REDUCING SOIL EROSION IN THE CLARKS FORK OF THE YELLOWSTONE RIVER WATERSHED

Improving surface water quality of the Clarks Fork of the Yellowstone River by decreasing soil erosion in sugar beet rotations through Reduced Tillage and Sprinkler Irrigation conservation practices. FY20-FY24.

USDA United States Department of Agriculture

Above photo: Larry Mayer, Billings Gazette, April 2015

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OVERVIEW

Since the early 1900s, sugar beets have been an important cash crop for farmers in Carbon County, Montana. However, conventional sugar beets are produced with intensive tillage and little crop residue is left after harvest. This creates the potential for large amounts of soil erosion via both wind and furrow irrigation. Although sugar beets are grown on only about 9,000 acres in Carbon County, they are one of the most erosion-inducing crops, and they create some of the largest resource concerns on a per acre basis in comparison with other crop systems. This erosion has negatively altered the Clarks Fork of the Yellowstone River, which is listed on the Montana Department of Environmental Quality's (DEQ) 303d list for nitrogen, phosphorus, and sediment impairments. This watershed is also labeled as a Source Water Priority Protection Area (SWPPA) by the USDA Montana Natural Resources Conservation Service (MT NRCS), in accordance with the 2018 Farm Bill (Figure 1).

This project's goal is to reduce soil erosion from wind and furrow irrigation in sugar beet rotations along the Clarks Fork of the Yellowstone River in Carbon County. The goal will be achieved by contracting the reduced tillage and sprinkler systems and other facilitating conservation practices on a total of 2,000 sugar beet acres over 5 years. The geographic target area is any cropland in a sugar beet rotation in the SWPPA in Carbon County.

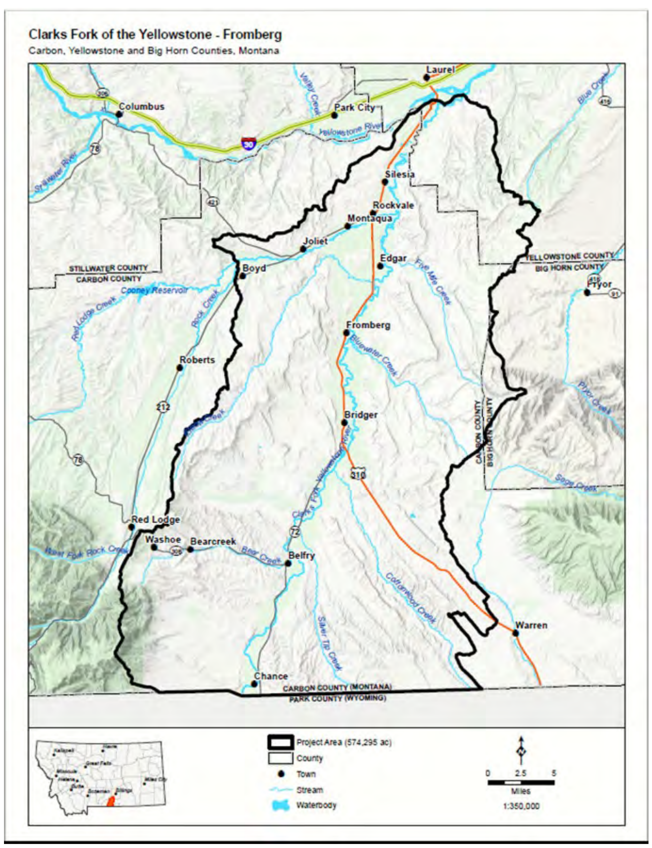

Figure 1. Clarks Fork of the Yellowstone River watershed boundary designation as a SWPPA.

BACKGROUND AND PROBLEM STATEMENT

Sugar beets have been grown in the irrigated river valleys around Billings since at least 1906, with the opening of the Western Sugar beet processing factory (Western Sugar Coop website). Beets continue to play a large role in Carbon County agriculture and all beets grown in the county are purchased by the Western Sugar Cooperative and processed at the factory in Billings.

