Section 5 - MANAGEMENT PRACTICES

5.1 Introduction

The intent of Section 5 is to present practical tools that can be used to address the problems and concerns identified in previous chapters. This section outlines management practices and structural alternatives that are available to achieve the water management goals and objectives for the Basin. Specific practices were highlighted in this section because of landowner preference, practice suitability based on management goals, and practice effectiveness. Included are site specific structural practices such as in-stream weirs and water quality basins, and non-structural practices such as no-till and nutrient management.

Landowners and producers will be encouraged to implement structural projects and non-structural management practices. In many cases, producers will take on the role of project sponsor, receive mutual benefits, and will voluntarily pay a share of the cost in constructing or adopting these practices. NRDs will be responsible for implementing water management projects in conjunction with other resource agencies. Water management projects will primarily be structural and will address water management priorities in the Basin.

While the impacts of short-term and immediate actions are easier to visualize, it is important to consider long-term issues, such as climate change, when planning future programs and projects. Climate change is projected to complicate food production in the world's semi-arid regions, which already have high climate variability (Molles et al. 1992, IPCC 2008). Regardless of land conservation practices, extreme climate events will likely convert apparently sustainable systems to unsustainable systems (Chang et al. 2014). Large structural projects will be needed in conjunction with sweeping adoption of watershed practices to manage, and when possible take advantage of opportunities provided by, these extremes.

Large-scale projects, such as dams or in-stream check dams, can have multiple benefits and for purposes of this Plan may be labeled as multi-beneficial projects. Benefits may include, but are not limited to, flood control, bank stabilization, groundwater recharge, increase in aquatic habitat, reduction in sedimentation, and capturing and infiltrating stormwater.

5.2 Conjunctive Management

Conjunctive management practices are those that coordinate combined management of surface water and groundwater to improve the available water supply throughout a region or basin and promote the sustainability of that supply. Conjunctive management, according to NDNR, recognizes that surface water and groundwater resources are hydrologically connected, and decisions to improve the management of one cannot be made properly without considering the other.

Specific to this Basin, conjunctive management can be accomplished by storing, re-timing, or recharging groundwater aquifers with excess surface water flows. Conjunctive management will alter the location and timing of water so it can be utilized more efficiently. According to NDNR, there are three components of conjunctive management:

1) Dual Water Source: Encouraging producers that have access to both surface and groundwater supplies to utilize surface water during years of sufficient streamflow and groundwater during

water-short years. This approach minimizes impacts to streamflow during drought years, while minimizing groundwater depletions during other periods.

2) Passive Retiming: Allowing water to seep into the aquifer to restore groundwater levels and increase baseflow to streams. This can be achieved through such mechanisms as surface water spreading, additional canal use, or injection wells.

3) Active Retiming: Using mechanical means, such as pipes, pumps, tanks, or reservoirs to store and release water as needed. These methods are often more costly than the other conjunctive management options.

5.3 Watershed Based Programs

SPARROW modeling and impairment listings provided in this Plan indicate that a majority of the nonpoint source problems in the Basin are tied to the system's response to agricultural activities. According to the results of the *Vadose Zone Assessment Report*, agricultural sources are causing an increase in nutrient leaching to groundwater aquifers, with the main concern being nitrate contamination of the groundwater.

The NRDs have been working with local agricultural producers to improve their operations by implementing land treatment and management practices. Most practices implemented through watershed programs reduce multiple pollutants, but some are more effective than others. While it is logical to promote practices that will provide the greatest benefit, landowners and producers typically construct/adopt practices that they are familiar with (conventional) and best fit their current operation. Most conventional practices are aimed at maintaining soil health and reducing runoff impacts to surface water quality. Local barriers to management practice adoption should continually be identified and addressed.

The NRDs encourage adoption/installation of practices eligible under USDA landscape conservation initiatives such as the Environmental Quality Incentive Program (EQIP), Agricultural Management Assistance (AMA) Program, Water Quality Initiative (WQI), and Wildlife Habitat Incentive Program (WHIP). Conservation practices targeted for local, state, and federal funding include those covered under the NRCS Field Office Technical Guide (FOTG) (USDA 2003) and new, innovative practices developed at the local, state, or federal level.

Of the practices listed in the FOTG, those most commonly adopted/installed by producers in the Basin include: constructed wetlands; critical area planting; fencing; filter strips; grade stabilization; integrated pest management; nutrient management; residue management; ponds and sediment basins; terraces; tree and shrub planting; and stream channel stabilization. While encouraging implementation and incentives for most of the conventional practices will be offered Basin-wide, specific practices appropriate for the management goals in a given area may be promoted through increased education, cost-share, and/or incentives. Coordination between the NRDs and NRCS on efforts can benefit actions within target areas identified in this Plan. Collaboration with all resource agencies can enhance funding opportunities for the implementation of management practices.

