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Determination of Soil Sensitivity Ratings

for the Oregon Water Quality Decision Aid (OWQDA)

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The Oregon Water Quality Decision Aid (OWQDA) is a first-tier screening tool that allows you to make a broad determination of the likelihood that a specific chemical, when applied to a specific Oregon soil, will move through the soil and contaminate groundwater. The OWQDA develops separate assessments of *soil sensitivity* and *pesticide movement*, and combines them into an overall *groundwater vulnerability rating*.

This publication provides detailed information on the development and interpretation of soil sensitivity ratings. Publication EM 8561 provides information on pesticide movement ratings. The OWQDA is described more fully in publication EM 8705.

What is soil sensitivity?

Soil sensitivity is a soil's *general tendency to allow a chemical to be transported through the soil to groundwater*. It is expressed as a rating in one of five classes ranging from Very Low to Very High (Table 1). Very Low soil sensitivity ratings imply that it is unlikely a chemical will reach and contaminate groundwater. Very High ratings imply that the soil is unable to act as a buffer to protect groundwater from pesticides. Risk of groundwater contamination also depends on the chemical's properties and the management practices associated with its use.

Soil sensitivity depends on two kinds of soil behavior: *leaching potential* and *sorption potential*. Leaching potential is a measure of the driving force available to move

Table 1.—Determination of irrigated soil sensitivity ratings.

Irrigated leaching potential rating	Sorption potential rating				
	Very low	**Low**	**Moderate**	**High**	**Very high**
Very low	Moderate	Low	Very low	Very low	Very low
Low	Moderate	Moderate	Low	Very low	Very low
Moderate	High	High	Moderate	Low	Low
High	Very high	Very high	High	Moderate	Moderate
Very high	Very high	Very high	Very high	High	Moderate

OREGON STATE UNIVERSITY EXTENSION SERVICE

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chemicals down through the soil. It is determined by soil permeability, soil depth, depth to groundwater, and hydraulic loading. Soils with a high leaching potential generally are more sensitive because water tends to move rapidly and completely through the soil to the water table.

Sorption potential is a measure of the soil's ability to retain chemicals in the soil by reaction with particles of clay and organic matter. Soils with a high sorption potential are not very sensitive because they tend to retain the chemical until it can degrade naturally. In this way, sorption potential can counteract some of the sensitivity due to high leaching potential.

Soil sensitivity ratings are a function of leaching potential and sorption potential, as shown in Table 1. Procedures for determining ratings of leaching potential and sorption potential are discussed later in this publication.

Evaluation of leaching potential

Leaching is a natural process that occurs in all soils. As water moves through the soil, it carries with it anything sufficiently soluble to be dissolved during the time it's in contact with water. When hydraulic loading from rainfall or irrigation is sufficient to move water below the root zone, soluble materials in the soil can be transported all the way to groundwater.

Salts such as NaCl and $CaCl_2$, gypsum ($CaSO_4$), and lime ($CaCO_3$) are soluble and easily leached. That's why these materials generally are not found in western Oregon soils. Free lime is found in some eastern Oregon soils, however, because the hydraulic loading is not sufficient to leach it completely out of the soil. Leaching gradually removes basic cations such as Ca, Mg, and K, which are replaced by H and Al. That's why western Oregon soils are acidic, but eastern Oregon soils generally are neutral or slightly alkaline.

Soluble fertilizers, especially nitrate, are particularly subject to leaching below the root zone and into groundwater when there are high amounts of hydraulic loading. For the same reasons, relatively soluble pesticides can be transported through the soil.

In the OWQDA, leaching potential is a rating of the relative degree to which a chemical is likely to be transported through the soil below the root zone. Leaching potential is strictly a function of soil characteristics and hydraulic loading; it does not depend on the nature of the chemical applied to the soil. Instead, it depends on *throughflow potential*, which is the time of travel through the soil; *runoff potential*, which is hydraulic loading due to the balance between infiltration and runoff; and *hydraulic loading* from rainfall and irrigation.

