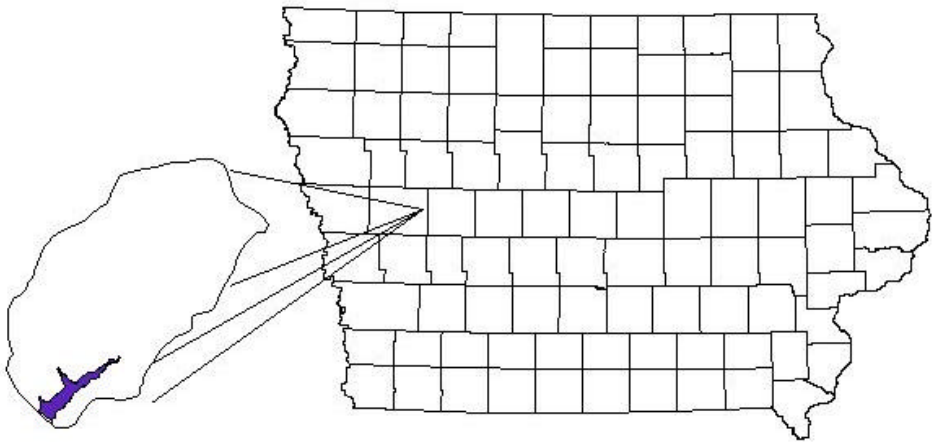
Total Maximum Daily Load
For Siltation
Yellow Smoke Lake
Crawford County, Iowa

December 13, 2001

Iowa Department of Natural Resources
Water Resources Section

TMDL for Siltation
Yellow Smoke Lake
Crawford County, Iowa

Waterbody Name:	Yellow Smoke Lake
IDNR Waterbody ID:	IA 06-BOY-00510-L
Hydrologic Unit Code:	HUC11 10230060030
Location:	S6, T83N, R38W
Latitude:	42 Deg. 2 Min. N
Longitude:	95 Deg. 20 Min. W
Use Designation Class:	A (primary contact recreation) B(LW) (aquatic life)
Watershed Area:	1444 acres
Lake Area:	40 acres
Major River Basin:	Western Iowa River Basin
Tributaries:	Unnamed intermittent streams
Receiving Water Body:	Unnamed
Pollutant:	Siltation
Pollutant Sources:	Agricultural Nonpoint
Impaired Use:	Aquatic Life
1998 303d Priority:	Low



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1. Introduction

The Federal Clean Water Act requires the Iowa Department of Natural Resources (DNR) to develop a total maximum daily load (TMDL) for waters that have been identified on the state's 303(d) list as impaired by a pollutant. The purpose of this siltation TMDL for Yellow Smoke Lake is to calculate the maximum amount of a sediment that the lake can receive and still meet water quality standards, and then develop an allocation of that amount of sediment to the sources in the watershed.

Specifically this siltation TMDL for Yellow Smoke Lake will:

- Identify the adverse impact that siltation is having on the designated use of the lake and how the excess load of sediment is violating the water quality standards,
- Identify a target by which the water body can be assured to achieve its designated uses,
- Calculate an acceptable sediment load, including a margin of safety, and allocate to the sources, and
- Present a brief implementation plan to offer guidance to Department staff, DNR partners, and watershed stakeholders in an effort to achieve the goals of the TMDL and restore the lake to its intended use.

Iowa DNR believes that sufficient evidence and information is available to begin the process of restoring Yellow Smoke Lake. The Department acknowledges, however, that to fully restore Yellow Smoke Lake additional information will likely be necessary. Therefore, in order to accomplish the goals of this TMDL, a phased approach will be used. By approaching the restoration process in phases, feedback from future assessment can be incorporated into the plan.

Phase I of the siltation TMDL for Yellow Smoke Lake will address the first target associated with achieving a reduction in the sediment load associated with the aquatic life impairment. Phase II will evaluate the effect that the sediment load targets have on the intended results. Included in Phase II will be monitoring for results, reevaluating the extent of the siltation impairment, and evaluating if the specific aquatic life impairment originally identified in the TMDL has been remedied. Ultimately, the intent of this TMDL is not to set in stone arbitrary targets, but restore the aquatic life that have been impaired. The phased approach allows DNR to utilize a feedback loop to determine if the initial sediment load target has been effective.