5.3.1 Conservation Practices

While there are a host of practices available to producers to address specific or multiple issues, there are core practices that have either been widely accepted in the Basin or have a high potential to benefit water resources. The core practices are as follows.

Crop to Grass/Alfalfa Conversion

Grasslands provide valuable environmental services. Globally, the amount of semi-arid grassland converted to cropland is unknown; however, in North Dakota, South Dakota, Nebraska, Iowa, and Minnesota alone it has been estimated that over 1.3 million acres of grassland were converted to row crop production between 2006 and 2011(Wright and Wimberly 2013). This conversion is driven by many factors including high grain prices, increasing global food demand (Tilman et al. 2011), the development of more drought resistant maize cultivars (*Zea mays*) (Chang et al. 2014), policy changes designed to produce economic development, and equipment improvements.

Significant environmental gains can be achieved in the Basin by 1) reducing the amount of current grassland put into crop production and 2) restoring current cropland to grass/alfalfa. Crop ground to grass conversions are considered by producers for multiple reasons including economic gains, wildlife enhancement, and pastureland establishment. The need for economic development and improved food production must be balanced with agricultural long-term sustainability and the services provided by grasslands (Global Food Security 2014).

Pasture Management

Healthy grasslands provide extensive environmental benefits. Grasslands used for livestock production can constitute upland pastures or riparian areas. While surface water can improve forage production throughout the growing season, it also creates additional management challenges such as periodic flooding of the adjacent riparian pasture, wet soils that may be prone to compaction damage, stream banks that are vulnerable to erosion, and fencing issues. The boundaries of a riparian pasture can be established to exclude these areas so that livestock can be easily managed to minimize disturbance during high-water periods and to allow appropriate grazing management during drier soil conditions.

Livestock find their own favorite areas to graze, drink, congregate, and rest within a riparian area. Without management, some areas will be overused and the resulting impacts will impair or destroy the riparian system. Management strategies that address livestock distribution, timing of grazing, access to water, supplemental feeding locations, and intensity and duration of use will protect wet soils and riparian vegetation during vulnerable periods (UWEX 2011). A combination of seasonal riparian management strategies can be used to develop a plan that best fits each farm's riparian resources and livestock forage needs; these combinations can increases management flexibility across the farm. Grazing management principles that are familiar to livestock producers practicing managed grazing can also be applied to riparian pastures.

Continuous No-Till and Other Low-Tillage Farming Practices

One conventional practice that will help address most of the surface and groundwater priorities in the Basin is no-till or limited tillage farming. By reducing soil erosion, conservation tillage practices and no-till acreage can significantly improve soil, water and air quality. No-till farming can reduce soil erosion by 90 to 95 percent or more compared to conventional tillage practices, and continuous no-till can make the soil more resistant to erosion over time (CTIC 2010). In fact, Baker and Laflen (1983) documented a 97 percent reduction in sediment loss in a no-till system as compared with conventional tillage practices.

Fawcett et al. (1994) summarized natural rainfall studies covering more than 32 site-years of data and found that, on average, no-till resulted in 70 percent less herbicide runoff, 93 percent less erosion and 69 percent less water runoff than moldboard plowing, in which the soil is completely inverted. Additional benefits from conservation tillage adoption are increased carbon storage, increased plant available water, and reduced water evaporation from the soil surface (Smika 1983; Hatfield et al. 2000; Pryor 2006; Su et al. 2007; Triplett and Dick 2008; Salado-Navarro and Sinclair 2009; Klocke et al. 2009; Baumhardt et al. 2010; Clay et al. 2012; and Mitchell et al. 2012). In addition to providing environmental benefits, the use of no-till practices can result in as much as a 52 percent higher producer profit than conventional till methods (UNL 2015).

Nutrient Management

Crops are not efficient at removing fertilizer and manure nitrogen from the soil during the growing cycle. Unused or residual nitrogen is vulnerable to leaching prior to the start of the next production year; especially during the fall and winter months if precipitation occurs when fields lay fallow.

The potential exists for accelerated nutrient loss when essential nutrient amounts exceed crop uptake needs. Nutrient reactions and pathways in the soil-water system are complex. Nutrient flow to surface water and groundwater vary from nutrient to nutrient as do the threats to water quality. Potential surface water impacts include sedimentation, eutrophication, and overall water quality degradation. Groundwater concerns center around the potential migration of pesticides and nitrates in recharge waters, and the resulting degradation to drinking water quality. Groundwater contributes to surface water as baseflow discharge, furthering the extent of groundwater contamination (Alfera and Weismiller 2002).