Rating throughflow potential

Throughflow potential is an empirical rating of the relative amount of time required for water to pass through the soil to groundwater. It assumes there is enough hydraulic loading that water supply is not limiting. Throughflow potential is derived by interacting time of travel through the soil with depth to seasonal groundwater levels.

The first step in the procedure is to determine time-of-travel classes. Time of travel is the length of time it takes a slug of water added to the surface to travel through the soil under conditions of saturated flow to a depth of 60 inches, to bedrock, or to a cemented hardpan, whichever is shallower.

Time of travel is calculated using soil permeability and soil depth data in the Natural Resources Conservation Service State Soil Survey Database. For example, if a soil horizon is 8 inches thick and its permeability is estimated at 0.2 inches per hour, then time of travel through the horizon is 8 inches/0.2 inches per hour, or 40 hours.

Permeability data in the Soil Survey Database are given as ranges, i.e., 0.06–0.2 inches per hour. By convention, we used the midpoint of each range to calculate times of travel. For the permeability class <0.06, we used a value of 0.04 for calculations. For the permeability class >20, we used a value of 40 for calculations.

Travel time to a 60-inch depth is determined by summing travel time through each soil layer. Possible values range from 1.5 hours to 1,500 hours. This range was divided into 10 classes, as shown in Table 2.

Table 2.—Time of travel classes for evaluating throughflow potential.

Permeability class	Hours
1	>1,024
2	512.5–1,024
3	256.5–512.4
4	128.5–256.4
5	64.5–128.4
6	32.5–64.4
7	16.5–32.4
8	8.5–16.4
9	4.5–8.4
10	0–4.4

The second step in evaluating throughflow potential is to interact time of travel with depth to groundwater. The logic here is that a rapidly permeable soil with a permeability class of 9 or 10, combined with a shallow depth to groundwater, should create a very high throughflow potential. Conversely, a slowly permeable soil in which groundwater is far beneath the surface should create a very low throughflow potential. These relationships are shown in Table 3.

Ratings of throughflow potential depend on whether the water table is classified as *apparent* (Table 3a) or *perched* (Table 3b), as indicated in the Soil Survey Database. Water tables are apparent when soil permeability throughout the upper 6 feet is relatively uniform. Water tables are perched when a restrictive layer of much slower permeability is present beneath a more permeable layer, such that the upper layer becomes saturated while the restrictive layer remains unsaturated, at least for a period

Table 3a.—Criteria for evaluating throughflow potential for soils with apparent water tables.

Time of travel class	Depth to apparent water table (feet)				
	≥6.0	3.0–5.9	1.5–2.9	0.5–1.4	<0.5
1	Very low	Very low	Low	Low	Moderate
2	Very low	Low	Low	Moderate	Moderate
3	Very low	Low	Moderate	Moderate	High
4	Low	Moderate	Moderate	Moderate	High
5	Low	Moderate	Moderate	Moderate	High
6	Moderate	Moderate	Moderate	High	Very high
7	Moderate	High	High	High	Very high
8	High	Very high	Very high	Very high	Very high
9	High	Very high	Very high	Very high	Very high
10	Very high	Very high	Very high	Very high	Very high

Table 3b.—Criteria for evaluating throughflow potential for soils with perched water tables.

Time of travel class	Depth to perched water table (feet)			
	≥3.0	1.5–2.9	Not flooded <1.5	Flooded <1.5
1	Very low	Very low	Low	Low
2	Very low	Low	Low	Moderate
3	Very low	Low	Low	Moderate
4	Low	Low	Moderate	Moderate
5	Low	Moderate	Moderate	Moderate
6	Low	Moderate	Moderate	High
7	Moderate	Moderate	Moderate	High
8	Moderate	Moderate	High	High
9	Moderate	Moderate	High	Very high
10	Moderate	High	High	Very high

of time. With respect to groundwater contamination, a perched water table tends to protect groundwater as compared to an apparent water table present at the same depth.

