Development of a Web-Based APEX Tool, VT STAR, for Optimizing Best Management Practices and Conservation Planning on Vermont Farms: Final Report

Prepared for Vermont Natural Resources Conservation Service and Vermont Agency of Agriculture Food and Markets

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1. Introduction

This report documents the development and evaluation of a web-based APEX model simulation tool, Vermont Systematic Tool for Analyzing Resources (VT STAR), designed for the Vermont Natural Resources Conservation Service (NRCS). The VT STAR tool was developed to design conservation plans for Vermont farms using the United States Department of Agriculture's (USDA's) latest agricultural water quality modeling technology (APEX) and farm field specific topography, soil, weather, and agronomic management data sources. The tool was designed such that comparisons of multiple conservation management alternatives can be evaluated as part of a single conservation planning assessment in order to efficiently arrive at the best management practice choices for a specific field and farm. While VT STAR was targeted for use by NRCS conservation planners, the tool will be of value to additional Vermont stakeholders concerned with water quality and the optimal implementation of agricultural best management practices throughout the state.

The first section of this report describes the datasets that have been compiled for use in VT STAR and for populating the APEX model simulations generated for each assessment. This is followed in Section 2.2 by an overview of the VT STAR application development components that were implemented to meet the needs requirements for STAR use in Vermont. The testing and evaluation of VT STAR is covered in Section 3 and focuses on the APEX model simulation results over a range of crop management systems and field conditions. The objective of the testing and evaluation was to assess whether the results generated by APEX and reported in VT STAR fell within expectations based on our conceptual understanding of agricultural water quality in Vermont. The evaluation included both a relative comparison of multiple fields with and without conservation practices under similar cropping systems, as well as a comparison of STAR-predicted results with site specific edge-of-field monitoring data. Overall, the testing and evaluation of VT STAR provided increased confidence in the model predictions. The relative comparisons of sediment and nutrient load predictions followed the expected trends across the different fields and practices, and the comparisons of the model predictions with the monitoring data were reasonable. As the use and testing of VT STAR continues, it is quite possible that additional adjustments to the parameterization of some types of management schedules and conservation practices will occur. In the meantime, the conservation planning assessment data being generated by VT STAR has been found to be representative of a broad range of conditions important to Vermont agriculture.

Both the VT STAR Training Exercise Workbook and the VT STAR Application manual are included as appendices in this report. The training exercise workbook was used for VT STAR training that was conducted at the VT NRCS office on September 15th, 2015. This workbook guides new STAR users through the critical steps required when conducting a conservation planning assessment. It includes clear examples that provide users with a strong foundation for using VT STAR. The VT STAR Application Manual provides additional documentation of VT STAR features and functionality that were not touched upon in the Exercise Workbook.

2. Development of the VT STAR Database and Application

2.1. Database Development

The STAR database stores the spatial and non-spatial datasets required to run the APEX model. Vermont specific soils, weather, practices and operation schedules data were compiled and formatted for use in STAR.

2.1.1. **Spatial Datasets**

The STAR database contains spatial datasets that are created by the user for use in the development of a STAR assessment and additional spatial layers that have been compiled for use as inputs to the APEX model.

2.1.1.1. STAR Planning Land Unit and Field Layers

The conservation planning land unit feature class contains all the fields that make up a conservation plan and are created by the user either by importing NRCS Toolkit xml data, importing a conservation plan shapefile, or by creating a conservation plan through the STAR interface.

The field, or APEX subarea, feature class contains the fields being modeled in the current STAR assessment. These fields can be modified by practices that are selected by the user. The field layer is used in the spatial analysis to determine the predominant soil, slope, and weather station. The geometry of the fields is also provided as inputs to the APEX model.

2.1.1.2. Topography

The USGS Vermont 10 meter statewide DEM (2012) was obtained from Vermont Center for Geographic Information (VCGI). This dataset was extracted from USGS National Elevation Dataset (NED) 1/3 arc second data. A slope grid was calculated from the elevation grid for use in the STAR application.

The elevation and percent slope grids were imported to a file geodatabase for use by STAR geoprocessing scripts prior to APEX execution. The scripts calculate the average percent slope for each field and the average elevation over all the fields in a STAR assessment.

2.1.1.3. Land Use

The 2013 Cropland Data Layer (CDL) from the National Agricultural Statistics Service (NASS) was downloaded for Vermont. The CDL serves as a reference layer in the STAR application so that user can view crop data for the area of interest (Figure 2-1).

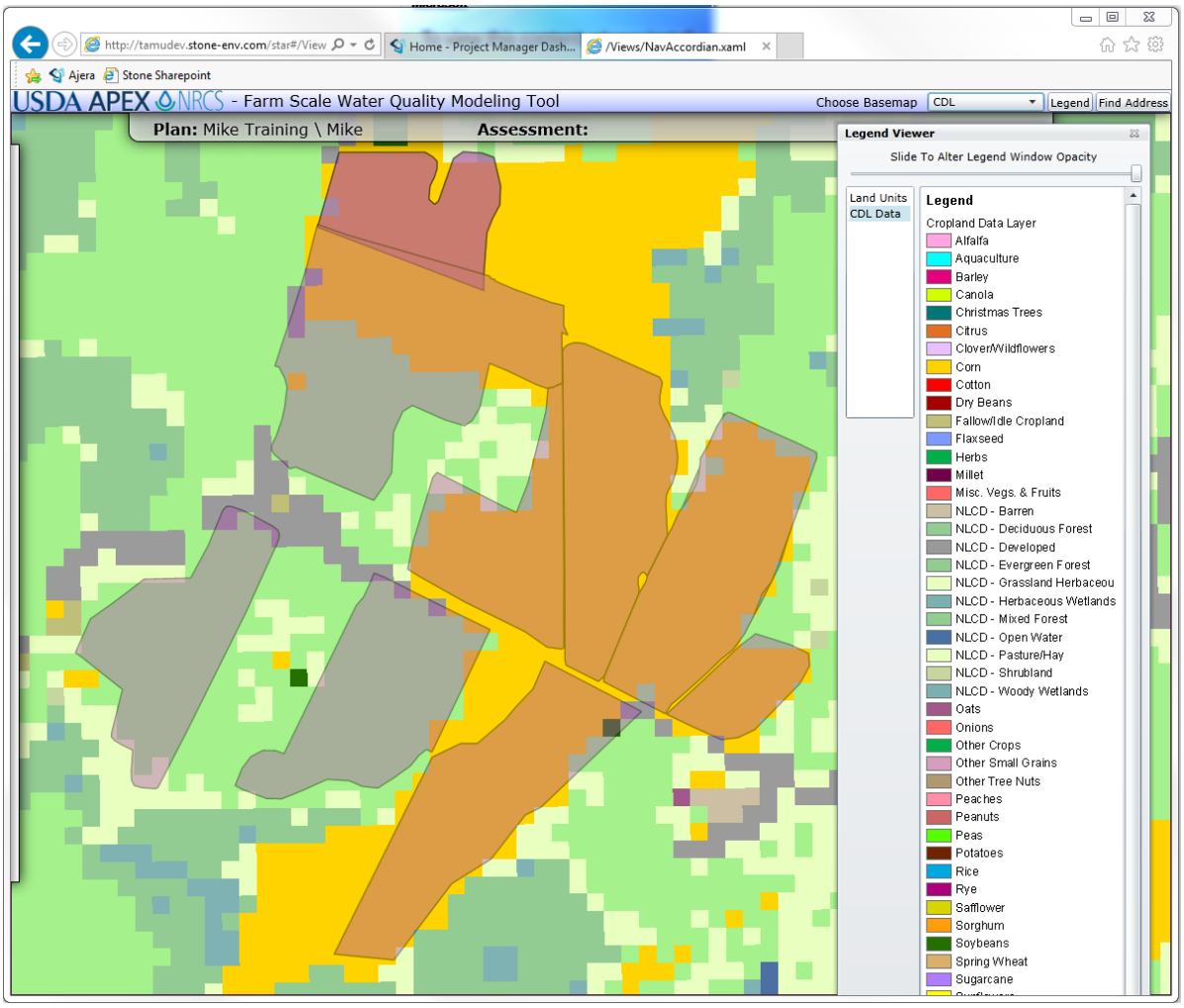

Figure 2-1. Cropland data layer (CDL) view in STAR

2.1.1.4. Soils

The USDA/NRCS SSURGO data dataset is the foundational soils dataset used by STAR. A live map service of the SSURGO soil polygon layer is available as a reference layer in the STAR application (http://server.arcgisonline.com/ArcGIS/rest/services/Specialty/Soil_Survey_Map/MapServer), while the STAR backend database provides a local source of the spatial data for geoprocessing and APEX inputs parameterization. The spatial layer of SSURGO map units used by STAR was obtained from the NRCS as part of a national data request in March of 2012. The soil parameters required by the APEX model are very similar to those required by the Soil and Water Assessment Tool (SWAT). The SWAT developers have compiled a database of soil parameters by SSURGO "mukey" (available from: http://swat.tamu.edu/software/arcswat/), which was adapted for use in parameterizing the APEX soils inputs for VT STAR.

2.1.1.5. Weather

The VT STAR application uses a database of monthly weather statistics to create synthetic daily time series of weather inputs required by APEX. These daily inputs include precipitation, temperature, relative humidity,

wind speed, and solar radiation. The statistical approach of generating daily time series abed on monthly climate normals is allows users to runs extended simulations of the APEX model (40 plus years) to evaluate long term water quality and field environmental conditions. The weather database was compiled by our partners at the Texas A&M Blackland Research and Extension Center, and is used with the most recent version of the iEPIC model. The national database includes 17 stations in Vermont, 24 stations in New Hampshire, 103 stations in New York, and 31 stations in Massachusetts. An APEX simulation with VT STAR will identify the closest monthly weather station to a given field, which can be pulled from neighboring states.

2.1.2. Non-Spatial Datasets

The STAR database contains non-spatial datasets used by the STAR application to derive inputs for the APEX model. Stone worked with NRCS to develop appropriate crop lists, practices, and operation schedules for Vermont.

2.1.2.1. Crop, Fertilizer, Pesticide, and Tillage

The APEX model contains an extensive national database. In order to simplify the STAR interface for Vermont, the crop, fertilizer, pesticide, and tillage datasets were reviewed by NRCS and Stone and modified to include only Vermont appropriate data. The Vermont crop list is contained in Appendix A and the Vermont fertilizer list is contained in Appendix B of this report.

Since manure is an important source of fertilizer application in VT, a VT specific dairy liquid manure record was added to the default APEX fertilizer database. A new fertilizer in the APEX database requires the fraction (kg/kg) of mineral and organic N and P. The main literature source for nutrient content in liquid dairy manure was based on manure samples analyzed by the University of Vermont Agricultural and environmental lab (Table 2-1). The manure values from lb/1000 gal were converted to dry weight assuming a manure density of 8.5 lb/gal. Also, it was assumed that 72.5% of manure P was in the mineral form and the rest in organic form. Based on these calculations, the mineral and organic P fractions were calculated to 0.00426 kg/kg and 0.00162 kg/kg, respectively. Similarly, the mineral and organic N fractions were set to 0.0202 kg/kg and 0.0218 kg/kg, respectively.

Table 2-1. Typical values for total nutrient content of manure (Source: Table 14, Nutrient Recommendations for Field Crops in Vermont, The University of Vermont)

Dry Matter	Total N	NH4-N	Organic N	P_2O_5
%	lb/1000 gal			
7	25	12	13	

2.1.2.2. Conservation Practices

Conservation practices specific to Vermont that can be simulated in APEX were added to the STAR database. STAR handles conservation practices in one of the following three ways:

1. Prompts the user to draw the conservation practice on the field and then splits the field into the field and the practice area. APEX treats the two areas as separate fields (or subareas) and requires the user to define the routing accordingly.

2. Prompts the user to create a custom conservation operation schedule. For some practices, the operation schedule is assigned automatically.

3. Adjusts APEX parameters automatically.

Table 2-1 below contains a list of the conservation practices and how they are handled by STAR.

Table 2-2. List of conservation practices in STAR

NRCS Code	Practice Name	STAR User Info
328	Conservation Crop Rotation	Create a custom conservation operation schedule
329	Residue Management, No-till, Strip Till	Create a custom conservation operation schedule
330	Contour Farming	Create a custom operation schedule. APEX parameters will automatically be updated based on the contour farming.
382	Fence	Draw the fence using the STAR splitting tool and then create a custom operation schedule for each of the fields.
391	Riparian Forest Buffer	Draw the buffer using the STAR splitting tool. The operation schedule for the buffer is automatically assigned.
393	Filter Strip	Draw the filter strip using the STAR splitting tool. The operation schedule for the filter strip is automatically assigned.
412	Grassed Waterways	Draw the grass waterway using the STAR splitting tool. The operation schedule for the grass waterway is automatically assigned.
512	Pasture and Hayland Planting	An appropriate operation schedule has been added for this field.
528	Prescribed Grazing	Draw the grazing area using the STAR splitting tool. The operation schedule for the grazing area is automatically assigned.
590	Nutrient Management	Create a custom operation schedule following the nutrient management plan.
595	Pest Management	Create a custom operation schedule that includes pesticide applications.
633	Waste Utilization	Create a custom operation schedule following alternative manure management practices
340	Cover Crop	Add a cover crop using the crop mix tool in the planting operation editor.
362	Diversion	Create a custom operation schedule. APEX parameters will automatically be updated based on the diversion.
410	Grade Stabilization Structure	Create a custom operation schedule. APEX parameters will automatically be updated based on the grade stabilization structure.
386	Field Border	Create a custom operation schedule. APEX parameters will automatically be updated for the field border.

606	Subsurface Drain	Create a custom operation schedule. APEX parameters will automatically be updated based on the subsurface drain.

2.1.2.3. Management Schedules

The crop management schedules represent one of the most important inputs in an APEX simulation. The management schedules for VT STAR were derived from standard RUSLE2 database schedules, then filtered and modified for use with VT STAR. The RUSLE2 schedules were first exported from RUSLE2 and translated into an APEX database format by our partners at the Texas A&M Blackland Research and Extension Center. This resulted in 556 management schedules for Crop Management Zone 60. Working with VT NRCS scientists, this list of 556 schedules was reduced down to a more practical list of 68 schedules. A list of these schedules is provided in Appendix C. This list was selected to represent the crop rotations and management practices that are most important to agriculture in Vermont.

The management schedules derived from the RUSLE 2 database did not include mineral fertilizer of manure applications. To complete each of the selected schedules, Stone worked with VT NRCS scientists to derive the appropriate fertilizer/manure application amounts and timing for each schedule. In addition, the planting, tillage, and harvest operations within each schedule were evaluated both to identify errors and make adjustments if needed. The final crop management schedules were uploaded into the VT STAR database. These schedules serve as the foundation for APEX simulations, but can also be customized to match specific farmer practices.

2.2. Application Development

2.2.1. Conservation Plan Entry

The STAR interface provides several options for creating a conservation plan which then serves as the basis for creating assessments. Initial development of STAR required import of an NRCS Toolkit xml file to create a conservation plan. While this option is still available, users can now also create a conservation plan within the STAR application.

The "Create New Conservation Plan" tool allows the user to create a Conservation Plan by specifying the plan name and land owner. The user can then either import a shapefile of field boundaries or create field boundaries using a drawing tool. The area of interest can be located using the Find Address tool. Both of these methods create fields in the STAR field layer and are associated with the Conservation Plan created by the user.

2.2.2. Conservation Practices

The VT STAR interface has been developed to allow users to select specific practices to be simulated on each field in in a conservation plan. This listing of conservation practices available in VT STAR was provided in Section 2.1.2.2. The user interface and backend database were developed to provide users the feedback on how each practice will be implemented by STAR to parameterize APEX. As much as possible, the interface and database were designed to make the necessary parameter adjustments to APEX automatically, with limited

additional user interaction. For some types of practices, the user must provide additional information (such as the specific location of a grassed waterway) in order for APEX to be accurately parameterized. For these types of practices, STAR provides additional user feedback as guidance for properly setting the additional inputs.

2.2.3. Custom Soils

The STAR application automatically determines the predominant SSURGO soil for each field after the user completes the operation schedule definition. The name of the predominant soil is then displayed in the soil panel. Users have the option of modifying soil parameters based on local knowledge of soil conditions on the field.

A tool was developed to provide users with the option of entering field specific soil test results for phosphorus. Users can choose from either the Modified Morgan test or the Mehlich test and are prompted to enter Soil P and pH. When the user selects Modified Morgan the interface also prompts the user for an Aluminum value. The Initial Soluble P Concentration using the Modified Morgan is then calculated using the following equation:

$$(6.718*UserP)-(11.83*pH)-32.757*(UserP/Al)+90.73$$

The user has the option of modifying soil parameter values for each soil layer.

2.2.4. Output Reporting

STAR provides the user with a summary of the APEX model inputs and results for each of the fields in the assessment. The user has the option of selecting a Baseline assessment and up to two alternative assessments. Table 2-3 contains the APEX parameters can be included in the STAR report.

Table 2-3. List of APEX output variables that can be included in the STAR report

Total Outflow (inches)
Total Sediment Yield (t/ac)
Total Soluble P in Outflow (lb/ac)
Total Sediment P in Outflow (lb/ac)
Tile Drain Phosphorus Loss (lb/ac)
Total Soluble N in Outflow (lb/ac)
Total Sediment N in Outflow (lb/ac)
Tile Drain Nitrogen Loss (lb/ac)
Total Soluble Pesticide in Outflow (lb/ac)
Total Sediment Pesticide in Outflow (lb/ac)
Nitrogen Volatilization (lbs/acre)
Forage Crop Yield (t/ac)
Grain Yield (t/ac)
Drought Stress (days)
Phosphorus Stress (days)
Nitrogen Stress (days)

3. VT STAR Simulation Results Evaluation

Several tests were conducted during the VT STAR development process, to not only test STAR functionality, but also to evaluate its output. This chapter documents the testing that was done to ensure that STAR outputs were reasonable.

3.1. Comparison of STAR Results Across Different Crop Practices and Field Conditions

3.1.1. Objectives

Cropping practices such as fertilizer application, tillage and cover crop play an important in the pollutant loss dynamics of any field. For instance, conservation tillage practices such no till, mulch, or strip till are known to reduce sediment and phosphorus (P) losses. In addition to cropping practices, field conditions such as topography and soil conditions can influence the transport capacity of pollutants from the fields. For example, we would expect fields with higher slopes to contribute to greater soil and P loss compared to fields in flatter areas, when managed under similar cropping practices. Similarly, fields with soils under hydrologic soil group (HSG) D are likely to have more runoff than a field with soil HSG B. In addition to cropping practices and field conditions, implementation of conservation practices can be beneficial. Practices such as field buffer and subsurface drainage, can reduce sediment and P losses.

This variability in pollutant losses resulting from different cropping practices, field condition, and conservation practices was considered an important aspect of STAR testing. The objective of this testing was to compare relative runoff, sediment and phosphorus loss simulated by STAR due to these factors.

3.1.2. Methods

Three fields in Vermont were identified using STAR to provide variation in slope and soil hydrologic group. The first had a slope of 1.07% and soil hydrologic group B. The second field had 10.5% slope and soil hydrologic group B. Finally, the third field had same slope as field 2, but was under soil hydrologic group C. Once the fields were identified, two types of cropping practices were selected. These schedules were selected to provide variability in tillage practices. For each schedule, the baseline simulation was compared against those with 50 ft field buffer and subsurface drainage. While several conservation practices are available to a STAR user, only two practices (subsurface drainage and buffers) were considered to limit the scope of this testing.

For each run, the results for annual runoff, sediment loss, soluble P, tile drain P, and sediment P losses were recorded. Relative comparisons were made to check against our general conceptual understanding of how various factors described above could influence these outputs.

3.1.3. Results

Table 3-1 provides key annual results from 12 STAR simulations that cover a range cropping practices, field conditions and conservation practices. The results are discussed for each of these factors below. The main difference between scenario 1 and 2 is the presence of tillage. Scenario 1 includes a mulch till applied just before planting in early May, while scenario 2 has no till throughout the year. Inclusion of tillage resulted in greater runoff, sediment, and sediment P losses. This was considered reasonable because no-till practices leave greater amount of residue on the field, which reduces transport of water and pollutants.

Scenarios 1 output was compared against similar scenarios when applied to high slope (10.5%) slope field and having soil hydrologic group C (scenario 3) and D (scenario 4). In other words, Scenario 1, 3, and 4 used the same cropping practice but different field conditions. Between scenarios 1 and 3, runoff increases slightly but sediment loss increases greatly from 0.2 t/ha to 7.4 t/ha. Similarly, total P increased almost five times from 0.8 kg/ha to 3.7 kg/ha. This can be attributed to increase in slope and change in HSG from B to C. Between scenarios 5 and 6, the runoff and sediment losses further increased, which highlights the role of soil properties in influencing off-field sediment and P transport. These results are consistent with our understanding of the relation between soil hydrologic groups and sediment loss/runoff.

Table 3-1. STAR output for annual runoff, sediment, and phosphorus (P) loss under different condition of cropping practice, field conditions and conservation practice.

Scenario	Cropping Practice (schedule[1])	Field Condition	Practice	Runoff (mm)	Sediment (t/ha)	Soluble P Yield (kg/ha)	P in Tile Drain (kg/ha)	P in Sediment (kg/ha)	Total P (kg/ha)
1	Corn silage, Mulch till Winter cover, Manure (A)	1.07% slope, HSG B	Baseline	42.582	0.212	0.091	0	0.68	0.771
			Subsurface drainage	42.592	0.213	0.091	0.068	0.68	0.839
			Buffer (50 ft)	39.693	0.164	0.084	0	0.701	0.785
2	Corn silage, No till, Winter cover, Manure (B)	1.07% slope, HSG B	Baseline	34.531	0.024	0.09	0	0.502	0.592
			Subsurface drainage	34.541	0.024	0.09	0.084	0.502	0.676
			Buffer (50 ft)	31.378	0.016	0.084	0	0.557	0.641
3	Corn silage, Mulch till, Winter cover, Manure (A)	10.5% slope, HSG C	Baseline	48.234	7.392	0.104	0	3.62	3.724
			Subsurface drainage	19.579	2.771	0.036	0.102	1.622	1.76
			Buffer (50 ft)	45.818	2.18	0.102	0	1.759	1.861
4	Corn silage, Mulch till, Winter cover, Manure (A)	10.5% slope, HSG D	Baseline	82.138	12.552	0.194	0	6.216	6.41
			Subsurface drainage	19.579	2.771	0.036	0.102	1.622	1.76
			Buffer (50 ft)	78.045	3.892	0.184	0	3.342	3.526

[1](A) Corn Silage\Corn, silage; mulch till, SC, wintercover, manure, Z60; (B) Corn Silage\Corn, silage; no till, SC, wintercover, manure, Z60; (C) Corn Grain\Corn, grain; mulch till, SC, spring manure, Z60, 4Corn Grain\Corn, grain; No Till, Z60, (D) Corn Silage\Corn, silage; mulch till, SC, wintercover, manure, Z60

The conservation practices tested were subsurface drainage and field buffer to compare against baseline. The default depth of subsurface drain in STAR is 1067 mm (3.5 ft), while the field buffer width was set to 50 ft. Results showed that the subsurface drainage was most effective in reducing runoff on poorly drained, higher slope fields. For higher slope fields, erosion and sediment bound P reduced greatly when subsurface drains

were implemented. However, implementation of subsurface drain provided a new transport pathway for P through the tile drains. The P loss in tile drains ranged from 0.07 kg/ha to 0.1 kg/ha

Placement of a 50 ft buffer consistently reduced runoff and sediment loss across all scenarios. The benefits, however, were higher for higher slope fields. For example, the reduction of sediment was highest for scenarios 3 and 4, due to it higher slopes. These results are consistent with our conceptual understanding that higher sloped fields are most prone to high sediment and sediment P losses and buffers placed for such fields can provide the greatest benefits.

3.2. Comparison of STAR Results with Edge of Field Monitoring Data

3.2.1. Objectives

APEX is a complex agricultural water quality model that simulates a field's hydrology, crop growth, and nutrient cycling. It uses well-established, peer-reviewed mathematical equations to perform the simulations on a daily basis. Based on a default parameterization, the model provides reasonable output, which was also verified in the previous section of this report. When site-specific data is available, such as cropping practices and monitoring data, the model can be refined to more closely represent regional conditions. The most common use of a site-specific calibrated model is to evaluate alternative scenarios (e.g. implementation of cover crops) for that particular site.

Although calibration is considered valuable for model usability, over conditioning for a single site can make it less useful for other sites. For STAR, which was developed to be applicable to any field in VT, a generalized set of parameter values - one that provides acceptable simulations over a range of conditions in topography, soils and cropping conditions – is more desirable than those conditioned for a single farm.

To evaluate if the current set of parameters could be further refined, the APEX model inputs generated through STAR were further calibrated. Calibration of environmental models traditionally involves adjusting parameter to reflect site-specific conditions and to match output recorded for every monitoring event. However, for this testing, the model was not evaluated for every event, but rather focused on the longer term (annual) runoff, sediment, and nutrient transport predictions across multiple fields.

The main objective was to identify broad parameters value adjustments that could improve overall simulations in STAR. In a multi-parameter model like APEX, a set of parameters values that match monitoring output at one site, perform less ideally at other sites. Therefore, caution was exercised to not over-condition the existing parameter values to one site, but identify parameter values that generally improved simulations for all sites.

3.2.2. Methods

To develop a regionally specific calibration of APEX, water quality data is required. Stone has been conducting edge-of-field monitoring in several corn and hay fields in VT since the fall of 2012. Data from five such fields located in Ferrisburgh (FER; 4.6 acres), Shoreham (SHO; 5.9 acres), Shelburne (SHE; 6.8 acres), Pawlet (PAW; 6.0 acres), and Williston (WIL; 4.3 acres) were used to evaluate STAR predictions. At the time this testing began, monitoring data from 2012 and 2013 was available. Detailed information from farmer-reported cropping schedules was also available and included in the APEX models (Table 3-2 through Table 3-6).

Table 3-2. Crop schedule at the Ferrisburgh field

Year	Month	Day	Activity
1	4	12	Apply tillage 820 ROLLHRRW (Roller Harrow 15 FT)
1	4	16	Plant red clover using "drill, air deliver" on straight row cover type
1	7	4	Harvest without kill using "Baler, Harvest Forage" Method
1	9	1	Harvest without kill using "Baler, Harvest Forage" Method
2	6	19	Harvest without kill using "Baler, Harvest Forage" Method
2	7	24	Harvest without kill using "Baler, Harvest Forage" Method
2	8	25	Harvest without kill using "Baler, Harvest Forage" Method
2	9	19	Harvest without kill using "Baler, Harvest Forage" Method
2	10	11	Fertilizer application (WoodAsh @ 4400 lb/acre using "Fertilizer app surface broadcast no incorp")
2	10	17	Fertilizer application (Manure @ 4000 gal/acre using "Fertilizer app surface broadcast no incorp")
2	12	6	Fertilizer application (Manure @ 4000 gal/acre using "Fertilizer app surface broadcast no incorp")

Table 3-3. Crop schedule at the Shorham field

Year	Month	Day	Activity
1	1	1	Plant alfalfa and tal fescue using "drill, air deliver"on straight row cover type
1	3	25	Fertilize "45-0-0 Urea" using "Fertilizer app surface broadcast no incorp" @ 150 lb/acre
1	5	18	Harvest without kill using "Baler, Harvest Forage" Method
1	7	2	Fertilizer application (Dairy Fresh Manure @ 5000 gal/acre using "Fertilizer app surface broadcast no incorp")
1	7	4	Harvest without kill using "Baler, Harvest Forage" Method
1	8	21	Harvest without kill using "Baler, Harvest Forage" Method
1	11	20	Harvest without kill using "Baler, Harvest Forage" Method
2	4	15	Fertilize "45-0-0 Urea" using "Fertilizer app surface broadcast no incorp" @ 150 lb/acre
2	5	18	Harvest without kill using "Baler, Harvest Forage" Method
2	7	12	Harvest without kill using "Baler, Harvest Forage" Method
2	7	20	Fertilizer application (Dairy Fresh Manure @ 4500 gal/acre using "Fertilizer app surface broadcast no incorp")
2	8	16	Harvest without kill using "Baler, Harvest Forage" Method
2	9	29	Harvest without kill using "Baler, Harvest Forage" Method
2	10	14	Fertilizer application (Dairy Fresh Manure @ 4300 gal/acre using "Fertilizer app surface broadcast no incorp")

Table 3-4. Crop schedule at the Shelburne field

Year	Month	Day	Activity
1	1	1	Plant Timothy, plant with drill using "drill, air deliver", straight row cover type
1	6	9	Harvest without kill using "Baler, Harvest Forage" Method

1	7	24	Harvest without kill using "Baler, Harvest Forage" Method
1	9	3	Fertilizer application (Dairy Fresh Manure @ 5561 gal/acre using "Fertilizer app surface broadcast no incorp")
2	7	13	Harvest without kill using "Baler, Harvest Forage" Method
2	8	2	Fertilizer application (Dairy Fresh Manure @ 7300 gal/acre using "Fertilizer app surface broadcast no incorp")
2	9	3	Harvest without kill using "Baler, Harvest Forage" Method

Table 3-5. Crop schedule at the Pawlet field

Year	Month	Day	Activity
1	5	12	Fertilizer application (Dairy Fresh Manure @ 4000 gal/acre using "Fertilizer app surface broadcast no incorp")
1	5	12	Tillage using equipment "Chisel plow 6i"
1	5	29	Plant corn silage using "Planter 32 inch"
1	6	1	Fertilize (30-10-20 using "Fertilizer app attached to implement" @ 200 lbs/acre)
1	9	27	Harvest without kill using "Combine Self-prop 4WD" and kill
2	5	2	Fertilizer application (Dairy Fresh Manure @ 4500 gal/acre using "Fertilizer app surface broadcast no incorp")
2	5	3	Apply tillage "Chisel plot 6i"
2	5	8	Plant corn using "Planter 32 inch". Fertilize (27-9-18 using "Fertilizer app attached to implement" @ 225 lbs/acre)
2	10	1	Harvest corn without kill, using "cSilage Harvestor, kill on next day
2	10	15	Plant Winter Wheat, plant in drill using "broadcast seeder", straight row cover type

Table 3-6. Crop schedule at the Williston field

Year	Month	Day	Activity
1	4	29	Fertilizer application (Dairy-Solid Manure @ 15 ton/acre using "Fertilizer app surface broadcast no incorp")
1	5	1	Tillage using equipment "Chisel plow 6i"
1	5	24	Apply tillage 820 ROLLHRRW (Roller Harrow 15 FT)
1	5	26	Plant corn grain using "Planter 32 inch"
1	9	8	Planting winter rye (Equipment: Broadcast aerial)
1	11	9	Harvest corn without kill, using "combine self-prop 4wd", kill on next day
1	12	8	Fertilizer application (Dairy-Solid Manure @ 15 ton/acre using "Fertilizer app surface broadcast no incorp")
2	5	7	Fertilizer application (Dairy Fresh Manure @ 9485 gal/acre using "Fertilizer app surface broadcast no incorp")
2	5	9	Apply tillage "Finishing harrow LT15FT" (3.9" inch depth)
2	5	16	Plant corn silage using "Planter 32 inch"
2	9	1	Plant winter rye using "broadcast seeder"
2	10	9	Harvest corn without kill, using "combine self-prop 4wd", kill on next day
2	11	10	Fertilizer application (Dairy Fresh Manure @ 9485 gal/acre using "Fertilizer app surface broadcast incorp")

A new conservation plan was setup for each field in STAR. The field drainage boundaries – that is the area of the field that drains to the monitoring station - were available in a GIS shapefile format and were uploaded to STAR to delineate the fields. For each conservation plan, an existing STAR baseline assessment was chosen. Then edits were made to each schedule based on site-specific conditions. Finally, the automatic soils processing was conducted within STAR to identify the representative soils for each field. Once the baseline conservation plan was established for each field, the APEX model was run within STAR and the output folder was downloaded to further refine the model, analyze the output, and conduct calibration as necessary.

Refinements for the model of each site included incorporating custom soil and weather data. For all the fields, soil sample data were available. The parameters sampled included texture (sand/silt/clay/gravel), pH, organic matter, cation exchange capacity, aluminum, and soil test phosphorus (Table 3-7). Organic carbon (C) was calculated from organic matter by dividing by 1.72. Organic nitrogen (N) was assigned assuming that the C:N ratio for humic materials is 14:1 (Neitsch et al., 2011). Organic P values were assigned assuming that the N:P ratio for humic materials is 8:1 (Neitsch et al., 2011). Soil test phosphorus, which was obtained based on modified Morgan method for each field, was converted to Mehlich 3 equivalent using the following equation (Winchell et al., 2011).

$$Mehlich3 = 6.718 \times Modified\ Morgan - 11.83 \times pH - 32.757 \times \frac{Modified\ Morgan}{Aluminum} + 90.73$$

The Mehlich 3 values were then halved to parameterize the soluble P values in APEX. The phosphorus sorption ratio (PSP) parameter in APEX was calculated as follows (Vadas and White, 2010).

$$PSP = -0.053 \times \log(Clay) + 0.001 \times Soluble\ P - 0.029 \times Organic\ C + 0.42$$

Table 3-7. Soil properties of the fields simulated by STAR

Field	Sand (%)	Silt (%)	Gravel (%)	pH	Organic C (%)	CEC (cmol/kg)	Soluble P (g/Mg)	PSP	Organic P (g/Mg)	Organic N (g/Mg)
Pawlet	35.0	49.6	18.8	7.9	2.1	18.8	19.4	0.2	186.9	1495.0
Ferrisburgh	10.1	57.9	8.7	6.4	1.8	12.2	23.1	0.2	160.9	1287.4
Shelburne	43.9	25.5	8.4	7.3	2.3	20.0	18.9	0.2	207.6	1661.1
Williston	24.1	63.6	1.4	7.2	2.9	11.3	68.4	0.3	259.6	2076.4
Shorham	7.6	26.5	9.2	6.1	2.7	17.3	13.6	0.1	244.0	1951.8

By default, STAR generates weather data based on historical weather patterns at a nearby weather station relative to the location of the user-defined field. For this testing, however, site-specific daily precipitation and temperature data were organized for the 2010-2013 period. The data sources for this time-series data included both on-site weather stations as well as data from nearby National Weather Service gages.

Although APEX provides numerous outputs, calibration was restricted to flow, sediment and total phosphorus outputs only. The monitoring data provided the average depth of water, mass of sediment and phosphorus leaving the field for several events during the 2012-2013 season. A script was written using the R language to automatically read and sum APEX output, from output files, for the dates corresponding to each event. Then, the flow, sediment, and total phosphorus were aggregated for the entire 2012-2013 monitoring

period. This two-step aggregation simplified calibration and provided a single value, per field, for each of the three outputs to compare against corresponding totals from monitoring data.

The four models were simulated for the period between 2010 and 2013. The period of 2010 and 2011 was used as a model warm-up, while event-specific data from 2012-2013 was used for model calibration. Table 3-8 provides a summary of the parameters that were calibrated in the APEX models that were built from STAR.

Table 3-8. Parameters calibrated in the APEX model

Parameter	Description	Default Value	Calibrated Value
PARM(15)	Runoff CN residue adjustment parameter	0.5	0.05
PARM(46)	C-factor coefficient in exponential residue function in residue factor	0.5	1.5
PARM(47)	C-factor coefficient in exponential crop height function in biomass factor	1	0.2
PARM(59)	P upward movement by evaporation coefficient	0.1	5
PARM(62)	Manure erosion equation coefficient	0.25	0.35
PARM(76)	Standing dead crop fall rate coefficient	0.001	0.03
PARM(96)	Soluble P leaching partition coefficient	1	10
ITYP	Peak runoff rate estimator flag. A value of 3 indicates SCS TR55 type 2 rainfall pattern	0	3
NVCN	Non-varying curve number flag. A value of 0 indicates a variable daily nonlinear CN weighted by depth of soil water	4	0
ISLF	Slope length steepness factor. A value of 1 indicates the MUSLE slope length/steepness factor	0	1
DRV	Equation for water erosion. When set to a value of 4, the model uses the MUSLE method.	0	4

3.2.3. Results

Figure 3-1 shows the comparison of STAR/APEX output with the monitoring data from five field sites. Parameters were adjusted such that reasonable results were simulated at all sites. The graphs below indicate that applying a single set of parameters to all sites results in trade-offs for model performance. At some sites the model over predicts, while at other sites it under predicts. For example, the water yield output showed a modest under prediction at three out of the five fields, but over predicted at the Williston field. Similarly, phosphorus loss was slightly over predicted at two sites (PAW, WIL), slightly under predicted at two sites (FER, SHE), and nearly matched at one site (SHO). The monitoring data for sediments showed wider variability, with nearly no sediment loss at Shorham and Shelburne to much larger loss at Pawlet. The APEX model captured a similar trend from low to high, although simulated loss at Pawlet is higher than what was observed.

An adjustment of APEX parameters to lower sediment yield at Pawlet was successful, but when these refined parameters were transferred to other fields, the results there were unsatisfactory. It is also likely that

monitoring data may not have captured some events completely. Overall, the model performance was considered very reasonable and there appears to be no systematic bias in model predictions. Most importantly, the relative differences between the model predictions of total phosphorus and sediment closely match the monitoring data.

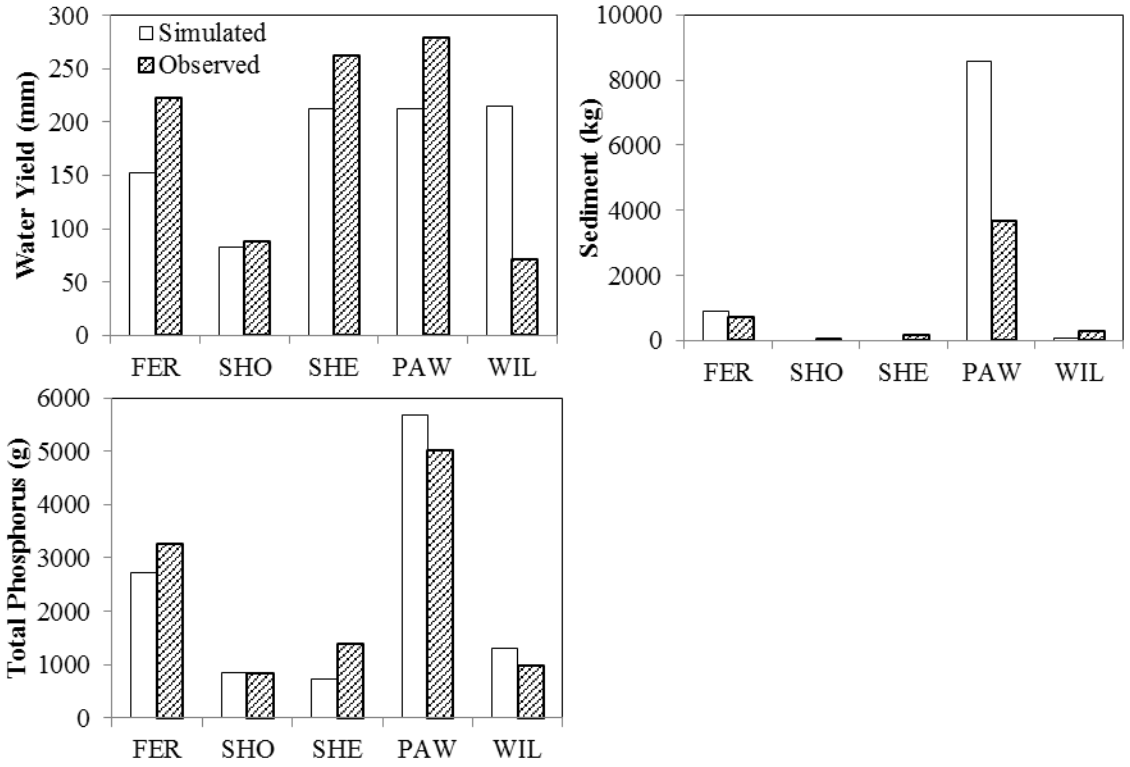

Figure 3-1. STAR output comparison with monitoring data (2012-2013) at fields located in Ferrisburgh (FER), Shorham (SHO), Shelburne (SHE), Pawlet (PAW), and Williston (WIL) in Vermont

4.
Conclusions

The Vermont STAR tool has been developed to allow NRCS conservation planners and other agricultural water quality stakeholders to conduct farm and field specific assessments to identify management practice alternatives that help reduce sediment and nutrient losses from farms. VT STAR provides a simplified, web-based interface to the APEX model, enabling a broader group of scientists and planners to access the model's agronomic and water quality simulation capabilities than would otherwise be possible. This pilot project to develop and evaluate VT STAR with the Vermont NRCS has exposed approximately two dozen conservation planners and interested scientists to how the APEX model can be used to address agricultural water quality challenges in Vermont. Documentation of the VT STAR tool in the form of a Training Exercise Workbook and Application Manual are provided in Appendix D and E of this report. These documents will introduce others interested in agricultural best management practices in Vermont to STAR's capabilities. It is anticipated that the use of VT STAR will increase both within and outside of NRCS after the completion of this initial pilot project. An increase in STAR's use will allow for further refinement of the tool and increase its value in the conservation planning process throughout Vermont and beyond.

5. References

Neitsch, S. L., J. G. Arnold, J. R. Kiniry and J. R. Williams. 2011. Soil and Water Assessment Tool Theoretical Documentation Version 2009. Technical Report No. 406. College Station, TX: Texas Water Resources Institute.

Vadas, P. A. and M. J. White. 2010. Validating soil phosphorus routines in the SWAT model. *Trans. ASABE* 53(5):1469-1476.

Winchell, M., D. Meals, S. Folle, J. Moore, D. Braun, C. DeLeo and K. Budreski. 2011. Identification of critical source areas of phosphorus within the Vermont sector of the Missisquoi Bay basin. Grand Isle, VT: Lake Champlain Basin Program.

