Buffalo Rapids District No. 2
Sediment Transport &
Nutrient Loss Reduction Project

Terry Field Office
2023 - 2027

Overview/Background Information

This Targeted Implementation Plan (TIP) will encompass Buffalo Rapids Irrigation District No. 2 (BR), from the Shirley pump site in northeastern Custer County through the Fallon system paralleling the Yellowstone River. Town boundaries, existing sprinkler systems and roadways were excluded from the TIP boundary. The Buffalo Rapids Irrigation Project was constructed by the U.S. Bureau of Reclamation between 1937 and 1950 in an effort to spur settlement and development along the Yellowstone after the Great Depression. The Fallon unit was the last to be completed in 1950. District 2 has a total of 10,593 irrigable acres and is made up of three units – Shirley, Terry, and Fallon. Table 1 lists acres of irrigated land in the Buffalo Rapids Irrigation District No. 2.

Table 1: Current Irrigation Delivery Methods		
Dist. No. 2 Division	**Flood Acres**	**Pivot Acres**
Shirley	3,979	1,303
Terry	1,781	1,554
Fallon	1,970	1,091

Transportation of sediment in the Buffalo Rapids system was first analyzed in the late 1990s[1,2] and both studies note that sedimentation and irrigation induced erosion are primary natural resource concerns that need addressed. This was reinforced in the Yellowstone River Cumulative Effects study, which noted that reaches C and D of the Yellowstone River, encompassing the Buffalo Rapids project, have a moderate to major altered sediment regime due to irrigation for agriculture[3].

Since the mid-1990s, and in particular after the NRCS Priority Area Initiative in 1998, considerable effort has been put into replacing earthen laterals that serve multiple producers with PVC pipe and lining large canals to reduce seepage. However, very little effort has been put into on-farm improvements; many producers continue to flood irrigate or utilize gated pipe.

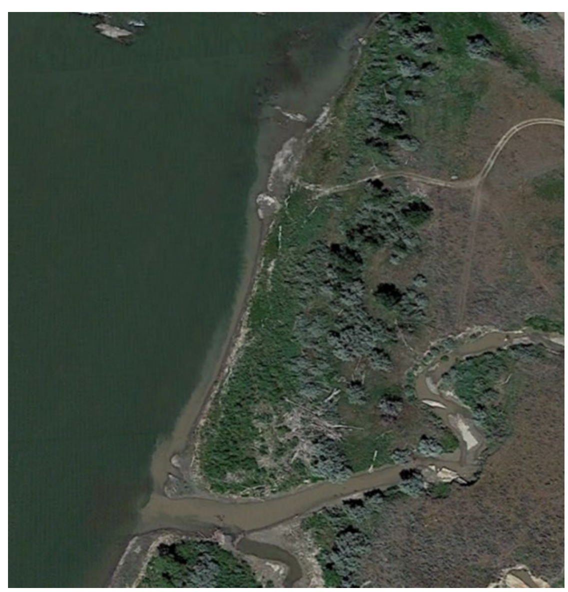
Irrigation water quality and irrigation improvements have been discussed at every Local Work Group meeting as far back as 2009 and are clearly outlined in the Prairie County Long Range Plan, page 40. The last investment in irrigation projects by NRCS in Prairie County was in 2013 through PL-566, but interest remains high. Producers realize the benefits of improved irrigations systems but cannot afford to implement them on their own; they are ready and willing to partner with NRCS for the conversion of flood to sprinkler irrigation.

Problem Statement

The lack of on-farm irrigation system improvements on the Buffalo Rapids District No. 2 project contributes largely to sediment transport, nutrient loss, and labor inefficiencies. Currently, flood irrigators apply upwards of four inches per irrigation on timed sets; the bulk of that application is lost as runoff, which carries sediment and sediment attached nutrients away from the field. When using the Surface Irrigation Soil Loss Model, gated pipe irrigation systems, the most common in the TIP area, can contribute up to an average of 6.4 tons/year of surface soil loss per system. Along with excess sediment transportation and inefficient water use, over-application of irrigation water results in wasted labor and energy. Throughout the irrigation season, irrigators on the BR No. 2 system spend an average $45.71/acre in labor, just setting water. Sprinkler irrigation systems apply much less water per set in more frequent applications. The uniform distribution reduces sediment runoff, provides more timely water applications for crops, and decreases expenditures of time, labor, and energy. Sprinkler irrigation systems could also contribute to changing tillage practices, further reducing sediment loss.

Inefficient irrigation systems result in overapplication of water which leaves the field as runoff. Sediment carried in runoff is deposited in drain ditches, eventually reducing their capacity. Runoff from improperly irrigated fields also impacts water quality by contributing to sediment in the Yellowstone River. Every year Buffalo Rapids spends an average of 120 hours cleaning the drains that serve multiple producers. These producers must then also clean their own on-farm drains to remove deposits of sediment carried off the irrigated fields (Figure 1). Changing to sprinkler irrigation systems would reduce decrease the cost and time of cleaning drain ditches and reduce the amount sediment, nutrients and contaminates reaching the river (Figures 2, 3).

Figure 1: Sediment that's been cleaned from the drain ditch at the end of the crop field.



Figures 2, 3: Sediment leaving the BR drain reaches the Yellowstone River.

T Value is an estimate of the maximum average annual rate of soil erosion by wind and/or water that can occur without affecting crop productivity over a sustained period. The rate is in tons per acre per year. Soils within the TIP boundary range from 1T to 5T and are predominantly 5T (Appendix C, figures 7, 8, 9).

Soils within the proposed TIP boundary typically have a higher clay content (Appendix C, figure 1). Although a higher clay content tends to increase available water holding capacity, these soils have higher K-factors and are much more susceptible to runoff due to small particle size. These soils are suited better for lower gross water applications per irrigation due to their tendency for increased runoff potential. As previously discussed, the Surface Irrigation Soil Loss Model (Appendix B) reinforces this susceptibility by decreasing the average soils loss from 6.8 tons/year to 1.4 tons/year.

Nitrogen, a critical nutrient for plant growth, is easily transported by water and is often associated with the impairment of ground and surface water quality[4] (Appendix C, figure 2). As previously mentioned, soils in the TIP area have a higher percentage of clay, which also lends to nitrogen transport as those fine clay particles attract ammonium nitrogen[4]. While it seems that the nitrate leaching potential above appears to be low, it should be noted that the map units are rated under a non-irrigated condition. When water is applied, the potential for nitrate leaching increases. Further, after modeling before and after scenarios with the Montana Nitrogen Risk Assessment tool (Appendix A), the risk of leaching decreases from High to barely within the medium category with the conversion flood to sprinkler irrigation.

Phosphorus, like nitrogen, is a critical nutrient for crops. When overapplication occurs, phosphorus can be carried with sediment to surface waters during erosion events[6]. Soil tests within the TIP area show an Olson P range from 8-12ppm; therefore, phosphorus transport risk is low. However, for the sake of investigation the Phosphorus Risk Assessment tool (Appendix A) was run. The risk decreases from Medium to Low with the conversion from flood to sprinkler irrigation.

Prime Farmland, Soils of Statewide Importance and Prime if Irrigated Soils are designations assigned by U.S. Department of Agriculture defining soils that have the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed crops and is also available for these land uses.

Farmland of Statewide Importance are soils that have been determined to be of significance for production of food, feed, fiber, forage, and oilseed crops. These soils have an adequate and dependable water supply from precipitation or irrigation, favorable temperature and growing season, acceptable acidity or alkalinity, acceptable salt and sodium content, and few or no rocks. They are permeable to water and air, are not excessively erodible or saturated with water for a long period of time, and either do not flood frequently or are protected from flooding. They are available for farming, but could currently be cropland, pastureland, rangeland, forestland, or other land.

Prime Farmland if Irrigated soils are those with the best combination of physical and chemical characteristics for agriculture such as the soil quality and adequate growing season necessary to produce high yields of crops suited to the region but occur in areas of limited rainfall. Approximately 66.7% of soils within the TIP project area are either Prime Farmland if Irrigated or Farmland of Statewide Importance (Appendix C, Figure 3). It is critical to the sustainability of agriculture in Prairie County that these soils remain healthy and productive. Appendix C, figures 4 and 5 show the locations of these soils within the project area.

In 2017, NRCS published “Economics of Reduced Tillage in Sugar Beets,” which included data from a Prairie County producer. Among other factors, the study compared erosion estimates, SCI (Soil Conditioning Index) and STIR (Soil Tillage Intensity Rating) values in conventional and reduced tillage sugar beet systems. 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 (Wind Erosion Prediction System). 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. SCI is a unitless measure of the soil organic matter trend; a positive SCI indicates an increasing trend in soil organic matter, while a negative SCI indicates a decreasing trend in soil organic matter.