2. Description of Waterbody and Watershed

2.1 General Information and Conditions at Time of Listing

Yellow Smoke Lake was built in 1980 and is located in western Iowa, about 2 miles northeast of Denison, Iowa. Yellow Smoke Lake has a surface area of roughly 40 acres, a mean depth of 11 feet, a maximum depth of 26 feet, and a storage volume of 325 acre-feet.

Yellow Smoke Lake is entirely within the 320 acre Yellow Smoke Park, managed by the Crawford County Conservation Board. Yellow Smoke Lake has designated uses of Class A (primary contact recreation) and Class B (LW) (aquatic life). The lake provides facilities for boating, swimming, fishing, camping, picnicking, and hiking. Estimated Park usage is approximately 59,000 visits per year. Of those publicly owned lakes with swimming available, Bachmann (1992) reported that Yellow Smoke Lake is in the top 10% for swimming use.

The Yellow Smoke Lake watershed has an area of approximately 1,444 acres and has a watershed-to-lake ratio of 38:1. This ratio is considered high by the DNR, with an ideal ratio

being approximately 20:1. Land uses and associated areas for the watershed are shown in Table 1.

Table 1. Current land use in Yellow Smoke Lake watershed.

Landuse	Area in Acres	Percent of Total Area
Cropland	907	63
Pasture & Hayland	479	33
Other (roads, etc)	58	4
Total	1,444	100

Topography of the watershed is gently sloping to moderately steep (2-18%) prairie-derived soils developed from loess or loess-derived sediments. These soils are generally composed of Marshall, Monona, and Ida soils. These types of soils are described as having moderate to very fine granular structure and are very friable.

Average rainfall in the area is 32 inches/year, with the greatest monthly amount (5.5 inches) occurring in June.

Prior to the construction of the dam at Yellow Smoke Lake, the Crawford County Conservation Board constructed three sediment dams. The lake was impounded in 1980, but due to irreversible problems with the fishery, the lake was drained and killed out in 1984. It was then allowed to refill and was restocked with game fish. A water quality project was developed for the watershed using REAP funds, special ACP funds, state cost-share, and county funds. Work resulting from the project included:

1984 – 1991	52,000 feet of terraces installed
1986	two sediment and water control basins constructed
1992	2.1 acres of waterways installed
1986 – 1991	five detention dams built.

1992 was the first year that the siltation impairment at Yellow Smoke Lake was noted in the DNR's 305(b) Water Quality Assessment Report. To fully describe this watershed, an estimate of sediment delivery to the lake was calculated. Two sets of calculations, both developed by the Natural Resource Conservation Service (NRCS), were used in developing this estimate. These two calculations are generally accepted in the agricultural community as simple and straightforward methods for determining erosion and its resultant delivery to a body of water. Sheet and rill erosion was determined using "Predicting Rainfall Erosion Losses, The Revised Universal Soil Loss Equation (RUSLE)" Section I, Erosion Prediction (USDA/NRCS 2000). The sediment delivery factors used were derived from the "Erosion and sediment Delivery procedure", Section I, Erosion Protection (USDA/NRCS 1998). 1992 land use and farming practices used in the calculations were supplied by the Crawford County NRCS (Ford, 2001). The following equation was used to calculate sediment delivery to Yellow Smoke Lake:

Sediment Delivery (t/y) = Drainage Area x Gross Erosion Rate x SDR

Where: Drainage Area is the subwatershed in acres
Gross Erosion is 4.66 Tons/acre/year (T)
SDR is the Sediment Delivery Rate = 23%

Gross sheet and rill erosion from subwatersheds I, II, and III at the time of listing was determined. Applying the sediment delivery factor and the trap efficiencies of sediment retention basins, the delivery of sheet and rill sediments to the lake is estimated at 398 tons per year. In addition, one gully originating from subwatershed III is estimated to have been contributing 225 tons per year. The total annual sediment load to the lake in 1992 was 623 tons per year.

