NORTH DAKOTA
ENGINEERING PRACTICE PLANNING GUIDE
Sprinkler System Irrigation
4-26-2023

TYPICAL PRACTICE STANDARDS: 442 (Sprinkler System), 430 (Irrigation Pipeline), 533 (Pump), 587 (Structure for Water Control), 449 (Irrigation Water Management)

OVERVIEW

A conservation irrigation system is the complete arrangement of the delivery and application facilities needed to distribute irrigation water efficiently to all land served by the system. The conservation irrigation plan needs to provide a system of delivery, application, measurement, management, and disposal of water (if necessary) that is consistent with the soil, relief of the land, crops, and the management ability of the irrigator. Resource concerns may include water savings, water quality improvements to ground or surface water, soil health, energy savings, and erosion control. Additional goals of the irrigator, not related to resource concerns, may include saving labor, increasing crop yields, lowering production costs, and long-term productivity.

As with all engineering practices, the final plan must be completed or approved by an ND NRCS employee with appropriate Job Approval Authority (JAA) (per ND NEM 501 supplement). Design and Construction approval must be completed or approved by either a ND NRCS employee with appropriate JAA or by a non-NRCS registered professional engineer in ND per NEM 501, 505 procedures. However, even with appropriate JAA or PE registration, involving others in the planning and design process can provide a different perspective. The designer should always be involved with the planning process, no matter the planners' ability or authority. It is also useful to involve potential suppliers and/or contractors during the planning process to ensure consistency throughout the project, safeguard against changes later in the process, and to ensure the producer is aware of project cost estimate and their responsibilities.

REFERENCES

In addition to Section IV of the Field Office Technical Guide, the following are recommended technical references for planning Sprinkler Irrigation Systems and related practices:

- NEH Part 632, Irrigation
- NEH Part 634, Hydraulics
- NEH Part 652, Irrigation Guide
- NEH Part 650, Chapter 3 (Hydraulics) and Chapter 15 (Irrigation)
- NEH Part 636, Structural Engineering
- NRCS Irrigation Websites (national and North Dakota)
- Irrigation Training Toolbox
- NRCS Energy Estimator – Irrigation
- North Dakota State University Irrigation Website: https://www.ag.ndsu.edu/irrigation
- North Dakota Agricultural Weather Network Website: http://ndawn.ndsu.nodak.edu
- Utah NRCS YouTube Channel: https://www.youtube.com/user/UtahNRCS/featured
- PVC Pipe- Design and Installation, American Water Works Association Manual M23, Second Edition, 2002
- Handbook of PVC Pipe Design and Construction, PVC Pipe Association, 5th Edition, 2012
- PE Pipe – Design and Installation, American Water Works Association Manual M55, First Edition, 2006

- Handbook of Polyethylene Pipe, Second Edition, 2012
- Steel Water Pipe-A Guide for Design and Installation, American Water Works Association Manual M11, Fourth Edition 2004
- Air-Release, Air/Vacuum & Combination Air Valves, American Water Works Association Manual M51, First Edition, 2001
- Backflow Prevention and Cross-Connection Control Recommended Practices, American Water Works Association Manual M14, Fourth Edition, 2015

RESOURCE INVENTORY CONSIDERATIONS

Meet with the producer at the field site. Planning an irrigation system involves cooperatively working with a producer to look at their entire crop production area and water delivery system, not just a single field or portion of a system. Although the conversation may start by a producers' interest of installing certain practice on a specific field, the conservation planning process can help identify other conservation opportunities and priorities.

Soils Evaluation

Irrigation can pose significant risks for degrading the quality of some soils, resulting in a decline of crop yields or even necessitate abandonment of land for cropping. The current reference for soils irrigability in ND is the NDSU Extension Publication AE-1637 "Compatibility of North Dakota Soils for Irrigation", Franzen, Scherer, Seiler, 2013 which is available on the ND NRCS Engineering website, under the Irrigation section. Soils series are categorized into irrigation groups, and each group is categorized into one of three irrigation categories. Non-irrigable soils should not be irrigated by any water source under any circumstances. Irrigable soils can typically be irrigated through any water application method, with some unusual exceptions in the case of very poor water quality. Conditional soils may be irrigated without undue risk of soil quality degradation, only with certain combinations of water application, agronomic practices, and/or drainage systems. To obtain direct geospatial information for soils irrigability ratings, utilize the ND SWC MapService "Irrigation" layer. Alternatively, look through the soil series listed for each of the individual map units within the project area in Web Soil Survey, and correlate each of those to the tabular information in AE-1637. Typically map unit boundaries will be identical between the two sources. The NRCS Engineering SharePoint has a help sheet: How to Find Irrigability of Soils to assist with this.

Planning should include an evaluation of soils irrigability, as described above, in the following situations:

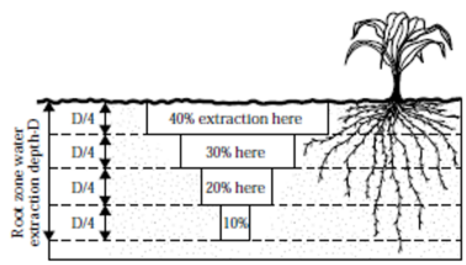
1. Proposals for a new sprinkler system on cropland not currently being irrigated.
2. Proposals for conversion from flood irrigation to sprinkler systems. In these situations, previous decades of flood irrigation may have served to effectively leach salts below the root zone. A typical furrow or graded border irrigation system in ND is designed to apply 6 inches of water per set, with those sets several weeks apart (typically 2-3 times per year). By comparison, center pivot or linear move systems are designed to apply only 1 inch of water but on a much more frequent basis (at peak crop use intervals of ~3 days are recommended). Over time, salinity in these fields will continue to build as a result of the fact that water is applied efficiently, i.e., in a manner that eliminates deep percolation.
3. Proposals on currently irrigated fields that exhibit signs of surface salinity (i.e., salt crusts, reduced plant vigor due to suspected salinity). Often this occurs where cropland is adjacent to an escarpment (i.e., steep uplands) or elevated irrigation canal where subsurface water movement affects the soil.

Projects that only involve retrofit of an existing sprinkler system, for example installation of zone control variable rate irrigation or conversion from high to low pressure nozzles, do not carry a risk of causing soil quality degradation as a result of their installation and therefore evaluation of soils irrigability is not necessary.