The flood potential data in Table 3b are used to represent position of the soil within the landscape. For example, several Oregon soils with restrictive layers at shallow depths lie on convex upland landscapes. In these kinds of landscapes (labeled as “Not flooded” in Table 3b), nearly all of the water in the saturated zone moves laterally downslope above the restrictive layer, thereby reducing the odds of groundwater contamination. Restrictive layers on landscapes such as floodplains (“Flooded” in Table 3b), however, offer a higher potential for groundwater contamination because the soil eventually could become saturated throughout.

Rating runoff potential

Runoff potential is a factor in groundwater contamination potential because of its influence on hydraulic loading. When runoff potential is low, more of the rain or irrigation water enters the soil, increasing groundwater contamination potential and hydraulic loading. When runoff potential is high, water runs off and becomes part of the surface water system, reducing both infiltration and hydraulic loading.

Factors such as texture, structure, organic matter, residue management, tillage, nature of vegetative cover, and antecedent moisture influence the balance between runoff and infiltration. Many of these variables are temporal and dynamic, and therefore are not characterized in the Soil Survey Database.

Consequently, we used only three variables for which database information is available to develop an empirical assessment of runoff potential. These variables are permeability of the surface soil, depth to a restrictive layer, and soil slope.

Infiltration rate would be a key variable for rating runoff potential, but it varies with time and moisture content. We therefore used the static variable, permeability of the surface soil, as a surrogate.

Similarly, antecedent moisture content would be a key variable, but it varies for each storm and infiltration event. So instead we used depth of soil to a restrictive layer such as bedrock, duripan, clay, abrupt textural change, or seasonally frozen soil. The logic here is that the shallower the depth to any of these features, the faster the soil will become saturated, causing any additional water to run off. Soil slope is included in the database and was taken directly from the phase of the map unit.

Runoff potential using the three variables is shown in Table 4. The ratings assume the soil is cultivated for agricultural crops. Forested soils and soils with a continuous vegetative cover are rated one class lower than that shown in Table 4.

Intrinsic leaching potential

Throughflow potential and runoff potential determine the intrinsic leaching potential (Table 5). These ratings assume that moisture from rainfall or irrigation is adequate to move water through the soil to a depth of at least 6 feet, i.e., to cause leaching of any soluble constituents. Corrections to the intrinsic leaching potential ratings are necessary when moisture is more limiting or more excessive than is assumed for the intrinsic condition.

Corrections for hydraulic loading

Average annual rainfall in Oregon ranges from well over 100 inches in parts of the Coast Range to less than 8 inches in some parts of southeastern Oregon. Soils in such widely divergent climates may have the same intrinsic properties, giving rise to identical intrinsic leaching potentials. By failing to correct for hydraulic loading, one could mistakenly conclude that groundwater vulnerability in the desert environment, where rainfall is insufficient to completely leach the soil, is equal to groundwater vulnerability in the wet regions of the Willamette Valley.

Two corrections are necessary: one for the amount of rainfall in the soil's region, and one for the change in hydraulic loading brought about by irrigation.

Table 4.—Criteria for evaluating runoff potential.

Surface permeability (in/hr)	Soil depth* (in)	Slope — Use midpoint value of slope range ≤5%	6–16%	17–30%	>30%
Very slow (<0.06)	<20	Very high	Very high	Very high	Very high
	20–40	High	Very high	Very high	Very high
	>40	High	Very high	Very high	Very high
Slow (0.06-0.60)	<20	High	High	Very high	Very high
	20–40	Moderate	Moderate	High	Very high
	>40	Low	Moderate	High	High
Moderate (0.60–6.00)	<20	Moderate	High	High	Very high
	20–40	Low	Moderate	Moderate	High
	>40	Very low	Low	Moderate	High
Rapid (>6.00)	<20	Low	Moderate	High	High
	20–40	Very low	Low	Low	Moderate
	>40	Very low	Very low	Low	Low

* Soil depth is calculated to shallowest of:
Restrictive layer, such as: duripan (if not rippable), claypan, cemented pan, etc.
or bedrock,
or seasonal high water table,
or ice layer (frozen soil = High = <20" depth, Frozen soil = Moderate = 25" depth),
or abrupt textural change [a permeability class (as defined by NRCS) change of two or more classes lower].

