EVALUATING THE SURFACE IRRIGATION SOIL LOSS (SISL) MODEL

D. L. Bjorneberg, C. J. Prestwich, R. G. Evans

ABSTRACT. *The SISL (surface irrigation soil loss) model was developed by the Idaho Natural Resources Conservation Service (NRCS) in 1991 to estimate annual soil loss from furrow irrigated fields to assess benefits of conservation practices, such as converting from furrow to sprinkler irrigation. This empirical model was based on over 200 field-years of data from southern Idaho, but it has not been independently evaluated. Data collected in 2003 from six production fields near Kimberly, Idaho, along with previously published furrow irrigation erosion data from Kimberly, Idaho and Prosser, Washington, were used to evaluate the SISL model. Predicted soil loss correlated reasonably well with measured soil loss for all three data sets (r^2= 0.73, n = 30). The model predicted the relative effects of conservation tillage practices, straw mulching, and surge irrigation reasonably well, however, the absolute differences between measured and predicted soil loss were sometimes large. Number of irrigations is embedded in the base soil loss so SISL cannot be applied when irrigation application varies significantly from typical southern Idaho conditions. The limited number of conservation practice factors included in SISL also did not represent all types and frequencies of tillage operations that occurred in the field. A better approach may be to calculate the base soil loss from field length, slope, soil, and some estimate of runoff rather than selecting base soil loss from slope and crop categories in the current model.*

Keywords. *Furrow irrigation, Furrow erosion, Irrigation Erosion Model.*

Although the percentage of surface irrigated land in the United States is declining, it is still used on 43% of the irrigated land, and 51% of the surface irrigated land is irrigated down furrows or rows (USDA, 2004). Water flowing in irrigation furrows often detaches and transports soil, reducing crop productivity and impairing off-site water quality. Crop yields were at least 25% less on fields eroded from over 80 years of furrow irrigation in south-central Idaho (Carter et al., 1985). Measured soil loss from furrow irrigated fields in this area varied from 1 to 141 Mg ha^{-1} annually (Berg and Carter, 1980) while the annual average soil loss from the entire irrigated tract was 0.46 Mg ha^{-1} in 1971 (Brown et al, 1974). This soil, and associated nutrients, is transported with irrigation water as it returns to the Snake River.

The Natural Resources Conservation Service (NRCS) and other land planning agencies need a tool to predict furrow irrigation erosion to assess the extent of the problem and to compare conservation practices applied to irrigated land. An evaluation of the Water Erosion Prediction Project (WEPP) model indicated that it could not be used to predict furrow irrigation erosion without substantially adjusting erodibility parameter values (Bjorneberg et al., 1999). The model also over-predicted sediment transport capacity resulting in no predicted sediment deposition on the lower end of fields, although data and observations document much on-field deposition (Bjorneberg et al., 1999).

The Idaho NRCS, in consultation with scientists and engineers at the Northwest Irrigation and Soils Research Laboratory, Kimberly, Idaho, developed a simple empirical model for estimating annual irrigation-induced soil loss from furrow irrigated fields. The SISL (surface irrigation soil loss) model was developed in 1991 based on over 200 field-years of data from southern Idaho. This model estimates soil loss at the end of the furrow and does not account for deposition or additional erosion that may occur in the drainage ditch at the end of the field. The only published documentation of this model is Idaho NRCS Agronomy Technical Note No. 32. Idaho NRCS uses this model to assess benefits of conservation practices, such as converting from furrow to sprinkler irrigation, but this model has not been independently evaluated. Therefore, the objective of this study was to compare the SISL model with erosion data collected from furrow irrigated fields near Kimberly, Idaho and Prosser, Washington.

METHODS AND MATERIALS

MODEL DESCRIPTION

The SISL model is an empirical model with form similar to the Universal Soil Loss Equation (USLE). A base soil loss value is multiplied by several factors to account for variations in soil erodibility, previous crop, conservation practices, and irrigation management. The SISL equation is:

$$\text{SISL} = \text{BSL} \times \text{KA} \times \text{PC} \times \text{CP} \times \text{IP} \qquad (1)$$

Submitted for review in September 2006 as manuscript number SW 6672; approved for publication by the Soil & Water Division of ASABE in March 2007.