For proposals that meet any of the situational criteria (1-3) listed above, NRCS will make a risk determination prior to providing technical or financial assistance where the proposed irrigated acreage includes over 10% of conditional or non-irrigable lands. For these proposals, follow the guidance below:

1. Conduct field soil sampling and submit to the State Soil Scientist for evaluation or submit justification for not conducting field sampling by documenting that the following conditions are met. All four conditions must be met, typically, in order for sampling to be excluded:
    a. Cropland acres are irrigated by mainstem Missouri or Yellowstone River water,
    b. The proposed irrigated acreage is not adjacent to an escarpment (e.g., steep uplands) where subsurface saline water affects the soil,
    c. The proposed irrigated acreage is not adjacent to an elevated irrigation channel, and
    d. Soil salinity is not visible on the soil surface or evident in crop response (e.g., inconsistent crop height and/or droughty appearance).
2. When scheduling planning activities, be cognizant of the fact that soil sampling cannot be done when the soil is frozen (typically October 30).
3. Collect samples for each map unit within the proposed irrigated acreage, regardless of irrigability rating. Sample following the protocol described below:
    a. Sample one site per 40 acres of each soil map unit, or a minimum of 1 sample per 40 acres.
    b. Reference sample sites by use of GPS, or by reference to permanent landmarks.
    c. Sample soils at one-foot increments, or by major soil horizons, to at least 70% of the effective rooting depth of the deepest crop in the planned rotation. The table below, from NEH Part 652, Table 3-4 lists typical rooting depths, however onsite factors such as soil compaction, soil stratification, or groundwater tables often modify these. Verification of rooting depths in the field is therefore suggested.

Crop	Rooting Depth (feet)
Alfalfa	5
Beans, Dry	2-3
Corn	3-4
Grass pasture/hay	2-4
Potatoes	2-3
Sugar beets	4-5
Sunflower	4-5
Wheat	5



4. Send soil samples to a reputable lab, and request test results for EC and SAR (if sodic soils are present in the mapping unit). If only EC testing is deemed necessary, handheld field EC meter results are an acceptable alternative.
5. In central and eastern portions of the state, seasonally high groundwater tables may have a large impact on soil salinity (depending on the site, this may be positive or negative). If groundwater information is available directly from monitoring wells or from the USGS produced groundwater database, collect, and summarize that as well.
6. Send project summary, maps with sampling locations shown on them, soils lab test results, and water quality test results where applicable (see below) to the State Soil Scientist for evaluation. Staff with adequate technical expertise in soils may prepare a formal recommendation for the site, for concurrence by the State Soil Scientist.

Soils data from Web Soil Survey useful for planning and preliminary design of all sprinkler systems includes:

- Available water holding capacity (Soil Data Explorer-Soil Properties and Qualities-Soil Physical Properties)
- Hydrologic group (Soil Data Explorer-Soil Properties and Qualities-Soil Qualities and Features)
- Irrigation interpretations (Soil Data Explorer-Suitabilities and Limitations for Use - Water Management-Irrigation Sprinkler (General))

Note that the available water holding capacity listed in NDSU Extension Publication AE-1637 is an average for multiple soils. More accurate information can be obtained through Web Soil Survey using help sheet: How to Find Available Waterholding Capacity.

One issue to keep in mind, in terms of utilizing soil survey information for planning, is that it is designed to be used at a 1:20,000 scale and is intended to provide an indication of the dominant soil condition. The planner should be able to recognize issues in the field that do not correlate well with the data and interpretations in the soil survey. Get assistance from a resource soil scientist when such issues are recognized. Get assistance from a resource soil scientist if you are not comfortable using the soil survey. A resource soil scientist will be able to teach you how to correctly use the soil survey data and its related interpretations and will also spend time in the field teaching you how to develop an understanding of the soil/landscape relationships for the soils in your area of responsibility.

Water Quality Evaluation

Dissolved salts and/or sodium within irrigation water contribute to soil salinity and can cause crop yield loss or exacerbate existing soil quality issues as described above. Even in soils classified as irrigable, irrigation with poor quality water can generate long-term losses in production and soil quality. In North Dakota, both ground and surface water sources are known to have significant quality issues in regard to irrigation. The only sources of reliable overall water quality for irrigation in ND are those that originate from the main stem Missouri or Yellowstone Rivers (including irrigation districts that divert directly from those rivers). All other water sources should be tested, and the results compared per NDSU Extension Publication AE-1637 “Compatibility of North Dakota Soils for Irrigation”.

Planning should include an evaluation of a current water quality test, when planning sprinkler systems in the following situations:

1. Proposals for a new sprinkler system on cropland not currently being irrigated.
2. Proposals for conversion from flood irrigation to sprinkler systems. In these situations, previous decades of flood irrigation may have served to effectively leach salts below the root zone. A typical furrow or graded border irrigation system in ND is designed to apply 6 inches of water per set, with those sets several weeks apart (typically 2-3 times per year). By comparison, center pivot or linear move systems are designed to apply only 1 inch of water but on a much more frequent basis (at peak crop use intervals of ~3 days are recommended). Over time, salinity in these fields will continue to build as a result of the fact that water is applied efficiently, i.e., in a manner that eliminates deep percolation.
3. Proposals on currently irrigated fields that exhibit signs of surface salinity (i.e., salt crusts, reduced plant vigor due to suspected salinity). Often times this occurs where cropland is adjacent to an escarpment (i.e., steep uplands) or elevated irrigation canal where subsurface water movement affects the soil.

Projects that only involve retrofit of an existing sprinkler system, for example installation of zone control variable rate irrigation or conversion from high to low pressure nozzles, do not carry a risk of causing soil quality degradation as a result of their installation and therefore evaluation of water quality is not necessary.

Water quality varies both seasonally, and year to year, in both ground and surface water sources depending on rates of inflow (surface water precipitation, dam releases, aquifer recharge) and rates of withdrawals from the source. It is recommended, therefore, to take the water quality sample during the irrigation season and within 18 months of making a technical decision as to the feasibility of a sprinkler practice.

Estimates of thresholds and expected crop yield reductions are presented in Table 1-8 of NEH Part 623 Chapter 1 and are summarized for ND crops in the table below. They are rated as sensitive (S), moderately sensitive (MS), moderately tolerant (MT), and tolerant (T) to salinity. Note that this is for EC of saturated soils, not the applied irrigation water:

Crop	EC Threshold (dS/M)	Percent Yield Reduction per each 1 dS/M above Threshold	Rating
Barley	8.0	7.0	MS
Corn	1.7	19.0	MT
Flax	1.7	12.0	MS
Soybean	5.0	10.0	MT
Sugar beet	7.0	5.9	T
Wheat	6.0	7.1	MT
Wheat, Durum	5.9	3.8	T
Alfalfa	2.0	7.3	MS

Converting irrigation water EC to expected soils EC is dependent on the leaching fraction of the proposed irrigation system. Leaching fraction is simply the percentage of water lost to deep percolation versus water that will remain in the root zone. For flood systems, NRCS typically would estimate that utilizing the WinSRFR software on the existing systems in conjunction with date from the soil survey for intake and available water holding capacity. Depending on soils, field grade, and irrigation lengths that leaching factor typically ranges from 15-30% for a surface irrigated system. Installation of a wheel line will typically result in the ability to obtain a leaching fraction of 15% with maximum application depths of 6 inches per set. Center pivot and linear move systems, with maximum application depths of 1.5 inches per set are not effective at leaching. The chart below from “Agriculture Salinity and Drainage” can be used to roughly estimate the change in leaching due to conversion from flood to sprinkler systems.