2.2 Current Watershed Conditions

Since 1992, many of the producers in the Yellow Smoke Lake watershed have adopted farming practices that have limited soil loss from their farms. In addition, one additional free flow sediment control structure has been constructed immediately above the lake in subwatershed II. Based on present day land use and farming practices supplied by the local NRCS and the same sediment delivery factor used to estimate 1992 delivery, the current sediment delivery from the same subwatersheds for sheet and rill erosion to the lake is 149 tons per year. The gully in subwatershed III continues to exist and continues to deliver 225 tons per year. The current total annual sediment load to the lake is 374 tons per year.

3. Applicable Water Quality Standards

The Iowa Water Quality Standards (IAC, 1996) list the designated uses for Yellow Smoke Lake as Primary Contact Recreation (Class A) and Aquatic Life (Class B(LW)). The State of Iowa does not have numeric water quality standards for siltation. In the 1992 Department of Natural Resources (DNR) biennial water quality 305(b) report the fishable uses (Class B) for Yellow Smoke Lake were assessed as partially supported due to excessive sediment from agricultural sources, based on the best professional judgement of DNR Fisheries staff. This assessment was based on information collected during the 1990-1991 period. That assessment of partially supporting of Class B (LW) has continued to be used in subsequent biennial reports. Excess sediment impacts the Class B (LW) designated use by altering the physical and chemical characteristics of the lake so that a balanced community normally associated with lake-like conditions is not maintained (IAC 567-61.3(1)b(7)). The altering of the physical and chemical characteristics causes impairments of the following beneficial uses: 1) aquatic habitat; 2) spawning, reproduction and development; and, 3) sport fishing. In addition, siltation reduces food supplies by smothering benthic macro invertebrates, which are the food source for fish.

The primary impact of sediment at Yellow Smoke Lake was identified as interference with reproduction and growth of fish and other aquatic life. DNR Fisheries biologists cited, as well as Bachmann's report in 1992, that siltation impacts aquatic life primarily in the eastern portion of the lake. Although the entire lake was listed, it is the excessive sediment deposition in the east arm of the lake that has lead to the lake being assessed as not meeting water quality standards. The lake has steep sides and a hard clay bottom, overall not suitable to spawning, but the east arm of the lake was shallow and was ideal as an aquatic habitat. That area is now covered with several feet of fine silt that make successful spawning almost impossible. Although this is a very small portion of the lake overall (under 10% of the total surface area of the lake), it is a key habitat (50%-70% of available habitat), and therefore has a proportionally greater impact. The deposition of sediment in this arm has severely limited the fishery in the entire lake.

3. Water Quality Conditions

Water Quality Studies

Three Water Quality studies have been conducted at Yellow Smoke Lake. They include an Iowa Lakes Study by University Hygienic Laboratory (UHL) (1986); a Classification of Iowa's Lakes for Restoration Study by Iowa State University (ISU) (1990); and the Iowa Lakes Survey. The survey is a current study of in-lake water monitoring, which includes sampling three times

per year for each of the field seasons 2000 – 2005. Table 2 provides a summary of pertinent data collected during these studies. Secchi disk depth in the second study was found to be much better than the overall average for lakes sampled during that study. Secchi disk depth average was again better than previous measurements when taken during the 2000 season. Water clarity is not an issue at Yellow Smoke Lake, and the high swimming use, cited by Bachmann and shown in park attendance, support this.

Table 2. Summary of Pertinent Data from Water Quality Studies of Yellow Smoke Lake

Study Year	Total Suspended Solids	Chlorophyll a	Secchi Disc Depth	Phosphorus
1986	12.6 mg/l	23.6 ug/l	1.4 m	0.083 mg/l
1990	5.03 mg/l	10.8 mg/m3	1.5 m	0.028 mg/l
2000	5.0 mg/l	7 ug/l	3.6 m	0.040 mg/l

Note that units were reported differently during studies. No attempt has been made to convert the values to consistent units. The express purpose of this table is to present available data to demonstrate whether trends can be seen, not to indicate that any exist.