The authors are **David L. Bjorneberg, ASABE Member Engineer,** Agricultural Engineer, USDA-ARS NW Irrigation and Soils Research Lab, Kimberly, Idaho; **Clare J. Prestwich, ASABE Member Engineer,** Irrigation Engineer, USDA-NRCS West National Technology Support Center, Portland, Oregon; and **Robert G. Evans, ASABE Member Engineer,** Agricultural Engineer, Research Leader, USDA-ARS Northern Plains Agricultural Research Lab, Sidney, Montana. **Corresponding author:** David L. Bjorneberg, USDA-ARS NW Irrigation and Soils Research Lab, 3793 N 3600 E, Kimberly, ID 83341; phone: 208-423-6521; fax: 208-423-6555; e-mail: bdavid@nwisrl.ars.usda.gov.

where SISL is the annual furrow irrigation soil loss from a field (Mg ha^{-1}), BSL is the base soil loss (Mg ha^{-1}), KA is the soil erodibility adjustment factor, PC is the prior crop adjustment factor, CP is the conservation practice adjustment factor, and IP is the irrigation management adjustment factor. The SISL model is described in Idaho NRCS Agronomy Technical Note No. 32 (NRCS, 2003), which uses English units that were converted to metric for this study.

The BSL (table 1) was developed from measured soil loss from more than 200 furrow irrigated fields in southern Idaho. The BSL varies by crop type, field slope, field length, and end of field slope shape (convex end). Three separate BSL tables are available for different types of inflow (siphon tube, gated pipe, or feed ditch). The BSL varies from 0 Mg ha^{-1} for permanent crops on fields with <1% slope to >173 Mg ha^{-1} for intensive row crops (e.g., sugar beet or onion) with >3% slope. Embedded within the BSL is the typical irrigation practices (number of irrigations, inflow rate, furrow spacing, irrigation duration, etc.) used for the various crop categories in southern Idaho.

Baseline soil loss is defined for only two field lengths: 200 and 400 m (660 and 1320 ft). BSL for a 200-m long field is 25% greater than the BSL for the 400-m field, presumably to account for the typically longer advance time (i.e. less runoff time) and greater opportunity for deposition on longer fields. BSL for gated pipe and feed ditch are 5% and 15% greater, respectively, than siphon tube BSL, presumably to account for additional erosion at the inflow point.

Convex end refers to the elevation difference between the end of the furrow and the bottom of the drain ditch where water flows from the field. A severe convex end has greater than 0.15 m (6 in.) of elevation change and moderate convex end has less than 0.15 m (6 in.) of elevation change. BSL for moderate convex end is 25% greater than BSL for no convex end. BSL for severe convex end is 75% greater than the BSL for no convex end.

Adjustment factors to the baseline soil loss were defined based on field observations, data, and impressions of the model developers. The soil erodibility factor (KA) varies from 0.45 to 1.12 (table 2) based on the soil erosion factor “K” from the NRCS soil survey. Most erosion data that were used to define the BSL were collected on fields with Portneuf silt loam, which has a soil K of 0.49. Thus KA was set to 1.0 when soil K equals 0.49. KA for other soils varies linearly with the soil survey K (KA equals 2.04 multiplied by the soil survey K).

Table 2. Soil erodibility (KA) adjustment factor.

Soil K	KA
0.22	0.45
0.28	0.57
0.32	0.65
0.37	0.76
0.43	0.87
0.49	1.00
0.55	1.12

The prior crop (PC) factor accounts for crop residue from the previous crop, varying from 0.65 for pasture to 1.0 for low residue crops like beans and onions (table 3). The conservation practice factor (CP) varies from 1.0 for conventional moldboard plow tillage to 0.10 for no-till and 0.30 for full-season polyacrylamide (PAM) use (table 4). Most PC and CP factors were developed from tillage and residue relationships found in SCS Western Region Conservation Agronomy Technical Note No. 27 (SCS, 1967). The irrigation practice (IP) factor accounts for the level of irrigation management combined with practices such as cutback and surge irrigation (table 5). The IP factor reduces the BSL to account for management practices that reduce runoff volume.

Table 3. Prior crop (PC) adjustment factor.

Prior Crop	PC
Pasture	0.65
Alfalfa	0.70
Mint	0.70
Alfalfa seed	0.75
Small grain – high residue	0.75
Small grain – residue harvested	0.85
Corn – high residue	0.75
Peas	0.80
Corn silage	0.85
Sugar beets	1.00
Beans	1.00
Potatoes	1.00
Onions	1.00

Table 1. Base soil loss (BSL) for gated pipe.