For example, say you are evaluating the impacts of switching from flood to sprinkler (pivot) on sugar beets. The average of EC from soil tests in the field is 5.0 dS/M, while the EC of the water is 3.0 dS/M. The system is currently furrow irrigated, and when you run the field slope, border length, soils intake group for the application depths of the current system through WinSRFR you get a deep percolation estimate of 20%. From the chart below, an irrigation water EC of 3.0 dS/M at a leaching rate of 20% would have estimated soil EC in the 4.3 dS/M range. (Not too far off, and some salinity may not be solely from the irrigation water itself of course.) By switching to a pivot, that deep percolation value will effectively drop to 0% unless the pivot is operated after a summer rainstorm that fills the soil profile. Going from a 3.0 dS/M water EC, up to 5% leaching fraction, yields an expected long-term soil EC of 8.2 dS/M. Using the chart above, that would generate an estimated production loss of (8.2-7) x5.9= 8.3 bu./ac. over the long-term (8-10 years). In locations where unlimited water supply is available, and crop needs can be fully met by irrigation, some additional leaching may be done to lessen these impacts, but a plan would need to be developed of how much water would need to be applied for a leaching event. Those would be estimated based on available water holding capacity of the soils and local precipitation data.

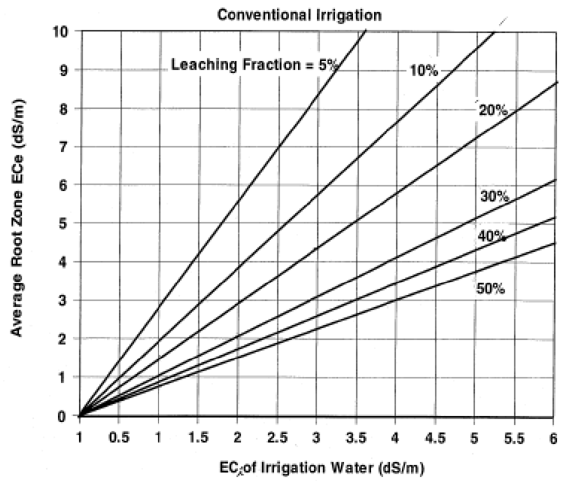


Figure 1. Assessing the maintenance leaching fraction under conventional irrigation methods.

AGRICULTURAL SALINITY AND DRAINAGE
Maintenance Leaching

The sodium absorption ratio (SAR) is a measure of the abundance of sodium relative to the abundance of calcium and magnesium in water and is directly related to the amount of sodium that is absorbed by soils. A high SAR in irrigation water has the potential to damage soil structure, reducing permeability and crop water availability. This surface crusting phenomena is particularly an issue when the EC of the applied water is insufficient to counteract the negative effects of adsorbed sodium on soil structure. Again, this is a concern even on good soils (i.e., those classified as "irrigable" in the publication listed above). The chart below provides guidance when water quality alone poses a risk in this regard:

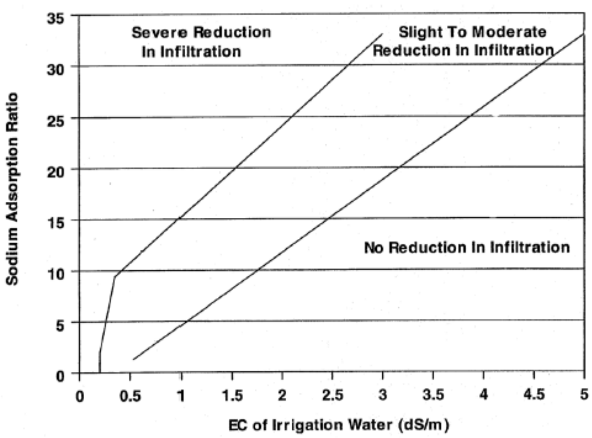


Figure 2. Relationship between EC and SAR and the effect on infiltration of water into the soil (Hanson, et al., 1999)

Evaluate Crop Water Needs, Water Availability

Utilize the NRCS Irrigation Water Requirements (IWRpm) software, with ND databases, for the nearest weather station and crops in the planned rotation. Utilize the FAO Penman-Monteith method NEH2 for ET computation, do not change the default precipitation ratios, and in general do not change the humidity/wind condition that loads for the selected weather station (unless there is truly an unusual microclimate present at the site). For center pivot and linear move systems, typically utilize a net irrigation depth of 1 inches and carryover of 0.5 inches at both the beginning and end of the season. Set surface soil and irrigation type for the site and proposal. Do not change fraction wetted or water stress factor. If planting and harvest dates do not load for the combination of weather station and crop selected, reference the ND Engineering NRCS SharePoint for recommended planting/harvest dates to use by zone.

Evaluate the summary reports for the peak consumptive use, average net irrigation requirement, dry and normal year conditions, for each crop in the proposed rotation. Based on the proposed system efficiency, compute the gross water requirement for the system. Compare water requirements with that available from the water permit, to confirm feasibility of the project. The NRCS Engineering SharePoint has a help sheet: How to Look up Water Permits to assist with this. If the system is within an irrigation district, it will be operating under an overall water permit for the entire district- therefore allotted shares and/or system capacity will typically be the limiting factors. In an irrigation district, water may not be available on demand, therefore it is important to investigate the frequency of water availability to evaluate the feasibility of a sprinkler system. In some cases that issue may be solved by relocating the intake from a lateral to a main canal.

For irrigation systems off groundwater wells it is useful to evaluation long-term groundwater monitoring records in the design/evaluation of pumps. A USGS groundwater model for central/eastern ND should be used, where data is available, to obtain an estimate of operating conditions.

Field Inventory/Producer Interview

NEH Part 652 has irrigation system inventory worksheets (Chapter 10, Page 10-15) that may be helpful reminders of what questions to ask, and what information to gather in the field. The following is a summary of some of the key inventory items for planning new installation, or retrofit, of sprinkler systems.

- Irrigation history. Records to show that irrigation has occurred 2 out of the last 5 years on the acreage proposed for inclusion in the new system is an eligibility requirement for EQIP (440-515.52). In addition, the actual history of irrigation on the property, O&M issues, water usage records, and other pertinent background information can be extremely useful in planning.
- Determine and document resource concerns. The producer may be concerned about yield, productivity, costs, labor, ability to rent the land, etc. However, for farm bill program participation there must be a conservation benefit and identifying the resource concern is the first step in developing alternatives that result in a conservation benefit. Typical resource concerns may be insufficient use of irrigation water, groundwater quality, soil quality, and soil erosion.
- Existing supply infrastructure. Document location, dimensions, and other pertinent technical information of delivery ditches, control gates, wells, pipelines, pumps, and power supply. In the case of existing sprinkler systems, determine current nozzle size, spacing, and condition. Conduct a catch can test to field determine uniformity if appropriate.
- Pumping plant evaluation. If appropriate, NDSU Extension has the equipment and personnel to assist onsite with this.
- Existing drainage infrastructure. Document existing surface and subsurface drainage facilities including existing ditches, underground drains, sources of water, problems associated with poor drainage, determine if poor drainage is a result of mismanagement or natural causes.
- Existing water measurement infrastructure. Document location of existing water measurement devices such as weirs and flowmeters. Find out how these are currently being used to inform management decisions.
- Site characteristics.

