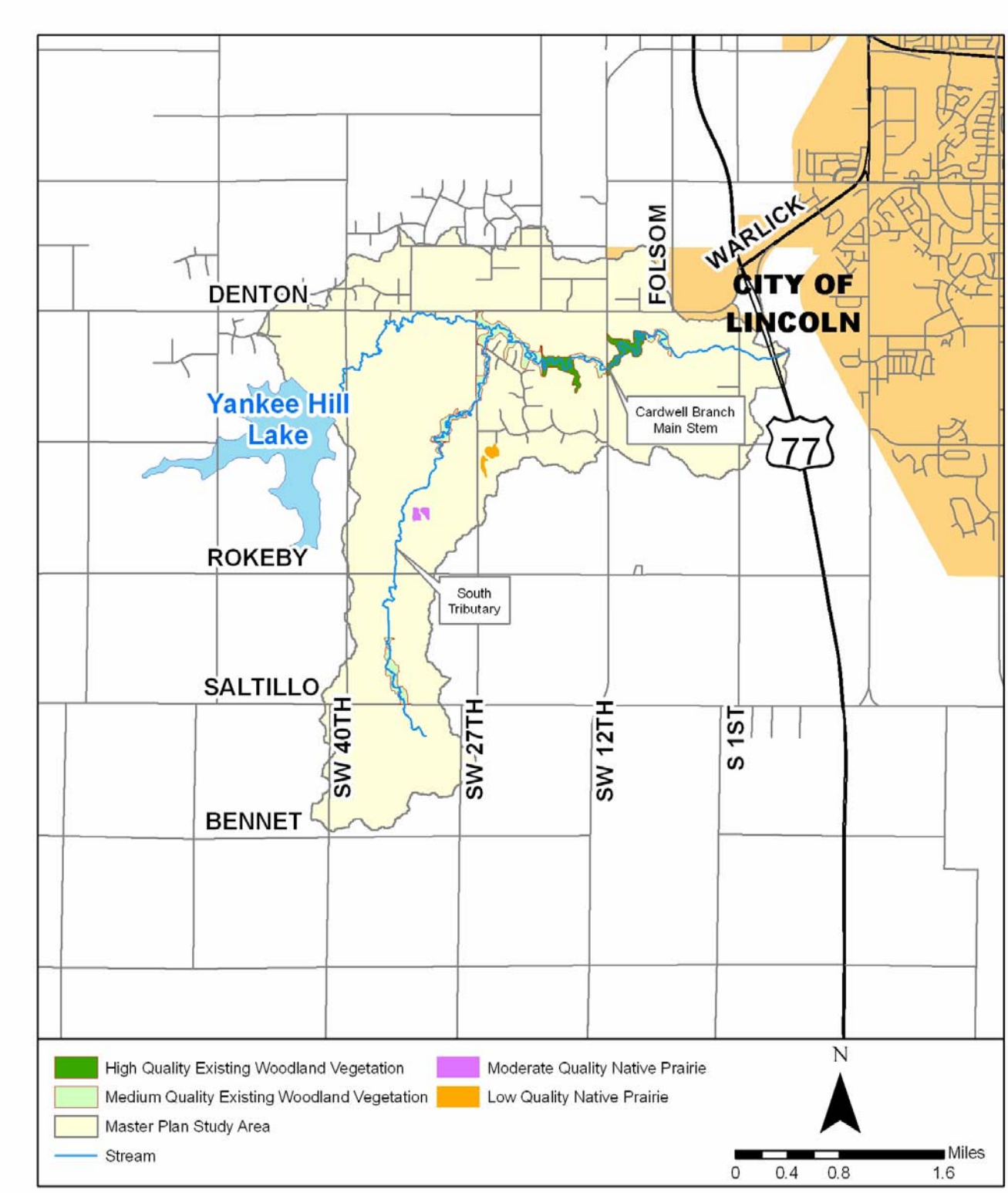

Figure 3-1
Cardwell Branch Existing Woodland Riparian Corridors and Native Prairie

moderate mix of native grasses and forbs and should be preserved. However, these prairie areas were considered low quality because of their moderate diversity, the prevalence of smooth brome, small acreage size, and lack of close native buffers.