		Base Soil Loss (Mg ha^{-1})											
		Field Slope											
	Field Length (m)	<1%			1 to 1.9%			2 to 2.9%			>3%		
Crop Type		N[a]	M	S	N	M	S	N	M	S	N	M	S
Permanent cover	200	0.0	0.0	0.0	1.6	2.0	2.9	5.4	6.7	9.7	13.2	16.6	23.1
	400	0.0	0.0	0.0	1.3	1.6	2.2	4.3	5.4	7.6	10.6	13.2	18.4
Close growing	200	2.7	3.1	4.3	7.6	9.4	13.2	15.0	18.9	26.5	24.5	30.8	42.9
	400	2.2	2.5	3.4	6.1	7.6	10.6	12.1	15.0	21.1	19.5	24.7	34.4
Row crop	200	5.8	7.4	10.3	20.4	25.6	36.2	43.3	54.3	72.3	66.0	82.6	115.6
	400	4.7	5.8	8.3	16.4	20.4	29.0	34.6	43.6	57.9	52.8	66.0	92.5
Intensive row crop	200	7.6	9.4	13.2	28.5	35.9	50.1	62.2	77.9	108.9	103.7	129.8	181.7
	400	6.1	7.6	10.6	22.9	28.7	40.0	49.8	62.4	87.1	83.1	103.7	145.3

[a] N, M and S refer to none, moderate and severe convex ends.

Table 4. Conservation practice (CP) adjustment factor.

Conservation Practices	CP
Conventional tillage	1.00
Seasonal residue management	0.20
Mulch till residue management	0.15
No-till residue management	0.10
Chisel plow/subsoiling	0.50
Alfalfa hay	0.20
Straw mulch – full season	0.15
Straw mulch – part season	0.35
Polyacrylamide – full season	0.30
Polyacrylamide – part season	0.50

Furrow Erosion Data

Three sets of field data were used to evaluate the SISL model: a two-year tillage study conducted at Kimberly, Idaho; a two-year surge irrigation study conducted at Prosser, Washington; and a one-year study on six commercial fields near Kimberly, Idaho.

Tillage Study

The tillage study at Kimberly included four conservation tillage treatments (fall chisel plow, fall disk, spring disk, and direct seed) with a dry bean (*Phaseolus vulgaris*)-spring wheat (*Triticum aestivum*) crop rotation. Treatments were replicated three times. The soil was Portneuf silt loam and field slope was 1%. Each plot was 12 dry bean rows wide (6.7 m) and 150 m long. Half of the irrigation furrows in each dry bean plot were treated with anionic, water soluble polyacrylamide (PAM) to reduce erosion (Lentz et al., 1992). Treatments and results are discussed in more detail in Bjorneberg and Aase (2004).

Dry bean plots were irrigated five times in 1999 and six times in 2000. Soil erosion was measured from two furrows (one with and one without PAM) during each irrigation on only the dry bean plots. Furrow inflow was measured by the time required to fill a known volume (3.8 L). Furrow outflow was measured with a trapezoidal flume. Sediment concentration was calculated by pouring a 1-L runoff sample into an Imhoff cone and reading the settled volume after 30 min (Sojka et al., 1992). Sixteen Imhoff cone samples were filtered and weighed in the laboratory to determine the relationship between sediment volume and mass. Six to nine flow and sediment concentration measurements were made during each irrigation. Measurement interval progressively increased from 15 min to 2 or 3 h with irrigation time. Runoff volume was calculated by multiplying flow rate by the measurement interval. Soil loss was calculated by multiplying sediment concentration by runoff volume for each measurement interval. Total soil loss for a furrow during an irrigation was the sum of the soil loss for each time interval.

Soil loss for the tillage study was predicted using BSL for row crop, 200 m long furrow, <1% slope, and no convex end (table 1). KA was 1.0 for Portneuf silt loam (table 2). PC was 0.75 for high residue small grain (table 3). CP was 0.50 for chisel plow, 0.20 for fall disk (seasonal residue management), 0.15 for spring disk (mulch till residue management), and 0.10 for direct seed (no-till residue management). An additional CP of 0.30 was included for PAM-treated furrows (table 4). IP was 0.90 for high level irrigation management without cutback (table 5).

Table 5. Irrigation management practice (IP) adjustment factor.