    - Determine high and low point in the fields to be irrigated (either from LiDAR or survey)
    - Observe if erosion is occurring with the current system
    - Determine physical features that could affect the system such as location of access roads, utilities, oil wells, etc.
    - Identify any potential wetland areas within the planning area. If there are wetlands present in the planning area of a new pivot, notify producer of possible minimal effect needed for travel ways.
    - Identify possible water pollution sources and floodplains hazards.
    - Discuss management such as tillage system, use of cover crops, crop rotation, etc.
    - Determine the amount and skill of labor available. Observe the level of present farm management.
    - Determine the availability and costs of energy sources. If a new pump is planned, will it be powered by diesel, natural gas, gasoline, or electrical engines?
- Future Goals
    - Discuss future plans. Will additional irrigation infrastructure or modifications be potentially installed in the future?
    - How will field corners be managed? (Irrigated with new system, irrigated with existing system, left fallow, converted out of cropland, etc.).
    - If ditches or streams are adjacent to, or within the fields, will they be closed after a new system is installed or will crossings need to be installed?
- Management of a New/Improved System
    - Discuss how the producer plans to manage a new system
    - Discuss Irrigation Water Management and options for the producer to monitor site conditions throughout the irrigation system which will enable them to manage the irrigation system with more precision.
    - If EQIP is being considered, discuss IWM requirements to determine what level of management the producer will be comfortable with and if they are willing and able to meet the EQIP requirements.

Existing System Evaluation

Analyze the existing system for conformance with applicable NRCS standards, and its effectiveness in supplying crop water needs (as outlined in the previous section). The following is a list of some typical items requiring evaluation, and recommended technical tools to complete the analysis (see NEH Part 652 for additional technical background):

- Surface irrigation efficiency and design flow requirements- furrow, graded border, or level basin. IWR for highest water use crop in rotation and WinSRFR.
- Surface irrigation efficiency and design flow requirements for gated pipe. IWR for highest water use crop in rotations, WinSRFR, and AgPIPE
- Surface irrigation field leveling. LandImprove (would need to “borrow” from MT NRCS, this is kept on an offline laptop at the Glasgow Field Office) is the best tool that will optimize the grading. Alternatively, many tedious alternatives may be run though LandImprove.
- Center pivots and linear move flow rate requirements. IWR for highest water using crop in the rotation and ND Pivot Analysis excel sheet. (Note CPED will generate the predicted flow rate from a system, after

entering system info including nozzles) This can then be compared against the flow rate needed to meet peak consumptive use requirements of the crops.

- Center pivot nozzle uniformity. Catch can test (can borrow supplies from NDSU). If nozzles are new can also use CPED excel sheet
- Center pivot erosion potential. CPNozzle or CPED excel sheet
- Wheel lines and handlines. MT NRCS Wheel/Hand Line excel sheet
- Delivery capacity through open ditches, gates, weirs, culverts. HEC-RAS, NRCS Hydraulics Formulas, HY8
- Pressurized pipeline hydraulics. ND Pipeline Hydraulics with Surge Analysis
- Pressurized pipeline networks (typically used for multiple wells/pumps supplying multiple sprinklers). EPANET
- Open channel flow condition pipeline hydraulics. MT NRCS OpenPipe excel sheet
- Air/vacuum control and pipe stability Structural Design of Flexible Conduit – Plastic Pipe ND NRCS excel sheet
- Evaluate pumping plant efficiency.

    - Use manufacturer pump curve information from the pump and motor (may not be accurate for an older installation due to wear and tear)
    - Alternatively do a pump test in the field to develop a pump curve. ND NRCS owns a clamp on flow meter as well as a tool that will measure wall thickness of pipe that can be used in combination with a quality pressure gauge to generate an onsite pump curve through varying motor speed on a diesel drive/PTO pump directly or by throttling the valve at the pump.
    - Develop a system curve via survey/pipe data and the ND Pipeline Hydraulics with Surge Analysis.
    - Overplot system and pump curves to evaluate efficiency.
        - The Central National Technical Center (CNTC) Pumping Plant Evaluation and Energy Use Estimator can assist with generating over plot and total seasonal cost estimates for the existing pumping plant versus proposed changes.
        - Evaluate whether a VFD could improve efficiency by use of the CNTC VFD Economic Efficiency Spreadsheet.

Determine whether resource concerns may be met with improvements to the existing irrigation system, or installation of alternatives other than sprinkler systems, such as:

- Land leveling
- Resizing or relocating delivery ditches
- Converting open canal/ditches to buried pipe to eliminate seepage losses
- Converting field ditch (siphons or cuts) to gated pipe (with or w/o surge valves)
- Canal/ditch lining with EPDM or concrete to reduce seepage losses
- Renozzling pivots to a more efficient package, or one that will minimize erosion
- Installing variable rate nozzle packages where variable site conditions warrant
- Installing subsurface irrigation systems
- Other systems such as microirrigation or solid set sprinklers on specialty crops

DEVELOPING AND EVALUATING ALTERNATIVES

Each irrigation project is unique, to some extent, but below are some of the common steps involved in completing preliminary design work on alternatives.

a. Preliminary Design
    - ✓ Utilizing orthophotos and topographic data in AutoCAD or ArcMap, determine potential system layouts in relation to the fields, water sources, power lines, and other infrastructure. Be cognizant of the NRCS EQIP policy limitation on bringing previously non-irrigated ground under irrigation. For possible VRI conversions look at soils and exclusionary areas to determine feasibility to match policy as well if speed control could be used as an alternative.
    - ✓ Develop layout maps to provide to the producer to show alternatives. Need to show existing system, ditches, laterals, water flow paths, proposed layout of key components for each option, ditches to close, etc. If dealer has already given them 1 option, show them other options as are appropriate to the site.
    - ✓ Compute the required peak flow rate for potential layouts, utilizing the Pivot Analysis design spreadsheet or other tools (see above) and IWR information for peak consumptive use requirements.
    - ✓ Size (or evaluate existing) pipelines, ditches, pumps, inlet structures, and other infrastructure that would be required for each potential layout. If necessary, complete a field survey to acquire adequate elevation data for the preliminary design work. Run preliminary pipeline hydraulic computations.
    - ✓ Evaluate pump / motor alternatives as appropriate. Note that the OR Pumping from a Sump excel tool can be utilized to check feasibility per NPSH criteria for suction intake layouts.