Notes:
Runoff potential assumes cultivated conditions exist.
Forest soils and other undisturbed lands with vegetative cover would be rated one class lower.

Table 5.—Criteria for determining intrinsic leaching potential.

Throughflow potential rating	Runoff potential rating — Very low	Low	Moderate	High	Very high
Very low	Very low	Very low	Very low	Very low	Very low
Low	Low	Low	Very low	Very low	Very low
Moderate	Moderate	Moderate	Low	Very low	Very low
High	High	High	Moderate	Low	Low
Very high	Very high	Very high	High	Moderate	Moderate

Nonirrigated leaching potential. Table 6a lists four ranges of average annual rainfall. Where average annual rainfall is 40 inches or more, we assume it is enough to completely leach the soil. In this case, the nonirrigated leaching potential is equal to the intrinsic leaching potential. Where average annual rainfall is less than 40 inches, ratings of intrinsic leaching potential are lowered by one class successively as the rainfall class decreases. The effect of this correction is more pronounced for soils with a high or very high intrinsic leaching potential than for soils with a low or moderate intrinsic leaching potential.

Irrigated leaching potential. Oregon has a Mediterranean climate with cool, wet winters and warm, dry summers. Thus, even where winter rainfall is 40 inches or more, high-value agricultural crops need irrigation during the summer. In these situations, the irrigated leaching potential is determined by raising the nonirrigated leaching potential one class. This is shown in the far-right column of Table 6b.

In regions where rainfall is less than 40 inches, it is assumed that irrigation merely removes the moisture deficit, and the irrigated leaching potential is equal to the intrinsic leaching potential. For example, if soil in an 11- to 24-inch rainfall zone had a moderate intrinsic leaching potential, its nonirrigated leaching potential would be lowered to very low (Table 6a), but its irrigated leaching potential would be moderate (Table 6b).

Evaluation of sorption potential

Sorption of pesticides onto soil particles is a chemical process by which bonds form between the applied chemical and the organic matter in the soil. Because many pesticides are themselves organic compounds, covalent bonding probably is the most common and effective

Table 6a.—Criteria for determining nonirrigated leaching potential.

Intrinsic leaching potential rating	Annual rainfall (inches)			
	0–10	11–24	25–39	≥40
Very low	Very low	Very low	Very low	Very low
Low	Very low	Very low	Very low	Low
Moderate	Very low	Very low	Low	Moderate
High	Very low	Low	Moderate	High
Very high	Low	Moderate	High	Very high

Table 6b.—Criteria for determining irrigated leaching potential.

Intrinsic leaching potential rating	Annual rainfall (inches)			
	0–10	11–24	25–39	≥40
Very low	Very low	Very low	Very low	Low
Low	Low	Low	Low	Moderate
Moderate	Moderate	Moderate	Moderate	High
High	High	High	High	Very high
Very high	Very high	Very high	Very high	Very high

means of retaining chemicals in the soil. It follows that soils with high organic matter content should have a higher sorption potential than soils low in organic matter, simply because of the number of sites available for sorption to occur.

Another sorption mechanism is the formation of electrostatic bonds between positively charged sites on a pesticide molecule and negatively charged sites on soil clays and organic matter. The total number of negatively charged sites in a soil can be expressed quantitatively by determining the soil's cation exchange capacity, which then serves as a good measure of the potential for sorption via this mechanism.

Rating organic matter

Because sorption can occur at any point during a chemical's transport through the soil, the most useful measure of organic matter's contribution to sorption is the weighted average organic matter, or organic carbon content, throughout the upper 6 feet of soil. The problem is that the Soil Survey Database provides information only on a range of organic matter (expressed as a percentage) for the surface horizon of the soil, so it is not possible to determine a distribution function with depth.