Nutrient management utilizes farm practices that permit efficient crop production while controlling nutrient runoff and percolation. Nutrient management plans must be tailored to specific soils and crop production systems. The goal of the Plan is to minimize detrimental environmental effects (primarily on water quality), while optimizing farm profits. Nutrient losses still occur with plans, but are controlled to an environmentally acceptable level. Nutrient management programs emphasize how proper planning and implementation will improve water quality and enhance farm profitability through reduced input costs. Nutrient management plans incorporate soil test results, manure test results, yield goals and estimates of residual nitrogen to generate field-by-field recommendations (Alfera and Weismiller 2002).

Cover Crops

A cover crop is grown to benefit topsoil and/or other crops intended for harvest. If the length of the growing season permits, cover crops can also be harvested prior to planting a summer crop, but they are not planted for the sole purpose of being harvested. Typical cover crops include cereal rye, oats, sweet clover, winter barley, and winter wheat. Cover crops serve two main purposes, 1) to decrease runoff, erosion and leaching between cropping seasons, and 2) to provide nitrogen to succeeding crops. They may also be used to extract surplus nutrients, reduce pest problems, and decrease runoff. The cover crop maintains these functions by keeping the ground covered, adding organic matter to the soil, trapping nutrients, improving soil tilth, and reducing weed competition. Cover cropping is a short-term practice, not exceeding one crop-year. When properly grown, cover crops or green manure may contain 1-2 percent nitrogen, 0.5-0.75 percent of phosphorus, and 3-5 percent potassium; equivalent to low-analysis fertilizing materials. Legumes are usually used as green manure (Michigan State University 1998). Crop covers can reduce soil erosion by 70 percent and runoff by 11 to 96 percent (Dillaha 1990).

Terraces and Diversions

Terraces consist of an earthen embankment, channel, or a combined ridge and channel built across the slope of the field (USEPA 1993). They may reduce the topsoil erosion rate as well as the sediment load and content of associated pollutants in surface water runoff. They have been reported to reduce soil loss by 94 to 95 percent, nutrient losses by 56 to 92 percent, and runoff by 73 to 88 percent (Dillaha 1990). Terraces intercept and store surface runoff, trapping sediments and pollutants. Underground drainage outlets are used to collect soluble nutrient and pesticide leachates, reducing the risk of movement of pollutants into the groundwater, and improving field drainage.

A diversion is very similar to a terrace, but its purpose is to direct or divert surface water runoff away from an area, or to collect and direct water to a pond. When built at the base of a slope, the diversion diverts runoff away from the bottomlands. Filter strips should be installed above the diversion channel to trap sediments and protect the diversion. Similarly, vegetative cover should be maintained in the diversion ridge. The outlet should be kept clear of debris and animals.

This practice stabilizes the drainage network and reduces soil erosion on lowlands by catching runoff water and preventing it from reaching farmland. In addition, the vegetation in the diversion channel filters runoff water, thereby improving the water quality. The diversion also serves to provide cover for small birds and animals. An additional benefit to producers includes improved crop growth on bottomlands.

Water Quality Basins

Two types of water quality basins are often used for flood control and stormwater runoff treatment: wet ponds and dry ponds. Both basins function to settle suspended sediments and other pollutants typically present in stormwater runoff. Wet ponds are also called retention ponds and they hold back water similar to a dam. The retention pond has a permanent pool of water that fluctuates in response to precipitation and runoff from the contributing areas. Maintaining a pool discourages re-suspension and keeps deposited sediments at the bottom of the holding area.

Detention ponds can serve as flood control features. They are usually dry except during or after rain or snow melt. Their purpose is to slow down water flow and hold it for a short period of time (e.g., 24 hours). These structures will reduce peak runoff rates associated with storms, decreasing flood damage. Dry ponds can be designed for a variety of storm events and purposes. The land area available for construction, slope of the site, and contributing area are all factors to be considered.

Seasonal Wetland Habitat Improvement Projects

Seasonal Habitat Improvement Projects (SHIP) are designed for drained and cropped wetlands within the RWB. The land remains in production during the growing season, but serves as migratory bird habitat during the non-growing season, when water is allowed to pond in the wetland soil area. They involve constructing a shallow berm with a stop log outlet at the low end of a field. The boards are installed after harvest so the lower end of the field floods in the fall. The boards are removed in the spring before planting to dewater the field. SHIP structures can also contribute to ground water recharge and to sediment and nutrient load reductions to streams.

