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SELECTING SPRINKLER PACKAGES TO MINIMIZE POTENTIAL RUNOFF

Derrel L. Martin
Biological Systems Engineering
University of Nebraska – Lincoln
Lincoln, NE
Email:dmartin2@unl.edu
402-472-1586

C. Dean Yonts
Panhandle Res. & Ext. Center
University of Nebraska – Lincoln
Scottsbluff, NE
Email:cyonts1@unl.edu
308-632-1246

INTRODUCTION

Avoiding runoff requires assessment of soil properties across the field of concern along with the characteristics of the center pivot and the attributes of available sprinkler devices. The assessment begins with obtaining soil properties of the field. These data can be obtained from printed soil surveys for your county, or, you can use the relatively new electronic tool provided by the USDA Natural Resources Conservation Service. The tool is called the web soil survey and is available on the internet at http://websoilsurvey.nrcs.usda.gov . The following example illustrates the application of the web soil survey to a center pivot located in Platte County Nebraska.

The state and county were selected in his example. You can also directly enter the legal description of the field (*i.e.,* township, range, and section). You can then zoom to your field using the magnifying glass icon. Once you have zoomed so that the field is visible in the map you then need to use the **area of interest** icon (AOI) to draw a rectangle around your field. After you have defined the area of interest you can then click on the **Soil Map** tab. This will bring up the soil map for your field as illustrated in the second figure below. The **Soil Map** includes information about the soil series in the field along with the fraction of the field represented by each mapping unit. This is the information that will be used to help select appropriate sprinkler devices for the conditions in your field. The important characteristics for the mapping units are the general soil texture (such as silty clay loam in this example for the Belfore soil). We also need the slope for the mapping unit. While the slope is only a generalization of slope categories it helps classify the soil. If you have better slope information you should certainly use that data.

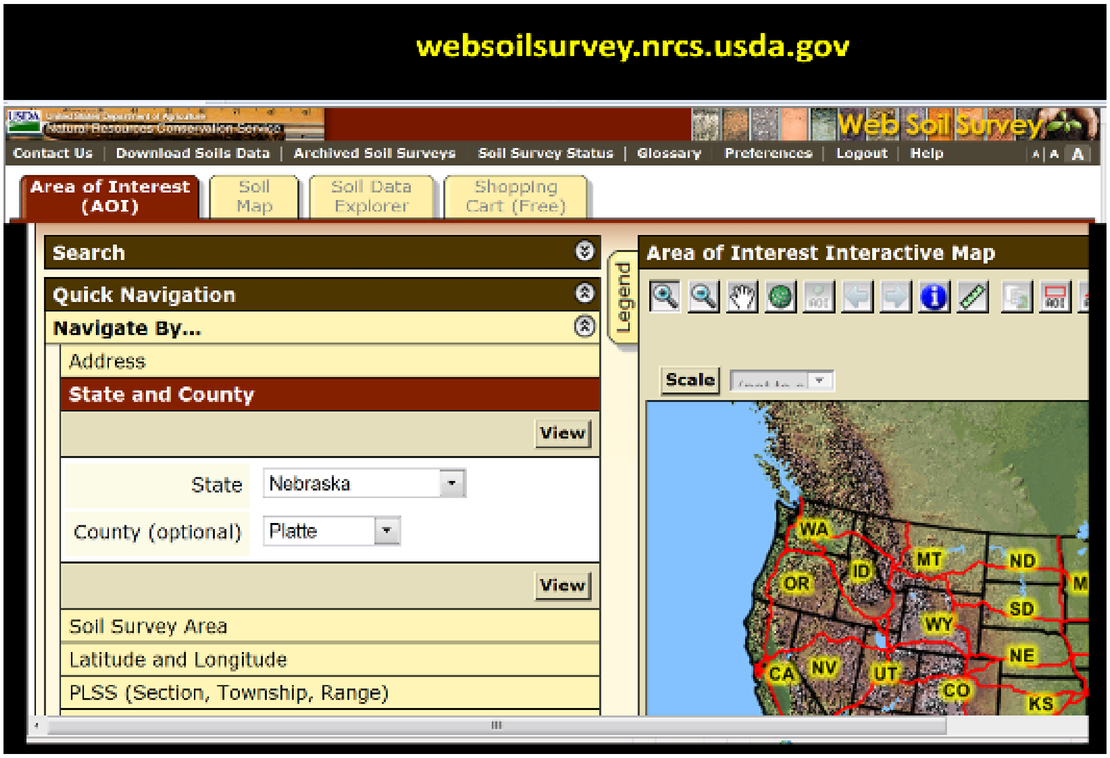

Figure 1 Selection of general area of interest in Web Soil Survey.

