**Comprehensive Water Resource Management Plan –
Big Sioux River Headwaters Study Area**

Executive Summary

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1.0 Concept and Purposes of Plan

This comprehensive water resource management plan (Plan) incorporates an integrated natural resources and watershed-based approach to provide flood protection and enhance water quality throughout the Lake Pelican Water Project District (LPWPD). Implementation of this Plan will result in the following benefits:

- Significant flood and peak flow reductions in the Big Sioux River, especially in and near the City of Watertown.
- 10% – 15% reduction in peak flows in every major basin.
- Prevention of structural damages by reducing the peak flow rates in the Big Sioux River at Watertown by 77% in the 100-year 10-day snowmelt event (78% in the 100-year 24-hour rainfall event).
- Reductions in the sediment load to the Big Sioux River, Lake Pelican, and Lake Kampeska, as a result of reduced flows and the corresponding reduction in erosion of farmland, ravines, roads, and riverbanks.
- Reduction in nutrient loads to the Big Sioux River, Lake Pelican, and Lake Kampeska, as a result of reduced flows and reduced sediment loads.
- Improved river and lake water quality (e.g. Big Sioux River, Lake Pelican and Lake Kampeska) as a result of reduced erosion in the watershed, reduced nutrient loads to the streams, rivers and lakes, and reduced sedimentation in the streams, rivers and lakes.
- Promotion of groundwater recharge upstream of road crossings and other flow restriction locations.
- Improved wildlife habitat and ecological conditions, resulting from 1) reduced erosion, which will allow for revegetation of previously eroded areas; 2) reduced "flashiness" of stream flows, which will stabilize base flows and increase the stability of river banks; and 3) reduced sedimentation, which previously clouded the water and smothered habitat.
- Retention of agricultural sediments closer to their origin.
- No relocation of homes required as part of implementation.

- Protection and improvement of the township, county and state infrastructure, including utilities and rural water systems, resulting from reduced incidences of road overtopping, road washout and bank failure and the reduced frequency of road maintenance (including fence replacement).
- Protection of Interstate Highway 29 and U.S. Highway 81 from flooding, as a result of reduced flows in the streams and rivers.

This Plan presents the results of a combination of a series of studies to address the environmental problems in the Big Sioux River Headwaters (BSRH) Study Area. The Lake Pelican Water Project District (LPWPD) began the development of this Plan in 1999 and completed it in 2002. For more information on technical methods and technical results, please refer to the Technical Report section of this Plan.

2.0 Background

2.1 Project Location

This Plan targets several upstream watersheds tributary to the Big Sioux River in northeastern South Dakota, upstream of the City of Watertown. The study area for this Plan, called the Big Sioux River Headwaters (BSRH) Study Area, covers 1036 square miles in Codington, Day, Grant, Roberts and Clark counties (see Figure 1). The study area extends to just downstream of the Lake Kampeska weir, which is the location of the "At Watertown Gauge" (a USGS stream gauging station). About five miles downstream of the BSRH study area, the Big Sioux River winds through the City of Watertown. This means that the flows through the City of Watertown itself were not modeled as part of this study. The BSRH study area contains the majority of the 345 square mile Lake Pelican Water Project District (LPWPD – see Figure 2). The BSRH study area was divided into 11 major basins, 8 that are "regularly contributing" and 3 that are "periodically contributing" to the Big Sioux River. The periodically contributing basins were found to have only intermittent effects on flows in the Big Sioux River, and they comprise 528 square miles of the BSRH study area. The majority of the periodically contributing basins do not lie within the boundaries of the LPWPD. The remaining eight basins discharge directly to the Big Sioux River, and account for 508 square miles of the BSRH study area.

The following table shows the subdivision of the 1,036-square mile BSRH study area into eleven major basins:

Basin Name	**Basin Area, square miles**
Upper Sioux Basin	71
Indian River Basin	39
Soo Creek Basin	30
Mahoney Creek Basin	23
Middle Sioux Basin	58
Mud and Gravel Creek Basin	69
Lower Sioux Basin	24
Still Lake Basin	194
Cottonwood Lake Basin (periodically contributing)	12
Waubay Lakes Basin (periodically contributing)	403
Upper Still Lake Basin (periodically contributing)	113
Total	1,036

The majority of the land in the BSRH study area is used for agricultural purposes, with a few forest, wetland and residential areas. In the regularly contributing basins, there are no major bodies of water, except for Still Lake and the chain of lakes upstream of Still Lake, but there are several creeks that are tributary to the Big Sioux River. Most of the BSRH study area is located in the Prairie Coteau glacial outwash region. In general, there is considerable topographic relief in the eastern portions of the BSRH study area (roughly east of Interstate 29); the remainder of the BSRH study area is significantly flatter. A ridge runs north-south through the following portions of the BSRH study area: Upper Sioux Basin (part), Indian River Basin, Soo Creek Basin, Mahoney Creek Basin, and Mud and Gravel Creek Basin.

2.2 Environmental Problems

This Plan addresses numerous major environmental problems in the BSRH study area. The environmental problems include:

- ***Severe*** channel, streambank, road crossing and farmland ***erosion***;
- High levels of ***sediment*** in the Big Sioux River;
- ***Sedimentation*** in Lakes Pelican and Kampeska;
- ***High nutrient loadings*** to the Big Sioux River and its tributaries;
- ***Poor water quality*** in the Big Sioux River, Lake Pelican and Lake Kampeska;
- ***Degraded wildlife habitat***;
- State/federal ***endangered, threatened, and rare*** animal and plant ***species***,
- ***Unstable stream corridors***; and
- ***Frequent flooding*** along the Big Sioux River, its tributaries, at road crossings and within the City of Watertown, South Dakota.