A reduction in erosion rates can be attributed to the change in tillage (reduced STIR value), but furrow irrigation also plays a role. By artificially creating furrows, water easily carries sediment off the field (Figure 4). An additional benefit of the change from furrow or flood to sprinkler irrigation is the ability to plant perpendicular to the prevailing wind.


Figure 4: Irrigation induced erosion at the end of crop fields within the project area; the original wood posts in the photos were 42" high. Sediment has run in and around posts reducing their height by half.

To get a sense of the impact of changing to sprinkler irrigation on erosion Field Office staff looked at a typical conversion scenario within the TIP boundary. The producer in this scenario is an average producer in terms of amount of soil disturbance. A common rotation within the TIP boundary is malt barley, beans, spring wheat, and grain corn. Maps of his plan and associated WEPS runs are available in Appendix E. While the producer doesn't till extensively, he will not meet the 345 practice standard due to yearly burning of residue on his fields. With the conversion from flood to pivot irrigation, and elimination of the burning and tillage, his STIR goes from 42.2 per year down to 7.2 and gross loss of soil goes from 1.2 t/ac to a trace.

Table 2: Wind and Water Erosion Reduction Estimates

	Current Condition	Planned Condition
Surface Loss Model	6.8	1.4
WEPS Model	1.2	0.1
Total Soil Loss	**8.0 t/ac**	**1.5 t/ac**

Anecdotal data from the above example producer indicates that switching to sprinkler irrigation systems can reduce or eliminate certain tillage practice that are currently necessary in gated pipe/furrow irrigation systems- i.e., ditching (furrowing) would no longer be needed. This reduction/elimination of tillage practices from an operation drastically decreases Soil Tillage Intensity Rating (STIR) values which will also contribute to the reduction of sediment/nutrient loss and improve soil structure. Additionally, decreasing tillage practices decreases expenditures of time, labor, and energy.

Irrigation Water Management plans implemented in sprinkler irrigation systems contribute to significantly lower potential for sediment and nutrient runoff due to lower gross irrigation water application and increased uniformity of application. Conversion from flood to sprinkler irrigation will help reduce runoff and sediment transport to field ditches and the Yellowstone River.

Goals and Objectives

Primary Resource Concern: Sediment Transported to Surface Water
Secondary Resource Concern: Nutrients transported to Surface Water

The goal of this TIP is to reduce sediment transport to surface water on 3,860 acres in Buffalo Rapids Irrigation District No.2 Shirley, Terry, and Fallon systems through the installation of more efficient irrigation systems. Inefficient irrigation causes runoff that transports large amounts of sediment. The modernization of irrigation systems on the farm, together with the implementation of management practices, provide producers important tools to conserve resources (irrigation water, energy, and human capital) and to reduce sediment transport. Modelling data show that Nitrogen Risk decreases from High to Medium and Phosphorus Risk decreases from Medium to Low (Appendix A). Further, sediment transport can be reduced from 8 tons per acre to 1/5 tons per acre (Table 2, Appendix B).

The objective is to target irrigated crop fields that are currently flood irrigated, have high erosion and sediment transfer rates where producers are willing to convert to sprinkler irrigation, reduce their average annual STIR level and encourage implementation of irrigation water management or nutrient management practices. Wind Erosion Prediction System software, Nitrogen Risk Assessment model, and Surface Irrigation Loss Model will be used with each producer's specific information to model baseline conditions.

Alternatives & Implementation

Alternative One (not selected) - Replace surface flood irrigation with sprinkler systems and flow meters to increase irrigation efficiency, reduce sediment transport to surface water, and lower labor inputs. Implementation of Alternative One will cost an average of $75,801 per system. With this initial investment, several producers will be able to improve their irrigation system and those improved efficiencies will result in improved crop yields. Conservation plans may include the following practices:

- 442 – Sprinkler System (Center Pivot)
- 430 – Irrigation Pipeline
- 500 – Obstruction Removal
- 533 – Pumping Plant
- 587 – Structure for Water Control

Alternative Two (preferred) encompasses the whole of Alternative One and will include required implementation of Irrigation Water Management (449) and Nutrient Management (590) during the first three years. Management practices develop and apply strategies to improve sustainability and reduce production costs by using inputs (irrigation water and fertilizer) conservatively.

Alternative Three (not selected)– Include the entirety of alternatives one and two plus the addition of Residue Tillage and Management (345) as a required management practice. After investigation of operations within the TIP boundary, it is unnecessary to include this practice as most of the operations already have a STIR rating below 80.

Alterative Four - No action (not selected). Under this alternative, current conditions persist. Without irrigation system improvements, erosion will carry soil from the crop fields, inefficiency of irrigation water application will continue, and producers will experience shortages of labor and time.

This TIP will span five years. Program applications will be accepted in years 2023 through 2026 with infrastructure planned in the first four years.

Cost

Cost Share estimates are based on the FY2022 NRCS EQIP General Cost List payment rates.

Table 3: Cost Share Estimate (Irrigation TIP 2023)						
EXAMPLE		*80 acres*				
By: Terry Field Office		December 2021	Checked By:		Date:	
	Item		***Unit***	***Amount***	***PR Unit Cost***	***Total Cost***
Center Pivot Sprinkler System (442)						
	Center Pivot, 801 to 1,200 feet		ac	80	$611.13	$ 48,890.40
Irrigation Pipeline (430)						
	Polyvinyl Chloride (PVC), Pipe, less than or equal to 8 inch		lb	1782	$2.58	$ 4,597.56
Pumping Plant (533)						
	Electric-Powered Pump, greater than 5 to 30 Horse Power		hp	30	$415.02	$ 12,450.60
	Variable Frequency Drive, less than 75 HP		hp	25	$100.57	$ 2,514.25
Structure For Water Control (587)						
	Miscellaneous Structure, Extra Small		ea	1	$3,407.42	$ 3,407.42
	Flow Meter with Electronic Index		in	8	$222.50	$ 1,780.00
Irrigation Water Management (449)						
	Intermediate IWM, Year 1		ea	1	$1,050.41	$ 1,050.41
	Intermediate IWM, Years 2 and 3		ea	2	$555.38	$ 1,110.76
Nutrient Management (590)						
	Basic NM (Non-Organic/Organic)		ac	80	$6.68	$ 534.40
					Total Cost Per System	$ 76,335.80
					Total Cost Per Acre	**$ 954.20**

After a preliminary inventory of the TIP area, we predict that more applicants with smaller acreages will participate. There are approximately 7,720 acres within the inventory area that have the potential to convert from flood irrigation to sprinkler systems. These conversions will address the resource concern of Sediment Transported to Surface Water for the selected area. Our goal is to address this resource concern on 50% of the available acres within the three-year signup period.

The Terry Field Office requests the following:

TIP Funds					
Fiscal Year	**Number of Contracts**	**Acres Treated**	**Average Expected Cost Per Acre**	**Average Expected Cost per Contract**	**Total**
2023	10	965	$947.52	$76,335.80	$763,358
2024	10	965	$947.52	$76,335.80	$763,358
2025	10	965	$947.52	$76,335.80	$763,358
2026	10	965	$947.52	$76,335.80	$763,358
TOTALS	**40**	**3,860**			**$3,053,432**

Technical assistance from NRCS will include cultural resources inventories and field visits, system design and plan development, construction checks, operation and maintenance plans, and assistance with soil moisture monitoring and irrigation water management.

The Terry Field Office will require assistance from the Miles City Area engineering staff for training and development of Job Approval Authority for larger TIP irrigation systems. Prairie County Conservation District, Prairie County Grazing District, and Prairie County Extension Service will also provide technical assistance as needed.

Ranking and Prioritization

Prioritization

Application screening & prioritization will be done using the current year program screening bulletin when it becomes available.

Local Ranking Questions

The following questions will be used to rank all eligible applications for this TIP:

1) Will the participant contract Irrigation Water Management and Nutrient Management?
   - Both IWM and NM
   - IWM
   - NM only
   - None

2) Will the application include Intermediate or Advanced Irrigation Water Management that includes soil moisture monitors?
   - Yes
   - No

Progress Evaluation and Monitoring

Progress will be measured primarily using the erosion and nutrient loss models specific to each producer's operation. WEPS will also be used to model baseline and planned wind erosion. Staffing and funding limitations inhibit our ability to directly measure sediment and nutrient values in irrigation runoff. Implementation success will be measured by the number of acres converted from flood to sprinkler irrigation upon the conclusion of the TIP.

References

[1] Buffalo Rapids PL 83-566 Watershed Plan Environmental Assessment, November 1999

[2] Improving Irrigation Efficiency and Water Quality – A Priority Area Proposal, June 1998

[3] Yellowstone River Cumulative Effects Analysis, December 2015

[4] NRCS Agronomy Tech Note MT-91

[5] Economics of Reduced Tillage in Sugar Beets, NRCS, January 2017

[6] NRCS Agronomy Tech Note MT-77

Appendix A
Nitrogen & Phosphorus Risk Assessment Tool Models

Before model:

Montana Nitrogen Risk Assessment Tool

Completing Risk Ratings

Each site category's weighting factor in Table 3 is multiplied by the site risk rating (value) to get a weighted risk value. All categories are rated (according to individual category instructions), and the overall rating is the sum of all values. After individual sites/fields are rated, refer to the appropriate vulnerability rating in Table 5.

