Regulatory Implementation of VFS as a Mitigation for Transport of Pesticides via Runoff and Erosion: The European 'Reduction Efficiency Factor' Approach.

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What is a VFS?

- A VFS is a *Vegetative Filter Strip*, also known as vegetated buffer strip.
- Vegetative filter strips are "…areas of grass or other permanent vegetation used to reduce sediment, organics, nutrients, pesticides, and other contaminants in runoff and to maintain or improve water quality. Filter strips are located between crop fields and waterbodies." (USDA, 2000)

Figure 1: Filter strip along a stream in western Iowa (NRCS, 2011)

Key issues

- **Though a well-maintained VFS can reduce pesticide transport from agricultural fields to receiving waterbodies, US risk assessments do not currently quantify the effect of VFS for refinement of predicted pesticide concentrations.**
- **Challenges to implementing VFS in the risk assessment process include questions about how to deal with variations in VFS efficiency and how to quantify the impact of VFS on estimated environmental concentrations (EECs).**
- **The European Union (EU) incorporates VFS in the risk assessment process as a higher tier refinement to exposure calculations. The EU method is described here as an example of one approach that could be used to incorporate VFS into the US risk assessment process.**

VFS in the EU regulatory process

The EU approach is a pragmatic one "…developed with due consideration that the aim of the EU Annex I risk assessment is to demonstrate that a major safe use of the compound in the EU is possible (i.e. not necessarily to be protective of every individual set of circumstances)" (FOCUS, 2007a)

Fundamental aspects of the EU approach include (FOCUS, 2007a & 2007b):

- VFS is accounted for in EU exposure calculations via standard 'reduction efficiency' factors, which are summarized in Table 1, below.
- The reduction factors are 90th percentile values derived from empirical datasets and are considered "…reasonable worst-case assumptions for efficacy of vegetated buffer zones in good condition."
- Reduction efficiency depends on buffer width, among other things. The standard widths considered in the EU approach are 10 and 20 m. (Table 1). Shorter or longer buffer widths are employed at the discretion of EU Member States. For example, in Germany, a 5 m buffer strip is considered to provide 50% reduction.
- Reduction efficiency also depends on whether the compound is transported primarily in the aqueous or sediment (sorbed) phase. The corresponding reduction efficiency values are applied separately to the aqueous and sediment phase pesticide loads that are calculated by the runoff and erosion model (e.g., PRZM).
- The aqueous phase reduction factor is also applied to the volume of runoff water. Therefore, the net reduction in EEC will be less than the reduction efficiencies shown in Table 1 due to a decrease in dilution within the waterbody.
- The maximum allowable reduction in EEC is 90%.

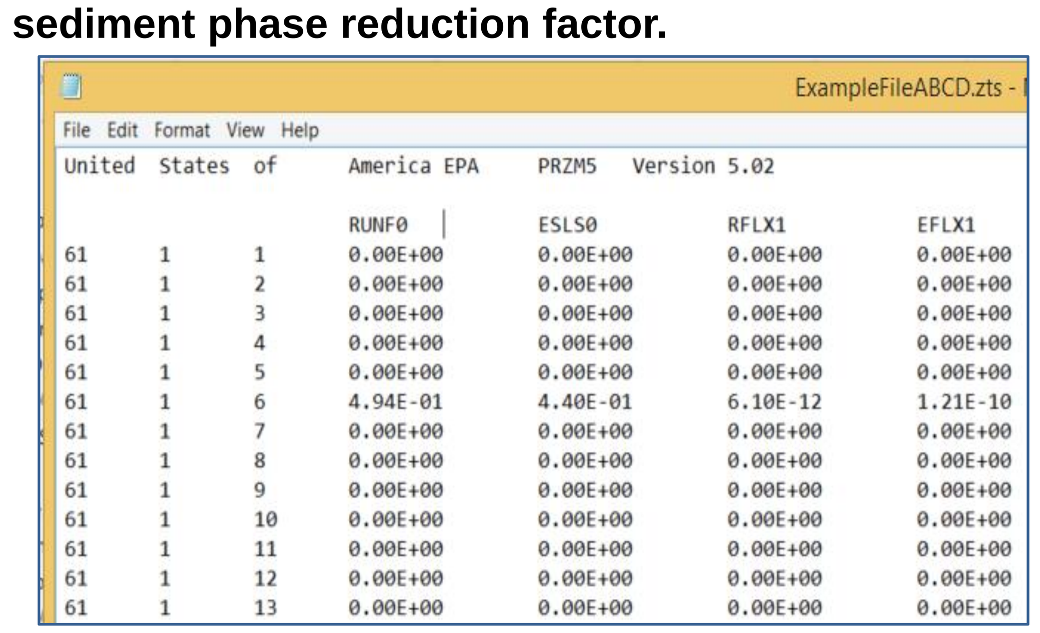
Table 1: 90th percentile worst-case values for VFS reduction efficiencies. (FOCUS, 2007a). The n values are the number of studies that were considered in each category of VFS width and transport phase.