High quality riparian woodland vegetation downstream of SW 12th Street

The plant communities not shown on Figure 3-1 (which are along the riparian corridors of the study area) had a low quality rating as a result of anthropomorphic origins (CRP grassland), predominance by non-native invasives (smooth brome grassland and reed canary wetland), and a narrow buffer width (weedy field, smooth brome grassland, and reed canary grassland). Plant communities located outside of the riparian corridors were assigned a low quality ranking given their small size and likelihood of lower diversity, more disturbance, and invasives.

Other Considerations

Non-native invasive plants can have a negative effect on natural plant communities by reducing cover and diversity of native plant species, and as a result, reducing the quality of wildlife habitat and ecosystem and landscape functionality. Consequently, it is important to control these invasives and their spread. Smooth brome and reed canary grass are quite prevalent in the plant communities along the riparian corridors of the watershed. Their removal and replacement with native tall grass, woodland, or wetland species would be a major step in improving the quality of the plant communities on site. With these native species in place, stormwater runoff can be reduced, streambanks can be better stabilized, and habitat can be improved.

3.4.2 Stream Asset Inventory Results

An SAI analysis was performed as part of the field work conducted in May 2006. The following paragraphs summarize the results of this field work.

Using the stream classification system discussed in Section 3.3.2, the stream data indicated three quality rankings or types—II, III, and IV. No highest (Type I) or lowest (Type V) stream quality rankings were generated during the analysis. Figure 3-2 graphically illustrates the stream type of each major channel reach within the study area.