Table 3. MONTANA NITROGEN RISK ASSESSMENT TOOL

SITE CATEGORY	NONE (0)	LOW (1)	MEDIUM (2)	HIGH (4)	VERY HIGH (8)	RISK VALUE (0, 1, 2, 4, 8)	WEIGHT FACTOR	WEIGHTED RISK FACTOR
Water and Wind Erosion	N/A	<5 ton/ac/yr	5-10 tons/ac/yr	10-15 tons/ac/yr	>15 tons/ac/yr	4	x 1.0	4
Soil Series Risk Assessment	N/A	LOW	MEDIUM	HIGH	VERY HIGH	2	X 2.0	4
Precipitation Minus ET (October 1 – April 1)		LOW	MEDIUM	HIGH	VERY HIGH	1	x 2.0	2
Irrigation Method	N/A	Sprinkler system with soil moisture sensors or IWM	Sprinkler system without sensors or IWM	Other irrigation systems with sensors or IWM	Other irrigation systems without sensors or IWM	8	x 2.0	16
Nitrogen Soil Test N	------	< 50 lbs / ac	50-100 lbs / ac	101-150 lbs / ac	>150 lbs / ac	1	x 0.5	.5
Nitrogen Application Method	None Applied	Applied according to current soil tests and MSU guidelines with split applications based on growth stages	Applied according to current soil test and MSU guidelines < 2 weeks of planting or surface applied during the growing season	Applied < 2 weeks of planting with no soil testing	Applied > 2 weeks of planting with no soil testing	8	x 0.5	4
Nitrogen Application Rate	None Applied	Total N application rate below agronomic rate	Total N application rate equal to agronomic rate	Total N application rate 1-50 lbs above agronomic rate	Total N application rate >50 lbs above agronomic rate	2	x 0.5	1
							Overall Risk Factor	31.5
							Overall Risk Rating	High

Interpreting Results of Site Vulnerability Ratings

After multiplying the weighting factor by the risk value for each category and totaling all values in Table 3, assign the overall site/field vulnerability to nitrogen loss from Table 4.

Table 4. SITE/FIELD VULNERABILITY TO NITROGEN LOSS

Total of Weighted Risk Values	Site Vulnerability	Site/Field Number(s)
<11	LOW	
11-21	MEDIUM	
22-43	HIGH	Current Condition
> 43	VERY HIGH	

After model:

Montana Nitrogen Risk Assessment Tool

Completing Risk Ratings

Each site category's weighting factor in Table 3 is multiplied by the site risk rating (value) to get a weighted risk value. All categories are rated (according to individual category instructions), and the overall rating is the sum of all values. After individual sites/fields are rated, refer to the appropriate vulnerability rating in Table 5.

Table 3. MONTANA NITROGEN RISK ASSESSMENT TOOL

SITE CATEGORY	NONE (0)	LOW (1)	MEDIUM (2)	HIGH (4)	VERY HIGH (8)	RISK VALUE (0, 1, 2, 4, 8)	WEIGHT FACTOR	WEIGHTED RISK FACTOR
Water and Wind Erosion	N/A	<5 ton/ac/yr	5-10 tons/ac/yr	10-15 tons/ac/yr	>15 tons/ac/yr	1	x 1.0	1
Soil Series Risk Assessment	N/A	LOW	MEDIUM	HIGH	VERY HIGH	2	X 2.0	4
Precipitation Minus ET (October 1 – April 1)		LOW	MEDIUM	HIGH	VERY HIGH	1	x 2.0	2
Irrigation Method	N/A	Sprinkler system with soil moisture sensors or IWM	Sprinkler system without sensors or IWM	Other irrigation systems with sensors or IWM	Other irrigation systems without sensors or IWM	1	x 2.0	2
Nitrogen Soil Test N	------	< 50 lbs / ac	50-100 lbs / ac	101-150 lbs / ac	>150 lbs / ac	1	x 0.5	.5
Nitrogen Application Method	None Applied	Applied according to current soil tests and MSU guidelines with split applications based on growth stages	Applied according to current soil test and MSU guidelines < 2 weeks of planting or surface applied during the growing season	Applied < 2 weeks of planting with no soil testing	Applied > 2 weeks of planting with no soil testing	2	x 0.5	1
Nitrogen Application Rate	None Applied	Total N application rate below agronomic rate	Total N application rate equal to agronomic rate	Total N application rate 1-50 lbs above agronomic rate	Total N application rate >50 lbs above agronomic rate	2	x 0.5	1
				Overall Risk Factor				11.5
				Overall Risk Rating				Medium

Interpreting Results of Site Vulnerability Ratings

After multiplying the weighting factor by the risk value for each category and totaling all values in Table 3, assign the overall site/field vulnerability to nitrogen loss from Table 4.

Table 4. SITE/FIELD VULNERABILITY TO NITROGEN LOSS

Total of Weighted Risk Values	Site Vulnerability	Site/Field Number(s)
<11	LOW	
11-21	MEDIUM	Planned Condition
22-43	HIGH	
> 43	VERY HIGH	

Before model:

Montana Phosphorus Risk Assessment Tool

Completing Risk Ratings

Each site category's weighting factor in Table 4 is multiplied by the site risk rating (value) to get a weighted risk value. All categories are rated (according to individual category instructions), and the overall rating is the sum of all values. After individual sites/fields are rated, refer to the appropriate vulnerability rating in Table 5.

Table 4. MONTANA PHOSPHORUS RISK ASSESSMENT TOOL

SITE CATEGORY	NONE (0)	LOW (1)	MEDIUM (2)	HIGH (4)	VERY HIGH (8)	RISK VALUE (0, 1, 2, 4, 8)	WEIGHT FACTOR	WEIGHTED RISK FACTOR
Water and Wind Erosion	N/A	<5 ton/ac/yr	5-10 tons/ac/yr	10-15 tons/ac/yr	>15 tons/ac/yr	1	x 1.5	1.5
Furrow Irrigation Erosion	N/A	Tailwater recovery, QS > 6 very erodible soils, or QS> 10	QS> 10 for erosion resistant soils	QS > 10 for erodible soils	QS > 6 for erodible very soils	2	x1.5	3
Sprinkler Irrigation Erosion	All sites 0-3% slope, all sandy sites, or site evaluation indicates little or no runoff, large spray on silts 3-8%	medium spray on silty soils 3-15% slopes, large spray on silty soils 8-15% slope, low spray on silt soils 3-8%, large spray on clay soil 3-15% slope	medium spray on clay soils 3-8% slopes, large spray on clay soils >15% slope, medium spray on silt soil >15% slope	medium spray on clay soils >8% slopes, low spray on clay soils 3-8% slope, low spray on silty soil >15% slope	low spray on clay soils >8% slopes,	0	x 0.5	0
Runoff Class	Negligible	very low or low	medium	high	very high	1	x 0.5	0.5
Olsen Soil Test P	< 10	10-20 ppm	20-40 ppm	41-80 ppm	>80 ppm	1	x 1.0	1
Phosphorus Application Method	None Applied	Injected deeper than 2 inches or subsurface applied	Incorporated < 2 weeks or surface applied during the growing season	Incorporated >2 weeks and < 1 month or surface applied < 1 month before crop emerges	Surface applied to pasture or applied > 1 month before crop emerges	1	x 1.0	1
Phosphorus Application Rate	None Applied	< 30 lbs./ac. P_2O_5	31-90 lbs./ac. P_2O_5	91-150 lbs./ac. P_2O_5	> 150 lbs./ac. P_2O_5	1	x 1.0	1
Distance to Concentrated Surface Water Flow	> 1000 feet	200-1000 feet, or functioning grass waterway in concentrated surface water	100-200 feet	< 100 feet with a vegetated buffer at least 35 feet in width	< 35 feet with no vegetated buffer	4	x 1.0	4
				Site/Field Phosphorus Risk Assessment Value				12
				Site/Field Phosphorus Risk Assessment Rating				Medium

Interpreting Results of Site Vulnerability Ratings

After multiplying the weighting factor by the risk value for each category and totaling all values in Table 3, assign the overall site/field vulnerability to phosphorus loss from Table 4.

Table 5. SITE/FIELD VULNERABILITY TO PHOSPHORUS LOSS

Total of Weighted Risk Values	Site Vulnerability	Site/Field Number(s)
<11	LOW	
11-21	MORDERATE or MEDIUM	Current Condition
22-43	HIGH	
> 43	VERY HIGH	

NRCS–Montana–Technical Note–*Agronomy MT-77* (Rev. 4)

Montana Phosphorus Risk Assessment Tool

Completing Risk Ratings

Each site category's weighting factor in Table 4 is multiplied by the site risk rating (value) to get a weighted risk value. All categories are rated (according to individual category instructions), and the overall rating is the sum of all values. After individual sites/fields are rated, refer to the appropriate vulnerability rating in Table 5.