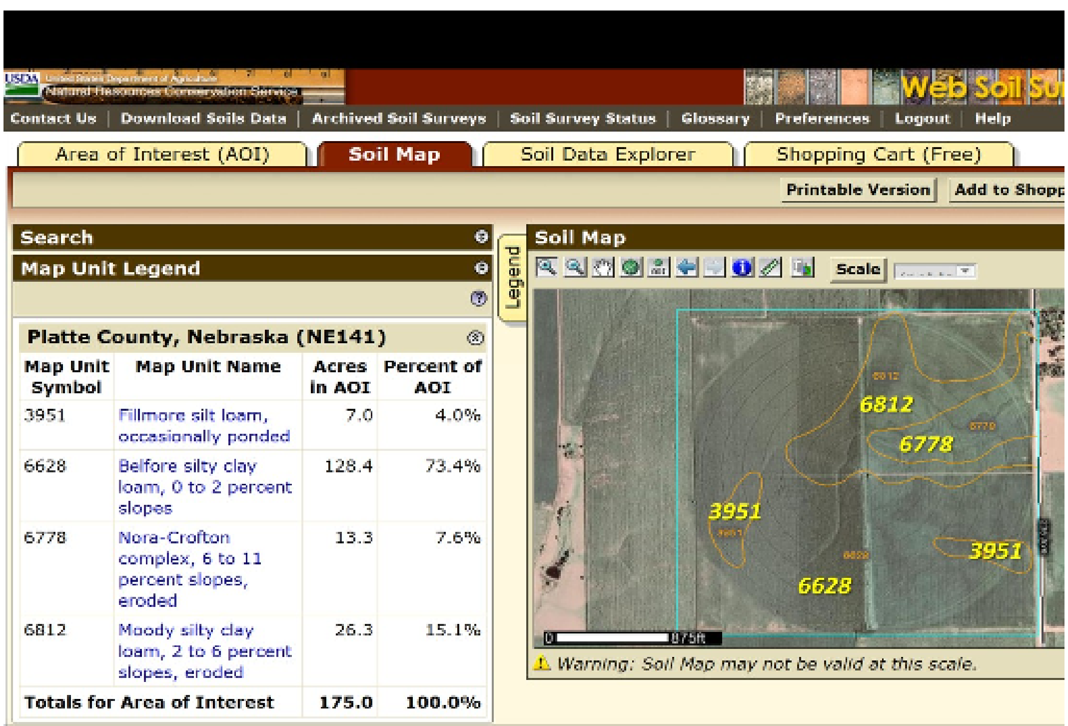

Figure 2. Soil map produced for the area of interest selected for your field.

We use the information from the USDA-NRCS to estimate the amount of surface storage that is available in a field. Their method depends on the general slope in the field and the amount of residue cover in the field. The USDA-NRCS presents typical values as listed in Table 1 below. You can estimate the amount of residue in the field using the method described by Shelton and Jasa (2009, *Estimating Percent Residue Cover Using the Line-Transect Method,* available at http://www.ianrpubs.unl.edu/sendIt/g1931.pdf). This table shows that soils with the slope that average about 2% produces surface storage of 0.30 inches when there is no crop residue and up to 0.65 inches when residue cover is about 70%.

We have developed some general guidelines for some typical sprinkler devices that commonly used. Table 2 shows the amount of surface storage that is required to avoid runoff for general soil textures when one inch of water is applied with the pivot. Results in Table 2 for the silty clay loam texture class shows that about 0.49 to 0.62 inches of surface storage for any devices suspended on drops while storage would have to be from 0.38 to 0.53 inches for devices installed on top of the center pivot lateral. Clearly, the silty clay loam soil will require significant residue cover to avoid runoff for even mild soil slopes.

Applying smaller applications per irrigation can help reduce the runoff potential. Results in Table 3 are for an application of 0.75 inches per irrigation. As the table illustrates the amount of surface storage required to avoid runoff for applications of 0.75 inches drops to a range from 0.37 to 0.47 inches for devices installed on drops and from 0.29 to 0.40 inches for installation on top of the pivot lateral. Thus smaller applications may allow for steeper slopes and less residue.

Table 1. Surface storage available due to residue and slope (from NRCS).