Appendix A:
VT STAR Crop List

Alfalfa	Alfalfa HAY	Annual Rye Grass
Apple Tree	Artichokes	Asparagus
Barley all	Barley feed	Barley feed or malt
Barley malt	Beans dry edible	Bermuda hay
Big Blue Stem grass	Blueberries	Broccoli
Brome grass	brome grass mountain	brome grass smooth
Buckwheat	Cabbage fresh	Camelina
Canadian Oats	Canadian Spring Wheat	Canadian Sunflowers
Canadian Winter Pasture	Canola	Cantaloupe
Carrots	Cauliflower	Celery
Cheat Grass	Chicory	Christmas tree
Cilantro	Clover	Clover Alsike
Clover Crimson	Clover White	Collard Greens
Corn all	Corn grain	Corn seed
Corn silage	Corn white	Cucumbers for pickles processed
Cucumbers fresh	Duram Wheat	EasternGamagrass
Eggplant	Emmer Spelt	Fallow
Fava beans	Flax	Forage Oats
Forage Sorghum	Garlic	Ginseng
Gladiola	Grape	Green Beans
Green peas fresh	Honey Dew Melon	Horseradish
IMPERVIOUS	Kale	Ladino Clover
Lettuce Head	Lettuce other	Lettuce romaine
Lima beans dry	LittleBluestemGr	Meadow Fescue
med grass	Millet	Musk Melon
MustardGreens	Oats	Onions dry
Onions green	Orchard grass	PEAS
Peas Austrian winter	Peas cowpeas	Peas Dry
Peas Field	Peppers bell	Peppers chile all excluding bell
Perennial Ryegrass	Pinto Beans	Potatoes
Pumpkin	Radish	Raspberry

Red Beets	Red Clover	Reed Canarygrass
Rice	Rye	sage
short grass	Silage & haylage	Smooth Brome Grass
Snap Beans	Snap beans fresh	Sorghum all
Sorghum grain	Sorghum hay	Soybeans
Spinach fresh	Spinach processes	squash
Strawberries	Suden grass	Sugar Maple Trees
Summer Pasture	Sunflower seed oil	Sweet corn fresh
Sweet potatoes	Sweetclover	Switch Grass
Tall fescue	Tall grass	Tillage Radish
timothy	Tomatilla	Tomatoes fresh
Triticale	Turnips	Velvetleaf
Vetch	Watermelon	Wheat durum
Wheat other spring	Wheat winter	Winter Pasture
Winter Peas	Winter Rye	

Appendix B:
VT STAR Fertilizer List

11-46-00	14-46-00	16-00-00 Nitrate Of Soda
16-20-00	16-20-00	18-18-00
18-46-00	19-00-00	20-00-00
20-10-10	21-00-00	22-00-00
23-00-00	26-00-00	28-00-00
28-10-10	28-14-00	30-00-00
32-00-00	32-02-10	33-00-00
34-00-00	39-00-00	45-00-00 Urea
46-00-00	Elemental N	Elemental P
Elemental K	Anhydrous Ammonia - 82% N	Aqua Ammonia - 20.5% N
Ammonium Nitrate - 34% N	Ammonium Nitrate Solution - 20% N	Ammonium Nitrate-Limestone Mixtures - 21% N
Ammonium Nitrate-Sulfate - 30% N	Ammonium Polysulfide - 20% N	Ammonium Sulfate - 21% N
Ammonium Sulfate Solution - 6% N	Ammonium Sulfate-Nitrate - 26% N	Ammonium Sulfate-Urea - 33.5% N
Ammonium Thiosulfate - 12% N	Sodium Nitrate -160% N	Sulfur Coated Urea - 36% N
Urea - 46% N	Urea Solution - 20% N	Ammonium Metaphosphate - 12% N, 22.3% P2o5
Ammonium Phosphate - 11% N, 20.9% P2o5	Diammonium Phosphate - 18% N, 20% P2o5	Ammonium Polyphosphate - 15% N, 26.2% P2o5
Ammonium Phosphate Nitrate - 27% N, 6.1% P2o5	Ammonium Phosphate Sulfate - 16% N, 8.7% P2o5	Basic Slag - 3.9% P2o5
Monoammonium Phosphate - 11% N, 22.7% P2o5	Bone Meal, Raw - 3.9% N, 9.6% P2o5	Bone Meal, Steamed - 2.2% N, 11.8% P2o5
Bone, Precipitated - 15.3% P2o5	Limestone, Phosphatic - 5.6% P2o5	Phosphate Rock - 1.3% P2o5
Superphosphate, Normal - 9.6% P2o5	Superphosphate, Enriched - 10% P2o5	Superphosphate, Triple - 20% P2o5
Superphosphoric Acid - 29.7% P2o5	Beef Composted Manure	Beef Liquid-Other
Beef Liquid-Runoff Storage Pond For Open Lot Runoff	Beef Liquid-Single Stage Lagoon Or Holding Pond	Beef Slurry-Concrete Or Steel Tank, Basin, Or Pit
Beef Slurry-Earthen Storage Facility	Beef Slurry-Other	Beef Solids-Barn, Shed, Or House 30% Ts
Beef Solids-Covered Slab 55% Ts	Beef Solids-Manure Pack 59 - 67% Ts	Beef Solids-Other 45% Ts
Beef Solids-Stacking Slab 50% Ts	Beef-Feedlot Pit Manure	Beef-Feedlot Scrapping Manure
Beef-Fresh Manure	Beef-No Storage	Biosolids Slurry All
Biosolids Solid All	Dairy Liquid-Other	Dairy Liquid-Runoff Storage Pond For Open Lot Runoff

Dairy Liquid-Single Stage Lagoon Or Holding Pond	Dairy Liquid-Two Stage Lagoon System	Dairy Slurry-Concrete Or Steel Tank, Basin, Or Pit
Dairy Slurry-Earthen Storage Facility	Dairy Slurry-Other	Dairy Solids-Barn, Shed, Or House 18% - 25% Ts
Dairy Solids-Covered Slab 30% Ts	Dairy Solids-Manure Pack 67% Ts	Dairy Solids-Other 45% Ts
Dairy Solids-Stacking Slab 35%Ts	Dairy-Fresh Manure	Dairy-Lagoon Liquid Manure
Dairy-Lagoon Solid Manure	Dairy-Lagoon-Efficient Water Use	Dairy-Liquid Manure
Dairy-No Storage	Dairy-Solid Manure	Equine Solids-Any Storage
Equine Solids-No Storage	Goat-Fresh Manure	Hog-Fresh Manure
Horse-Fresh Manure	Poultry Broilers-Fresh Manure	Poultry Layers -Deep Pit Manure
Poultry Layers -Fresh Manure	Poultry Layers -Liquid Manure	Poultry Solids-Litter In House (#4,5, Or 6 Solid Storage Types)
Poultry Solids-Stockplied Litter (#1, 2, Or 3 Solid Storage Types)	Poultry Turkeys -Fresh Manure	Sheep Solids-Barn, Shed, Or House
Sheep Solids-Manure Pack	Sheep-Fresh Manure	Swine Liquid All
Swine Slurry All	Swine Solids All	Swine Solids-No Storage
10-10-10	32-06-00	20-20-20
80-60-120	75-40-45	40-40-60
00-20-20	00-40-40	VT Manure

Appendix C:
VT STAR Management Schedule List

Corn Grain\Corn,grain; FC,SD,fall and spring manure, Z60
Corn Grain\Corn,grain; FP,fall and spring manure, Z60
Corn Grain\Corn,grain; mulch till,SC, spring manure, Z60
Corn Grain\Corn,grain; mulch till,SC, Z60
Corn Grain\Corn,grain; mulch till,SD, Z60
Corn Grain\Corn,grain; No Till, manure, Z60
Corn Grain\Corn,grain; No Till, Z60
Corn Grain\Corn,grain; SC, spring manure, Z60
Corn Grain\Corn,grain; SC, Z60
Corn Grain\Corn,grain; SD, Z60
Corn Grain\Corn,grain; SP, spring manure, Z60
Corn Grain\Corn,grain; SP, Z60
Corn Silage\Corn,silage; FC,fall and spring manure, Z60
Corn Silage\Corn,silage; FP,fall and spring manure, Z60
Corn Silage\Corn,silage; mulch till,SC, manure, Z60
Corn Silage\Corn,silage; mulch till,SC, wintercover, manure, Z60
Corn Silage\Corn,silage; No till, manure, winter rye cover, Z60
Corn Silage\Corn,silage; No till, manure, Z60
Corn Silage\Corn,silage; No till, Z60
Corn Silage\Corn,silage; SC, manure, Z60
Corn Silage\Corn,silage; SC, wintercover, manure, Z60
Corn Silage\Corn,silage; SC, Z60
Corn Silage\Corn,silage; SD, manure, Z60
Corn Silage\Corn,silage; SD, Z60
Corn Silage\Corn,silage; SP, Z60
Corn Silage\Corn,silage; SP, manure. Z60
Hay Crops\Alfalfa-Grass\Alfalfa-grass; 3 cuts,FP,manure applied,5 years,Z60
Hay Crops\Alfalfa\Alfalfa; 3 cuts,FP,manure applied,5 years, Z60
Hay Crops\Alfalfa\Alfalfa; 3 cuts,SD,manure applied,5 years, Z60
Hay Crops\Clover\Clover, spring seeded, SD, green chop 3 cuts, 2 years, manure, Z60
Hay Crops\Timothy-Red Clover\3 cuts\Timothy-Red Clover; 3 cuts,SD,spring spin seeded,cultipacker,manure applied,5 years,Z60

Hay Crops\Timothy-Red Clover\4 cuts\Timothy-Red Clover; 4 cuts,FD,fall seeded,5 years,Z60
Hay Crops\Timothy-Red Clover\4 cuts\Timothy-Red Clover; 4 cuts,SD,spring seeded,5 years,Z60
Hay Crops\Timothy-Red Clover\4 cuts\Timothy-Red Clover; 4 cuts,SD,spring seeded,manure applied,5 years,Z60
Hay Crops\Timothy\2 cuts\Timothy; 2 cuts,SD,spring seeded,manure applied,5 years,Z60
Hay Crops\Timothy\3 cuts\Timothy; 3 cuts,FD,fall seeded,manure applied,5 years,Z60
Hay Crops\Timothy\3 cuts\Timothy; 3 cuts,SD,spring seeded,manure applied,5 years,Z60
Small Grains\Oats,spring; FP,manure, Z60
Small Grains\Oats,spring; FP,Z60
Small Grains\Oats,spring; SD, manure, Z60
Small Grains\Oats,spring; SD,Z60
Small Grains\Rye,cereal; fall plant, drilled, Z60
Small Grains\Wheat,spring 7 inch rows; SD,manure, Z60
Small Grains\Wheat,spring 7 inch rows; SD,Z60
Sorghum-Sudangrass\Sorghum,silage; 1 cut, no-till, manure, Z60
Soybeans\Soybeans; 30in row, FD, Z60
Soybeans\Soybeans; 30in row, FP, Z60
Soybeans\Soybeans; 30in row, mulch till, SC, Z60
Soybeans\Soybeans; 30in row, SD, Z60
Soybeans\Soybeans; 30in row, SP, Z60
Soybeans\Soybeans; drilled, mulch till, SC, Z60
Vegetables\Sweet corn\Corn,sweet,cultivated; SD,Z60
Vegetables\Sweet corn\Corn,sweet; SP,Z60
Vegetables\Greens, Lettuce\Greens,spinach,chard,beet,kale,leaf lettuce; SD,3 cutsZ60
Vegetables\Greens, Lettuce\Greens,spinach,chard,beet,kale,leaf lettuce; SP,Z60
Vegetables\Peppers, Tomatoes\Peppers; SD, plastic mulch, Z60
Vegetables\Peppers, Tomatoes\Peppers; SD,Z60
Vegetables\Peppers, Tomatoes\Peppers; SP,Z60
Vegetables\Pumpkins, Squash\Pumpkin; SD,Z60
Vegetables\Pumpkins, Squash\Pumpkin; SP,Z60
Corn Grain - Hay(soybeans,silage,etc.)\2 yrs Corn Grain,FP - 7 yrs legume-grass hay,FP, 3 cuts, manure, Z60
Corn Grain - Hay(soybeans,silage,etc.)\3 yrs Corn Grain,FP - 5 yrs legume-grass hay,FP, 3 cuts, manure, Z60
Corn Silage - Hay\Legume-grass Hay - 3 cuts\1 yr Corn Silage,FP - 5 yrs legume-grass Hay; 3 cuts, manure, Z60
Corn Silage - Hay\Legume-grass Hay - 3 cuts\1 yr Corn Silage,SC - 5 yrs legume-grass Hay; 3 cuts, manure, Z60
Corn Silage - Hay\Legume-grass Hay - 3 cuts\3 yrs Corn Silage,FP - 5 yrs legume-grass Hay; 3 cuts, manure, Z60
Corn Silage - Hay\Legume-grass Hay - 3 cuts\5 yrs Corn Silage,SC - 5 yrs legume-grass Hay; 3 cuts, manure, Z60
Vegetables\Corn,sweet,SD,cultivated - Tomatoes,SD,plastic - Squash,SD,plastic - Peas,SD,drilled; Z60
Grass Filter Strip

6. Appendix D: VT STAR Training Exercise Workbook

APEX STAR Tool Exercise Workbook

Prepared for Vermont Natural Resources Conservation Service and Vermont Agency of Agriculture Food and Markets

September 15th, 2015

Prepared by:

STONE ENVIRONMENTAL

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An Exercise Manual for Training on the APEX Systematic Tool for Analyzing Resources (STAR)

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STONE ENVIRONMENTAL

Contents

1.
Introduction

The exercises in this workbook will walk through a conservation planning assessment performed on a single field of your choosing. Each exercise will utilize different features of STAR useful for conducting a conservation planning analysis. This will begin with an exercise demonstrating the development of a baseline assessment using current cropping practices. This will be followed by modification of current practices to evaluate the soil and nutrient conservation impacts of modifying the crop rotation and fertilizer applications. Next, several alternative BMPs will be assessed to characterize their site-specific benefits to sediment and nutrient load reductions. Finally, field specific soils information will be added to the assessment to refine the results of the conservation planning assessment.

An aerial view of the farm being assessed in the examples in this workbook is shown below. This workbook uses the field labeled "1" throughout. You are welcome to work with one of the other numbered fields on this farm, or pick a field from a location of your choosing. If you evaluate one of the fields from the farm below, first check in with the instructors for an assignment of a field to work with.

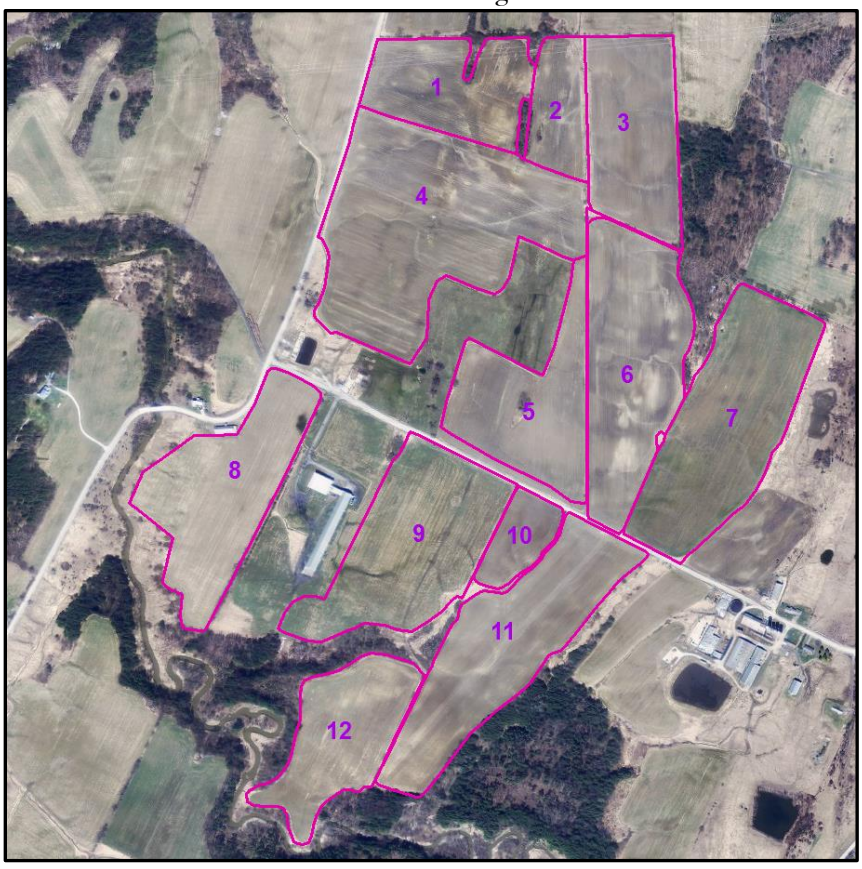


Figure 1.1: Aerial view of example farm.

2.
Exercise 1, Running a Baseline Assessment with STAR

This exercise will walk through the process of running a baseline conservation planning assessment with STAR. The exercise will start with the creation of a new conservation plan using on-screen sketching of a field to be assessed. No special practices will be added to the baseline assessment. A crop operation schedule will be added from the VT STAR database of common operation schedules. STAR will then characterize the soil and slope conditions for the selected field, which will be viewed in the Soil Editor. The exercise will finish by running the APEX model and generating a report of the model results describing average annual flow, sediment, and nutrient loadings. Throughout this exercise, you may at times refer to the STAR User's Manual, in addition to this Exercise Workbook, for guidance on different steps in a STAR assessment.

2.1. Create a New Conservation Plan

In this step, you will login to STAR, create a new conservation plan, and create the field you will be assessing.

2.1.1. Login to STAR and Locate Farm

STAR may be accessed at the following URL: http://tamudev.stone-env.com/star

It is best to use the Firefox web browser, however recent versions of Internet Explorer will work as well. Your username will be the first letter of your first name, followed by your last name. E.g., "mwinchell." Your password has already been provided to you in a previous email (it is most likely the first 5 letters of your last name).

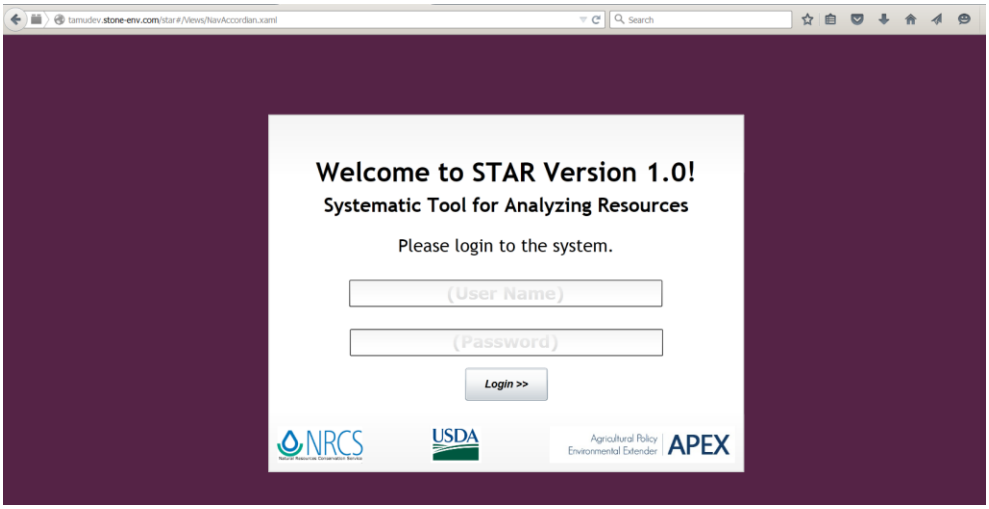


Figure 2.1: STAR login screen.

Once you login to STAR, you will be brought to an aerial imagery view of Vermont, along with the STAR navigation pane on the left-hand side of the screen.

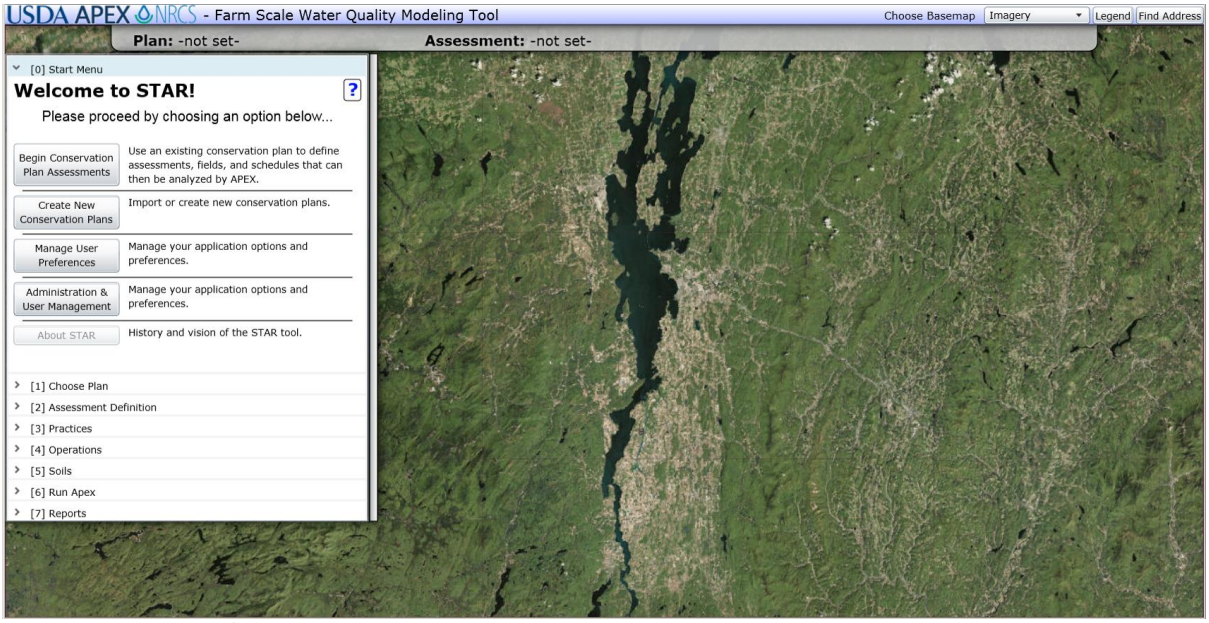


Figure 2.2: STAR initial map screen.

We will start the assessment by searching for an address using the address locator. Click on the **Find Address** button on the upper right hand corner of the map. This will open an input form where the address, city, and state can be entered. Type in the address of the farm you plan to assess. If you choose to evaluate the example farm, enter the address "**Boucher Rd., Highgate, VT,**" then click the "**Find**" button. STAR will then zoom into the location of the address specified. This is the approximate location of the farm.

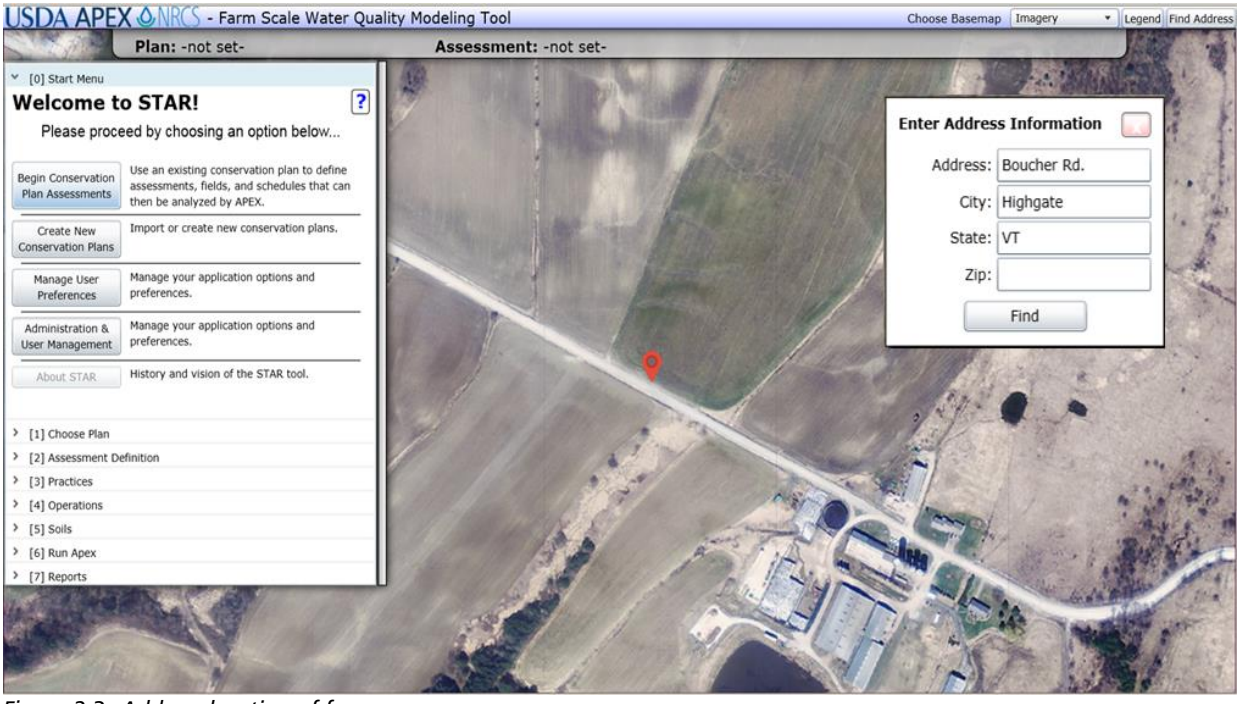


Figure 2.3: Address location of farm.

2.1.2. Create New Conservation Plan

Each group working on this exercise will choose their own field to work with. This may be a field of the group's choosing, or a field based on the map provided in Figure 1.1. This example will work on Field 1 from Figure 1.1.

Begin by clicking on the "**Create New Conservation Plans**" button on the STAR navigation panel. This action will launch the "**Conservation Plan Editor.**"

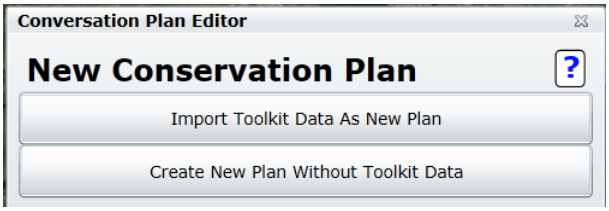


Figure 2.4: Conservation plan editor.

Next, click on the "**Create New Plan Without Toolkit Data**" button. You will now be prompted to enter information on the new conservation plan. Enter this information and then click "**Create & Define PLUs**" (PLUs stands for "Planning Land Units"). PLUs are equivalent to fields for this exercise.

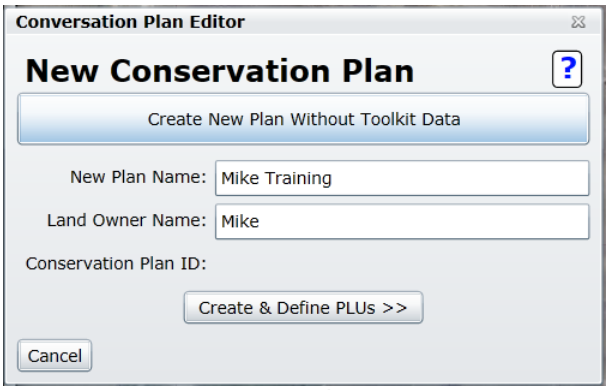


Figure 2.5: New conservation plan entry.

Clicking the "**Create & Define PLUs**" button will open another dialog where you will have 2 options for creating the PLUs: 1.) importing a shapefile and, 2.) drawing the field on-screen. In this exercise, you will draw the PLUs on screen.

2.1.3. Create a PLU for the conservation plan

Make sure the field is visible on the map at a scale that you can trace, the click on the "**New PLU**" button to start sketching a field. Your cursor will now be active for sketching the field. Click along the border of the field, one vertex at a time, until you get all the way around the field, and then "double click" to complete the boundary.

If you are happy with your field boundary, click on the "**Save**" button. If you are not happy, and want to redo the boundary, then click on the "**Cancel**" button and redo the sketch. Note: Your original sketch may not disappear when you start redrawing the field boundary. That is fine, it will remove the old drawings once you "**Save**" the sketch. Once you click "**Save,**" the field will turn a transparent purple, and you will be ready to move on with the assessment. Click the "**Close**" button on the "**Conservation Plan Editor**" to move on to the

next step. You can also click the **"x"** button at the top right-hand corner of any other open windows that remain. You now have created a new conservation plan to begin working with.

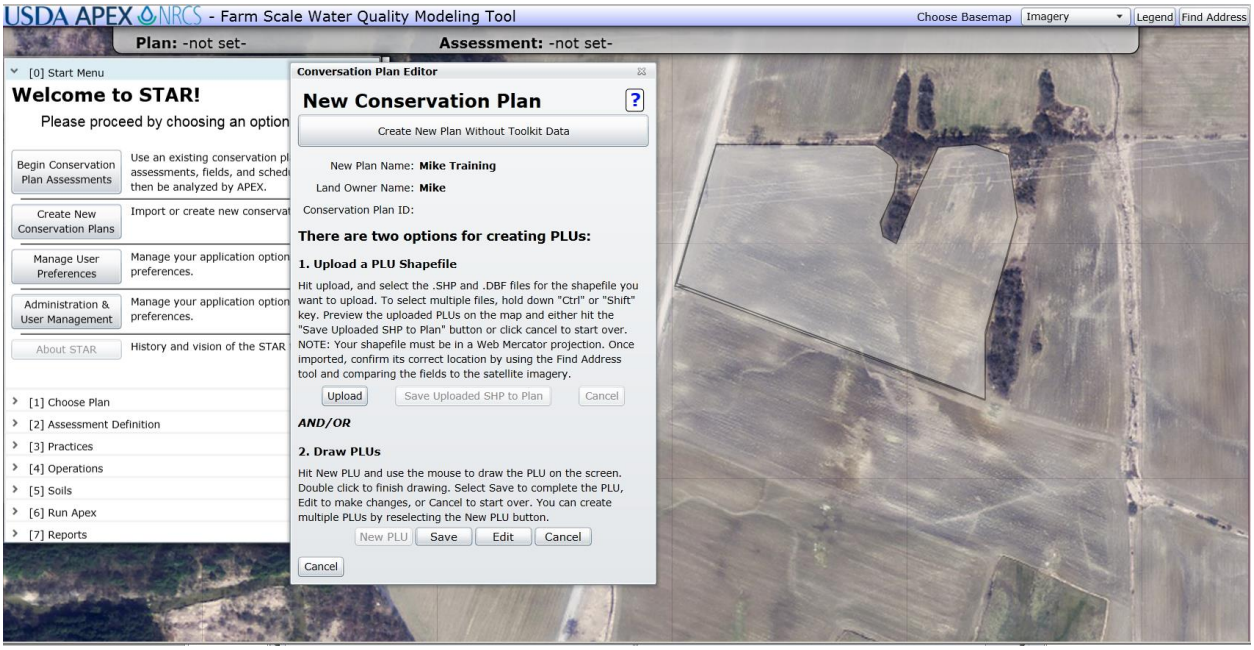


Figure 2.6: Sketching field boundaries on screen.

2.2. Creating a New Baseline Assessment

You have now created the foundation of a **Conservation Plan**. The next step is to create the inputs for a **Baseline Assessment**.

2.2.1. Choose Current Conservation Plan

On the STAR navigation panel, you can click on the button **"Begin Conservation Plan Assessments"** or click on **"[1] Choose Plan.**" You will now see the list of your current conservation plans (there should only be 1). Click on the current plan that you just created and click "**Load the Selected Conservation Plan.**"

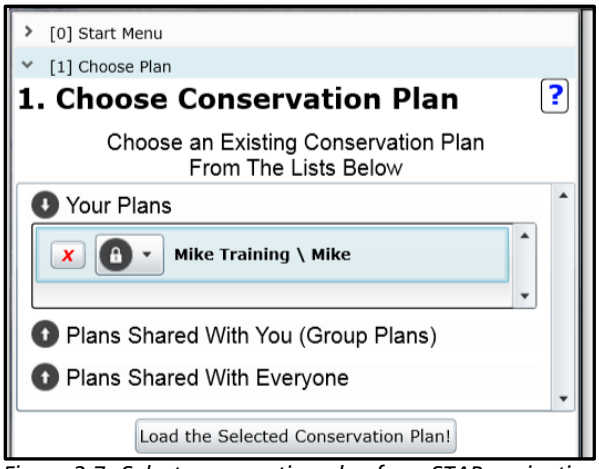


Figure 2.7: Select conservation plan from STAR navigation pane.

2.2.2. Create a New Baseline Assessment

A baseline assessment is designed to represent an APEX simulation of your "current" or "baseline" conditions on a field (or fields). All other assessments (called alternatives) will be derived from the baseline assessment. While baseline assessments can contain multiple fields, we will be working with a single field at a time. With the current version of STAR, assessing one field at a time is a good option.

Click on the "**Create New Baseline Assessment"** button. A new dialog will open and ask for the name of the assessment. You can call it "**Baseline**."

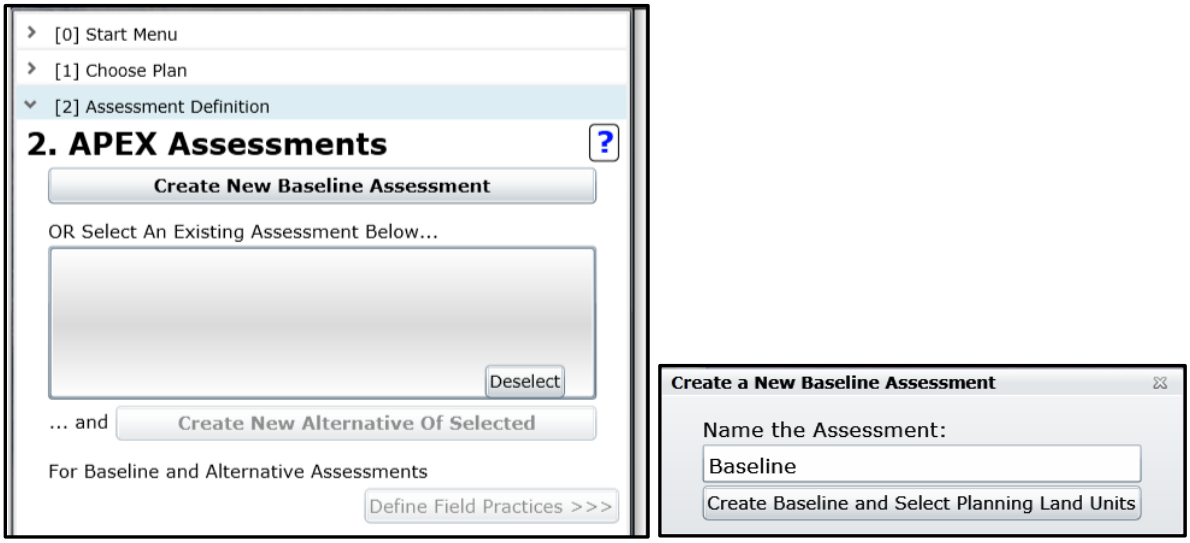


Figure 2.8: Creating baseline assessment.

Click on the "**Create Baseline and Select Planning Land Units**" button. A new "**Field Selection Tools**" dialog box will open that allows you to pick a field to add to the assessment. Use the left most (single hand) button to select a single field at a time. Only select YOUR field. When the "**Gully Type**" message box comes up, keep the "**None**" selection, and click "**Confirm.**" To finish, click the **"x"** box in the upper right corner of the "**Field Selection Tools**" dialog.

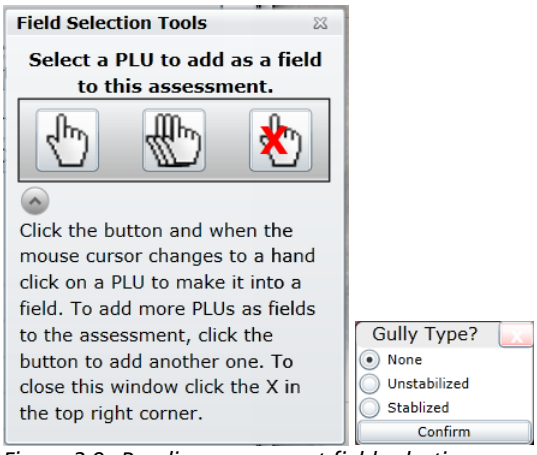


Figure 2.9: Baseline assessment field selection.

Your selected field will now be shaded red and have a default name of "**Crop 1.0**" applied to it. You have now completed initial creation of the baseline assessment. Next will be setting up the field conditions.

Figure 2.10: Field selected for baseline assessment.

2.3. Defining Practices and Default Crop Management Operations Schedule

In STAR, "Practices" refer to special operations or characteristics of a planning land unit/field that are designed to improve natural resource conservation or crop management. Examples of practices include "Nutrient Management", "Subsurface Drainage", and "Filter Strips." In a Baseline Assessment, it is common for there not to be any special practices. However, it is still appropriate to visit the "Practices" component and indicate that no conservation practices are present. The selection of a crop management operations schedule is required for all STAR simulations and is a critical component to the assessment.

2.3.1. Definition of Field Practices

After creating the baseline assessment, click on the "**Define Fields Practices >>>**" button to move to the practices portion on the STAR navigation pane.

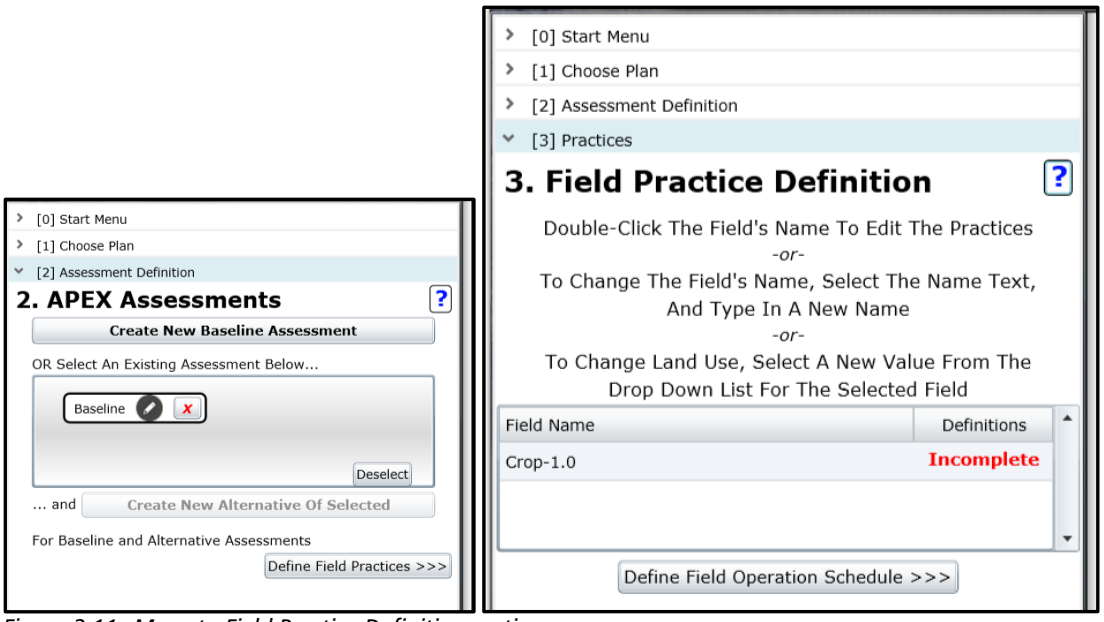


Figure 2.11: Move to Field Practice Definition section.

The table at the bottom of the "**Field Practice Definition**" dialog indicates that definition of practices on this field is incomplete. To define the practices (and confirm the type of landuse) double click the "**Field Name**" (i.e., "Crop-1.0"). Note: Text is provided within the STAR navigation pane to explain what action needs to happen at the current step.

After double-clicking the "Field Name," a dialog will appear that asks to set the land use type. This is a generic land use, and specific crop or vegetation types will be defined in the operation schedule definition. Make sure that "Crop" is shown as the land use, and click "Save."

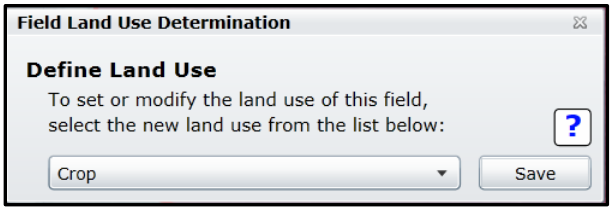


Figure 2.12: Selection of land use.

The "**Field Practices Editor**" will show the collection of possible practices ("**All Practices**") as well as the "**Selected Practices on Field**." Since there are no practices assumed in this baseline assessment, simply click "**Close**" to exit the "**Field Practices Editor**." The STAR navigation pane will now show that the field practices definition is complete. Click the "**Define Field Operation Schedule**" button to move on to the operation schedule definition.

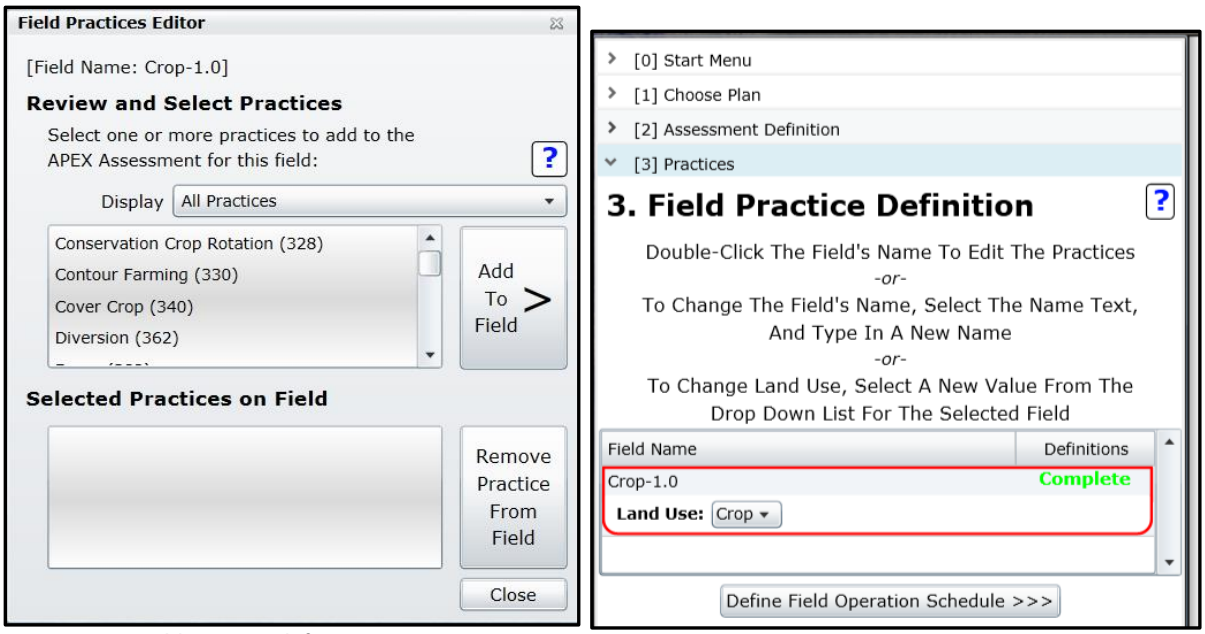


Figure 2.13: Field practice definition.

2.3.2. Operation Schedule Definition

The **"Field Operations Definition"** portion of the STAR navigation pane will now show that the operations definition is incomplete. Double click in the **"Field Name"** table cell to define the operation schedule. The **"Operation Schedule Editor"** will open and provide several options for selecting an operation schedule.

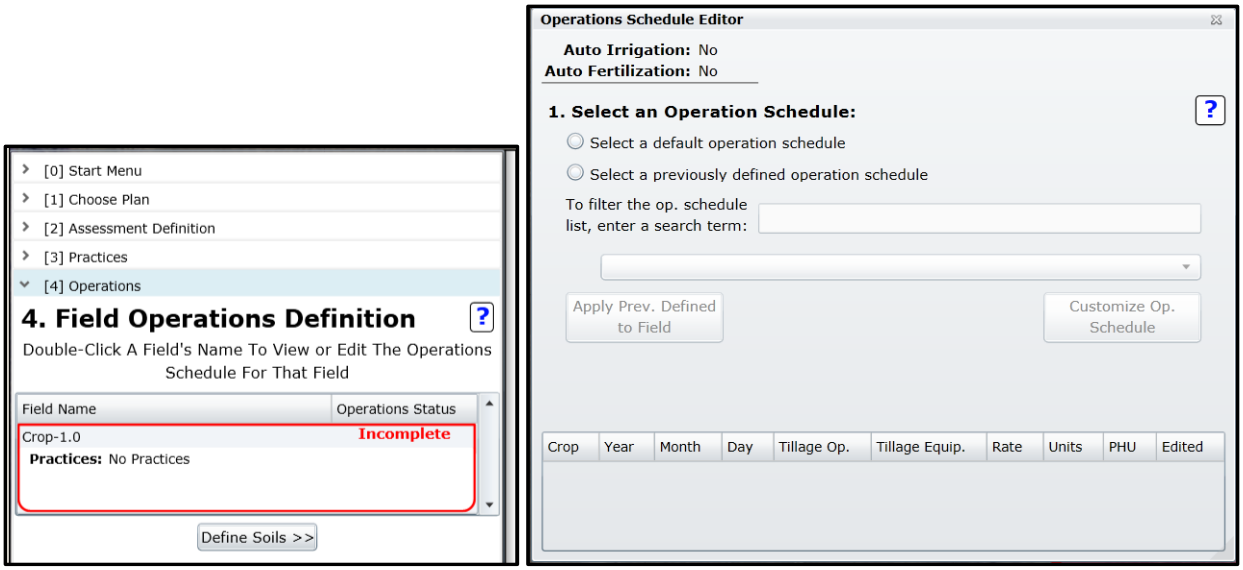
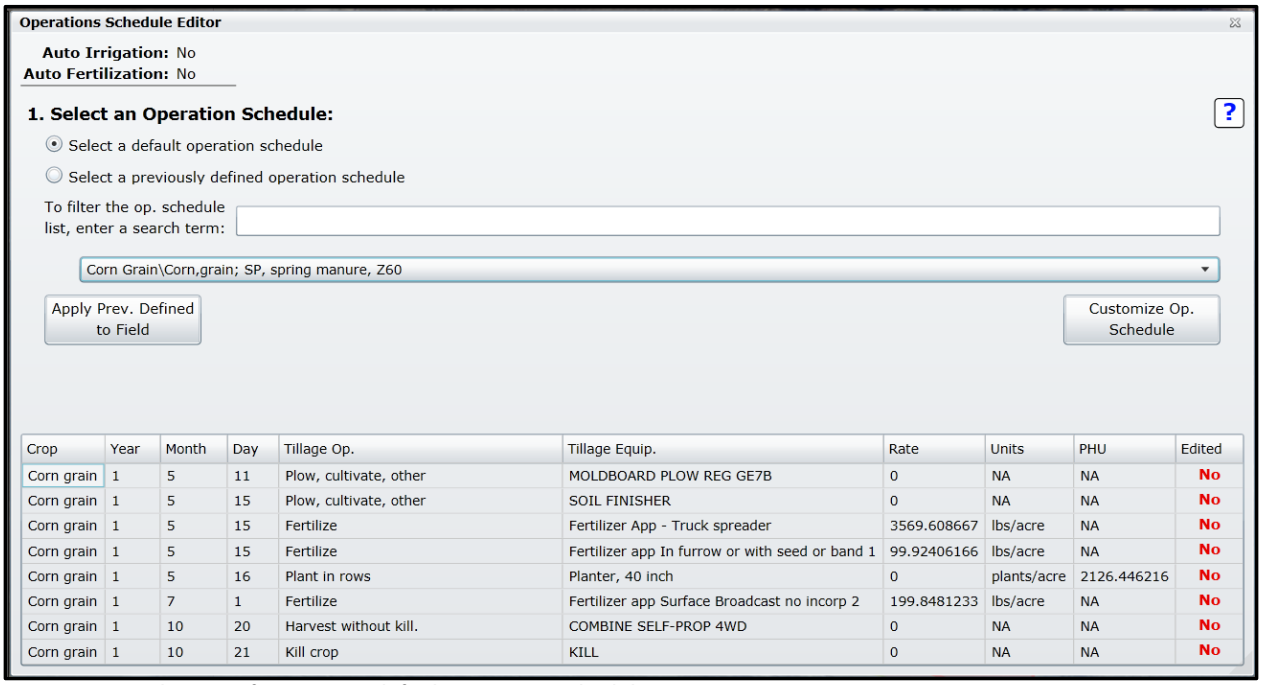


Figure 2.14: Field operations definition entry.

We will select a "**default operation schedule.**" In VT STAR, the default operation schedules have been developed to represent typical crop rotations and management practices found in Vermont. This includes typical fertilizer and manure applications.

Choose the **"Select a default operation schedule"** option, and from the drop-down combo-box, select "**Corn Grain\Corn, grain; SP, spring manure, Z60.**" The specifics of this operation schedule are shown in the table at the bottom of the input form.



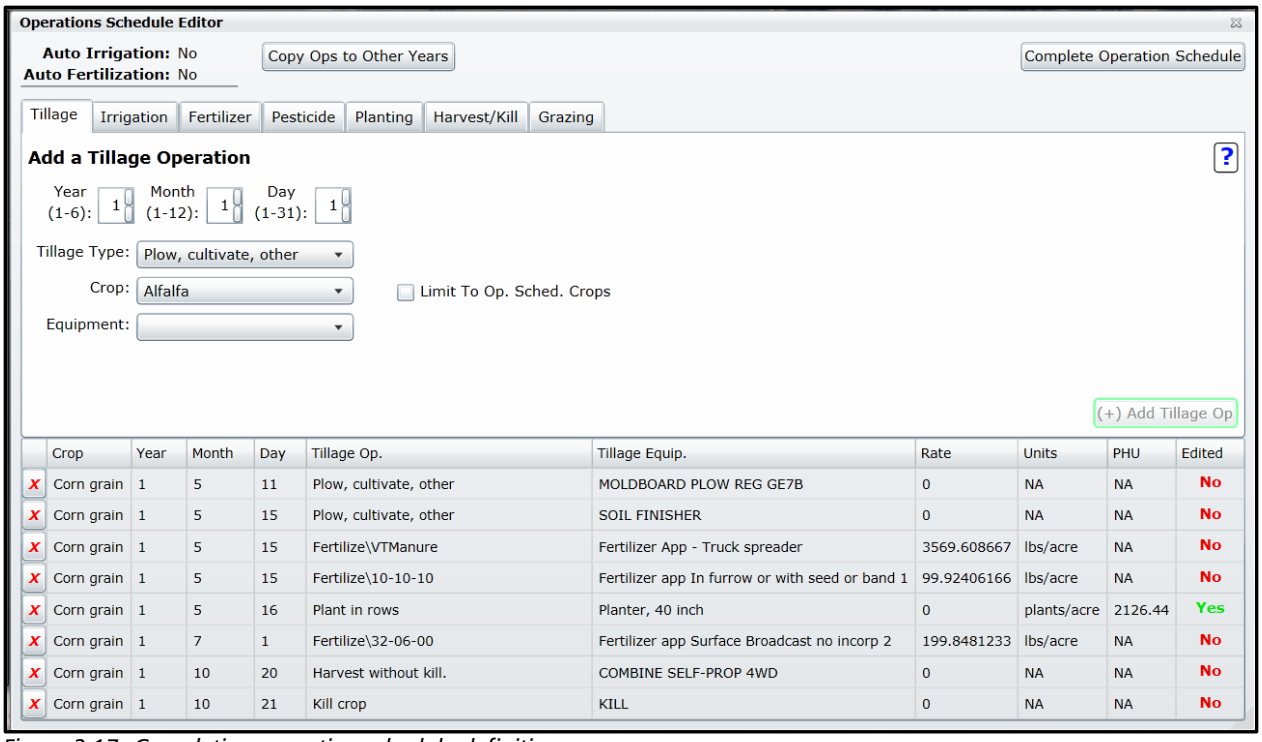
Crop	Year	Month	Day	Tillage Op.	Tillage Equip.	Rate	Units	PHU	Edited
Corn grain	1	5	11	Plow, cultivate, other	MOLDBOARD PLOW REG GE7B	0	NA	NA	No
Corn grain	1	5	15	Plow, cultivate, other	SOIL FINISHER	0	NA	NA	No
Corn grain	1	5	15	Fertilize	Fertilizer App - Truck spreader	3569.608667	lbs/acre	NA	No
Corn grain	1	5	15	Fertilize	Fertilizer app In furrow or with seed or band 1	99.92406166	lbs/acre	NA	No
Corn grain	1	5	16	Plant in rows	Planter, 40 inch	0	plants/acre	2126.446216	No
Corn grain	1	7	1	Fertilize	Fertilizer app Surface Broadcast no incorp 2	199.8481233	lbs/acre	NA	No
Corn grain	1	10	20	Harvest without kill.	COMBINE SELF-PROP 4WD	0	NA	NA	No
Corn grain	1	10	21	Kill crop	KILL	0	NA	NA	No

Figure 2.15: Selection of corn grain default operation schedule.

Next, click the "**Customize Op Schedule**" button. This step is necessary to save the operation schedule in your personal library of operation schedules, even if no changes are made. You are now prompted to "**Enter Name for the Custom Operation Schedule**". Name the schedule, "**T1 Crop 1.0 Corn Grain\Corn, grain; SP, spring manure, Z60**" (T1 stands for "training 1"). However, you can name the schedule anything you'd like to help remember what it represents.

Figure 2.16: Naming operation schedule.

After naming the schedule, click on the "**Apply Name & Start Customizing >>>**" button. You will now see all of the tabs of the "**Operation Schedule Editor,**" however for this exercise, you do not need to make any changes to the operation schedule (we will show how to do that in a later example). Cick on the "**Complete Operation Schedule**" button to close the "**Operation Schedule Editor.**"



	Crop	Year	Month	Day	Tillage Op.	Tillage Equip.	Rate	Units	PHU	Edited
X	Corn grain	1	5	11	Plow, cultivate, other	MOLDBOARD PLOW REG GE7B	0	NA	NA	No
X	Corn grain	1	5	15	Plow, cultivate, other	SOIL FINISHER	0	NA	NA	No
X	Corn grain	1	5	15	Fertilize\VTManure	Fertilizer App - Truck spreader	3569.608667	lbs/acre	NA	No
X	Corn grain	1	5	15	Fertilize\10-10-10	Fertilizer app In furrow or with seed or band 1	99.92406166	lbs/acre	NA	No
X	Corn grain	1	5	16	Plant in rows	Planter, 40 inch	0	plants/acre	2126.44	Yes
X	Corn grain	1	7	1	Fertilize\32-06-00	Fertilizer app Surface Broadcast no incorp 2	199.8481233	lbs/acre	NA	No
X	Corn grain	1	10	20	Harvest without kill.	COMBINE SELF-PROP 4WD	0	NA	NA	No
X	Corn grain	1	10	21	Kill crop	KILL	0	NA	NA	No

Figure 2.17: Completing operation schedule definition.

The "**Operation Status**" in the STAR navigation pane will now read "**Complete.**"

2.4. Defining Field Soils and Running APEX

The soils, slope, and nearest weather station will be identified based on STAR's back-end SSURGO, USGS NED DEM, and weather station databases. Users do have the opportunity to modify the soil characteristics of a field where local data is available.