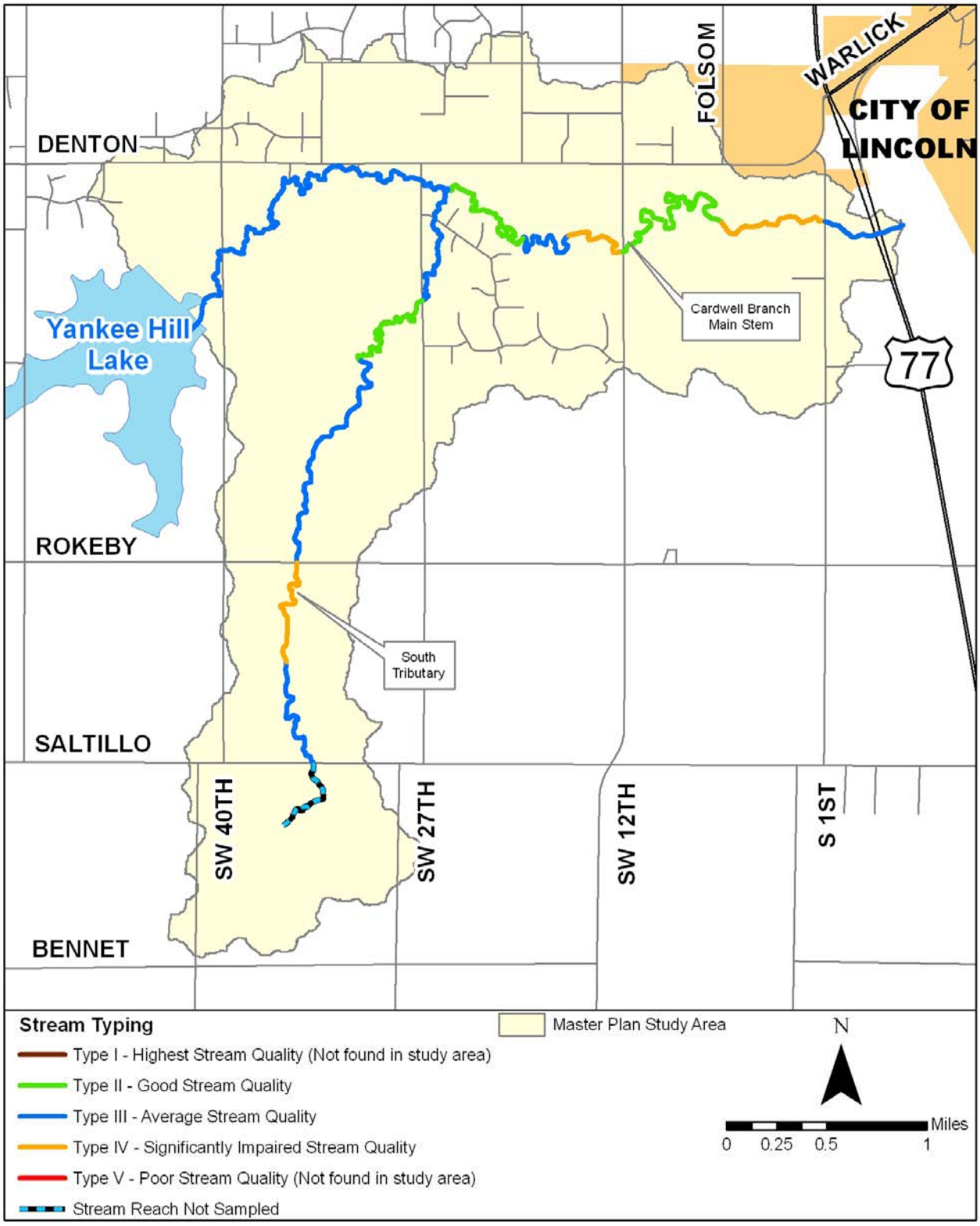

Figure 3-2
Cardwell Branch Stream Quality Rating

The water quality and aquatic habitat components of the analysis had limited influence on the ranking of the higher quality stream reaches since streamflow was nonexistent. Essentially, the higher ranking stream reaches were located in wider woodland buffers, as depicted on Figure 3-1. These wooded corridors were of moderate to higher quality because of intact, ungrazed, diverse vegetation with limited invasives. These stream reaches, due to their wide and intact corridors, are worth preserving.

Type II stream reach located adjacent to the Cardwell Woods residential development

The average rated Type III stream reaches were located in varying habitat and stream channels. The lower rated Type IV stream reaches contained low to moderately stable channels and low to moderate quality habitat. The low to moderate stability in these reaches is due, in part, to the incised channels and numerous erosional features (e.g., toe erosion, bank slump, and incision). The low to moderate quality habitat is due, in general, to the narrower vegetative widths, impacts from adjacent land uses, lower woodland richness, and limited invasive species. Low aquatic habitat scores also contributed to the lower ratings of stream reaches where limited instances of macrohabitat and instream fish and macroinvertebrate cover were observed.

Type III stream reach located downstream of Rokeby Road

Type IV stream reach located upstream of SW 12th Street

3.4.3 Conclusions

The following conclusions are based on the field work, data analysis, and plant and stream ecology:

- Critical, unique, endangered, or high quality natural resources were not observed in the study area, with the exception of two small tracts of native prairie that should be preserved.
- Portions of existing riparian corridor contain medium to high quality woodland habitat that should be preserved.
- The majority of existing riparian corridors has been depleted and needs to be reestablished to improve aquatic and territorial habitat. This finding is consistent with the conclusions presented in the draft USGS report.
- An abundance of invasive plant species such as reed canary grass and smooth brome, which are symptoms of a degraded riparian ecosystem, were observed. Removing these species and replacing them with native wetland and prairie vegetation will improve habitat quality and the overall function of the riparian corridors.
- The riparian corridors can be used for the establishment of trails to provide recreational opportunities by connecting outlying areas (e.g., City of Lincoln, Salt Creek, and Yankee Hill) with the Cardwell Branch watershed. A network of trails can be linked to selected opportunity areas within the watershed, an abandoned railroad track, and other sites.
- Implementation of watershed management strategies such as stream buffers, conservation easements, green space preservation, land use planning, and structural and nonstructural best management practices (BMPs) will help protect the streams from future degradation.