The South Dakota Department of Environmental and Natural Resources (SD DENR) placed the Big Sioux River within the LPWPD on its 303(d) list for 2002 and slated it as a "Priority 1" (high priority) for development of a Total Maximum Daily Load (TMDL). The SD DENR's 2002 305(b) water quality assessment report to the U.S. Congress lists the Big Sioux River as "non-supporting" for its assigned beneficial uses within the LPWPD. The 2002 305(b) report also states that for the Big Sioux River "sediment sources are overland runoff from nearby croplands and feedlots, inflow from tributaries, and considerable streambank erosion."

Lake Kampeska, within the Upper Big Sioux watershed, was on the 303(d) list for 1998. The SD DENR's 2002 305(b) water quality assessment report to the U.S. Congress lists Lake Kampeska as "non-supporting" for its assigned beneficial uses ("overall use"). Since a TMDL study was completed for Lake Kampeska and approved by the U.S. EPA in late 1996, the SD DENR did not place the lake on its 303(d) list for 2002. According to the SD DENR's 1998 303(d) list, the TMDL for Lake Kampeska calls for a 35% reduction in nutrient loadings and a 25% reduction in sediment loadings to the lake. The diagnostic/feasibility study for Lake Kampeska (1994) states that the lake has an overabundance of nutrients and sediments (hypereutrophic), and the Big Sioux River carries the majority of the nutrients and sediments into Lake Kampeska.

The SD DENR placed Lake Pelican on the 303(d) list for 1998. The SD DENR's 2002 305(b) water quality assessment report to the U.S. Congress lists Lake Pelican as "partially supporting" for its assigned beneficial uses ("overall use"). Since a TMDL study was also completed for Lake Pelican and approved by the U.S. EPA in late 1996, the SD DENR did not place the lake on its 303(d) list for 2002. According to the SD DENR's 1998 303(d) list, the TMDL for Lake Pelican calls for a 55% reduction in nutrient loadings and a 65% reduction in sediment loadings to the lake. Similar to Lake Kampeska, the Lake Assessment Project report (1995) for Lake Pelican states that the lake has an overabundance of nutrients and sediments (hypereutrophic), and the Big Sioux River carries the majority of the nutrients and sediments into Lake Pelican.

All of these environmental problems are interrelated, and are a direct result of the lack of watershed-wide water resources management. There was an urgent need for a watershed-based approach to stormwater and water resources management in the upper portions of the watershed to alleviate these problems and restore the watershed and the Big Sioux River back to a healthy state.

The flooding problems and erosion and sedimentation problems are discussed in more detail in the following sections.

2.2.1 Flooding Problems

One of the major environmental problems in this watershed is the frequent flooding experienced in the Big Sioux River. The City of Watertown has experienced severe flooding during six of the past 45 years; the largest event occurred in the spring of 1997. The U.S. Army Corps of Engineers (Corps) estimated the flood to be a 35-year event, according to their March 2000 study, *Big Sioux River, Watertown and Vicinity, SD (General Re-evaluation Report)*. The severe flooding in Watertown occurs during events greater than the 10-year frequency flood, when the river banks are overtopped, and is caused by (1) the large flows from the upstream watershed, (2) the limited channel capacity, (3) several channel restrictions in the City of Watertown (e.g. bridges and abrupt changes in channel flow direction), and (4) "backing up" of flows from Willow Creek into the Big Sioux River. The river channel through the city has capacity for flows just under the 10-year flood (1,600 cubic feet per second (cfs)).

The primary flooding problem experienced throughout the Big Sioux River Headwaters (BSRH) Study Area (the watershed area north of and not including Watertown) is the overtopping and washing out of road crossings, which act as restrictions to the flow. Model results predict that under existing conditions, water would overflow the roadway at 155 (18%) of the road crossings in the 100-year 10-day snowmelt event, and at 360 (43%) of the road crossings in the 100-year 24-hour rainfall event. The counties and townships installed numerous larger-diameter culverts to alleviate the problem of road overtopping and road failures. However, these actions have led to even higher flows and velocities in the streams, creeks and rivers of the BSRH study area, pushing the flooding problem downstream.

Another contributing factor to the flooding problems in the BSRH study area is the additional flows into the Big Sioux River from the Still Lake Basin. These additional flows are the result of recently constructed outlets from Still Lake and from the upstream lakes in the Still Lake Basin. These lakes did not have outlets in the past; the outlets were installed to relieve flooding problems.

2.2.2 Erosion and Sedimentation Problems

There are erosion problems throughout the Big Sioux River Headwaters (BSRH) Study Area that cause sedimentation downstream, culminating in large amounts of sediment being carried by the Big Sioux River and deposited in the river and downstream lakes (i.e. Lakes Pelican and Kampeska). The LPWPD, the federal Natural Resource Conservation Service, Codington County Conservation District, and DENR performed an Agricultural Nonpoint Source (AGNPS) model of the portion of the Big Sioux River watershed in Codington County (1994-1995). According to the 1994-1995 report, there is significant farmland erosion in the county, which includes much of the BSRH study area.

Although erosion, sedimentation and flooding are natural processes, human activities (such as poor agricultural and stormwater management practices) have accelerated erosion and increased the magnitude, duration and frequency of flooding. These changes in flow regime also result in alterations to the stream channel, often to an "unstable" (i.e. continuously degrading) form. There is generalized channel and riverbank erosion throughout the BSRH study area, including erosion at road crossings. The erosion at road crossings is the result of high flows overtopping roads and subsequent road failures. As discussed in Section 2.2.1, the counties and townships installed numerous larger-diameter culverts to alleviate these problems. However, these actions have led to even higher flows and velocities in the streams, creeks and rivers of the BSRH study area, further increasing channel and riverbank erosion and downstream sedimentation. Before the rivers and streams can be restored to a more natural/stable condition, the stormwater must be controlled and the flows in the rivers and streams must be reduced.

