TECHNICAL NOTES

US DEPARTMENT OF AGRICULTURE **NATURAL RESOURCES CONSERVATION SERVICE**

AGRONOMY TECHNICAL NOTE NUMBER - 15 **Temple, TX**

March 2000

PHOSPHORUS ASSESSMENT TOOL

For Texas

BACKGROUND AND INTRODUCTION

Phosphorus is an essential element for plant and animal growth and has long been recognized as necessary to maintain optimum agricultural production. Phosphorus inputs can also increase the biological productivity of surface waters by accelerating eutrophication. Eutrophication is the natural aging of lakes or streams brought on by nutrient enrichment. Phosphorus enrichment can come from any number of sources; however, agricultural non-point sources are currently receiving much attention. The amount of phosphorus contribution to surface water from agricultural sources is dependent on a number of factors.

A simple P index was developed by the U.S. Department of Agriculture, Agricultural Research Service, in cooperation with several research scientists, as a screening tool for use by field staffs, watershed planners, and farmers to rank the vulnerability of fields as sources of P loss in surface runoff. This Index was first published for NRCS use in the South National Technical Center publication*, Engineering Technical Note 1901, A Phosphorus Assessment Tool,* August 1994.

The index accounts for and ranks transport and source factors controlling P loss in surface runoff and predicts where the risk of P movement is expected to be higher than that of others. Each site characteristic affecting P loss is weighted according to the assumption that certain characteristics have a relatively greater effect on potential P loss than others do. This index was modified to establish a P Index for East Texas and a P Index for West Texas see **Figure 1**. NRCS and Extension Service specialists in Texas developed the P indices discussed in this Technical Note.

An assessment of site vulnerability to P loss in surface runoff is made by selecting the rating value for each site characteristic from the P index. Each rating is multiplied by the appropriate weighting factor. The P index value for the site is the sum of weighted values of all site characteristics, which can then be used to categorize the site's vulnerability to P loss (**Table 1 and Table 2**).

PURPOSE

The index is a tool for field personnel to identify agricultural areas or practices that have the greatest potential to accelerate eutrophication. It can be used to identify management options available to land users and will allow them flexibility in developing field specific remedial strategies. The first step is to determine the P index for each field and prioritize the efforts needed to reduce P losses. Then, management options appropriate for soils with different P index ratings and critical P buildup levels can be implemented. Refer to “P Vulnerability Class Ratings Described” for general guidance for management of fields according to P Index Classification. P management is very site specific and requires a well-planned, coordinated effort among farmers, extension agronomists, and soil conservation specialists.

SITE CHARACTERISTICS

The site characteristics fall into two main categories, source factors and transport factors. These factors can have an influence on phosphorus availability, retention, management, and movement. The P Index is a simple 8 by 5 matrix that relates site characteristics with a range of value categories.

Field specific data for the 8 site characteristics of the Phosphorus Index can be collected and readily interpreted at the field level. The producer must provide soil and organic material test results in order to determine their rating levels. This soil and material analyses are considered essential as a basis for the assessment.

Each site characteristic is rated VERY LOW, LOW, MEDIUM, HIGH, or VERY HIGH, by determining the range for each category.

DEFINITIONS

The definitions of each of the 8 site characteristics are:

Soil Test P Level

The soil test P rating used in the P Index are applicable to the accepted extraction methods (TAMU, Mehlich III ,Bray I, Bray II or Olsen), outlined in the current Texas NRCS Nutrient Management Standard. The soil samples will be collected according to Texas A&M sampling guidelines in the current Texas NRCS Nutrient Management Standard. **NOTE:** If the soil testing is being completed as part of a TRNCC permit requirement, the soil test must be run using either the Texas A&M extraction method or the Mehlich III extraction method.

The soil test level for "available P” does not ascertain the total P in the surface soil. It does however, give an indication of the amount of total P that may be present because of the general relationship between the forms of P (organic, adsorbed, and labile P) and the solution P available for crop uptake.