3.5 Watershed Management Recommendations

Based on the conclusions of the natural resource assessment and SAI analysis, the following suite of watershed management strategies is recommended to protect the streams and adjoining riparian corridors as future development occurs:

- Riparian Corridor Enhancements
- Stormwater Management Practices
- Opportunity Area Locations
- Vegetative Maintenance/Restoration/ Protection Efforts
- Habitat Corridors and Connectivity
- Stream Stabilization Measures

Brief overviews of these watershed management strategy recommendations are provided below.

3.5.1 Riparian Corridor Enhancements

One of the key ecological stressors identified during the natural resource assessment was the loss of stream riparian habitat as a result of past land use practices. The City's floodplain standards for new growth areas include a minimum flood corridor that provides a setback distance from the stream that must be preserved in its natural condition. This would include streams draining 150 acres or more and streams draining less than 150 acres with a defined bed and bank. For the Cardwell Branch stream reaches within the City's 3-mile jurisdiction, it

is critical that this ordinance be strictly enforced to preserve the existing medium and high quality woodland riparian habitat as discussed above and shown on Figure 3-1. Outside of the City's 3-mile jurisdiction where this ordinance does not apply, preserving a buffer equivalent to the minimum flood corridor setback distance is still important to provide the opportunity to restore the riparian corridor, which will help reduce runoff, enhance water quality, and improve habitat. A supplemental benefit of the flood corridor is to use it as a filtering mechanism and energy dissipater for point-source discharges. To accomplish this, stormwater outfalls should be located within the riparian buffer rather than discharging directly into the stream.

The approximate minimum flood corridor setback distance was estimated for the stream reaches within the study area using the City's ordinance and is included as part of the GIS deliverables. The setback distance was based on aerial photography and a limited field reconnaissance effort; therefore, this information should only be used as an initial starting point when establishing the final flood corridor width as development continues in the watershed.

3.5.2 Stormwater Management Practices

Stormwater 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

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). In addition, nonstructural measures include requirements to protect the natural resources within a given area. For the Cardwell Branch watershed, the recommended nonstructural BMPs include:

- **Education Program** - A proactive education program focused on water quality issues to educate homeowner associations, private facility owners, engineers, and developers. A series of seminars could be implemented to discuss the methods of pollution reduction and removal, structural BMP and natural stream design methods, and conservation strategies. The topic of each seminar would vary depending on the targeted audience.

- **Erosion and Sediment Control** - The enforcement of the erosion and sediment control provisions as outlined in the *Drainage Criteria Manual* will be an integral component of preserving the aquatic habitat within the streams.

- **Land Development Planning** - A development planning process that includes a detailed assessment of existing natural resources to identify strategies to address unique environmental issues and concerns.

Structural BMPs

Structural BMPs are constructed facilities 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 and are believed to cause the greatest amount of erosion and sediment deposition, which directly impacts the aquatic and riparian habitat. In recent years, a significant amount of research has been conducted that shows a direct measurable relationship between the smaller more frequent runoff events and the long-term erosive impacts to a natural stream channel. A brief overview of this research is described below.

Recent research in urban hydrology and geomorphology indicates the key to providing long-term stream channel stability is to install stormwater facilities that control a full range of hydrologic conditions, including the water quality control volume (WQCV), the channel forming flow (which is commonly between a 1- and 2-year design storm), and the flood events such as the 10- and 100-year design storms (Rohrer and Roesner, in press; Rohrer and Roesner 2006; O'Neill et al. 2006; Rohrer et al. 2005). The WQCV is controlled using structural BMPs sized to entirely capture 70 to 90 percent of all runoff-producing events from a development. Research studies have been conducted in a variety of climate and soil conditions, including study areas in Atlanta, Georgia; Fort Collins, Colorado (Rohrer and Roesner, in press; Rohrer and Roesner 2006); Lenexa, Kansas (Rohrer et al. 2005); and Lincoln, Nebraska (O'Neill et al. 2006), which all have concluded there is a direct measurable relationship between the increased magnitudes and durations of flows from smaller, more frequent runoff events and the erosive impacts to the stream. The major recommendation from all theses studies is that a full range of hydrologic conductions must be controlled to provide long-term stream stability.