Beets are a high-value crop, intensively grown on irrigated river valley land on the most productive soils. Conventional beets have historically been grown with a large amount of tillage compared with other crops. Historically, it was common for a producer to make 12 tillage passes over a field in the beet year alone due to the field preparation of moldboard plow, disc ripping, land levelling, ridging, in-crop cultivation, and harvesting required for production.

EROSION ISSUES

This intensive tillage has led to large amounts of soil erosion due to the dual factors of wind erosion and water erosion induced by furrow irrigation. After the enactment of the 1985 Food Security Act, producers participating in USDA farm programs were required to create conservation plans that would reduce erosion values to below two times the allowable annual erosion limit ("T"). Beet farmers in Montana came together and met with the MT NRCS state agronomist in the late 1980's to protest this rule and to make their case that this was not possible for beet production at the time. MT NRCS agreed with their assessment and granted a state-wide Highly Erodible Land Compliance (HELC) exemption for beet production.

This allowance by NRCS was appropriate at the time. However, beet production has greatly advanced since the 1980's and growers now have the ability to reduce their tillage due to the advancement of technology. Improved seed and planter technology allowed for precise seed placement in the soil. Satellite guidance steering systems now allow for accurate tractor guidance and seed placement within a half-inch of the desired location and eliminate the need for thinning the young beet stand via cultivation. The release of Roundup-Ready™ sugar beets in 2007 finally made it possible for growers to discontinue in-crop tillage for weed control. In addition, installation of sprinkler irrigation has reduced the need for farmers to till ridges for furrow irrigation. Together, these advances have now made it possible for beet growers to reduce their tillage and reduce soil erosion. Several beet farmers in MT have made the switch to reduced tillage, with some even forgoing all tillage except for the harvest digging operation. However, we estimate that about 80% of beet farmers continue to use a high amount of tillage for beet field preparation, even with the advancement of new technology.

As recently as 2015, the effects of this tillage were on display. A large windstorm hit the Billings area in March, creating a giant dust storm that shut down the Interstate and resulted in one traffic fatality. The Billings Gazette ran a front-page article on the windstorm (Lutey, 2015) and took photos of the damage west of town. Farmers across multiple counties lost their newly-emerged barley crop due to blowing sediment and had to replant.

***Figure 2**. March 2015 dust storm near Billings, MT. Photo credit: Larry Mayer, Billings Gazette*

From 2016 to 2019, MT NRCS interviewed seven farmers across Montana to estimate wind erosion values in conventional beet systems. Information collected was entered into the NRCS Wind Erosion Prediction System (WEPS) to model erosion for a defined area and time period. WEPS output results are listed in Table 4. Notice there is a wide range of values, from 3.1 to 29.5 ton/acre/year. Most soils in these rotations have a T, or allowable annual soil loss, of 5 tons/acre/year. Our professional experience indicates that most wind erosion values from conventional beet production is equal to or greater than this T value.

Furrow irrigation only adds to the erosion problem. Furrows create perfect drainage channels for water to wash away sediment and carry it directly to the river (Figure 3). Most beet fields in Carbon County are oriented east to west to accommodate drainage towards the river, resulting in a large sediment load carried to the Clarks Fork every year. In addition, most of the irrigated soils in the Clarks Fork Valley are silty clay loams. These soils have low infiltration rates and are particularly susceptible to runoff if irrigation water is over-applied or applied at rates that are greater than the intake rates of the soils. As an example, 2018 was a year with greater than average precipitation. Spring rains made it difficult to get in the field and many conventional sugar beet fields washed out due to flooding directly down the furrows. Even in a normal precipitation year, the irrigation induced erosion can be enough to exceed the T value of the soil without the addition of wind erosion. As a result, to mitigate soil erosion in the Clarks Fork valley, reduced tillage should be coupled with sprinkler irrigation. Conversion from furrow to sprinkler irrigation removes the need for furrows and positive drainage. Thus, rows can be planted perpendicular to the natural slope of the field rather than parallel to the slope.