b. Complete a Benefit Analysis for Alternatives and provide to producer
    - ✓ Evaluate electricity, fuel, labor, etc. needed for long-term operation and maintenance of alternatives.
    - ✓ Develop an estimated quantity list for each option, and construction cost estimate as possible. Provide program payment estimate for alternatives as well.
    - ✓ ND NEM 510 – Planning requires a +/-20% degree of accuracy for expected materials, quantities, and actual construction costs.
    - ✓ Compute estimated water savings for each alternative utilizing the Farm Irrigation Rating Index spreadsheet (FIRI).
    - ✓ Compute estimate energy savings for a potential VFD if multiple flow conditions will exist on the system utilizing the "VFD Economic Calculator" spreadsheet.

c. Preliminary Package for Producer
    - ✓ Create a preliminary package for the producer to review. Include the layout maps showing the alternatives, example detail drawings, photos, and/or portions of construction specifications what would be similar to the proposed project. Include the estimated quantities, cost estimates, and estimated program payments (i.e., EQIP payment) if applicable.
    - ✓ Determine the Job Approval Class for each practice. If you do not have adequate Job Approval Authority (JAA), have someone with adequate JAA review and approve your work.

d. Meet with the Producer
    - ✓ Explain what following NRCS standards and specifications means in relation to construction of the project.

- ✓ Review each of the alternatives, discuss factors important to them choosing an alternative such as: installation requirements, initial investment, operating costs and time requirements, lifespan, and maintenance needs.
- ✓ For high dollar projects, encourage the producer to take the estimated quantity sheet to potential suppliers for construction cost estimates.
- ✓ In the case of a program application, it is important that producers understand exactly how implementation would proceed and what restrictions they will operate under. Ensure that they understand that used materials are not acceptable (with a few exceptions), licensed well drillers and pump installers must be utilized (with some exceptions on tribal lands), no construction may proceed until they have received final design drawings and specifications, and that NRCS will be onsite inspecting during construction to ensure compliance with the design.

e. Producer Decision/Lack of Decision

Provide adequate time for the producer to make an informed decision. If they don't have time to meet to discuss alternatives, they likely haven't had time to adequately complete a good decision-making process resulting in commitment to implement the plan. Offer and be willing to defer an application, to allow time for a quality planning process and good decision making on the part of the producer. Don't forget to provide documentation of all the above steps in the conservation assistance notes!

FINAL DESIGN

Each irrigation project is unique, to some extent, but below are some of the common steps involved in completing final design work on alternatives.

Design Calculations

- Review preliminary design, refine calculations as necessary, incorporate producers input from preliminary design.
- Design final pipe materials, pipeline alignment, pipeline profile, and specify pump requirements. Consider net positive suction Head (NPSH) for pumps running at atmospheric pressure (use "Pumping from a Sump" spreadsheet or hand calculate).
- Identify locations for air valves, pressure relief valves, pumpouts, flow meters, pressure gauges, and drains.
- Compute and evaluate surge pressures if necessary (design velocities >5fps or fast closing valves such as lever action butterfly valves)
- Design pipe backfill and trench based on NEH structural requirements and industry guidelines (use Structural Design of Flexible Conduit – Plastic Pipe ND NRCS excel sheet or hand calculate).
- Calculate net positive suction Head (NPSH) for pumps running at atmospheric pressure (use "Pumping from a Sump" spreadsheet or hand calculate).
- Thrust Block design (use Structural Design of Flexible Conduit – Plastic Pipe ND NRCS excel sheet or hand calculate).

- Complete design report summarizing the inputs and outputs (required by NEM 511 for JC IV and higher)

- Complete an inspection plan summarizing activities required during inspection, designating specific personnel to do them (required by NEM Part 512 for JC IV and higher)

- Complete an O&M Plan providing guidance to the producer for seasonal startup/shutdown (draining) procedures,

- Complete an Irrigation Water Management Plan, utilizing the ND IWM Templates, providing guidance to the producer on taking field moisture measurements, tracking water application amounts, pulling precipitation/evapotranspiration data, recording data. Ensure that FO staff are present, and fully understand their role in working with the producer to ensure successful IWM on the system.

Final Design Package

<u>Drawings</u>

- Cover Page
  - General Notes, Quantities, location, JAC/who has JAA for each practice. (There is no such thing as "controlling job class", that was an error on an old ND NRCS standard cover sheet)

- Plan View
  - Pipeline location
  - Irrigation system location
  - Show where end guns/swing arms come on and off (if applicable)
  - Survey control points and stakeout notes for pipelines and structures
  - Planned zones and/or shutoff areas for VRI systems
  - Disclaimer "Pivot Points to be chosen by the pivot dealer. NRCS location stake is an approximation only."

- Profile of Pipeline
  - Must drain out or pump out (can't blow out large diameter pipeline)
  - Add note: trench must be left open for inspection, or similar.
  - Station/invert elevation data for the contractor/inspection staff to follow

- Detailed Drawings
  - Inlet structure, pivot point, pumping plant, trench, thrust blocks, risers, etc. Gravity inlets require special engineering design considerations. Screening/bubblers installed at pipeline inlets also require special design.
  - Pressure relief valves – typically one always installed at the pump. If multiple pivots are on the same pump, place pressure relief valves at each pivot. Where closed conditions may exist (i.e. shutoff valves out the line to branch lines or other systems) a combination PRV/2-way Tri-Axial valve typically installed on the pump side of the shutoff valve.
  - Air/Vacuum relief valves – typically a 3-way always at the pump, and on any summits.

Construction Specifications

- ENG-1 completed and filled out
- All relevant construction specifications, with detailed project specific requirements
- ENG-533 if appropriated, NRCS portion filled out

Design Report, Construction Inspection Plan

- Required for Job Class IV and above projects, see requirements in GM 210, Part 511, Subpart B

Operation and Maintenance Plan

- Subsection for each practice, filled out specific to the project

CONSTRUCTION

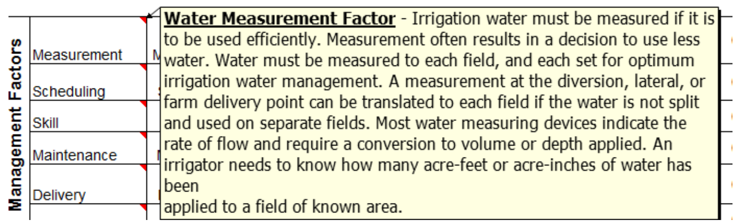
- Complete preconstruction conference with contractor and producer.
- Collect and document the ND One Call ticket number.
- Stake proposed pipeline and structures.
- Proposed Pump. Obtain a copy of the pump curve and evaluate all potential operating conditions for the pump (with and without swing arms and endguns running, for example) against NRCS Conservation Practice Standard 533 – Pumping Plant requirements.
- Proposed Nozzle Package
    - Check CU and potential for runoff
        - Can use dealer printout from CPED if provided or complete a CPED evaluation on the proposed nozzle package.
        - Use CPNOZZLE, or NEH tables, to check on runoff potential.
- Check pipeline materials, trench bedding/backfill, structural components, and valves against design requirements. Evaluate any proposed used materials based on NEM 512.
- Check pipeline during construction to ensure it is installed to design grade. Check bedding, deflection angles, backfill material & compaction, thrust blocks… etc.
- Ensure that state laws regarding electrical inspections and certified pump installers have been met and obtain documentation on ND-ENG-533.
- Complete As-Built drawings and final quantities