Tree Planting

Riparian buffer strips consist of an area of trees, usually accompanied by shrubs and other vegetation down slope of fields and pastures that are adjacent to a body of water. They reduce the impact of non-point pollution sources by trapping and filtering sediments, nutrients, and other chemicals. When vegetated buffers are located at the edges of the crop fields, they absorb nutrients and trap phosphorus-laden sediments that otherwise would runoff of the fields.

Streambank Stabilization

Streambank protection consists of restoring and protecting banks of streams and excavated channels against scour and erosion by using vegetative plantings, soil bioengineering, and structures. Streambank erosion is a process that occurs when the forces exerted by flowing water exceed the resisting forces of bank materials and vegetation. Stream erosion refers to the active erosion within a stream channel or adjacent floodplain. The erosion can be the result of lateral instability (bank erosion) or vertical instability (gullying).

Eroding stream banks can be a major contributor of sediment and other pollutants to rivers, lakes, and streams. The principal causes of bank erosion may be classed as geologic, climatic, vegetative, hydrologic/hydraulic, or human induced. These causes may act independently, but normally work in an interrelated manner. Erosion occurs in many natural streams that have vegetated banks; however, land use changes or natural disturbances can cause the frequency and magnitude of water forces to increase. Loss of streamside vegetation leads to reduced resistance; making stream banks more susceptible to erosion. Benefits of streambank protection include, but are not limited to, the following:

- Prevent the loss of land, soil, and vegetation adjacent to a watercourse
- Minimize damage to utilities, roads, buildings or other facilities adjacent to a watercourse
- Reduce sediment loads to streams
- Maintain the capacity of the stream channel and control unwanted meander of a river or stream
- Improve the stream for recreational use or as habitat for fish and wildlife.

Undesirable/Invasive Species Removal

Several invasive vegetation species, such as eastern red cedar (*Juniperus virginian*a), honey locust (*Gleditsia triacanthos*), and mulberry (*Morus*), have created a dense cover surrounding the Little Blue River and its tributaries. Dense vegetation limits the diversity of native plants growing in the riparian corridor often resulting in barren soils during the non-growing season. This leads to a sediment pollutant source, limitation of wildlife habitat, obstructions in the waterway, and evapotranspiration. Removal of vegetation, including physical removal of trees and disking of the river bed, has several benefits:

- Water conveyance efficiency through removal of blockages, which will maintain and enhance stream flows in the river system.

- Higher river base flows and reduced flood damage resulting from the elimination of noxious plants and in-channel vegetation blocking river flow.

- Riparian forest health is improved through selective cutting of undesirable eastern red cedar and other invasive species.

- Re-establishment of natural landscapes to promote native plants, aquatic habitat for game and fish species through removal of non-beneficial plant species.

- Livestock grazing and haying by restoring riparian areas and suppressing invasive plants after treatment.

- Long-term control of invasive plants within and adjacent to stream channels to prevent wasteful consumptive use of water and help mitigate degradation of water supply.

In the past these undesirable/invasive species management efforts have been led by the Twin Valley Weed Management Area (TVWMA) through LBNRD (LBNRD 2013).

<u>Soil Sampling</u>
As determined by the Steering Committee, soil sampling is one of the most important practices to address groundwater nitrate contamination. The primary objectives of soil sampling are to determine the average nutrient status and degree of variability in a field in order to allow for applying fertilizer at calculated agronomic rates. Correct fertilizer use, based on accurate information about soil fertility levels in fields, can result in increased crop yield, reduced cost, and minimized environmental impact. Knowing a field's nutrient status variability means fertilizer application can be adjusted to more closely meet the supplemental nutrient needs of a crop for specific field areas. Soil sampling is beneficial when applied with management practices that reduce nitrate application, and therefore reduce loading to surface and groundwater resources.

<u>On-site Wastewater System Improvements</u>
Inadequate on-site wastewater systems can contribute to bacteria loading and has been identified as a concern. Although no data were collected as part of the planning effort on the locations or conditions of systems, it is important to consider a cost-share program for upgrading inadequate systems. Within target areas, the NRDs should consider addressing problems with systems through Basin-wide education and voluntary repair/upgrades with possible cost-share assistance.

5.3.2 Pollutant Reduction Efficiencies

It is very difficult to categorize the effectiveness of any given management practice. Effectiveness is often a function of local conditions, including soils, topography, climate, and crop management. Other factors such as proper site selection, installation, maintenance, and degree of implementation are also critical to how well a practice performs. In addition, most practices are used not alone, but in conjunction with one or more complimentary practices.