Figure 3. *Water washing out the corner of a conventionally tilled beet field (left). Washed-out furrows after a heavy rainstorm (right). Carbon County, 2018. (Photo: Greg Schlemmer (left), Tasha Gibby (right).*

We interviewed two Carbon County farmers with furrow irrigation and used the MT NRCS Irrigation Manual (1983, Koluvek, Curtis and Light) to calculate furrow irrigation sediment yields. In both cases, the irrigation-induced erosion alone exceeded the T value for each soil. Results are listed in Table 1.

Table 1. *Irrigation-induced and total erosion in conventional beet production, Carbon County, MT.*

Farmer	Rotation	Average Annual Irrigation-induced Erosion (tons/acre/year)	Average Annual Wind Erosion (tons/acre/year)	Average Annual Total Erosion (tons/acre/year)
B	Beet-barley-barley	7.1	3.8	10.9
C	Beet-barley-silage corn	9.7	29.5	39.2

WATER QUALITY ISSUES

The MT DEQ lists 43 miles of the Clarks Fork of the Yellowstone River on the 303d list, from Bridger Creek to the confluence with the Yellowstone River (MT DEQ, 2018). The listed impairments are nitrate-nitrite, Total N, ammonia, phosphorus, and sediment, among others, with irrigated crop production listed as a possible cause. It is not possible to say with certainty if agriculture is the primary cause of these impairments, as DEQ has not completed an assessment for the watershed (MT DEQ, 2017). However, reducing soil erosion on nearby fields will improve water quality and help address the listed impairments.

In addition, the Clarks Fork watershed has been designated by MT NRCS as a SWPPA watershed for the 2018 Farm Bill, based on recommendations from multiple partners including the MT DEQ and MT Rural Water Systems (Figure 1). There are two main public source water concerns in this watershed. The first is the possibility of excess nutrient loads within the Clarks Fork contaminating the City of Fromberg's municipal water supply. Also, both Billings and Lockwood have intakes on the Yellowstone River below the Clarks Fork confluence and have serious sedimentation issues during high run-off events. During these events, the Clarks Fork is noticeably more turbid than the Yellowstone River at their confluence; thus, visually illustrating the significance of the sediment loading generated within the designated watershed.

We estimate about 9,200 acres are in some phase of a beet rotation in any given year in Carbon County. Western Sugar requires that growers have a three-year rotation, with 2-years of alternative crops in between each beet year. Typical rotations include beets-malt barley-malt barley and beets-malt barley-silage corn. United States Department of Agriculture (USDA) National Agriculture Statistics Service (NASS) data from 2018 gives a three-year average of 3,066 acres of sugar beets per year in Carbon County from 2015 to 2017 (Table 2). Multiplying this amount by 3 to account for a typical three-year rotation results in 9,200 total acres.

Table 2. *Average beet acres per year in Carbon County, 2015-2017 (USDA NASS).*

Year	Beet acres harvested in Carbon County
2015	3,300
2016	3,100
2017	2,800
AVERAGE	**3,066**

Our professional estimate is that about 80% of these beet acres are farmed with conventional tillage, the scope of the problem encompasses 7,360 acres. These acres are primarily located in a narrow strip on either side of the Clark Fork River from the Wyoming border to the confluence with the Yellowstone River (Figure 4).

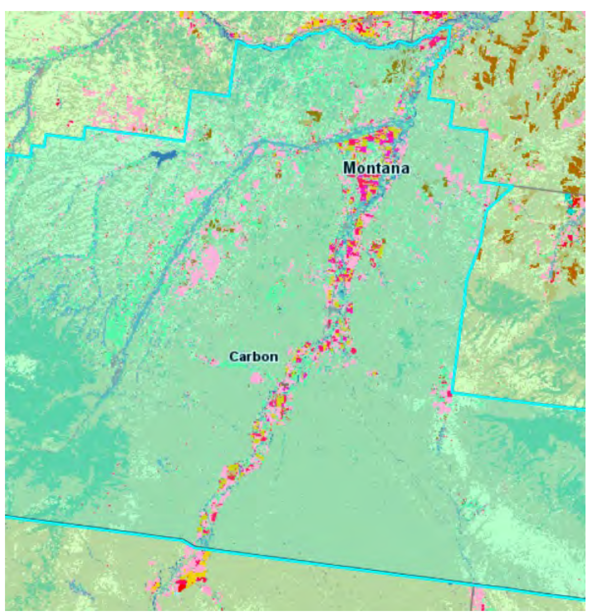

Figure 4. *2018 sugar beet fields along the Clarks Fork of the Yellowstone indicated in dark pink (USDA NASS Cropscape, 2018).*