Table 4. MONTANA PHOSPHORUS RISK ASSESSMENT TOOL

SITE CATEGORY	NONE (0)	LOW (1)	MEDIUM (2)	HIGH (4)	VERY HIGH (8)	RISK VALUE (0, 1, 2, 4, 8)	WEIGHT FACTOR	WEIGHTED RISK FACTOR
Water and Wind Erosion	N/A	<5 ton/ac/yr	5-10 tons/ac/yr	10-15 tons/ac/yr	>15 tons/ac/yr	1	x 1.5	1.5
Furrow Irrigation Erosion	N/A	Tailwater recovery, QS > 6 very erodible soils, or QS> 10	QS> 10 for erosion resistant soils	QS > 10 for erodible soils	QS > 6 for erodible very soils	0	x1.5	0
Sprinkler Irrigation Erosion	All sites 0-3% slope, all sandy sites, or site evaluation indicates little or no runoff, large spray on silts 3-8%	medium spray on silty soils 3-15% slopes, large spray on silty soils 8-15% slope, low spray on silt soils 3-8%, large spray on clay soil 3-15% slope	medium spray on clay soils 3-8% slopes, large spray on clay soils >15% slope, medium spray on silt soil >15% slope	medium spray on clay soils >8% slopes, low spray on clay soils 3-8% slope, low spray on silty soil >15% slope	low spray on clay soils >8% slopes,	0	x 0.5	0
Runoff Class	Negligible	very low or low	medium	high	very high	1	x 0.5	0.5
Olsen Soil Test P	< 10	10-20 ppm	20-40 ppm	41-80 ppm	>80 ppm	1	x 1.0	1
Phosphorus Application Method	None Applied	Injected deeper than 2 inches or subsurface applied	Incorporated < 2 weeks or surface applied during the growing season	Incorporated >2 weeks and < 1 month or surface applied < 1 month before crop emerges	Surface applied to pasture or applied > 1 month before crop emerges	1	x 1.0	1
Phosphorus Application Rate	None Applied	< 30 lbs./ac. P_2O_5	31-90 lbs./ac. P_2O_5	91-150 lbs./ac. P_2O_5	> 150 lbs./ac. P_2O_5	1	x 1.0	1
Distance to Concentrated Surface Water Flow	> 1000 feet	200-1000 feet, or functioning grass waterway in concentrated surface water	100-200 feet	< 100 feet with a vegetated buffer at least 35 feet in width	< 35 feet with no vegetated buffer	4	x 1.0	4
				Site/Field Phosphorus Risk Assessment Value				9
				Site/Field Phosphorus Risk Assessment Rating				Low

Interpreting Results of Site Vulnerability Ratings

After multiplying the weighting factor by the risk value for each category and totaling all values in Table 3, assign the overall site/field vulnerability to phosphorus loss from Table 4.

Table 5. SITE/FIELD VULNERABILITY TO PHOSPHORUS LOSS

Total of Weighted Risk Values	Site Vulnerability	Site/Field Number(s)
<11	LOW	Planned Condition
11-21	MORDERATE or MEDIUM	
22-43	HIGH	
> 43	VERY HIGH	

Before model- flood irrigation

Appendix B
Surface Irrigation Soil Loss Model

Surface Irrigation Soil Loss Model - Worksheet

Prepared for: 2023 Pivot Tip **Date** 2/9/2022

Prepared by Nate Bumgardner **SCD**

Soil Map Unit 115 **Slope** 1-1.9% **K factor** 0.43

Present Condition: Flood Irrigation - Before Conversion

Irrigation System Gated Pipe **Length of run** 1320 feet **Convex End** Moderate

Crop Rotation	BSL	PC	CP	IP	SISL
Malt Barley	9.10	0.75	1	1	5.94
Beans	9.1	0.85	1	1	6.73
Spring Wheat	9.1	1	1	1	7.92
Grain Corn	9.1	0.85	1	1	6.73
	0	1	1	1	0.00
	0	1	1	1	0.00
	0	1	1	1	0.00
	0	1	1	1	0.00
	0	1	1	1	0.00
	0	1	1	1	0.00
				Total (tons)	27.31
				Average (tons/year)	6.83

After model- sprinkler irrigation

Alternative 1 Sprinkler Irrigation - After Conversion

Irrigation System **Length of run** 1320 feet **Convex End** Moderate

Crop Rotation	BSL	PC	CP	IP	SISL
Malt Barley	10.00	0.75	0.2	0.9	1.17
Beans	10.00	0.85	0.2	0.9	1.33
Spring Wheat	10.00	1	0.2	0.9	1.57
Grain Corn	10.00	0.85	0.2	0.9	1.33
0	0.00	1	1	1	0.00
0	0.00	1	1	1	0.00
0	0.00	1	1	1	0.00
0	0.00	1	1	1	0.00
0	0.00	1	1	1	0.00
0	0.00	1	1	1	0.00
				Total (tons)	5.40
				Average (tons/year)	1.35

***Note: The same rotation was used in both the present condition and Alternative 1. The model moved from gated pipe to a sprinkler, switched from conventional tillage to seasonal reduced tillage and added irrigation water management as a second conservation practice.*

Appendix C
Soil Characteristic Maps

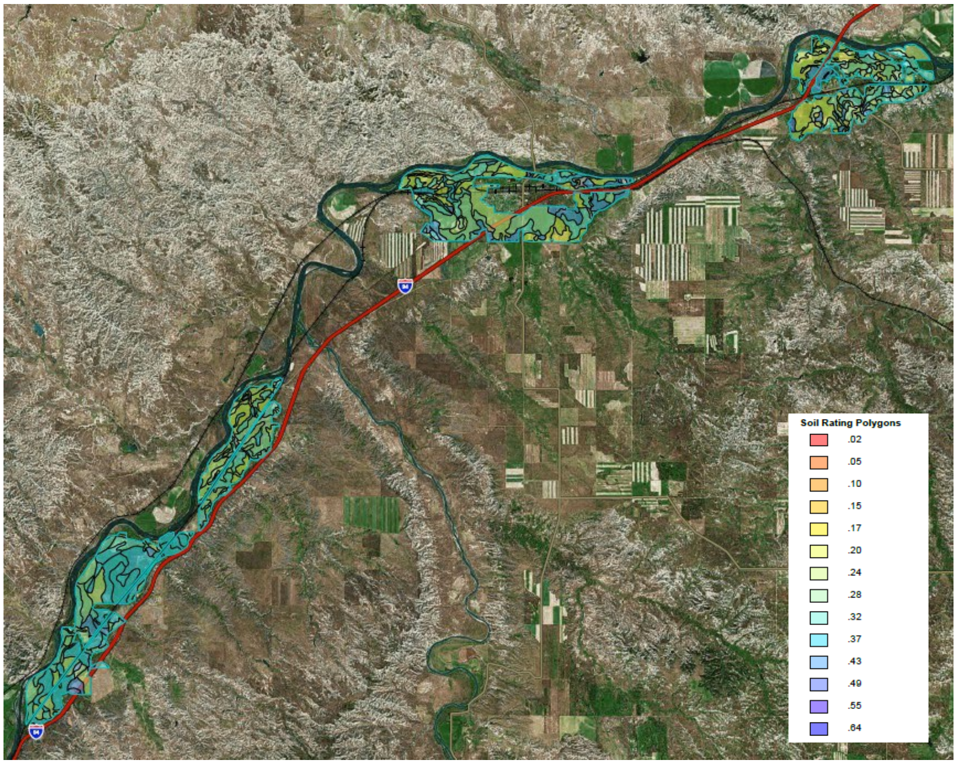


Figure 1. TIP K-factor Map. Higher K-factor values indicate soils with higher erodibility. Soils within the TIP boundary have an average K-factor of 0.31.