2.4.1. Run Soils/Slope Characterization

From the STAR navigation pane, click on the "**Define Soils >>**" button. This action will fire off background geo-processing operations that identify the dominant soil from SSURGO, the average slope from a NED DEM, and the nearest weather station. The processing takes a little time, so you will be given a message that indicates this. Be patient, and wait for the results to return. When finished, a message box will appear indicating that "**Soils Processing Is Complete.**"

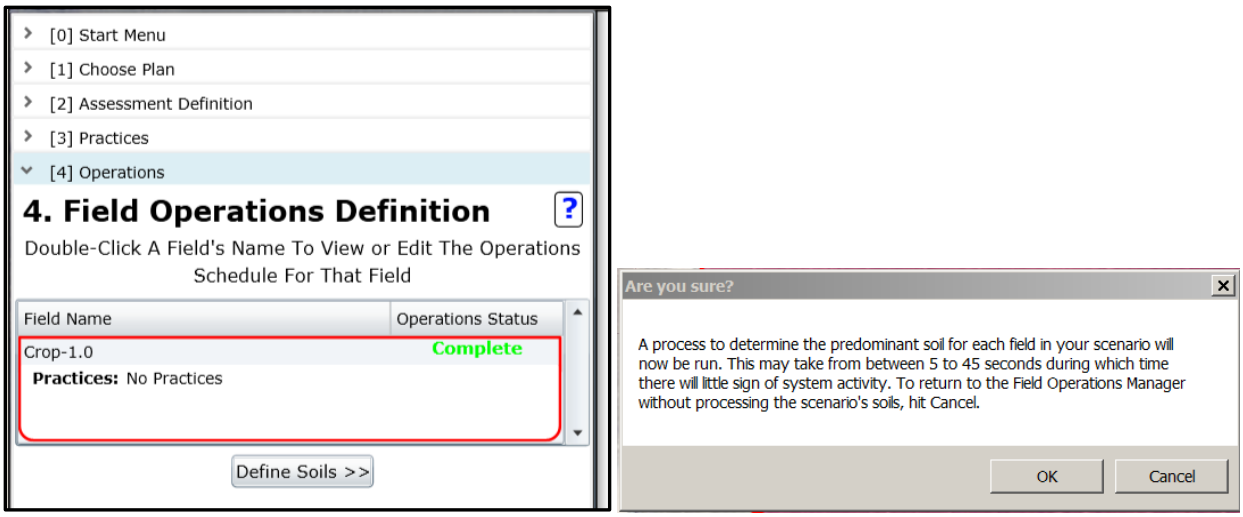


Figure 2.18: Definition of field soils from geo-processing operations.

After soils processing is complete, the "**Field Soil Parameter Editing**" section of the STAR navigation pane will become active. By double clicking on the "**Field Name**", the soil characteristics for the current field can be viewed or edited. For the baseline assessment, we will view the soil characteristics, but will not edit them. Click the "**x**" in the upper right hand corner of the form to go back to the STAR navigation pane.

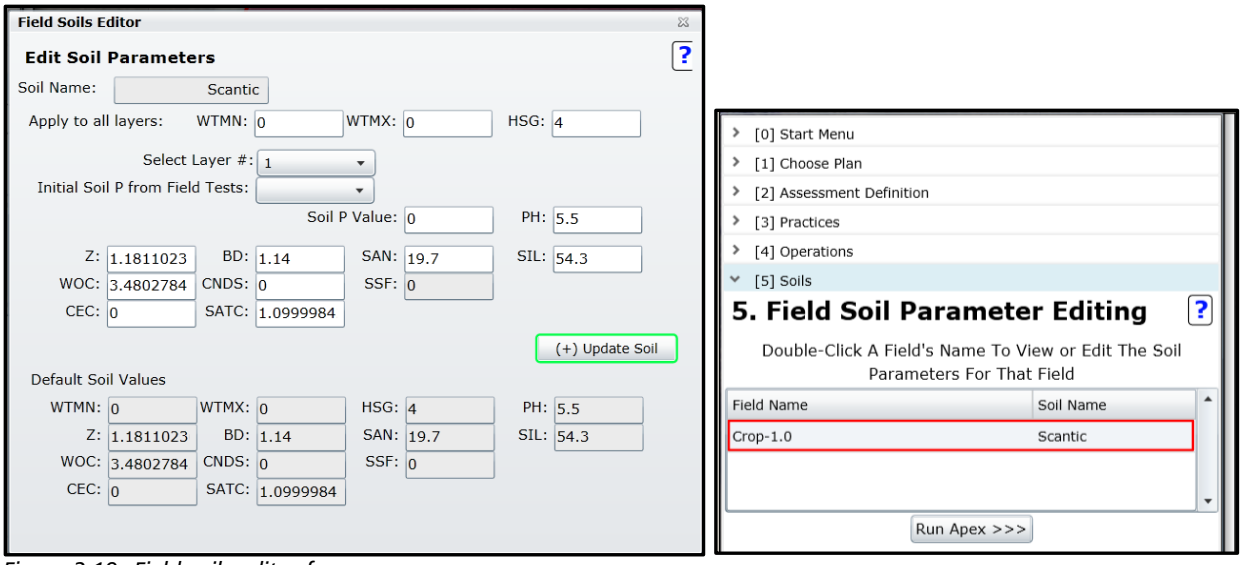


Figure 2.19: Field soils editor form.

2.4.2. Run APEX Model

Now that the entire baseline assessment has been defined, and it is time to run APEX. Click the "**Run APEX>>**" button. A message box will appear, confirming your intention to run the simulation. Click the "**OK**" button and wait for a minute or two. The **"APEX Processing Status"** will update itself, indicating the progress of the APEX simulation.

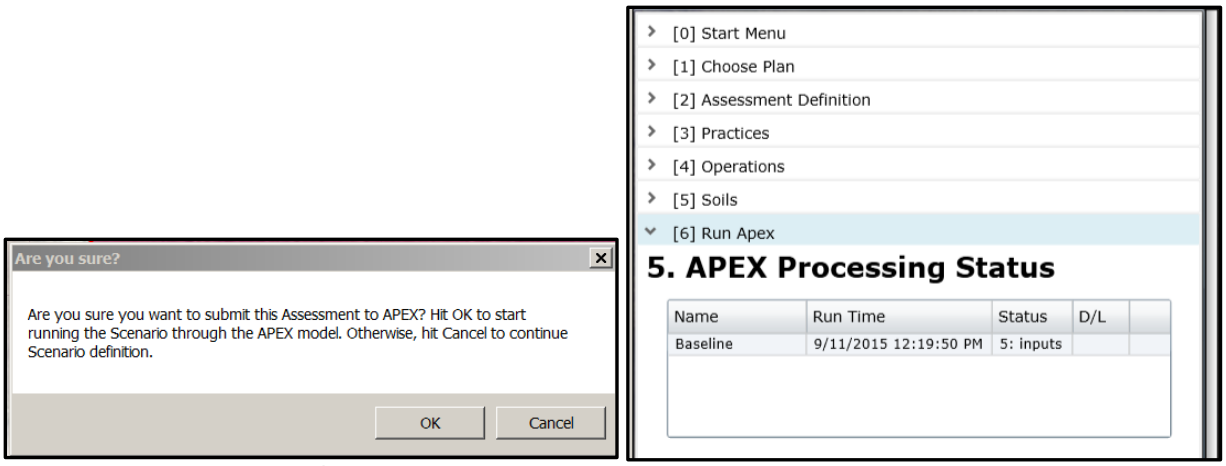


Figure 2.20: Running APEX and progress status.

When the simulation is complete a message will appear, indicating if the simulation was unsuccessful, and will ask if you would like to download a zip file of all the model input and output files. Advanced users may want to download these files, or these files can be downloaded and evaluated by Stone/Texas A&M to troubleshoot a failed simulation. Click "**Cancel**" for the download option for this baseline simulation.

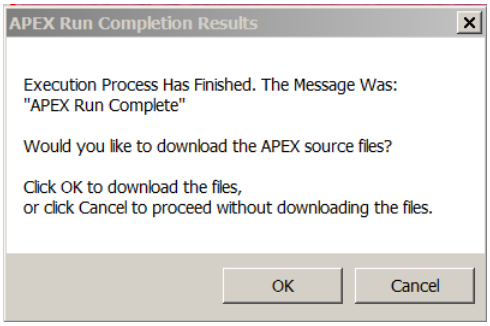


Figure 2.21: Download APEX results option dialog.

The STAR APEX simulation is now complete, and the results can be viewed in the STAR "**Reports**" section.

2.5. Viewing Results Reports

Clicking on the "**[7] Reports**" item on the STAR navigation pane will open up the "**Reports**" section of the STAR navigation pane.

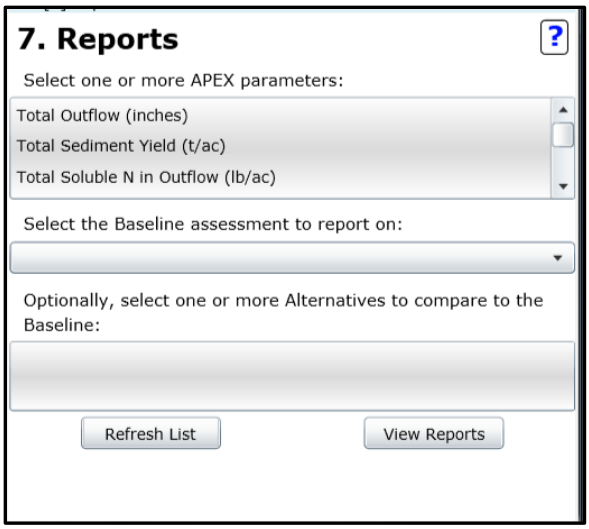


Figure 2.22: Reports section of STAR navigation pane.

A list of APEX output parameters is provided in a list box at the top part of the pane. These outputs include flow (runoff), sediment, nutrient, pesticide, and yield information. Select all of the APEX outputs by clicking on the first item, then scrolling down and clicking on the last item with the "**shift"** key down. All of the items will now be highlighted.

From the "**Select the Baseline assessment to report on:**" drop down, select the **"Baseline"** assessment. Since there are no alternatives yet to report on for comparison with the baseline, click on "**View Reports**" to launch the report generator. It will take up to a minute or two for the report to complete. Once completed, a new web browser page with a pdf of the report will appear.

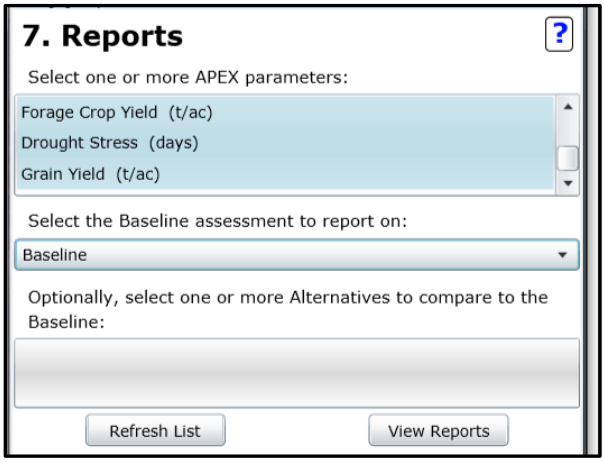


Figure 2.23: Selection of parameters and baseline assessment to report on.

The first section of the report describes many of the inputs to the APEX simulation. This includes field area, crop and operation schedule, soil and slope conditions, and nutrient inputs. The second section of the report summarizes all of the outputs. The items summarized in the output section include all of the outputs selected by the user from the STAR Reports interface. The outputs from each field will be different because STAR uses all the site specific conditions when parameterizing an APEX simulation. From this baseline assessment, alternatives can be created to evaluate the effects of modifying crop rotations, management operations, and practices.

Summary of Field Inputs:

		Assessments
Field Name		**Baseline**
Crop-1.0	Practices	
	Op Schedule	T1 Crop-1.0-Corn Grain \Corn,grain; SP, spring manure, Z60
	Dominant Soil	Scantic
	Field Acres	12.63
	Hydrologic Soil Group	D
	Slope	4.11%
	Slope Length (ft)	45.72
	Weather Station	ST ALBANS RADIO
	Avg Annual Precip (in)	36.87
	Total N Applied (lbs/ac)	199.69
	Total P Applied (lbs/ac)	27.66
	Total Irr Applied (in/ac)	0.00
	STIR Tillage Value	130.18

Figure 2.24: Inputs summary from STAR report.

Apex Parameter	Field Name	Baseline
Total Outflow (inches)	Crop-1.0	9.15
Total Sediment Yield (t/ac)	Crop-1.0	9.51
Total Soluble P in Outflow (lb/ac)	Crop-1.0	0.40
Total Sediment P in Outflow (lb/ac)	Crop-1.0	10.66
Tile Drain Phosphorus Loss (lb/ac)	Crop-1.0	0.00
Total Soluble N in Outflow (lb/ac)	Crop-1.0	206.85
Total Sediment N in Outflow (lb/ac)	Crop-1.0	82.62
Tile Drain Nitrogen Loss (lb/ac)	Crop-1.0	0.00
Total Soluble Pesticide in Outflow (lb/ac)	Crop-1.0	0.00
Total Sediment Pesticide in Outflow (lb/ac)	Crop-1.0	0.00
Nitrogen Volatilization (lbs/acre)	Crop-1.0	38.64
Forage Crop Yield (t/ac)	Crop-1.0	0.00
Grain Yield (t/ac)	Crop-1.0	2.43

Figure 2.25: Outputs summary from STAR.

3.
Exercise 2, Simulating an Alternative Crop Schedule with STAR

This exercise will walk through the process of running two alternative conservation planning assessments and comparing them to the baseline. For the first alternative assessment, we will select a different crop schedule so that we can compare the baseline Corn grain\Corn rotation to a Corn Grain\ Hay\legume-grass rotation. The second alternative will use the operation schedule from the first alternative, but we will remove the fall plowing. We will use the STAR reporting tool to compare the results of these assessments to the baseline and to eachother.

3.1. Alternative Crop Schedule Assessment

An alternative assessment is designed to allow for comparisons to the "baseline" conditions on a field (or fields) by adding conservation practices and/or modifying the crop schedule. Alternative assessments are always derived from the baseline assessment. This first alternative will assess changes by modifying the crop rotation from permanent corn grain to a corn grain/hay rotation.

3.1.1. Create a New Alternative Assessment

If you have exited STAR you will want to select the conservation plan you created from "**[1] Choose Plan"** then select **"Load the Selected Conservation Plan."**

Click on **"Baseline"** assessment. When there is more than one baseline you want to make sure that you first select the baseline that you want to create an alternative from. Once you have selected the baseline, click on "**Create New Alternative of Selected**" button. A new dialog will open and ask for the name of the alternative assessment. You can call it **"Crop_Alternative"**. Click on the **"Create Alternative"** button and a new assessment that is a copy of the baseline will be created.

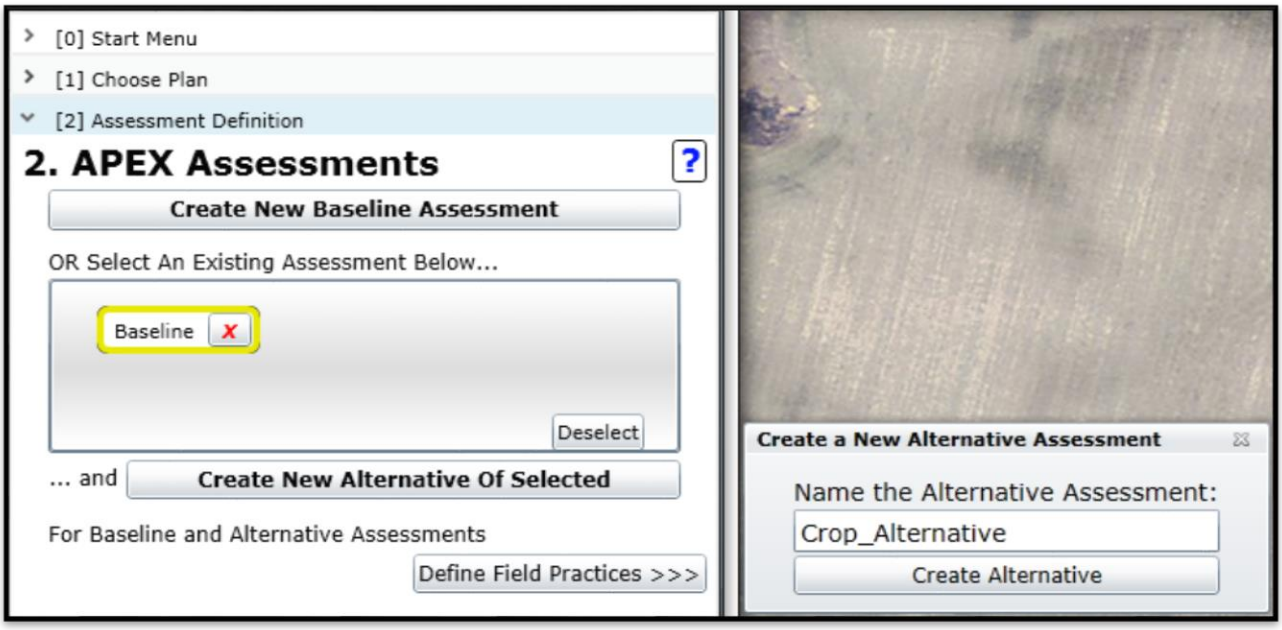


Figure 3.1: Creating an alternative assessment.

To start using the alternative, click on the small arrow to the left of the Baseline to expand the list of alternative assessments associated with it. Then select the **"Crop_Alternative."** The active assessment is always highlighted with a yellow boudary. You have now completed initial creation of the alternative assessment. Next will be setting up the field conditions

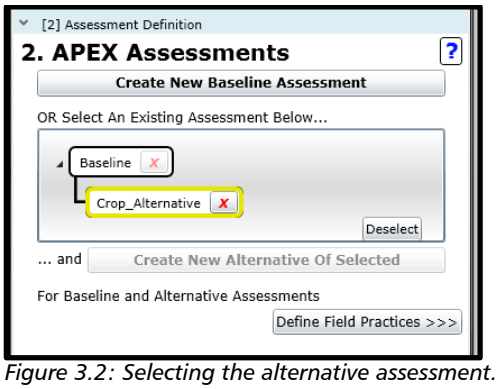


Figure 3.2: Selecting the alternative assessment.

3.1.2. Definition of Field Practices

After creating the alternative assessment, click on the "**Define Fields Practices >>>**" button to move to the practices portion on the STAR navigation pane.

It is not necessary to select any practices at this point, however, land use should be confirmed. Refer to Exercise 1 for the detailed steps.

Continue to the Operation Schedule Definition by selecting the button "**Define Field Operation Schedule>>>>.**"

3.1.3. Operation Schedule Definition

The "**Field Operations Definition**" portion of the STAR navigation pane will now show that the operations definition is incomplete. Double click in the "Field Name" table cell to define the operation schedule. The "**Operation Schedule Editor**" will open and provide several options for selecting an operation schedule.

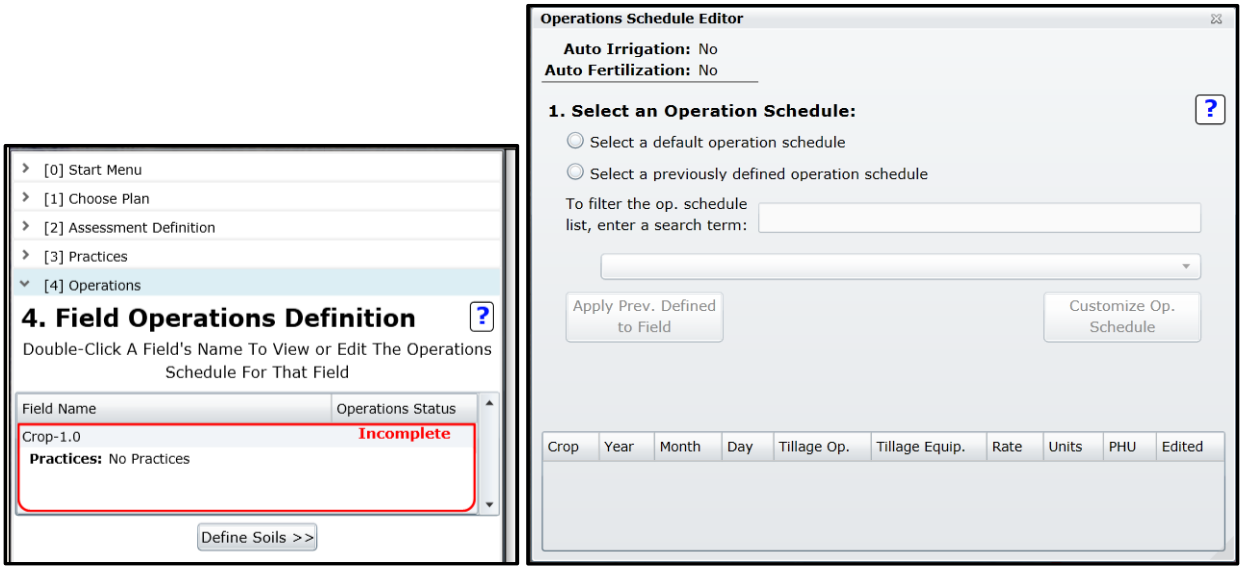
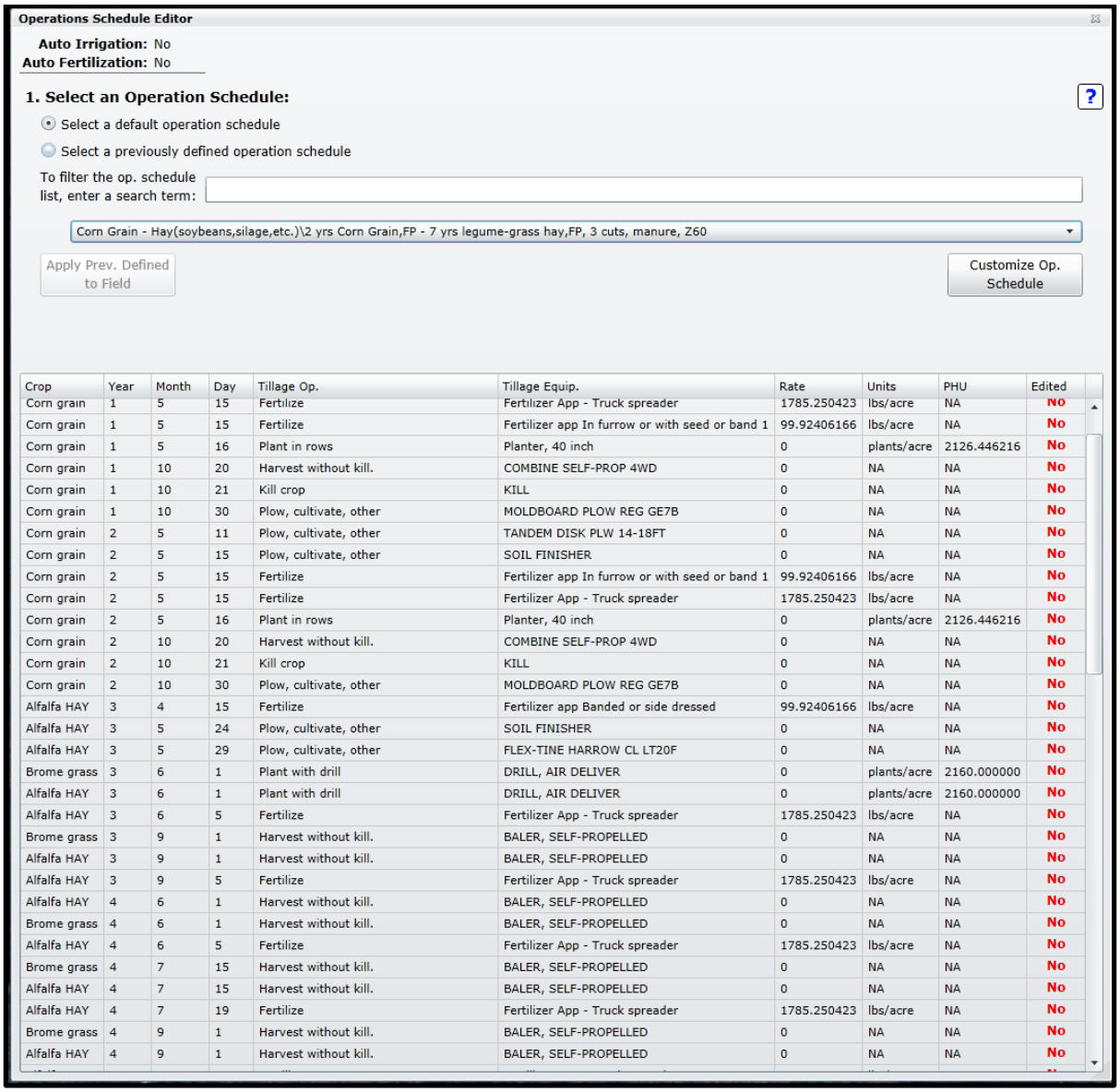


Figure 3.3: Field operations definition entry.

We will select a different "**default operation schedule**" for this alternative to compare to our baseline. Choose the "**Select a default operation scheule**" option, and from the drop-down combo-box, select "**Corn Grain-Hay(soybeans,silage,etc.)\2 yrs Corn Grain,FP - 7 yrs legume-grass hay,FP,3 cuts, manure, Z60**." The specifics of this opertion schedule are shown in the table at the bottom of the input form.



Crop	Year	Month	Day	Tillage Op.	Tillage Equip.	Rate	Units	PHU	Edited
Corn grain	1	5	15	Fertilize	Fertilizer App - Truck spreader	1785.250423	lbs/acre	NA	No
Corn grain	1	5	15	Fertilize	Fertilizer app In furrow or with seed or band 1	99.92406166	lbs/acre	NA	No
Corn grain	1	5	16	Plant in rows	Planter, 40 inch	0	plants/acre	2126.446216	No
Corn grain	1	10	20	Harvest without kill.	COMBINE SELF-PROP 4WD	0	NA	NA	No
Corn grain	1	10	21	Kill crop	KILL	0	NA	NA	No
Corn grain	1	10	30	Plow, cultivate, other	MOLDBOARD PLOW REG GE7B	0	NA	NA	No
Corn grain	2	5	11	Plow, cultivate, other	TANDEM DISK PLW 14-18FT	0	NA	NA	No
Corn grain	2	5	15	Plow, cultivate, other	SOIL FINISHER	0	NA	NA	No
Corn grain	2	5	15	Fertilize	Fertilizer app In furrow or with seed or band 1	99.92406166	lbs/acre	NA	No
Corn grain	2	5	15	Fertilize	Fertilizer App - Truck spreader	1785.250423	lbs/acre	NA	No
Corn grain	2	5	16	Plant in rows	Planter, 40 inch	0	plants/acre	2126.446216	No
Corn grain	2	10	20	Harvest without kill.	COMBINE SELF-PROP 4WD	0	NA	NA	No
Corn grain	2	10	21	Kill crop	KILL	0	NA	NA	No
Corn grain	2	10	30	Plow, cultivate, other	MOLDBOARD PLOW REG GE7B	0	NA	NA	No
Alfalfa HAY	3	4	15	Fertilize	Fertilizer app Banded or side dressed	99.92406166	lbs/acre	NA	No
Alfalfa HAY	3	5	24	Plow, cultivate, other	SOIL FINISHER	0	NA	NA	No
Alfalfa HAY	3	5	29	Plow, cultivate, other	FLEX-TINE HARROW CL LT20F	0	NA	NA	No
Brome grass	3	6	1	Plant with drill	DRILL, AIR DELIVER	0	plants/acre	2160.000000	No
Alfalfa HAY	3	6	1	Plant with drill	DRILL, AIR DELIVER	0	plants/acre	2160.000000	No
Alfalfa HAY	3	6	5	Fertilize	Fertilizer App - Truck spreader	1785.250423	lbs/acre	NA	No
Brome grass	3	9	1	Harvest without kill.	BALER, SELF-PROPELLED	0	NA	NA	No
Alfalfa HAY	3	9	1	Harvest without kill.	BALER, SELF-PROPELLED	0	NA	NA	No
Alfalfa HAY	3	9	5	Fertilize	Fertilizer App - Truck spreader	1785.250423	lbs/acre	NA	No
Alfalfa HAY	4	6	1	Harvest without kill.	BALER, SELF-PROPELLED	0	NA	NA	No
Brome grass	4	6	1	Harvest without kill.	BALER, SELF-PROPELLED	0	NA	NA	No
Alfalfa HAY	4	6	5	Fertilize	Fertilizer App - Truck spreader	1785.250423	lbs/acre	NA	No
Brome grass	4	7	15	Harvest without kill.	BALER, SELF-PROPELLED	0	NA	NA	No
Alfalfa HAY	4	7	15	Harvest without kill.	BALER, SELF-PROPELLED	0	NA	NA	No
Alfalfa HAY	4	7	19	Fertilize	Fertilizer App - Truck spreader	1785.250423	lbs/acre	NA	No
Brome grass	4	9	1	Harvest without kill.	BALER, SELF-PROPELLED	0	NA	NA	No
Alfalfa HAY	4	9	1	Harvest without kill.	BALER, SELF-PROPELLED	0	NA	NA	No

Figure 3.4: Selection of corn grain\hay\corn grain\legume alternative operation schedule.

Click the "**Customize Op Schedule**" button. This is a necessary step to save the operation schedule in your personal library of operation schedules, even if no changes are made. You are now prompted to "**Enter Name for the Custom Operation Schedule**". Name the schedule, "**T2 Crop 1.0 Corn Grain-Hay(soybeans,silage,etc.)\2 yrs Corn Grain,FP - 7 yrs legume-grass hay,FP,3 cuts, manure, Z60**" (T2 stands for "training 2"). However, you can name the schedule anything you'd like to help remember what it represents.

Click on the "**Apply Name & Start Customizing >>>**" button. You will now see the planting operations that need editing.

3.1.4. Specifying the Cover Type of Planting Operations

All planting operations with more than one possible cover type need to be reviewed individually. The operation schedule we selected has a Brome grass planting in year 3 that needs review.

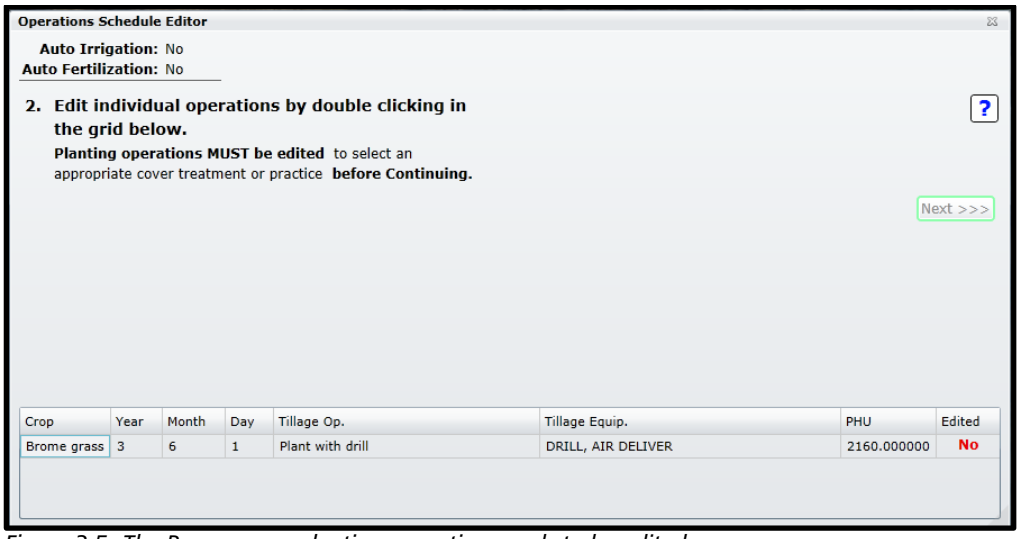


Figure 3.5: The Brome grass planting operation needs to be edited.

Double click the record to open the "**Update Planting Operation**" form. Any of the planting operation fields can be modified but for this exercise we will only edit the Cover Type. Select **"Not Contoured >75% ground cover lightly or only occasionally grazed"** from the Cover Type drop down list.

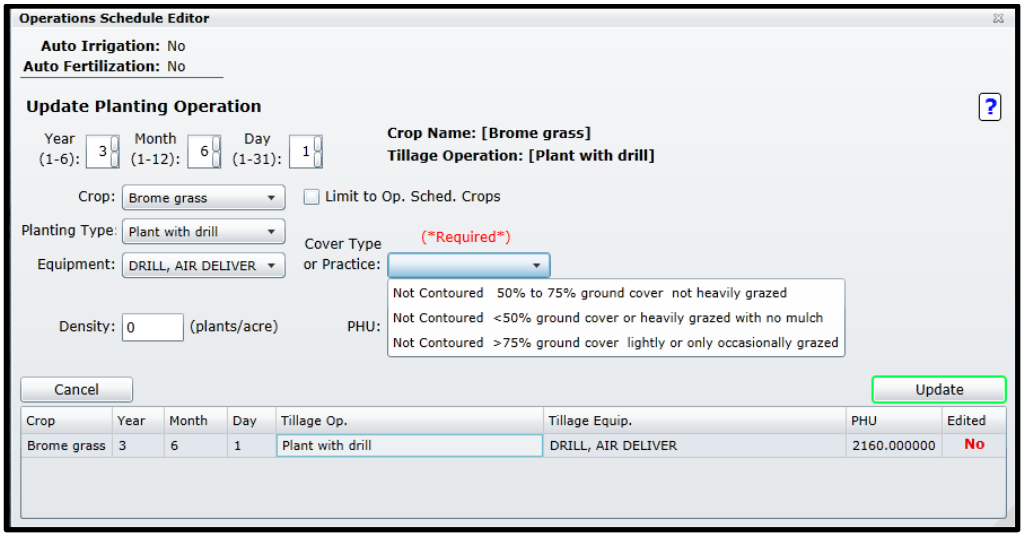


Figure 3.6: There are 3 possible cover types for the Brome grass operation.

Click the **"Update"** button and then on the next screen click on the "**Complete Operation Schedule**" button to close the "**Operation Schedule Editor.**" The "**Operation Status**" in the STAR navigation pane will now read "**Complete**."

3.1.5. Defining Field Soils and Running APEX

For each APEX assessment, the soils processing needs to be re-run before executing APEX since STAR does not automatically determine if the field has been split by practices. After soils processing is complete select **"Run APEX."**

For information on re-running and reviewing the soils and running APEX see Exercise 1.

After the APEX simulation is complete, the successful run will be listed in APEX Processing Status table. At any time, you can download a zip file of all the model input and output files by returning to this panel and selecting the paper clip. You can now view the results of both assessments in the STAR **"Reports"** section.

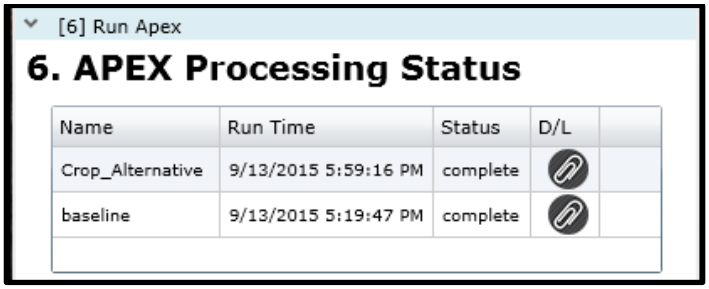


Figure 3.7: APEX Processing Status.

3.1.6. Viewing Results Reports to Compare Alternative to Baseline

Clicking on the "**[7] Reports**" item on the STAR navigation pane will open up the "**Reports**" section of the STAR navigation pane.

In the APEX parameters list, select all of the APEX outputs by clicking on the first item, then scrolling down and clicking on the last item with the "shift" key down. All of the items will now be highlighted.

From the "**Select the Baseline assessment to report on:**" drop down, select the "**Baseline**" assessment. This will refresh the list of completed Alternative Assessments. Select the "**Crop_Alternative**" assessment and then click on **"View Reports"** to run the STAR report for the selected parameters.

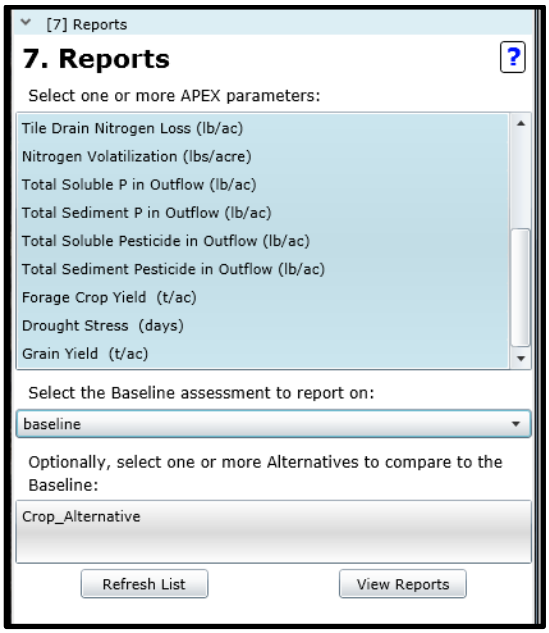


Figure 3.8: Selection of parameters and the baseline and alternative assessments for the STAR report.

The report will have an added column for comparing the "**Crop_Alternative**" assessment to the "**Baseline.**" The first section of the report describing inputs to the APEX simulation shows a small decrease in the total nitrogen total phosphorus applied. As expected, many of the field inputs did not changesince there were no changes to the field dimensions.

Summary of Field Inputs:

		Assessments	
Field Name		**Baseline**	**Crop_Alternative**
Crop-1.0	Practices		
	Op Schedule	T1 Crop-1.0-Corn Grain \Corn,grain; SP, spring manure, Z60	T2 Crop-1.0-Corn Grain - Hay (soybeans,silage,etc.)\2 yrs Corn Grain,FP - 7 yrs legume-grass hay,FP,
	Dominant Soil	Scantic	Scantic
	Field Acres	12.63	12.63
	Hydrologic Soil Group	D	D
	Slope	4.11%	4.11%
	Slope Length (ft)	45.72	45.72
	Weather Station	ST ALBANS RADIO	ST ALBANS RADIO
	Avg Annual Precip (in)	36.87	36.87
	Total N Applied (lbs/ac)	199.69	167.35
	Total P Applied (lbs/ac)	27.66	25.42
	Total Irr Applied (in/ac)	0.00	0.00
	STIR Tillage Value	130.18	51.43

Figure 3.9: STAR Report output, comparison of baseline and alternative field inputs.

In the second half of the report, you can see the effects of the alternative assessment. Total outflow and sediment yield are approximately half of what they were in the baseline assessment. Significant reductions can also be seen in phosphorus and nitrogen outputs.

Apex Parameter	Field Name	Baseline	Crop_Alternative
Total Outflow (inches)	Crop-1.0	9.15	5.52
Total Sediment Yield (t/ac)	Crop-1.0	9.51	4.68
Total Soluble P in Outflow (lb/ac)	Crop-1.0	0.40	0.17
Total Sediment P in Outflow (lb/ac)	Crop-1.0	10.66	4.98
Tile Drain Phosphorus Loss (lb/ac)	Crop-1.0	0.00	0.00
Total Soluble N in Outflow (lb/ac)	Crop-1.0	206.85	83.86
Total Sediment N in Outflow (lb/ac)	Crop-1.0	82.62	35.50
Tile Drain Nitrogen Loss (lb/ac)	Crop-1.0	0.00	0.00
Total Soluble Pesticide in Outflow (lb/ac)	Crop-1.0	0.00	0.00
Total Sediment Pesticide in Outflow (lb/ac)	Crop-1.0	0.00	0.00
Nitrogen Volatilization (lbs/acre)	Crop-1.0	38.64	30.76
Forage Crop Yield (t/ac)	Crop-1.0	0.00	5.28
Grain Yield (t/ac)	Crop-1.0	2.43	0.62
Drought Stress (days)	Crop-1.0	31.07	67.89
Phosphorus Stress (days)	Crop-1.0	0.00	0.00
Nitrogen Stress (days)	Crop-1.0	0.00	0.00

Total soluble N in outflow includes N in tile drainage. Total soluble P in outflow does NOT include P in tile drainage.

Figure 3.10: STAR Report output, comparison of baseline and alternative APEX outputs.

3.2. Creating a Second Alternative Assessment

We now want to create a second alternative assessment to further evaluate how changes in the crop operation schedule affect APEX outputs. In this second alternative, we will be modifying the default operation schedule for corn grain\hay by removing the fall plowing and looking at the effects of this change.

3.2.1. Create a Second Alternative Assessment

Click on **"[2] Assessment Definition"** to open up the assessment panel. Click on the "**Baseline**" assessment and then **"Create New Alternative of Selected"** as you did for the first alternative. Name the alternative "**Crop_Alternative Tillage Mod**" since will be modifying the previous default operation schedule.

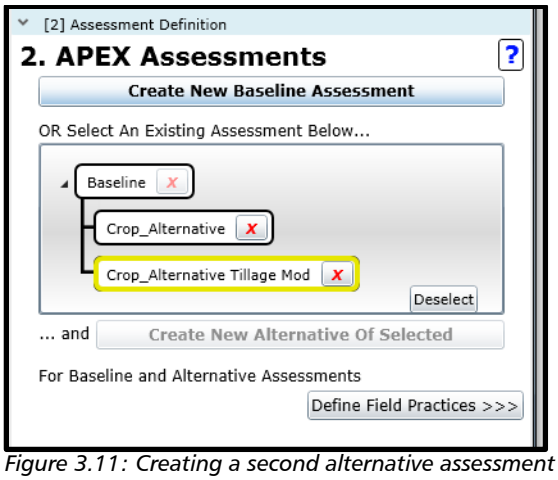


Figure 3.11: Creating a second alternative assessment

3.2.2. Definition of Field Practices

After finishing the alternative assessment creation, click on the "**Define Fields Practices >>>**" button to move to the practices portion on the STAR navigation pane.

It is not necessary to select any practices at this point, however, land use should be confirmed. Double click the "**Field Name**" to begin the selectin of the field practices. Set the land use to "**Crop**", and "**Save**". Continue to the "**Operation Schedule Definition**" by selecting the button **"Define Field Operation Schedule>>>>**."

3.2.3. Operation Schedule Definition

The "**Field Operations Definition**" portion of the STAR navigation pane will now show that the operations definition is incomplete. Double click in the "**Field Name**" table cell to define the operation schedule. The "**Operation Schedule Editor**" will open and provide several options for selecting an operation schedule.

We will select the option **"Select a previously defined operation schedule"** for this alternative to compare to our baseline and first alternative. From the drop-down combo-box, select the schedule you created for the first alternative:**"T2 Crop-1.0-Corn Grain- Hay(soybeans,silage,etc.)\2 yrs Corn Grain,FP - 7 yrs legume-grass hay,FP,3 cuts, manure, Z60**."

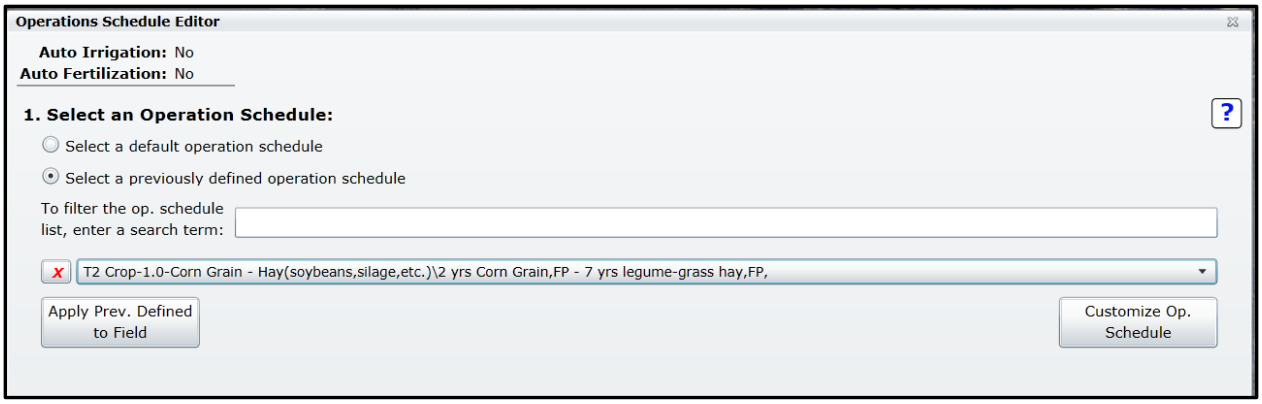


Figure 3.12: Selecting a previously created operation schedule.

Next, click the "**Customize Op Schedule**" button. Again, this is a necessary step to save the operation schedule in your personal library of operation schedules, even if no changes are made. You are now prompted to "**Enter Name for the Custom Operation Schedule**". Name the schedule, **"T3-Crop-1.0-Corn Grain - Hay(soybeans,silage,etc.)\2 yrs Corn Grain,FP - 7 yrs legume-grass hay,FP, No fall plow."** However, you can name the schedule anything you'd like to help remember what it represents.

Click on the "**Apply Name & Start Customizing >>>**" button. You will now see the planting operations that need editing.

3.2.4. Specifying the Cover Type of Planting Operations

As we did in the first alternative, we need to update the Brome grass planting in year 3. Double click the record to open the "**Update Planting Operation**" form. Any of the planting operation fields can be modified but for this exercise we will only edit the "**Cover Type."** Select **"Not Contoured >75% ground cover lightly only occasionally grazed"** from the Cover Type drop down list. Click the "**Update**" button to finish the planting operation editing and open the full operation schedule editor.

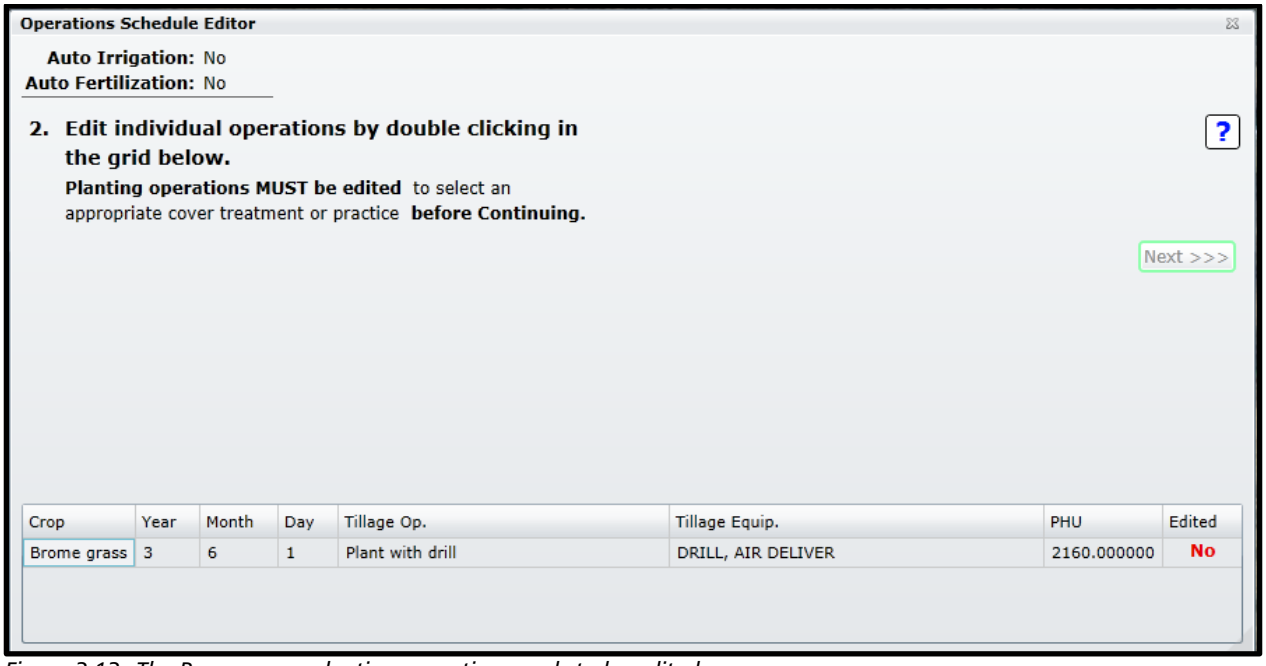
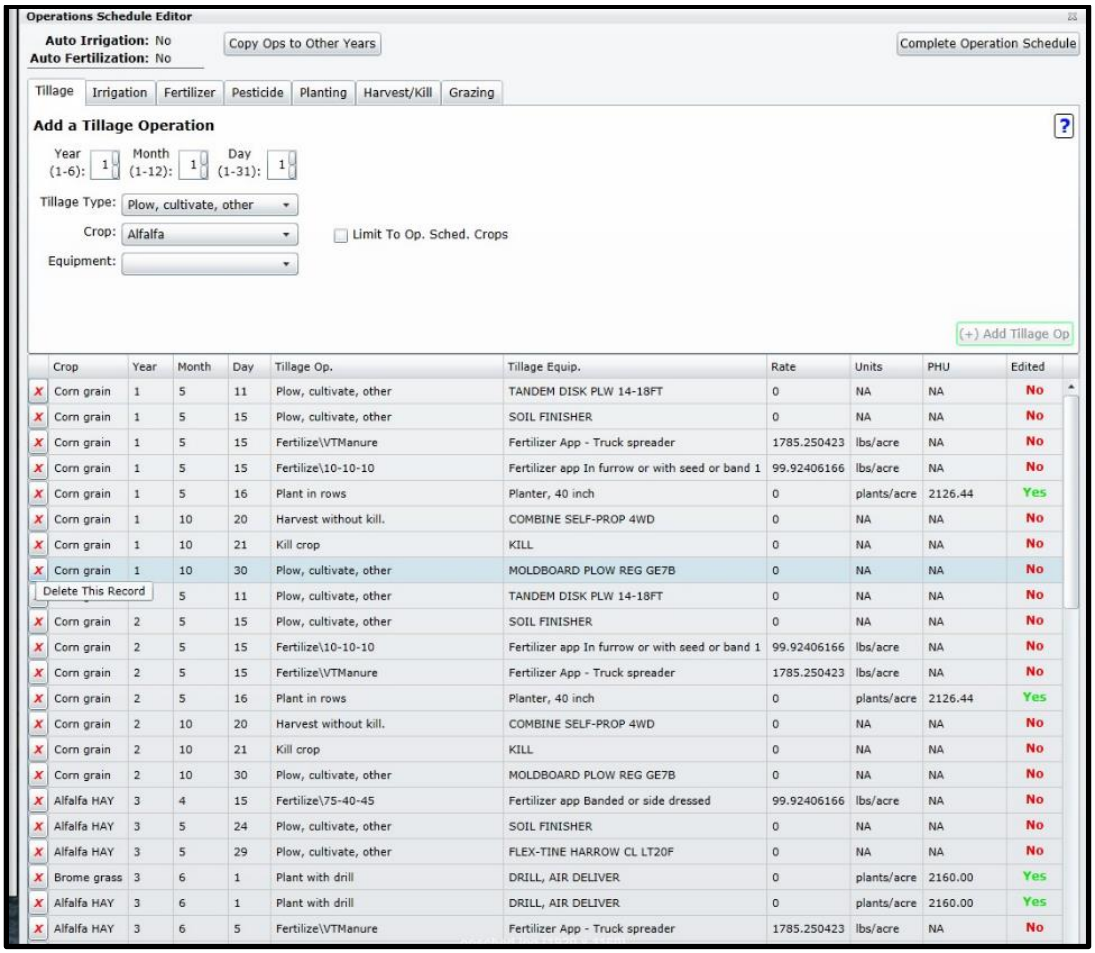


Figure 3.13: The Brome grass planting operation needs to be edited.