Percent Residue Cover	Storage Due to Residue, inches	Field Slope, %								
		0.5	1	1.5	2	2.5	3	3.5	4	5
0	0.00	0.50	0.44	0.38	0.30	0.26	0.20	0.16	0.10	0.00
10	0.01	0.51	0.45	0.39	0.31	0.27	0.21	0.17	0.11	0.01
20	0.03	0.53	0.47	0.41	0.33	0.29	0.23	0.19	0.13	0.03
30	0.07	0.57	0.51	0.45	0.37	0.33	0.27	0.23	0.17	0.07
40	0.12	0.62	0.56	0.5	0.42	0.38	0.32	0.28	0.22	0.12
50	0.18	0.68	0.62	0.56	0.48	0.44	0.38	0.34	0.28	0.18
60	0.24	0.74	0.68	0.62	0.54	0.5	0.44	0.4	0.34	0.24
70	0.35	0.85	0.79	0.73	0.65	0.61	0.55	0.51	0.45	0.35

http://efotg.sc.egov.usda.gov//references/public/NE/NE_Irrig_Guide_Index.pdf

Table 2. General guidelines of surface storage (inches) needed to avoid runoff for 1-inch application for common sprinkler devices.

Texture Class	Device Installed on Top of Lateral			Device Suspended on Drops				
	Xi-Wob @ 10 psi White Pad	Rotator @ 20 psi White Pad	Impact with Vane	Spray @ 10 psi - Multi Trajectory	LDN @ 10 psi - Concave	Spinner @ 15 psi	I-Wob @ 10 psi	Rotator @ 15 psi Multi Trajectory
Sand	NR	NR	NR	NR	NR	NR	NR	NR
Loamy Sand	NR	NR	NR	NR	NR	NR	NR	NR
Sandy Loam	NR	NR	NR	NR	NR	NR	NR	NR
Loam	0.07	NR	NR	0.22	0.17	0.10	0.10	0.01
Silt Loam	0.11	0.00	NR	0.25	0.22	0.15	0.15	0.05
Sandy Clay Loam	0.40	0.28	0.21	0.52	0.49	0.43	0.43	0.34
Clay Loam	0.54	0.44	0.38	0.63	0.60	0.56	0.56	0.49
Silty Clay Loam	0.53	0.44	0.38	0.62	0.60	0.56	0.56	0.49
Sandy Clay	0.67	0.60	0.56	0.74	0.72	0.69	0.69	0.64
Silty Clay	0.70	0.64	0.59	0.76	0.74	0.72	0.72	0.67
Clay	0.77	0.72	0.68	0.81	0.80	0.78	0.78	0.74

Table 3. Guidelines of surface storage (inches) needed to avoid runoff for 0.75-inch application for common sprinkler devices.

Texture Class	Device Installed on Top of Lateral			Device Suspended on Drops				
	Xi-Wob @ 10 psi White Pad	Rotator @ 20 psi White Pad	Impact with Vane	Spray @ 10 psi - Multi Trajectory	LDN @ 10 psi - Concave	Spinner @ 15 psi	I-Wob @ 10 psi	Rotator @ 15 psi Multi Trajectory
Sand	NR	NR	NR	NR	NR	NR	NR	NR
Loamy Sand	NR	NR	NR	NR	NR	NR	NR	NR
Sandy Loam	NR	NR	NR	NR	NR	NR	NR	NR
Loam	0.05	NR	NR	0.16	0.13	0.08	0.08	0.01
Silt Loam	0.08	0.00	NR	0.19	0.16	0.11	0.11	0.03
Sandy Clay Loam	0.30	0.21	0.16	0.39	0.37	0.32	0.32	0.26
Clay Loam	0.40	0.33	0.29	0.47	0.45	0.42	0.42	0.37
Silty Clay Loam	0.40	0.33	0.29	0.47	0.45	0.42	0.42	0.37
Sandy Clay	0.50	0.45	0.42	0.55	0.54	0.52	0.52	0.48
Silty Clay	0.53	0.48	0.45	0.57	0.56	0.54	0.54	0.50
Clay	0.57	0.54	0.51	0.61	0.60	0.58	0.58	0.56

The USDA-NRCS uses a computer program that we developed called CPNozzle to develop guidelines based on designation of soils into intake families. The procedure is available at: http://efotg.sc.egov.usda.gov//references/public/NE/NE_Irrig_Guide_Index.pdf. A portion of the table of contents for the Nebraska Irrigation Guide is listed below.