Fishery

The lake in general has steep sides and a hard clay bottom. These characteristics are not suitable for ideal fish spawning habitat so what shallow, spawning habitat that existed at the time the lake was constructed is of critical importance. The east arm of the lake was originally shallow and very conducive to spawning and in the early history of Yellow Smoke Lake the fishery was diversified and abundant. Erosion of sediment from subwatersheds I, II, and III have been deposited in this arm and have effectively covered and smothered the east arm's spawning beds with several feet of fine silt. A second critical spawning area to the northwest has received some siltation from subwatershed V and was damaged by the flood of 1993 when a structural failure associated with an overflow pipe of a retention basin upstream was damaged. Attempts have been made to artificially establish attractive spawning areas in other areas of the lake. This has met with limited success.

5. Desired Target

The listing of Yellow Smoke Lake is based on narrative criteria. There are no numeric criteria for siltation applicable to Yellow Smoke Lake or its sources in Chapter 61 of the Iowa Water Quality Standards (IAC, 1996). Various proposals for how to develop numeric criteria are being considered, but no good numeric measure currently exists. An indirect measure of sediment is accomplished by demonstrating the linkages between excess sediment and the impacts to aquatic life. Since excessive sediment deposition has impacted this water body, the target needs to include both sediment loads to the lake and measurement of the aquatic life within the lake. Therefore, this TMDL will incorporate two targets.

Target One

The Phase I target will deal with direct deposition of eroded sediment delivered to the lake. A direct measure of the sediment load is difficult, given seasonal variability and actual measurement tools. Acceptable estimates using established soil loss equations can be made to predict the erosion rates in the watershed, and subsequent delivery to the lake. To best capture the conditions in this watershed due to the high number of structures, the watershed was broken down into six subwatersheds (See Figure 1, Appendix II). Four subwatersheds (I, IV, V, and VI) are protected by 90% efficient sediment control structures. Subwatershed I drains into Subwatershed II, and is thereby reduced again by a 65% efficient modified free flow structure protecting II. That reduced load then is delivered to Subwatershed III, which delivers directly to the east arm of the lake.

As stated in Section 2.1, the primary aquatic life impact is due to excessive sediment deposition to the east arm of the lake. To be protective of that, this TMDL recognizes that sediment deposition needs to be reduced to a level that will lead to necessary sediment removal from the east arm of the lake only at ten-year intervals. In order to meet that criteria, no more than 12" of sediment can be deposited over 75% of the area over a ten-year period. That area extends from the footbridge at the campground back upstream to the road. Only Subwatersheds I, II, and III drain into that east arm. So, for the purpose of this TMDL, the Phase I target is a reduction only from those Subwatersheds. Calculations below show how the target was determined:

$(49{,}000\ ft^2)(1\ ft)\ (0.75)\ (85\ lbs/ft^3\ )/\ (2000)(10) = 156\ t/yr$

The combined sediment delivery target from subwatersheds I, II, and III is 156 t/yr. This reduces the need to dredge to no more than every ten years. This is an initial first estimate and may be revised with new information and better technology.

Target Two

The Phase II target for this TMDL will be achieved when the fishery of Yellow Smoke Lake is determined to be fully supporting the Class B aquatic life uses. This determination will be accomplished through an assessment conducted by the DNR Fisheries Bureau in either 2001 or 2002. The DNR Fisheries Bureau will conduct an assessment of Yellow Smoke Lake in accordance with the Statewide Biological Sampling Plan protocol (Larscheid, 2001) by the end of the 2002 season to characterize the condition of aquatic life. IDNR Fisheries Bureau is using this protocol to help develop benchmarks for fishery integrity in Iowa lakes. Sampling techniques for these surveys are outlined in “Standard Gear and Techniques for Fisheries Surveys in Iowa”, 1995. This assessment will include growth, size structure, body condition, relative abundance, and species.