3.2.5. Remove Operations from the Crop Operation Schedule

In this alternative we are going to delete the fall plow operations for corn on year 1 and year 2 which occur on 10/30.

Click on the red X to the left of the Plow operation on 10/30 in Year 1. A confirmation will open asking you if you are sure you want to delete the operation schedule record. Click **"OK"**. Do the same for the plow operation on 10/30 in Year 2.



Crop	Year	Month	Day	Tillage Op.	Tillage Equip.	Rate	Units	PHU	Edited
Corn grain	1	5	11	Plow, cultivate, other	TANDEM DISK PLW 14-18FT	0	NA	NA	No
Corn grain	1	5	15	Plow, cultivate, other	SOIL FINISHER	0	NA	NA	No
Corn grain	1	5	15	Fertilize\VTManure	Fertilizer App - Truck spreader	1785.250423	lbs/acre	NA	No
Corn grain	1	5	15	Fertilize\10-10-10	Fertilizer app In furrow or with seed or band 1	99.92406166	lbs/acre	NA	No
Corn grain	1	5	16	Plant in rows	Planter, 40 inch	0	plants/acre	2126.44	Yes
Corn grain	1	10	20	Harvest without kill.	COMBINE SELF-PROP 4WD	0	NA	NA	No
Corn grain	1	10	21	Kill crop	KILL	0	NA	NA	No
Corn grain	1	10	30	Plow, cultivate, other	MOLDBOARD PLOW REG GE7B	0	NA	NA	No
		5	11	Plow, cultivate, other	TANDEM DISK PLW 14-18FT	0	NA	NA	No
Corn grain	2	5	15	Plow, cultivate, other	SOIL FINISHER	0	NA	NA	No
Corn grain	2	5	15	Fertilize\10-10-10	Fertilizer app In furrow or with seed or band 1	99.92406166	lbs/acre	NA	No
Corn grain	2	5	15	Fertilize\VTManure	Fertilizer App - Truck spreader	1785.250423	lbs/acre	NA	No
Corn grain	2	5	16	Plant in rows	Planter, 40 inch	0	plants/acre	2126.44	Yes
Corn grain	2	10	20	Harvest without kill.	COMBINE SELF-PROP 4WD	0	NA	NA	No
Corn grain	2	10	21	Kill crop	KILL	0	NA	NA	No
Corn grain	2	10	30	Plow, cultivate, other	MOLDBOARD PLOW REG GE7B	0	NA	NA	No
Alfalfa HAY	3	4	15	Fertilize\75-40-45	Fertilizer app Banded or side dressed	99.92406166	lbs/acre	NA	No
Alfalfa HAY	3	5	24	Plow, cultivate, other	SOIL FINISHER	0	NA	NA	No
Alfalfa HAY	3	5	29	Plow, cultivate, other	FLEX-TINE HARROW CL LT20F	0	NA	NA	No
Brome grass	3	6	1	Plant with drill	DRILL, AIR DELIVER	0	plants/acre	2160.00	Yes
Alfalfa HAY	3	6	1	Plant with drill	DRILL, AIR DELIVER	0	plants/acre	2160.00	Yes
Alfalfa HAY	3	6	5	Fertilize\VTManure	Fertilizer App - Truck spreader	1785.250423	lbs/acre	NA	No

Figure 3.14: Remove the fall plow operations.

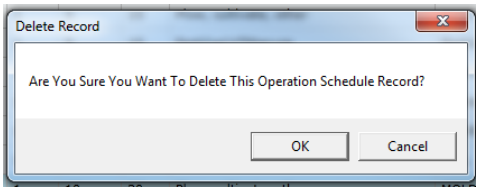


Figure 3.15: Remove the fall plow operations.

Click on the "**Complete Operation Schedule**" button to close the "**Operation Schedule Editor.**" The "**Operation Status**" in the STAR navigation pane will now read "**Complete**."

3.2.6. Define Soils and Run APEX

*Each time a new alternative is created, the soils processing must be re-run. This is because new assessments may contain modifications to the field boundaries if practices such as buffers or grass waterways are added. Click the "**Define Soils**" button.*

Figure 3.16: Define Soils.

*Click on "**Run APEX >>>**" to run the current alternative assessment.*

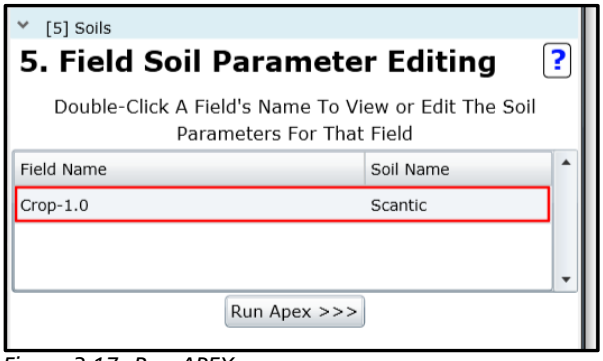


Figure 3.17: Run APEX.

3.2.7. Viewing Results Reports to Compare Both Alternatives to Baseline

Clicking on the "**[7] Reports**" item on the STAR navigation pane will open up the "**Reports**" section of the STAR navigation pane.

In the APEX parameters list, select all of the APEX outputs by clicking on the first item, then scrolling down and clicking on the last item with the **"shift"** key down. All of the items will now be highlighted.

From the "**Select the Baseline assessment to report on:**" drop down, select the "**Baseline**" assessment. This will refresh the list of completed Alternative Assessments and both alternatives will now be listed. Select both the "**Crop_Alternative**" assessment and the "**Crop_Alternative_ Tillage_Mod**" alternative and then click on **"View Reports"** to run the STAR report for the selected parameters.

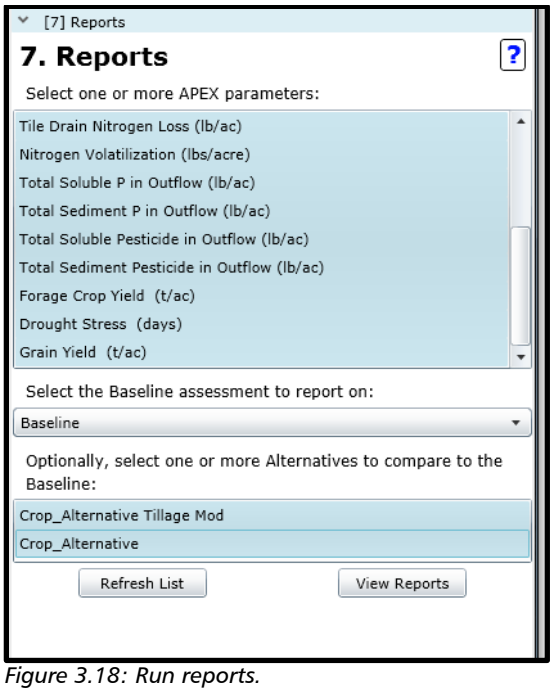


Figure 3.18: Run reports.

The new alternative appears as a third column in the report. (The current formatting of the reports only allows for 3 assessments to be compared side by side. Additional assessments can be added to the report but they will appear on separate pages).

There are almost no changes in the field inputs between the two alternatives except for a reduction in the STIR tillage value.

Summary of Field Inputs:

		Assessments		
Field Name		**Baseline**	**Crop_Alternative**	**Crop_Alternative_Tillage Mod**
Crop-1.0	Practices			
	Op Schedule	T1 Crop-1.0-Corn Grain \Corn,grain; SP, spring manure, Z60	T2 Crop-1.0-Corn Grain - Hay (soybeans,silage,etc.)\2 yrs Corn Grain,FP - 7 yrs legume-grass hay,FP,	T3 Crop-1.0-Corn Grain - Hay (soybeans,silage,etc.)\2 yrs Corn Grain,FP - 7 yrs legume-grass hay,FP,
	Dominant Soil	Scantic	Scantic	Scantic
	Field Acres	12.63	12.63	12.63
	Hydrologic Soil Group	D	D	D
	Slope	4.11%	4.11%	4.11%
	Slope Length (ft)	45.72	45.72	45.72
	Weather Station	ST ALBANS RADIO	ST ALBANS RADIO	ST ALBANS RADIO
	Avg Annual Precip (in)	36.87	36.87	36.87
	Total N Applied (lbs/ac)	199.69	167.35	167.35
	Total P Applied (lbs/ac)	27.66	25.42	25.42
	Total Irr Applied (in/ac)	0.00	0.00	0.00
	STIR Tillage Value	130.18	51.43	34.09

Figure 3.19: Report Field Input summary for baseline and 2 alternatives.

In reviewing the APEX outputs, we see that the total sediment load and sediment P load have been significantly reduced by removing the fall plow operation. There other default operation schedules in the STAR database that include much more limited plow operation compared to our original baseline assessment.

Apex Parameter	Field Name	Baseline	Crop_Alternative	Crop_Alternative_Tillage Mod
Total Outflow (inches)	Crop-1.0	9.15	5.52	5.11
Total Sediment Yield (t/ac)	Crop-1.0	9.51	4.68	0.88
Total Soluble P in Outflow (lb/ac)	Crop-1.0	0.40	0.17	0.11
Total Sediment P in Outflow (lb/ac)	Crop-1.0	10.66	4.98	1.41
Tile Drain Phosphorus Loss (lb/ac)	Crop-1.0	0.00	0.00	0.00
Total Soluble N in Outflow (lb/ac)	Crop-1.0	206.85	83.86	77.41
Total Sediment N in Outflow (lb/ac)	Crop-1.0	82.62	35.50	9.85
Tile Drain Nitrogen Loss (lb/ac)	Crop-1.0	0.00	0.00	0.00
Total Soluble Pesticide in Outflow (lb/ac)	Crop-1.0	0.00	0.00	0.00
Total Sediment Pesticide in Outflow (lb/ac)	Crop-1.0	0.00	0.00	0.00
Nitrogen Volatilization (lbs/acre)	Crop-1.0	38.64	30.76	28.00
Forage Crop Yield (t/ac)	Crop-1.0	0.00	5.28	5.37
Grain Yield (t/ac)	Crop-1.0	2.43	0.62	0.62
Drought Stress (days)	Crop-1.0	31.07	67.89	65.58
Phosphorus Stress (days)	Crop-1.0	0.00	0.00	0.00
Nitrogen Stress (days)	Crop-1.0	0.00	0.00	0.15

Total soluble N in outflow includes N in tile drainage. Total soluble P in outflow does NOT include P in tile drainage.

Figure 3.20: Report APEX output summary for baseline and 2 alternatives.

4.
Exercise 3, Simulating Alternative Practices with STAR

This exercise will build upon the baseline and alternative crop schedule assessments that we have evaluated up to this point. Now, the focus will be on evaluating the effects of adding specific conservation or field management practices to the assessment. The practices that will be included in this exercise (subsurface drainage, filter strips, and cover cropping) are common to Vermont farms. For each alternative assessment, we will be able to compare the predicted sediment and nutrient outputs with our baseline assessment.

4.1. Subsurface Drainage Alternative Assessment

In exercise 2, an alternative assessment was created that modified the crop rotation from permanent corn grain to a corn grain/hay rotation, as well as a modification to the tillage operations during the corn years. For the first alternative practices assessment, we will add subsurface drainage to the alternative with the custom corn/hay operation schedule (with modified tillage).

4.1.1. Create an Alternative Assessment

In the "**Assessment Definition**" item from the STAR navigation pane, select the "**Baseline**" assessment and click "**Create New Alternative of Selected**."Name the alternative"**Crop_Alternative_Tillage_Mod_Drainage**" and click, "**Create Alternative**."

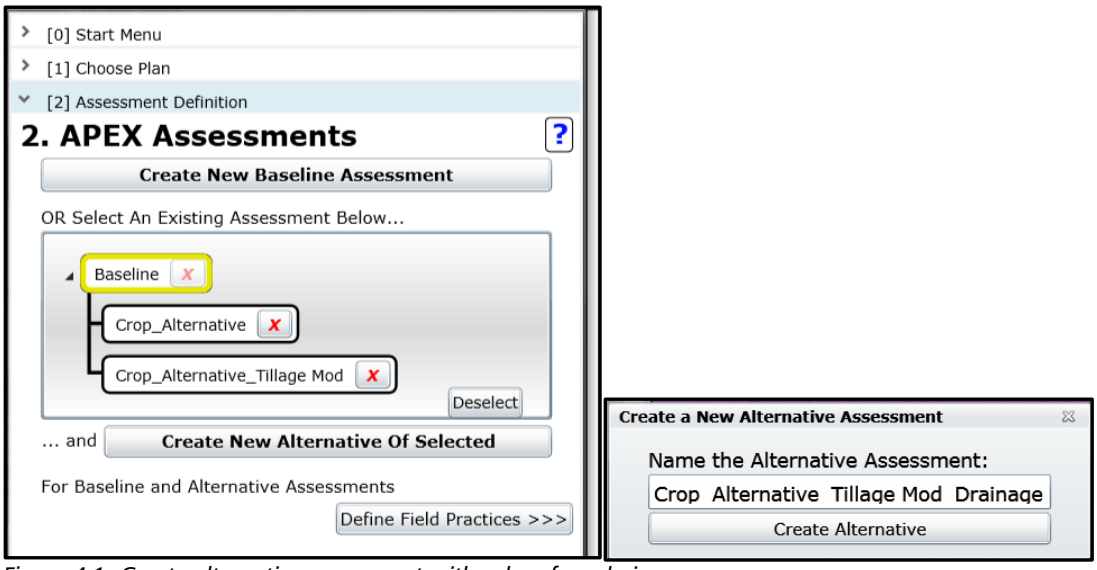


Figure 4.1: Create alternative assessment with subsurface drainage.

Select the new alternative assessment created, and click on the "**Define Field Practices >>>**" button.

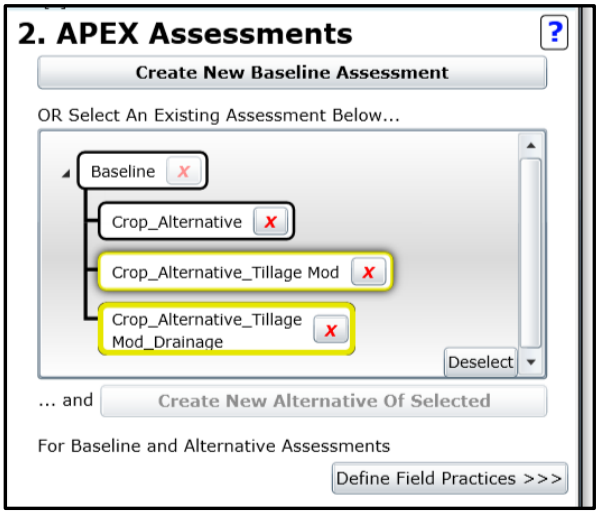


Figure 4.2: Select new drainage alternative.

4.1.2. Define the Field Practices

Double click the "**Field Name**" to begin the selection of the field practices (you can refer to Exercise 1 for the detailed steps). Set the land use to "**Crop**", and "**Save**". From the list of practices in the "**Field Practices Editor,**" select "**Subsurface Drain (606)**" and click "**Add to Field**." The "Subsurface Drain (606)" practice will now be shown in the list of "**Selected Practices on Field**." Close the "**Field Practices Editor**" and click the "**Define Field Operation Schedule >>>**" button to move on to the next step.

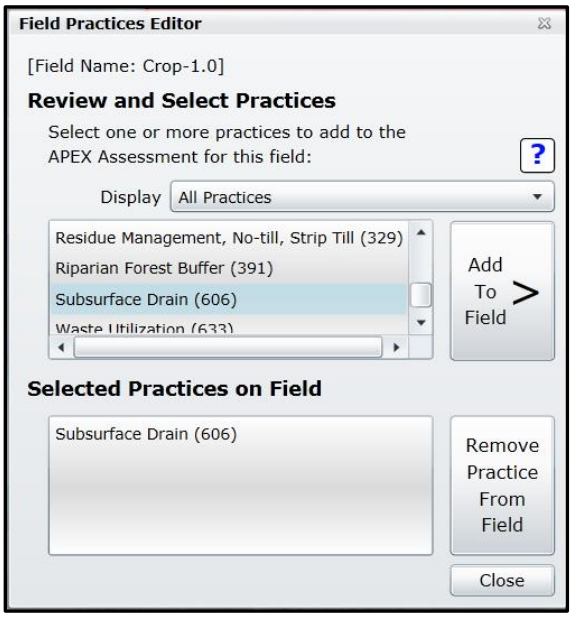


Figure 4.3: Add subsurface drainage practice to field.

4.1.3. Select Field Operation Schedule

Double click the **"Field Name"** to open the "**Operation Schedule Editor,**" then choose the "**Select a previously defined operation schedule**" option. From the drop-down list, choose the operation schedule created in the previous exercise where the fall plow operation was removed from the corn/hay rotation (T3).

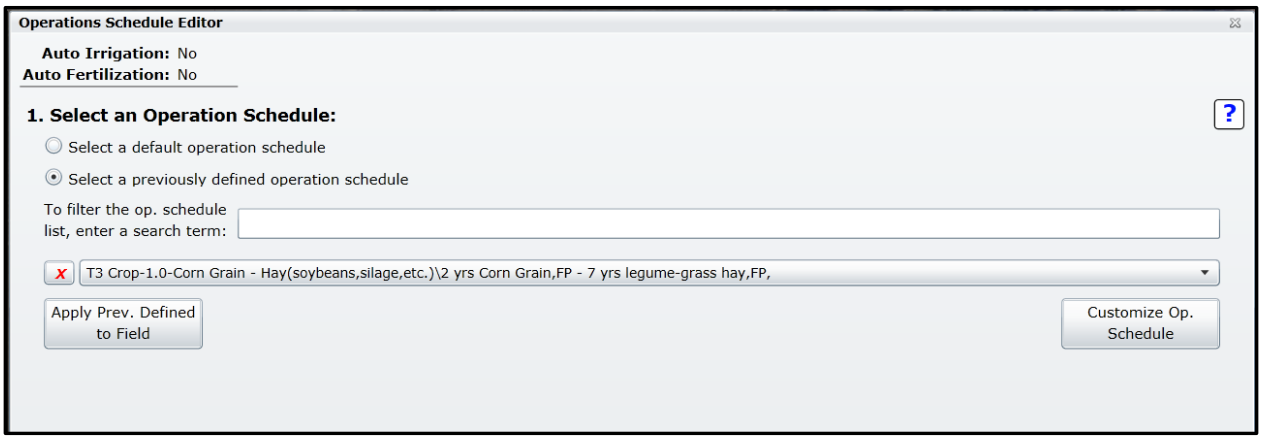


Figure 4.4: Select previously defined operation schedule.

Click the "**Apply Prev. Defined to Field**" button to apply this schedule to the current alternative assessment. Next, click the "**Complete Operation Schedule**" button to finish the operation schedule definition.

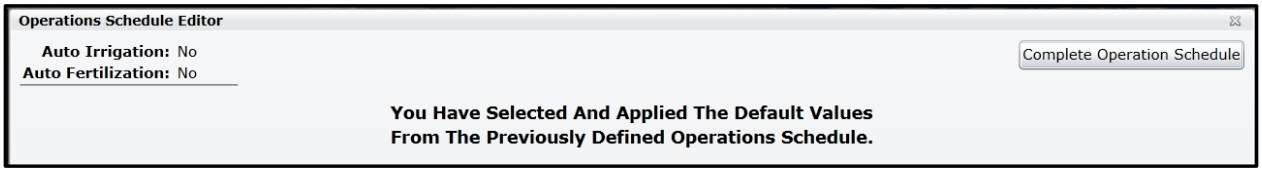


Figure 4.5: Complete operation schedule definition.

4.1.4. Define Soils and Run APEX

Each time a new alternative is created, the soils processing must be re-run. This is because new assessments may contain modifications to the field boundaries if practices such as buffers or grass waterways are added. Click the **"Define Soils"** button.

Figure 4.6: Define Soils.

Click on **"Run APEX >>>"** to run the current alternative assessment.

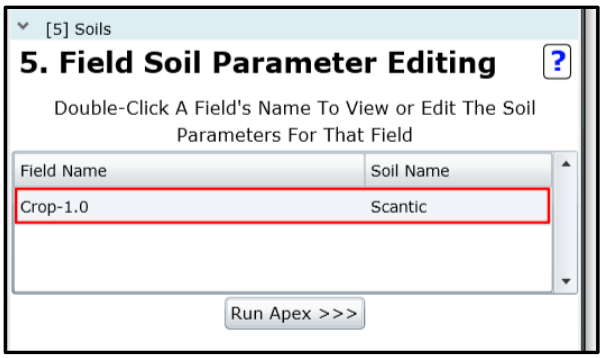


Figure 4.7: Run APEX.

4.1.5. View Report

In the "**Reports**" section of the STAR navigation pane, select the **"Baseline"** assessment to report on. You will now see that there are 3 alternative assessments to report on. Choose all of the APEX parameters, and the "**Crop_Alternative_Tillage Mod**" and "**Crop_Altermative_Tillage Mod_Drainage**" alternatives. Then, click "**View Reports**."

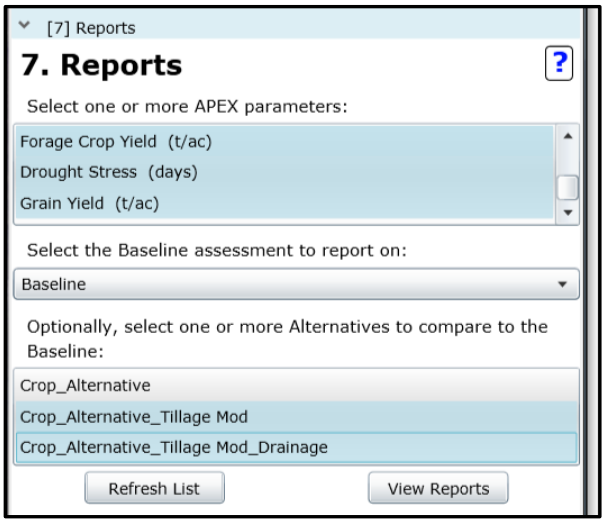


Figure 4.8: Selection of inputs for report.

The output summary shows that the reduction in the outflow (runoff) that occurs with the addition of the subsurface drainage leads to a lowering of the sediment losses as well as the soluble and sediment P. However, the soluble P in the tile drainage now makes up a significant proportion of the total P losses. The sum of total P (soluble, sediment, and tile) is actually higher with the subsurface drainage practices than without it.

Summary of Field Inputs:

		Assessments		
Field Name		**Baseline**	**Crop_Alternative_Tillage Mod**	**Crop_Alternative_Tillage Mod_Drainage**
Crop-1.0	Practices			Subsurface Drain
	Op Schedule	T1 Crop-1.0-Corn Grain \Corn,grain; SP, spring manure, Z60	T3 Crop-1.0-Corn Grain - Hay (soybeans,silage,etc.)\2 yrs Corn Grain,FP - 7 yrs legume-grass hay,FP,	T3 Crop-1.0-Corn Grain - Hay (soybeans,silage,etc.)\2 yrs Corn Grain,FP - 7 yrs legume-grass hay,FP,
	Dominant Soil	Scantic	Scantic	Scantic
	Field Acres	12.63	12.63	12.63
	Hydrologic Soil Group	D	D	D
	Slope	4.11%	4.11%	4.11%
	Slope Length (ft)	45.72	45.72	45.72
	Weather Station	ST ALBANS RADIO	ST ALBANS RADIO	ST ALBANS RADIO
	Avg Annual Precip (in)	36.87	36.87	36.87
	Total N Applied (lbs/ac)	199.69	167.35	167.35
	Total P Applied (lbs/ac)	27.66	25.42	25.42
	Total Irr Applied (in/ac)	0.00	0.00	0.00
	STIR Tillage Value	130.18	34.09	34.09

Figure 4.9: Report inputs summary for baseline and 2 alternatives.

Apex Parameter	Field Name	Baseline	Crop_Alternative_Tillage Mod	Crop_Alternative_Tillage Mod_Drainage
Total Outflow (inches)	Crop-1.0	9.15	5.11	2.02
Total Sediment Yield (t/ac)	Crop-1.0	9.51	0.88	0.21
Total Soluble P in Outflow (lb/ac)	Crop-1.0	0.40	0.11	0.03
Total Sediment P in Outflow (lb/ac)	Crop-1.0	10.66	1.41	0.42
Tile Drain Phosphorus Loss (lb/ac)	Crop-1.0	0.00	0.00	1.26
Total Soluble N in Outflow (lb/ac)	Crop-1.0	206.85	77.41	88.37
Total Sediment N in Outflow (lb/ac)	Crop-1.0	82.62	9.85	2.84
Tile Drain Nitrogen Loss (lb/ac)	Crop-1.0	0.00	0.00	34.04
Total Soluble Pesticide in Outflow (lb/ac)	Crop-1.0	0.00	0.00	0.00
Total Sediment Pesticide in Outflow (lb/ac)	Crop-1.0	0.00	0.00	0.00
Nitrogen Volatilization (lbs/acre)	Crop-1.0	38.64	28.00	27.96
Forage Crop Yield (t/ac)	Crop-1.0	0.00	5.37	5.39
Grain Yield (t/ac)	Crop-1.0	2.43	0.62	0.63

Figure 4.10: Report outputs summary for baseline and 2 alternatives.

4.2. Filter Strip Alternative Assessment

For the next alternative practice assessment, we will add a filter strip, or buffer, to the alternative with the custom corn/hay operation schedule (with modified tillage).

4.2.1. Create an Alternative Assessment

In the "**Assessment Definition**" item from the STAR navigation pane, select the "**Baseline**" assessment and click "**Create New Alternative of Selected**." Name the alternative, "**Crop_Alternative_Tillage_Mode_Filter**" and click, "**Create Alternative**."

Select the new alternative assessment created, and click on the "**Define Field Practices >>>**" button.

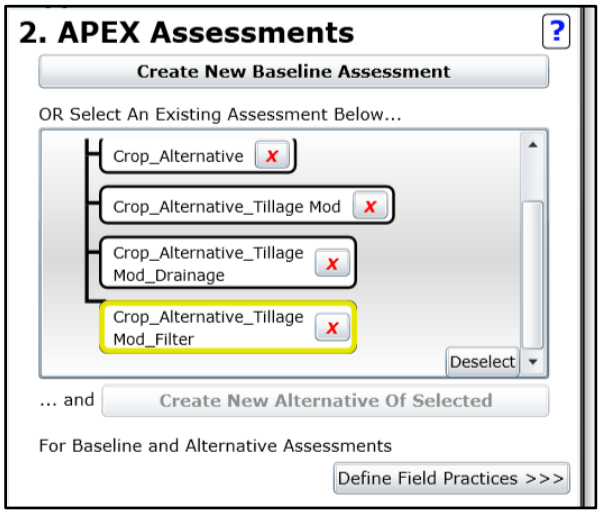


Figure 4.11: Select new filter alternative.

4.2.2. Define the Field Practices

Double click the "**Field Name**" to begin the selection of the field practices. Set the land use to "**Crop**", and click **"Save**." From the list of practices in the "**Field Practices Editor,**" select "**Filter Strip (393)**" and click "**Add to Field**." A message box will open to tell you that you will need to use the "**STAR Splitting Tool**" to create this filter strip practice. Click "**OK**", and then click the "**Locate Practices Boundaries**" button to start defining the filter strip. You will be able to draw the location of the filter strip on the map.

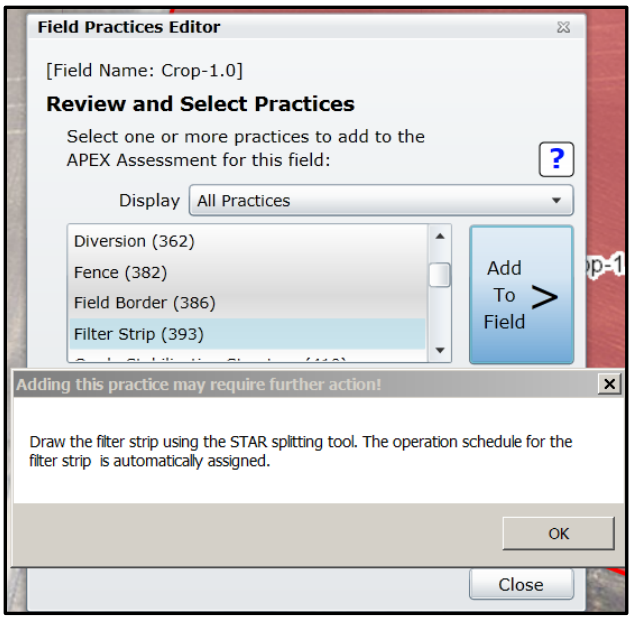


Figure 4.12: Add subsurface drainage practice to field.

After clicking on "**Locate Practice Boundaries,**" the "**Field Split Manager**" will open.

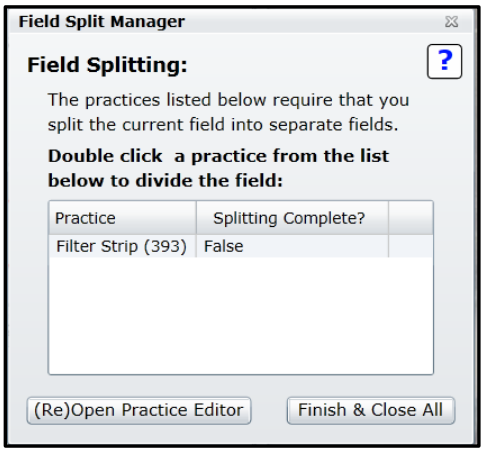


Figure 4.13: Field practices editor.

Double click the "**Filter Strip**" practice to start the process. This will open a dialog to enter the width of the filter strip, and the "**Field Split Editor**." Type in a width of 25 ft and click "**Preview**." This will draw a 25 ft buffer along the inside of the field. This buffer, around the whole field, serves as a guide for the user to draw in a buffer along the desired portion of the field. We will draw a buffer along just one long edge of the field.

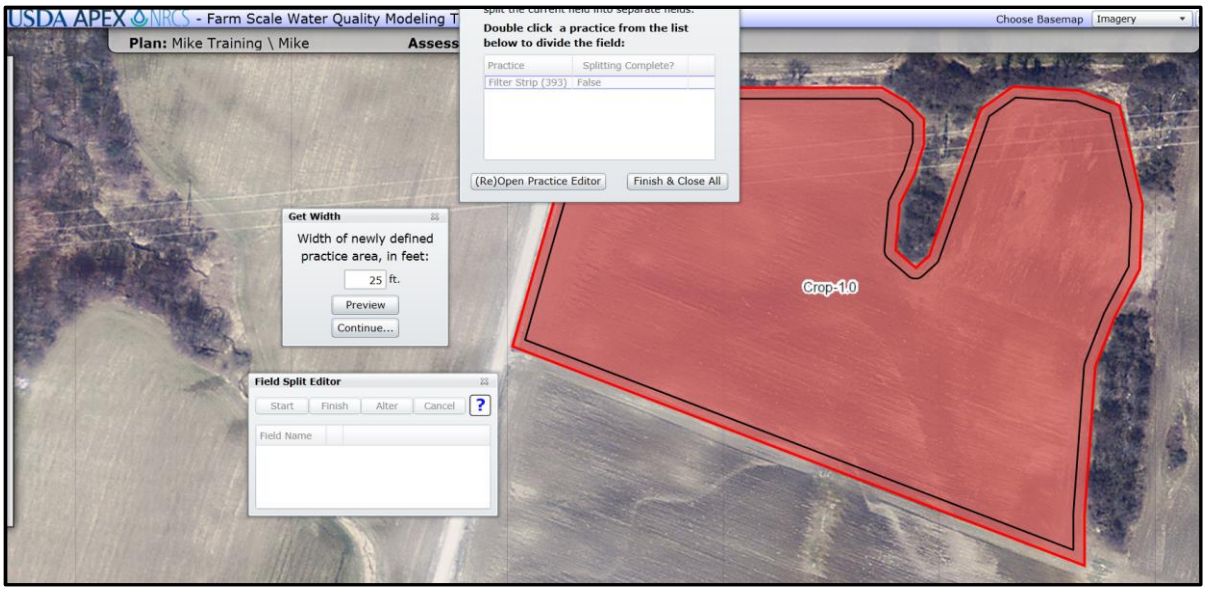


Figure 4.14: Field split editor preview.

If you select the **"Continue**" button, the "**Field Split Editor**" will become active. Click on the "Start" button to start drawing the filter strip. Sketch along the edge of the field where you'd like to place the filter, following the 25 ft guide (in black). The edge of the new filter will be in yellow. When finished drawing the filter, double click. Then, click the "**Finish**" button on the "**Field Split**" editor.

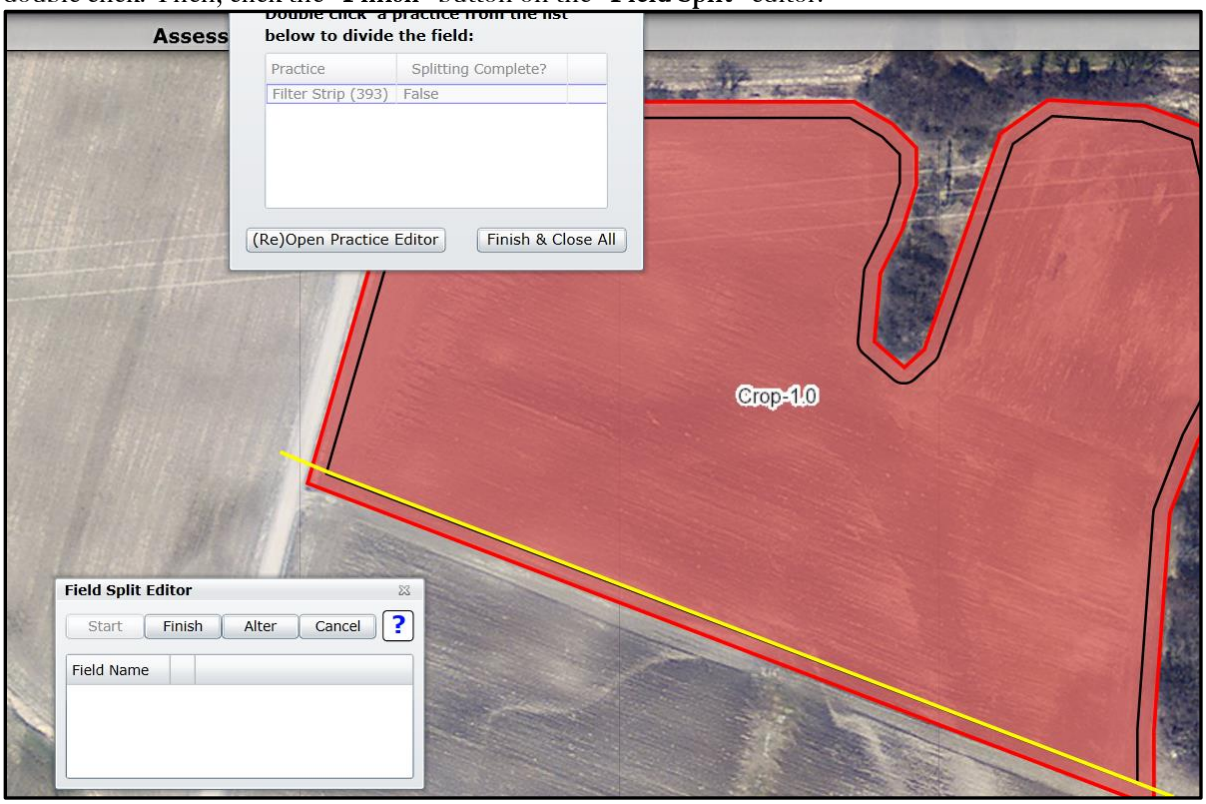


Figure 4.15: Sketch of buffer using the field split editor.

Now, we need to name the new filter and define the hydrologic connectivity from the field to the filter. Change the name of "**NewField [1]**" to "**Filter**". Set the "**Crop-1.0**" field to drain to the "**Filter**." The "**Filter**" should drain to the "**Outlet**."

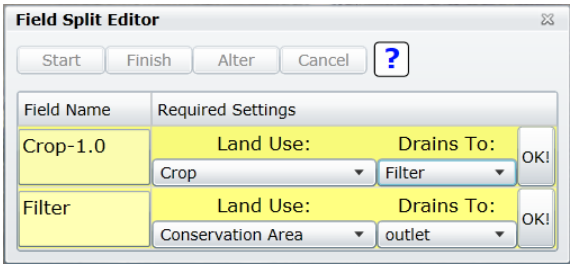


Figure 4.16: Field Split Editor.

Click "**OK!**" for both the "**Crop-1.0**" and "**Filter**". Click the "x" to close out the "**Field Split Editor**". This will close the windows associated with the definition of the filter practice. Now, click the "**Define Field Operation Schedule >>>**" to go on to the selection of the operation schedules.

4.2.3. Select Field Operation Schedule

The field operation schedule for the "**Filter**" is automatically set by STAR. To view the "**Filter**" operation schedule, double click the "**Field Name**" to open the "**Operation Schedule Editor**". You will see that there is fall-planted timothy grass for the filter. Exit out of the "**Operation Schedule Editor**" by clicking the "**x**" in the upper right hand corner of the form.

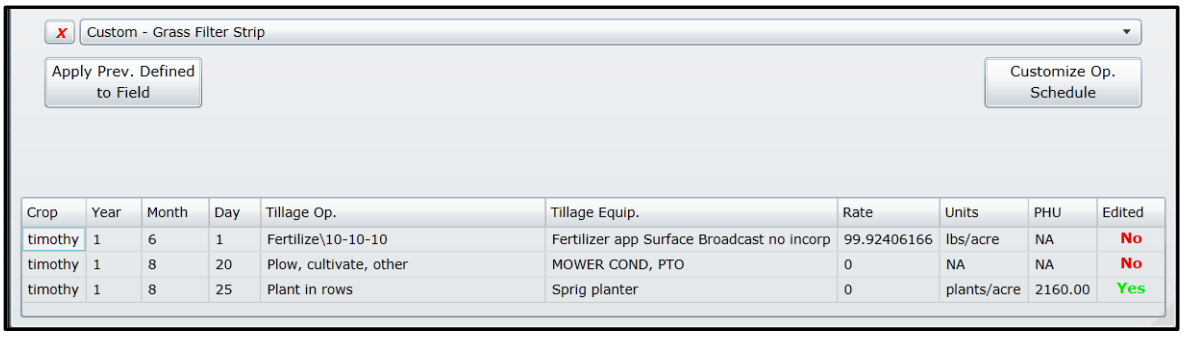


Figure 4.17: Filter operation schedule.

The operation schedule for the "**Crop-1.0**" field must be selected. We will select the schedule that we used for the "**Subsurface Drainage**" practice. Double click the "Crop1.0" under "**Field Name,**" then choose the "**Select a previously defined operation schedule**" option. From the drop-down list, choose the operation schedule created in the previous exercise where the fall plow operation was removed from the corn/hay rotation (T3).

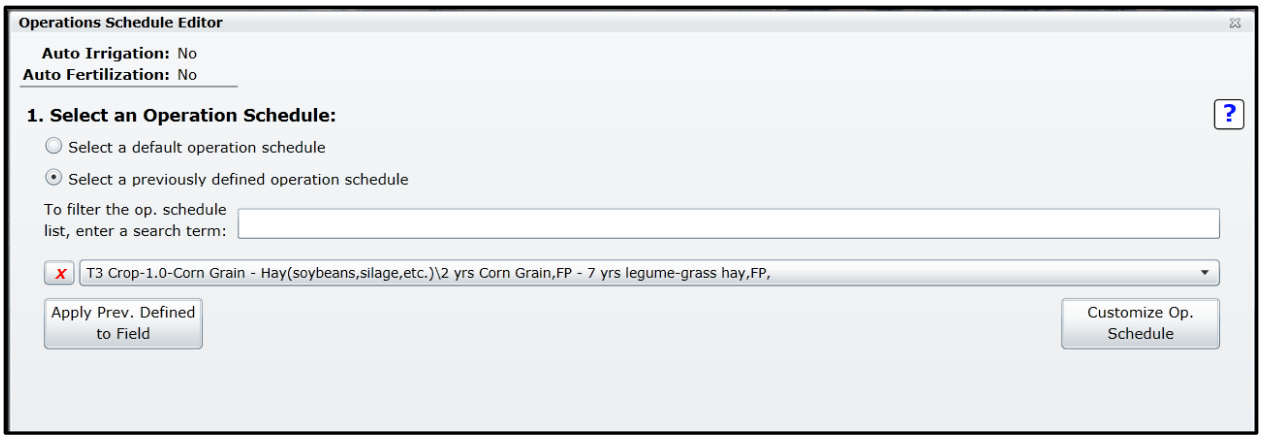


Figure 4.18: Select previously defined operation schedule.

Click the "**Apply Prev. Defined to Field**" button to apply this schedule to the current alternative assessment. Next, click the "**Complete Operation Schedule**" button to finish the operation schedule definition.

4.2.4. Define Soils and Run APEX

Click the "**Define Soils**" button. This will characterize the soils for the field and the filter strip.

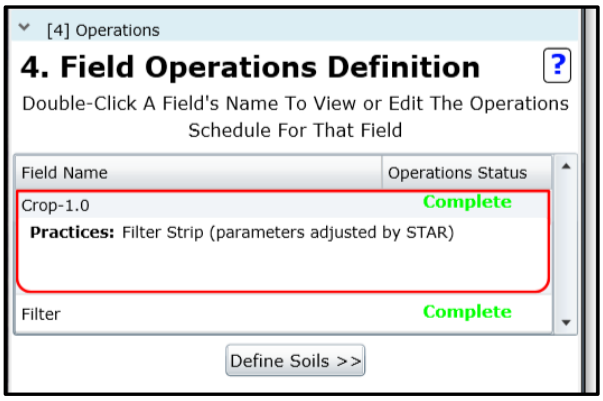


Figure 4.19: Define Soils.

Click on "**Run APEX >>>**" to run the current alternative assessment.

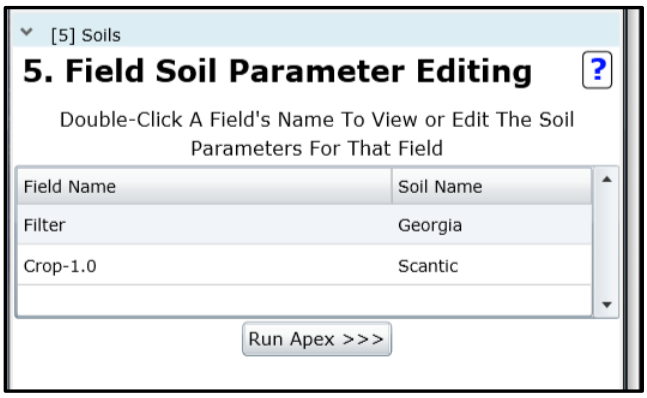


Figure 4.20: Run APEX.

4.2.5. View Report

In the "**Reports**" section of the STAR navigation pane, select the "**Baseline**" assessment to report on. You will now see that there are 4 alternative assessments to report on. Choose all of the APEX parameters, and the "**Crop_Alternative_Tillage Mod**" and "**Crop_Altermative_Tillage Mod_Filter**" alternatives. Then, click "**View Reports.**"

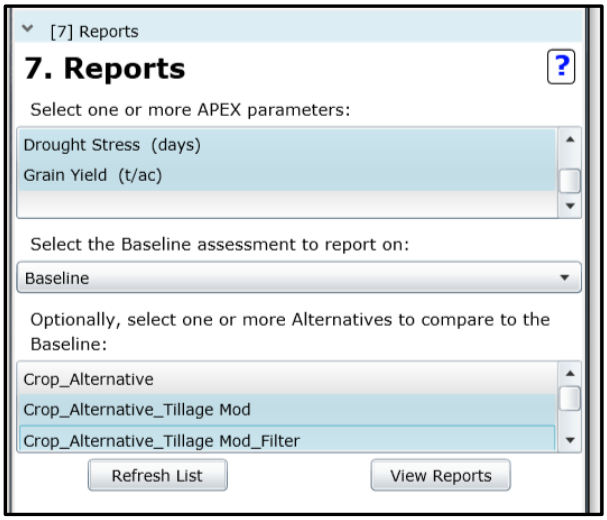


Figure 4.21: Selection of outputs and alternatives for report.

The inputs section for the filter strip alternative show the characteristics of the filter "subarea," in addition to the cropped field. Note that the area of the field is now slightly smaller, due to the area that was taken out of production to create the filter strip. The soil type and the slope of the filter may also be different. In the example of Field 1, the field area was a hydrologic group D soil and the filer area was a hydrologic group C soil. The filter practice input information is only presented for the filter alternative, because it is not relevant for the baseline and the first alternative.

The STAR outputs report shows the loads (flow, sediment, nutrients) reflective of the "outlet" of the field. In the case of the alternative with the filter strip, these are the loads that make it from the field and through the filter strip. In the example shown in this workbook for field 1, the filter strip is effective at reducing the sediment P by almost 50%. The amount of reduction in sediment and sediment P loss will be different for each field, depending of the soil and slope conditions of the field and the filter strip.