Although under normal channel flow conditions little flow from the Big Sioux River enters Lake Pelican and Lake Kampeska, significant amounts of flow from the river can enter both lakes during flooding events. Since the Big Sioux River carries a high sediment load during flooding events, the sediment is carried into both Lake Pelican and Lake Kampeska.

The water surface area of Lake Pelican is about 2,800 acres. The lake is used for commercial and recreational purposes. The South Dakota Department of Game, Fish and Parks (recreation area) own almost half of the shoreline. Lake Kampeska has a water surface area of about 4,800 acres. The area around Lake Kampeska is largely developed and the lake is heavily used for commercial and recreational purposes. The lake also supplies the City of Watertown with a portion of its municipal water supply.

Both Lake Pelican and Lake Kampeska are relatively shallow and have experienced severe sedimentation resulting from upstream watershed erosion and shoreline erosion. These lakes are among only a few in this region, so they are considered vital water resources and people from all over the region are generally concerned about the high amount of sedimentation in both lakes and the Big Sioux River. The relatively recent sediment deposition has significantly reduced the depth of both lakes, which affects the fish and wildlife, water quality and recreational potential. The original depth of Lake Pelican is believed to have been about 25 feet. Presently, Lake Pelican has a maximum depth of 8 feet with an average depth of 6 feet (*Thickness and Volume of Sediment in Pelican Lake, South Dakota, June 1994*, USGS Water-Resources Investigations Report 96-4247, 1996). Similarly, the DENR's *Diagnostic/Feasibility Study, Lake Kampeska, Codington County, South Dakota* (1994) reports that Lake Kampeska currently has a maximum depth of 15 feet and an average depth of 10 feet. The report also states that the average sediment depth in Lake Kampeska is nearly 7 feet.

In 1997 the LPWPD constructed a diversion control structure (weir) between the Big Sioux River and Lake Pelican that significantly reduced the amount of sediment entering the lake through normal river flows. In 2001 the City of Watertown constructed a weir between the Big Sioux River and Lake Kampeska. It is too early to tell if this structure will have any significant impact on the sediment load entering Lake Kampeska through river flows.

The high level of sediment in the Big Sioux River creates additional problems in the downstream reaches of the Big Sioux River, which directly affects the sediment load to the Missouri River. The current sediment level in Lake Pelican and Lake Kampeska causes the following fisheries management problems:

- Reduced water depth and nutrient enriched sediment result in internal phosphorus loading. The resultant algal blooms reduce the lake's fisheries habitat and produce significant foul odor issues.
- Shallower depth and low water levels during drought conditions result in frequent winterkills and summerkills (from lack of oxygen).
- Reduced water depth results in poor fisheries habitat.
- Poor fisheries habitat results in poor populations of game fish, such as northern pike, rock bass, white bass, largemouth bass, walleye, perch, bluegill, and black crappie.
- A poor game fish population allows rough fish to increase because of reduced predation of young rough fish. The bottom-feeding rough fish stir up sediments, which further reduces the lake's water quality.
- Increased sedimentation produces an increased number of sediment deltas supporting abundant submerged vegetation, which interferes with predation of bluegills, crappie, and perch, bass, walleye, and northern pike.

In addition to fisheries issues, the poorer water quality of Lake Kampeska also impacts the City of Watertown's water treatment plant operations and operating budgets.

3.0 Lake Pelican Water Project District

The Lake Pelican Water Project District (LPWPD) was established in 1988. At the time it was established, the LPWPD's jurisdictional boundaries covered only Lake Pelican and the land directly tributary to the lake. Landowners outside of the LPWPD petitioned for an expansion of the LPWPD's boundaries, which resulted in an election. The election in 1999 enlarged the LPWPD's jurisdictional boundaries to cover the 345 square miles shown in Figure 2. The LPWPD now includes nearly all of the basins that are normally tributary to the Big Sioux River upstream of Lake Kampeska, near the City of Watertown (Upper Sioux Basin, Indian River Basin, Middle Sioux Basin, Soo Creek Basin, Mahoney Creek Basin, Mud and Gravel Creek Basin, and Lower Sioux Basin).

The LPWPD board manages water-related projects for Lake Pelican, the Pelican Basin, and the watershed normally tributary to the Big Sioux River, upstream of Lake Kampeska (see Figure 1). The LPWPD is a unit of government that was established to sponsor and implement water projects for the "conservation, storage, distribution and utilization of water and for the prudent management of water resources" (quoted from South Dakota State Laws 46A-18). The goals of the LPWPD are to:

- Reduce flood levels on the Upper Big Sioux River
- Improve water quality in the lakes, rivers and streams within LPWPD
- Implement integrated natural resource management practices
- Reduce erosion and sedimentation
- Manage water resources on a regional, watershed-wide basis
- Improve/encourage groundwater recharge
- Enhance wildlife habitat
- Protect roadways from overtopping and failure

The LPWPD board manages projects, provides direction on analyses, coordinates with local townships and counties, and prioritizes improvements and subsequent studies. There are currently eight LPWPD board members, of which seven are voting members/directors. The seven voting members/directors are elected positions with three-year terms.