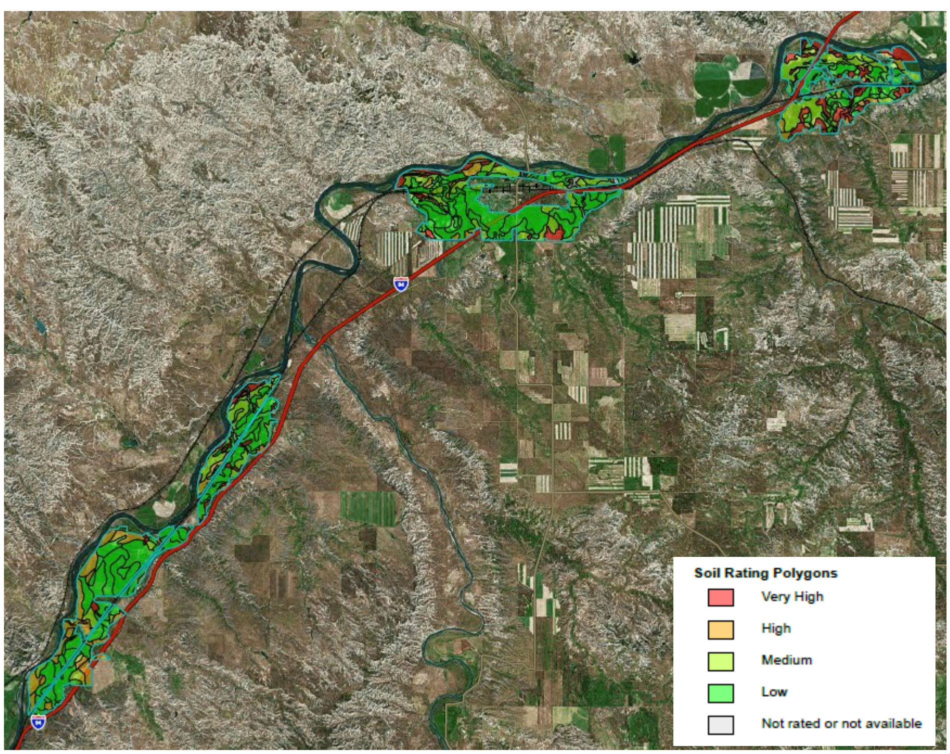


Figure 2. Nitrogen Leaching Potential Map

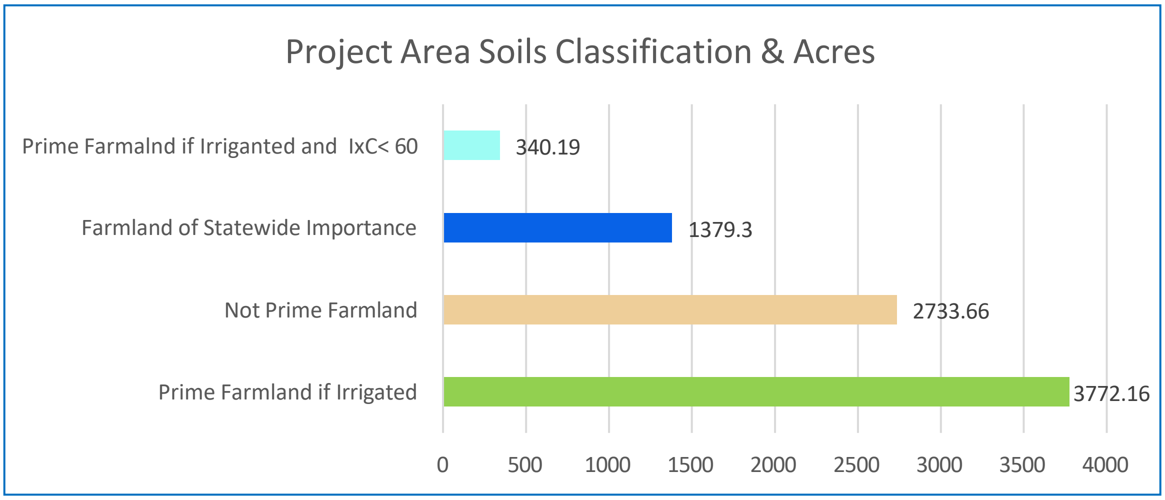


Figure 3. Acres of Important Soils in the TIP Project Area.

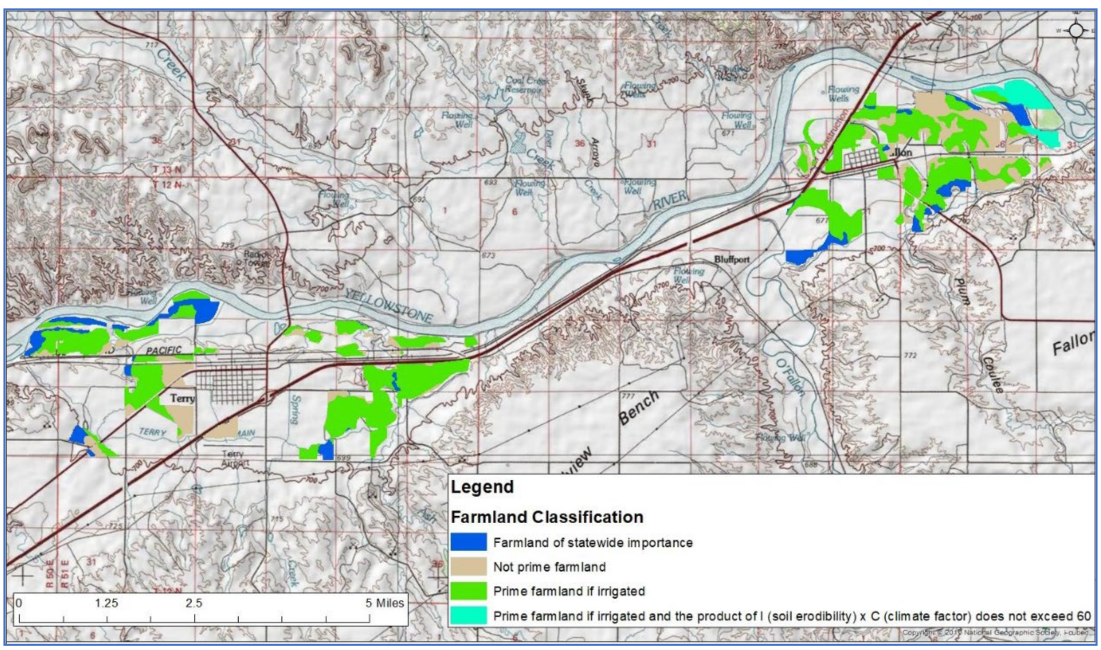


Figure 4. Important Soils, East End of Project Area – Terry and Fallon.

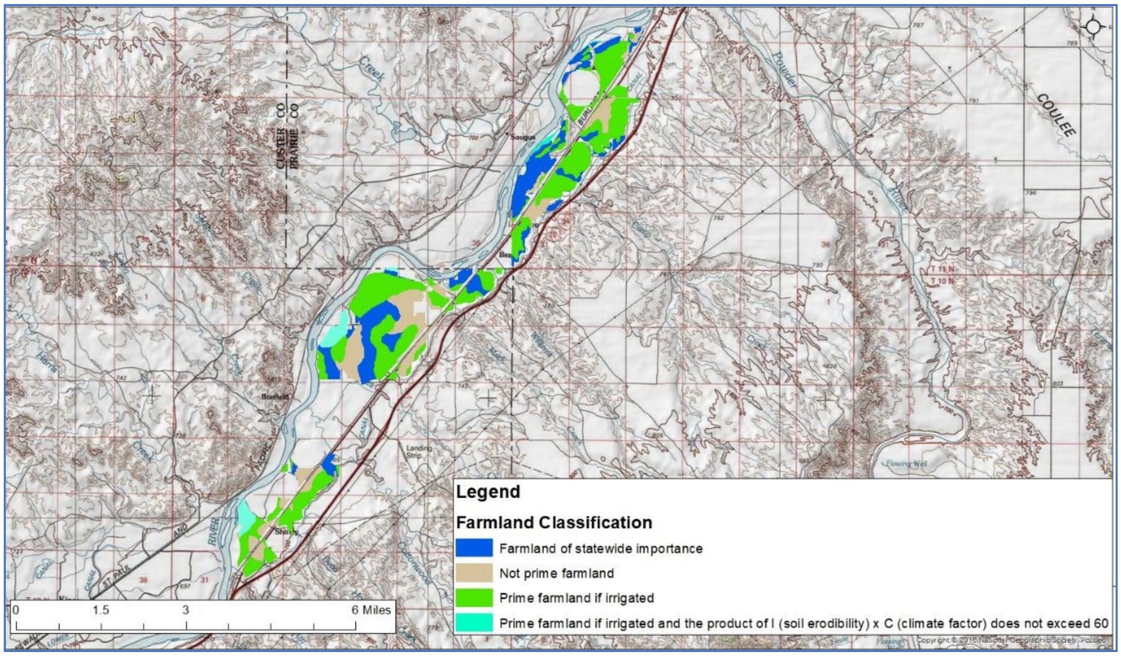


Figure 5. Important Soils, West End of Project Area – Powder River to Shirley.