Chapter 2	Soils	Part 652 Irrigation Guide
NEBRASKA AMENDMENT		

NIG – National Irrigation Guide Part 652

NEBRASKA SUPPLEMENTS TO NIG:

CHAPTER 2 - SOILS

Figure 3. Copy of a portion of the table of contents for Nebraska Irrigation Guide.

The USDA-NRCS has categorized soil series as shown in the Soils Map above into general soil intake families. We generally find that three intake familes (0.3, 0.5, and 1.0) are appropriate for many soils. Generally these intake families represent most soils that pivots are adapted to and that express some runoff potential. You can refer to the file from the NRCS if your soil is not listed on the following tables.

Table 4. Soil Series in the INTAKE FAMILY 0.3

Deep soils with a clay loam, silty clay loam, or sandy clay loam surface layer and moderate or moderately slow permeability in the subsoil.

Aksarben Silt clay loam	Haverson Silt clay loam	Nora variant Silt clay loam
Alcester Silt clay loam	Hobbs Sandy loam	Norrest Clay loam
Bazile Silt clay loam	Holder Silt clay loam	Norrest Silt clay loam
Belfore Silt clay loam	Holder variant Silt clay loam	Nuckolls variant Silt clay loam
Betts Clay loam	Holdrege Silt clay loam	Onita Silt clay loam
Blake Silt clay loam	Holdrege variant Silt clay loam	Paka Sandy clay loam
Blyburg Silt clay loam	Hord Silt clay loam	Pohocco Silt clay loam
Boel Silt clay loam	Judson Silt clay loam	Ponca Silt clay loam
Buffington Silt clay loam	Kanorado Silt clay loam	Reliance Silt clay loam
Bufton Clay loam	Kennebec Silt clay loam	Roxbury Silt clay loam
Bufton Silt clay loam	Kenridge Silt clay loam	Rusco Silt clay loam
Burchard Clay loam	Lamo Clay loam	Rusco variant Silt clay loam
Coleridge Silt clay loam	Lamo Silt clay loam	Salix Silt clay loam
Colo Silt clay loam	Lawet Silt clay loam	Salmo Silt clay loam
Cortland Loam	Lohmiller Silt clay loam	Saltine Silt clay loam
Cozad Silt clay loam	Manvel Silt clay loam	Savo Silt clay loam
Deroin Silt clay loam	Marshall Silt clay loam	Sharpsburg variant Silt clay loam
Geary Silt clay loam	McCook Silt clay loam	Shelby Clay loam
Geary variant Silt clay loam	Merrick Sandy clay loam	Shell Silt clay loam
Gibbon Silt clay loam	Minnequa Silt clay loam	Shell Variant Silt clay loam
Gibbon Variant Silt clay loam	Moody Silt clay loam	Skilak Silt clay loam
Gymer Silt clay loam	Morrill Clay loam	Steinauer Clay loam
Hall Silt clay loam	Muir Silt clay loam	Steinauer Loam
Hastings Silt clay loam	Nodaway Silt clay loam	Trent Silt clay loam
Hastings variant Silt clay loam	Nora Silt clay loam	Uly variant Silt clay loam
		Yutan Silt clay loam

Table 5. Soil Series in the Intake Family 0.5

Deep soils with a silt loam or loam surface layer and moderate or moderately slow permeability in the subsoil.

Alliance Loam	Holdrege Silt loam	Moody Loam
Alliance Silt loam	Humbarger Loam	Moody Silt loam
Belfore Silt loam	Humbarger variant Silt loam	Nuckolls Silt loam
Betts Loam	Janise Loam	Nuckolls variant Silt loam
Burchard Loam	Janise Silt loam	Nunn Silt loam
Burchard Silt loam	Johnstown Loam	Onita Silt loam
Calco Silt clay loam	Judson Silt loam	Ord Variant Silt loam
Calco Silt loam	Kadoka Silt loam	Paka Loam
Calco Sandy loam	Keith Loam	Ree Loam
Caruso Loam	Keith Silt loam	Ree Silt loam
Caruso variant Loam	Keya Loam	Reliance Silt loam
Clarno Loam	Kuma Loam	Richfield Loam
Coleridge Silt loam	Kuma Silt loam	Richfield Silt loam
Colo Silt loam	Lamo Loam	Rusco Silt loam
Geary Silt loam	Lamo Silt loam	Salix Silt loam
Goshen Loam	Lamo Variant Loam	Salmo Silt loam
Goshen Silt loam	Lawet Loam Lawet	Satanta Loam
Hall Silt loam	Silt loam Lawet	Satanta Very fine sandy loam
Harney Silt loam	variant Loam Leisy	Thirtynine Loam
Hastings Silt loam	Loam	Thirtynine Silt loam
Hastings variant Silt loam	Loretto Loam	Tomek Silt loam
Hemingford Loam	Mace Silt loam	
Holder Loam	Marshall Silt loam	
Holder Silt loam	Maskell Loam	