Yellow Smoke Lake will not be considered restored until the Phase II target is achieved. If the aquatic life target is achieved prior to the sediment delivery target, then the level of conservation practices implemented at the time of the assessment may become the baseline for the watershed. If however, after a reasonable time following the completion of the sediment delivery practices the aquatic life use has not been restored, then further study and practices may be necessary.

6. Loading Capacity

The Iowa DNR has determined that maintaining the gross erosion rate from fields in the watershed at or below current levels, and eliminating, to the extent possible, gully erosion delivery, will enable the lake to meet water quality standards. The sediment load capacity is 156 tons/year from subwatersheds I, II, and III on an annual basis.

7. Pollutant Sources

Water quality in Yellow Smoke Lake is influenced only by non-point sources. There are no point source discharges in the watershed. Nonpoint source pollution is caused by material transported to the lake by runoff from the watershed. Gully, streambank/streambed, sheet and rill, and shoreline erosion can contribute significantly to poor water quality and deterioration of the lake. There has been shoreline stabilization conducted around the lake, and therefore the contribution from this source is minimal. Although all land within a watershed contributes to

sediment runoff, the main sources of this pollutant in Yellow Smoke Lake watershed are from gully erosion, and sheet and rill erosion from agricultural fields.

In addition to sheet and rill, erosion from one gully in subwatershed III, is a significant source of the sediment delivered to the lake. Gully erosion has a cumulative effect since the gully itself contributes high amounts of sediment, as well as acting as a conduit for sheet and rill erosion delivered from above it.

8. Pollutant Allocation

8.1 Point Sources

The park has several waste treatment lagoons within the park, but all of them are located well away from the lake. Since there are no point discharges within the Yellow Smoke Lake watershed the Wasteload Allocation established under this TMDL is zero.

8.2 Non-Point Sources

Production agriculture dominates the watershed of Yellow Smoke Lake. Sheet and rill erosion accounts for most of the sediment entering the lake. There is an active gully present in the watershed. Some minor streambank / streambed erosion is present, but it is not a factor. Shoreline stabilization has been conducted, eliminating a contribution from that source.

The sediment delivery allocation form subwatersheds I, II, and III to the east arm of Yellow Smoke Lake as well as current and past conditions are displayed in Table 3.

Table 3. Sediment Delivery Allocation to the East Arm of Yellow Smoke Lake (T/YR).

Source	Acres	1992 Sediment Delivery	2001 Sediment Delivery	Load Allocation
I	641	62	17	17
II	96	93	26	26
III	139	243	106	106
Gully (III)		225	225	7
Total	1,444	623	374	156

8.3 Margin of Safety

An implicit margin of safety is recognized by virtue of the fact that the aquatic life use must be restored to Yellow Smoke Lake. The use of the dual targets of 1) sediment-load reduction and 2) aquatic life assessment assures that the uses will be restored regardless of the accuracy of the sediment delivery target. Failure to achieve water quality standards will trigger review and probable revision of the TMDL, allocations, and/or further sediment source management approaches.

9. Seasonal Variation

It is expected that the majority of all erosion in the Yellow Smoke Lake watershed occurs in the spring and early summer during periods of high rainfall when vegetative cover may be reduced. This TMDL recognizes that sediment loading and transport varies substantially from year to year as well as seasonally. In addition, sediment impacts are felt over longer timeframes, and predictions regarding those impacts can only be assessed over multi-year periods. Therefore, the Load Allocations in this document are appropriate when expressed as an average per year.

10. Monitoring Plan

The DNR Fisheries Bureau will conduct an assessment of Yellow Smoke Lake in accordance with the Statewide Biological Sampling Plan protocol (Larscheid, 2001) by the end of the 2002 season to characterize the condition of aquatic life. Sampling techniques for these surveys are outlined in "Standard Gear and Techniques for Fisheries Surveys in Iowa", 1995. This assessment will include growth, size structure, body condition, relative abundance, and species.