GOALS AND OBJECTIVES

The goal of this Targeted Implementation Plan (TIP) is to reduce wind and irrigation-induced soil erosion on 2,000 conventional beet production acres in the Carbon County SWPPA within 5 years. Each field in the program will have a final erosion level of less than T over the average length of the rotation, thereby reducing the sediment and nutrient load to the Clarks Fork watershed.

The objective is to target irrigated crop fields which have produced sugar beets within the past 3 years, that have wind erosion above the NRCS soil loss tolerance, where producers are willing to reduce their tillage to an average annual Soil Tillage Intensity Rating (STIR) level of 80 or below and maintain a positive Soil Conditioning Index (SCI) rating throughout the entire crop rotation as well as reduce their average annual soil erosion to less than the soil loss tolerance of each field. To cost share center pivot irrigation to address the irrigation-induced erosion resource concern by discontinuing the use of furrow irrigation.

STIR is a measure the of the level of tillage disturbance, with greater values indicating greater disturbance. Each piece of machinery is assigned a STIR value in WEPS. For example, a moldboard plow is assigned a STIR value of 65, while a double-disc drill is assigned a STIR value of 6. To calculate the average annual STIR value, WEPS adds each individual machinery STIR value for the entire rotation and divides by the number of years in the rotation. A STIR of 80 or less is required to meet the NRCS standard for Reduced Tillage (345), while a STIR of 20 or less is required to meet the NRCS standards for No-Till (329).

SCI is a unitless measure of the soil organic matter trend, normally ranging from -2 to +2 in annual crop systems. A positive SCI indicates an increasing trend in soil organic matter, while a negative SCI indicates a decreasing trend in soil organic matter. The size of the number indicates the magnitude of the trend. For example, a field with an SCI of +1.2 is gaining soil organic matter more rapidly than a field with an SCI of +0.3.

The NRCS WEPS software and the MT NRCS Irrigation Manual will be used to measure the benchmark wind and irrigation-induced erosion levels on each field. WEPS will be used to measure the planned wind erosion levels, and the STIR and SCI values. Note that no measurement of the planned irrigation induced erosion is required because sprinkler systems are designed to have minimal runoff per CPS 442.

Workshops will be provided by local staff and Area Agronomist during the signup period to inform producers of the extent of the erosion problem, farming practices to reduce erosion, and TIP program requirements.

ALTERNATIVES

To solve the problem, multiple alternatives have been considered. These include:

ALTERNATIVE ONE – NO ACTION

NRCS will not provide technical assistance or financial assistance to reduce erosion in beet systems in the Clarks Fork River Valley. The likely outcome will be soil erosion by wind and furrow irrigation continuing at high levels and the watershed impaired by sediment and nutrients for the foreseeable future. Farmers may slowly adopt reduced tillage and improved irrigation practices as they see the success of early-adopters. However, the rate of adoption will be slower than desired, due to the hurdle of funding expensive infrastructure improvements when the price for sugar beets and other commodity crops is at a decadal low.

ALTERNATIVE TWO – RESIDUE AND TILLAGE MANAGEMENT, REDUCED TILL (345), SPRINKLER SYSTEM (442), IRRIGATION PIPE (430), PUMP (533), AND STRUCTURE FOR WATER CONTROL (587)