Table 6. Soil Series in the Irrigation Intake Family 1.0

Deep soils with a silt loam, loam, or very fine sandy loam surface layer and a moderately permeable, medium-textured subsoil.

Ackmore Silt loam	Graybert Very fine sandy loam	Napier Silt loam
Alcester Silt loam	Grigston Silt loam	Nimbro Silt loam
Angora Very fine sandy loam	Haverson Loam	Nodaway Silt loam
Aowa Silt loam	Haverson Silt loam	Nodaway variant Silt loam
Benkelman Very fine sandy loam	Haynie Silt loam	Nora Silt loam
Bigbend Loam	Haynie Very fine sandy loam	Nora variant Silt loam
Blackwood Loam	Haynie variant Silt loam	Norwest Loam
Blackwood Silt loam	Hobbs Silt loam	Oglala Loam
Blyburg Silt loam	Hobbs Sandy loam	Oglala Very fine sandy loam
Bridget Loam	Hord Silt loam	Olmitz Loam
Bridget Silt loam	Hord Very fine sandy loam	Olney Loam
Bridget Very fine sandy loam	Ida Silt loam	Omadi Silt loam
Bushman Very fine sandy loam	Janude Loam	Pohocco Silt loam
Colby Loam	Kenesaw Silt loam	Ponca Silt loam
Colby Silt loam	Kennebec Silt loam	Ralton Loam
Coly Silt loam	Kezan Silt loam	Roxbury Silt loam
Cozad Loam	Laird Fine sandy loam	Rushcreek Loam
Cozad Silt loam	Leshara Silt loam	Saltine Loam
Cozad variant Loam	Malcolm Silt loam	Saltine Silt loam
Cozad variant Silt loam	McCash Very fine sandy loam	Shell Silt loam
Craft Loam	McConaughy Loam	Sidney Loam
Craft Very fine sandy loam	McCook Loam	Sulco Loam
Creighton Very fine sandy loam	McCook Silt loam	Sulco Silt loam
Crofton Silt loam	McCook variant Loam	Sulco Very fine sandy loam
Duroc Loam	McPaul Silt loam	Sully Loam
Duroc Silt loam	Merrick Loam	Sully Silt loam
Duroc Very fine sandy loam	Merrick variant Loam	Trent Silt loam
Eltree Silt loam	Mitchell Silt loam	Tripp Loam
Eudora Loam	Mitchell Very fine sandy loam	Tripp Very fine sandy loam
Eudora Silt loam	Mitchell variant Silt loam	Uly Silt loam
Gates Silt loam	Modale Silt loam	Ulysses Loam
Gates Very fine sandy loam	Modale Very fine sandy loam	Ulysses Silt loam
Gibbon Loam	Monona Silt loam	Yockey Fine sandy loam
Gibbon Silt loam	Morrill Loam	Yockey Loam
Gosper Loam	Moville Silt loam	Yockey Silt loam
Grable Silt loam	Muir Silt loam	Yockey Very fine sandy loam
Grable Very fine sandy loam	Munjor Loam	
Grable variant Silt loam		

Sandy soils that are classified into soil intake families with larger infiltration rates such as Intake Family 1.5 or higher seldom have serious runoff problems with most sprinkler devices.

We have developed a graphical procedure to estimate the required wetted diameter of a sprinkler packages for selected application depths, available surface storage and system capacity expressed as the system flow rate divided by the size of the field (*i.e.,* gpm/acre). To use the chart you should determine which intake family for the most runoff prone areas in the field. Those soils should include enough area to be significant and should be located at the outer end of the pivot lateral where the water application rate is the highest.

The next step is to select your typical application depth per irrigation and move horizontally across the chart until the horizontal line intersects the available surface storage for your field. Move vertically downward to the lower portion of the graph until the vertical line intersects the system capacity of your system. Move horizontally to the right from that intersection point to read the required wetted diameter for sprinkler devices located near the end of a traditional center pivot with a lateral that is about 1300 feet long. You can then compare the required wetted diameter to the value produced by an array of sprinkler devices that are installed at various heights above the crop. You can obtain sprinkler performance data directly from the web page for most sprinkler manufacturers.