Fertilizer Phosphorus (P_2O_5) Application Rate

The P fertilizer application rate is the amount, in pounds per acre (lbs/ac), of phosphorus as P_2O_5 from commercial sources that is applied to the soil. The rate ranges from 0 application to greater than 150 lbs/ac P_2O_5.

Organic Phosphorus (P_2O_5) Application Rate

The P organic application rate is the nutrient amount, in pounds per acre (lbs/ac), of phosphorus as P_2O_5 from organic sources (manure, poultry litter, lagoon effluent, etc.) that is applied to the soil. The rate ranges from 0 application to greater than 150 lbs/ac P_2O_5.

Organic P and Fertilizer P Source Application Method and Timing

The manner in which organic and/or commercial P material is applied to the soil and the time of year or length of time that the material is exposed on the soil surface until crop utilization can affect potential P movement. The date ranges in the "Medium" through "Very High" categories of the East Texas Index (**Table 1**) are based on the average intensity, duration, frequency, and quantity of rainfall in the region. Due to the somewhat less predicable timing and the lower quantity of rainfall in West Texas, the application factors are primarily based on the duration of time the materials are on the surface before crop use (**Table 2**). Regardless of the methodology, the function of this factor in the P index is to differentiate between periods of higher and lower potential for surface loss within the year.

Incorporation implies that the organic P material is buried below the soil surface at >2 inches. If the material is not incorporated within 48 hours, the application will be rated according to whichever higher category is appropriate. The value categories of increasing severity, ranging from no application to surface applied during the period of the year when rainfall intensity, frequency, and duration is highest in East Texas. Or, in the case of West Texas, greater than 4 months before there will be a crop planted to utilize the applied material.

Proximity of Nearest Field Edge to Named Stream or Lake

This factor considers the flow distance from the edge of a field nearest a water body to that water body. The term "named stream or lake" means any named water body on a USGS Topographic Map or USDA/NRCS Soil Survey Sheet. The closer the water body to the edge of the field, the higher the parameter category's value. These values should consider the local topography and existing setback and buffer regulations for application of manure. Local or state guidelines should be used where available.

Soil Erosion

Soil erosion is defined as the loss of soil along the slope or unsheltered distance caused by the processes of water and wind. Soil erosion is estimated from erosion prediction models currently used (RUSLE, Revised Universal Soil Loss Equation, for water erosion and WEQ, Wind Erosion Equation, for wind erosion. The value category is given in tons of soil loss per acre per year (ton/acre/year). These soil loss prediction models do not predict sediment transport and delivery to a water body. The prediction models are used in this index to indicate a movement of soil, thus potential for sediment and attached phosphorus movement across the slope or unsheltered distance and toward a water body.

Runoff Class

The runoff class is the runoff potential of soluble P moving from locations of placement. The runoff class of the site can be determined from the runoff curve number for the field and slope measurements in the field. Guidance in determining the runoff curve number can be attained from Texas Engineering Technical Note*, "Hydrology 210-18-TX5, Estimating Runoff for Conservation Practices*, 10/90. **Table 3** depicts the relationship between the predominant percent slope of the field and the runoff curve. The results of using the matrix relating slope and runoff curve number provides the value categories: NEGLIGIBLE, LOW, MEDIUM, HIGH, and VERY HIGH. **Table 4** contains a partial listing of runoff curve value that may be used for the P index.

PROCEDURES FOR MAKING AN ASSESSMENT

The site characteristics have been assigned weighting based on the reasoning that particular site characteristics may be more prominent than others in allowing potential phosphorus movement from the site. There is scientific basis for concluding that these relative differences exist; however, the absolute weighting factors given are based currently on professional judgment. The site characteristic weighting factors are:

Soil Test P Level (1.0)
Fertilizer Phosphorus Application Rate (0.75)
Organic Phosphorus Application Rate (0.75)
Fertilizer Phosphorus Application Method and Timing (0.50)
Organic Phosphorus Source Application Method and Timing (0.50)
Proximity of Field Edge to Named Stream or Lake (1.25)
Runoff Class (1.0)
Soil Erosion (1.5)

The value categories are rated using a log base of 2. The greater ratings, the proportionally higher are the values. The higher the value, the higher potential for significant problems related to phosphorus movement.