NRCS will provide beet farmers in the Clarks Fork Valley with financial assistance to implement reduced tillage and sprinkler system improvements. Reduced tillage will require a producer to change his field management operations to a STIR equal to or below 80 and a positive SCI for the entire rotation. Sprinkler System improvements will stop the overland flow of surface water via furrow irrigation and minimize sediment and nutrient loads to the Clarks Fork watershed. Financial assistance will be given for Residue and Tillage Management- Reduced Till (345), Sprinkler System (442), Irrigation pipeline (430), Pumping Plant (533), and Structure for Water Control (587), as needed. Irrigation Water Management (449) and Nutrient Management (590) will be included in the conservation plan but will not be included in the contract. During the planning process, the rotation and field operations will be designed such that the combined wind and irrigation-induced erosion levels of the planned condition will be T or less over the average duration of the rotation. The likely outcome of this alternative is a 30% reduction in soil erosion in beet rotations in Carbon County after 5 years. This assumes 7,360 acres are currently in conventional tillage, and 2,000 acres can be converted to reduced tillage.

ALTERNATIVE THREE – COMPLETE RESOURCE MANAGEMENT SYSTEM

NRCS will provide beet farmers in the Clarks Fork Valley with financial assistance to implement a complete package of conservation practices that minimize soil erosion via wind and water, according to the individual needs of the producer. The conservation practices will include Residue and Tillage Management – Reduced Till (345) for 3 years, Sprinkler System (442), Irrigation Pipeline (430) Pumping Plant (533) and Structure for Water Control (587) as well as Conservation Crop Rotation (328), Nutrient Management (590), Cover Crop (340), Irrigation Water Management (449), and possibly more. With Conservation Crop Rotation, producers will be encouraged to alter their crop rotations to include more forage crops such as alfalfa, or grass hay, which keep the soil covered during the most erosive months of November to March. Nutrient Management will require producers to soil test annually and apply fertilizer at or below the recommended agronomic rate or use slow-release fertilizers to reduce nitrate leaching losses to groundwater. Cover crops will increase soil stability and resilience by adding carbon to the soil through increased root and shoot biomass. The likely outcome of this alternative is also a 30% reduction in soil erosion in beet rotations in Carbon County after 5 years, as we target 2,000 acres to be converted to reduced tillage.

PROPOSED SOLUTION

The proposed solution is Alternative Two, providing financial assistance to contract Residue and Tillage Management – Reduced Till (345), Sprinkler System (442), Irrigation Pipeline (430), Pumping Plant (533) and Structure for Water Control (587). This is the preferred alternative as it targets the most likely causes of erosion, tillage and furrow irrigation. Alternative One is not acceptable, as the status quo will maintain high levels of soil erosion. Alternative Three is of value, but the additional conservation practices will require additional staff time to implement with only a small incremental benefit compared with Alternative Two.

Residue and Tillage Management – Reduced Till (345) will be the primary conservation practice of the solution, as it requires producers to reduce their STIR to 80 or less and maintain a positive SCI. This practice will be contracted for 3 years, to help program participants apply residue and tillage management through their cropping rotation.

Irrigation improvements will be contracted with the Sprinkler System (442) Conservation Practice Standard (CPS), which will increase the water efficiency, as measured by the Farm Irrigation Rating Index (FIRI). In addition, deep percolation of nutrients into groundwater will be minimized by discontinuing the deep saturation of soils via flood irrigation. Surface runoff will also be minimized with irrigation improvements.

Table 3. *Core conservation practices and payment rates for all sugar beet erosion reduction acres. FY20 EQIP rates.*

Core Practices	Payment Rate ($)	Unit	Years
Residue and Tillage Mgmt – Reduced Till (345)	14.58	Acre	3
Sprinkler System (442)	33.63	Linear foot	1
Sprinkler Swing Arm (442)	153.23	Linear foot	1
Irrigation Pipe (430)	1.19	Pound	1
Pump (533)	225.50	Horsepower	1
Structure Small (587)	4381.91	Each	1
Structure Flow Meter (587)	183.53	Inch	1

Nutrient management assessments for nitrate leaching (Hensleigh, 2013a) and phosphorus runoff (Hensleigh, 2013b) will be conducted during the planning process and fields with a High or Very High rating will be given either a nitrate management plan and/or a phosphorus drawn-down plan via Conservation Technical Assistance (CTA). A current soil test will be required from the producer to complete these assessments. Additional conservation practices such as those listed in Alternative Three will be suggested to the producer and could be planned via CTA but will not be available for financial assistance through this TIP.