The LPWPD board has been working to improve the water quality of Lake Pelican since the inception of the LPWPD. In 1993, the LPWPD worked with the South Dakota Department of Environment and Natural Resources (DENR) to conduct a Lake Assessment Project (LAP) at Lake Pelican near Watertown, South Dakota. The LAP report concluded that Lake Pelican was acting as a sediment and nutrient retention basin for the Big Sioux River watershed (*Lake Assessment Project, Pelican Lake, Codington County, South Dakota*, South Dakota Department of Environment and Natural Resources April 1995). In 1994 the LPWPD, in conjunction with the USGS, undertook a seismic survey of Lake Pelican. In 1997 the LPWPD acted on the recommendations of the LAP and the USGS report, and (with EPA 319 grant assistance) installed a diversion control structure (weir) where the Big Sioux River enters Lake Pelican. Under normal flow conditions and during frequent small storms, the weir restricts flows from an approximately 30-foot wide channel to a 3-foot wide notch. This notch significantly restricts sediment-laden flows from entering the lake, while enabling fish migration. The LPWPD continued to follow the recommendations of the LAP report by implementing shoreline stabilization measures and animal waste management systems in 1998. These projects have successfully reduced the sediment load into Lake Pelican and the water quality has improved significantly. As outlined in the LAP report, the LPWPD will continue to work on implementing best management practices, such as grazing management, grassed waterways, buffer strips, and feedlot runoff management. Through implementation of this Plan, the LPWPD will continue their water quality improvement efforts by reducing the sediment load in the river from the upstream watersheds.

The powers of the LPWPD include the ability to levy taxes (annual general tax levy), levy special assessments, borrow money, and enter into contracts for professional services and construction projects. These powers mean that the LPWPD is qualified to implement this Plan. By law, the LPWPD is restricted to levying no more than $1 per $1,000 of taxable valuation on each dollar of taxable property (1 mill) in the district (levy limit). In LPWPD, levying the maximum amount would generate approximately $95,000 annually. The LPWPD currently levies 0.84 mill, which generates about $80,000 annually. South Dakota law restricts the amount the levy can increase each year. Based on the state's formula, it would take about five years for the LPWPD to reach its maximum levy amount. Even with the maximum levy amount in place, the LPWPD Board recognizes that they need additional sources of funding to accelerate implementation of the Plan recommendations. The LPWPD will actively pursue other sources of available funding to augment their tax levy.

A variety of funds have been used to pay for this Plan, including LPWPD general tax levy funds, grants from Codington County, East Dakota Water Development District, Save Our Farmland

Coalition, the member townships, and four private contributions. This funding has also been supplemented with substantial in-kind work from LPWPD board members and LPWPD residents.

4.0 Proposed Strategy

4.1 Overall Results

This Plan presents a strategy for effectively managing the water quality and water quantity within the Big Sioux River Headwaters (BSRH) Study Area, by restricting and slowing flows and trapping sediment at multiple locations throughout the BSRH study area. The proposed projects are spread out across all of the basins within the BSRH study area that contribute water to the Big Sioux River. Figure 3 shows the basins in the BSRH study area and the proposed project locations (the different types of projects are denoted by different symbols on the figure). Implementation of this strategy will reduce peak flow rates throughout the BSRH study area, which will reduce flooding in the Big Sioux River, and thereby reduce channel/ waterway erosion, reduce sediment loads in the water courses, and improve water quality. For example, implementing this strategy will reduce peak flow rates in the Big Sioux River, at the downstream end of the BSRH study area, up to 77% (from 8,710 cfs to 2,030 cfs) for the 100-year 10-day snowmelt event, and 78% (from 7,150 cfs to 1,560 cfs) for the100-year, 24-hour storm event. Figures 4a and 4b illustrate the effectiveness of this strategy on reducing flow rates for the 100-year 10-day snowmelt and 100-year 24-hour rainstorm events. These figures show the flow rates over time (hydrograph) at the downstream end of the BSRH study area, before and after implementation of the strategy. Similarly, Table 4.1 compares the flow rates at the downstream end of each major basin, before and after implementation of the proposed projects.

The strategy includes the implementation of approximately 822 projects to control stormwater and restrict flows. The proposed projects take advantage of the tremendous amount of infrastructure already in place to further manage surface water runoff in the BSRH study area. This infrastructure includes the township, county and state roads, culverts, and bridges that serve as dikes, which provide some control of surface water runoff. Individual culverts and bridge openings were installed (and in many cases increased in size/number) with little consideration given to the upstream drainage area, the restrictions that could be provided, or the downstream effect of the culverts/bridges. The BSRH study area involves numerous counties and townships that had not coordinated their efforts prior to the formation of the LPWPD. Therefore, prior to this study, it was difficult to take a watershed-wide approach to managing the network of roads, culverts, bridges and overflows. As a result, this collective system of infrastructure allows water to flow downstream much faster than necessary, resulting in the environmental problems discussed in Sections 2.2.1 and 2.2.2.

The strategy of this Plan is to build upon the existing infrastructure in a watershed-wide approach to managing the surface water runoff in the BSRH study area. Therefore, of the 822 projects identified in this Plan, 790 are located at existing crossings (culverts or bridges), with small dams proposed at the remaining 32 proposed project locations. Of the 790 proposed projects at existing crossings:

- 485 of the proposed projects require the roadway to be raised to prevent flooding of roadway. Where proposed road raises are shown along the interstate, and major state and federal highways, it is unlikely that the roads themselves could be raised. In these locations (and possibly at certain paved county and township road locations), a small dam would be constructed upstream of the road instead of raising the road.

- 697 of the proposed projects involve installing smaller-diameter pipes at the upstream end of existing culverts;

- 34 of the proposed projects call for the installation of new culverts (where there are currently no culverts), to prevent overtopping of the road during the 100-year event.

- 10 of the proposed projects involve installing larger diameter pipes to prevent roadway overtopping during the 100-year event.

- 49 of the proposed projects require diversion of flows to an adjacent crossing.

Table 4.2 summarizes the proposed projects and types of projects in each major basin.