The column value ratings are:

0 = None or very low
1 = Low
2 = Medium
4 = High
8 = Very high

Table 1 or **Table 2** for East Texas or West Texas respectively can be used to record the values from the index for a specific field. To make an assessment using the P Index, select a rating value for each site characteristic using the information in the appropriate Table for either East or West Texas. The values in the tables are the result of multiplying the site characteristic weighting factor by the column value to get the weighted value for that characteristic. Proceed to rate and factor each characteristic of the index. Sum the weighted values for all 8 characteristics, and compare the total using the Phosphorus Index Classification. The P Vulnerability Class is then related to the Critical Soil Test P Level. There are 2 sets of these values for both East and West Texas, one for non-impaired watersheds and one for impaired watersheds. The sampling and testing guidelines for the critical P level are as stated in definition section of this document for soil test P level. An impaired watershed for the purposes of the P index is defined as one identified on the TNRCC 303d list as being impaired by agricultural phosphorus. **Once a field reaches the critical soil test P level listed for a given P index classification class no further P application is recommended until the soil test P level is below the critical level or index factors are modified to result in a lower P index classification rating (if applicable)**. A description of site vulnerability by the Vulnerability Class Rating is given to describe the potential loss of P for a given field.

There is a Microsoft Excel spread sheet available (TX-PI.xls) to automate the evaluation.

INTERPRETATIONS OF SITE VULNERABLITY RATINGS FOR THE P INDEX

P Vulnerability Class Rating Described

VERY LOW OR LOW - This site has a VERY LOW OR LOW potential for P movement from the site. If farming practices are maintained at current level, the probability of an adverse impact to surface water resources from P losses from this site would be very low or low. The non-impaired Critical soil test P for this P index classification is 500 ppm, and the impaired is 300 ppm.

MEDIUM - This site has a MEDIUM potential for P movement from the site. The probability for an adverse impact to surface water resources is greater than that from a LOW vulnerability rated site. Some remedial action should be taken to lessen the probability of P movement. The non-impaired Critical soil test P for this P index classification is 400 ppm, and the impaired is 250 ppm.

INTERPRETATIONS OF SITE VULNERABLITY RATINGS FOR THE P INDEX continued

P Vulnerability Class Rating Described

HIGH- This site has a HIGH potential for P movement from the site. There is a high probability for an adverse impact to surface water resources unless remedial action is taken. Soil and water conservation as well as phosphorus management practices are necessary to reduce the risk of P movement and probable water quality degradation**.** The non-impaired Critical soil test P for this P index classification is 300 ppm, and the impaired is 200 ppm.

VERY HIGH - This site has a VERY HIGH potential for P movement from the site. The probability for an adverse impact to surface water resources is very high. Remedial action is required to reduce the risk of P movement. All necessary soil and water conservation practices plus a phosphorus management plan must be put in place to reduce the potential of water quality degradation. The non-impaired Critical soil test P for this P index classification is 200 ppm, and the impaired is 200 ppm.