Several sugar beet farmers across Montana are early adopters of reduced tillage production methods. NRCS has measured their reduction in wind erosion and documented their production techniques. As a result, we are confident that the proposed solution is possible, and the goal of decreased erosion and an improved watershed is achievable. Table 4 and 5 illustrate the decreased wind erosion and STIR, and increased SCI, after implementation of the Reduced Till (345) practice standard in 6 sugar beet farms across Montana (Ruffin and Tallman, 2017).

Table 4. *Wind erosion in conventional beet production systems across Montana, 2016.*

	Rotation	County	Average Annual Wind Erosion (tons/acre)	STIR	SCI
A	Beet-barley-silage corn	Carbon	3.4	170	1.2
B	Beet-barley-barley	Carbon	7.1	77	0.1
C	Beet-barley-silage corn	Carbon	29.5	91	-2.3
D	Beet-corn silage-spring wheat	Prairie	11.3	133	-0.6
E	Beet-barley	Richland	3.1	157	-0.2
F	Beet- grain corn-spring wheat	Treasure	5.9	98	0.1
G	Beet-barley-barley	Big Horn	7.6	159	-0.6

Table 5. *Wind erosion in reduced tillage beet systems across Montana, 2016.*

Farmer	Rotation	County	Average Annual Wind Erosion (tons/acre)	STIR	SCI
A	Beet-barley-silage corn	Carbon	0	18	1.7
B	Beet-barley-barley	Carbon	1.1	24	0.9
C*	Beet-barley-silage corn	Carbon	NA	NA	NA
D	Beet-corn silage-spring wheat	Prairie	0	50	0.8
E	Beet-barley	Richland	trace	21	0.9
F	Beet- grain corn-spring wheat	Treasure	0.1	31	0.8
G	Beet-barley-barley	Big Horn	2.2	62	0.3

**Farm C is still in conventional tillage.*

In addition to erosion reduction, NRCS estimates these producers will realize between $45 - $150 per acre of savings in operating and ownership costs and between 0.3 to 1.8 hours of labor saving per acre (Ruffin and Tallman, 2017).

In 2018, NRCS produced a 20-minute video, highlighting personal interviews with four reduced tillage sugar beet farmers across the state (MT NRCS, 2019). This video gives practical tips and tricks for planter settings, irrigation and residue management, and helps serve as a practical guide for other producers trying reduced tillage beet production for the first time. Resources such as this should help to make the transition to reduced tillage easier for a conventional farmer. It is important to note that it is possible for a farmer to make the transition with no additional equipment purchases other than irrigation improvements.

PARTNERSHIPS

Carbon Conservation District (CCD) is a primary partner in the project. CCD will sponsor meetings, workshops, and tours and help promote the benefits of reduced tillage practices.

Montana Rural Water Systems, Inc.- Source Water Protection Specialist is working with down-stream Public Water Systems (PWSs), Laurel, Billings and Lockwood Water/Sewer District to develop a joint Source Water Protection Plan. SWP Plan management strategies include collaborative projects with these PWSs that will assist to prioritize projects to improve erosion and water quality issues of the Clarks Fork River and its' connection with the PWSs Yellowstone River source water.

Montana Fish, Wildlife & Parks (MTFWP) has water quality interests for the species they manage. They have participated in water quality sampling. In 2019, baseline water quality sampling was conducted on the Clarks Fork River by MTFWP. They measured sediment, nitrate, and phosphorus at several locations along the Clarks Fork River.

Montana Bureau of Mines and Geology (MBMG) will work with the NRCS on appropriate projects to analyze the effects on ground water when converting from flood to center pivot. They will assist in education and outreach.

IMPLEMENTATION

Funding for this project is being requested for FY20 -FY24. Contract development for the TIP will be completed within this timeframe. Implementation of contracts will begin in FY20 with all contracts obligated by the end of FY24. It is expected that all irrigation improvements will be completed within two years of contract obligation.