Irrigation Practice	IP
High level – without cutback	0.90
High level – with cutback	0.70
Surge irrigation system	0.50

Surge Irrigation Study

Soil erosion from hops (*Humulus lupulus*) was measured in the Prosser, Washington study (Evans et al., 1995). This study compared the effects of surge irrigation in combination with applying straw mulch to irrigation furrows. Plots were 8.5 m wide and 390 m long on Shano sandy loam with 3.5% slope. Four plots had continuous inflow during irrigation and four plots were surge irrigated with the same inflow rate for 50% of the time, resulting in half the applied water. Typically a greater inflow rate is used for 50% of the time for surge irrigation. Plots were split with half of the furrows receiving straw mulch at about 0.66 Mg ha^{-1} of furrow area. Straw mulch was applied once in 1990 and three times in 1991. Plots were irrigated six times in 1990 and five times in 1991.

Surface runoff from each treatment was collected in 2.44-m wide × 4.88-m long × 1.22-m deep plywood boxes. Furrow runoff rate was measured with small HF flumes and 24-h Belfort water level stage recorders. Water flowed from the plywood boxes through a perforated pipe covered with filter fabric to retain sediment in the box. Sediment volume was measured manually after each irrigation. Sediment mass was calculated using an assumed bulk density of 1400 kg m^{-3}.

Intensive row crop BSL was used for hops with >3% slope, 400-m long furrows, and no convex end (83 Mg ha^{-1}). KA was 1.12 for Shano sandy loam. Hops are frequently tilled and leave little crop residue so PC was 1.00. Conservation practice included full season straw mulch (CP = 0.15) when straw was applied to furrows and irrigation management included surge irrigation (IP = 0.50) for the surge irrigation treatment.

Commercial Fields

Soil loss from six commercial fields near Kimberly, Idaho, was measured in 2003. Characteristics of each field are shown in table 6. Growers managed all irrigations according to their schedules. Irrigation sets usually lasted 24 h, except for field 5 which was irrigated for 12 h during each set. Furrow flow and sediment concentration were measured in the same six furrows for each irrigation, except preplant irrigations in May which were not monitored. Start and stop times for each irrigation were noted from field observations or supplied by producers. Furrow inflows and outflows were measured with trapezoidal flumes. Similar to the tillage study, sediment concentration was calculated from the sediment volume settled in 1-L Imhoff cones (Sojka et al., 1992). Five to ten cone samples from each field were filtered and weighed in the laboratory to determine the relationship between sediment volume and mass for each field. Three to five flow measurements and sediment concentration samples were collected during each irrigation. Sampling intervals varied among fields and irrigations depending on when the irrigation started and number of fields being monitored on a given day. Generally, the sampling interval was 30 to 120 min for

Table 6. Characteristics of commercial fields used for soil loss measurements in 2003 near Kimberly, Idaho.

Field	Number of Irrigations	Field Length (m)	Field Slope (m m^{-1})	Convex End (m)	Previous Crop	Current Crop	Tillage	Soil Loss (Mg ha^{-1})
1	7	270	0.75	0.14	Barley	Dry bean	Conservation	23.3
2	6	210	0.58	0.10	Dry bean	Sweet corn	Conventional	2.0
3	8	210	0.96	0.15	Dry bean	Sweet corn	Conventional	9.9
4	8	240	1.22	0.21	Dry bean	Dry bean	Conventional	33.0
5	7	150	0.40	0.15	Sugar beet	Dry bean	Conventional	4.7
6	6	190	0.76	0.03	Wheat	Sweet corn	Conventional	10.5

the first 4 h of runoff. Sampling intervals increased to 4 to 6 h, possibly 10 h for overnight irrigations, for the remaining irrigation time.

Runoff volume was calculated by multiplying flow rate by the sampling time interval. Soil loss was calculated by multiplying sediment concentration by runoff volume for each sample interval. Total soil loss for a field was the average of the six furrows measured in each field. Soil loss for each preplant irrigation was estimated as the average soil loss per irrigation for that field. This additional soil loss was added to the measured total to estimate total annual soil loss for each field. SISL parameters used for each field were matched as close as possible to the field characteristics listed in table 6 and are shown in table 7.

SISL MODEL EVALUATION

Annual soil loss was predicted for each field using the SISL model. BSL and adjustment factors for each treatment and field are shown in table 7. SISL predicted soil loss values were compared against treatment averages for the tillage and surge irrigation studies, and field averages for the commercial fields. Predicted soil loss values were related to measured values by linear regression. A good relationship, with coefficient of determination approaching one, would indicate that the model adjustment factors accurately described the relative variation in the measured data. A relationship with intercept near 0 and slope near 1.0 would indicate a good comparison between measured and predicted values.