An alternative method used in some models is to multiply the percent organic matter for the surface horizon by the thickness of the surface layer, as reported in the database. The problem with this method is that layer thickness is determined primarily by soil texture, not soil organic matter. For example, a thick, silty soil in eastern Oregon with 2 percent organic matter in the surface horizon may seem to have a higher sorption rating than a soil in western Oregon with a thinner surface layer containing 4 percent organic matter.

Because neither database method was satisfactory for evaluating sorption potential, we developed empirical classes of organic matter content to use in the OWQDA. Criteria for making placements of organic matter class are shown in Table 7. As its primary source of information, the key uses inferences that can be drawn from terminology used in soil taxonomy. This information is supplemented by inferences about general organic matter content associated with rainfall regions in Oregon, certain soil textures, and depth to bedrock.

Table 7.—Key for determining classes of organic matter content for evaluating sorption potential.

I. Aridisols
- A. Coarse silty, sandy families .... Very low
- B. Loamy, fine silty, fine families .... Low

II. Alfisols
- A. Aqualfs
  - 1) Albaqualfs .... Medium
  - 2) Other Aqualfs .... High
- B. Other suborders—use the matrix below with the following modifications:
  - 1) Aquic intergrades—raise one class, up to a maximum of High
  - 2) Sandy families—lower one class

	Rainfall <10"	Rainfall 10–25"	Rainfall >25"
Lithic intergrades and shallow families	Very low	Low	Medium
Moderately deep and deep soils	Low	Medium	High

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Table 7.—continued

III. Andisols
- A. Torrands
  - 1) Coarse silty, sandy, skeletal families .... Very low
  - 2) Other particle-size families .... Low
- B. Vitrands .... Medium
- C. Other suborders
  - 1) Vitric great groups .... Medium
  - 2) All other great groups .... High

IV. Entisols
- A. Aquents
  - 1) Psammaquents .... Medium
  - 2) Others .... High
- B. Psamments
  - 1) Torripsamments .... Very low
  - 2) Others .... Low
- C. Other suborders
  - 1) Torri Great Groups .... Low
  - 2) Other Great Groups—use the matrix below with the following modifications:
    - a) Aquic intergrades—raise one class, up to a maximum of High

	Rainfall		
	<10"	10–25"	>25"
Lithic intergrades and shallow families	Very low	Low	Medium
Moderately deep and deep soils	Low	Medium	High

V. Histosols .... Very high

VI. Inceptisols
- A. Aquepts
  - 1) Histic intergrades .... Very high
  - 2) Other Aquepts
    - a) Rainfall $\leq$12 inches .... Medium
    - b) Rainfall >12 inches .... High
- B. Ochrepts
  - 1) Aquic intergrades .... High
  - 2) Lithic subgroups .... Low
  - 3) Sandy families, Skeletal soils .... Low
  - 4) All others .... Medium

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Table 7.—continued

C. Umbrepts
  1) Lithic subgroups .... Medium
  2) Sandy families, Skeletal soils .... Medium
  3) All others .... High

VII. Mollisols
A. Aquolls, Albolls
  1) Rainfall ≤12 inches .... Medium
  2) Rainfall >12 inches .... High
B. Other suborders
  1) Aridic intergrades
    a) Coarse silty, sandy, skeletal soils .... Low
    b) Other particle-size families .... Medium
    c) Lithic subgroups .... Low
  2) All others—use the matrix below with the following modifications:
    a) Aquic intergrades—raise one class, up to a maximum of High
    b) Sandy families and skeletal soils—lower one class

	Rainfall ≤25"	Rainfall >25"
Lithic intergrades and shallow families	Low	Medium
Moderately deep and deep soils	Medium	High