Anticipating the need to apply a phased approach to implement such a large number of projects, a sensitivity analysis was performed to study the effect on flow rates in the Big Sioux River if projects are implemented one major basin at a time. The sensitivity analysis ranked the major basins based on the amount of flow reduction, weighted according to the number of proposed projects in the basin. According to the sensitivity analysis, the proposed projects within the major basins should be implemented in the following order, with the percent reduction in flows at Watertown also noted:

1. Mahoney Creek Basin – 9%

2. Soo Creek Basin – 12%

3. Indian River Basin – 11%

4. Mud and Gravel Creek Basin – 13%

5. Upper Sioux Basin – 16%

6. Middle Sioux Basin – 14%

7. Still Lake Basin and Cottonwood Lake Basin – 2% (five of the seven proposed projects in these basins are located outside of the LPWPD legal boundary)

8. Lower Sioux Basin – 0% (the projects proposed for this basin will not provide flood control benefits, but will provide water quality benefits. See Section 4.2.7)

Within each basin, the individual projects will be implemented starting at the upstream end and working downstream. Although the sensitivity analysis shows that the proposed projects in the Lower Sioux Basin will provide relatively fewer flood control benefits, they will provide water quality benefits.

The LPWPD board will guide their implementation efforts towards following the results of the sensitivity analysis. However, this Plan is conceptual, which means the LPWPD board may implement projects "out of order." This may occur in circumstances where the LPWPD board responds to opportunities or encounters difficulties when attempting to implement projects in certain locations. The priority ranking is also likely to change upon completion of the prioritization/ implementation plan, which will take into account project costs and other considerations (see Section 5.0 – Step 1). The LPWPD board will implement as many of the proposed projects as possible, knowing that even if only a percentage of the proposed projects are implemented, there will be a significant reduction of flooding in the Big Sioux River and the study area overall.

4.2 Major Basin Results

The following paragraphs summarize the results for each major basin. The Technical Report presents the analytical results and specific design criteria for the proposed projects in detail, along with more detailed mapping and descriptions of the methodology used in the analysis.

4.2.1 Upper Sioux Basin

The Upper Sioux Basin is one of eight "regularly contributing" basins within the BSRH study area. The Upper Sioux Basin tributary area is 71 square miles; it was subdivided into 208 subwatersheds for modeling purposes. The Big Sioux River originates in the northeastern comer of the Upper Sioux Basin. There is a USGS flow gauging station along the Big Sioux River, "Big Sioux River near

Florence" gauge (#06479430), at the outlet of the Upper Sioux Basin. Outflows from the Upper Sioux Basin discharge into the Middle Sioux Basin.

There are 187 proposed flow restriction projects in the Upper Sioux Basin. Of these, 176 are located at existing culverts or bridges, where it is proposed to reduce the size of 146 culverts, add culverts at 20 locations (where there are currently no culverts) and divert flows at 10 culvert locations. Eleven of the projects are proposed locations for small dams. Road raises are proposed at 117 locations. The outlet of the Upper Sioux Basin is proposed to be reduced from the existing 9-foot high by 51-foot wide concrete bridge to two 54" diameter reinforced concrete pipes. By implementing the recommended projects, the peak discharge from the Upper Sioux Basin could be reduced by 83%, from 2,580 cfs to 450 cfs, in the 100-year, 10-day snowmelt event and by 84%, from 2,440 cfs to 390 cfs, for the 100-year, 24-hour storm event.

4.2.2 Indian River Basin

The Indian River Basin is one of eight "regularly contributing" basins within the BSRH study area. The Indian River Basin tributary area is 39 square miles; it was subdivided into 141 subwatersheds for modeling purposes. Indian River originates in the northeastern corner of the Indian River Basin and combines with the Big Sioux River at the outlet of the basin. Outflows from the Indian River Basin discharge into the Middle Sioux Basin.

There are 98 proposed flow restriction projects in the Indian River Basin. Of these, 92 are located at existing culverts or bridges, where it is proposed to reduce the size of 86 culverts, increase the size of 4 culverts and divert flows at 2 culvert locations. Six of the projects are proposed locations for small dams. Road raises are proposed at 46 locations. The outlet of the Indian River Basin is proposed to be reduced from the existing 12-foot high by 40-foot wide concrete bridge to three 54" diameter reinforced concrete pipes. By implementing the recommended projects, the peak discharge from the Indian River Basin could be reduced by 68%, from 2,190 cfs to 700 cfs, in the 100-year, 10-day snowmelt event and by 82%, from 3,650 cfs to 650 cfs, in the 100-year, 24-hour storm event.

4.2.3 Soo Creek Basin

The Soo Creek Basin is one of eight "regularly contributing" basins within the BSRH study area. The Soo Creek Basin tributary area is 30 square miles; it was subdivided into 104 subwatersheds for modeling purposes. Soo Creek originates in the northeastern corner of the watershed and combines with the Big Sioux River at the outlet of the Soo Creek Basin. Outflows from the Soo Creek Basin discharge into the Middle Sioux Basin.

There are 103 proposed flow restriction projects in the Soo Creek Basin. Of these, 96 are located at existing culverts or bridges, where it is proposed to reduce the size of 93 culverts, increase the size of one culvert and divert flows at 2 culvert locations. Seven of the projects are proposed locations for small dams. Road raises are proposed at 63 locations. The furthest downstream control structure for the Soo Creek Basin is proposed to be reduced from the existing three 6-foot high by 12-foot wide concrete box culverts to two 48" reinforced concrete pipes. The Soo Creek Basin discharges to the Big Sioux River about 8,400 feet downstream of the proposed 48" outlets. By implementing the recommended projects, the peak discharge from the Soo Creek Basin could be reduced by 78%, from 1,720 cfs to 380 cfs, in the 100-year, 10-day, snowmelt event and by 91%, from 3,580 cfs to 320 cfs, in the 100-year, 24-hour storm event.