Predicted and measured values were also compared using model efficiency (Nash and Sutcliffe, 1970). Model efficiency was calculated by

$$ME = 1 - \Sigma(m-p)^2 / \Sigma\,(m-m_{ave})^2 \qquad (2)$$

where ME is the model efficiency coefficient, m is the measured value, p is the predicted value, and m_{ave} is the average of measured values. Model efficiency compares predicted values to the 1:1 line of measured versus predicted rather than comparing predicted values to the best fit regression line as is done with coefficient of determination. Model efficiencies near 1 indicate good agreement between measured and predicted values. Biased model results are indicated when model efficiency is less than the coefficient of determination. A negative model efficiency indicates that the average measured value is a better estimate than the model output (Nash and Sutcliffe, 1970).

RESULTS AND DISCUSSION

TILLAGE STUDY

The relative effects of conservation practices (tillage and PAM treatments) were predicted reasonably well for the tillage study, with coefficients of determination of 0.55 and 0.88 for 1999 and 2000, respectively (fig. 1). Both of these coefficients were statistically significant ($P < 0.05$). The model efficiency was -3.0 for 1999 and 0.77 for 2000, indicating that the model poorly predicted soil loss in 1999 but predicted soil loss well in 2000. Measured soil loss was much greater than

Table 7. Baseline soil loss, adjustment factors and SISL predicted soil loss.

Study	Treatment/Field	Baseline Soil Loss (BSL) (Mg ha^{-1})	KA	PC	CP	IP	Predicted Annual Soil Loss (Mg ha^{-1})
Tillage	Chisel plow	5.8	1.00	0.75	0.50[a]	0.90	2.0
	Fall disk	5.8	1.00	0.75	0.20[a]	0.90	0.78
	Spring disk	5.8	1.00	0.75	0.15[a]	0.90	0.59
	Direct seed	5.8	1.00	0.75	0.10[a]	0.90	0.39
Surge	Conventional	83	1.12	1.00	1.00	1.00	93.
	Convent. straw	83	1.12	1.00	0.15	1.00	14
	Surge	83	1.12	1.00	1.00	0.50	46
	Surge straw	83	1.12	1.00	0.15	0.50	7.0
Commercial	1	7.0	1.00	0.85	0.20	1.00	1.2
	2	7.0	1.00	1.00	1.00	0.90	6.3
	3	7.4	1.00	1.00	1.00	1.00	7.4
	4	36	1.00	1.00	1.00	1.00	36
	5	7.0	1.00	1.00	1.00	1.00	7.0
	6	5.6	1.00	0.85	1.00	1.00	4.8

[a] CP factors are multiplied by 0.30 for PAM treated furrows.

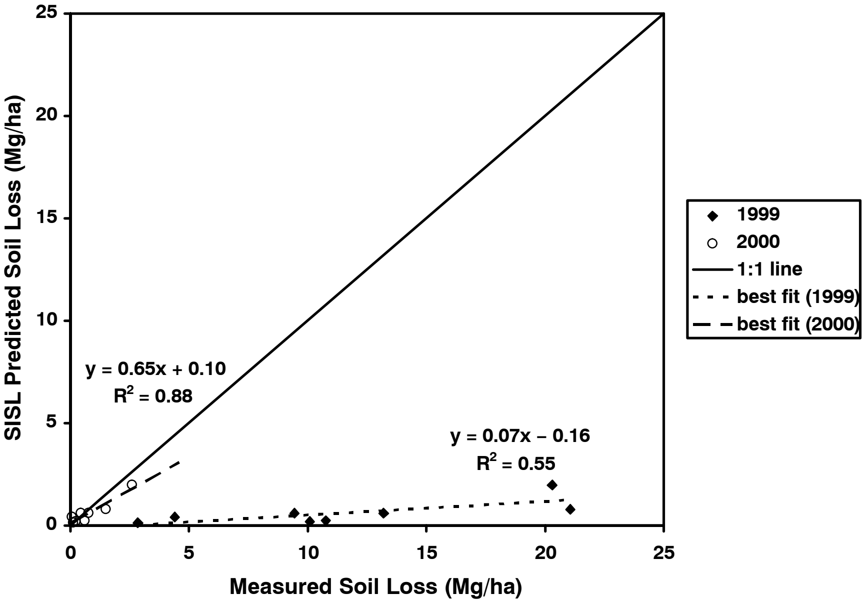

Figure 1. Measured vs. predicted soil loss for Kimberly, Idaho, tillage study.

predicted in 1999, probably because tillage treatments were initiated in 1998. Surface residue on tilled treatments (excluding direct seed) varied from 7% to 27% in 1999 and increased to 43 to 44% in 2000 after these plots had been planted to wheat in 1997 and 1999 (Bjorneberg et al., 2004). This indicates that the model did not account for the low initial accumulation of residue as new tillage practices were implemented, but that the model better predicted the longer term effects of tillage practices on this field. The under-predicted soil loss in 1999 also indicates that the limited number of conservation practice options in the SISL model did not represent the number, type, severity, and frequency of tillage operations that occur in the field.