In conclusion, as the Cardwell Branch watershed continues to develop, the key to preserving water quality, maintaining long-term stream stability, and providing flood control benefits for new developments is to install stormwater facilities that control the full range of hydrologic conditions, including the smaller rainstorms, and the 2-, 10-, 100-year storm events. Site-specific structural BMPs are recommended to control the smaller rainstorms, with detention basins being used to control the larger rainstorms (2-, 10-, and 100-year design storms). Two implementation approaches are recommended to control the full range of hydrologic conditions, including (1) integrated detention facility, and (2) alternative site design. The paragraphs below describe each approach, followed by a discussion of sensitive areas within the watershed.

Integrated Detention Facility

The integrated detention facility approach is based on upgrading the standards for privately owned and operated detention ponds on each individual development site. The detention ponds would be designed to control not only the 2-, 10-, and 100-year storm events (current City standards) but also to include a structural BMP to provide long-term stream stability and pollutant removal benefits. This integrated facility would provide both quantity and quality benefits.

The integration approach would require detention basins to have staged outlet control structures to control the 2-, 10-, and 100-year design storms and detain the WQCV using a

40-hour drain time. In addition, sediment forebays and energy dissipaters are recommended to capture sediment and reduce the velocity of the stormwater runoff before draining into the pond. This will require changing the City's stormwater ordinances and *Drainage Criteria Manual* from a voluntary to mandatory program for site-specific structural BMPs, which will result in significantly increasing the protection of natural streams and supporting the requirements of U. S. Environmental Protection Agency (EPA) NPDES Stormwater Programs. Appendix G provides additional detail regarding how to implement the integrated detention facility approach.

Alternative Site Design

The design approach described above combines the water quantity (2-, 10-, and 100-year controls) requirements with the water quality component (structural BMP) into a single integrated facility. This integrated approach is one of many design concepts that can be employed to achieve the desired results. The following paragraphs provide other alternative design approaches where the site-specific structural BMP can be separated from the detention basin to achieve the same overall goals and objectives. Appendix G provides additional details regarding how to design site-specific structural BMPs within a given development site.

The structural BMP can be designed to take many different forms including grass swales, bioretention filters, infiltration devices, and constructed wetlands. The site designer has the flexibility of selecting which type of structural BMP best fits the development site layout. The structural BMPs can be easily configured to become an integral part of the development site by supplementing landscape features, park amenities, and passive recreation amenities. When considering alternative site designs, two key design concepts need to be followed: (1) the structural BMP must be placed upstream of the detention basin to properly regulate the smaller rainstorms, and (2) outlet control structures must be designed for both the structural BMP (WQCV released over 40 hours) and the detention basin (2-, 10-, and 100-year).

Another site design approach is to use conservation development practices or low impact development (LID) techniques. The conservation development strategy is focused on preserving and utilizing an area's natural resources for stormwater management, water conservation and water quality protection, streamflow velocity and energy management, and maintaining the natural aesthetic qualities of an area. Conservation development strategies include using techniques in which buildings are clustered to preserve undeveloped natural areas to maximize green space. Strategies may also involve less clustered housing but incorporate native soils and vegetation on private lots to reduce stormwater runoff volumes and maximize infiltration. On private streets, consideration can be given to narrowing pavement width and reducing or eliminating curbs and gutters, particularly adjacent to waterways. Using these techniques reduces the amount of impervious surfaces, which in turn reduces stormwater runoff. Parkland dedicated with new developments can also be compatible with this approach, especially when native

Conservation development example

landscaping or other water quality plantings are incorporated. The development costs to implement LID practices have been shown to be lower than conventional development, and land values are typically higher because of the desirability of the community.

When implementing conservation development strategies, the site design criteria needs to be consistent, including detaining the WQCV using a 40-hour drain time and controlling the 2-, 10-, and 100-year design storms. Because the WQCV is a function of percent impervious cover; conservation strategies will likely reduce but not eliminate the requirement for structural BMPs on a particular development site. Similarly, conservation strategies will likely reduce the size of detention ponds to control the 2-, 10-, and 100-year design storms but not eliminate the requirement for onsite detention. The selection of structural BMPs to compliment conservation strategies can vary depending on the site characteristics, thus providing flexibility on how the site is developed. Similar to the integrated detention facility approach, requiring conservation development and/or structural BMPs would require changing the City's stormwater ordinances and *Drainage Criteria Manual* from a voluntary to mandatory program for requiring practices to address water quality.