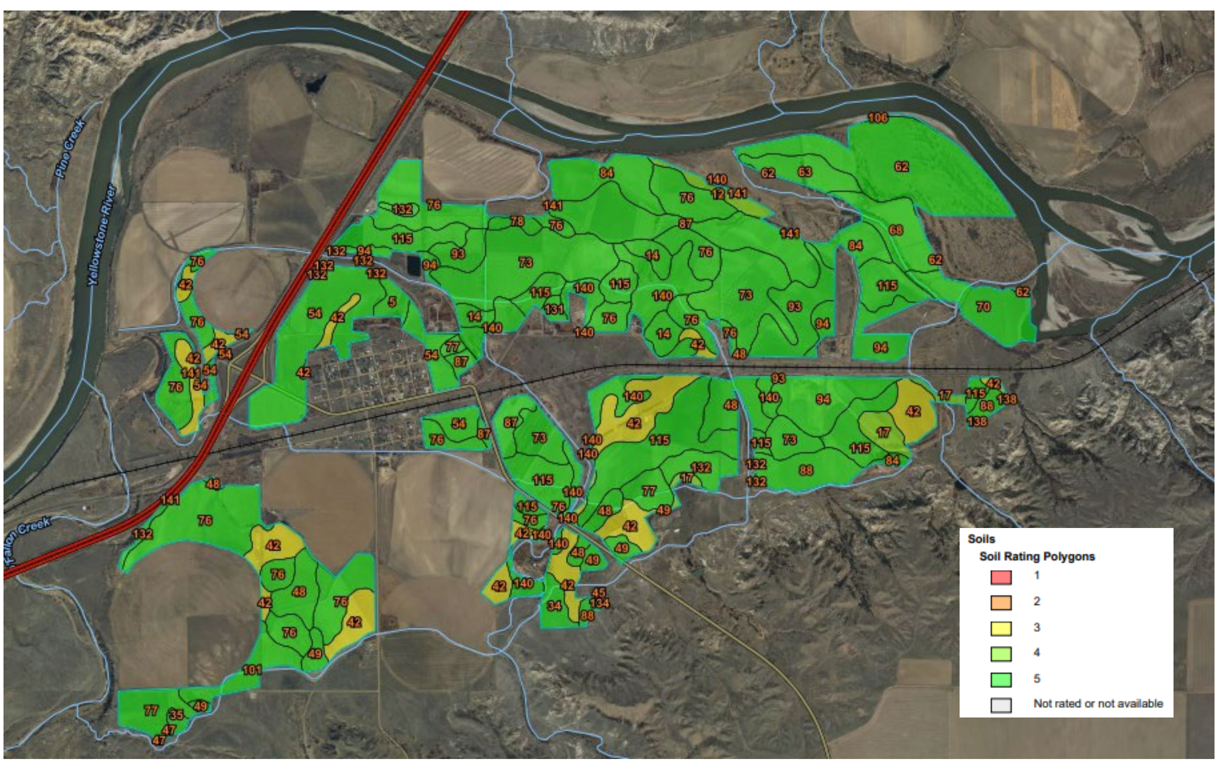


Figure 6. Fallon Unit T Values

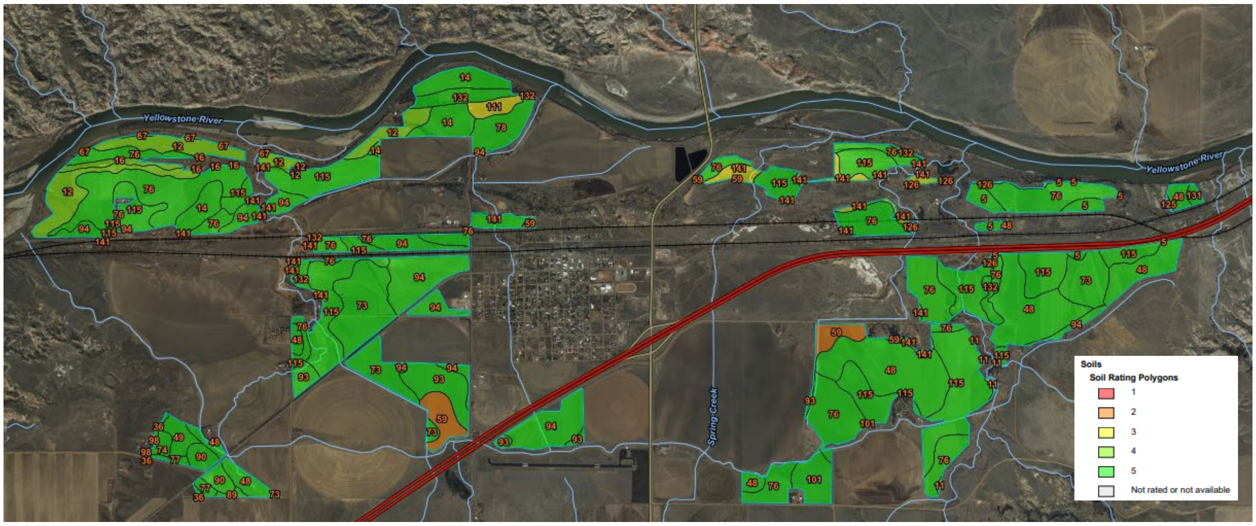


Figure 7. Terry Unit T Values

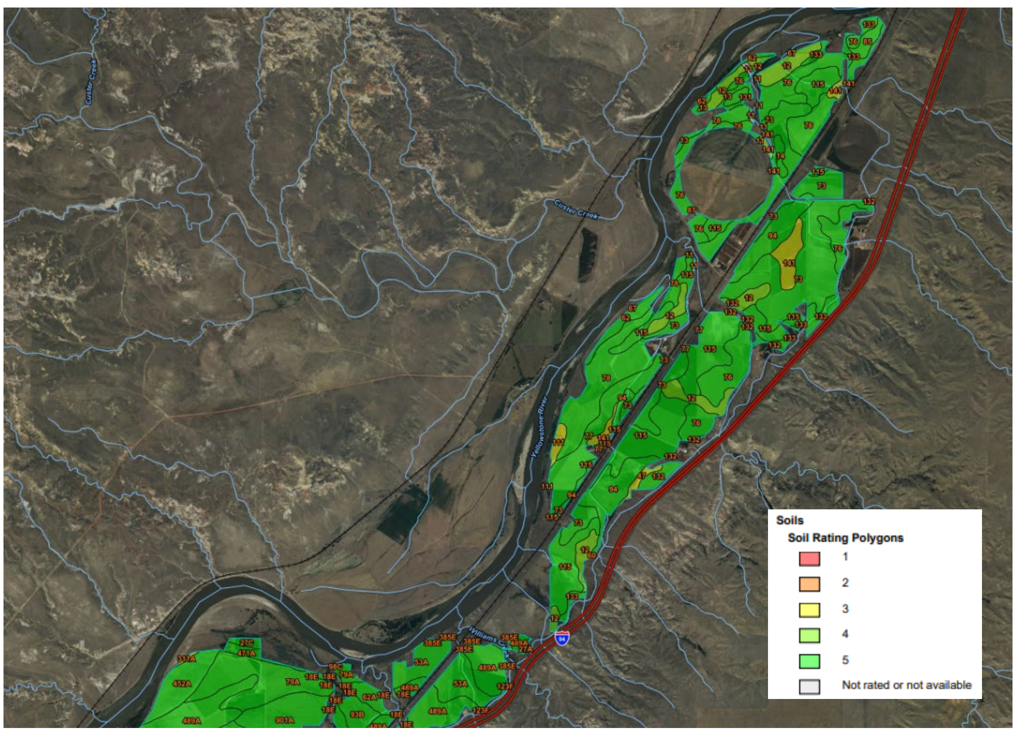


Figure 8. Shirley Unit North T Values

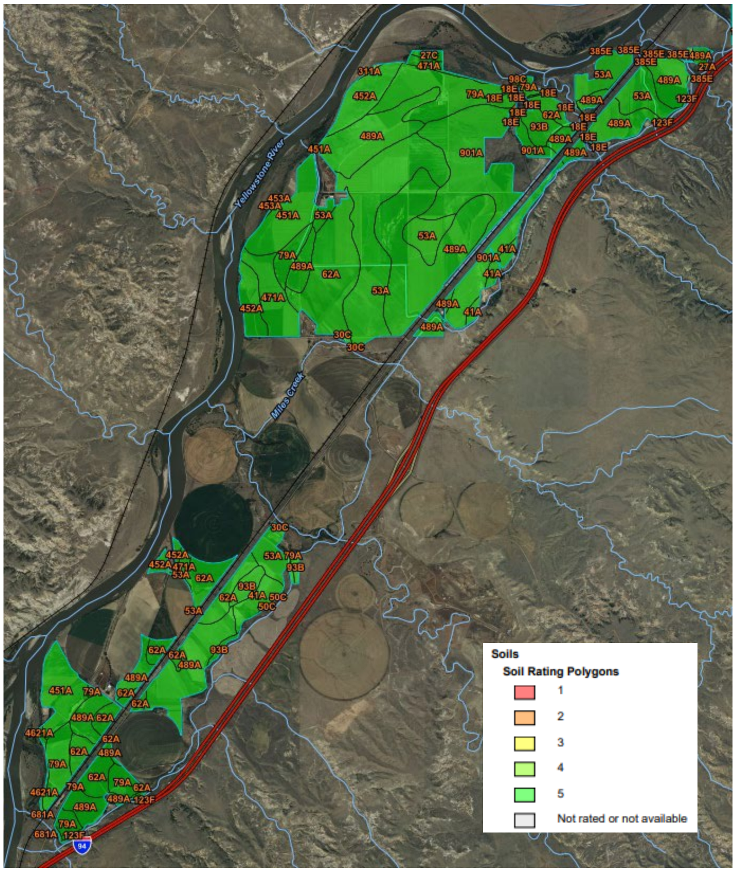


Figure 9. Shirley Unit South T Values

Appendix D: Producer Example Map & WEPS run – Before Conversion

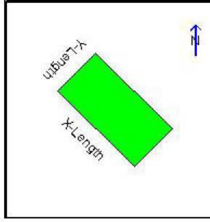
Run Summary

NRCS Natural Resources Conservation Service

[redacted] before

Run Date:	Thursday, February 03, 2022, 01:33 PM		
Client Name:	[redacted]		
Farm No:	1	**Tract No:** [redacted]	**Field No:** 1P
Run Location:	Runs		
Management:	[redacted]before_calib.man		
Soil:	Spinekop_115_85_SICL.ifc		