Pollutant removal efficiencies for several watershed-based practices have been well documented by EPA and are provided in Tables 5-X, 5-Y, and 5-Z. While these performance estimates can be used for planning purposes, actual performance may be much different than documented in the literature. Whenever possible, management practice performance should be measured locally and documented for future planning purposes.

Because data on bacteria removal are limited, both in the number of data points and the representativeness of the data, rigorous statistical conclusions cannot be drawn based on available data. Significantly more studies are needed for all BMP types to increase the confidence of performance estimates with regard to bacteria (Jones 2012).

Table 5-1: Pollutant Removal Efficiencies for Targeted Watershed Based Practices

Practice\Pollutant and Removal	Sediment (%)	Phosphorus (%)	Nitrogen (%)
Terraces[1]	85	70	20
Reduced Tillage[1]	75	45	55
Diversions[1]	35	30	10
Streambank Stabilization & Fencing[1]	75	-	-
Wetlands[1]	78	44	20
Wet Detention[1]	86	69	55
Filter Strips/Buffers[1]	65	75	70
Dry Detention[1]	58	26	30
Nutrient Management[2]	-	35	15
Cover Crops[3]	70	-	-
Average Reduction	70	49	34

Note: Pollutant trapping efficiencies were taken from: 1) Statistical Tool for the Estimation of Pollutant Load (STEPL) model (TetraTech 2003), 2) Pennsylvania University 1991, and 3) Dillaha 1990.

Table 5-2: Practices for Reducing Atrazine Runoff from Dryland and Irrigated Corn Ground (Franti 1997)

Management Practice	Potential Percent Reduction[(a)]	Mulch Till	Ridge Till	No-Till
Alternative Herbicides	100	Yes	Yes	Yes
Crop Rotation	50-66	Yes	Yes	Yes
Herbicide Rotation	50-66	Yes	Yes	Yes
Band Application	50-66	Yes	Yes	No
Soil Incorporation	35-66	Yes	No	No
Post Application	50	Yes	Yes	No
Early Pre-plant	50	Yes	Yes	Yes
Split Application or Split Application with Post Alternatives	33-50	Yes	Yes	Yes
Reduced Rates and Combination Products	33-50	Yes	Yes	Yes

(a) Percent reduction is based on potential reduction in atrazine runoff compared to 100% surface spray applied to each crop.

Table 5-3: Effectiveness of Traditional Management Practices in Reducing Pesticides

Management Practice	Potential Percent Reduction[(a)]
Terrace	0 - 20%
Contouring	0 - 20%
Conservation tillage	-40% - 20%

Grassed waterways	0 - 10%
Sediment basins	0 - 10%
Filter strips	0 - 10%
Cover crops	-20% - 10%
Optimal application techniques	40% - 80%
Crop rotation	0 - 20%

Source: World Bank 2003

5.4 Urban Conservation Practices

Urban conservation practices have been included within the Plan to allow Cities and Villages an opportunity to install small scale practices that can reduce pollutant loading from stormwater runoff, conserve water, and provide an opportunity for education. In many cases urban conservation practices can be utilized in public places, such as parks, and serve as demonstration sites for educational purposes. Below are several urban conservation practices commonly used within municipalities.

Bioretention Cells

Bioretention is the capturing and facilitating of stormwater runoff infiltration from impervious surfaces to reduce water pollution and reduce stream flows. Bioretention cells have an engineered and constructed subgrade to ensure adequate percolation and infiltration of captured runoff. Bioretention cells can be used in most settings including parking lots and residential areas where soils don't adequately percolate. They use plants that can tolerate a wide range of moisture conditions. Native plants are encouraged because they are deep-rooted, maintain soil quality, and provide percolation of rainwater. A limiting factor for placement of a bioretention cell may be the lack of an outlet for the subdrain. An outlet is necessary to ensure proper drainage. The subdrain often outlets into the storm sewer or can discharge down-gradient of the bioretention cell.

Bioswales

Bioswales are vegetated paths installed as an alternative to underground storm sewers. The bioswale is engineered so runoff from frequent, small rains infiltrate into the soil below. When larger storms occur, bioswales slow the flow of runoff while using above ground vegetation to filter and clean the runoff before it ends up in the local stream. For example, if a low-flow concrete liner needs an expensive repair, and alternative would be to install a vegetated bioswale.

Native Landscaping/Turf

Native vegetation enhances a landscape's ability to manage stormwater, and also require less water to survive. Diversified habitats with native vegetation encourages use by birds, butterflies, and other wildlife. In most cases, native vegetation doesn't require fertilizer or pesticides for survival. Native landscaping and turf can replace bluegrass and other non-native water sensitive species commonly used in communities.