VIII. Spodosols
A. Aquods .... Medium
B. Orthods
  1) Aquic, Humic intergrades .... Medium
  2) All others .... Low

IX. Ultisols
A. Aquults .... High
B. Humults .... High
C. Udults .... High
D. Xerults
  1) Palexerults .... High
  2) All others .... Medium

X. Vertisols
A. Aquerts .... High
B. Xererts
  1) Pello Great Groups .... High
  2) Chromo Great Groups .... Medium

Rating clay content

Data on cation exchange capacity are not uniformly available in the Soil Survey Database, so we could not use that parameter directly. Cation exchange capacity is a function of the type and amount of clay and the amount of organic matter. Because we already accounted for the overall effect of organic matter, we chose to use the soil's clay content as a surrogate for the cation exchange capacity.

We could have used the actual clay data reported in the database, but opted to generalize by associating clay contents with five broad groups of soil texture, and we evaluated only the surface horizon. Coarse textures equated to sands and loamy sands; moderately coarse textures to sandy loams; medium textures to loams and silt loams; moderately fine textures to silty clay loams, clay loams, and sandy clay loams; and fine textures to silty clays, clays, and sandy clays.

Sorption potential ratings

Final sorption potential ratings were determined by interacting the organic matter class for a soil with the surface texture class. The specific criteria are shown in Table 8.

Nonirrigated soil sensitivity ratings

Soil sensitivity is a function of leaching potential and sorption potential. Nonirrigated soil sensitivity ratings are determined by interacting the nonirrigated leaching potential ratings from Table 6a with the sorption potential ratings from Table 8. The specific criteria are shown in Table 9a.

Irrigated soil sensitivity ratings

Irrigated soil sensitivity ratings are determined by interacting the irrigated leaching potential ratings from Table 6b with the sorption potential ratings from Table 8. The specific criteria are shown in Table 9b.

Interpretation of soil sensitivity ratings

As mentioned earlier, there are five classes of soil sensitivity ranging from Very Low to Very High. Each class depends on the leaching potential rating and the sorption potential rating. To a certain extent, especially in some of the intermediate sensitivity classes, leaching potential and sorption potential can compensate for each other. In these cases, it can be useful to examine the separate component ratings to determine whether a higher degree of sensitivity is due primarily to more rapid leaching, to limited sorption, or to both. Further general interpretations of soil sensitivity ratings are discussed below.

Very Low—The soil has slow or very slow permeability and an abundance of organic matter, which means the leaching potential is low or very low and the sorption potential is high. It is very unlikely that pesticides will move through this soil to contaminate groundwater.

Low—Combinations of slow permeability and deep soil to bedrock or groundwater create a low leaching potential; moderate to high amounts of clay and organic matter create a high sorption potential. Under these conditions, only a few of the most mobile pesticides are likely to contaminate groundwater.

Moderate—One or more soil properties is beginning to limit the soil's ability to protect groundwater quality. The

Table 8.—Soil surface texture rating.

Organic matter rating	Soil surface texture rating: Coarse	Moderately coarse	Medium	Moderately fine	Fine
Very low	Very low	Very low	Low	Low	Low
Low	Very low	Low	Low	Moderate	Moderate
Moderate	Low	Moderate	Moderate	High	High
High	Moderate	Moderate	High	High	Very high
Very high	Moderate	High	Very high	Very high	Very high

Table 9a.—Criteria for determining nonirrigated soil sensitivity ratings.

Nonirrigated leaching potential rating	Sorption potential rating: Very low	Low	Moderate	High	Very high
Very low	Moderate	Low	Very low	Very low	Very low
Low	Moderate	Moderate	Low	Very low	Very low
Moderate	High	High	Moderate	Low	Low
High	Very high	Very high	High	Moderate	Moderate
Very high	Very high	Very high	Very high	High	Moderate

Table 9b.—Criteria for determining irrigated soil sensitivity ratings.