Sensitive Areas

Sensitive areas are defined as general planning locations within the watershed that contain natural and/or unique characteristics that should be given the highest priority for implementing structural BMPs and conservation strategies for protection of water resources. This could also include strategies like transfer of development rights if available as a zoning tool in the future. During the Master Plan development, two sensitive areas within the study area were identified as shown on Figure 3-3 and described below:

***Sensitive Area 1*:** This area lies along the main stem of Cardwell Branch between South 1st Street and SW 27th Street. As depicted on Figure 3-3, this area contains floodplain, riparian stream corridor, medium to high quality woodland habitat, potential/future conservation easements, and a future trail. This area is within the Tier 1 growth area for the City of Lincoln. To protect these high value natural resources, surrounding development sites need to be encouraged to use structural BMPs and conservation strategies to protect this riparian corridor.

Sensitive Area 2: This area includes the headwaters of the south tributary, located south of Saltillo Road and between SW 40th Street and SW 27th Street. The protection of the headwaters is particularly important, due to the rolling, steep topography in this area and because any increase in stormwater runoff at this location could exacerbate stream instability and water quality degradation further downstream. This sensitive area is zoned AG Agriculture, and it is currently outside of the City's 3-mile jurisdiction. Thus, neither the City's Minimum Flood Corridor (stream buffer protection) standard, nor the stormwater management practices described above (if adopted) would apply in this location. For the time being, the existing vegetative buffers should be conserved and enhanced. Consideration should be given to protection of stream buffers and addressing stormwater runoff if special uses permitted in the agriculture district are proposed that would have the potential to impact this area and the downstream area.