BSL on this field was 5.8 Mg ha^{-1}, which was much less than measured soil loss for all treatments in 1999 except direct seed (fig. 1). Field slope was 1%, which falls between two slope categories. Using the 1% to 1.9% slope category increased predicted soil loss 3.5-fold for all treatments, which still under-predicted soil loss for 1999 while over-predicting soil loss for 2000. Changing the BSL did not change the correlation between measured and predicted soil loss because all treatments increased by the same relative amount.

Surge Irrigation Study

The relative effects of surge irrigation and straw mulching were accurately predicted for the second year of the surge irrigation study (fig. 2). Coefficients of determination were 0.55 ($P = 0.26$) and 0.997 ($P < 0.01$) for 1990 and 1991, respectively. Similar to the tillage study, model efficiency was poor the first year (-1.9) and good the second year (0.97), but for no obvious reason in this study. Combining the data from both years resulted in a 0.67 coefficient of determination ($P = 0.01$) and a 0.58 model efficiency. The significant correlation between measured and predicted soil loss only gives limited support that the model can be applied to areas other

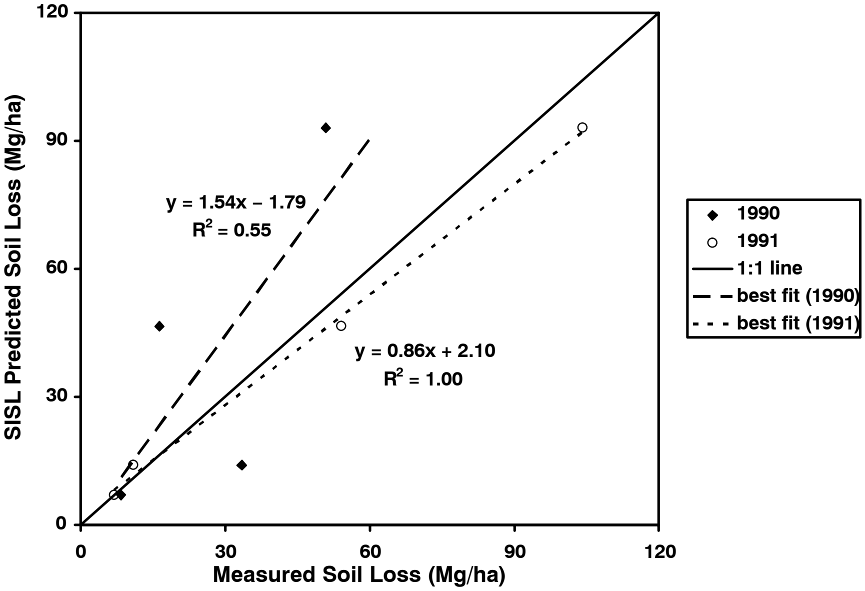

Figure 2. Measured vs. predicted soil loss for Prosser, Washington, surge irrigation study.