The analysis is illustrated in Figures 4-6 for the three soils when the available surface storage is 0.3 inches and the system capacity is 6 gallons per minute per acres. The results in Figure 4 show that sprinkler devices at the end of a traditional lateral would need to produce a wetted diameter of about 70 feet for the 0.3 Intake Family such as found in the Soil Map for the field in Platte County. The required wetted diameter drops to about 45 feet for the 0.5 Intake Family Soils and to about 25 feet for the 1.0 Intake Family Soils. Obviously, the correct sprinkler choice will vary a great deal for these conditions. Choices are fairly limited for the 0.3 Intake Family and efforts to increase residue cover and enhance the infiltration rate would be strongly recommended.

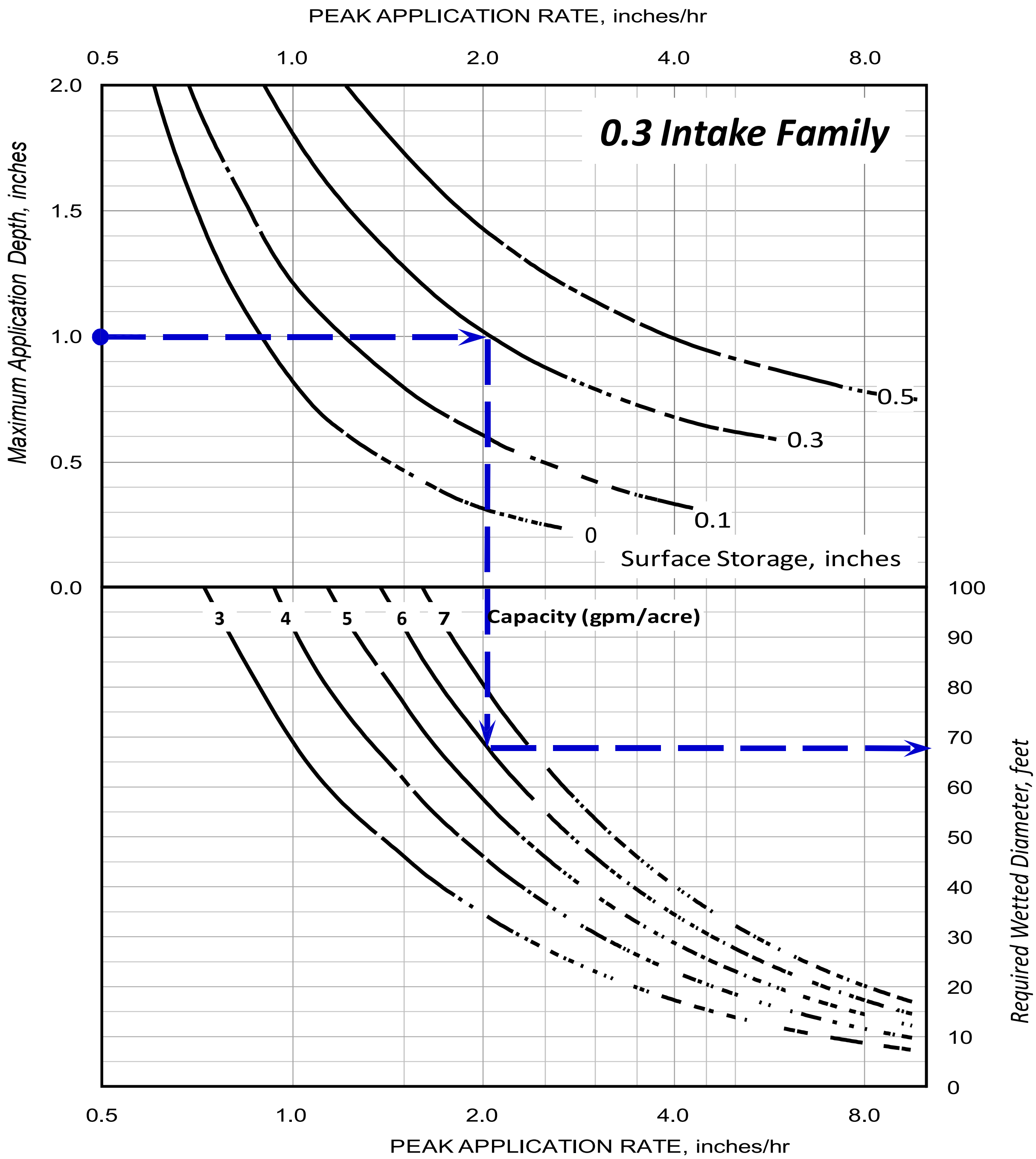

Figure 4. Graphical procedure to estimate the wetted diameter of the sprinkler devices to avoid runoff at the end of a traditional pivot that is 1300 feet long for soils that are categorized in the 0.3 Intake Family.