North Dakota Guidance for using FIRI

A fresh spreadsheet should be downloaded from the Water Management Engineering SharePoint every time!
https://ems-team.usda.gov/sites/NRCS_ST_WNTSC/coreteam/engineering/WME/ISoft/_layouts/15/start.aspx#/Excel/Forms/AllItems.aspx

You can use the sync feature on sharepoint to ensure your downloaded version to up to date. See instructions at the end of this guide on how to use the sync version.

The spreadsheet is loaded with help tips! Cells that have a red triangle in the upper right corner have comments. Hoover over the cell with a red triangle to show the tips.



The Factors tab lists the choices for each drop down. Listed below are the selections and definitions typically found in ND irrigation projects, and guidance for use of FIRI. Unique circumstances may certainly require additional consideration.

Irrigation Type

Efficiency	Definition
60%- see notes	Flood, Controlled (flood systems on fields without borders)
80%- see notes	Border, Graded Border (flood systems on fields with borders)
75%- see notes	Furrow, Graded Furrow (flood systems on fields that are furrow irrigated)
80%- see notes	Furrow, Surge (flood systems on furrow irrigated fields with surge valves)
60%	Sprinkler- Big Gun
70%	Sprinkler- Hand Line or Wheel Line
85%	Center Pivot- MESA (typical ND center pivot with drops/nozzles 4-6 above ground)
87%	Center Pivot- VRI
87%	Lateral Move- MESA (typical ND linear move)

Actual irrigation efficiency on flood systems is extremely sensitive to soils intake family, border width, slope, roughness, and length in the direction of irrigation. The default figures in FIRI for graded border and graded furrow systems are higher than typical ND surface irrigation systems. The preferred methodology for determining application efficiency is to utilize WinSRFR to model the surface irrigation system. Alternative, NEH Part 623 Chapter 2, Table 2-49 (furrow) or Table 2-51 (graded border), may be utilized with the typical application depth of 4 inches for a rough estimate. The addition of surge valves to a surface irrigation system (gated pipe delivery) may be assumed to add an additional 25% efficiency to a <u>well-designed</u> system in intake groups >= 0.7.

*Water Measurement Factor – **(M)***

M Factor	Definition
0.93	Whole farm manually recorded.
0.95	Whole farm automatic recorded.
0.97	Whole farm plus individual field manually recorded.
1.00	Whole farm plus individual field automatically recorded.

Manually recorded = measurement devices on conveyance systems that provide instantaneous rate of flow information only (i.e. weirs, flumes, calibrated staff gages, pressure transducers, or flow meters without a totalizing function). In these cases, the operator has to keep side records of application times and rates to be able to quantify total volume applied.

Automatically recorded = measurement devices that include a totalizing function- typically flow meters. The same factor applies whether or not the meter has telemetry.

Whole farm = the measurement device will not indicate how much water is being applied to an individual field. For example, a flow meter at a pump that serves multiple pivots or a weir at the headgate of a ditch system that serves multiple fields.

Individual field = the measurement device will indicate how much water is being applied to an individual field.

To meet ND NRCS practice standard requirements, the planned condition for all projects should be M=1.

*Soil Moisture Monitoring and Scheduling Factor – **(S)***

S Factor	Definition
0.9	The operator irrigates without regard to indicators listed below either by choice, or due to the fact the irrigation district supplies water on a prescheduled rotating basis among users.
0.94	Visual crop stress. The operator irrigates when visual observation indicates plants are stressed and/or by soil moisture feel and appearance.
0.95	Checkbook/soil moisture by NRCS feel method. Equivalent to Basic IWM, the operator digs holes and utilizes both feel and appearance to estimate and record % moistures at 1 foot intervals. The operator utilizes a manual checkbook scheduling method.
0.97	Irrigation scheduling via regional weather network. Equivalent to Basic IWM and using the NDAWN online checkbook scheduling method.
0.98	Soil moisture using gypsum blocks, moisture probe, etc. Equivalent to Intermediate IWM and using the NDAWN online checkbook scheduling method, or Advanced IWM without telemetry.
1.0	Continuous measurement of soil moisture, water applied, and ET. Equivalent to Advanced IWM with telemetry capability.

To meet ND NRCS practice standard requirements, the planned condition for all projects should be S>=0.95.

*Irrigation Skill and Action Factor – **(I)***

I Factor	Definition
0.8	Significant over-irrigation. The operator has been significantly over irrigating, i.e., applying over 10% additional water than peak consumptive use and system efficiency dictates. This may be due to his management, or the physical infrastructure of his existing system.
0.92	Good lack of full attention. The operator has not been significantly over irrigating but is not following an IWM plan.
1.0	The operator is following an IWM plan.

Determination of whether the producer has been significantly over irrigating or not, will be made based on the inventory and evaluation work described previously in this guide. In many cases, infrastructure and management improvements will raise this factor from a 0.8 to a 1.0.

*Maintenance Factor – **(M)***

M Factor	Definition
0.9	Poor. Major components of the system are inefficient due to lack of maintenance. Heavy woody vegetation in ditches, >10% loss through leaking headgates or pipe, unsuitable equipment for the site, etc. Repairs occur only when there is a major breakdown.
0.94	Fair. Minor components of the system need maintenance however overall efficiencies are not substantially impacted. Moderately overgrown ditches, minor leaks, worn nozzles, fields that need touch up leveling. Occasional repairs are made.
0.98	Good. Maintenance and repairs occur annually, and the overall system is in good condition.
1.0	Excellent. Maintenance occurs regularly throughout the irrigation season and the overall system is in excellent condition. Even minor repairs are attended to immediately.

To some extent, this factor reflects on the operator's priorities and available time. Those factors are not likely to change. In some cases, however, a planned infrastructure change to a more convenient or more easily maintained system will guarantee an improvement to some degree.

*Water Delivery Factor – **(D)***

D Factor	Definition
0.90	Arranged- Limited Rate. Irrigation water is available subject to a delivery request (typically to an irrigation district) by the operator. Both timing and flow rate are out of the control of the operator. Typically, the case for ND irrigation districts.
0.98	Demand- Limited Rate. Irrigation water is available at any point in time, but at a rate that does not meet crop PCU. May be the case for wells or pumps/diversions located on large rivers in ND, with either water permit or delivery infrastructure limitations.