Summary of Field Inputs:

		Assessments		
Field Name		**Baseline**	**Crop_Alternative_Tillage Mod**	**Crop_Alternative_Tillage Mod_Filter**
Crop-1.0	Practices			Filter Strip
	Op Schedule	T1 Crop-1.0-Corn Grain \Corn,grain; SP, spring manure, Z60	T3 Crop-1.0-Corn Grain - Hay (soybeans,silage,etc.)\2 yrs Corn Grain,FP - 7 yrs legume-grass hay,FP,	T3 Crop-1.0-Corn Grain - Hay (soybeans,silage,etc.)\2 yrs Corn Grain,FP - 7 yrs legume-grass hay,FP,
	Dominant Soil	Scantic	Scantic	Scantic
	Field Acres	12.63	12.63	12.20
	Hydrologic Soil Group	D	D	D
	Slope	4.11%	4.11%	4.15%
	Slope Length (ft)	45.72	45.72	45.72
	Weather Station	ST ALBANS RADIO	ST ALBANS RADIO	ST ALBANS RADIO
	Avg Annual Precip (in)	36.87	36.87	36.87
	Total N Applied (lbs/ac)	199.69	167.35	167.35
	Total P Applied (lbs/ac)	27.66	25.42	25.42
	Total Irr Applied (in/ac)	0.00	0.00	0.00
	STIR Tillage Value	130.18	34.09	34.09
Filter	Practices			Filter Strip
	Op Schedule			Custom - Grass Filter Strip
	Dominant Soil			Georgia
	Field Acres			0.43
	Hydrologic Soil Group			C
	Slope			0.92%
	Slope Length (ft)			10.00
	Weather Station			ST ALBANS RADIO
	Avg Annual Precip (in)			36.87
	Total N Applied (lbs/ac)			8.91
	Total P Applied (lbs/ac)			3.92

Figure 4.22: Inputs from STAR report with filter practice.

Summary of APEX Output

Apex Parameter	Field Name	Baseline	Crop_Alternative_Tillage Mod	Crop_Alternative_Tillage Mod_Filter
Total Outflow (inches)	Crop-1.0	9.15	5.11	4.89
Total Sediment Yield (t/ac)	Crop-1.0	9.51	0.88	0.20
Total Soluble P in Outflow (lb/ac)	Crop-1.0	0.40	0.11	0.11
Total Sediment P in Outflow (lb/ac)	Crop-1.0	10.66	1.41	0.76
Tile Drain Phosphorus Loss (lb/ac)	Crop-1.0	0.00	0.00	0.00
Total Soluble N in Outflow (lb/ac)	Crop-1.0	206.85	77.41	77.45
Total Sediment N in Outflow (lb/ac)	Crop-1.0	82.62	9.85	3.95
Tile Drain Nitrogen Loss (lb/ac)	Crop-1.0	0.00	0.00	0.00
Total Soluble Pesticide in Outflow (lb/ac)	Crop-1.0	0.00	0.00	0.00
Total Sediment Pesticide in Outflow (lb/ac)	Crop-1.0	0.00	0.00	0.00
Nitrogen Volatilization (lbs/acre)	Crop-1.0	38.64	28.00	27.67
Forage Crop Yield (t/ac)	Crop-1.0	0.00	5.37	5.23
Grain Yield (t/ac)	Crop-1.0	2.43	0.62	0.62
Drought Stress (days)	Crop-1.0	31.07	65.58	65.44

Figure 4.23: Outputs from STAR report with filter practice.

4.3. Cover Crop Alternative Assessment

A cover crop will be simulated for the third conservation practice alternative assessment. In this alternative, we will go back to the "baseline" crop rotation of permanent corn for grain to see what impact a fall-planted cover crop will have on the original crop rotation.

4.3.1. Create an Alternative Assessment

In the "**Assessment Definition**" item from the STAR navigation pane, select the "**Baseline**" assessment and click "**Create New Alternative of Selected**." Name the alternative, "**Baseline_CoverCrop**" and click, "**Create Alternative.**"

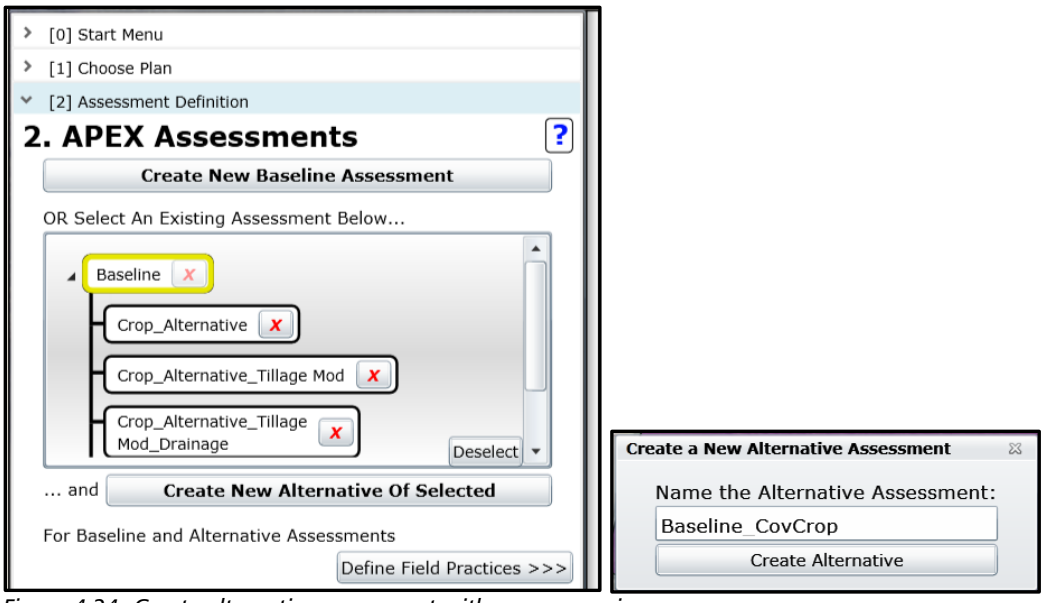


Figure 4.24: Create alternative assessment with cover cropping.

Select the new alternative assessment created, and click on the "**Define Field Practices >>>**" button.

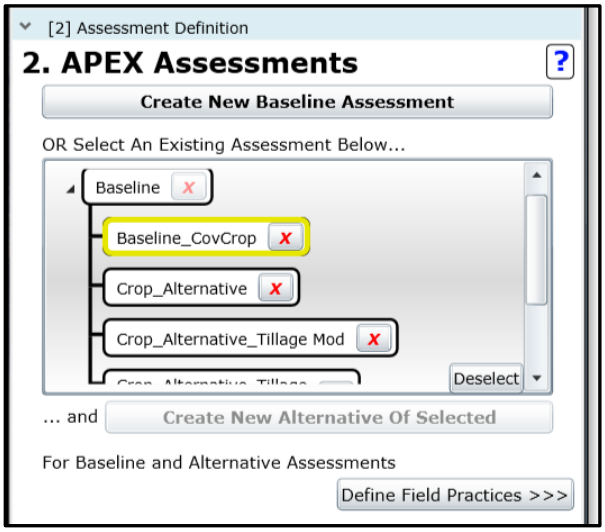


Figure 4.25: Select new cover crop alternative.

4.3.2. Define the Field Practices

Double click the "**Field Name**" to begin the selection of the field practices. Set the land use to "**Crop,**" and "**Save.**" From the list of practices in the "**Field Practices Editor,**" select "**Cover Crop (3403)**" and click "**Add to Field.**" A message box opens to tell you that you will need to use the "**Crop Mix Tool**" in the planting operation editor to define the cover crop input information. Click "**OK,**" and then click the "**Close**" button to exit the "**Field Practices Editor.**" Click the "**Define Field Operation Schedule >>>**" button to move on to the next step of defining the field operation schedule.

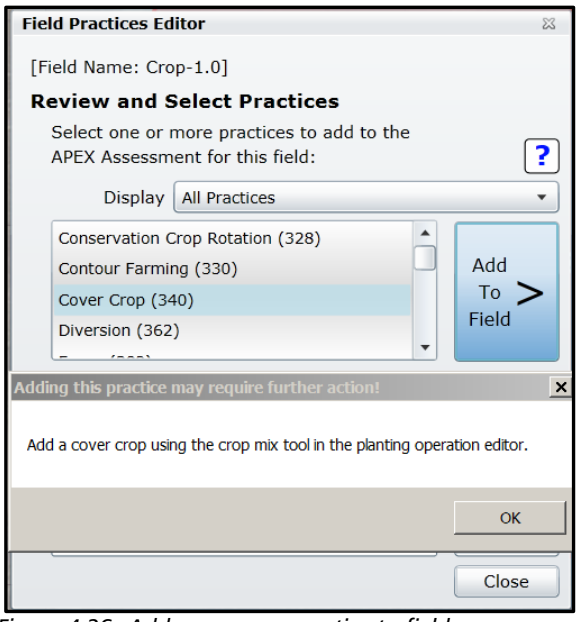


Figure 4.26: Add cover crop practice to field.

4.3.3. Select Field Operation Schedule

Double click the "**Field Name**" to open the "**Operation Schedule Editor,**" then choose the "**Select a previously defined operation schedule**" option. From the drop-down list, choose the operation schedule associated with the original baseline crop schedule of permanent corn grain (T1).

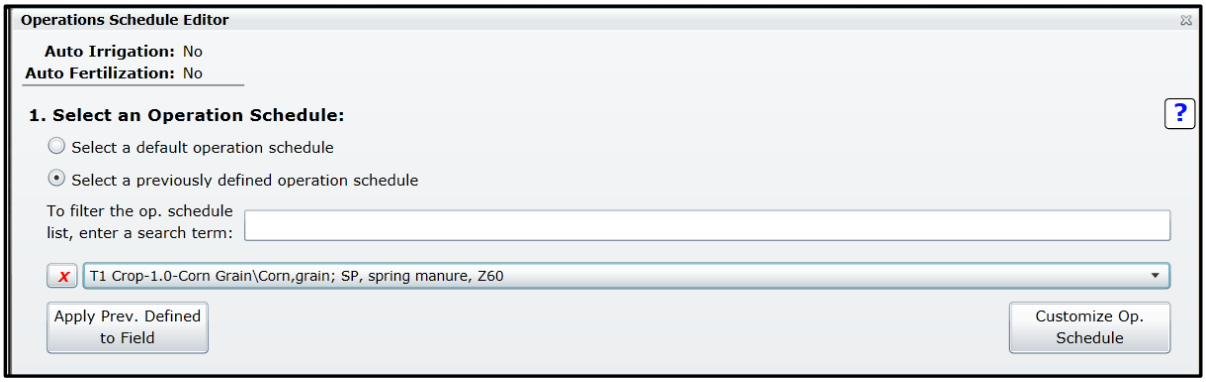


Figure 4.27: Select previously defined operation schedule.

Click the "**Customize Op. Schedule**" button to modify this operation schedule to include the cover crop. Name the op. schedule, "**T4 Cover Crop-Crop-1.0-Corn Grain\Corn,grain; SP, spring manure, Z60,**" then click "**Apply Name & Start Customizing.**"

Figure 4.28: Name and customize operation schedule.

First, double click on the "**Harvest without kill**" operation to edit the date to occur on 9/30 instead of 10/20. Click the "**Update**" button to update the operation in the schedule.

	Crop	Year	Month	Day	Tillage Op.	Tillage Equip.	Rate	Units	PHU
X	Corn grain	1	5	11	Plow, cultivate, other	MOLDBOARD PLOW REG GE7B	0	NA	NA
X	Corn grain	1	5	15	Plow, cultivate, other	SOIL FINISHER	0	NA	NA
X	Corn grain	1	5	15	Fertilize\VTManure	Fertilizer App - Truck spreader	3569.608667	lbs/acre	NA
X	Corn grain	1	5	15	Fertilize\10-10-10	Fertilizer app In furrow or with seed or band 1	99.92406166	lbs/acre	NA
X	Corn grain	1	5	16	Plant in rows	Planter, 40 inch	0	plants/acre	2126.4
X	Corn grain	1	7	1	Fertilize\32-06-00	Fertilizer app Surface Broadcast no incorp 2	199.8481233	lbs/acre	NA
X	Corn grain	1	10	20	Harvest without kill.	COMBINE SELF-PROP 4WD	0	NA	NA
X	Corn grain	1	10	21	Kill crop	KILL	0	NA	NA

Figure 4.29: Update harvest operation to occur in September.

4.3.4. Add Cover Crop Planting Operation

Next, move to the "**Planting**" tab to add a cover crop planting on October 1st. Set the month and date of the operation first. Then, for the crop, choose "**Cover Crop Mix**" to open the "**Cover Crop Mix Wizard**." The "**Cover Crop Mix Wizard**" allows a cover crop to be created from multiple plant species. For this exercise, we will create a cover crop from only "**Rye**" as shown below.

Click the "**Save Crop Mix**" button to close the "**Cover Crop Mix Wizard**."

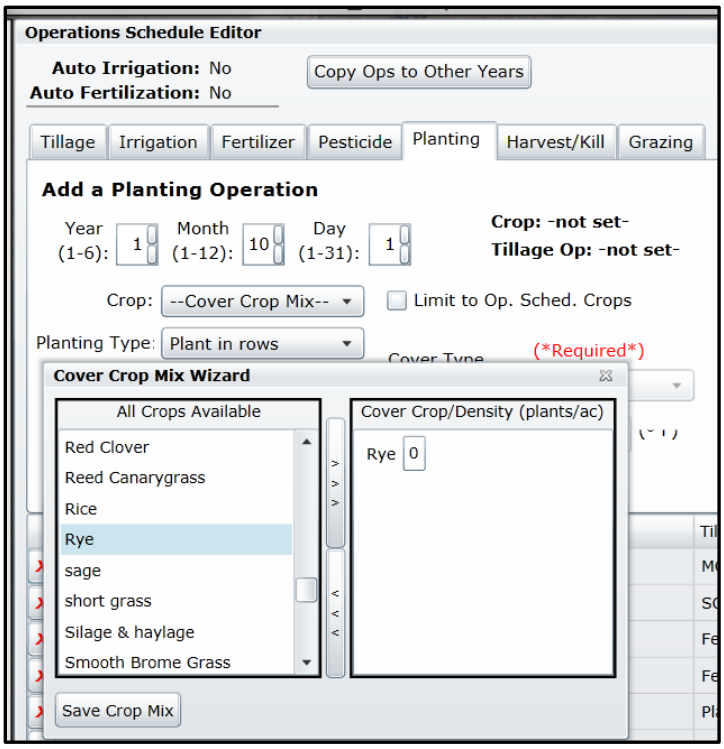


Figure 4.30: Creating cover crop inputs.

To finish adding the cover crop planting operation, choose "**DRILL, LISTER Disk**" for the equipment and "**Straight Row**" for the cover or practice type. Then click "**Add Planting Op.**". The cover crop planting will be added to the table of operations.

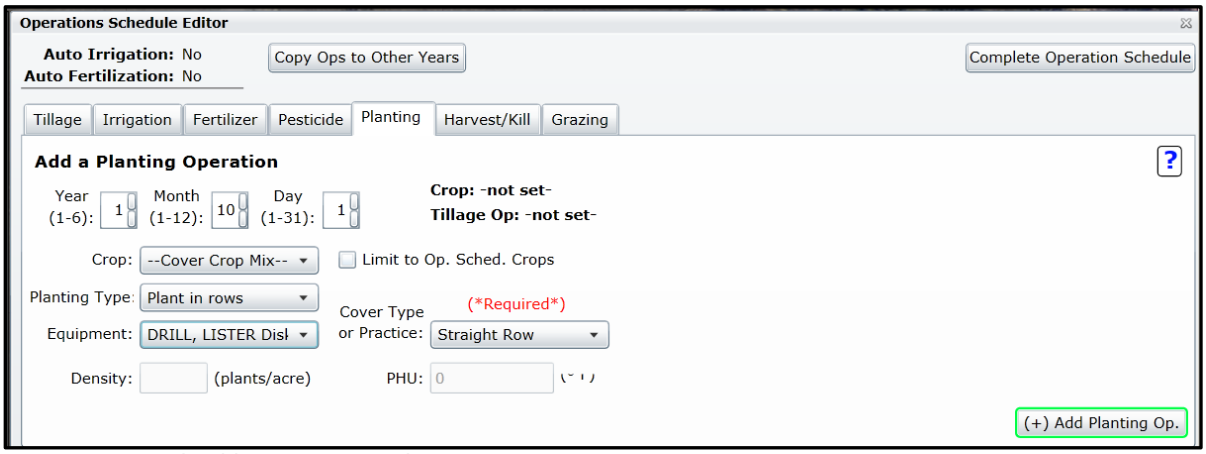


Figure 4.31: Finish adding cover crop planting operation.

4.3.5. Add Cover Crop Kill Operation

Any time that a crop is planted, it must also be killed at some point in the operation schedule. For this rye cover crop, we will assume it is killed in the spring, right before the plowing for preparation of the corn begins. Navigate to the "**Harvest/Kill**" tab. Set the kill date for the rye crop to be May 10th. Click on the "Add Op." button to add this kill operation to the schedule.

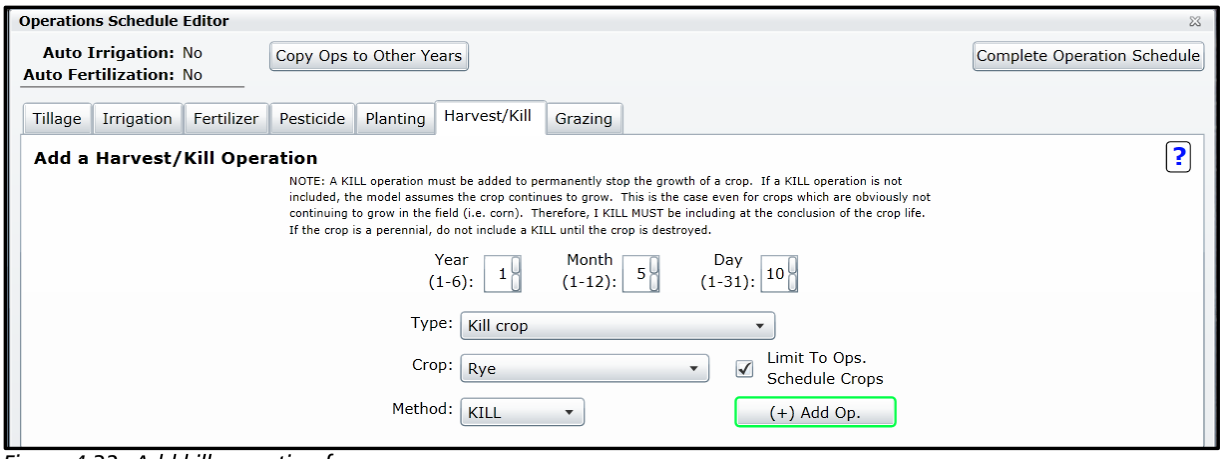


Figure 4.32: Add kill operation for rye cover crop.

Finally, click "**Complete Operation Schedule**" to finish this operation schedule.

4.3.6. Define Soils and Run APEX

Click the "**Define Soils**" button to re-characterize the soils for this alternative.

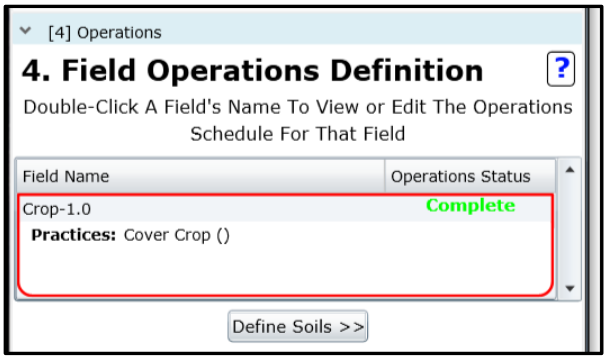


Figure 4.33: Define Soils.

Click on "**Run APEX >>>**" to run the current alternative assessment.

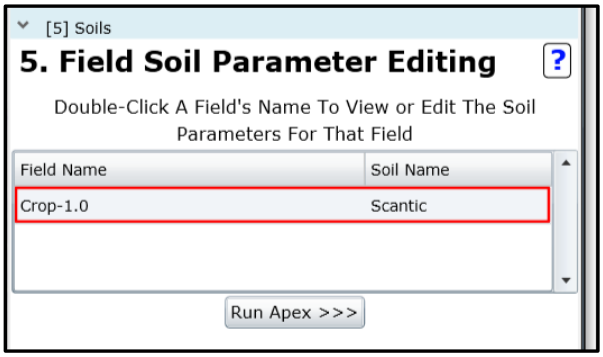


Figure 4.34: Run APEX.

4.3.7. View Report

In the "**Reports**" section of the STAR navigation pane, select the "**Baseline**" assessment to report on. You will now see that there are 5 alternative assessments to report on. Choose all of the APEX parameters, and the "**Baseline_CovCrop**" alternative. Then, click "**View Reports.**"

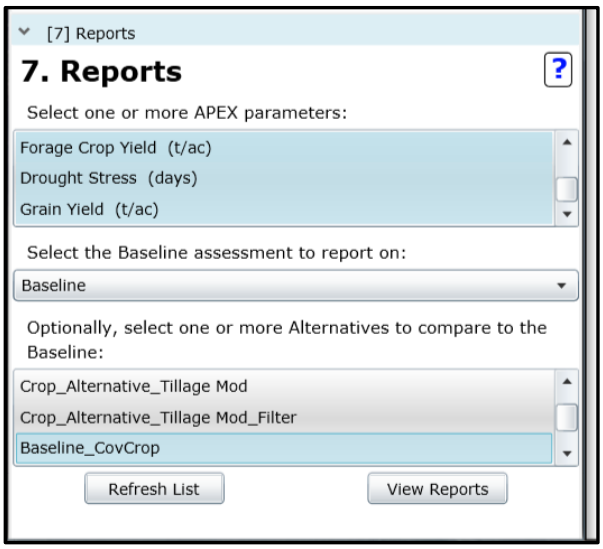


Figure 4.35: Selection of outputs and alternatives for report.

The output portion of the report shows that the rye cover crop, and earlier harvest of the corn, resulted in a little over a 30% reduction in the sediment P loss and a 50% reduction in the soluble P loss from this continuous corn grain rotation.

Apex Parameter	Field Name	Baseline	Baseline_CovCrop
Total Outflow (inches)	Crop-1.0	9.15	5.56
Total Sediment Yield (t/ac)	Crop-1.0	9.51	5.97
Total Soluble P in Outflow (lb/ac)	Crop-1.0	0.40	0.20
Total Sediment P in Outflow (lb/ac)	Crop-1.0	10.66	6.93
Tile Drain Phosphorus Loss (lb/ac)	Crop-1.0	0.00	0.00
Total Soluble N in Outflow (lb/ac)	Crop-1.0	206.85	173.74
Total Sediment N in Outflow (lb/ac)	Crop-1.0	82.62	50.67
Tile Drain Nitrogen Loss (lb/ac)	Crop-1.0	0.00	0.00
Total Soluble Pesticide in Outflow (lb/ac)	Crop-1.0	0.00	0.00
Total Sediment Pesticide in Outflow (lb/ac)	Crop-1.0	0.00	0.00
Nitrogen Volatilization (lbs/acre)	Crop-1.0	38.64	46.61
Forage Crop Yield (t/ac)	Crop-1.0	0.00	0.00
Grain Yield (t/ac)	Crop-1.0	2.43	2.40

Figure 4.36: STAR output report from cover crop alternative.

5.
Exercise 4, Using Local Soils Test Data

STAR allows users to override the soil survey (SSURGO) based soils information with data from local soil tests. Using local soil test data provides the ability to refine the APEX predictions. This exercise will modify the baseline assessment with site specific soils data from a soil sample test.

5.1. Create an Alternative Assessment

In the "**Assessment Definition**" item from the STAR navigation pane, select the "**Baseline**" assessment and click "**Create New Alternative of Selected**." Name the alternative, "**Baseline_SoilMod**" and click, "**Create Alternative**."

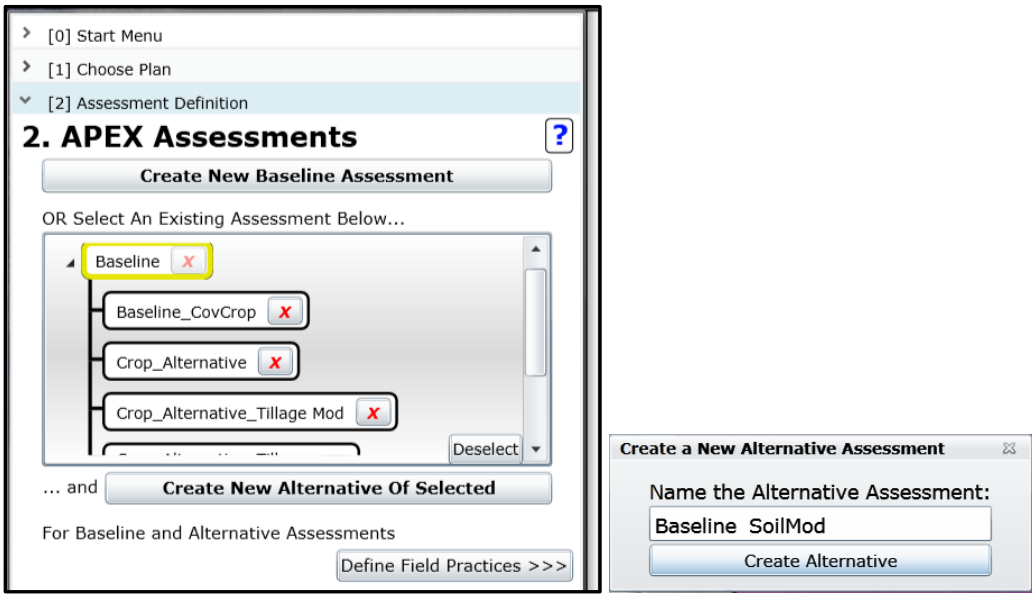


Figure 5.1: Create alternative assessment with cover cropping.

Select the new alternative assessment created, and click on the "**Define Field Practices >>>**" button.

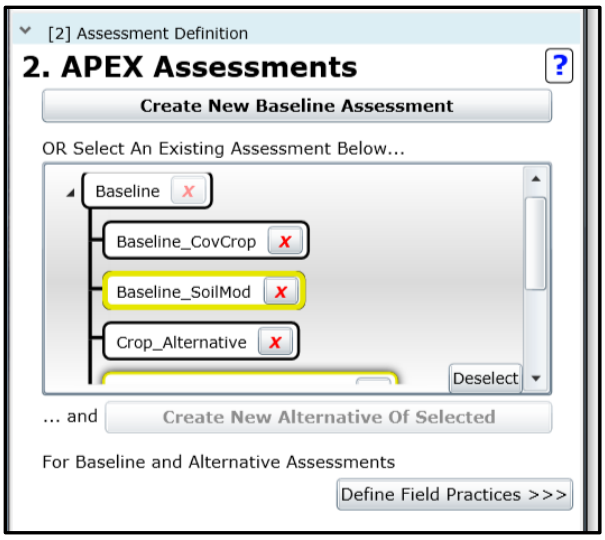


Figure 5.2: Select new cover crop alternative.

5.1.1. Define the Field Practices

For this alternative assessment, we will not add any practices. Follow the steps from previous exercises to setup the field practices to have no special conservation practices. Once completed, click the "**Define Field Operation Schedule >>>**" button to move on to the next step of defining the field operation schedule.

5.1.2. Define Field Operations

This alternative will have the same continuous corn for grain operation schedule as the baseline assessment (we called this schedule "**T1 Crop-1.0-Corn Grain\Corn,grain; SP, spring manure, Z60**"). Use the "**Apply Prev. Defined to Field**" option to assign the same operation to the current "**Baseline_SoilMod**" alternative.

5.1.3. Define Soils and Modify with Site Specific Soil Test Data

Begin by clicking the "**Define Soils >>**" button to characterize the field soils from SSURGO. Once complete, the "**Field Soil Parameter Editing**" section of the STAR navigation pane will be shown.

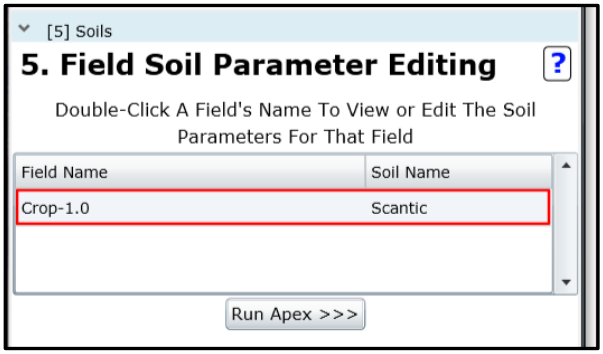


Figure 5.3: Soil parameter editing section of navigation pane.

Double click the "**Field Name**" to open the "**Field Soils Editor**". A soil test came back with the following results for your field:

- Modified Morgan's available P: 4.6 ppm

- pH: 7.2
- Al: 17 ppm
- Organic matter: 4.1% (2.38% organic carbon)

Modify the data for surface soil layer to reflect these site specific measurements as shown in the figure below. When all of the inputs are completed, click the "**Update Soil**" button. After the update is complete, close the "**Field Soils Editor**" by clicking the "**x**" in the upper right hand corner.

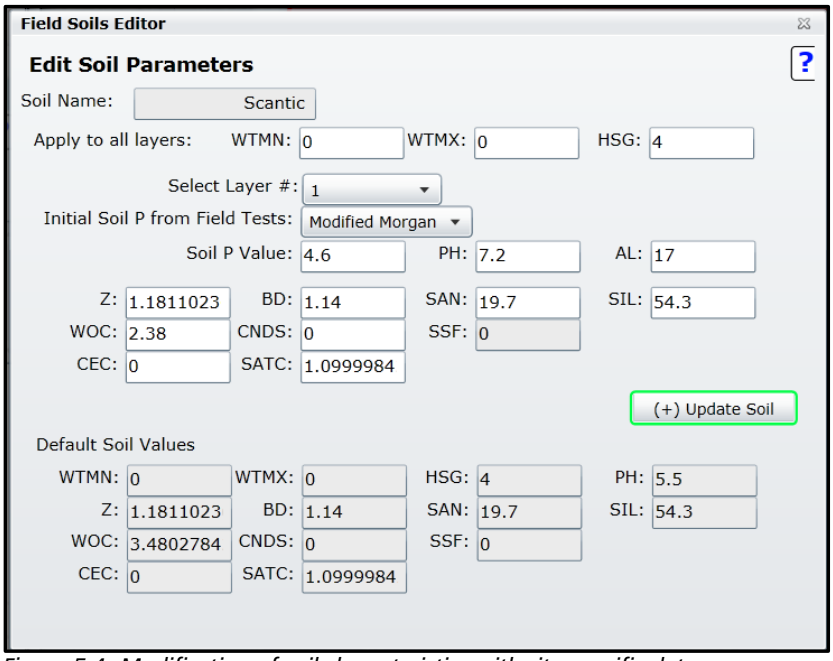


Figure 5.4: Modification of soil characteristics with site specific data.

5.1.4. Run APEX and View Report

Click the "**Run APEX >>>**" button to run the APEX simulation of the modified soil alternative. In the "**Reports**" section of the STAR navigation pane, select the "**Baseline**" assessment to report on. You will now see that there are 6 alternative assessments to report on. Choose all of the APEX parameters, and the "**Baseline_SoilMod**" alternative. Then, click "**View Reports**."

The results in the outputs section of the report show that the soluble and sediment P losses are smaller compared to the same baseline simulation using the SSURGO data (about 5% lower for soluble P and 20% lower for sediment P). This shows the value in being able to incorporate site specific soils data into a STAR assessment.

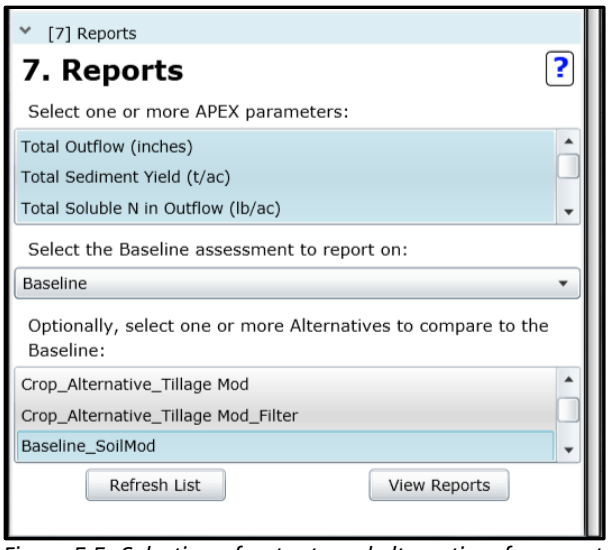


Figure 5.5: Selection of outputs and alternatives for report.

Apex Parameter	Field Name	Baseline	Baseline_SoilMod
Total Outflow (inches)	Crop-1.0	9.15	9.19
Total Sediment Yield (t/ac)	Crop-1.0	9.51	9.72
Total Soluble P in Outflow (lb/ac)	Crop-1.0	0.40	0.38
Total Sediment P in Outflow (lb/ac)	Crop-1.0	10.66	8.52
Tile Drain Phosphorus Loss (lb/ac)	Crop-1.0	0.00	0.00
Total Soluble N in Outflow (lb/ac)	Crop-1.0	206.85	160.44
Total Sediment N in Outflow (lb/ac)	Crop-1.0	82.62	65.64
Tile Drain Nitrogen Loss (lb/ac)	Crop-1.0	0.00	0.00
Total Soluble Pesticide in Outflow (lb/ac)	Crop-1.0	0.00	0.00
Total Sediment Pesticide in Outflow (lb/ac)	Crop-1.0	0.00	0.00
Nitrogen Volatilization (lbs/acre)	Crop-1.0	38.64	31.26
Forage Crop Yield (t/ac)	Crop-1.0	0.00	0.00
Grain Yield (t/ac)	Crop-1.0	2.43	2.40

Figure 5.6: STAR outputs from modified soil alternative.

Appendix E:
VT STAR Application Manual

STAR

Systematic Tool for Analyzing Resources

User's Guide

AgriLIFE RESEARCH
Texas A&M System

USDA NRCS
United States Department of Agriculture
Natural Resources Conservation Service

STONE ENVIRONMENTAL
535 Stone Cutters Way / Montpelier / VT / 05602 / USA
802.229.4541 / info@stone-env.com / www.stone-env.com

TABLE OF CONTENTS

A. STAR LOGIN PROCESS

1. To access the site, type in or click here for the STAR URL http://nrcs-star.tamu.edu . The login page will load and you will be prompted to enter your user name and password. Select the "*Login >>"* button to load STAR.

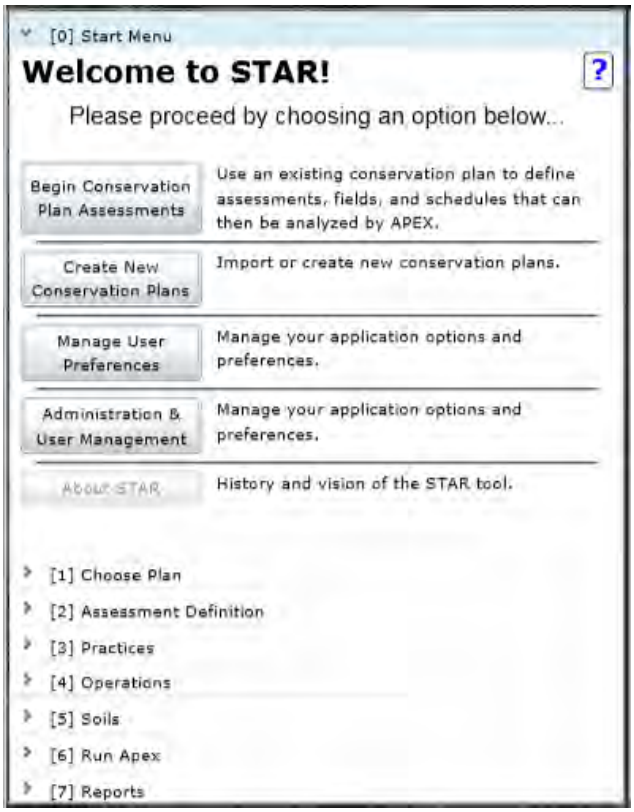
B. OVERVIEW of STAR

The Systematic Tool for Analyzing Resources (STAR) is a web-based interface that enables the user to couple NRCS Toolkit Conservation Plans to the Agricultural Policy/Environmental eXtender (APEX) model. APEX is a whole farm/ small watershed management model. The model has the capability of evaluating various land management strategies considering sustainability, erosion (wind, sheet and channel), economics, water supply and quality, soil quality, plant competition and weather. Through the use of the routing component in APEX, conservation practices such as grassed filter strips, riparian buffers, and grassed waterways can be evaluated for use in capturing sediment and nutrients from runoff.

STAR enables the user to compare current conditions/conservation practices with potential alternative scenarios to allow for the selection of the conservation practice(s) that will address the resource concern(s) providing the greatest benefits/savings.

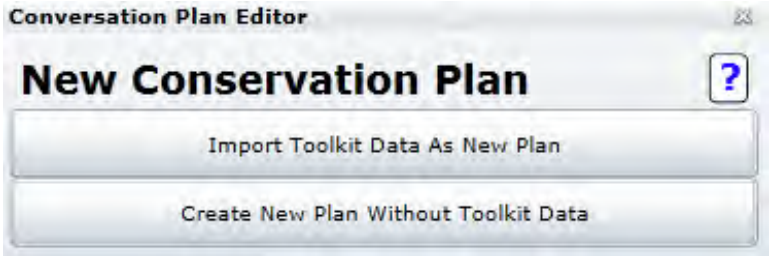
C. START MENU

When the user first logs in, four options are available. The user can 1) begin making conservation plan assessments by using an existing conservation plan to define assessments, fields and schedules that can then be analyzed by APEX, 2) import or create new conservation plans, 3) manage their user preferences, and 4) administrators have the option to edit user information.



BEGIN CONSERVATION PLAN ASSESSMENTS

If the first option, Begin Conservation Plan Assessments, is chosen, the user can proceed to Section D. If a new conservation plan needs to be added, click the ***Create New Conservation Plans*** button. The user will then have the choice to Import Toolkit Data As New Plan or Create New Plan Without Toolkit Data.



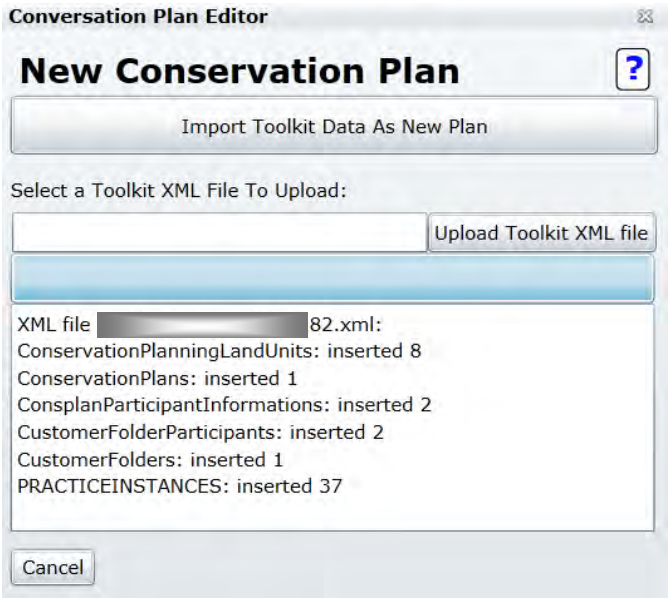
CREATING NEW CONSERVATION PLANS

1. To import toolkit data to create a new plan, click the ***Import Toolkit Data as New Plan*** button.

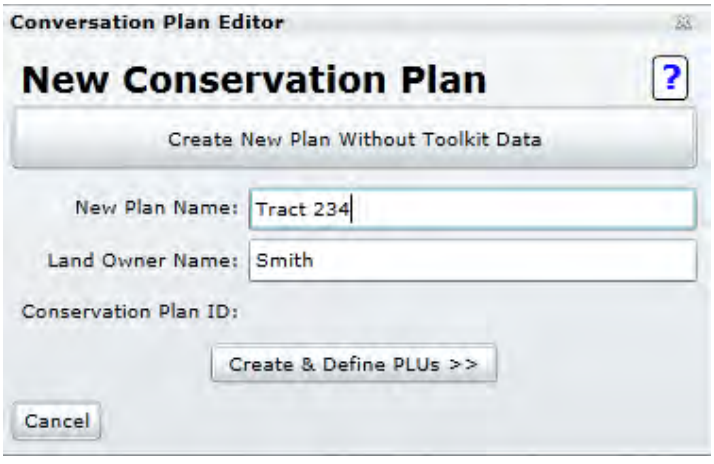
   In order to import conservation plan data, a properly formatted XML file needs to have been created through the NRCS Toolkit desktop application. Refer to Appendix A for instruction on

exporting an XML file from Toolkit. Before importing the XML, you should confirm that the planning land units have valid geometry. NOTE: Errors in the geometry, including overlapping polygons, can result in errors in STAR.

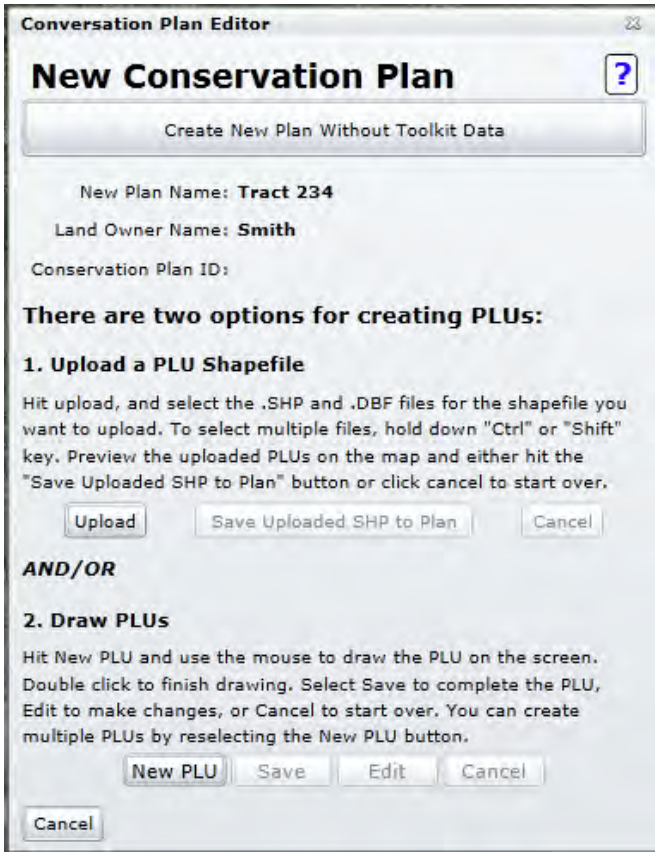
a. Click the ***Upload Toolkit XML File*** button and browse to the location where the XML file is saved. Open the file. The data will then be imported into STAR.
b. Once the files have been imported, a report will be generated which will indicate if any errors were encountered during the import.



2. If Toolkit data is not available, the user can still create a new plan.
   a. Click the ***Create New Plan Without Toolkit Data*** button.
   b. Then enter a name for the new plan and the land owner's name.
   c. Click the ***Create & Define PLUs*** button.



d. At this point the user has two options: a planning land unit (PLU) shapefile, containing boundaries of conservation area, can be uploaded and/or the user can draw the PLUs on the map.



i. PLU Shapefile

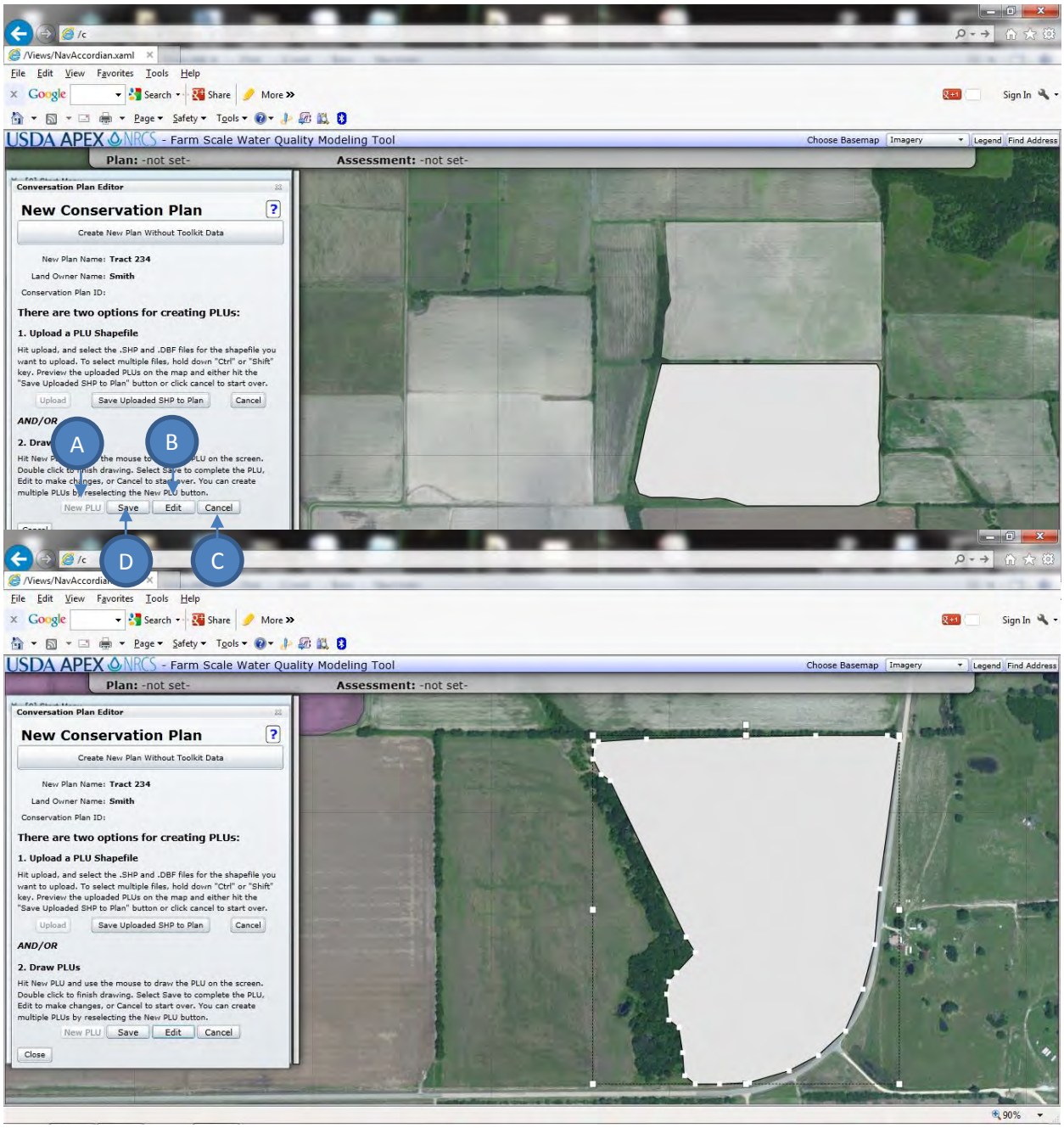
To add a shapefile of a PLU, click the ***Upload*** button under the first option – Upload a PLU Shapefile. The interface will prompt the user to browse to the location of where the shapefile is located.

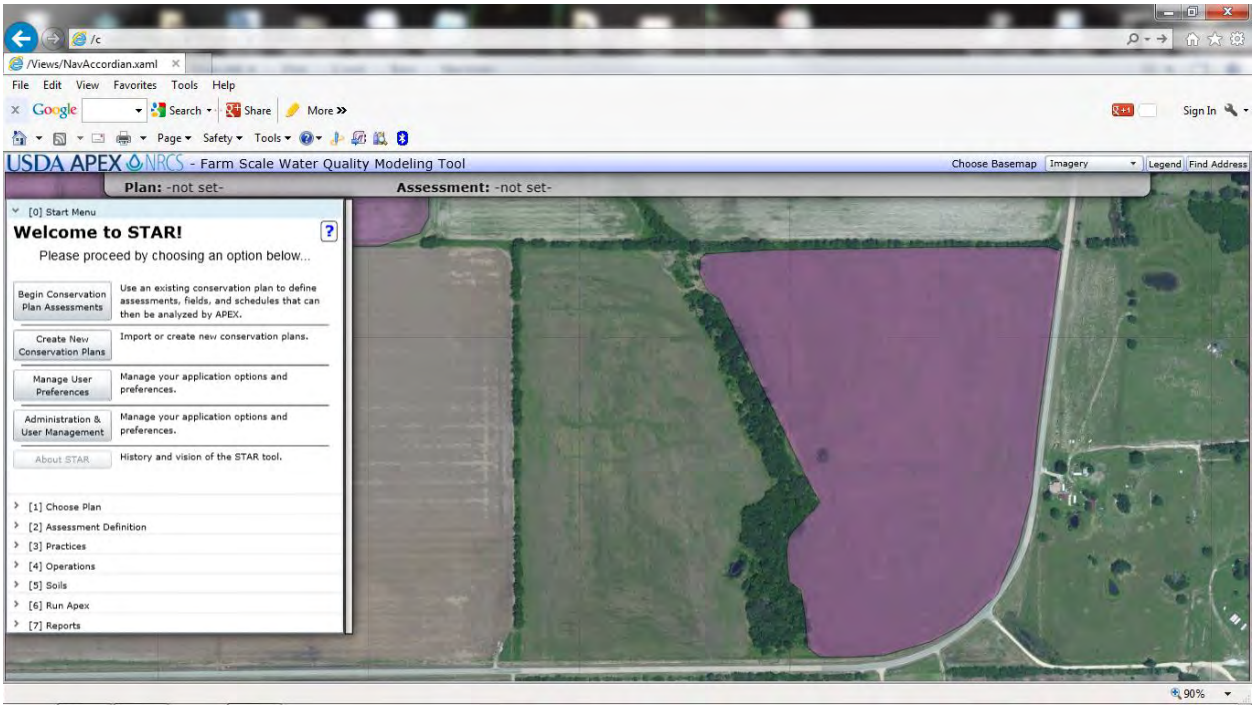
NOTE: The shapefile MUST be projected in Web Mercator (Auxiliary Sphere). This can be accomplished by reprojecting the shapefile in a geographical information system software such as ArcGIS.