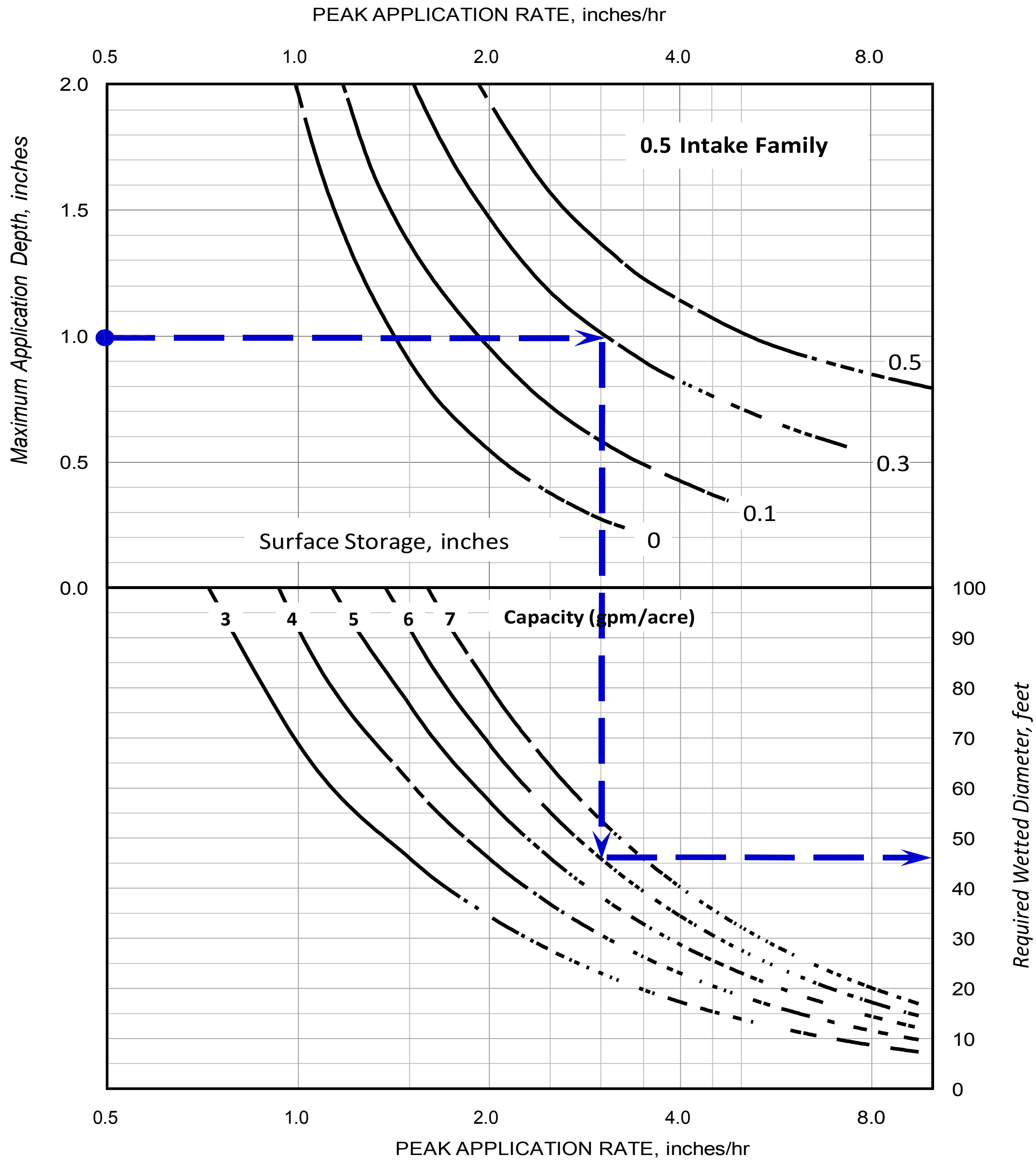

Figure 5. Graphical procedure to estimate the wetted diameter of the sprinkler devices to avoid runoff at the end of a traditional pivot that is 1300 feet long for soils that are categorized in the 0.5 Intake Family.