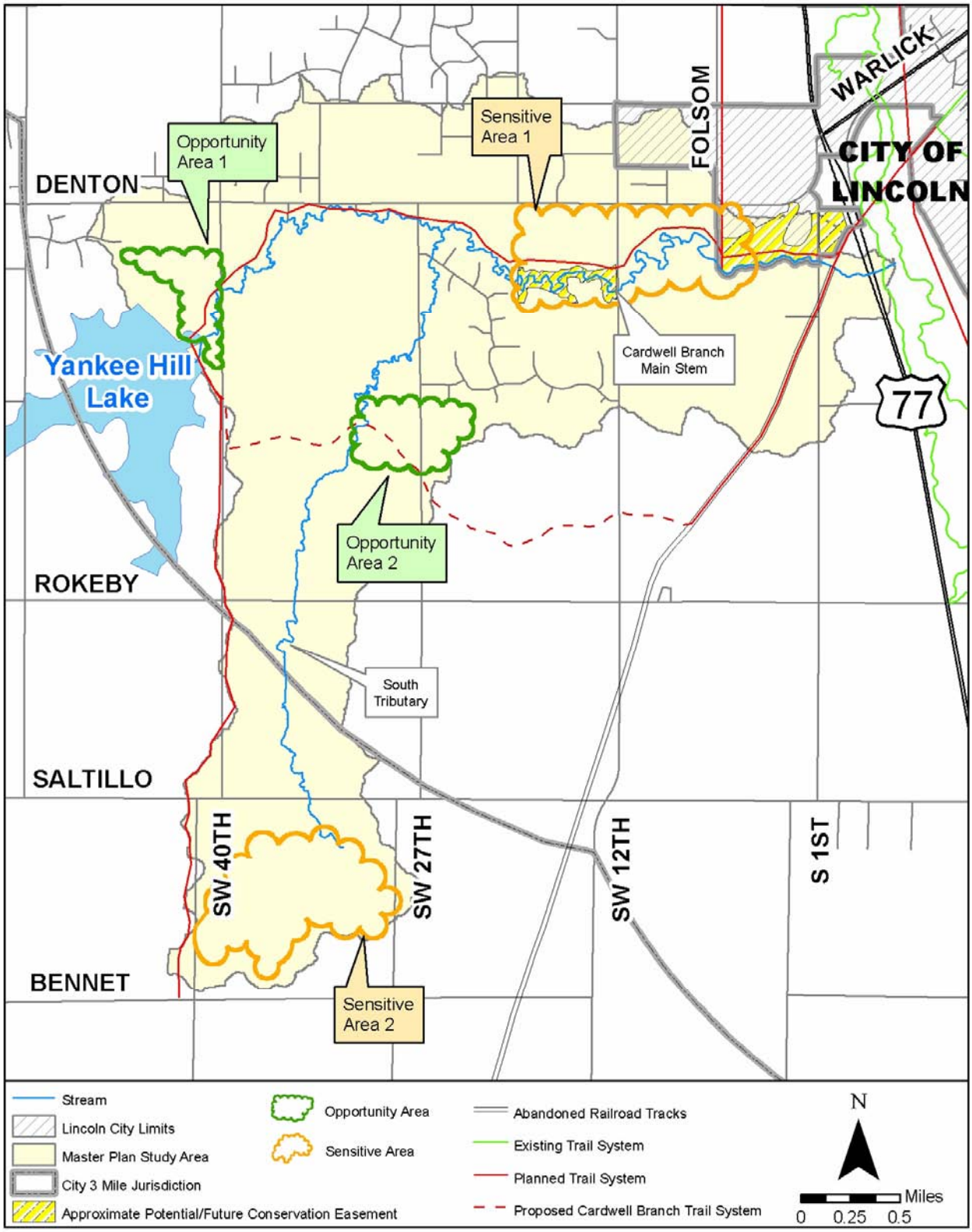

Figure 3-3
Cardwell Branch Watershed Management Recommendations

3.5.3 Opportunity Area Locations

Opportunity areas are general planning locations within the watershed where landscape features provide an opportunity to have a positive impact on water resources while realizing other goals. This approach recognizes that floodplains, tributaries and upland areas are all part of a comprehensive integrated watershed system. The Comprehensive Plan includes strategies for seeking "Rain to Recreation" project approaches that reduce flood damages, protect water quality and natural areas, while providing for recreational and educational opportunities so as to realize multiple benefits. To this end, the Cardwell Branch Watershed Plan has identified areas with the potential for multiple benefits such as enhancing water quality, protecting natural resources, and incorporating future amenities like parks, trails, and playing fields. These areas are generally identified on Figure 3-3. Due to these characteristics, it is recommended that these areas be designated as Green Space on the City/County Land Use Plan. Consideration should be given to future projects in these areas that protect, enhance, and provide opportunities for multiple benefits through voluntary/conservation easements or land acquisition, and/or water quality enhancements through native vegetation restoration. These sites would also be good candidates for using transfer of development rights if available as a zoning tool in the future.

Opportunity Area 1

This area is located at the base of Yankee Hill dam, adjacent to the Yankee Hill WMA, and provides an opportunity to reduce stormwater runoff and enhance water quality while providing for recreational opportunities. The area also includes the riparian corridor along Cardwell Branch that drains from the dam and a portion of the spillway. Key areas of the existing cropland and smooth brome fields could be converted to native tall grass prairie, thus enhancing runoff infiltration capacities and water quality benefits. The exact location and extent of native prairie grass plantings within this planning area would need to be carefully considered with the goal of protecting the integrity of the dam. Passive recreation areas with native vegetation could be coupled with active recreation areas (playing fields), to provide an optimal use of land that is located immediately downstream from an existing lake dam.

Opportunity Area 2

This area is south and west of SW 27th and W. Denton Road. It includes the main stem of the Cardwell Branch south tributary, the confluence with a secondary tributary flowing from the southeast, riparian corridors, native tall-grass prairie, and a future trail. In addition, the Master Plan identifies a stream stability CIP in this location and examines the potential for a regional detention basin for flood control. There are opportunities to enhance the native vegetation for water quality and wildlife, to consider future east-west trail connections, and to complete "Rain to Recreation" projects that provide multiple benefits. While this area is in the City's Tier II growth area, consideration should be given to amending the Future Parks map to identify a Neighborhood or Community Park once inside Tier 1.