Select both the shapefile (.SHP) and database file (.DBF) and click open. The shapefile will then be added to the map.

ii. Draw PLU on the map

To draw the PLU directly on the map, click the ***New PLU*** (A) button under the Draw PLUs option. Draw the boundaries of the PLU by clicking on the map and clicking around the edge of the PLU. Double-click when the PLU boundary is complete. To edit the boundary before saving, click the ***Edit*** (B) button. This will allow the user to edit points on the delineated boundary. To clear the delineated boundary, click the ***Cancel*** (C) button. Click the ***Save*** (D) button when complete.

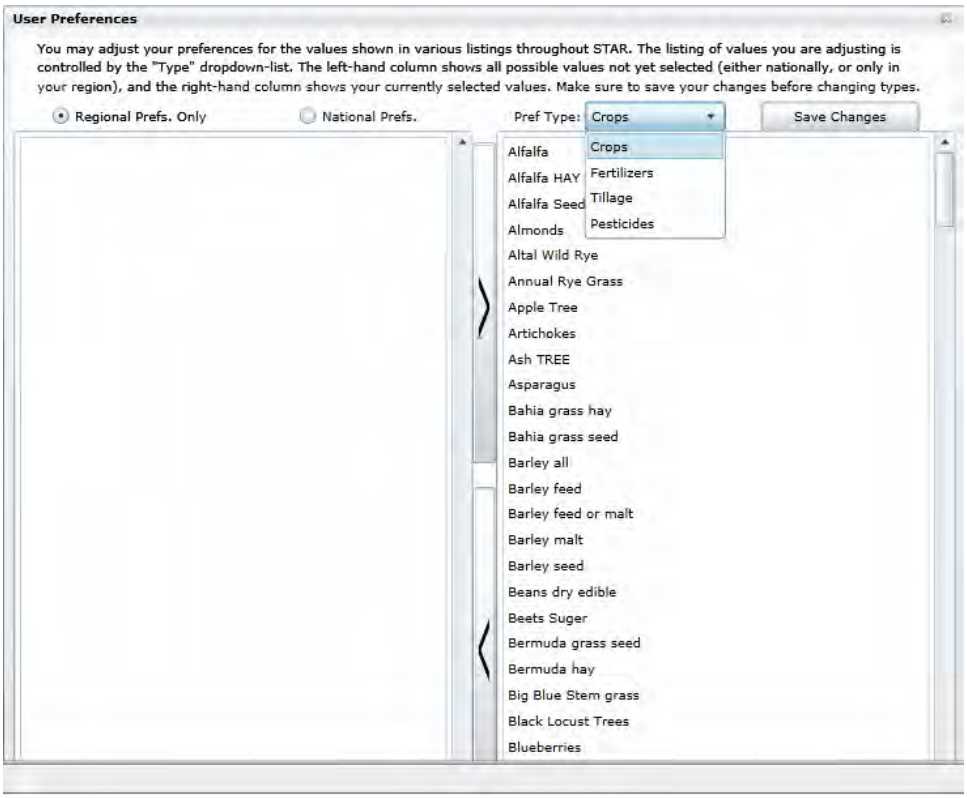




MANAGE USER PREFERENCES

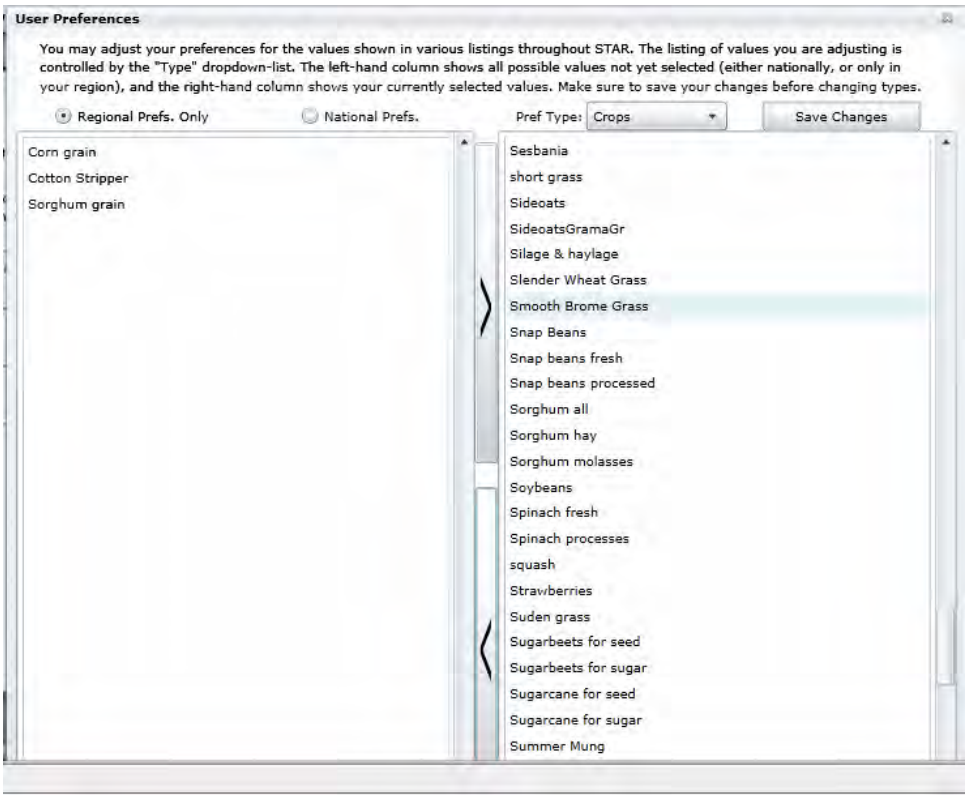
In the Manage User Preferences section, the user can manage application options and preferences such as crops, fertilizers, tillage, and pesticides. The interface provides an extensive list of crops, fertilizers, tillage equipment and pesticides. These lists will show in their entirety within the various sections of the interface unless trimmed down in this section. By selecting a subset of the lists, only the selected items will appear in menus later in the interface. The selected items in each list can be modified at any time. Depending on the user's level of user privileges, preferences can be set at a regional or national level. Only users with administrative privileges will be allowed to set preferences at the national level.

To begin selecting preferences, click the Manage User Preferences button. The User Preference screen will appear. To view the different lists (Crops, Fertilizers, Tillage and Pesticides), click on the Pref Type drop down menu and select one of the lists.



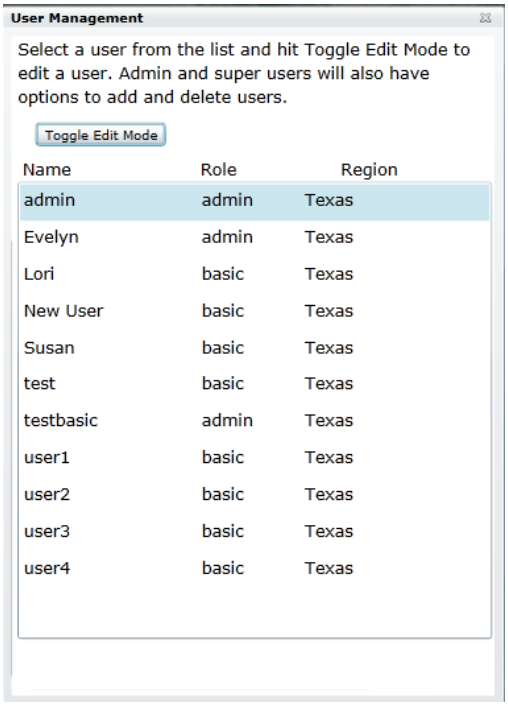
The list on the right is the complete default list, and the list on the left is the user selected list. To move an item from the right default list to the selected list, select the item in the default list and click the “<” button. To remove an item from the selected list, select the item, and then click the “>” button.

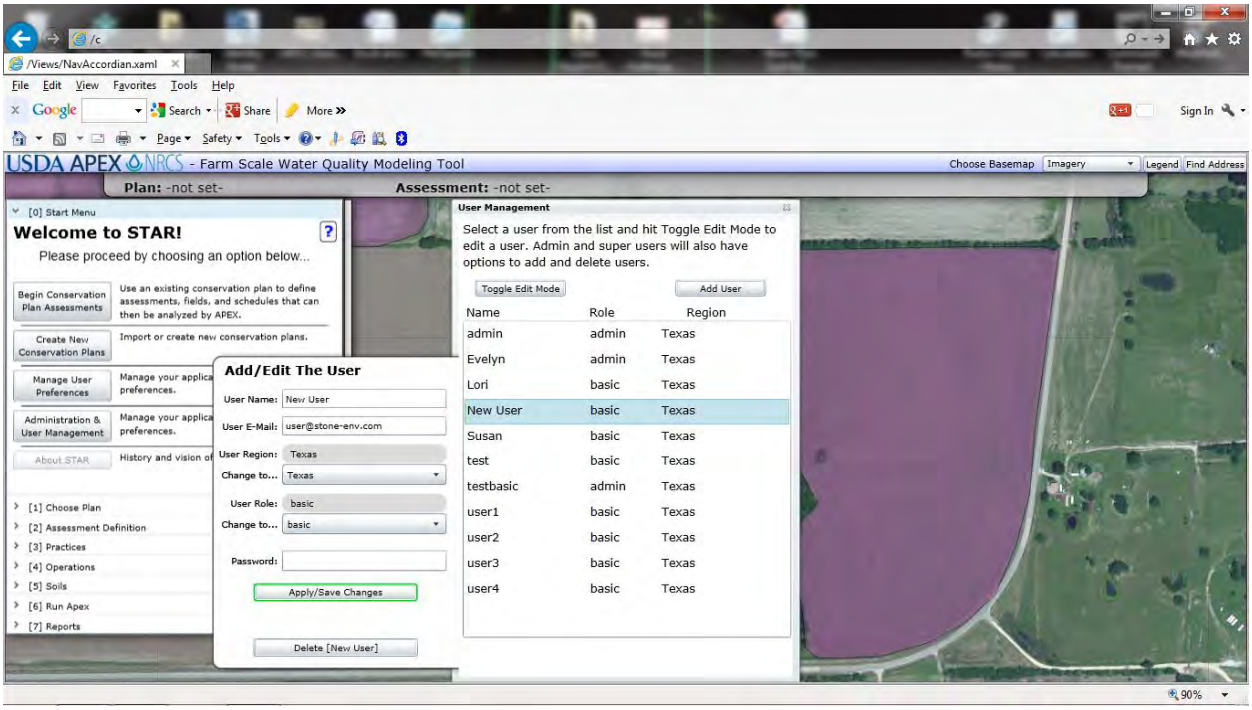
Make selections from each of the four lists. When all selections have been made, click the ***Save Changes*** button. Click the “X” at the top right of the screen to exit.



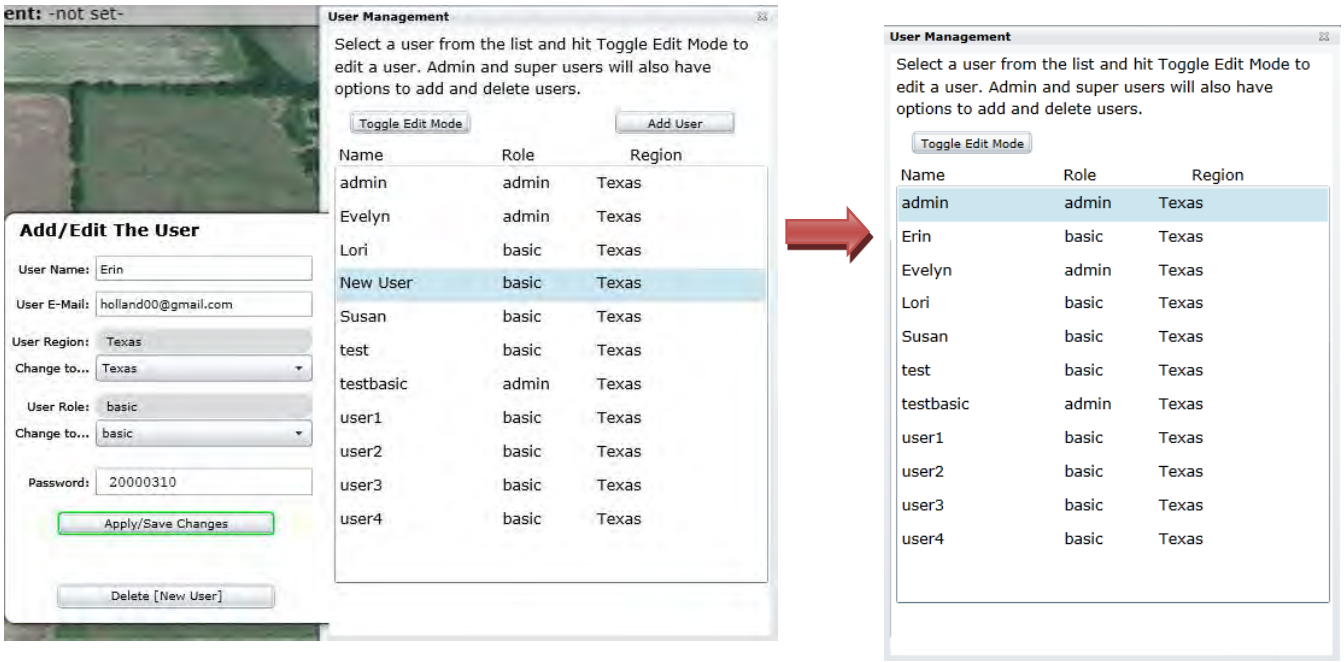
ADMINISTRATION & USER MANAGEMENT

This section allows administrator to add and edit user information. The list shows the user names, their user privileges and the region they are assigned to. Click the ***Toggle Edit Mode*** button to add or edit a particular user.



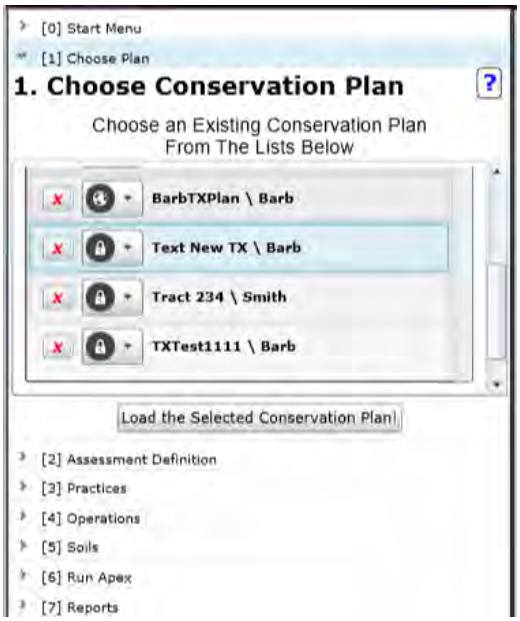


With administrator privileges, the user can update the user's name, email address, user region, user role and change the user login password. When all changes to a user have been made, click the ***Apply/Save Changes*** button. The administrator can also delete the user by selecting the user and clicking the ***Delete*** button at the bottom of the Add/Edit The User screen. To add a new user, click the ***Add User*** button and simply fill in the information for the user and click the **Apply/Save Changes** button. To close the editor screen, click the ***Toggle Edit Mode*** button. To exit the Administration & User Management section, click the "X" at the top right of the screen.

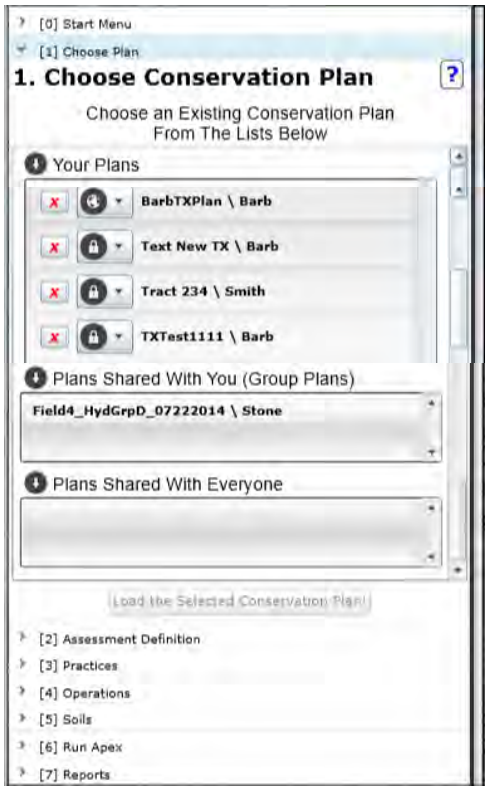


D. SELECT A CONSERVATION PLAN

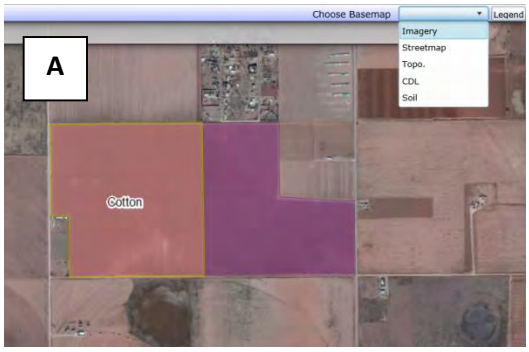
1. Click the ***Begin Conservation Plan Assessments*** button on the Start Menu and select a conservation plan from the list to work with an existing conservation plan and click the ***Load the Selected Conservation Plan!*** button. This will load step 2, Assessment Definition.

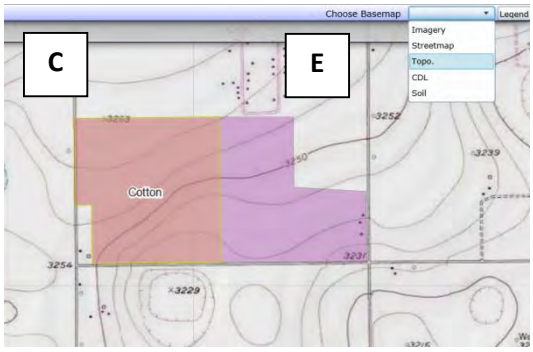


The user can not only select from conservation plans loaded by the user, but also from conservation plans shared with the user (Group Plans)by other conservation planners. The user can also select from plans that are shared with everyone in the region.



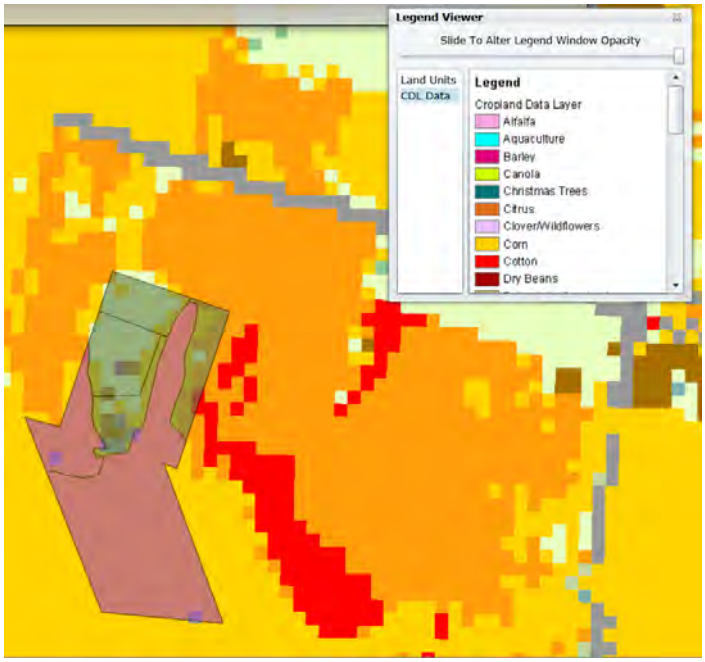
Within STAR, the user can view the planning land unit(s) overdrawn on top of several layer choices including: Imagery (aerial view), Streetmap, Topography, Crop Data Layer (CDL) and Soil. To switch between layers, simply click on the Choose Basemap drop down and select from one of the layer choices.





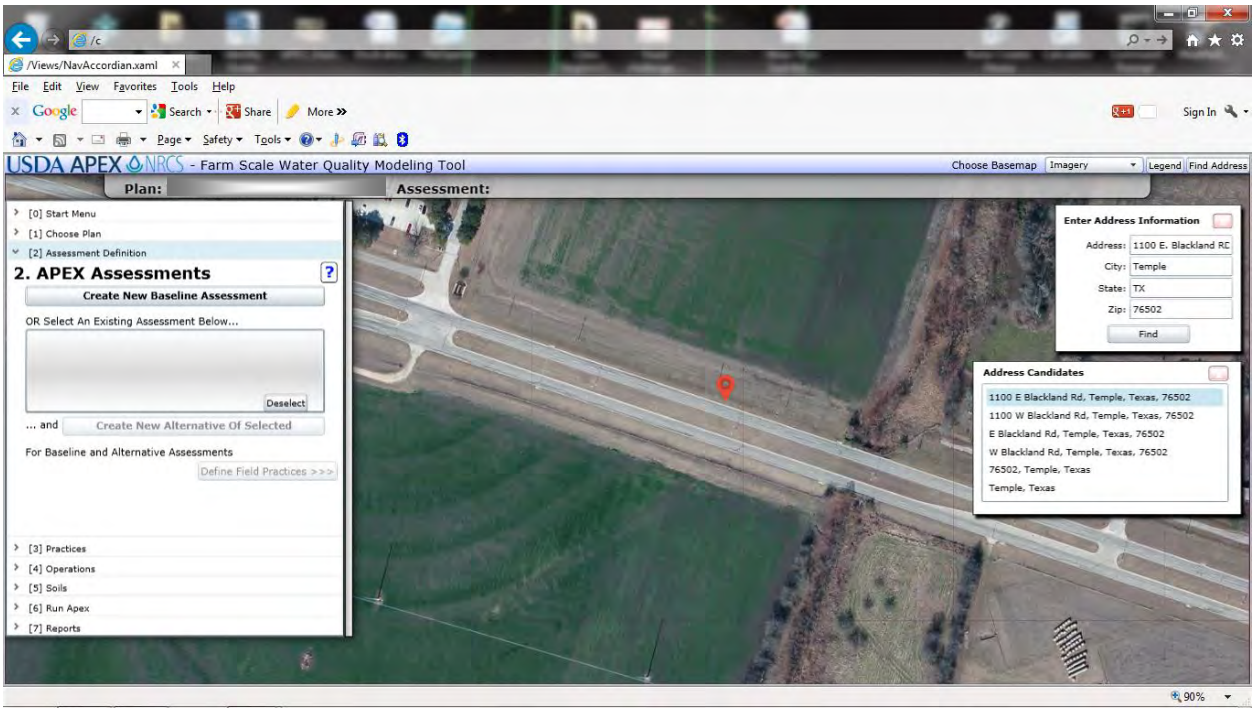
A. Imagery (aerial view)
B. Streetmap
C. Topography
D. Crop Data Layer (CDL)
E. Soil

When displaying the CDL layer, a CDL Data legend can be displayed for ease of identifying the various cropland data uses. To display the legend, simply click the Legend button in the top right corner of the screen. Then select the CDL Data legend to display.



The user can also determine the land use of the planning unit by selecting the Land Units legend. The Land Units legend displays a more general land use compared to the Cropland Data legend.

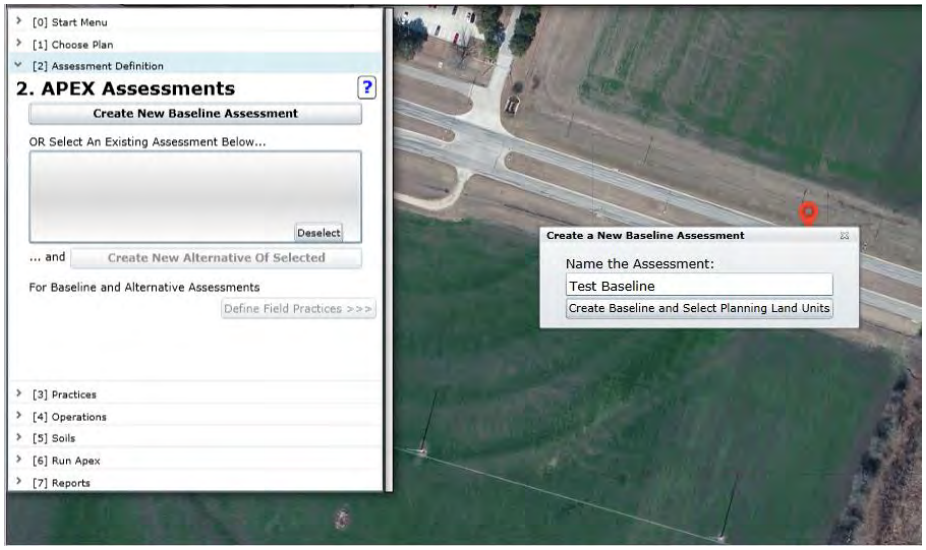
A user can navigate to a field either by panning/zooming to an area of interest or by clicking on the ***Find Address*** button at the top right of the screen. Enter the address and click ***Find***. A list of Address Candidates will appear. Select one and a red marker will be placed on the map at the address.



E. CREATE A BASELINE APEX ASSESSMENT

The purpose of the BASELINE ASSESSMENT is to establish a beginning point to which alternative assessments can be compared to. The baseline assessment would normally include all of the conservation practices currently in place on the planning land unit.

1. To create a baseline APEX assessment for the chosen conservation plan, click on the ***Create New Baseline Assessment*** button from the **APEX Assessments** panel, and then in the *Create a New Baseline Assessment* window, enter a name for the assessment and click the ***Create Baseline and Select Planning Land Units*** button.

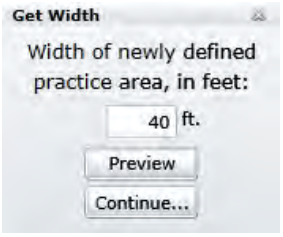


2. Once the new assessment has been named, you will be immediately prompted to select planning land units (PLUs) from the conservation plan to include in the assessment. To select PLUs one at a time, use the "single hand tool"  . To select multiple PLUs, use the "overlapping hands"  tool and draw a box to select any PLUs that are inside the box. Keep in mind that if more than one PLU is chosen, water, sediment, and nutrients will be routed to the edge of each PLU and will not be routed through the adjacent PLU. Routing through an adjacent PLU is only carried out in the case of specific conservation practices which will be discussed in greater detail later in this document. Once you have selected the PLU(s), they will be labeled with the land use that was identified in the Toolkit data.

3. Upon selecting a PLU, the user will be asked to select whether the PLU contains a gully. If the PLU does not contain a gully, select "None". If a gully is present in the PLU, select whether it is "Unstabilized" or "Stabilized".
    a. Unstabilized indicates the gully is bare earth and is continuing to erode.
    b. Stabilized indicates the gully has some cover and is no longer eroding.
4. If a gully is present, select whether the gully is on the edge of the field or extends into the middle of the field by clicking either the ***Edge of Field Only*** or ***Mid-field*** button.

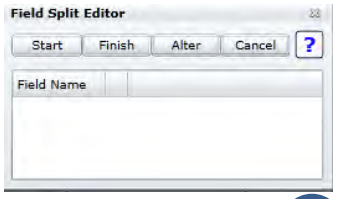
a. Edge of Field option

i. Enter the width of the gully. Click ***Preview*** to view a preliminary buffer equal to the width entered. This preliminary buffer will aid in delineating the proper width of the gully. To change the preliminary buffer width, simply change the entered width value and click ***Preview***. Click ***Continue*** to proceed with delineating the gully.



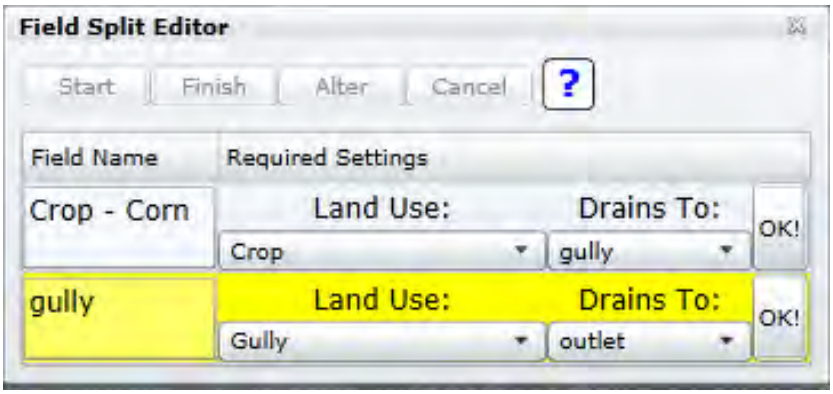
ii. A Field Split Editor screen will become active. Click the ***Start*** button to begin delineating the gully. Start splitting the field by first clicking slightly outside of the field (A), then clicking across the field, till you cross the boundary on the other side (B). The delineation will be seen as a yellow line (A-B) and can be altered by clicking the ***Alter*** button and clicking on a point on the line. Alter the line as needed. Click the ***Finish*** button to complete the gully delineation process.

iii.



iv. The user will then be asked to select the land use and drainage direction for the original field and the new gully area.

1. The field name of the delineated areas can be renamed by selecting and typing a new name into the Field Name cell. In the example below, the field name for the gully was renamed as “gully”.
2. Select the land use of the original field.
3. Select the drainage area to which the original field will drain to. This will likely be the gully area. Click the ***OK*** button adjacent to the original field row to submit the choices.
4. Select the land use of the gully area. The appropriate land use for the gully will likely be the “gully” selection.
5. Select the drainage area to which the gully area will drain to. This will likely be the outlet. Click the ***OK*** button adjacent to the gully row to submit the choices.

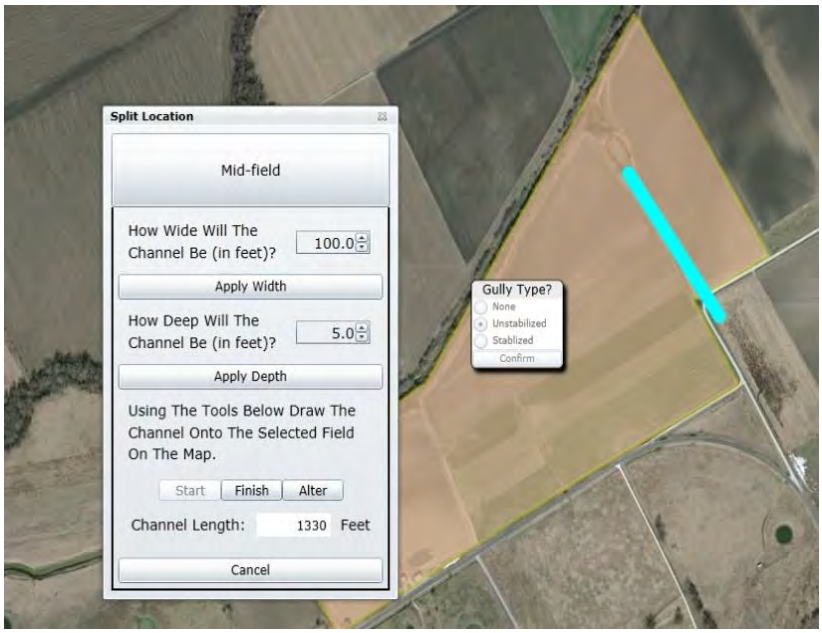


v. Close both the Field Split Editor and Field Selection Tools screens by clicking on the **“*x*”** in the upper right corner of the forms.

b. Mid-Field option

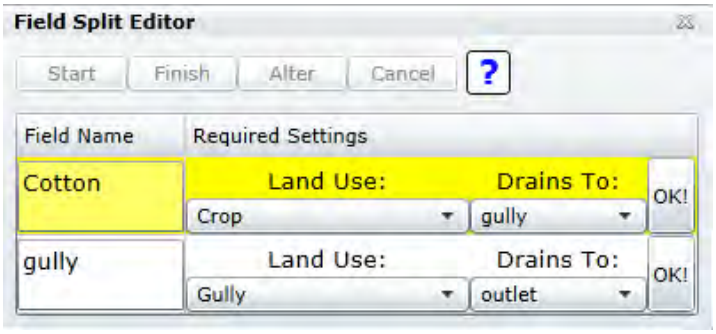
i. Enter the width of the gully and click ***Apply Width***. Enter the depth of the gully and click ***Apply Depth***.

ii. To delineate the gully, click the ***Start*** button and draw the gully on the field making certain to cross the field boundary. Once the gully has been drawn in, click the ***Finish*** button.



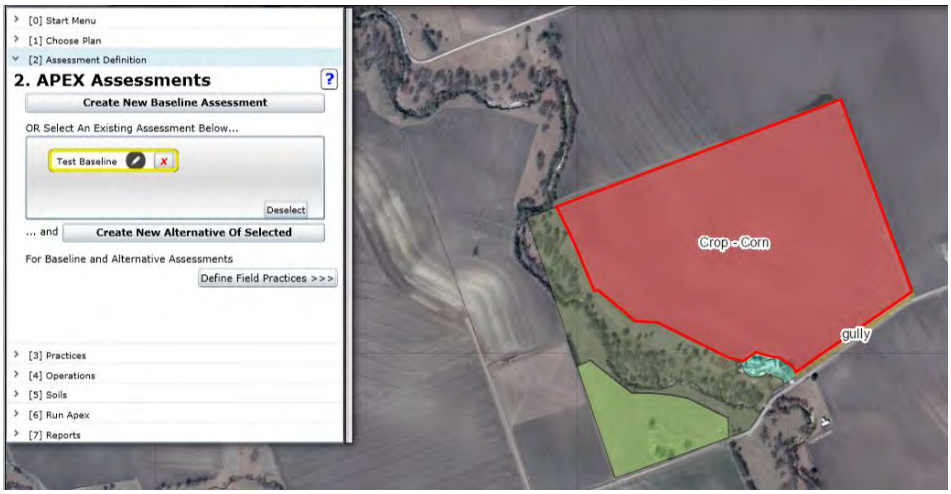
iii. The user will then be asked to select the land use and drainage direction for the original field and the new gully area.

1. The field name of the delineated areas can be renamed by selecting and typing a new name into the Field Name cell. For example, the field name for the gully was named as “gully”
2. Select the land use of the original field.
3. Select the drainage area to which the original field will drain to. This will likely be the gully area. Click the ***OK*** button adjacent to the original field row to submit the choices.
4. Select the land use of the gully area. The appropriate land use for the gully will likely be the “gully” selection.
5. Select the drainage area to which the gully area will drain to. This will likely be the outlet. Click the ***OK*** button adjacent to the gully row to submit the choices.



iv. Close both the Field Split Editor and Field Selection Tools screens by clicking on the **"*x*"** in the upper right corner of the forms.

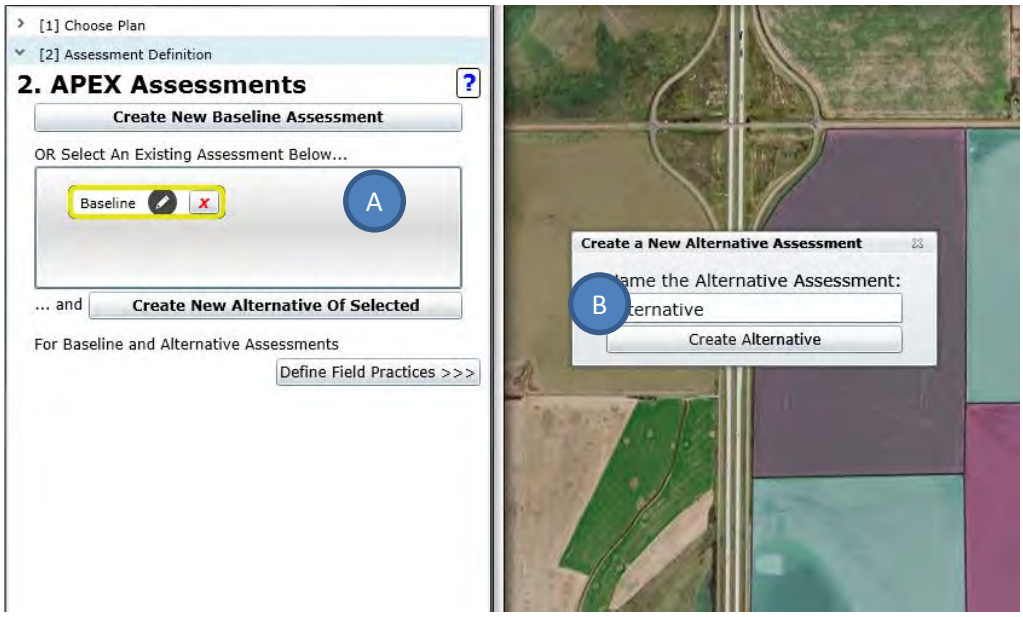
5. Select the assessment from the Existing Assessment list to work with the newly created assessment and then proceed to Define Field Practices (section G).



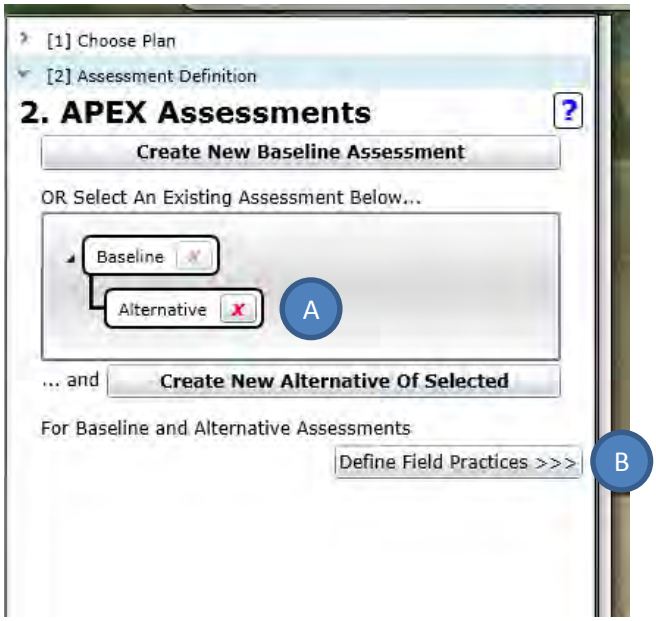
F. CREATE AN ALTERNATIVE ASSESSMENT

The purpose of an ALTERNATIVE ASSESSMENT is to develop one or more alternative conservation practice strategies to compare with the baseline assessment as well as other alternative assessments in order to determine the best conservation practice strategy to address the resource concern(s)

1. Select an existing baseline assessment (A) from the list of Existing Assessments and click the ***Create New Alternative of Selected*** (B) button. You will be prompted to enter a name for the alternative assessment in the *Create a New Alternative Assessment* window.

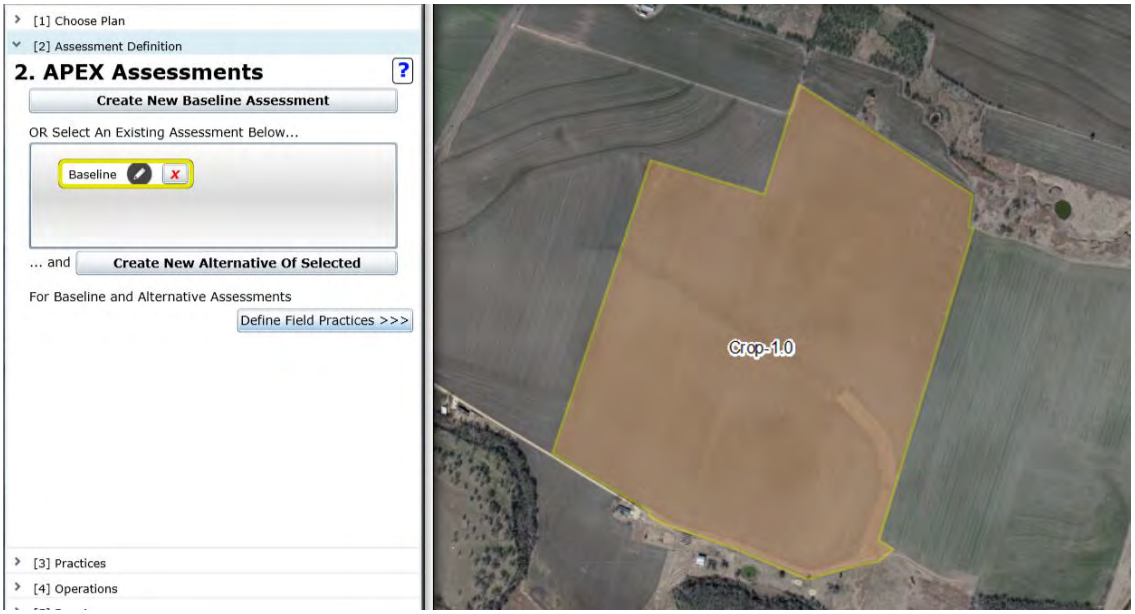


2. The alternative assessment will use the same fields as the baseline assessment. Make sure to select the newly created alternative (A) beneath the baseline before clicking on the Define Field Practices button (B) to continue.

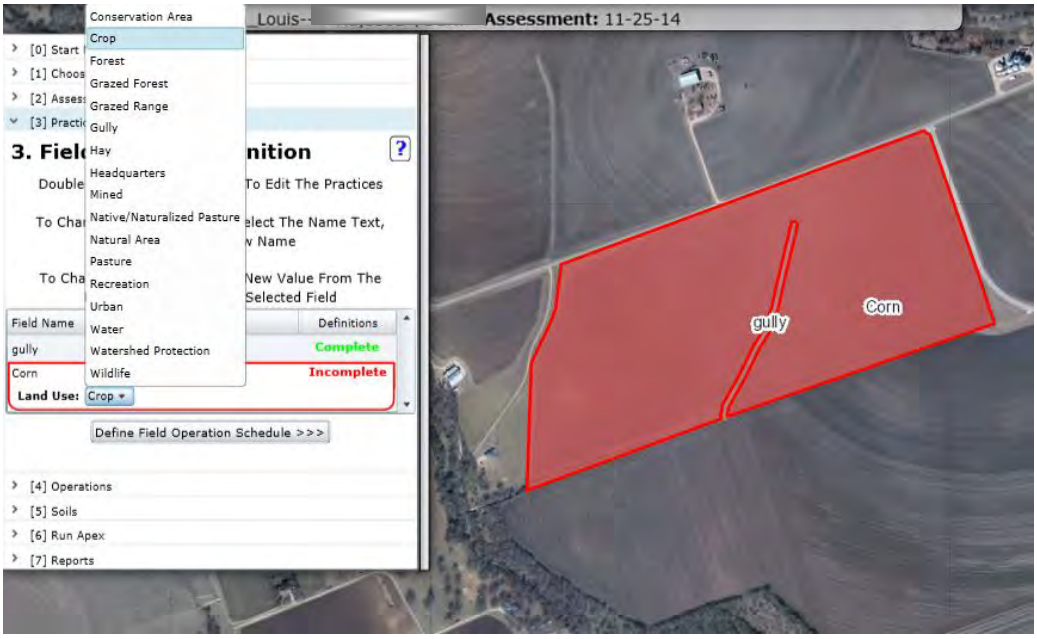


G. DEFINE FIELD PRACTICES

1. After an assessment has been selected from the Existing Assessment list, the user can proceed to defining the field conservation practices. Click the ***Define Field Practices*** button.

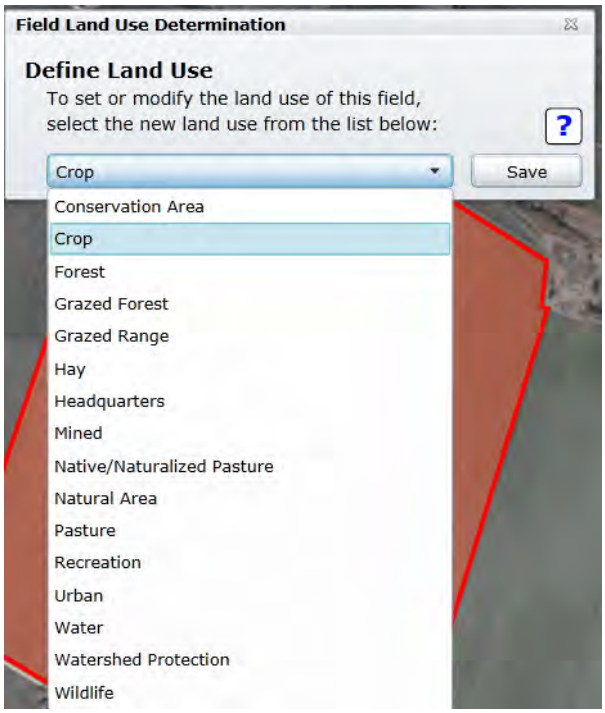


2. The **Field Practice Definition** panel will become visible. At this point the user can change the name of the field by double clicking the field name and typing in a new name. Any change to the name will be reflected in the field label in the map. For example, in the example below the name of the field was changed from Crop-1.0 to Corn. The field name can only be changed for a baseline assessment. The user can also change the Land Use by selecting a new land use from



the drop down menu.

3. To complete the practice definition step, the user must double click on the **Incomplete** label under definitions. This will prompt the *Field Land Use Determination* screen.
4. To define the land use, select a land use from the drop down box and click ***Save***.

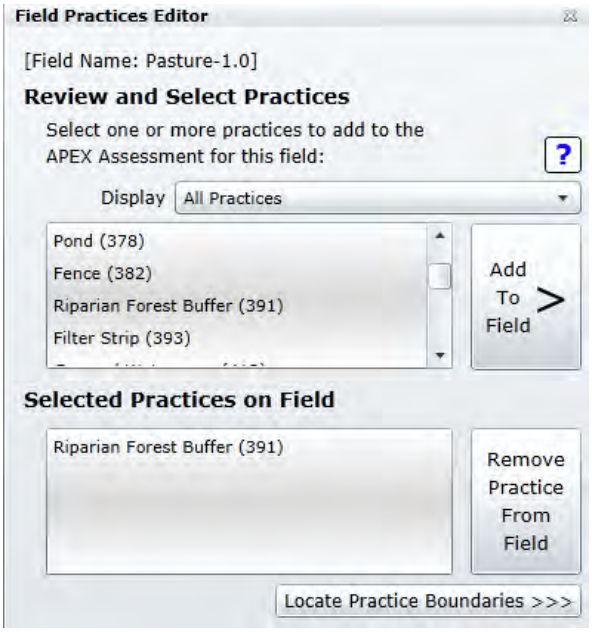


5. The *Field Practices Editor* screen will then appear. A list of conservation practices which were imported from Toolkit will be listed in the upper box. The user can select from those practices (Only Practices from Toolkit), or all practices can be displayed and chosen from. To add a practice to the Selected Practices on Field box (B), select it in the upper box and click ***Add To Field***. > button (A). A message will be displayed informing the user how the practice will be implemented by STAR.