4.2.4 Mahoney Creek Basin

The Mahoney Creek Basin is one of eight "regularly contributing" basins within the BSRH study area. The Mahoney Creek Basin tributary area is 23 square miles; it was subdivided into 70 subwatersheds for modeling purposes. Mahoney Creek originates in the northeastern corner of the Mahoney Creek Basin and combines with the Big Sioux River at the outlet of the basin. Outflows from the Mahoney Creek Basin discharge into the Middle Sioux Basin.

There are 62 proposed flow restriction projects in the Mahoney River Basin. Of these, 61 are located at existing culverts or bridges, where it is proposed to reduce the size of 57 culverts, increase the size of one culvert and divert flows at 3 culvert locations. One of the projects is a proposed location for a small dam. Road raises are proposed at 38 locations. The furthest downstream control structure for the Mahoney Creek Basin is proposed to be reduced from the existing two 6 foot high by 8 foot wide concrete box culverts to one 36" reinforced concrete pipe. The Mahoney Creek Basin discharges to the Big Sioux River about 8,600 feet downstream of the proposed 36" outlet. By implementing the recommended projects, the peak discharge from the Mahoney Creek Basin into the Big Sioux River could be reduced by 83%, from 960 cfs to 160 cfs, in the 100-year, 10-day snowmelt event and by 73%, from 1,290 cfs to 350 cfs, in the 100-year, 24-hour storm event.

4.2.5 Middle Sioux Basin

The Middle Sioux Basin is one of eight "regularly contributing" basins within the BSRH study area. The Middle Sioux Basin tributary area is 58 square miles; it was subdivided into 159 subwatersheds for modeling purposes. The Middle Sioux Basin collects drainage from the Upper Sioux, Indian River, Soo Creek, Mahoney Creek, Cottonwood Lake, and Still Lake basins. The Big Sioux River runs through the middle of the Middle Sioux Basin. Outflows from the Middle Sioux Basin discharge into the Lower Sioux Basin. There is a USGS flow gauging station along the Big Sioux River, "Big Sioux River near Watertown" gauge (#06479438), at the outlet of the Middle Sioux Basin.

There are 141 proposed flow restriction projects in the Middle Sioux Basin. Of these, 140 are located at existing culverts or bridges, where it is proposed to reduce the size of 113 culverts, increase the size of one culvert, add culverts at 9 locations (where there are currently no culverts) and divert flows at 17 culvert locations. One of the projects is a proposed location for a small dam. Road raises are proposed at 82 locations. The outlet of the Middle Sioux Basin is proposed to be reduced from the existing 10-foot high by 180-foot wide concrete bridge to a smaller bridge opening or four 72" diameter reinforced concrete pipes. By implementing the recommended projects, the peak discharge from the Middle Sioux Basin could be reduced by 79% from 6,570 cfs to 1,400 cfs, in the 100-year, 10-day snowmelt event and by 78%, from 5,040 cfs to 1,090 cfs, in the 100-year, 24-hour storm event.

4.2.6 Mud and Gravel Creek Basin

The Mud and Gravel Creek Basin is one of eight "regularly contributing" basins within the BSRH study area. The Mud and Gravel Creek Basin tributary area is 69 square miles; it was subdivided into 184 subwatersheds for modeling purposes. Mud Creek originates in the northeastern corner of the watershed and combines with the Big Sioux River about 1.5 miles downstream of the Mud and Gravel Creek Basin outlet, in the Lower Sioux Basin.

There are 181 proposed flow restriction projects in the Mud and Gravel Creek Basin. Of these, 176 are located at existing culverts or bridges, where it is proposed to reduce the size of 156 culverts, increase the size of three culverts, add culverts at three locations (where there are currently no culverts) and divert flows at 14 culvert locations. Five of the projects are proposed locations for small dams. Road raises are proposed at 110 locations. The outlet of the Mud and Gravel Creek Basin is proposed to be reduced from the existing eight 48" corrugated metal pipes, two 24" corrugated metal pipes and one 36" corrugated metal pipe to two 54" reinforced concrete pipes. By implementing the recommended projects, the peak discharge from the Mud and Gravel Creek Basin could be reduced by 84%, from 3,440 cfs to 540 cfs, in the 100-year, 10-day snowmelt event and by 89%, from 5,000 cfs to 540 cfs, in the 100-year, 24-hour storm event.

4.2.7 Lower Sioux Basin

The Lower Sioux Basin is one of eight "regularly contributing" basins within the BSRH study area. The Lower Sioux Basin tributary area is 24 square miles; it was subdivided into 49 subwatersheds for modeling purposes. The Lower Sioux Basin is the furthest downstream basin in the BSRH study area, and its outlet is the "Big Sioux River Control Structure." The Lower Sioux Basin collects drainage from the Middle Sioux and Mud and Gravel Creek basins. The Big Sioux River flows north to south through the Lower Sioux Basin.

There are 43 proposed flow restriction projects in the Lower Sioux Basin. Of these, 42 are located at existing culverts or bridges, where it is proposed to reduce the size of 39 culverts, add culverts at two locations (where there are currently no culverts) and divert flows at one culvert location. One of the projects is a proposed location for a small dam. Road raises are proposed at 28 locations. There are no proposed changes to the structures along the Big Sioux River itself within the Lower Sioux Basin. The furthest downstream structure in the Lower Sioux Basin is the Big Sioux River Control Structure.

Implementing the recommended projects in this basin would not reduce the peak discharges in the Big Sioux River, but would provide water quality treatment and erosion control benefits. Since the proposed projects in this basin would not achieve any flood control benefits, and flood control is the highest priority for implementing this Plan, implementation of the proposed projects in the Lower Sioux Basin were assigned the lowest priority of all of the basins.