PRECAUTIONS IN THE USE OF THE PHOSPHORUS INDEX

The Phosphorus Index is an assessment tool intended to be used by planners and land users to assess the risk that exists for phosphorus leaving the landform site and travelling toward a water body. It also can be used to identify the critical parameters of soil, topography, and management that most influence the movement. Using these parameters, the index then can help the selection of management alternatives that would significantly address the potential impact and reduce the risk. The index is intended to be part of the planning process that takes place between the land user and resource planner. It can be used to communicate the concept, process, and results that can be expected if various alternatives are used in the management of the natural resources at the site. THE PHOSPHORUS INDEX IS NOT INTENDED TO BE AN EVALUATION SCALE FOR DETERMINING WHETHER LANDUSERS ARE ABIDING WITHIN WATER QUALITY OR NUTRIENT MANAGEMENT STANDARDS THAT HAVE BEEN ESTABLISHED BY LOCAL, STATE, OR FEDERAL AGENCIES. Any attempt to use this index as a regulatory scale would be grossly beyond the intent of the assessment tool and the concept and philosophy of the working group that developed it. As discussed in this technical note, this Phosphorus Index has been adapted to local conditions by a process of regional adaptations of the site characteristic parameters. This local development involved those local and state agencies and resource groups that are concerned with the management of phosphorus. After the index was adapted to Texas, it was tested by the development group to assure that the assessments are giving valid and reasonable results for each region.

References

1. Sharpley, A.N., T. Daniel, T. Sims, J. Lemunyon, R. Steven, and R. Parry. 1999. Agricultural Phosphorus and Eutrophication. U.S. Department of Agriculture, Agricultural Research Service, ARS-149, 42 pp.
2. Renard, K.G., G.R. Foster, G.A. Weesies, D.K. McCool, and D.C. Yoder, coordinators. 1997. Predicting Soil Erosion by Water: A Guide to Conservation Planning with the Revised Soil Loss Equation (RUSLE). U.S. Department of Agriculture, Agricultural Handbook No. 703, 404 pp.
3. Anonymous. 1994. A Phosphorus Assessment Tool. U.S. Department of Agriculture, Soil Conservation Service, South National Technical Center Engineering Technical Note No. 1901, 15 pp.
4. Anonymous. 1990. Estimating Runoff for Conservation Practices. 1990. U.S. Department of Agriculture, Soil Conservation Service, Texas Engineering Technical Note on Hydrology No. 210-18-TX5, 47 pp.

TABLE 1. PHOSPHORUS INDEX WORKSHEET FOR EAST TEXAS

PHOSPHORUS INDEX WORKSHEET for East Texas						
Client Name:		**Field(s):**		**Date:**		
Planner:		**Location:**		**Crop:**		
Impaired Watershed (Y or N):		**Runoff Curve No.:**		**% Slope:**		

Site Characteristic (Weighting Factor)	**[Weighting Factor Times the Column Factor]**					**Sub Total**
	0	**1**	**2**	**4**	**8**	
Soil Test P Rating	N/A	Very Low – Low	Moderate	High	Very High	
(1.00)	**[0]**	**[1.0]**	**[2.0]**	**[4.0]**	**[8.0]**	
Fertilizer Phosphorus (P_2O_5) Application Rate	None Applied	1-40 lbs/ac P_2O_5	41-90 lbs/ac P_2O_5	91-150 lbs/ac P_2O_5	>150 lbs/ac P_2O_5	
(0.75)	**[0]**	**[0.75]**	**[1.5]**	**[3.0]**	**[6.0]**	
Organic Phosphorus (P_2O_5) Application Rate	None Applied	1-40 lbs/ac P_2O_5	41-90 lbs/ac P_2O_5	91-150 lbs/ac P_2O_5	>150 lbs/ac P_2O_5	
(0.75)	**[0]**	**[0.75]**	**[1.5]**	**[3.0]**	**[6.0]**	
Phosphorus Fertilizer Application Method and Timing	None Applied	Placed deeper than 2 in. or broadcast and incorporated within 48 hours	Surface applied 12/1-2/15	Surface applied 2/16-4/15 or 6/16-11/30	Surface Applied 4/16-6/15	
(0.50)	**[0]**	**[0.50]**	**[1.0]**	**[2.0]**	**[4.0]**	
Organic Phosphorus source Application Method and Timing	None Applied	Placed deeper than 2 in. or broadcast and incorporated within 48 hours	Surface applied 12/1-2/15	Surface applied 2/16-4/15 or 6/16-11/30	Surface Applied 4/16-6/15	
(0.50)	**[0]**	**[0.50]**	**[1.0]**	**[2.0]**	**[4.0]**	
Proximity of nearest field edge to named stream or lake	> 2000 feet	1000 – 1999 feet	500 – 999 feet	100 – 499 feet	< 100 feet	
(1.25)	**[0]**	**[1.25]**	**[2.5]**	**[5.0]**	**[10.0]**	
Runoff Class (Runoff Class Table 3)	Negligible	Low	Moderate	High	Very High	
(1.00)	**[0]**	**[1.0]**	**[2.0]**	**[4.0]**	**[8.0]**	
Soil Erosion (all sources)	Very Low <1 t/ac	Low 1-3 t/ac	Medium 3-5 t/ac	High 5-10 t/ac	Very High >10 t/ac	
(1.50)	**[0]**	**[1.5]**	**[3.0]**	**[6.0]**	**[12.0]**	
					Total Index Points:	