No-phosphorus Fertilizers

Nutrients are essential for plant growth, especially nitrogen, phosphorus, and potassium. Fertilizers, pesticides, animal waste, and detergents commonly include nutrients. Excessive phosphorus loading is a leading contributor to algae growth, which lowers water quality and causes several issues in community lakes.

Rain Gardens

Bioretention features, often referred to as 'rain gardens', are a small-scale structural conservation practice commonly used for stormwater quality improvement in urban areas. When properly designed and maintained, they can offer highly efficient reduction of phosphorus, as well as other pollutants, and are highly aesthetic.

A rule of thumb for sizing rain gardens is to use 10 percent of the impervious area (e.g., rooftops) to determine the size of the rain garden. Rain gardens are usually sized to temporarily pond runoff generated by a 1.25 inch rainfall event. Ponded water should infiltrate into the soil within 24 hours. Soils can be amended with sand and compost if topsoil quality is questionable. Plants with deep roots are encouraged to help maintain soil quality and increase percolation rates.

Urban Soil Quality Restoration

Healthy soil is the key to preventing polluted runoff. As buildings and houses are built, top soil is removed and the remaining sub-soil is compacted by grading and construction activity. The owner is left with heavily compacted subsoil, usually with high clay content and little organic matter. Soil quality restoration is simple - start by reducing soil compaction and increasing organic matter content with the addition of compost. Soil quality restoration can be completed on any existing yard, making this one of the easiest water quality conservation practices to implement.

Urban Wildlife Management

Bird droppings below bridges, underpasses, and on shorelines can be a significant source of *E. coli*, as well as phosphorus, in all watersheds. Several methods are available to either control the wildlife population or discourage wildlife from using sensitive areas. Bird activity under bridges and overpasses can be limited by retrofitting older bridges and overpasses crossing streams to modify habitat to reduce feeding, watering, roosting, and nesting sites for birds. Other visible perching sites, such as light posts, could be considered for placing mechanisms to discourage perching. Waterfowl can be discouraged from using shorelines by establishing tall grass buffer zones with controlled access areas. Trained dogs can also be used to control nuisance Canadian geese.

5.5 In-lake Based Practices

Several in-lake improvement alternatives have been identified that improve both water quality and restore aquatic habitat. These actions are intended to improve recreational amenities within the Basin by protecting or renovating existing facilities. Lakes targeted for improvements, listed in the Implementation Strategy, may each utilize some of the following lake renovation management practices.

Wetland Enhancement/Creation

Opportunities are available to enhance existing wetlands in the inlet area of several Basin reservoirs. Wetland enhancements can benefit water clarity by removing nutrients and sediments, and reducing bacteria through attenuation. Phosphorus reductions are a priority, and water quality benefits can improve fisheries. In addition, the inlet area of reservoirs service as a location for bird watching, fishing, and hiking. Secondary benefits of wetland enhancements include aesthetics, wildlife habitat creation, and restoration of the ecosystem's natural functionality.

Fish Renovation and Fishery Aquatic Habitat Features

Fisheries renovation and the restoration and enhancement of in-lake fish habitat can help decrease sediment and nutrient re-suspension and restore healthy ecosystem functions, including riparian and littoral vegetation. A focus of fishery renovation oftentimes involves removing rough fish, such as common carp. NGPC often leads fishery renovations with funding through their Aquatic Habitat Stamp program, and have plans for improvements at several of the Basin reservoirs. Potential in-lake restoration components might include shoreline stabilization, shoals, scallops, spawning beds, etc. Each lake is often unique in its fishery strengths and weaknesses. Specific combinations of habitat improvement techniques can help to improve fisheries at targeted lakes.

Shoreline Stabilization

As reservoirs age, they lose depth due to sediment deposition from the watershed. Shoreline/bank erosion processes can add additional sediment to the reservoir while affecting the depth and habitat diversity of shorelines. Physical factors, such as bank height, prevailing winds, fetch, and the amount of vegetation on the banks and in the water, can dictate the extent of shoreline erosion. Bank stabilization practices should be recommended based on a reconnaissance survey of each waterbody. A combination of rip rap (hard armor) and tall grass management or tall grass buffers are common for stabilization of shoreline. Operation and maintenance changes can also support a more stable shoreline by limiting mowing and allowing a healthy stand of vegetation to support the banks along shorelines.