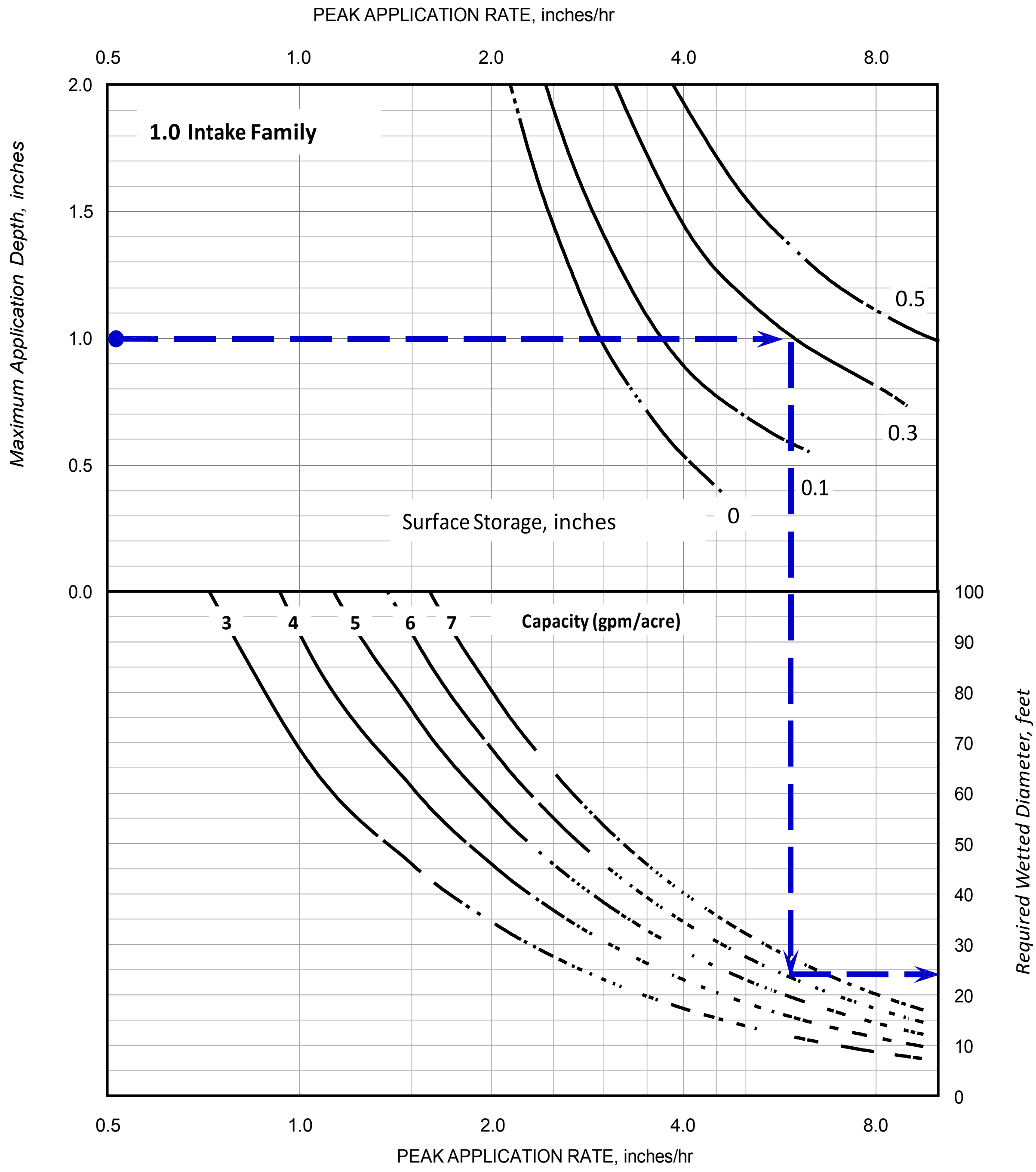

Figure 6. Graphical procedure to estimate the wetted diameter of the sprinkler devices to avoid runoff at the end of a traditional pivot that is 1300 feet long for soils that are categorized in the 1.0 Intake Family.