Phosphorus Index Classification – East Texas			
Index Pts.	**P Runoff Potential**	**Non-impaired Critical P Level (ppm)**	**Impaired Critical P Level (ppm)**
< 12	Very Low - Low	500	300
12 – 22.75	Medium	400	250
23 - 32	High	300	200
> 32	Very High	200	200

TABLE 2. PHOSPHORUS INDEX WORKSHEET FOR WEST TEXAS

PHOSPHORUS INDEX WORKSHEET for West Texas						
Client Name:		Field(s):		Date:		
Planner:		Location:		Crop:		
Impaired Watershed (Y or N):		Runoff Curve No.:		% Slope:		
Site Characteristic (Weighting Factor)	**[Weighting Factor Times the Column Factor]** **0**	**1**	**2**	**4**	**8**	**Sub Total**
Soil Test P Rating	N/A	Very Low – Low	Moderate	High	Very High	
(1.00)	**[0]**	**[1.0]**	**[2.0]**	**[4.0]**	**[8.0]**	
Fertilizer Phosphorus (P_2O_5) Application Rate	None Applied	1-40 lbs/ac P_2O_5	41-90 lbs/ac P_2O_5	91-150 lbs/ac P_2O_5	>150 lbs/ac P_2O_5	
(0.75)	**[0]**	**[0.75]**	**[1.5]**	**[3.0]**	**[6.0]**	
Organic Phosphorus (P_2O_5) Application Rate	None Applied	1-40 lbs/ac P_2O_5	41-90 lbs/ac P_2O_5	91-150 lbs/ac P_2O_5	>150 lbs/ac P_2O_5	
(0.75)	**[0]**	**[0.75]**	**[1.5]**	**[3.0]**	**[6.0]**	
Phosphorus Fertilizer Application Method and Timing	None Applied	Placed deeper than 2 in. or broadcast and incorporated within 48 hours	Incorporated immediately before planting	Incorporated >4 months before planting, or surface applied < 4 months before planting	Surface applied >4 months before planting	
(0.50)	**[0]**	**[0.50]**	**[1.0]**	**[2.0]**	**[4.0]**	
Organic Phosphorus source Application Method and Timing	None Applied	Placed deeper than 2 in. or broadcast and incorporated within 48 hours	Incorporated immediately before planting	Incorporated >4 months before planting, or surface applied < 4 months before planting	Surface applied >4 months before planting	
(0.50)	**[0]**	**[0.50]**	**[1.0]**	**[2.0]**	**[4.0]**	
Proximity of nearest field edge to named stream or lake	> 2000 feet	1000 – 1999 feet	500 – 999 feet	100 – 499 feet	< 100 feet	
(1.25)	**[0]**	**[1.25]**	**[2.5]**	**[5.0]**	**[10.0]**	
Runoff Class (Runoff Class Table 3)	Negligible	Low	Moderate	High	Very High	
(1.00)	**[0]**	**[1.0]**	**[2.0]**	**[4.0]**	**[8.0]**	
Soil Erosion (all sources)	Very Low <1 t/ac	Low 1-3 t/ac	Medium 3-5 t/ac	High 5-10 t/ac	Very High >10 t/ac	
(1.50)	**[0]**	**[1.5]**	**[3.0]**	**[6.0]**	**[12.0]**	
					Total Index Points:	