Location Site Information



X-Length:	2600.1 ft	**Mode:**	NRCS
Y-Length:	1299.9 ft	**Soil Loss Tolerance (T):**	5.0 t/ac/yr
Area:	77.6 ac	**Site:**	UNITED STATES MONTANA PRAIRIE
Elevation:	2076.8 ft	**Location:**	46.87047° N, 105.13991° W
Orientation:	45.0 °	**Cligen:**	GLENDIVE
		Windgen:	Interpolated (46.86047° N, 105.37791°

Erosion

Period	Crop/Residue	Gross Loss t/ac	Net Soil Loss From Field (t/ac) Total	Creep/Salt.	Suspen.	PM10
Rot. year: 1	Barley, spring	0.6	0.6	0.3	0.4	0.01
Rot. year: 2	Bean, field, dry	1.2	1.2	0.5	0.7	0.02
Rot. year: 3	Wheat, spring 7in rows	2.0	2.0	0.9	1.1	0.03
Rot. year: 4	Corn, grain	1.1	1.1	0.5	0.6	0.02
Ave. Annual		1.2	1.2	0.5	0.7	0.02

Crop Interval Erosion

Date Range	Days	Crop	Gross Loss t/ac	Net Soil Loss From Field (t/ac) Total	Creep/Salt.	Suspen.	PM10
Nov 15, 04 - Jul 31, 01	258	Barley, spring	0.6	0.6	0.3	0.4	0.01
Jul 31, 01 - Aug 20, 02	385	Bean, field, dry	1.0	1.0	0.4	0.6	0.02
Aug 20, 02 - Jul 31, 03	345	Wheat, spring 7in rows	2.2	2.2	1.0	1.2	0.04
Jul 31, 03 - Nov 15, 04	472	Corn, grain	1.1	1.1	0.5	0.6	0.02

Harvests

Date	Crop	Residue lb/ac	Harvest Yield	Yield % Moisture
Jul 31, 01	Barley, spring	5,598	82.6 bu/ac	9.6
Aug 20, 02	Bean, field, dry	1,434	1470.6 lb/ac	16.0
Jul 31, 03	Wheat, spring 7in rows	6,502	89.5 bu/ac	13.5

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Run Summary

NRCS Natural Resources Conservation Service

[redacted] before

Harvests

Date	Crop	Residue lb/ac	Harvest Yield	Yield % Moisture
Nov 15, 04	Corn, grain	6,605	118.4 bu/ac	15.5
Nov 15, 04	Corn, grain	1,567	1326.4 lb/ac	15.5

SCI Summary

Soil Conditioning Index:	0.3	**SCI Subfactors**	
Energy Calculator:	3.8 gal diesel/ac	**OM:**	-0.07
Average Annual STIR:	42.2	**FO:**	0.58
Wind Erosion Soil Loss:	1.2 t/ac	**ER:**	0.52
Water Erosion Soil	0.0 t/ac		

Rotation Stir Energy

Date	Operation	Fuel	Stir	Energy Btu/ac	Cost USD/ac
Apr 15, 01	Burn residue	Diesel	0.0	0	0.00
Apr 20, 01	Lister, 30 in	Diesel	35.1	157,452	4.50
Apr 25, 01	Drill or airseeder, double disk	Diesel	6.3	63,011	1.80
Apr 26, 01	Irrigation, Start Monitor (Border, Furrow)	Diesel	0.0	0	0.00
May 07, 01	Fert applic. surface broadcast	Diesel	0.1	27,988	0.80
May 25, 01	Sprayer, post emergence	Diesel	0.1	22,750	0.65
Jun 15, 01	Sprayer, post emergence	Diesel	0.1	22,750	0.65
Jul 23, 01	Irrigation, Stop Monitor	Diesel	0.0	0	0.00
Jul 31, 01	Harvest, killing crop 30pct standing stubble	Diesel	0.1	267,758	7.65
Aug 15, 01	Graze, stubble or residue 50 pct	Diesel	0.5	0	0.00
Sep 20, 01	Sprayer, post emergence	Diesel	0.1	22,750	0.65
Apr 15, 02	Burn residue	Diesel	0.0	0	0.00
Apr 20, 02	Lister, 30 in	Diesel	35.1	157,452	4.50
Apr 26, 02	Irrigation, Start Monitor (Border, Furrow)	Diesel	0.0	0	0.00
May 08, 02	Planter, double disk opnr	Diesel	2.4	76,930	2.20
May 25, 02	Sprayer, post emergence	Diesel	0.1	22,750	0.65
Jun 15, 02	Sprayer, post emergence	Diesel	0.1	22,750	0.65
Aug 13, 02	Irrigation, Stop Monitor	Diesel	0.0	0	0.00
Aug 20, 02	Harvest, knife, windrow, combine	Diesel	6.6	594,935	17.00
Aug 30, 02	Graze, stubble or residue 50 pct	Diesel	0.5	0	0.00
Sep 20, 02	Sprayer, post emergence	Diesel	0.1	22,750	0.65
Apr 15, 03	Burn residue	Diesel	0.0	0	0.00

Run Summary

NRCS Natural Resources Conservation Service

[redacted] before

Rotation Stir Energy

Date	Operation	Fuel	Stir	Energy Btu/ac	Cost USD/ac
Apr 20, 03	Lister, 30 in	Diesel	35.1	157,452	4.50
Apr 25, 03	Drill or airseeder, double disk	Diesel	6.3	63,011	1.80
Apr 26, 03	Irrigation, Start Monitor (Border, Furrow)	Diesel	0.0	0	0.00
May 07, 03	Fert applic. surface broadcast	Diesel	0.1	27,988	0.80
May 25, 03	Sprayer, post emergence	Diesel	0.1	22,750	0.65
Jun 15, 03	Sprayer, post emergence	Diesel	0.1	22,750	0.65
Jul 23, 03	Irrigation, Stop Monitor	Diesel	0.0	0	0.00
Jul 31, 03	Harvest, killing crop 30pct standing stubble	Diesel	0.1	267,758	7.65
Aug 15, 03	Graze, stubble or residue 50 pct	Diesel	0.5	0	0.00
Sep 20, 03	Sprayer, post emergence	Diesel	0.1	22,750	0.65
Apr 15, 04	Burn residue	Diesel	0.0	0	0.00
Apr 20, 04	Lister, 30 in	Diesel	35.1	157,452	4.50
Apr 26, 04	Irrigation, Start Monitor (Border, Furrow)	Diesel	0.0	0	0.00
May 07, 04	Fert applic. surface broadcast	Diesel	0.1	27,988	0.80
May 10, 04	Planter, double disk opnr	Diesel	2.4	76,930	2.20
May 25, 04	Sprayer, post emergence	Diesel	0.1	22,750	0.65
Jun 15, 04	Sprayer, post emergence	Diesel	0.1	22,750	0.65
Sep 15, 04	Irrigation, Stop Monitor	Diesel	0.0	0	0.00
Nov 15, 04	Harvest, corn grain and cobs	Diesel	0.1	267,758	7.65
Nov 19, 04	Graze, stubble or residue 50 pct	Diesel	0.5	0	0.00
		Total / ac		2,642,112	75.51
		Total	168.8	204,996,844	5,858.78

Crop Interval Stir Energy

Date Range	Days	Crop	Stir	Energy Btu/ac	Cost USD/ac
Nov 15, 04 - Jul 31, 01	258	Barley, spring	42.4	561,709	16.05
Jul 31, 01 - Aug 20, 02	385	Bean, field, dry	45.0	897,567	25.65
Aug 20, 02 - Jul 31, 03	345	Wheat, spring 7in rows	42.6	584,459	16.70
Jul 31, 03 - Nov 15, 04	472	Corn, grain	38.7	598,378	17.10