In-lake Sediment Forebays

Utilizing a portion of an existing reservoir, adding additional reservoir area above the existing reservoir, or a combination of both as a sediment/water quality basin is another means of minimizing the potential for materials to enter the main basin of a lake. Forebays, are commonly created at the headwaters of the reservoir to serve as an initial ‘trap’ for sediment and other pollutants. Forebays are multi-beneficial and can be comprised of soil or rock which can serve additional purposes (e.g., fishing jetty). In-lake sediment forebays can reduce sedimentation to the reservoir, capture nutrients, and promote establishment of wetlands as a natural filter. The layout of forebays allows for easier access of equipment to remove sediment when excavation efforts are necessary.

Sediment Management - Targeted Dredging

Removal of sediment in targeted areas can help improve water quality. The following is a summary of water quality benefits resulting from targeted dredging:

- Increased depth in shallow areas reduces sediment re-suspension and increases water clarity
- Targeted dredging is likely to improve fish habitat, thereby increasing the water quality benefits associated with fishery renovation.

Sediment Management - Whole Lake Dredging

Whole lake dredging involves draining the reservoir and physically removing sediment from the lake bottom. Similar to the benefits of targeted dredging discussed above, dredging in general increases the depth and storage capacity of a lake. When done correctly, depth diversity and habitat improvement designed into the dredging plan usually results in overall water-quality improvement when considering clarity, habitat, and overall aquatic function.

In-lake Nutrient Management Practices

The amount of nutrients entering a lake system and the timing of those loads are important in algal production, and thus, lake nutrient management. In-lake nutrient management alternatives include phosphorus inactivation, aeration, and bottom sealing. Aeration and phosphorus inactivation address hypolimnetic phosphorus release by minimizing the low oxygen conditions that allow for bottom sediments to release phosphorus into the water column. Phosphorus inactivation typically involves the addition of alum, which adheres to the phosphorus; thus preventing phosphorus from entering the water column. In-lake tools should be considered if internal sources of phosphorus (e.g., lakebed sediments) are found to be a significant portion of the overall nutrient budget.

Bottom sealing may be a useful management practice in systems such as Crystal Lake, which is a former Little Blue River oxbow that is dependent upon groundwater. When groundwater levels significantly decline during the irrigation season, the water quality of Crystal Lake declines.

5.6 Groundwater Quality Practices

Well Abandonment

Unsealed or improperly sealed wells may threaten public health and safety, and the quality of the groundwater resources. Therefore, the proper abandonment (decommissioning) of a well is a critical final step in its service life. Proper well abandonment accomplishes the following:

- Eliminates the physical hazard of the well (the hole in the ground),
- Eliminates a pathway for migration of contamination, and
- Prevents hydrologic changes in the aquifer system, such as the changes in hydraulic head and the mixing of water between aquifers.

Stay On Irrigated Acres

Irrigation is the largest user of groundwater resources, as well as the largest contributor of nitrate in the Basin. Of the land-use categories, grass and pasture land are the most effective at preventing nitrate leaching and lowering water consumption, and are extremely efficient management tools. Limiting the number of acres that convert from pasture or grassland to irrigated cropland will not necessarily decrease current levels of consumptive use or nitrate loading, but it will prevent increases or worsening of current conditions. Irrigated acre stays initiated for the purpose of achieving nitrate goals should focus on areas within or surrounding Wellhead Protection Areas (Figure 2-7), while stays initiated for maintaining groundwater levels should focus on areas with the greatest groundwater level declines (Figure 2-19).

Targeted Nitrogen Application

Targeted nitrogen application has the basic goal of reducing the total amount of nitrogen applied through sampling measures. Over-application of nitrogen fertilizers can occur in production agriculture settings. Crop consultants and soil sampling can benefit nitrate leaching goals when the use of these products leads to decreases in application rates and volumes. Targeted application may also decrease the timeframes for fertilizer application to months that the crops can effectively uptake the nutrients. Research also suggests that producers should consider the amount of nitrate applied to the crops that originates from groundwater. In areas with elevated groundwater nitrogen levels, groundwater irrigators could be applying significant quantities of nitrogen without additional fertilizers. Producers and crop consultants should consider groundwater nitrate levels due to irrigation water when calculating fertilizer rates for fields.

Cover Crops

Cover crops reduce nutrient leaching and runoff. Cover crops have longer growing seasons and are able to utilize nutrients for months outside of the traditional growing season. The amount of nitrate that cover crops prevent from leaching into surface or groundwater resources is highly variable. The effectiveness of cover crops depends upon the plant or plant mix chosen for the cover crop, as well as other field-scale management practices. Proper monitoring programs are necessary to quantify the amount of nitrate reduction that results from cover crops.