A

B

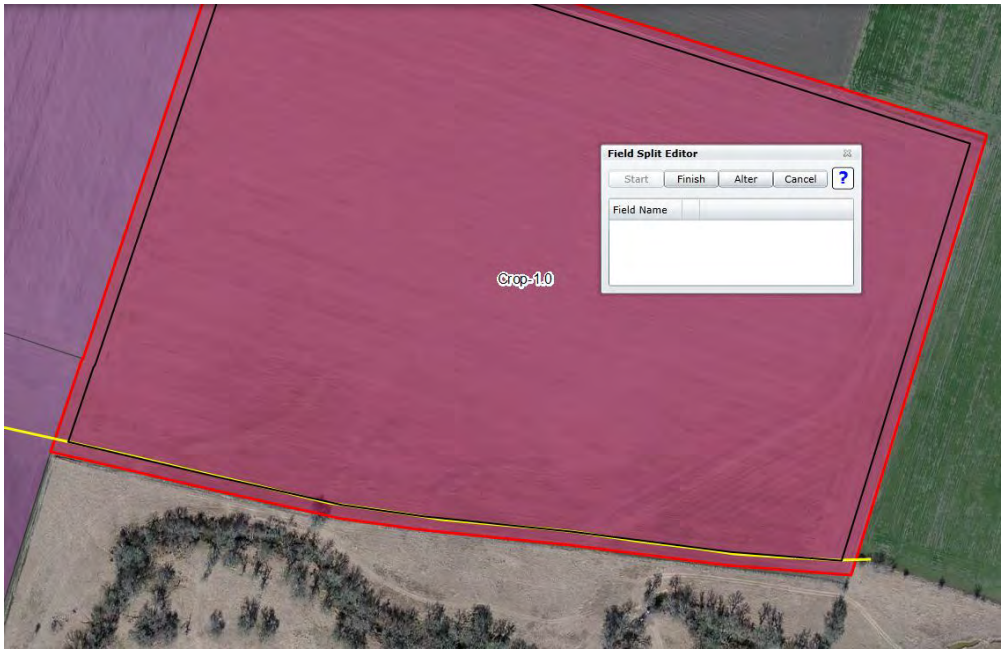
6. Once a practice has been added to the lower box, it can be deleted by selecting the practice in the lower box and clicking ***Remove Practice From Field***. If a practice that requires a field to be split into more than one field is chosen, the user will be prompted to delineate that boundary. If no splitting practices have been selected for the field, click ***Close***. If a splitting practice has been chosen for the field, click ***Locate Practice Boundaries***.



Double click the practice in the *Field Split Manager* screen list to be delineated.

Some splitting practices will invoke a *Get Width* screen. Enter the width of the splitting practice. Click ***Preview*** to view a preliminary buffer equal to the width entered. This preliminary buffer will aid in delineating the proper width of the splitting practice. To change the preliminary buffer width, simply change the entered width value and click ***Preview***.

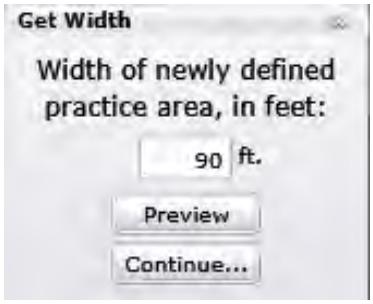
Click ***Continue*** to proceed to delineate the splitting practice.



Click the ***Start*** button. Click outside of the original field boundary at the point where the splitting practice boundary will intersect the original field boundary. Draw a line along the splitting practice boundary by single clicking. When finished delineating the splitting practice boundary, double click. Make certain that the splitting practice boundary has intersected the original field boundary in two locations. Then click ***Finish*** in the *Field Split Editor*.

Other splitting practices will invoke a Split Location screen. Select whether the splitting practice is on the edge of the field or extends into the middle of the field by clicking either the ***Edge of Field Only*** or ***Mid-field*** buttons.

a. Edge of Field option
    i. Enter the width of the splitting practice. Click ***Preview*** to view a preliminary buffer equal to the width entered. This preliminary buffer will aid in delineating the proper width of the splitting practice. To change the preliminary buffer width, simply change the entered width value and click ***Preview***. Click ***Continue*** to proceed with delineating the splitting practice. Click the ***Start*** button. Click



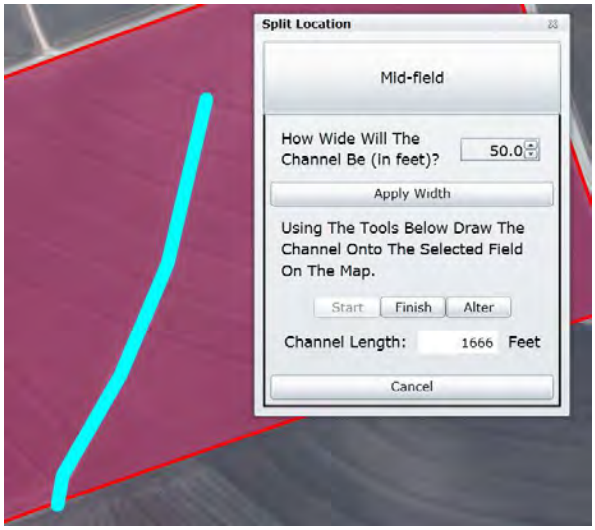
outside of the original field boundary at the point where the splitting practice boundary will intersect the original field boundary. Draw a line along the splitting practice boundary by single clicking. When finished delineating the

splitting practice boundary, double click. Make certain that the splitting practice boundary has intersected the original field boundary in two locations. Then click ***Finish*** in the *Field Split Editor*.

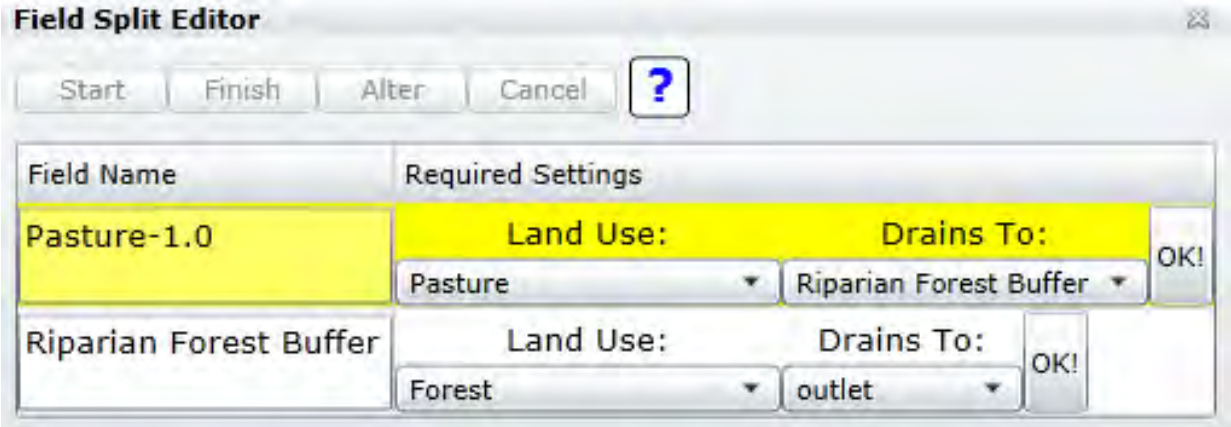
b. Mid-Field option

i. Enter the width of the splitting practice and click ***Apply Width***.

ii. To delineate the splitting practice, click the ***Start*** button and draw the location of the splitting practice on the field making certain to cross the field boundary. Once the splitting practice has been drawn in, click the ***Finish*** button. The length of the channel will display after the splitting practice has been delineated.



In all cases, the *Field Split Editor* will expand to include land use and drainage settings for each field. For each field select the land use and indicate where the field drains to. The name of the field can optionally be edited by highlighting the field name and typing a new name.

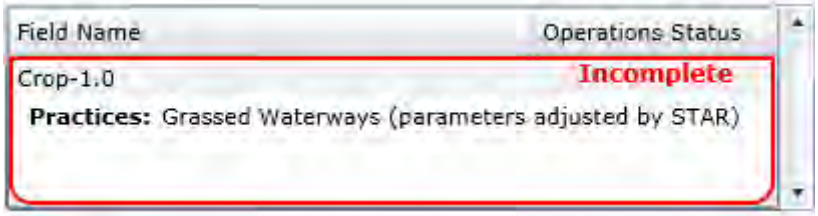


Click the ***OK*** button adjacent to each field settings when the required settings have been selected. Exit out of any other field split editor screens.

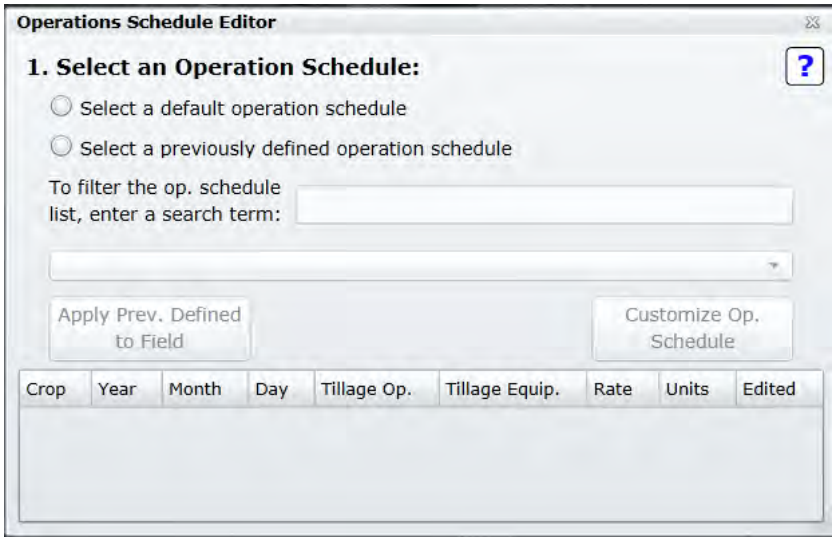
7. The Definitions column for the field just edited should now be labeled as **Complete**. Continue editing each field until all fields are labeled as **Complete**.

H. FIELD OPERATIONS DEFINITION

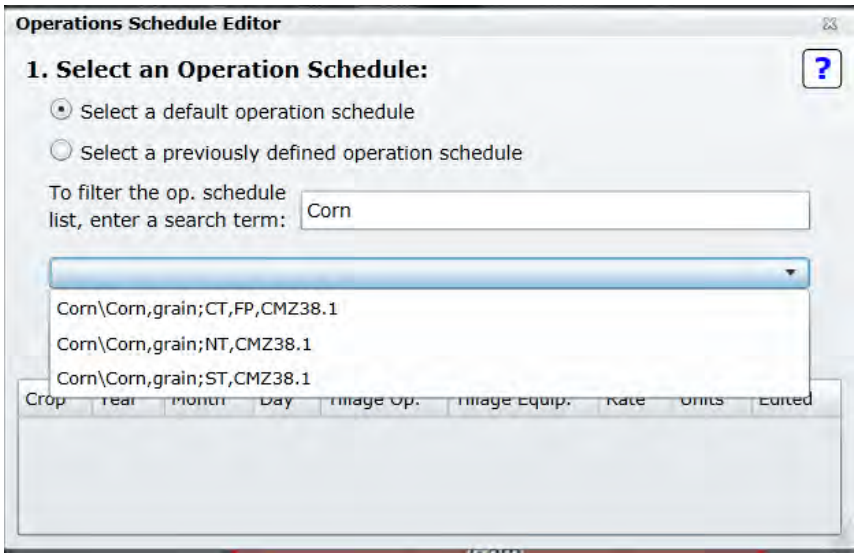
1. The next step is to define the field operation schedules for each field. To continue click the ***Define Field Operation Schedule*** button.
2. You will notice now that the conservation practices for each field are listed. To complete the field operation schedules click the **Incomplete** label under the Operations Status column.



3. The *Operations Schedule Editor* screen will appear. At this point the user has two options:
   a. Select a default operation schedule
   b. Select a previously defined operation schedule

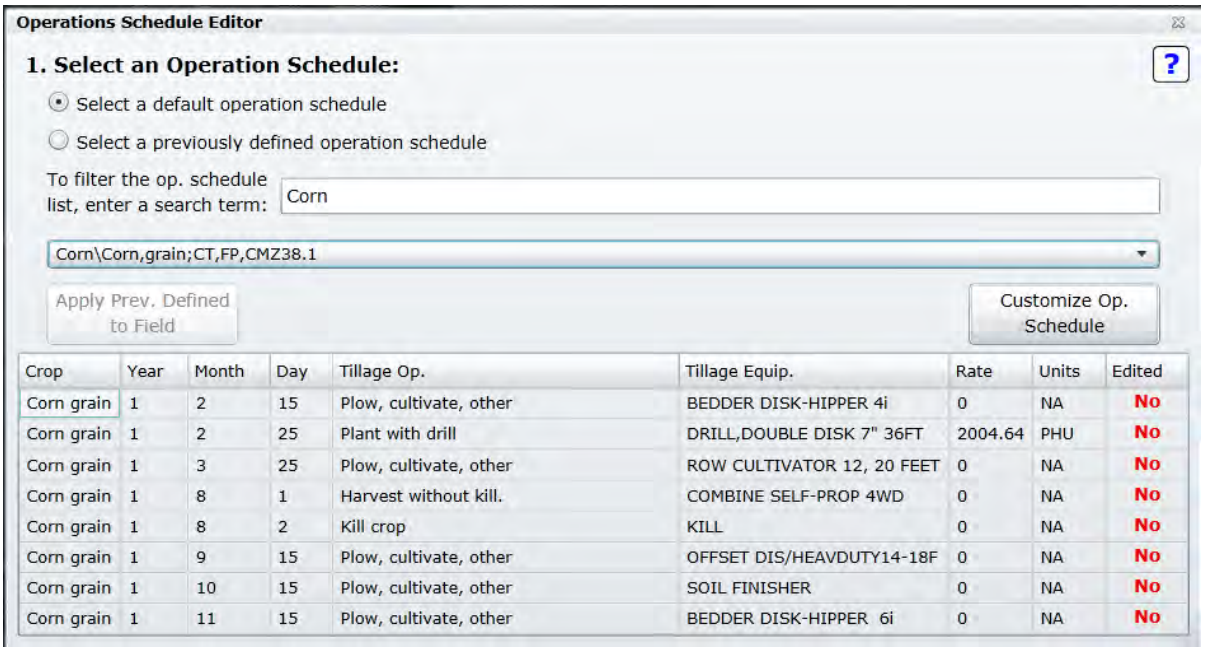


If the first option is chosen, the user will be able to select from default RUSLE2 operation schedules. To narrow down the list of operation schedules, type a search term in the filter box (for e.g. Corn). The list will then only include operation schedules that include the search term.



If the second option is chosen, the user can select from any previously edited and/or created operation schedules. Again, the operation schedule list can be narrowed by typing a search term in the filter box.

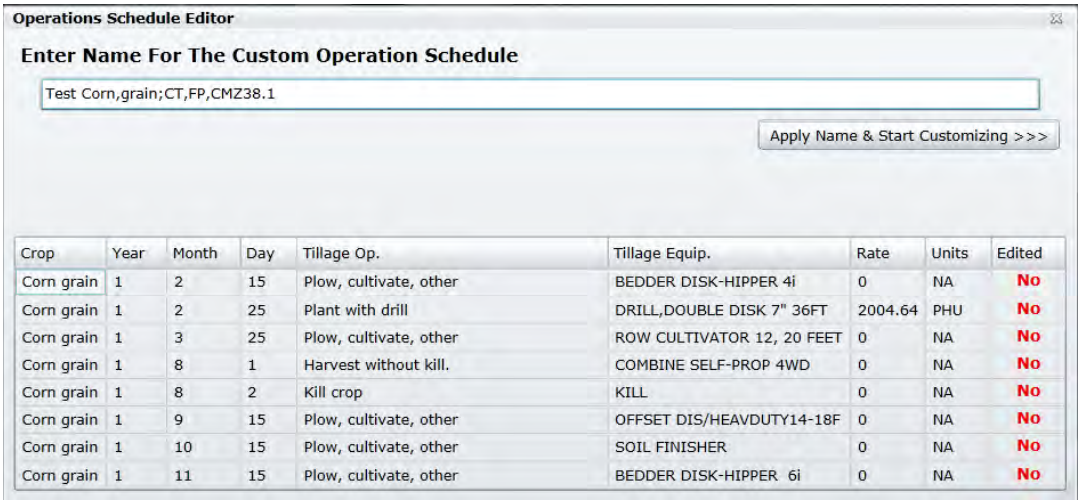
Once an operation schedule has been chosen from the list, the operations included in the schedule are displayed in the table below. The table includes a list of scheduled operations to be simulated by the APEX model, including information about the crop, year, month, day, operation type, equipment used, rate, and units. If satisfied with the selection, click the



Crop	Year	Month	Day	Tillage Op.	Tillage Equip.	Rate	Units	Edited
Corn grain	1	2	15	Plow, cultivate, other	BEDDER DISK-HIPPER 4i	0	NA	No
Corn grain	1	2	25	Plant with drill	DRILL,DOUBLE DISK 7" 36FT	2004.64	PHU	No
Corn grain	1	3	25	Plow, cultivate, other	ROW CULTIVATOR 12, 20 FEET	0	NA	No
Corn grain	1	8	1	Harvest without kill.	COMBINE SELF-PROP 4WD	0	NA	No
Corn grain	1	8	2	Kill crop	KILL	0	NA	No
Corn grain	1	9	15	Plow, cultivate, other	OFFSET DIS/HEAVDUTY14-18F	0	NA	No
Corn grain	1	10	15	Plow, cultivate, other	SOIL FINISHER	0	NA	No
Corn grain	1	11	15	Plow, cultivate, other	BEDDER DISK-HIPPER 6i	0	NA	No

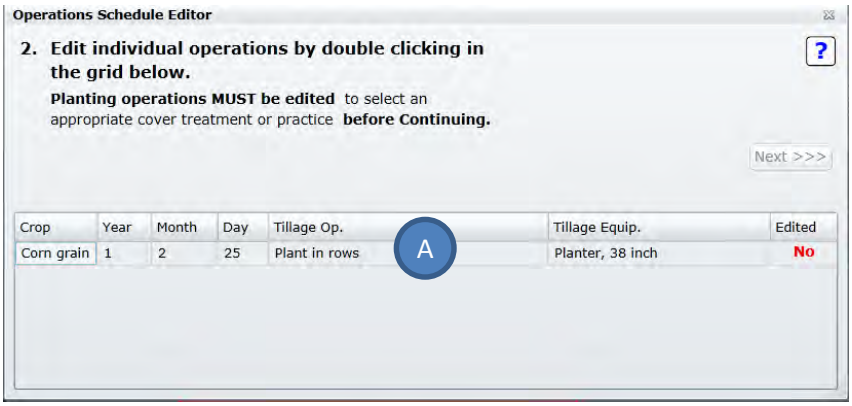
Customize Op. Schedule button. If not satisfied with the chosen schedule, choose another operation schedule from the list.

4. To begin customizing the operation schedule, enter a name for the operation schedule and click the ***Apply Name & Start Customizing>>>*** button.



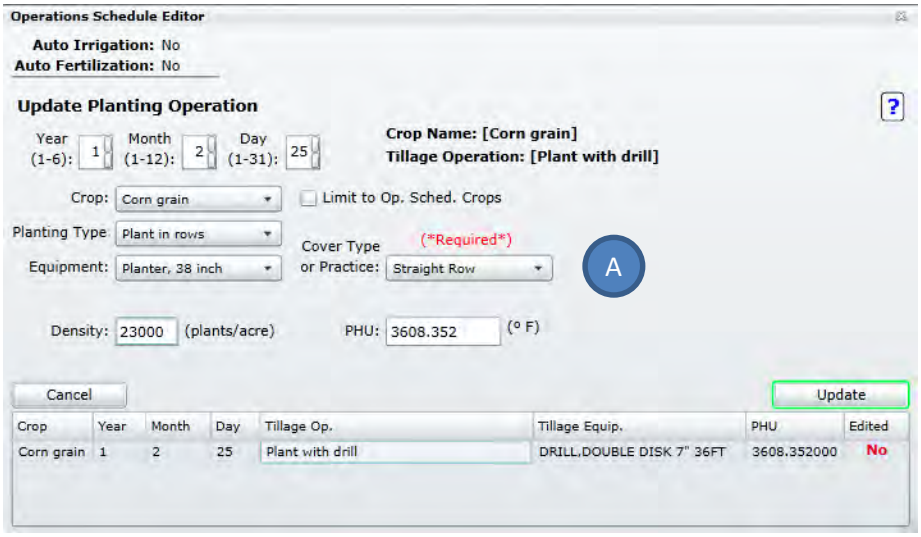
Crop	Year	Month	Day	Tillage Op.	Tillage Equip.	Rate	Units	Edited
Corn grain	1	2	15	Plow, cultivate, other	BEDDER DISK-HIPPER 4i	0	NA	No
Corn grain	1	2	25	Plant with drill	DRILL,DOUBLE DISK 7" 36FT	2004.64	PHU	No
Corn grain	1	3	25	Plow, cultivate, other	ROW CULTIVATOR 12, 20 FEET	0	NA	No
Corn grain	1	8	1	Harvest without kill.	COMBINE SELF-PROP 4WD	0	NA	No
Corn grain	1	8	2	Kill crop	KILL	0	NA	No
Corn grain	1	9	15	Plow, cultivate, other	OFFSET DIS/HEAVDUTY14-18F	0	NA	No
Corn grain	1	10	15	Plow, cultivate, other	SOIL FINISHER	0	NA	No
Corn grain	1	11	15	Plow, cultivate, other	BEDDER DISK-HIPPER 6i	0	NA	No

5. In order to define the appropriate cover treatment of practice, any planting operation must be edited. To begin editing a planting operation, double click on a planting operation in the table (A).

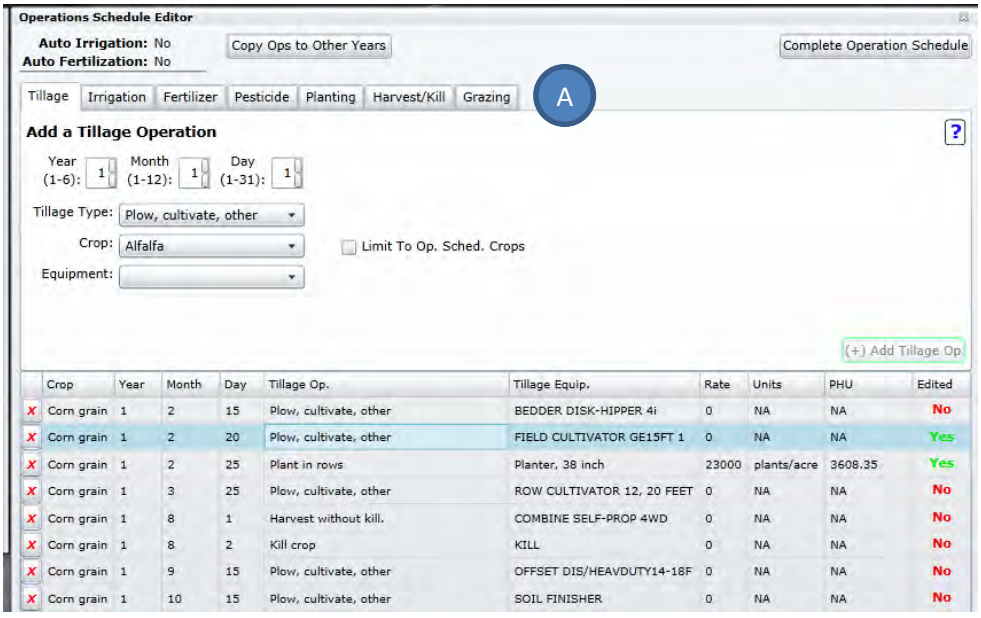


Select the crop, planting type, equipment used for planting and the cover type or practice.

If no contour farming or terracing type conservation practices are present on the field, the cover type or practice drop down (A) will default to Straight Row. To edit and define the planting operation, edit the information by selecting the appropriate data from the drop down menus. Then click the ***Update*** button. Do this for all of the planting operations in the operation schedule.

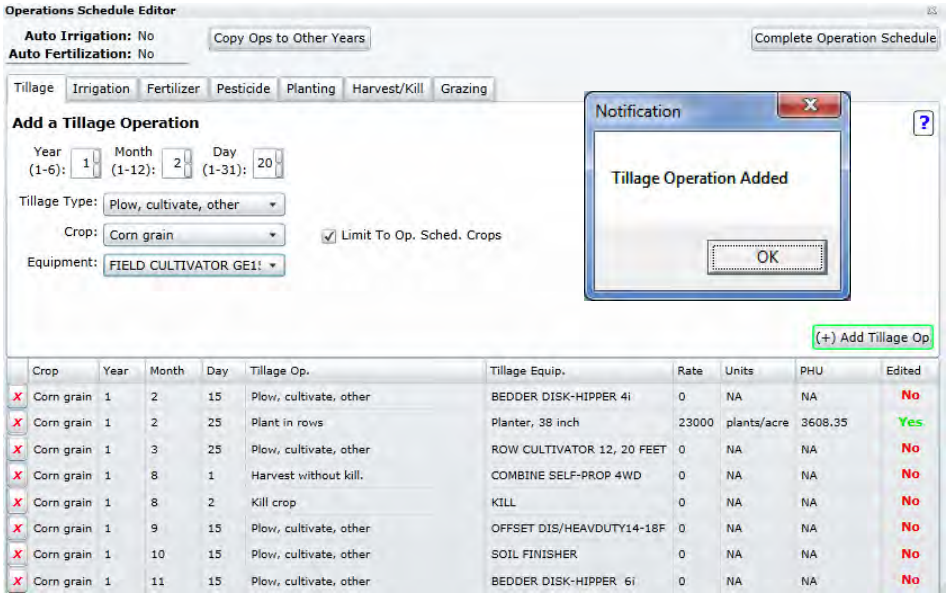


Once all planting operations have been updated, the user will be able to add/edit any tillage, irrigation, fertilization, pesticide, planting, harvesting/kill or grazing operations by clicking on the respective tabs.



6. Adding new operations
    a. TILLAGE

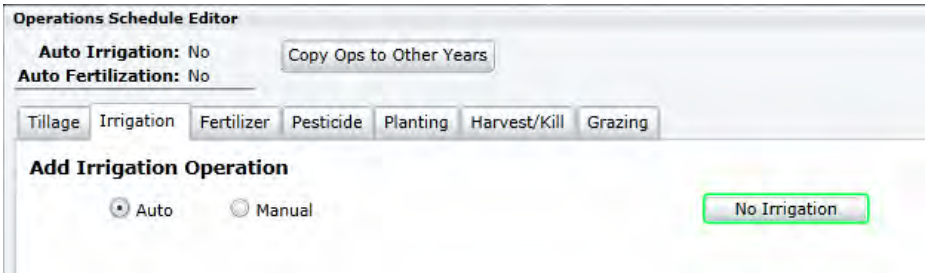
Add a tillage operation by selecting year/month/day in the rotation, the type of tillage, crop and tillage equipment used. Then click the ***Add Tillage Op*** button. When the new tillage operation has been added successfully, a notification will appear and then the new operation will appear in the table below



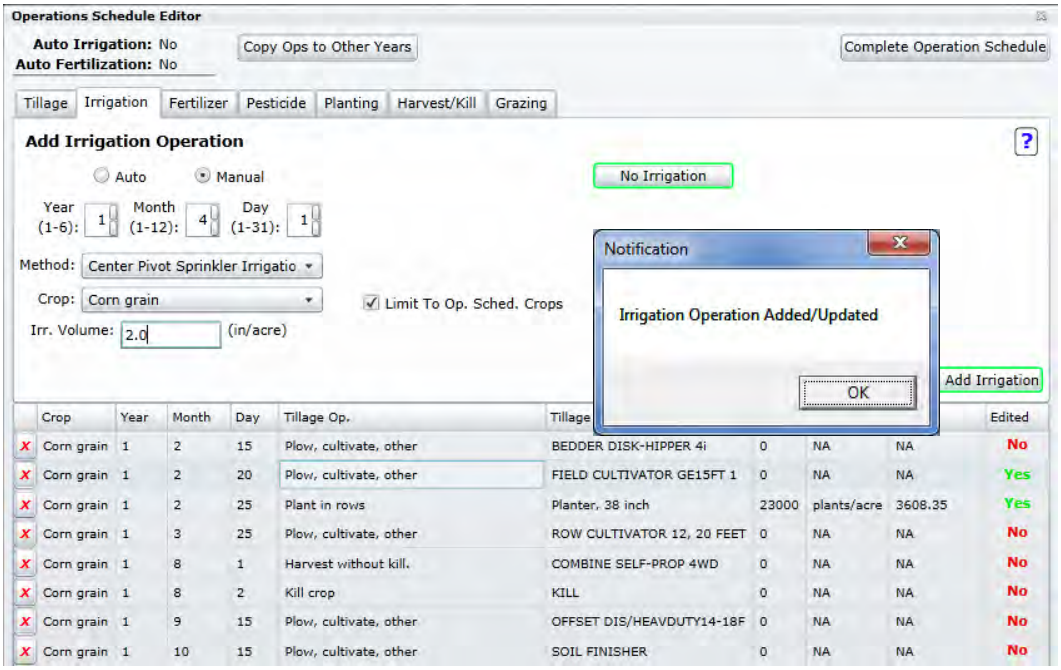
b. IRRIGATION

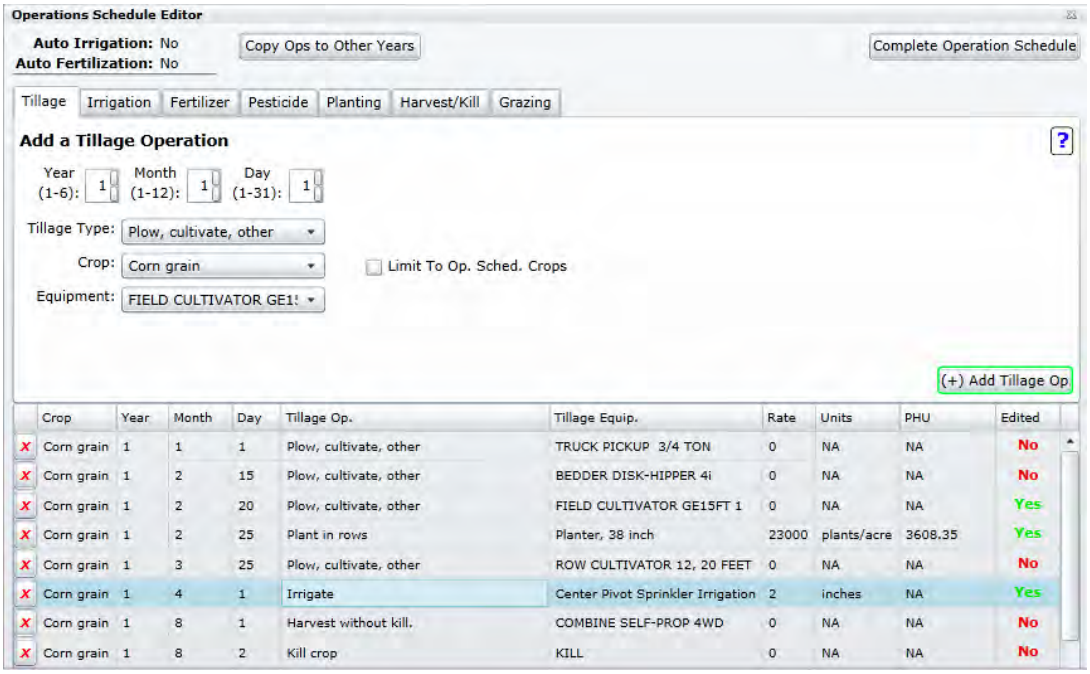
Three options are available for applying irrigation

1. No Irrigation – no irrigation is applied
2. Auto – If automatic irrigation is chosen, the model will irrigate the crop when it determines the crop has met the specified conditions. The model has been set to irrigate when the crop reaches a water stress level of 15%. If necessary, the crop will be irrigated once a day until a total maximum of 24 inches of water has been applied to the crop during the current growing season. To select this option, select the ***Auto*** radio button and then click the ***Add Irrigation*** button. Auto irrigation will be indicated in the top left corner.



3. Manual – If manual irrigation is chosen, select the year/month/day of application, method of application and enter the volume applied. Then click the ***Add Irrigation*** button. A notification will be received when the operation has been added successfully, and the new irrigation operation will be added to the spreadsheet below.

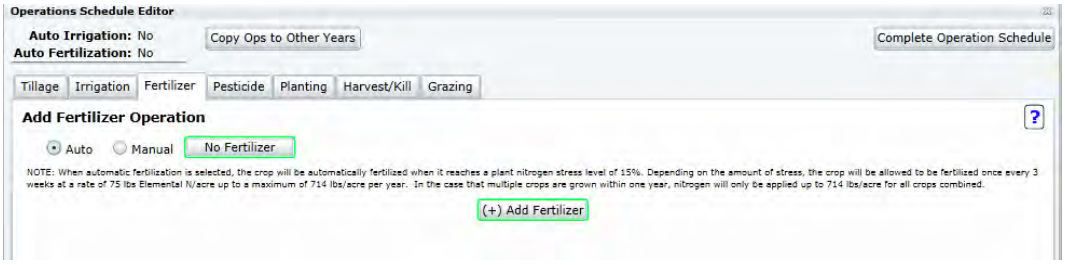




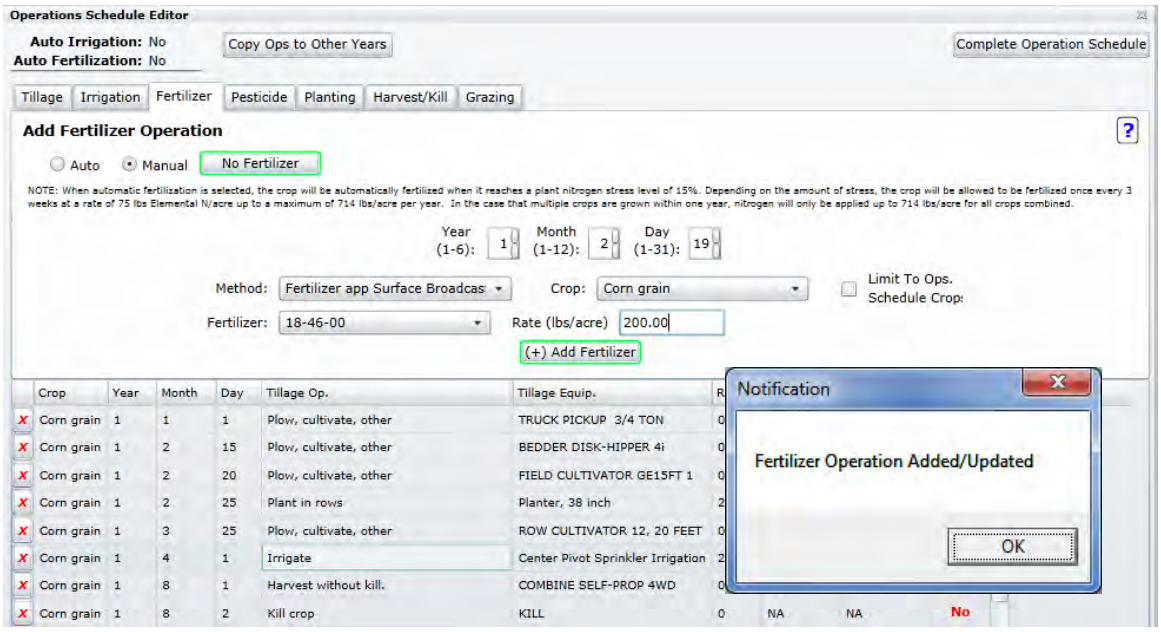
c. FERTILIZER

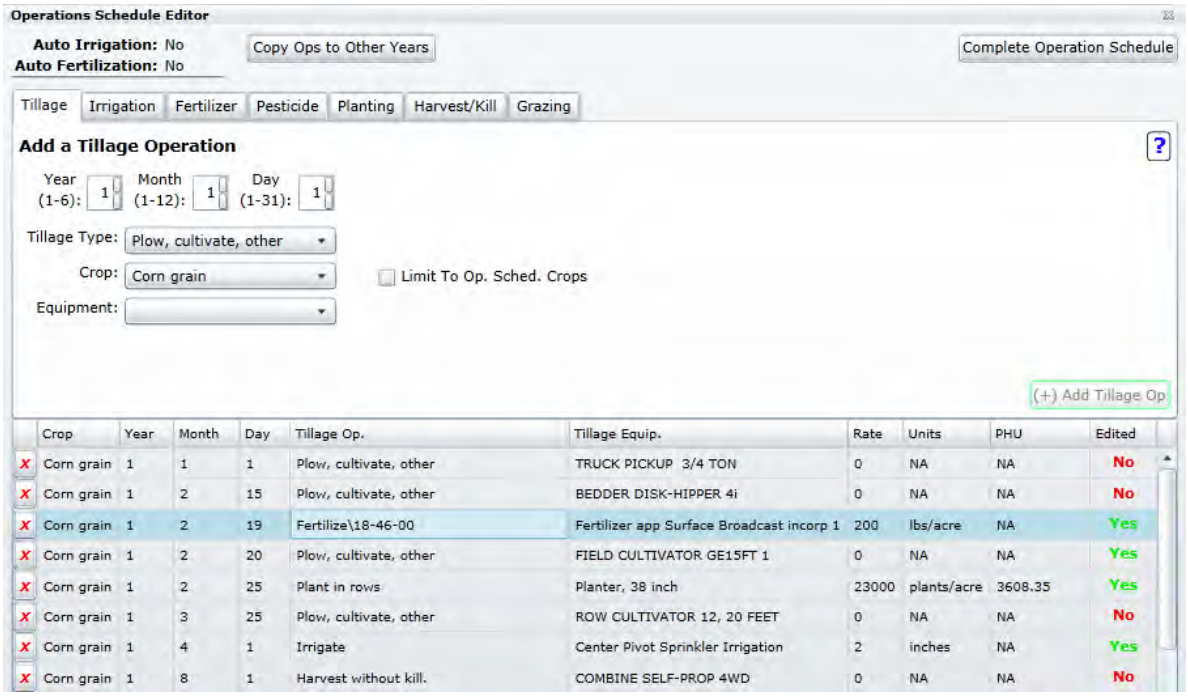
Three options are available for applying fertilizer

1. No Fertilizer – no fertilization is applied
2. Auto – If automatic fertilization is chosen, the model will fertilize the crop when it determines the crop has met the specified conditions. The model has been set to fertilize when the crop reaches a stress level of 15%. If necessary, the crop will be fertilized once every three (3) weeks at a rate of 67 lbs of elemental Nitrogen per acre until a total maximum of 714 lbs N/acre has been applied to the crop during the current growing season. In the case that multiple crops are grown within one year (double cropping, intercropping, etc.), nitrogen will only be applied up to 714 lbs N/acre for all crops combined. To select this option, select the ***Auto*** radio button and then click the ***Add Fertilizer*** button. Auto fertilization will be indicated in the top left corner.



3. Manual – If manual fertilization is chosen, select the year/month/day of application, method of application, type of fertilizer applied and enter the rate applied. Then click the ***Add Fertilizer*** button. A notification will be received when the operation has been added successfully, and the new irrigation operation will be added to the spreadsheet below.





	Crop	Year	Month	Day	Tillage Op.	Tillage Equip.	Rate	Units	PHU	Edited
X	Corn grain	1	1	1	Plow, cultivate, other	TRUCK PICKUP 3/4 TON	0	NA	NA	No
X	Corn grain	1	2	15	Plow, cultivate, other	BEDDER DISK-HIPPER 4i	0	NA	NA	No
X	Corn grain	1	2	19	Fertilize\18-46-00	Fertilizer app Surface Broadcast incorp 1	200	lbs/acre	NA	Yes
X	Corn grain	1	2	20	Plow, cultivate, other	FIELD CULTIVATOR GE15FT 1	0	NA	NA	Yes
X	Corn grain	1	2	25	Plant in rows	Planter, 38 inch	23000	plants/acre	3608.35	Yes
X	Corn grain	1	3	25	Plow, cultivate, other	ROW CULTIVATOR 12, 20 FEET	0	NA	NA	No
X	Corn grain	1	4	1	Irrigate	Center Pivot Sprinkler Irrigation	2	inches	NA	Yes
X	Corn grain	1	8	1	Harvest without kill.	COMBINE SELF-PROP 4WD	0	NA	NA	No

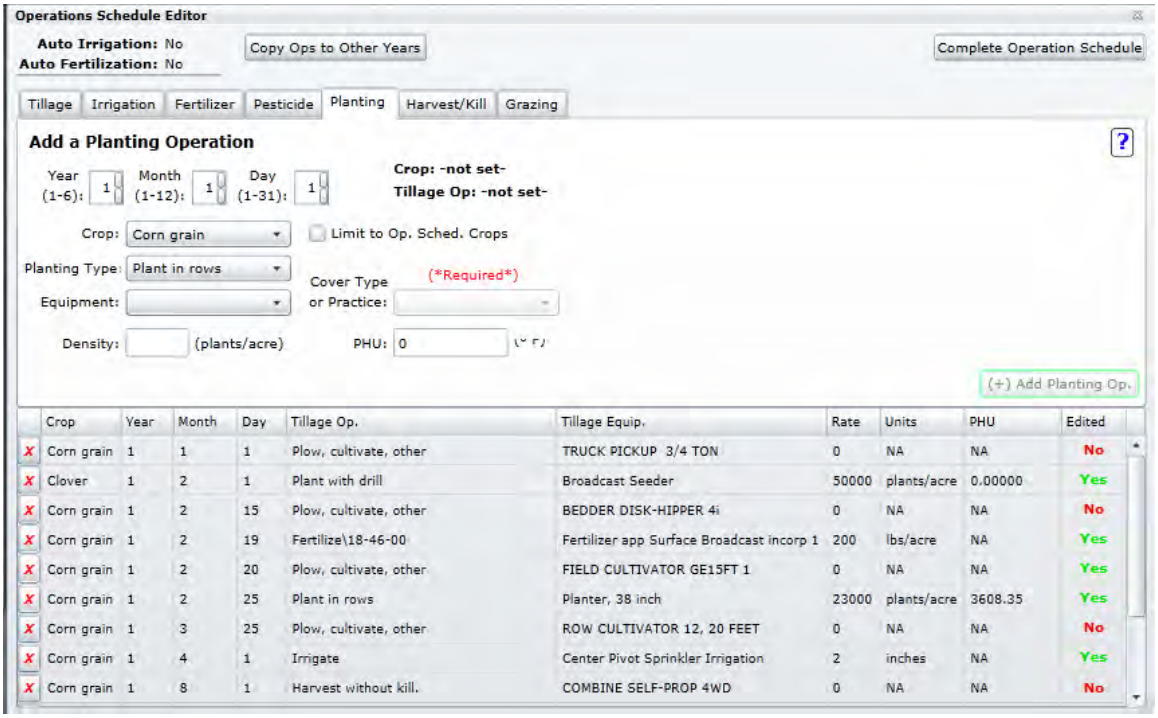
d. PESTICIDE

The Pesticide tab works much like the Tillage tab. The user selects the year, month and day of the operation. Then the user selects the application method, crop to which the pesticide is being applied, the pesticide being applied, the application rate of the pesticide and the units of the rate. To add the operation to the crop schedule, click the ***Add Pesticide*** button.

e. PLANTING

Intercropping

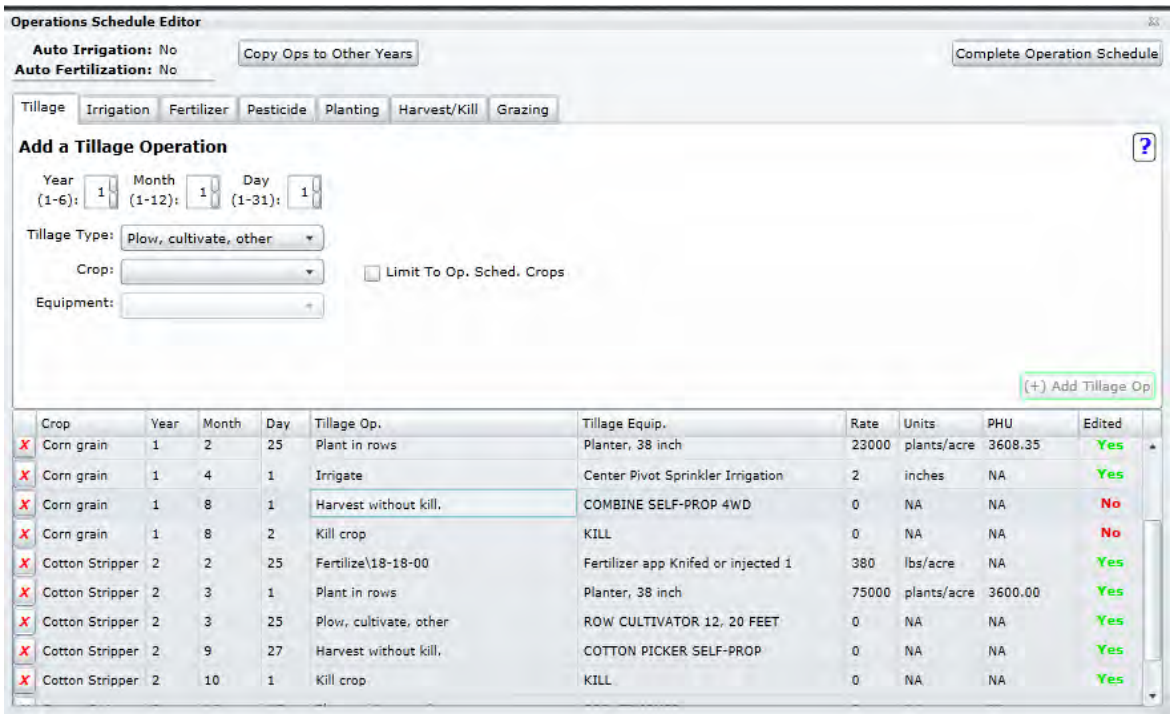
Multiple planting operations can be added if multiple crops are intercropped. Simply add a planting operation for each of the crops in the cropping system by selecting the year/month/day of planting, planting type, crop, equipment used for planting and the cover type or practice. Then click the ***Add Planting Op.*** button. The following screen shows an intercropping schedule which includes corn and clover.



	Crop	Year	Month	Day	Tillage Op.	Tillage Equip.	Rate	Units	PHU	Edited
X	Corn grain	1	1	1	Plow, cultivate, other	TRUCK PICKUP 3/4 TON	0	NA	NA	No
X	Clover	1	2	1	Plant with drill	Broadcast Seeder	50000	plants/acre	0.00000	Yes
X	Corn grain	1	2	15	Plow, cultivate, other	BEDDER DISK-HIPPER 4i	0	NA	NA	No
X	Corn grain	1	2	19	Fertilize\18-46-00	Fertilizer app Surface Broadcast incorp 1	200	lbs/acre	NA	Yes
X	Corn grain	1	2	20	Plow, cultivate, other	FIELD CULTIVATOR GE15FT 1	0	NA	NA	Yes
X	Corn grain	1	2	25	Plant in rows	Planter, 38 inch	23000	plants/acre	3608.35	Yes
X	Corn grain	1	3	25	Plow, cultivate, other	ROW CULTIVATOR 12, 20 FEET	0	NA	NA	No
X	Corn grain	1	4	1	Irrigate	Center Pivot Sprinkler Irrigation	2	inches	NA	Yes
X	Corn grain	1	8	1	Harvest without kill.	COMBINE SELF-PROP 4WD	0	NA	NA	No

Crop Rotations

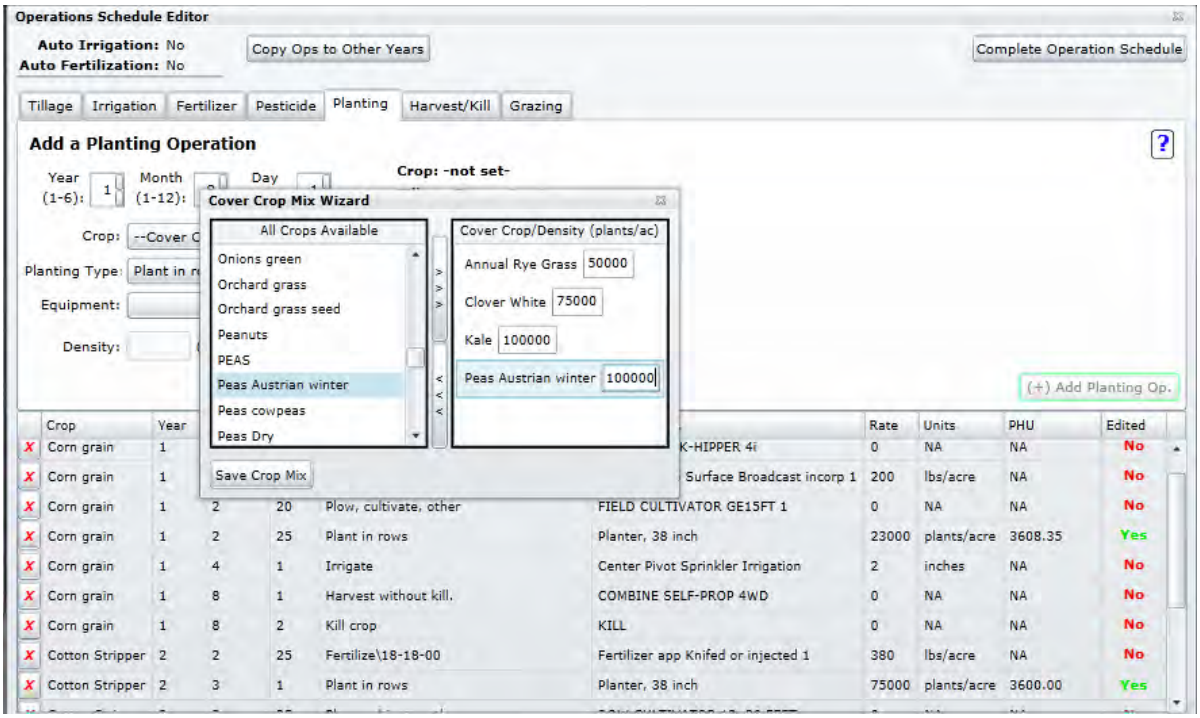
Crop rotations can also be created by added additional planting operations in consecutive years. The following screen shows a rotation of corn and cotton. Other operations such as tillage, irrigation, fertilization, harvesting and killing should be included for each crop in the respective year.