Phosphorus Index Classification – West Texas			
Index Pts.	**P Runoff Potential**	**Non-impaired Critical P Level (ppm)**	**Impaired Critical P Level (ppm)**
< 15	Very Low - Low	500	300
15 – 24.75	Medium	400	250
25 - 35	High	300	200
> 35	Very High	200	200

Figure 1 – East / West Map of Texas for P Index

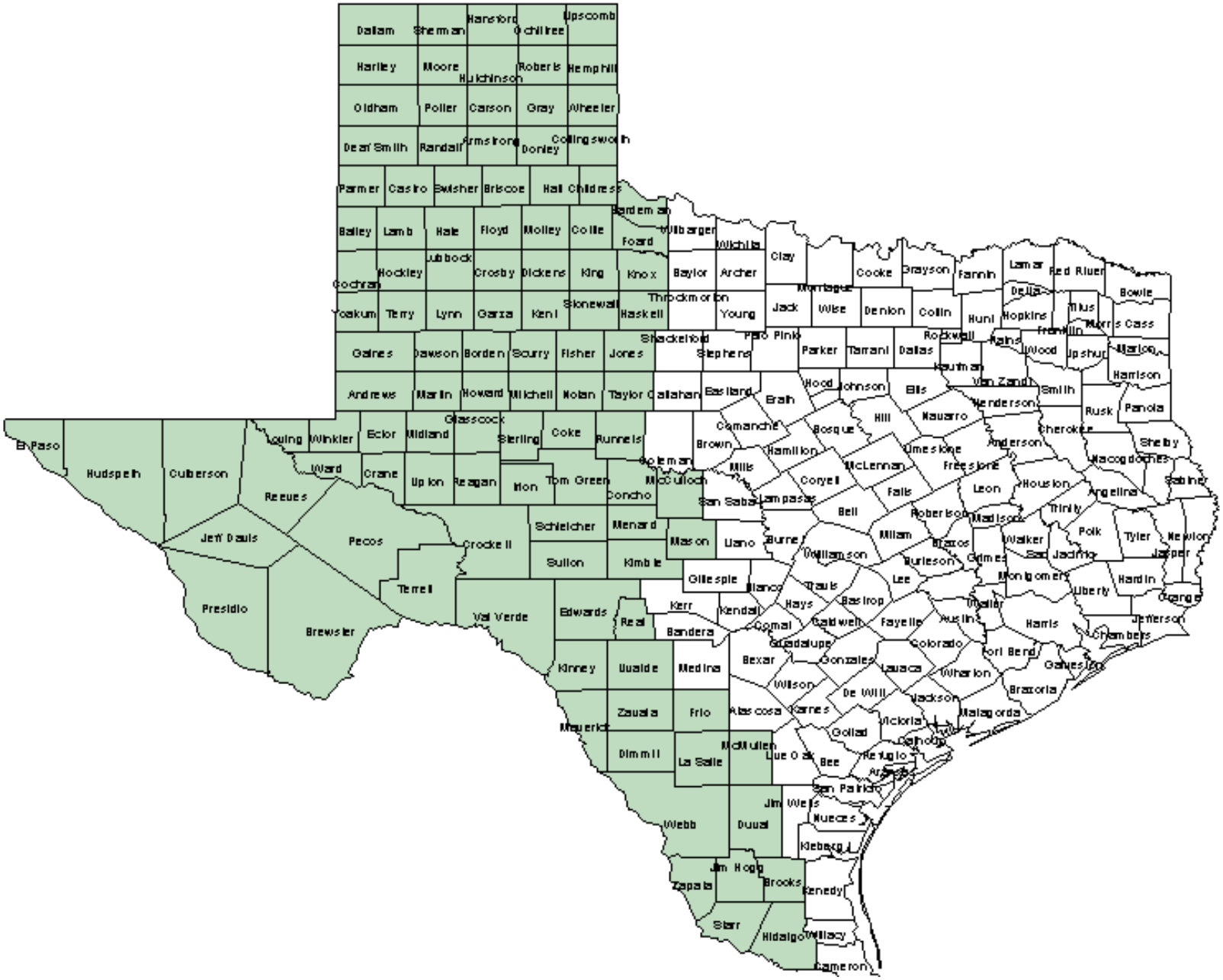

Table 3 Runoff Class Based on Field Slope and Runoff Curve Number

	Runoff Curve Number				
Slope %	<50	50 to 60	60 - 70	70 to 80	> 80
< 1	N	N	N	N	M
1 to 2	N	N	VL	L	M
2 to 4	N	N	L	M	H
4 to 8	N	VL	M	H	VH
8 to 16	VL	L	M	VH	VH
> 16	VL	L	H	VH	VH

Refer to Texas NRCS Engineering Technical Note - Hydrology, No. 210-18-TX5, *Estimating Runoff for Conservation Practices* - 10/90 for information on runoff curve numbers.
Estimating Runoff for Conservation Practices - 10/90 for information on runoff curve numbers.

N = Negligible, VL = Very Low, L = Low, M = Moderate, H = High, VH = Very High

Table 4 - Partial Listing of Curve Numbers 1/

Cover Type	Hydrologic Condition 2/	Soil Hydrologic Group				
		A	B	C	D	
Pasture	poor	68	79	86	89	
	fair	49	69	79	84	
	good	39	61	74	80	
Hayland not grazed		30	58	71	78	
Fallow - bare soil		77	86	91	94	
Fallow w/crop residue (CR)	poor	76	85	90	93	
	good	74	83	88	90	
Row Crop - Straight Row	poor	72	81	88	91	
	good	67	78	85	89	
Row Crop - Straight Row + CR	poor	71	80	87	90	
	good	64	75	82	85	
Row crops contoured & terraced	poor	66	74	80	82	