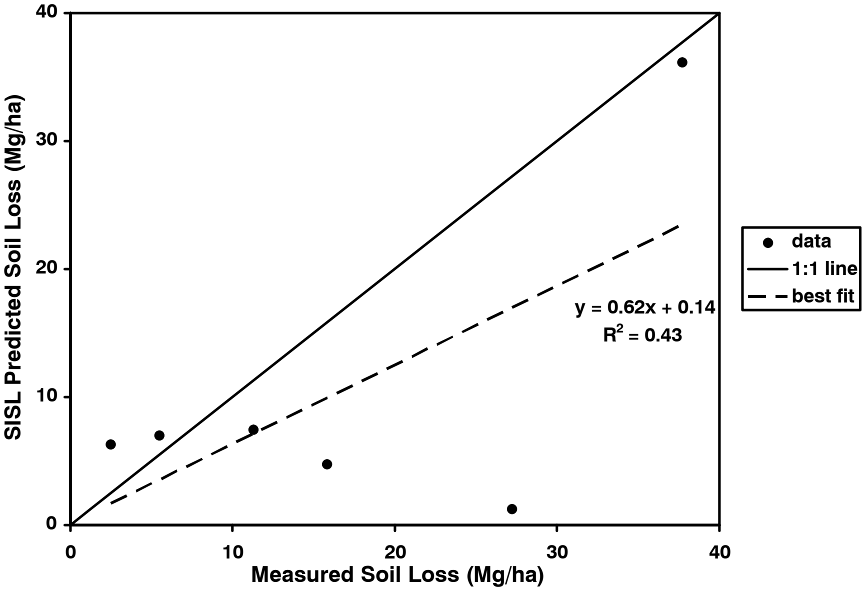

Figure 3. Measured vs. predicted soil loss for six production fields near Kimberly, Idaho.

than southern Idaho because the KA factor for Shano sandy loam was only 12% greater than Portneuf silt loam.

Commercial Fields

Soil loss was predicted reasonably well for five of the six production fields (fig. 3). The coefficient of determination, however, was not statistically significant ($r^2 = 0.43$, $P = 0.16$) and the model efficiency was low (0.08). The poor correlation was primarily influenced by Field 1. The SISL model predicted only 1.2 Mg ha^{-1} soil loss for Field 1 compared to 27 Mg ha^{-1} measured. The predicted value was small because of the low field slope, high residue from the previous crop, and conservation tillage. The high measured value occurred because Field 1 was irrigated weekly for six weeks, and each irrigation lasted 24 h, for a total irrigation application depth of 1200 mm. Applied irrigation depths for the other five fields were 470 to 730 mm during five to seven irrigations. High inflow rates and frequent irrigations on Field 1 overwhelmed the potential erosion control from conservation tillage and previous high residue crop. This field indicates a major weakness of the SISL model: it does not account for number of irrigations, amount of irrigation water applied, or amount of runoff. These factors are all imbedded in the base soil loss, which limits model application to areas with irrigation requirements and management similar to typical southern Idaho fields. This weakness could be overcome by allowing IP factors greater than 1.0 for poor practices and/or developing an additional irrigation factor to account for runoff volumes or irrigation amounts that are different from typical conditions in southern Idaho. Removing Field 1 from the analysis increased the coefficient of determination to 0.83 ($P = 0.03$) and model efficiency to 0.80 for the other five production fields.

Combining all three data sets showed a reasonable correlation between measured and predicted soil loss (fig. 4). The overall coefficient of determination was 0.73 ($P < 0.01$)

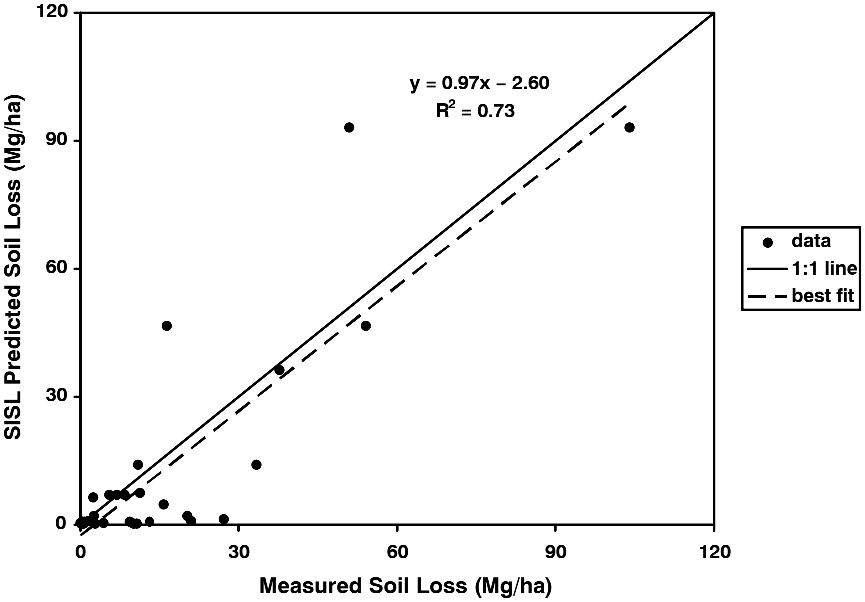

Figure 4. Measured vs. predicted soil loss for all three data sets.

and model efficiency was 0.62. However, this correlation was strongly influenced by the high soil loss values for the Washington study. The coefficient of determination and model efficiency decreased to 0.40 ($P < 0.01$) and 0.37, respectively, without the surge irrigation study.