4.2.8 Still Lake Basin

The Still Lake Basin is one of the eight "regularly contributing" basins within the BSRH study area. Different analytical tools were used in the study of this basin because of the large amount of storage available (see technical report for details). The upstream portions of the basin are considered "periodically contributing," and were separated into an additional basin, the Upper Still Lake Basin (see section 4.2.10 for details).

The Still Lake Basin tributary area is 194 square miles and discharges into the Middle Sioux Basin and the Big Sioux River during the 100-yr event. This contributing area was divided into six subwatersheds for the analysis; each subwatershed contains a large lake at the outlet. Several outlets have been installed on upstream lakes in the Still Lake Basin in recent years, increasing the flows downstream during all flooding events. Although the water levels on these upstream lakes are typically below their outlet elevation, the analysis assumed that the water levels were at the outlet elevation when the storm began.

There are six proposed project locations within the Still Lake Basin. It is proposed to reduce the size of all six culverts or bridges and raise the road at one location, decreasing the flows into Still Lake. These outlets would be designed as gated structures, so that high flood levels could be released after the peak flows subside in the Big Sioux River. Five 54" diameter corrugated metal pipes currently control the outlet of Still Lake and the Still Lake Basin. With the completion of these upstream projects, the Still Lake Basin outlet could be reduced to a 12" RCP culvert under normal flow conditions. A high level emergency weir or gated structure would be designed to prevent excessively high water levels on Still Lake, by allowing more water to discharge from the lake after the peak flows subside downstream. By implementing these recommendations, the peak discharges from the Still Lake Basin can be reduced from 250 cfs to 7 cfs, in the 100-year 10-day snowmelt event and from 112 cfs to 4 cfs, in the 100-year, 24-hour storm event.

4.2.9 Cottonwood Lake Basin

The Cottonwood Lake Basin is one of three "periodically contributing" basins within the BSRH study area. The Cottonwood Lake Basin is 12 square miles and it was modeled as one subwatershed. The water level of Cottonwood Lake is typically below the outlet pipe. When water levels on Cottonwood Lake are high, outflows from the lake are directed to the Middle Sioux Basin.

There is one proposed project within the Cottonwood Lake Basin. This proposed project would restrict the outlet of the Cottonwood Lake Basin from the existing 30" reinforced concrete pipe to a 12" reinforced concrete pipe. By implementing this recommended restriction, the peak discharge from the Cottonwood Lake Basin can be reduced from 18 cfs to 5 cfs in the 100-year, 10-day snowmelt event and 5 cfs to 2 cfs in the 100-year, 24-hour storm event.

4.2.10 Upper Still Lake Basin

The Upper Still Lake Basin is one of the three "periodically contributing" basins within the BSRH study area. The Upper Still Lake Basin contains the upper portions of the Still Lake Basin and is approximately 113 square miles. This area was divided into six subwatersheds that correspond to six lakes with significant storage in the basin. Different analytical tools were used in the study of this basin because of the large amount of storage available (see technical report for details).

The upstream lakes and basins within the Upper Still Lake Basin do not normally contribute flow to the Still Lake Basin and to the Big Sioux River during the 100-year event. For this reason, the Upper Still Lake Basin was excluded from the model of the BSRH Study Area and no projects are proposed for its subwatersheds.

4.2.11 Waubay Lakes Basin

The Waubay Lakes Basin is one of three "periodically contributing" basins within the BSRH study area. The most downstream lake in the Waubay Lakes Chain is Bitter Lake. The Waubay Lakes Basin is 403 square miles and the watershed was divided into ten subwatersheds in a previous study. The ten subwatersheds correspond to the ten lakes with significant storage in the basin.

There is no outflow from the Waubay Lakes Basin to the Big Sioux River (Upper Sioux Basin) in the 100-year event. For this reason, the Waubay Lakes Basin was excluded from the model of the Big Sioux River Headwaters (BSRH) Study Area and no projects are proposed for its subwatersheds.

4.2 Stakeholder Participation

Stakeholder participation was a key component of the planning process, and will be a key component during implementation of this Plan. Early on, the LPWPD and its consultant (Barr Engineering Company) identified and contacted the many stakeholders in the BSRH study area, held meetings with stakeholders, and sponsored several public meetings to discuss the progress and results of the studies. More than 300 people attended the June 2001 public meeting to hear the results of the Indian River Basin study. The most involved stakeholders include the LPWPD Board, the Codington County Commissioners, the Codington County Conservation District, and the Save Our Farmland Coalition. Other stakeholders include residents, the U.S. Army Corps of Engineers, South Dakota Department of Environment and Natural Resources, County and Township offices, Natural Resources Conservation Service, City of Watertown, South Dakota Department of Game, Fish and Parks, Sisseton-Whapeton Tribal Community, the South Dakota Association of Rural Water Systems, and the South Dakota Department of Transportation. Volunteers from the LPWPD board and LPWPD residents provided at least 300 hours of in-kind labor to obtain crucial road crossing information within the BSRH study area.