Irrigated leaching potential rating	Sorption potential rating: Very low	Low	Moderate	High	Very high
Very low	Moderate	Low	Very low	Very low	Very low
Low	Moderate	Moderate	Low	Very low	Very low
Moderate	High	High	Moderate	Low	Low
High	Very high	Very high	High	Moderate	Moderate
Very high	Very high	Very high	Very high	High	Moderate

property might be higher permeability, shallower depth to bedrock or groundwater, or lower amounts of clay and organic matter that limit sorption. Soils with moderate sensitivity will adequately protect groundwater quality with respect to most chemicals applied. However, chemicals with high or very high pesticide movement ratings should be evaluated carefully before use.

High—One or more soil properties is limiting the soil's ability to protect groundwater quality. Either rapid permeability and shallow depth to bedrock or groundwater create a high leaching potential, or low amounts of clay and organic matter create a low sorption potential. Groundwater is potentially vulnerable to contamination from pesticides, particularly those with high or very high pesticide movement ratings. This does not mean these chemicals cannot be used, however, but that detailed evaluation and planning are necessary to minimize the risk. Factors to consider include application rate, method, and timing.

Very High—These soils are limited by rapid permeability and by low clay and organic matter content. Coarse-textured sandy and gravely soils in rainfall-limited regions of eastern Oregon are of primary concern. Chemicals still can be used on these soils, but very careful planning and management must be invoked, including consideration of application rate, method, and timing. Where possible, alternative chemicals with lower pesticide movement ratings should be used.

Related OSU Extension materials

How Soil Properties Affect Groundwater Vulnerability to Pesticide Contamination, EM 8559, by J.H. Huddleston (1994). $1.00

A general introduction to the key factors involved in determining a soil's leaching potential and sorption potential. Explains the role of permeability, water table conditions, organic matter content, and clay content.

Introduction to the OSU Extension Soil Sensitivity Database, EM 8707, by J.H. Huddleston, W.R. Mendez, M. Brett, E.A. Kerle, and P.A. Vogue (1998). 50¢

A brief introduction to the factors included in the OWQDA soil sensitivity database, including throughflow potential, runoff potential, and hydraulic loading.

An Overview of the Oregon Water Quality Decision Aid (OWQDA), EM 8705, by J.H. Huddleston (1998). $1.00

An introduction to the OWQDA, including a brief explanation of the soil sensitivity and pesticide movement ratings.

Oregon Water Quality Decision Aid Computer Software, EM 8706, by J.H. Huddleston (1998). $25.00

Fully automated version of OWQDA, including the complete pesticide properties database and the complete soil sensitivity database.

The OSU Extension Pesticide Properties Database, EM 8709, by P.A. Vogue, E.A. Kerle, and J.J. Jenkins (1998). $2.50

Hard copy version of the pesticide database for using OWQDA manually.

The OSU Extension Soil Sensitivity Database (1998).

Hard copy version of the soils database for using OWQDA manually. *Order this publication from the OSU Department of Soil Science (541-737-5712)*. There is a nominal fee for photocopying and mailing.

Site Assessment for Groundwater Vulnerability to Pesticide Contamination, EM 8560, by E.A. Kerle, P.A. Vogue, J.J. Jenkins, and J.H. Huddleston (Revised 1998). $1.50

Step-by-step instructions for using OWQDA manually and worksheets for recording your data.

Understanding Pesticide Persistence and Mobility for Groundwater and Surface Water Protection, EM 8561, by E.A. Kerle, J.J. Jenkins, and P.A. Vogue (1994). $1.50

A general introduction to the key factors involved in determining the potential for pesticides to reach groundwater and surface water. Explains the role of photo-, chemical, and microbial degradation; sorption, plant uptake, volatilization, wind erosion, runoff, and leaching.

How to order

To order copies of the above publications (except for *The OSU Extension Soil Sensitivity Database*), or the OWQDA computer software, send the complete title and series number, along with a check or money order for the amount listed, payable to Oregon State University, to the address below. We offer discounts on orders of 100 or more copies of a single publication and of 12 or more copies of a single computer software program. Please call 541-737-2513 for price quotes.

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