The fact that the baseline soil loss was less than field measured soil loss for more than one occasion indicates that a different method of calculated BSL is needed. Calculating BSL based on field length, field slope, soil type, furrow spacing, and some estimate of runoff volume or rate for each irrigation may better estimate base soil loss conditions for a wider variety of field conditions. Then the BSL would account for irrigation amounts that are different from southern Idaho. Calculating BSL as a continuous function of field slope and length would also eliminate the breaks at slope and length categories that occur with the current model.

CONCLUSION

The SISL model is a user-friendly empirical model for predicting soil loss at the end of the furrow. The model predicted the relative effects of conservation practices quite well, but absolute differences between measured and predicted soil loss were sometimes large because the model did not account for all conditions in the field. Since southern Idaho furrow irrigation erosion data were used to develop this model, it was expected that the SISL model would predict soil loss reasonably well for the southern Idaho fields. The fact that the model worked well with data from one field near Prosser, Washington, gives some indication that the SISL model can be used in locations other than where it was developed, but the soil erodibility factor was only 12% different from southern Idaho silt loam soils. Additional season-long furrow irrigation soil loss data are needed from other areas to better evaluate the SISL model.

Several inadequacies of the model were identified during this study. One major limitation is that the model does not account for the amount of applied irrigation water, number of irrigations, or the amount of runoff. To apply this model in other regions, it may be better to develop an equation to calculate BSL from field length, slope, soil erodibility, and some estimate of runoff rather than selecting BSL from the slope and crop categories in the current tables. The baseline value could then be adjusted for previous and current crop, tillage, and irrigation practices. Furthermore, additional adjustment factors could be added for the effects of filter strips, sediment ponds, or other practices at the end of the field so the SISL model could be used to predict soil loss from furrow irrigated fields.

REFERENCES

Berg, R. D., and D. L. Carter. 1980. Furrow erosion and sediment losses on irrigated cropland. *J. Soil Water Conservation* 35(6): 267-270.

Bjorneberg, D. L., and J. K. Aase. 2004. Conservation tillage effects on sediment and phosphorus losses from a furrow irrigated field. ASAE/CSAE Paper No. 042040. St. Joseph, Mich.: ASAE.

Bjorneberg, D. L., T. J. Trout, R. E. Sojka, and J. K. Aase. 1999. Evaluating WEPP-predicted infiltration, runoff, and soil erosion for furrow irrigation. *Transactions of the ASAE* 42(6): 1733-1741.

Brown, M. J., D. L. Carter, and J. A. Bondurant. 1974. Sediment in irrigation and drainage waters and sediment inputs and outputs for two large tracts in southern Idaho. *J. Environ. Qual.* 3(4): 347-351.

Carter, D. L., R. D. Berg, and B. J. Sanders. 1985. The effect of furrow irrigation erosion on crop productivity. *Soil Sci. Soc. Am. J.* 49(1): 207-211.

Evans, R. G., B. N. Girgin, J. F. Chenoweth, and M. W. Kroeger. 1995. Surge irrigation with residues to reduce soil erosion. *Ag. Water Management* 27(3/4): 283-297.

Lentz, R. D., I. Shainberg, R. E. Sojka, and D. L. Carter. 1992. Preventing irrigation furrow erosion with small applications of polymers. *Soil Sci. Soc. Am. J.* 56(6): 1926-1932.

Nash, J. E., and J. V. Sutcliffe. 1970. River flow forecasting through conceptual models part I-A discussion of principles. *J. of Hydrology* 10(3): 282-290.

NRCS. 2003. Predicting irrigation induced soil loss on surface irrigation cropland using Surface Irrigation Soil Loss model (SISL). Idaho NRCS Agronomy Technical Note No. 32 (Rev. 3).

SCS. 1967. Soil conditioning rating indices for major irrigated and non-irrigated crops grown in the western United States. Conservation Agronomy Technical Note No. 27. Soil Conservation Service Western Region, Portland, Oreg.

Sojka, R. E., D. L. Carter, and M. J. Brown. 1992. Imhoff cone determination of sediment in irrigation runoff. *Soil Sci. Soc. Am. J.* 56(3): 884-890.

USDA. 2004. Farm and Ranch Irrigation Survey (2003). USDA National Agricultural Statistics Service. Available at: www.nass.usda.gov/census/. Accessed 22 November 2005.