At the time of submission of this proposal (December 2019), 5 applications have been received that would qualify for this TIP, representing 300 acres. 0% of all potential projects for FY20 have been surveyed or designed. In addition, planning and contract development have also been completed on 0% of all potential FY20 projects.

In addition to local NRCS staff, the Area Agronomist will provide technical and field support as needed. This may include providing erosion estimates, directly advising producers, and conducting soil health field assessments and infiltration tests.

To meet the goal of 2,000 acres contracted by FY24, we estimate contracting conservation on 400 acres per year with about 5 projects per year. Table 6 gives the total TIP cost estimate.

Table 6. *Annual cost estimate for Clarks Fork of the Yellowstone Erosion Reduction TIP.*

Fiscal Year	Total Projects	Total Acres	Total NRCS Financial Assistance (est.)
2020	5	400	**$400,000**
2021	5	400	**$400,000**
2022	5	400	**$400,000**
2023	5	400	**$400,000**
2024	5	400	**$400,000**
Total	**25**	**2000**	**2,000,000**

The 2018 USDA Farm Bill specifies that NRCS must spend 10% of its total program funding within designated SWPPAs. Because all potential project acres in the TIP are within a SWPPA boundary, it is possible that cost-share values could be increased, depending on state NRCS leadership approval.

The Carbon County NRCS office, along with the Carbon Conservation District, have sponsored a reduced tillage beet workshop and tour every summer since 2015. We expect these field tours to continue for every year of the TIP implementation. Tours will be experiential and hands-on, with the main audience being beet producers. Topics will include successes and failures of local producers as well as tips and tricks for improved management and monitoring.

As with any project involving NRCS technical or financial assistance, National Environmental Policy Act (NEPA) concerns will be addressed through environmental evaluations that include cultural resources and threatened and endangered species reviews.

PROGRESS EVALUATION AND ASSESSMENT

The bulk of the measurable progress will be from erosion models using the producer's current management under conventional tillage and comparing with the producer's future management with reduced tillage. WEPS will be used to model the wind erosion of the baseline and the planned conditions. The NRCS Montana Irrigation Manual will be used to model the irrigation induced erosion of the baseline and planned conditions. These planning models will guide NRCS' assistance to producers and will serve as the basis for all tillage operation reductions.

It was decided not to evaluate project effectiveness by direct field sampling of sediment and nutrient runoff, due to staffing and funding limitations as well as the difficulty of interpreting test results.

Implementation success of this TIP will be measured by the number of acres contracted to CPS 345 and CPS 442 over the geographic scope and within the given time limitations of the project.

PRIORITY AND RANKING

PRIORITIZATION QUESTIONS

1. Has the applicant had an NRCS program contract terminated since January 1, 2017; OR does the applicant have an existing contact that has been determined to be in noncompliance and currently under an active NRCS-CPA-153 (only answer as Yes if the non-compliance was for something within the participants' control)? If yes, identify the following: Date of Termination or date participant signed the NRCS-CPA-153 with an existing deadline to bring the contract back in compliance.

Yes – Application is a LOW priority
No – Continue to question 2.

2. Is the proposed conservation treatment within the geographic boundaries of this Targeted Implementation Plan (TIP)?

Yes – Continue to # 3
No – Application is a LOW priority

3. Does the application meet the intent of the TIP, and is for practices currently offered in the TIP that will treat the identified priority resource concern?

Yes – Continue to # 4
No – Application is a LOW priority
Yes – Application is a HIGH priority
No – Application is a LOW priority

LOCAL RANKING QUESTIONS (200 POINTS)

1. Will the planned wind erosion be reduced to < 0.5 ton/acre/year?	50
2. Will the planned wind erosion be reduced to < 1 ton/acre/year?	25
3. Will the planned wind erosion be reduced to < 1.5 ton/acre/year?	12
4. Will the beet crop interval STIR value be ≤ 40?	25
5. Will there be no full width tillage in the rotation other than beet harvest and a light harrow?	12
6. Will the average annual STIR be reduced to < 30?	37
7. Will the SCI move from negative to positive?	12
8. Will the difference between the benchmark and the planned SCI be ≥ 1?	25

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