Buffer width (m)	10-12	18-20
Reduction in volume of runoff water (%)	60	80
Reduction in mass of pesticide transported in aqueous phase (%)	60	80
n (for aqueous phase)	*36*	*30*
Reduction in mass of eroded sediment (%)	85	95
Reduction in mass of pesticide transported in sediment phase (%)	85	95
n (for sediment phase)	*19*	*11*

Technical aspects of incorporating the EU approach into the US risk assessment process

- The US and EU exposure modeling systems both use PRZM to predict runoff volume, eroded sediment mass, and associated pesticide loading from agricultural fields for a set of standard scenarios.
- Reductions in the predicted values due to an edge-of-field VFS can be accounted for by applying the reduction efficiencies to the PRZM output (*.zts file, Fig. 2). The 'scaled' file is then passed to a separate model that performs the EECs calculations for the waterbody, i.e., the VVWM model in the US; TOXSWA in the EU.

Figure 2: *.ZTS file from PRZM. RUNF0 and RFLX1 are scaled by the aqueous phase reduction factor. ESLS0 and EFLX1 are scaled by the sediment phase reduction factor.



ExampleFileABCD.zts -

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United States of America EPA PRZM5 Version 5.02

			RUNF0	ESLS0	RFLX1	EFLX1
61	1	1	0.00E+00	0.00E+00	0.00E+00	0.00E+00
61	1	2	0.00E+00	0.00E+00	0.00E+00	0.00E+00
61	1	3	0.00E+00	0.00E+00	0.00E+00	0.00E+00
61	1	4	0.00E+00	0.00E+00	0.00E+00	0.00E+00
61	1	5	0.00E+00	0.00E+00	0.00E+00	0.00E+00
61	1	6	4.94E-01	4.40E-01	6.10E-12	1.21E-10
61	1	7	0.00E+00	0.00E+00	0.00E+00	0.00E+00
61	1	8	0.00E+00	0.00E+00	0.00E+00	0.00E+00
61	1	9	0.00E+00	0.00E+00	0.00E+00	0.00E+00
61	1	10	0.00E+00	0.00E+00	0.00E+00	0.00E+00
61	1	11	0.00E+00	0.00E+00	0.00E+00	0.00E+00
61	1	12	0.00E+00	0.00E+00	0.00E+00	0.00E+00
61	1	13	0.00E+00	0.00E+00	0.00E+00	0.00E+00

- ❑ RUNF0 = runoff depth (cm)
- ❑ ESLS0 = eroded solids (tonnes, Mg)
- ❑ RFLX1 = Pesticide runoff flux (g AI/cm^2)
- ❑ EFLX1 = Pesticide erosion flux (g AI/cm^2)

Remaining technical hurdles

- The SWAN model (ECPA, 2015) is used for this purpose in EU. No model currently exists for this in the US, so the interface would need to be developed to scale PRZM outputs to account for VFS prior to passing the data to VVWM. SWAN also has the capability to run VFSMOD to predict reduction efficiency.
- The standard buffer lengths used in the EU modeling process are considerably longer than those commonly specified on pesticide labels in the US. Thus, reduction efficiencies would need to be determined for the shorter lengths. This could be done by the review of existing data, conducting new VFS efficacy studies, or referring to latest recommendations (MAgPIE, 2017).

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