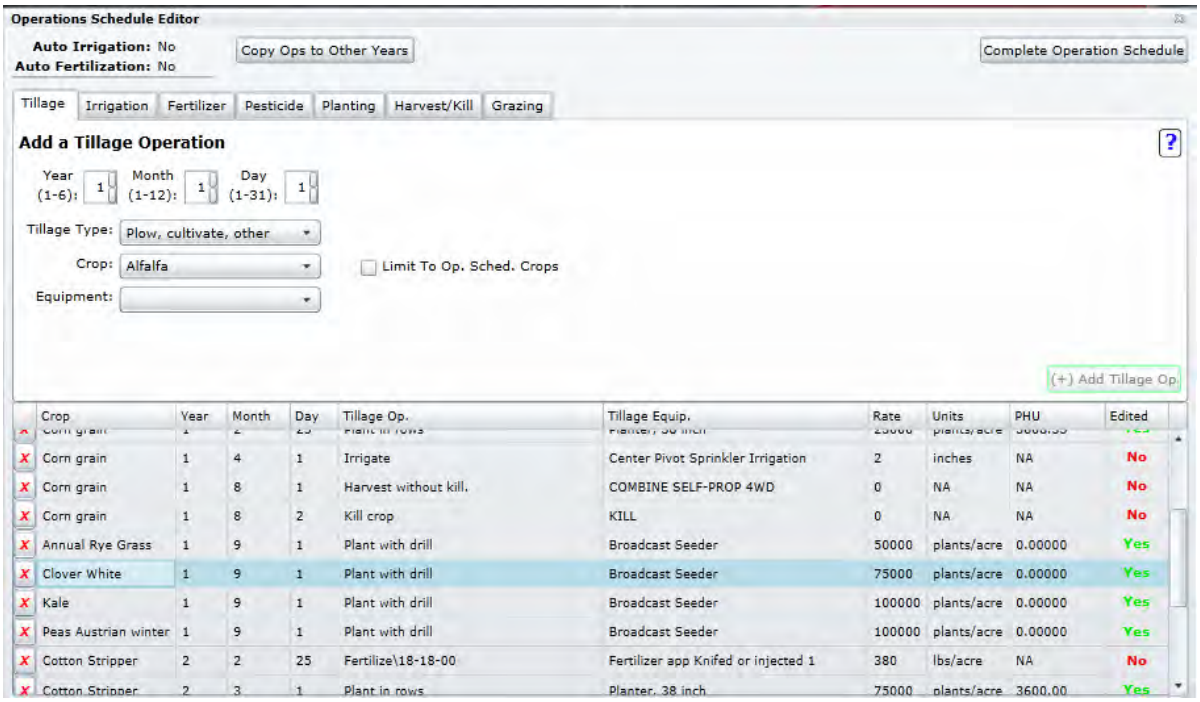
Crop	Year	Month	Day	Tillage Op.	Tillage Equip.	Rate	Units	PHU	Edited
Corn grain	1	2	25	Plant in rows	Planter, 38 inch	23000	plants/acre	3608.35	Yes
Corn grain	1	4	1	Irrigate	Center Pivot Sprinkler Irrigation	2	inches	NA	Yes
Corn grain	1	8	1	Harvest without kill.	COMBINE SELF-PROP 4WD	0	NA	NA	No
Corn grain	1	8	2	Kill crop	KILL	0	NA	NA	No
Cotton Stripper	2	2	25	Fertilize\18-18-00	Fertilizer app Knifed or injected 1	380	lbs/acre	NA	Yes
Cotton Stripper	2	3	1	Plant in rows	Planter, 38 inch	75000	plants/acre	3600.00	Yes
Cotton Stripper	2	3	25	Plow, cultivate, other	ROW CULTIVATOR 12, 20 FEET	0	NA	NA	Yes
Cotton Stripper	2	9	27	Harvest without kill.	COTTON PICKER SELF-PROP	0	NA	NA	Yes
Cotton Stripper	2	10	1	Kill crop	KILL	0	NA	NA	Yes

Cover Crops

When adding a mix of crops to be used as a cover crop, the crops can be added in one planting operation using the cover crop mix wizard. Select the planting date for the cover crop. Select "—Cover Crop Mix –" as the crop. This will invoke the Cover Crop Mix Wizard. Select a crop from the list of available crops and click the arrows to the right to add the crop to the list. Enter a plant density in the box to the right of the crop in the cover crop list. Continue to add additional crops as needed. When all crops have been added to the cover crop mix, click ***Save Crop Mix***. Select the planting type, equipment used for the cover crop and cover type or practice and click the ***Add Planting Op*** button.



A planting operation will be added to the spreadsheet for each crop in the cover crop mix. Each planting operation can be edited.



If fertilizer or irrigation is added manually to the cover crop, the fertilizer or water needs to be added to only one of the crops in the cover crop mix in order for all of the crops to take advantage.

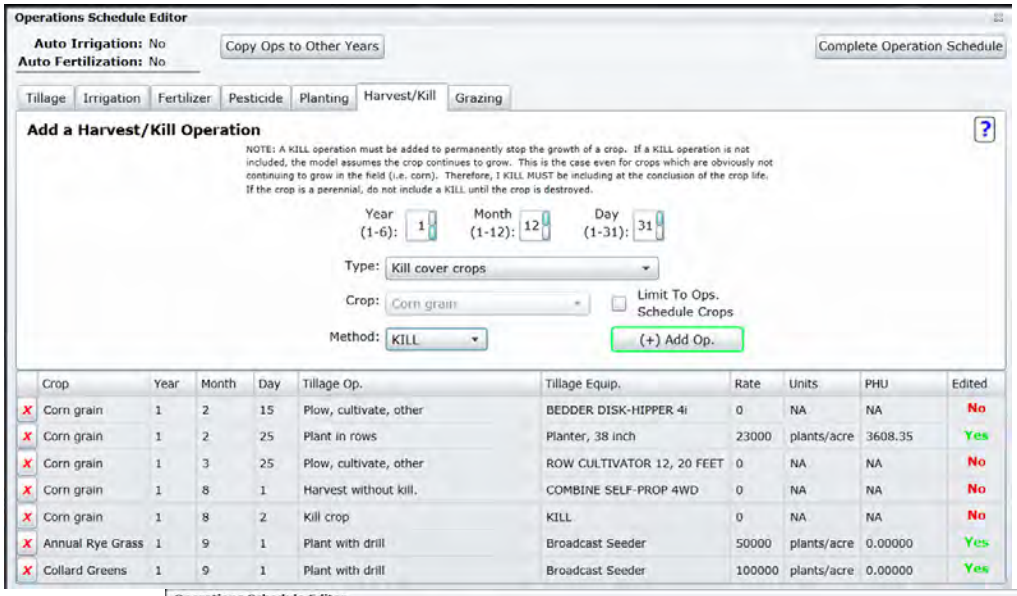
f. HARVEST/KILL/BURN

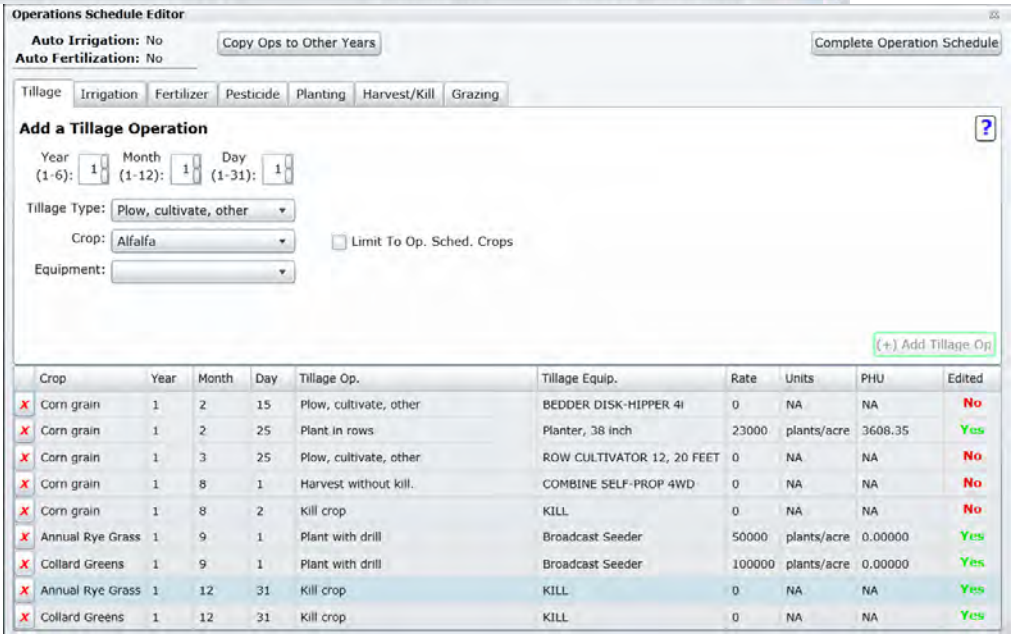
Harvest operations are used to harvest the crop. In the case of forage crops, numerous harvest operations can be included to simulate multiple cuttings. If a harvest operation is not included in the management schedule, no yield will be reported.

The burning operation is used to remove the above-ground plant material. Currently, the model is set to remove 90% of the above-ground biomass. All plants are affected equally. For example, trees are burned to the same extent as grasses.

The Kill operation must be added to permanently stop the growth of a crop. If a Kill operation is not included, the model assumes the crop continues to grow. This is the case even for crops which obviously do not continue to grow in the field after harvest (e.g. corn and wheat). The model will allow the plant to continue growing and using resources (nutrients, water, etc.). Therefore, a Kill operation MUST be included at the conclusion of the crop life. If the crop is a perennial, do not include a Kill operation until the crop is destroyed.

If a cover crop mix is included in the operation schedule, a Kill operation must be included for each crop in the mix. This can, however, be accomplished in one step. Select the date of kill, select KILL COVER CROPS for the Type, and then select Kill for the Method. This will add a kill operation for each crop in the cover crop mix.

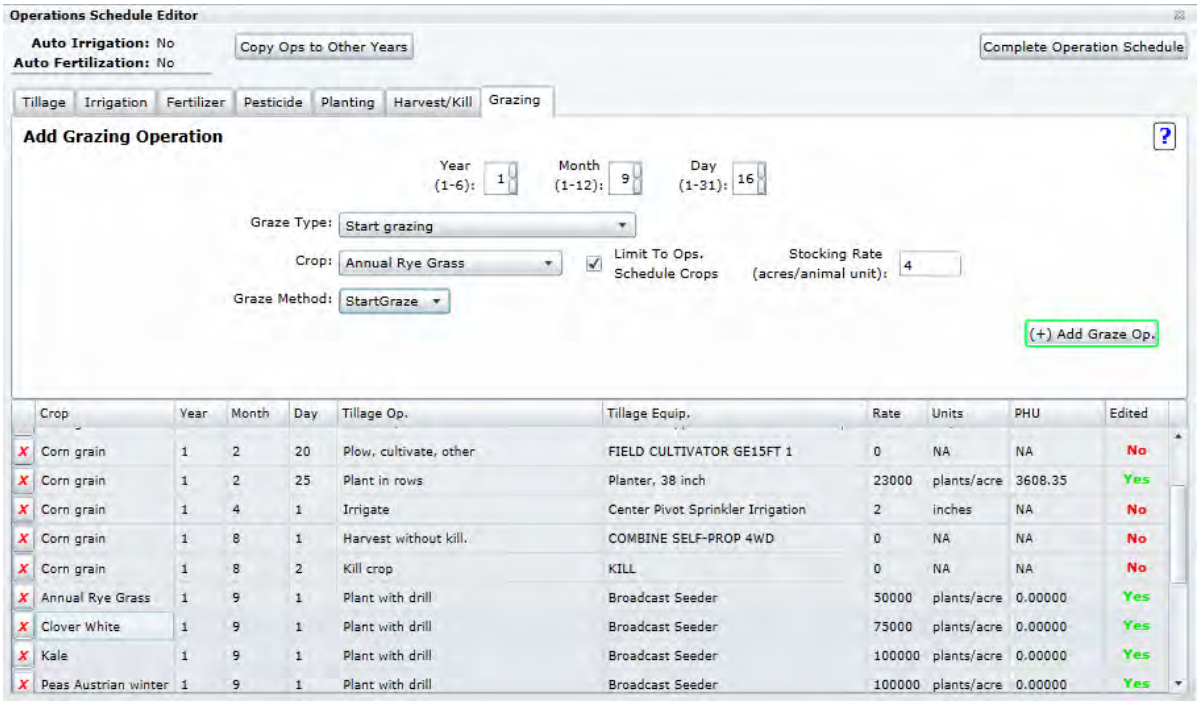




g. GRAZING

Grazing can also be simulated by adding Start and Stop Grazing operations. The animals can begin grazing a crop on the date as set on the Start Grazing operation. Grazing is also limited by the grazing limit which is set to 0.9 tons/acre. The animals will be allowed to graze provided the amount of forage as set by the grazing limit is available. Animals will be allowed to graze until they have grazed the forage to the grazing limit. This prevents the herds from overgrazing or grazing more than the producer would allow them to graze a particular pasture. When the herd has grazed down to the grazing limit, animals are removed from the field and held in an offsite holding area. When the amount of forage present on the field

surpasses the limit, the animals are allowed to return to the field and continue grazing. The limit is not a daily consumption limit but rather a forage availability limit. The Stop Grazing operation removes the animals from the field. A stocking density (acres/animal unit) can also be set on the Start Grazing operation. If stocking density changes throughout the season, additional Start Grazing operations can be added and the stocking rate modified.



7. Editing operations

   Existing operations can be edited by simply double-clicking on the operation line in the spreadsheet. The appropriate screen will appear. Edit the operation as needed and click the ***Update*** button.

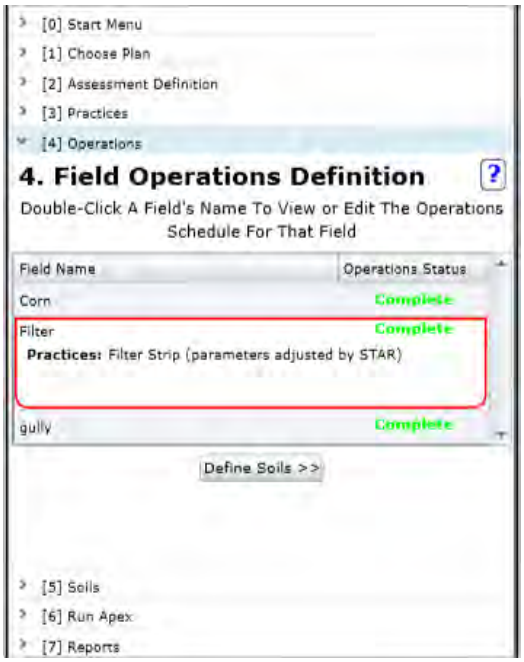
8. Deleting operations

   Operations can be deleted by simply clicking the X button beside the operation. A message will appear to verify that you want to delete the operation schedule record.

9. Completing the Operation Schedule

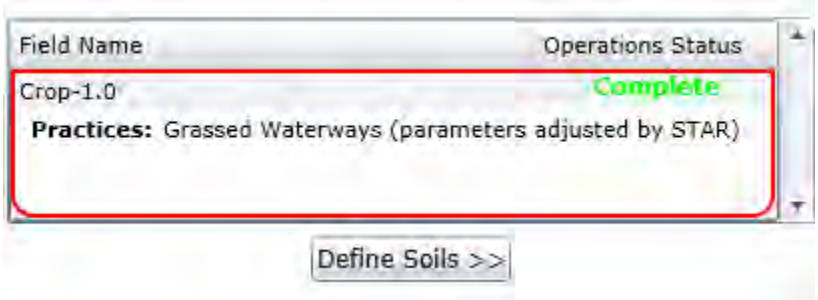
   Once all operations have been added, edited or deleted as desired, the operation schedule can be submitted. Click the ***Complete Operation Schedule*** button in the top right corner of the screen.

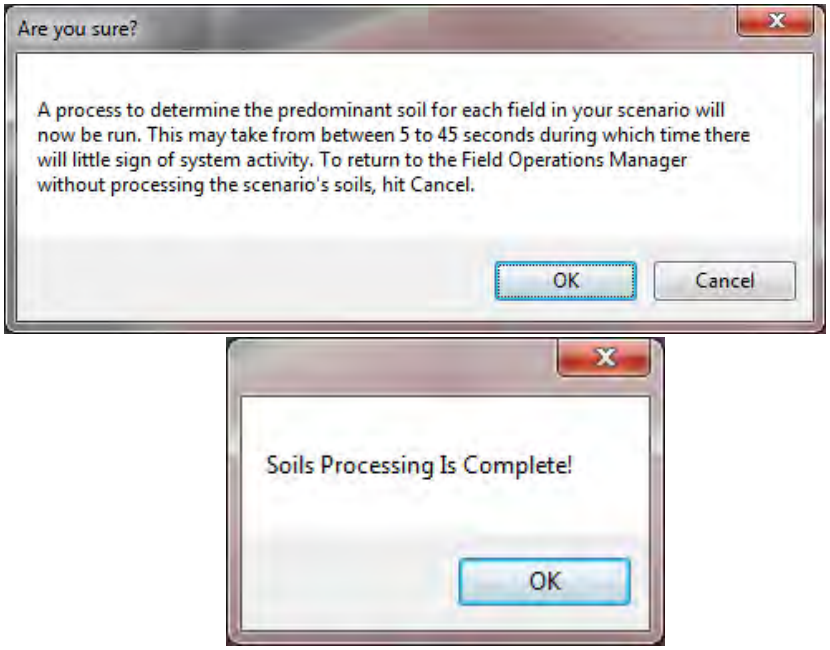
10. The Operations Status should now be **Complete**. At this point the user can define the soils by clicking the ***Define Soils*** button on the **Field Operations Definition** panel.



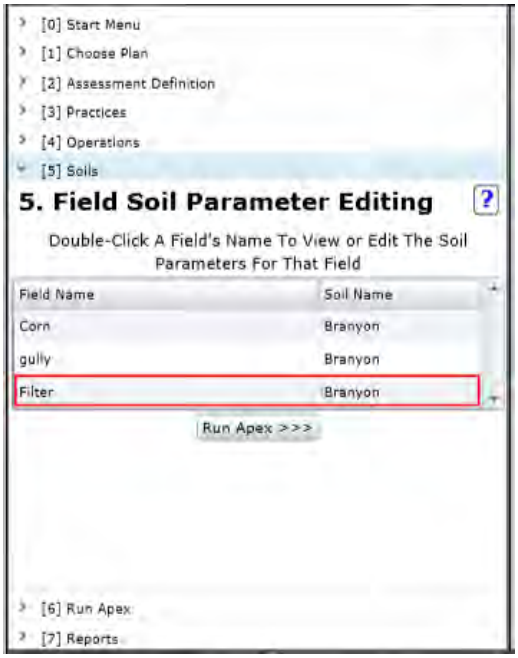
I. FIELD SOIL PARAMETER EDITING

The user can define the soils for the scenario. To accomplish this, click the ***Define Soils*** button on the **Field Operations Definition** panel. A window with additional information related to soils processing will appear. Click the OK button to continue with soil definition. The program will determine the predominant soil for each field in the scenario. Once processing has been completed, the user will receive a message confirming this.

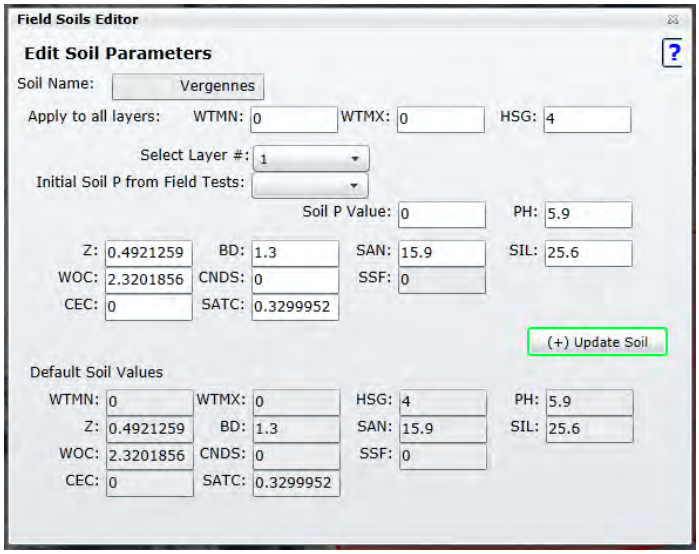




The predominant soil for each field will then be displayed in the **Field Soil Parameter Editing** panel.



To edit the soil parameters for a particular field, double click on the soil name of the field in interest. A Field Soil Parameters screen will appear.



The following soil parameters are defined only once for all soil layers:

WTMN: Minimum depth to the water table. This is the depth (ft) from the soil surface to the water table when the water table is at its highest level.

WTMX: Maximum depth to the water table. This is the depth (ft) from the soil surface to the water table when the water table is at its lowest level.

HSG: Soil hydrologic group

1 = A: Soils having high infiltration rates even when thoroughly wetted, consisting chiefly of sands or gravel that are deep and well to excessively drained. These soils have a high rate of water transmission (low runoff potential). Hydrologic Group A (1) soils generally have a sand content of 80% or greater.

2 = B: Soils having moderate infiltration rates when thoroughly wetted, chiefly moderately deep to deep, moderately well to well drained, with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission. Hydrologic Group B (2) soils generally have a sand content between 60% and 80%.

3 = C: Soils having slow infiltration rates when thoroughly wetted, chiefly with a layer that impedes the downward movement of water or of moderately fine to fine texture and a slow infiltration rate. These soils have a slow rate of water transmission (high runoff potential). Hydrologic group C (3) soils generally have a sand content less than 50% and a clay content less than 40%.

4 = D: Soils having very slow infiltration rates when thoroughly wetted, chiefly clay soils with a high swelling potential; soils with a high permanent water table; soils with a clay pan or clay layer at or near the surface; and shallow soils over nearly impervious

materials. These soils have a very slow rate of water transmission. Hydrologic group D soils generally have a clay content greater than 40%.

The remaining soil parameters are editable by layer (i.e. soil horizon). Layers can be selected by clicking on the Select Layer drop down box and choosing a desired layer. Soil parameters can be edited as needed. Default soil values are provided in the lower portion of the form for the user's knowledge.

User's can choose to enter initial soil phosphorus from soil field test results for each soil layer. Choose from the Mehlich test or the Modified Morgan test. For both tests, soil P and pH are required. For the Modified Morgan the user is also prompted to enter Aluminum, which is required for conversion of the value to model compatible units.

Z: Depth from the soil surface to the bottom of the layer (ft).

PH: Soil pH.

BD: Moist bulk density. The soil bulk density expresses the ratio of the mass of solid particles to the total volume of the soil. In moist bulk density determinations, the mass of the soil is the oven dry weight and the total volume of the soil is determined when the soil is at or near field capacity. Bulk density values should range between 1.1 and 1.9 Mg/m^3.

SAN: The percentage of sand in the soil. The percentage of soil particles which have a diameter between 2.0 and 0.05 mm.

SIL: Percentage of silt in the soil. The percentage of soil particles which have an equivalent diameter between 0.05 and 0.002 mm.

WOC: Percent of organic carbon in the soil layer. % organic carbon = % organic matter/1.72.

CNDS: Initial soluble nitrogen concentration. The user may define the concentration of nitrate (dry weight basis) for all soil layers at the beginning of the scenario. (ppm)

SSF: Initial soluble phosphorus concentration. This value will be calculated either by values entered by the user for the initial soil P test or automatically calculated by APEX. (ppm)

CEC: Cation exchange capacity. The cation exchange capacity of a soil is the quantity of positive ions necessary to neutralize charge of a unit quantity of soil, under a given set of conditions. (cmol/kg)

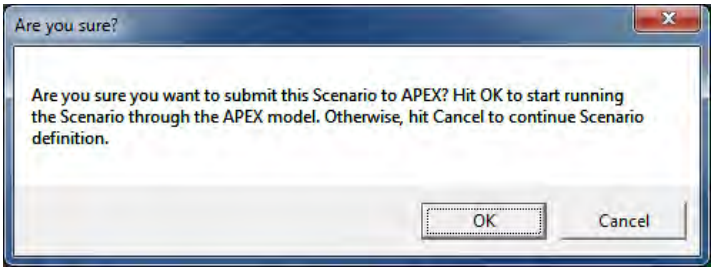
SATC: Saturated conductivity is the rate at which water passes through the soil layer, when saturated. The saturated hydraulic conductivity relates soil water flow rate (flux

density) to the hydraulic gradient and is a measure of the ease of water movement through the soil. The saturated conductivity is the reciprocal of the resistance of the soil matrix to water flow. (in/h).

Once the user has completed the soil parameter edits for the soil, click the ***Update Soil*** button. At this point the scenario can be submitted to APEX. To continue click the ***Run APEX*** button.

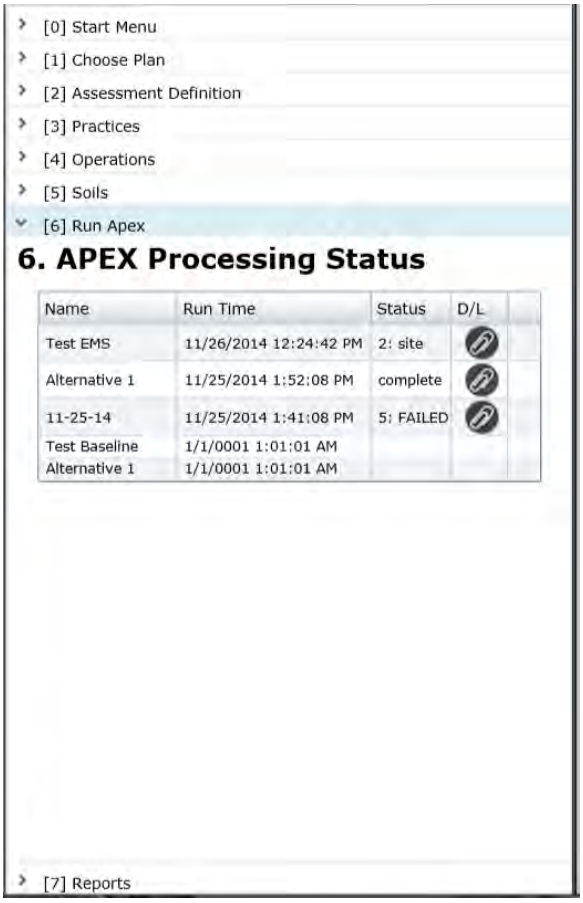
J. RUN APEX

1. To begin the simulation, click the ***Run APEX*** button.
2. Confirm that you want to submit the scenario to APEX.

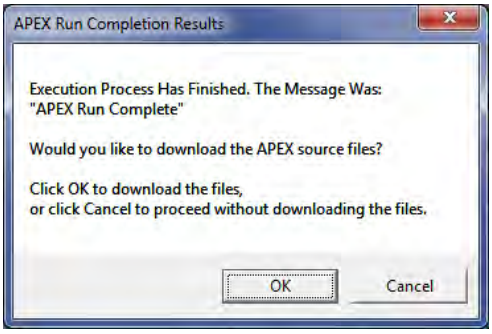


Once submitted, the assessment may take several minutes to process.

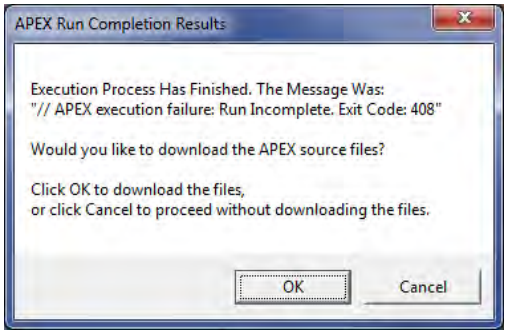
3. The status of the assessment can be viewed in the run table. As the model progresses through the various steps in the simulation, the Status column will reflect this progress.



Once the assessment is finished, a message will be displayed to inform you that the simulation has successfully finished processing and the status will display as complete.



If the run was not successful and a message such as the one pictured below is received, the simulation files should be sent to the support staff for further diagnosis.

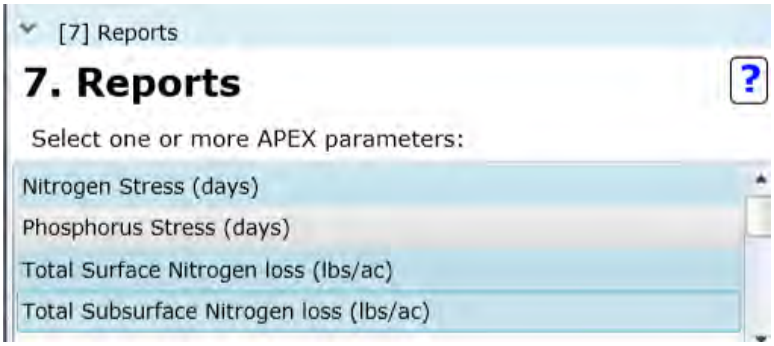


The simulation files can be downloaded as a .ZIP file by clicking ***OK*** on the message pictured above or by clicking on the button adjacent to the run under the D/L column.

4. If the simulation was successful, output can be viewed through the Reports section.

K. REPORTS

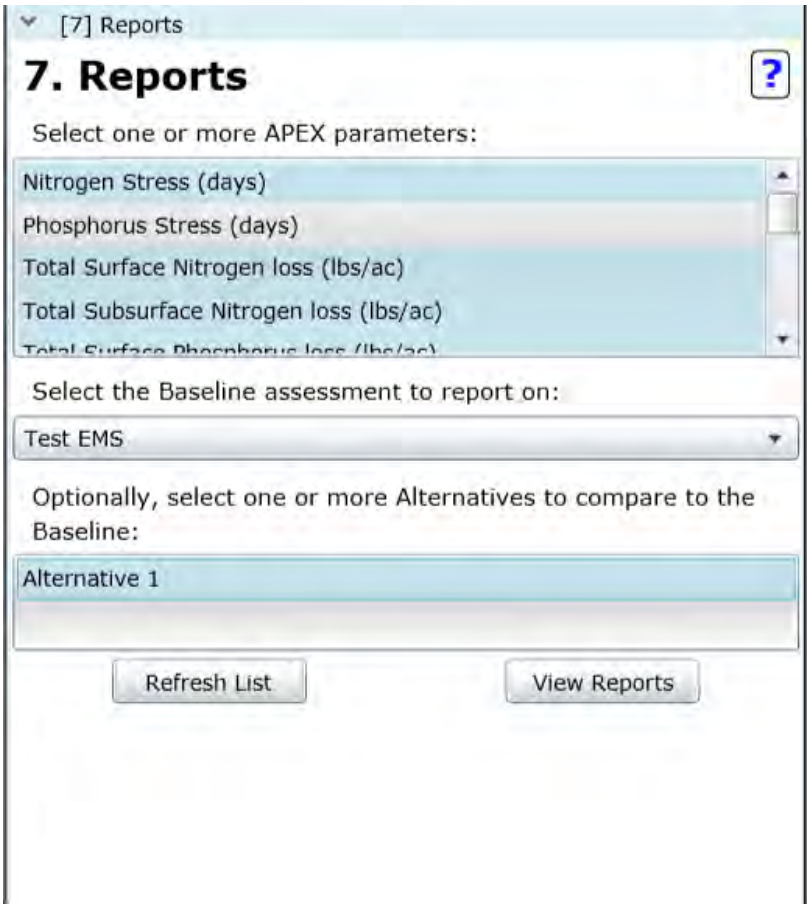
1. Click on the **Reports** tab.
2. Select one or more of the APEX output parameters from the list.



3. Then select the Baseline assessment from the drop down menu to display output for.

4. If any Alternative assessments have been made on the chosen baseline assessment, they will be listed in the Alternative box below. If desired, one or more Alternative assessments can be chosen to compare against the baseline assessment.

5. To clear all selections, click the ***Refresh List*** and reselect parameters and assessments.



6. Once all selections are made, click the ***View Reports*** button to display the report. If the report does not open, hold down the CTRL key and click the ***View Reports*** button again.

7. The report not only contains data for the parameters chosen in the previous step, but it also includes information regarding the location and cropping practices.

8. The following data is provided for each assessment and field in the Summary of Field Inputs section of the report:

    a. Practices: conservation practices applied to the field
    b. Op Schedule: operation/management schedule used for the field
    c. Dominant Soil: the dominant soil present in the field
    d. Field acres: calculated acres of the field
    e. Hydrologic Soil Group: The soil group of the dominant soil.
    f. Slope (%): The average slope of the field calculated from elevation data.
    g. Slope Length (ft): The calculated slope length based on field dimensions.
    h. Weather Station: Historical weather site used for simulation
    i. Avg. Annual Precip (in): Average annual precipitation received at this location based on the historical weather data
    j. Total N Applied (lbs/ac): Total amount of elemental nitrogen applied through automatic or manual fertilization as set in the operation schedule
    k. Total P Applied (lbs/ac): Total amount of elemental phosphorus applied through automatic or manual fertilization as set in the operation schedule
    l. Total Irr Applied (in/ac): Total amount of irrigation applied through automatic or manual irrigation as set in the operation schedule
    m. STIR Tillage Value: Soil Tillage Intensity Rating based on tillage equipment used in the operation schedule.

STAR* *Systematic Tool for Analyzing Resources*

APEX Outputs Report

Conservation Plan: MikePlan **SAMPLE**

Date Created: 9/9/2015 3:18:36 PM

Summary of Field Inputs:

		Assessments		
Field Name		**MikeBase**	**AltTile**	**AltFilter**
Crop-1.0	Practices		Subsurface Drain	Filter Strip
	Op Schedule	Crop-1.0-MW_031215-Crop-1.0-Corn Silage \Corn,silage; No till, Z60	Crop-1.0-MW_031215-Crop-1.0-Corn Silage \Corn,silage; No till, Z60	Crop-1.0-MW_031215-Crop-1.0-Corn Silage \Corn,silage; No till, Z60
	Dominant Soil	Vergennes	Vergennes	Vergennes
	Field Acres	19.42	19.42	19.17
	Hydrologic Soil Group	D	D	D
	Slope	4.62%	4.62%	4.61%
	Slope Length (ft)	45.72	45.72	45.72
	Weather Station	BURLINGTON WSO A	BURLINGTON WSO A	BURLINGTON WSO A
	Avg Annual Precip (in)	36.43	36.43	36.43
	Total N Applied (lbs/ac)	109.89	109.89	109.89
	Total P Applied (lbs/ac)	39.26	39.26	39.26
	Total Irr Applied (in/ac)	0.00	0.00	0.00
	STIR Tillage Value	48.09	48.09	48.09
Filter	Practices			Filter Strip
	Op Schedule			Custom - Grass Filter Strip
	Dominant Soil			Vergennes
	Field Acres			0.25
	Hydrologic Soil Group			D
	Slope			0.03%
	Slope Length (ft)			10.00
	Weather Station			BURLINGTON WSO A
	Avg Annual Precip (in)			36.43
	Total N Applied (lbs/ac)			8.91
	Total P Applied (lbs/ac)			3.92
	Total Irr Applied (in/ac)			0.00
	STIR Tillage Value			1.08

9. The Summary of APEX Output section contains the data for the selected APEX parameters for each assessment and field.

STAR* *Systematic Tool for Analyzing Resources*

APEX Outputs Report

Conservation Plan: MikePlan

Date Created: 9/9/2015 3:18:37 PM

Summary of APEX Output

Apex Parameter	Field Name	MikeBase	AltTile	AltFilter
Total Outflow (inches)	Crop-1.0	6.96	3.82	6.68
Total Sediment Yield (t/ac)	Crop-1.0	10.81	6.88	3.19
Total Soluble P in Outflow (lb/ac)	Crop-1.0	0.14	0.06	0.13
Total Sediment P in Outflow (lb/ac)	Crop-1.0	5.24	3.24	2.14
Tile Drain Phosphorus Loss (lb/ac)	Crop-1.0	0.00	0.95	0.00
Total Soluble N in Outflow (lb/ac)	Crop-1.0	16.15	22.92	16.44
Total Sediment N in Outflow (lb/ac)	Crop-1.0	50.13	32.40	20.89
Tile Drain Nitrogen Loss (lb/ac)	Crop-1.0	0.00	15.23	0.00
Total Soluble Pesticide in Outflow (lb/ac)	Crop-1.0	0.00	0.00	0.00
Total Sediment Pesticide in Outflow (lb/ac)	Crop-1.0	0.00	0.00	0.00
Nitrogen Volatilization (lbs/acre)	Crop-1.0	14.24	14.62	14.31
Forage Crop Yield (t/ac)	Crop-1.0	4.92	4.94	4.94
Grain Yield (t/ac)	Crop-1.0	0.00	0.00	0.00
Drought Stress (days)	Crop-1.0	10.22	10.00	9.85
Phosphorus Stress (days)	Crop-1.0	0.00	0.00	0.00
Nitrogen Stress (days)	Crop-1.0	0.00	0.00	0.00

Total soluble N in outflow includes N in tile drainage. Total soluble P in outflow does NOT include P in tile drainage.

L. SIMULATING CONSERVATION PRACTICES

Conservation practices selected during Step 3 Field Practices Definition are summarized below. The Vermont implementation of STAR does not include practices marked with an asterisk (*). All other practices are available for both Texas and Vermont.

a. MANAGEMENT RELATED CONSERVATION PRACTICES
Conservation practices in this category are accomplished through the use of management practices that simulate the practices. Management practices are constructed in the Field Operations Definition section (Section H)

1. Nutrient Management (590)
Nutrient management is simulated by modifying nutrient inputs using the Fertilizer operation schedule editor. Fertilizers can be added, removed, or modified using the editor.

2. * Brush Management (314)
Brush Management is simulated by removing targeted woody species, yucca, and/or prickly pear from the operation schedule. The baseline assessment will be simulated using a management schedule which includes the unwanted species. The alternative assessment management schedule should not include these species or should include the species at a reduced density to simulate partial removal.

3. Conservation Crop Rotation (328)
Conservation Crop Rotation is simulated by creating a management schedule which includes two or more crops grown in succession over several years. See Section G: Planting for an example of how to set up a crop rotation.

4. Residue Management, No-till, Strip Till (329)
Residue Management is simulated by incorporating fewer tillage operations or operations that do not disturb the soil to a great extent. The tillage operations used should not exceed a STIR value greater than 30.

5. *Prescribed Burning (338)
Prescribed burning of crops can be applied using the Harvest/Kill tab in the operation schedule editor.

6. *Critical Area Planting (342)
Critical Area Planting is simulated by including plants in the management schedule that are suited for the site conditions and intended uses.

7. *Residue Management, Seasonal (344)
   Seasonal Residue Management is simulated by including tillage operations at the proper time and intensity to be consistent with the NRCS Conservation Practice Standards for leaving the required amount of residue on the surface for erosion control.

8. *Irrigation Water Management (449)
   Irrigation Water Management is simulated by including irrigation operations at the appropriate time and in the appropriate amounts to manage soil moisture for proper plant growth, minimize soil erosion, and reduce runoff and deep percolation.

9. *Forage Harvest Management (511)
   Forage Harvest Management is simulated by harvesting numerous times during the growing season to promote plant re-growth.

10. Pasture and Hayland Planting (512)
    Pasture and Hayland Planting is simulated by planting species that are well suited for the climatic and soil conditions of the site. Species which will meet the level of nutrition for the livestock should also be considered.

11. Prescribed Grazing (528)
    Prescribed Grazing is simulated by scheduling grazing practices to control the harvest of vegetation. Stocking rate should be considered for the amount of predicted available forage.

12. *Range Planting (550)
    Range Planting is simulated by planting species that are well suited for the climatic and soil conditions of the site. Species which will meet the level of nutrition for the livestock should also be considered. Planting density should be adequate to prevent excessive soil and water loss and improve water quality.

13. Pest Management (595)
    Pest Management is simulated by including pesticide operations in the operation schedule. Pesticide fate in runoff, leached, and degraded can then be looked at for each pesticide applied.

14. *Tree and Shrub Establishment (612)
    Tree and Shrub Establishment is simulated by planting tree and shrub species. Depending on the purpose of the establishment (timber, pulpwood, energy biomass), the density of the establishment and the years to harvest can be modified.

15. *Upland Wildlife Habitat Management (645)
    Upland Wildlife Habitat Management is simulated by planting species that will provide adequate forage for wildlife. Other conservation practices which could be included but not limited to Upland Wildlife Habitat Management include prescribed grazing (528), range planting (550), brush management (314), prescribed burning (338), nutrient management (590), filter strip (393), contour buffer strips (332), riparian forest buffers (391), riparian herbaceous cover (390), and windbreak establishment (612).

16. *Forest Stand Improvement (666)
    Forest Stand Improvement can be simulated by first simulating in the baseline assessment the species that are currently present on the site. An alternative assessment should only simulate the desired species composition and density. Both tree and grass species can be simulated in conjunction with each other. Grazing can also be simulated.

17. Cover Crop (340)
    Cover Crop is simulated by planting a species or suite of species suitable for the climatic and soil conditions of the site. Planting density should be considered for each species in the mix. Cover crops are usually killed by means of tillage or chemical operations. To accomplish this, a KILL operation should be included to simulate the destruction of the cover crop.

b. CONSERVATION PRACTICES REQUIRING A DIVISION OF FIELD AREA
   Conservation practices in this category are accomplished by splitting out the conservation area from the original field of interest. The division of field area will result in two or more subareas. The hydrological routing between fields is also defined by the user. (Section G)

   1. Grassed Waterway (412)
      Using the Field Split Editor delineate where the grassed waterway is located in the original field. Define the hydrological routing by selecting the area which the original field and grassed waterway drains to. Enter the width of the grassed waterway in feet.

   2. Riparian Forest Buffer (391)
      Using the Field Split Editor delineate where the riparian forest buffer is located in the original field. Define the hydrological routing by selecting the area which the original field and riparian forest buffer drains to. Enter the width of the riparian forest buffer in feet.

   3. Fence (382)

Using the Field Split Editor delineate where the fence(s) are located in the original field.

4. Filter Strip (393)
   Using the Field Split Editor delineate where the filter strip is located in the original field. Define the hydrological routing by selecting the area which the original field and filter strip drains to. Enter the width of the filter strip in feet.

5. Grade Stabilization Structure (410)
   Using the Field Split Editor delineate where the grade stabilization structure (GSS) is located in the original field. Define the hydrological routing by selecting the area which the original field and GSS drain to. Enter the width of the GSS in feet.

6. Gully (for use with Baseline Assessment ONLY)
   Using the Field Split Editor delineate where the gully is located in the original field. Define the hydrological routing by selecting the area which the original field and gully drain to. Enter the width of the gully in feet.

c. CONSERVATION PRACTICES REQUIRING MODEL PARAMETER MODIFICATIONS

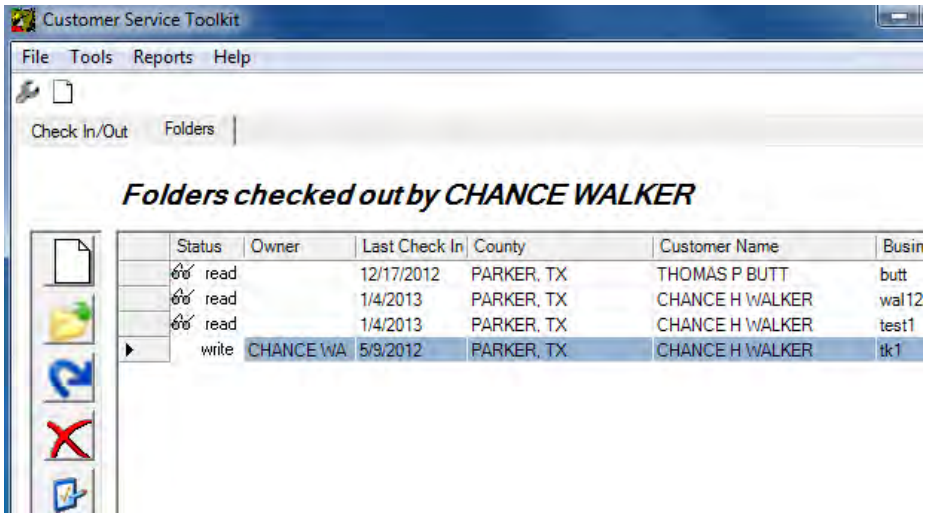
Conservation practices in this category are accomplished simply by selecting them for each field in the field practices editor screen. Once any of these practices are selected for a field, the model is automatically parameterized to simulate the practice. No additional action is required from the user. (Section G)

1. Contour Farming (330)
2. *Pond (378)
3. *Pipeline (516)
4. *Terrace (600)
5. *Watering Facility (614)
6. Waste Utilization (633)
7. *Irrigation System, Sprinkler (442)
8. *Irrigation Pipeline (430)
9. *Stripping Cropping (585)
10. *Contour Buffer Strips (332)
11. Diversion (362)
12. *Vegetative Barrier (601)
13. *Riparian Herbaceous Cover (390)
14. *Hedgerow Planting (422)
15. *Cross Wind Practices (589)
16. *Windbreak / Shelterbelt Establishment (380)
17. *Herbaceous Wind Barriers (603)
18. Field Border (386)
19. Subsurface Drain (606)

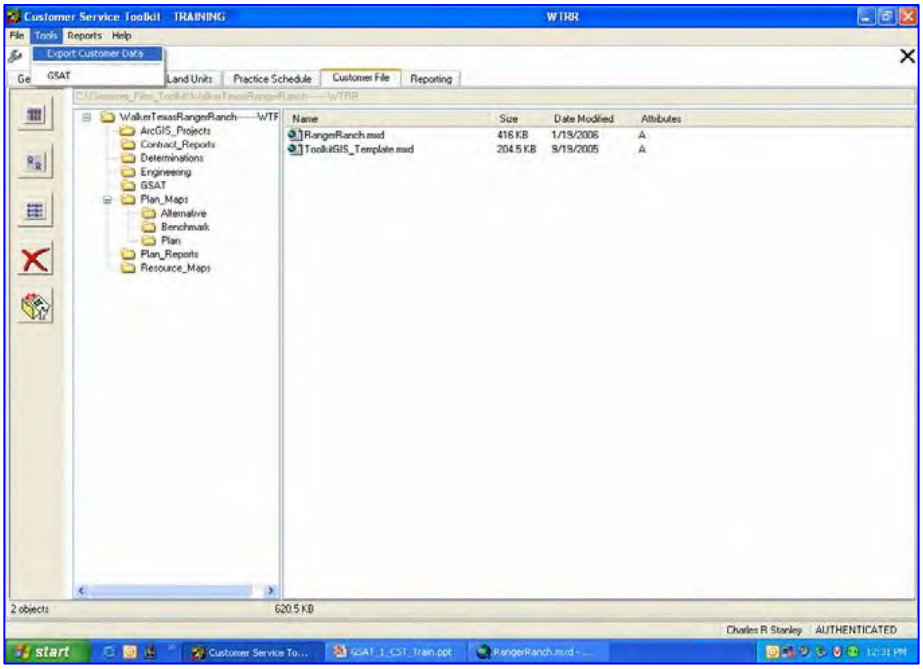
M. APPENDIX A: EXPORTING CUSTOMER DATA FROM TOOLKIT

The user can export customer data from Customer Service Toolkit such as the planned land units and practice schedule.

1. To export data from Toolkit, the user should check out the desired customer folder. Then click on the Folder tab and double-click the Customer to open the Customer File.



2. Select Tools from the Toolkit toolbar menu and select Export Customer Data



3. An Export Customer Data window will appear showing progress. Click the ***Close*** button when finished. The file will be save to the *C:\ Users \ <user.name> \ AppData \ Roaming \ USDA \ Toolkit5 \ SessionExportData* directory. This file can then be importing into STAR to create assessments.