1.0	Demand- Unrestricted. Irrigation water is available at any point in time, and at a rate that meets crop PCU. Typically, the case for wells or pumps/diversions located on large rivers in ND, so long as the water permit is adequate.

Unlimited = No restrictions and is under control of user.
Limited = Maximum flow rate restricted by physical size of outlet/supply.
Arranged = Days, flow rate conditions, and duration are arranged (negotiated by supplier to operator).
Constant = Conditions of rate and duration remain constant as arranged.
Fixed = Conditions remain unchanged during the season.

*Soil Condition Factor – **(Sc)***

Utilize SCI as calculated by RUSLE / IET. This factor should only change between the present and planned conditions if there is planned changes to the rotation.

*Water Distribution Control Factor – **(Wc)***

Wc Factor	Definition
0.9	Very poor diversion facilities, little control of flow rate to farm. This is rare situation and would be limited to instream diversions without an associated headgate.
0.94	Can control flow rates to farm, but the on-farm delivery system is such that Diversion facilities allow the operator to control the rate of flow at the inlet to the system (i.e., adjust the headgate or pump), but do not allow flow control to each field. An example would be a single diversion at a headgate, with delivery ditches that branch to individual fields without check structures or gates for controlling flow. Not common in ND.
0.98	Flow rates to each field are adequately controlled. Flow rates to each set are difficult to control. This is a fairly common situation with systems that rely on open ditches with ditch cuts, dams, or culverts to deliver to the field.
1.0	Diversion facilities allow the operator to control the rate of flow at the inlet to the system, allow flow control to each field, and allow flow control to each set. Typically, all types of sprinkler irrigation, gated pipe, and siphon tubes (so long as there are enough and are not oversized) meet these criteria.

*Conveyance Efficiency Factor – **(Ce)***

The factor is intended to account for water savings from closing irrigation delivery canals or ditches as a result of the project. Closing of tailwater ditches should not be included. Rather than entering the total length of ditches and pipelines in the delivery system, it is customary to simply enter the length of ditches that will be eliminated through the project as the present condition, and then simply enter zero for the planned condition.

A linear relationship between ditch length and seepage, by soil type, neglects the factors of flow rate and wetted perimeter of the ditch. Therefore, to compute more accurate water savings figures utilize the alternative method outlined in FIRI.

*Land Leveling Factor – **(L)***

This factor will trigger for a surface irrigation system type only. The following table provides a summary of the classes:

Class	Irrigation slope 1/	Cross slope	Possible irrigation water efficiencies	Irrigation operation labor requirement	Method limitations
A_1	Uniform but not more than 0.05 percent	None	High	Very low	None
A_2	Uniform				Length of level borders is restricted.
B_1		Uniform but not more than 0.3 percent			Length of level borders restricted. Border widths are restricted.
B_2		Variable but not more than 0.3 percent		Low	
B_3		Either uniform or variable and more than 0.3 percent but not more than 0.5 percent		Moderately low	Border widths are very restricted. Level borders not permissible. Shallow furrows not permissible on coarse or very coarse-textured soils. Corrugations must have down-slope of at least four times cross slope.
C_1	Fairly uniform - (When slopes are over 0.5 percent, convex slopes have maximum grades not over twice minimum; concave slopes have maximum grade not over 1 1/2 times minimum. Undulating slopes not permissible.)	Uniform or variable but not more than 0.3 percent	Good		Level borders not permissible. Border widths are restricted.
C_2		Uniform or variable but not more than 0.5 percent			Border widths are very restricted. Level borders not permissible. Shallow furrows not permissible on coarse or very coarse-textured soils. Corrugations must have down-slope of at least four times cross slope.
C_3	Either uniform or fairly uniform as defined above	Either uniform or variable and more than 0.5 percent		Moderate to high	Applicable only for contour ditches or to cross slope or contour furrow irrigation within special limitations of furrow depth and soil texture.
D_1	Variable but without level reaches or reverse grades	Variable but not more than 0.3 percent	Poor	Moderate	Border widths are restricted. Level borders or corrugations not permissible.
D_2		Variable but not more than 0.5 percent		High	Border widths are very restricted. Level borders or corrugations not permissible. Shallow furrows not permissible on coarse or very coarse-textured soils.
E		Variable and more than 0.5 percent	Very poor	Very high	Applicable only for contour ditches or furrows within special limitations of furrow depth and soil texture.

L factors within FIRI are set on the following basis:

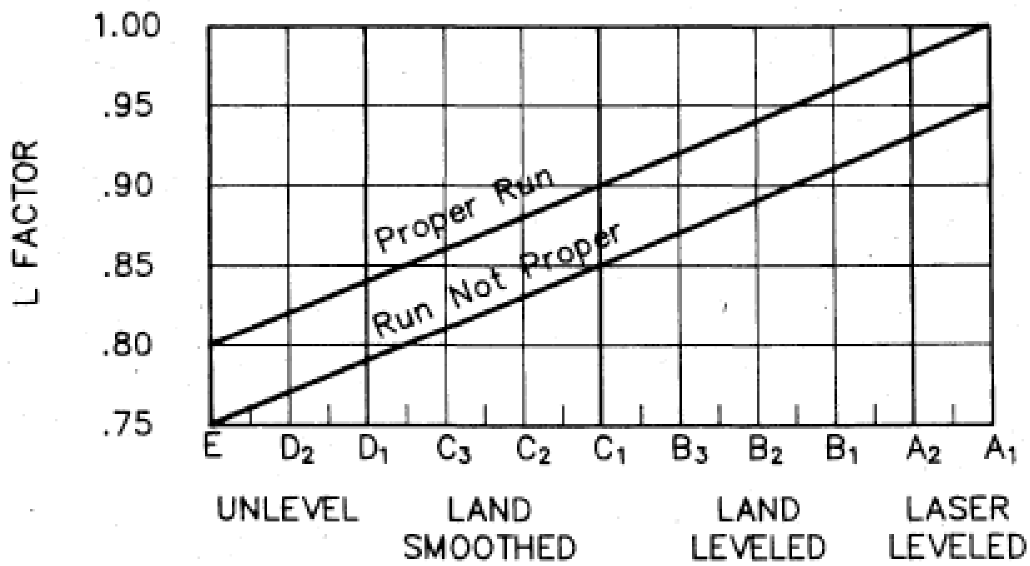


Fig. 9 — Land Leveling Factor

*Tailwater Reuse Factor – **(R)***

Irrigation systems in ND do not typically incorporate tailwater reuse (i.e. tailwater is not reapplied on the same field it is collected from by means of a collection reservoir/pump system), so this factor should be 0% for both the present and planned conditions.

*Climate Factor – **(C)***

This factor only applies to sprinkler systems and is based on the peak daily ET value. Choose the closest available based on IWR for typical crops in the rotation.