3.5.4 Vegetative Maintenance/Restoration/Protection Efforts

Vegetative maintenance and restoration efforts will improve the benefits of buffers including reduced runoff, enhanced wildlife habitat, and improved water quality and stream stability. Vegetative maintenance is proposed at two locations, including (1) Cardwell Branch main stem between Highway 77 and Folsom Road, and (2) Cardwell Branch main stem extending

from SW 12th Street to approximately 1,500 feet upstream. The vegetative maintenance efforts would vary depending on the specific reach in question, but could include thinning of the understory, selected application of herbicide on undesirable species, and replanting with native riparian species. These maintenance efforts will connect the two stream reaches with the highest quality of woodland vegetation (Figure 3-1) and improve the habitat in the lower reach of the watershed. In addition, the first stream reach and a portion of the second stream reach are within the proposed conservation easements, which will help facilitate these maintenance efforts with the overall goal of enhancing the riparian habitat health within Sensitive Area 1.

Vegetative restoration is recommended for the majority of the south tributary. The vegetative restoration efforts would involve the removal of the infestation of reed canary grass, which will greatly improve the habitat in those areas. Application of herbicide followed by a prescribed burn, and then seeding and/or planting of native wetland and prairie species will begin to eradicate the reed canary grass problem. Follow-up efforts for a number of years may be necessary given the possibility of long-term storage of reed canary grass in the soil or seed bank. The vegetative restoration efforts will also help meet the goals of Opportunity Area 2 and Sensitive Area 2, which are both located adjacent to the south tributary, by improving the overall health of the riparian corridor.

Vegetative protection is recommended for the moderate quality native prairie area as shown on Figure 3-1. This area contains a diverse mix of native grasses and forbs that should be preserved. The first step of the protection process should be updating the City/County land use plan and the City's Natural Resources GIS database to include this native prairie area. In addition, consideration should be given to future projects in this area that protect and enhance the native prairie, while providing opportunities for multiple benefits through voluntary conservation easements or land acquisition. This site would also be a good candidate for using transfer of development rights.

3.5.5 Habitat Corridors and Connectivity

The preservation and reestablishment of the riparian corridors, combined with vegetative restoration and maintenance activities, and stream stabilization measures (Section 3.5.6), will provide better habitat and connectivity between the Yankee Hill WMA and the Salt Creek floodplain corridor. In addition, the potential future conservation easements, as shown on Figure 3-3, provide an excellent opportunity for preserving a portion of this riparian corridor.

Similar riparian corridor improvement measures along the major south tributary will also provide better riparian habitat and another corridor for wildlife movement. Expected wildlife to use these improved corridors are generalists including white tailed deer, skunks, rabbits, raccoons, bobcats, and woodland birds. The improved riparian corridors will improve habitat within the watershed, provide a connection to larger tracts of woodland and prairie in outlying regions, and increase movement and use by a more diverse set of wildlife and birds. In addition, the reestablishment of the stream buffers may make some areas suitable for additional species.

The riparian corridors also offer an excellent avenue for future trail systems. As shown on Figure 3-3, the City's planned trail system alignment follows the Cardwell Branch main stem with the goal of connecting to the Yankee Hill WMA. To complement this trail

alignment, the City's planned trail system located east of the watershed could be connected to other features within the watershed by extending the trail system directly west across the Cardwell Branch watershed to the proposed Opportunity Area 2 (Section 3.5.3), portions of the south tributary, and eventually to the Yankee Hill WMA as shown on Figure 3-3.

3.5.6 Stream Stabilization Measures

The implementation of stormwater management practices to control the changes in hydrology will reduce the severity of erosion. However, it will be very difficult to exactly replicate historical streamflows and velocities with BMPs; therefore, stream stabilization projects are necessary in critical areas that already are severely eroded or are vulnerable to future erosion.

For areas that are already showing signs of severe erosion, stream stabilization projects using natural channel design techniques are recommended to improve the ecosystem health and to prevent the problem from migrating elsewhere. The recommended stream stabilization projects are discussed in Section 5 of this report.