Crop Rotation

Fields planted with continuous corn tend to show the highest vadose nitrate levels. Rotating corn with other crops tends to lower nitrate leaching, and demonstrates other benefits including improving soil health and reducing pesticide/herbicide resistance. Any crop can be used in rotations. Three-crop rotations are the most beneficial in terms of reducing nitrate loads.

Crop Selection

Planting crops other than corn reduces the level of nitrate loading through the soil profile and to groundwater. Alfalfa, or similar crops, are particularly efficient at reducing soil nitrate loading. Programs designed to encourage planting of alfalfa could be either district-wide or focus within Wellhead Protection Areas, depending upon the goal of the program.

5.7 Groundwater Recharge Practices

In recent years, a movement toward non-structural and small-scale solutions are preferred by permitting agencies and advocates for the environment. Non-structural measures that take advantage of the natural environment and processes can provide other benefits such as aesthetics and some habitat function. Therefore, the best alternatives are often a function of the collective project benefits desired and the programs available to help fund the project.

The groundwater recharge practices described below include non-structural practices, small-scale structures, and large-scale structures.

Conservation Practices

Any conservation practice that promotes soil moisture retention will provide some recharge benefits. Practices like no-till farming can play a significant role in reducing runoff; resulting in more available water for recharge and reduced needs for irrigation. Given that no-till farming can reduce runoff by 69 percent from fields currently tilled, wide-spread adoption of this practice across the Basin would provide substantial recharge benefits.

Modifications to Existing Structures

The Basin has an extensive, existing impoundment infrastructure, including many small dams and reservoirs. If these structures can be modified or enhanced to provide new or increased recharge benefits, recharge goals may be achieved more quickly and at a reduced cost than is possible through construction of new structures. The extent of modifications needed often depends on whether the structure will be utilized for conjunctive management purposes.

In-stream Weirs

In-stream weirs are small-scalestructures located within stream banks which can be used to impede stream flow; creating shallow pools for increased recharge. These pools can increase water infiltration to the underlying aquifer. The weirs may be equipped to slowly allow flow to pass through the structure, while temporarily detaining additional water during larger rainfall events. Excess flow from larger rainfall events would pass over the weirs. In-stream weirs can also provide benefits to biological communities, and if placed properly can provide grade control for the streambed. In general, in-stream weirs are effective because they take advantage of the proximity of available aquifer storage to the source of the water. Low-head solutions,which do not have to meet dam safety requirements, can provide environmental and stream health benefits as well. In-stream weirs are small-scale conjunctive management projects.

Off-Channel Diversions
Off-channel diversions, including temporary off-season water storage, include structures located along or within a stream channel that allow diversion of water into off-channel areas during periods of excess flows from heavy rainfall events. The diverted water is stored and allowed to spread out and soak through the unsaturated zone to the underlying aquifer. Off-channel areas are large low-lying areas that can include former sandpits, old oxbows, existing wetland areas, or water quality basins. The effects and implementation of off-channel diversions are similar to diversions for surface water canal systems, but are typically active only during large flow events.

Large-Scale Structures
Dams or major canals are examples of large-scale structures. Recharge at dams takes place in the areas directly below the impounded pool, and through controlled water releases to promote downstream recharge in the channel. Most of the larger structures detain flood water, which can be released at a rate that matches the capacity for infiltration into underlying aquifers, thereby significantly enhancing recharge. These controlled releases can also be used to supplement stream flows during critical periods. Water can recharge through the canal structure, and canals can also deliver water to recharge basins at locations further from the point of diversion.

When large-scale water quality and water quantity improvements are desired, projects capable of providing benefits associated with water quality and quantity (sediment/nutrient reduction, groundwater recharge, etc.) usually follow the same economic principal that other systems realize; the benefits are often maximized by taking advantage of economies of.

It is recognized that large, structural projects may offer a desirable benefit to cost ratio, but may face other challenges including public acceptance, water rights, legal considerations, and permitting.

5.8 Summary and Conclusions

Given the comprehensive nature of this Plan a wide variety of management practices should be considered and used in combination to enhance the project's benefits. Prior to project planning, it will be important to coordinate efforts with other agencies, such as NRCS, NDEQ, NDNR, NGPC, RWB Venture, and neighboring NRDs. Discussion with property owners and Basin stakeholders to determine the level of cost-share or financial incentive necessary to trigger wide-spread implementation will be necessary prior to selecting management practices. When project planning begins, a variety of management practices will need to be utilized. For example, when planning for a recharge project using in-stream weirs, incentives for soil health initiatives within the project area should also be offered.

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