Table 4.1 Big Sioux River Headwaters Study Area, Basin Outlet Flow Results

Basin	Basin Area (square miles)	100-year, 10-day Snowmelt			100-year, 24-hour Storm		
		Existing	Proposed	Percent Reduction	Existing	Proposed	Percent Reduction
Upper Sioux Basin	71	2,580	450	83%	2,440	390	84%
Indian River Basin	39	2,190	700	68%	3,650	650	82%
Soo Creek Basin	30	1,720	380	78%	3,580	320	91%
Mahoney Creek Basin	23	960	160	83%	1,290	350	73%
Cottonwood Lake Basin	12	18	5	72%	5	2	60%
Still Lake Basin	195	250	7	97%	112	4	96%
Middle Sioux Basin	58	6,570	1,400	79%	5,040	1,090	78%
Mud and Gravel Creek Basin	69	3,440	540	84%	5,000	540	89%
Lower Sioux Basin	24	8,710	2,030	77%	7,150	1,560	78%

Table 4.2 Big Sioux River Headwaters Study Area, Proposed Projects

Basin	Basin Area (sq miles)	Number of Subwatersheds	Number of Storage Areas	Proposed Projects	
Upper Sioux Basin	71	208	189	**Total proposed Projects**	**187**
				Changed Culvert Size	166
				Closed Outlets	10
				Proposed Dams	11
				Number of Road Raises	*117*
Indian River Basin	39	141	103	**Total proposed Projects**	**98**
				Changed Culvert Size	90
				Closed Outlets	2
				Proposed Dams	6
				Number of Road Raises	*46*
Soo Creek Basin	30	104	103	**Total proposed Projects**	**103**
				Changed Culvert Size	94
				Closed Outlets	2
				Proposed Dams	7
				Number of Road Raises	*63*
Mahoney Creek Basin	23	70	62	**Total proposed Projects**	**62**
				Changed Culvert Size	58
				Closed Outlets	3
				Proposed Dams	1
				Number of Road Raises	*38*
Middle Sioux Basin	58	159	145	**Total proposed Projects**	**141**
				Changed Culvert Size	123
				Closed Outlets	17
				Proposed Dams	1
				Number of Road Raises	*82*
Mud and Gravel Creek Basin	69	184	181	**Total proposed Projects**	**181**
				Changed Culvert Size	162
				Closed Outlets	14
				Proposed Dams	5
				Number of Road Raises	*110*
Lower Sioux Basin	24	49	49	**Total proposed Projects**	**43**
				Changed Culvert Size	41
				Closed Outlets	1
				Proposed Dams	1
				Number of Road Raises	*28*
Still Lake Basin	194	6	6	**Total proposed Projects**	**6**
				Changed Culvert Size	6
				Number of Road Raises	*1*
Cottonwood Lake Basin	12	1	1	**Total proposed Projects**	**1**
				Changed Culvert Size	1
				Number of Road Raises	*0*

5.0 Next Steps/Guide to Implementation

The LPWPD Board recognizes that implementing this Plan will require a continual effort for many years. Those efforts will include the steps discussed below.

Step 1. Develop Prioritization/Implementation Plan

The next step is for the LPWPD Board to develop a prioritization/implementation plan for all of the projects. The prioritization/implementation plan will discuss the importance of implementing the proposed projects in a certain order, starting with the upstream projects within a particular basin and working downstream. The plan will also:

- Develop preliminary cost estimates
- Prioritize the specific implementation projects, based on the results of the sensitivity analysis, cost estimates and other financial considerations, and other considerations.
- Present potential funding method(s) to be used for financing the projects
- Show the proposed schedule for project construction.

Step 2. Perform Feasibility Studies

After completion of the prioritization/implementation plan, the next step is for the LPWPD to complete feasibility studies. These feasibility studies must be undertaken before construction of any of the proposed projects, and would comply with South Dakota law that requires an engineer's report for proposed projects. A feasibility study would need to be completed for each project or group of projects, and would be completed in the order set forth in the prioritization/implementation plan. The feasibility studies would include the following:

- Collection of additional or more detailed information, such as topographic mapping, and surveying of culvert invert elevations, bridge elevations, road elevations, etc.
- Analysis/additional analysis of technical issues, such as geotechnical, water quality, wetlands, wildlife, and hydrology
- Consideration of concerns regarding state/federal endangered, threatened, and rare animal and plant species
- Development of more detailed cost estimates

- Preparation of schematic drawings of the proposed projects

Step 3. Construction of the Proposed Projects

After completion of the feasibility studies, the LPWPD Board will be ready to proceed with final design and construction of the proposed projects. During this step, the following work will need to be completed for each project/set of projects:

- Complete final design
- Obtain necessary permits from other units of government
- Prepare construction plans and specifications
- Hold public LPWPD hearing, if required, and approve project(s)
- Hold election to approve financing, if required
- Perform construction management activities, including bidding, construction observation, payments, etc.

The LPWPD Board wishes to begin implementing the Plan as soon as possible. This means that the LPWPD may construct projects in a basin as soon as the feasibility studies for that basin (or portion of the basin) are completed. At the same time projects are under construction, feasibility studies could be underway for other projects in the LPWPD.

Step 4. Operation and Maintenance of Constructed Projects

After completion of any construction project, it will be the responsibility of the LPWPD to operate and maintain the projects. Operation and maintenance work will include inspecting the physical conditions of the LPWPD's dams and culverts, clearing debris and undesirable vegetation from the dams and culverts, and continued monitoring of the existing flow gauges to measure the effectiveness of the projects. The LPWPD will consider installing additional flow gauges and installing lake level gauges in Still Lake. The LPWPD will need to develop an operation and maintenance program/ schedule since there will be such a large number of proposed projects.

Most of the existing structures are owned, operated and maintained by the state, county or township. Since the LPWPD does not currently employ staff that could perform operation and maintenance duties, the LPWPD Board would prefer to enter into an agreement with the state, county or township that would call for the state, county or township to maintain the LPWPD structure as part of their ongoing maintenance of their roads, culverts and bridges.

Ongoing Step. Continued Stakeholder Participation

As the LPWPD Board moves through the steps discussed above, they will seek continued participation and cooperation from the various stakeholders. This step could include providing information to interested parties, holding informational meetings, holding public hearings, and attending meetings with other organizations.