*Wind Factor – **(W)***

Use a design wind speed of 4-10 mph, unless special site conditions warrant. The definitions for spray type are not well defined so “medium” will be used for most wheel lines and pivot installations. Non-Spray could be used for a LEPA pivot system. Coarse would be used for a big gun system.

*Sprinkler Design Factor – **(Sd)***

The following table provides summary of options for this factor:

Sd Factor	Pressure Variation	Nozzles	Distribution Uniformity
0.86	+/- 40%	deliver more than soil intake	< 70%
0.93	+/- 30%	either	70-80%
1.0	+/- 20%	deliver equal or less than soil intake	>80%

Any new sprinkler systems that NRCS would design and cost share installation of would have an Sd of 1.0. Pressure variation on newer pivots is typically controlled by pressure regulators. If those are present on an existing system, you can safely assume a pressure variation <20%. Older systems may compensate using differing diameters of mainline and/or sprinkler spacing. Evaluation is for each lateral, in terms of the operating pressures range of the nozzles versus a design operating pressure. The maximum range determined for any one of the laterals should be used.

A common issue is how much length of field ditches to "take credit" for closing when converting from flood to sprinkler. Estimate the length of ditch that is in use at any one-time during irrigation with the existing system, to be most correct. That may be only ¼ to ½ of the total length of ditches. Also, be careful about utilizing the "sand" and "gravel" soil descriptions for the existing ditches. Those aren't intended to represent a "gravely clay loam", for example, the results apply to nearly a pure gravel soil.

SharePoint Sync Function

Problem: users save the file to their computer, never to download an updated one again…
Solution: use the sync function in SharePoint to always get the most recent document!

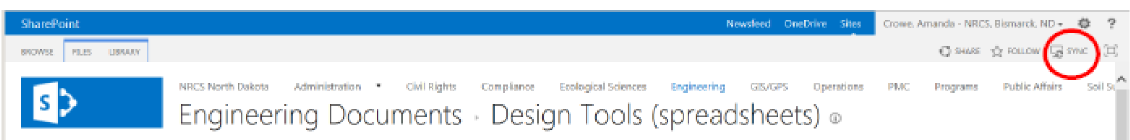
Microsoft Office contains “One Drive for Business” which allows you to sync libraries hosted on SharePoint to your computer.

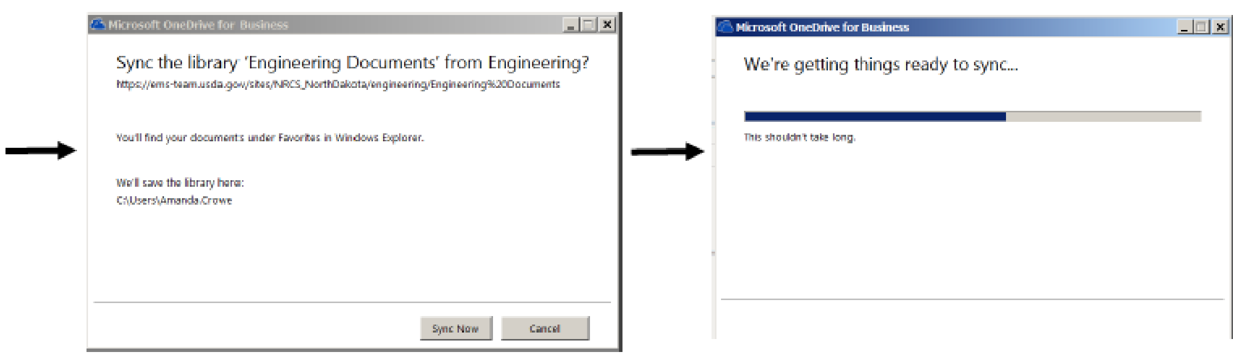
Important Notes: the files have a direct relationship with the SharePoint library…. So, depending on the permission you have for SharePoint will depend on what you can do with the synced files (i.e. adding, deleting, renaming files). Therefore, if you don’t want users to modify files on the SharePoint, don’t give them permission to do so!

In the meantime, any time you need to update the file, you simply reload it on SharePoint!

- Go to the where your file/folder of interest is.

- Click the Sync button





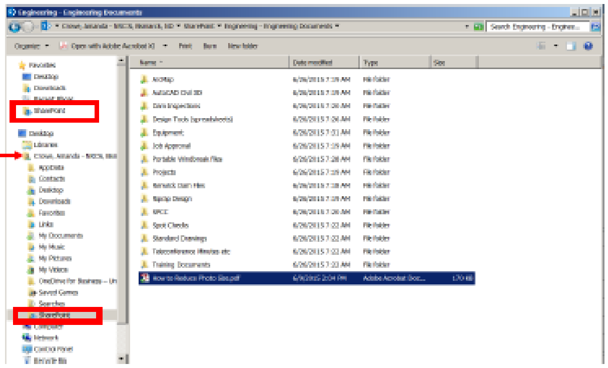
Finding Your Files:

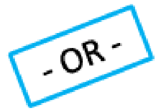
Windows Explorer –

> favorites > Sharepoint

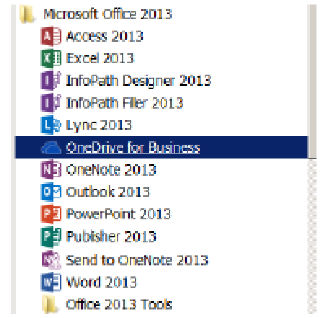
and

> C:\Users\firstname.lastname > Sharepoint





Click on OneDrive for Business under Start > Programs



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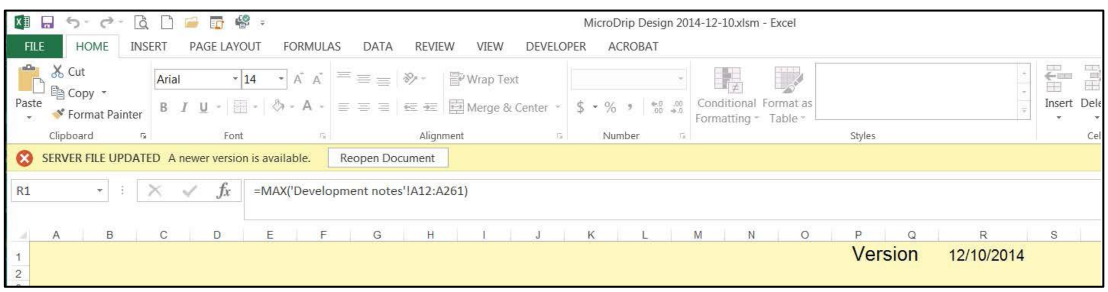

Now that I have the most recent version open, I am told this is read only. (Perfect for the person managing the SharePoint site!) After I "Save-As" the Read Only warning will go away, and I can continue to use the file.