	good	62	71	78	81	
Small grain - Straight Row	poor	65	76	84	88	
	good	63	75	83	87	
Small grain - Straight Row + CR	poor	64	75	83	86	
	good	60	72	80	84	
Small grain - Contoured and terraced	poor	61	72	79	82	
	good	59	70	78	81	

Table 4 - Partial Listing of Curve Numbers 1/ - continued

Cover Type	Hydrologic Condition 2/	Soil Hydrologic Group				
		A	B	C	D	
Drilled or broadcast legumes, rotational meadow - contoured & terraced	**poor**	**63**	**73**	**80**	**83**	
	good	**51**	**67**	**76**	**80**	

1/ All curve numbers shown assume average runoff conditions.
Refer to Texas NRCS Engineering Technical Note - Hydrology, No. 210-18-TX5
Estimating Runoff for Conservation Practices - 10/90
for information on runoff curve numbers.

2/ For **pasture** the hydrologic condition is interpreted as follows:

Poor: <50% ground cover or heavily grazed with no mulch
Fair: 50 - 70% ground cover not heavily grazed
Good: >70% ground cover and lightly or occasionally grazed

2/ For **cropland** the hydrologic condition is based on a combination of factors that effect infiltration and runoff:

a) Density and canopy of vegetative areas
b) Amount of year-round cover
c) Amount of grass or close seeded crops in the rotation
d) Percent residue cover (good > or = 20%)
e) Degree of surface roughness

Poor: Factors impair infiltration and tend to increase runoff.
Good: Factors encourage average or better infiltration and tend to decrease runoff.