Notes

This WEPS Run generated one or more Warning messages. For detailed information about these Warnings, see this run's 'warnings.txt' output file.

```
  25/ 4/ 1      Barley, spring          1.150
   8/ 5/ 2      Bean, field, dry                1.000
  25/ 4/ 3      Wheat, spring 7in rows          1.450
  10/ 5/ 4      Corn, grain            0.9531
```

Producer Example Map & WEPS run – After Conversion

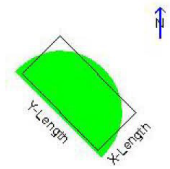
Run Summary

NRCS Natural Resources Conservation Service

[redacted] after_calib

Run Date:	Thursday, February 03, 2022, 01:51 PM
Client Name:	[redacted]
Farm No:	1 **Tract No:** [redacted] **Field No:**1P
Run Location:	Runs
Management:	[redacted] after_calib.man
Soil:	Spinekop_115_85_SICL.ifc

Location Site Information



Field shape approximate

X-Length:	1299.9 ft
Y-Length:	2600.1 ft
Radius:	1466.9 ft
Area:	77.6 ac
Elevation:	2076.8 ft
Orientation:	-45.0 °

Mode:	NRCS
Soil Loss Tolerance (T):	5.0 t/ac/yr
Site:	UNITED STATES MONTANA PRAIRIE
Location:	46.87047° N, 105.13991° W
Cligen:	GLENDIVE
Windgen:	Interpolated (46.86047° N, 105.37791°

Erosion

Period	Crop/Residue	Gross Loss t/ac	Net Soil Loss From Field (t/ac) Total	Creep/Salt.	Suspen.	PM10
Rot. year: 1	Barley, spring	0.0	0.0	0.0	0.0	0.00
Rot. year: 2	Bean, field, dry	0.1	0.1	0.1	Trace	Trace
Rot. year: 3	Wheat, spring 7in rows	0.1	0.1	0.1	0.1	Trace
Rot. year: 4	Corn, grain	0.0	0.0	0.0	0.0	0.00
Ave. Annual		Trace	Trace	Trace	Trace	Trace

Crop Interval Erosion

Date Range	Days	Crop	Gross Loss t/ac	Net Soil Loss From Field (t/ac) Total	Creep/Salt.	Suspen.	PM10
Nov 15, 04 - Jul 31, 01	258	Barley, spring	0.0	0.0	0.0	0.0	0.00
Jul 31, 01 - Aug 20, 02	385	Bean, field, dry	0.0	0.0	0.0	0.0	0.00
Aug 20, 02 - Jul 31, 03	345	Wheat, spring 7in rows	0.2	0.2	0.1	0.1	0.00
Jul 31, 03 - Nov 15, 04	472	Corn, grain	0.0	0.0	0.0	0.0	0.00

Harvests

Date	Crop	Residue lb/ac	Harvest Yield	Yield % Moisture
Jul 31, 01	Barley, spring	5,360	78.6 bu/ac	9.6
Aug 20, 02	Bean, field, dry	1,408	1442.0 lb/ac	16.0
Jul 31, 03	Wheat, spring 7in rows	6,591	90.7 bu/ac	13.5

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Run Summary

[redacted] after_calib

Harvests

Date	Crop	Residue lb/ac	Harvest Yield	Yield % Moisture
Nov 15, 04	Corn, grain	6,711	120.5 bu/ac	15.5
Nov 15, 04	Corn, grain	1,570	1349.4 lb/ac	15.5

SCI Summary

Soil Conditioning Index:	0.6	**SCI Subfactors**	
Energy Calculator:	3.0 gal diesel/ac	**OM:**	0.05
Average Annual STIR:	7.2	**FO:**	0.93
Wind Erosion Soil Loss:	0.1 t/ac	**ER:**	0.98
Water Erosion Soil	0.0 t/ac		

Rotation Stir Energy

Date	Operation	Fuel	Stir	Energy Btu/ac	Cost USD/ac
Apr 20, 01	Sprayer, post emergence	Diesel	0.1	22,750	0.65
Apr 25, 01	Drill or airseeder, double disk	Diesel	6.3	63,011	1.80
Apr 26, 01	Irrigation, Start Monitor (pivot, linear, wheelline)	Diesel	0.0	0	0.00
May 07, 01	Fert applic. surface broadcast	Diesel	0.1	27,988	0.80
May 25, 01	Sprayer, post emergence	Diesel	0.1	22,750	0.65
Jun 15, 01	Sprayer, post emergence	Diesel	0.1	22,750	0.65
Jul 23, 01	Irrigation, Stop Monitor	Diesel	0.0	0	0.00
Jul 31, 01	Harvest, killing crop 30pct standing stubble	Diesel	0.1	267,758	7.65
Aug 15, 01	Graze, stubble or residue 50 pct	Diesel	0.5	0	0.00
Sep 20, 01	Sprayer, post emergence	Diesel	0.1	22,750	0.65
Apr 20, 02	Sprayer, post emergence	Diesel	0.1	22,750	0.65
Apr 26, 02	Irrigation, Start Monitor (pivot, linear, wheelline)	Diesel	0.0	0	0.00
May 08, 02	Planter, double disk opnr	Diesel	2.4	76,930	2.20
May 25, 02	Sprayer, post emergence	Diesel	0.1	22,750	0.65
Jun 15, 02	Sprayer, post emergence	Diesel	0.1	22,750	0.65
Aug 13, 02	Irrigation, Stop Monitor	Diesel	0.0	0	0.00
Aug 20, 02	Harvest, knife, windrow, combine	Diesel	6.6	594,935	17.00
Aug 30, 02	Graze, stubble or residue 50 pct	Diesel	0.5	0	0.00
Sep 20, 02	Sprayer, post emergence	Diesel	0.1	22,750	0.65
Apr 20, 03	Sprayer, post emergence	Diesel	0.1	22,750	0.65
Apr 25, 03	Drill or airseeder, double disk	Diesel	6.3	63,011	1.80

Run Summary

[redacted] after_calib

Rotation Stir Energy

Date	Operation	Fuel	Stir	Energy Btu/ac	Cost USD/ac
Apr 26, 03	Irrigation, Start Monitor (pivot, linear, wheelline)	Diesel	0.0	0	0.00
May 07, 03	Fert applic. surface broadcast	Diesel	0.1	27,988	0.80
May 25, 03	Sprayer, post emergence	Diesel	0.1	22,750	0.65
Jun 15, 03	Sprayer, post emergence	Diesel	0.1	22,750	0.65
Jul 23, 03	Irrigation, Stop Monitor	Diesel	0.0	0	0.00
Jul 31, 03	Harvest, killing crop 30pct standing stubble	Diesel	0.1	267,758	7.65
Aug 15, 03	Graze, stubble or residue 50 pct	Diesel	0.5	0	0.00
Sep 20, 03	Sprayer, post emergence	Diesel	0.1	22,750	0.65
Apr 20, 04	Sprayer, post emergence	Diesel	0.1	22,750	0.65
Apr 26, 04	Irrigation, Start Monitor (pivot, linear, wheelline)	Diesel	0.0	0	0.00
May 07, 04	Fert applic. surface broadcast	Diesel	0.1	27,988	0.80
May 10, 04	Planter, double disk opnr	Diesel	2.4	76,930	2.20
May 25, 04	Sprayer, post emergence	Diesel	0.1	22,750	0.65
Jun 15, 04	Sprayer, post emergence	Diesel	0.1	22,750	0.65
Sep 15, 04	Irrigation, Stop Monitor	Diesel	0.0	0	0.00
Nov 15, 04	Harvest, corn grain and cobs	Diesel	0.1	267,758	7.65
Nov 19, 04	Graze, stubble or residue 50 pct	Diesel	0.5	0	0.00
		Total / ac		2,103,303	60.11
		Total	29.0	163,191,562	4,663.99

Crop Interval Stir Energy

Date Range	Days	Crop	Stir	Energy Btu/ac	Cost USD/ac
Nov 15, 04 - Jul 31, 01	258	Barley, spring	7.5	427,006	12.20
Jul 31, 01 - Aug 20, 02	385	Bean, field, dry	10.1	762,864	21.80
Aug 20, 02 - Jul 31, 03	345	Wheat, spring 7in rows	7.6	449,756	12.85
Jul 31, 03 - Nov 15, 04	472	Corn, grain	3.7	463,675	13.25

Notes

This WEPS Run generated one or more Warning messages. For detailed information about these Warnings, see this run's 'warnings.txt' output file.

```
 25/ 4/ 1     Barley, spring          1.123
  8/ 5/ 2     Bean, field, dry               0.9062
 25/ 4/ 3     Wheat, spring 7in rows          1.504
 10/ 5/ 4     Corn, grain            0.9084
```

Appendix E: Buffalo Rapids District No. 2 Sediment Transport & Nutrient Loss Reduction Project Area
Custer & Prairie Counties, Montana