In-lake water monitoring will be completed as part of the Iowa Lakes Survey, which includes sampling three times per year for each of the field seasons 2000 – 2004. That plan includes monitoring a number of parameters annually over a five-year period. Sampling includes total phosphorus in the water column, chlorophyll a in the lake to measure planktonic growth, total nitrogen, total suspended solids, and Secchi disc depth.

11. Implementation

The Iowa Department of Natural Resources recognizes that an implementation plan is not a required component of a Total Maximum Daily Load. However, the IDNR offers a two-phase implementation strategy to DNR staff, partners, and watershed stakeholders as a guide to improving water quality at Yellow Smoke Lake. A phased TMDL is used to create an initial "plan of attack", so to speak, to address the impairment with available information. The initial first step towards meeting water quality standards is to substantially reduce the amount of sediment that will be delivered to the east arm of the lake in the future. The second one is to evaluate the impact of that action.

There are two phases to addressing the water quality issues involved at Yellow Smoke Lake. The primary impact of sediment at Yellow Smoke Lake is interference with reproduction and growth of fish and other aquatic life, predominately in the east arm. Habitat degradation as a result of excess sediment contributes to the lake being assessed as not meeting water quality standards. Phase I of this TMDL reduces the sediment delivery to the lake. This will stop the continuing negative impact to the lake. Phase II includes the restoration of the fishery to a level that fully supports the Class B aquatic life uses.

Phase I: Field investigations to determine landuses, cropping patterns, fertilizer use, conservation practices, livestock operations, and gully erosion were made in early 2001 by the local Soil and Water Conservation District (SWCD) office. Over the last nine years numerous conservation practices have been implemented in the Yellow Smoke watershed. As a result, the sediment delivery targets for subwatersheds I and II have already been achieved.

This TMDL allows near zero allocation toward delivery from gullies. Therefore the 225 tons being delivered by gullies to the east arm of the lake remains to be reduced. In support of the gully delivery reduction portion of Phase I, the Crawford County Conservation Board and Crawford County NRCS are coordinating efforts to address this problem. One option is the construction of a sediment control structure above the northeast arm of Yellow Smoke Lake.

There are a variety of BMPs that can help with erosion control. They include tillage practices such as contour, cross-slope, no till, and conservation tillage; terraces; grassed waterways; grade-stabilization structures; conservation cover; filter strips; buffers and riparian zones; and wetland development. Each has an impact directly related to the conditions they address, and often need to be used in combination to get the maximum benefit.

These delivery numbers are based on the receiving body and the impact to it. However, the interpretation of the results must be done carefully, using them in the context they are presented, and only for the purpose they are intended. The calculations may mistakenly imply that the gross erosion in the watershed has been mitigated, and it has not. A sediment structure is the last line of defense in sediment delivery to a water body, and is not a long-term solution. As part of the cost share agreements for structures the recipient is required to maintain those structures for a predetermined amount of time. Although the structures in this watershed are maintained, and must be to protect the lake, this is an area with high erosion due to the nature and slope of the soils present, and every effort must be made to manage erosion and runoff at the source throughout the entire watershed. Numerous conservation practices have already been implemented in the Yellow Smoke Lake watershed. The level of practices needs to be maintained or increased to properly protect Yellow Smoke Lake.

Funds to assist in the construction and development of best management practices in the water shed may be available through the Division of Soil Conservation and EPA Section 319 funding sources. Impaired waters may be given priority consideration in the allocation of these funds.

Phase II: The DNR Fisheries Bureau will conduct an assessment of Yellow Smoke Lake in accordance with the Statewide Biological Sampling Plan protocol (Larscheid, 2001) by the end of the 2002 season to characterize the condition of aquatic life. Sampling techniques for these surveys are outlined in “Standard Gear and Techniques for Fisheries Surveys in Iowa”, 1995. This assessment will include growth, size structure, body condition, relative abundance, and species.

As stated in Section 5, these target loads are reasonable initial estimates to accomplish a resultant average rate of deposition in the lake low enough to minimize the impact on aquatic life. A phased TMDL is used to address the impairment with available information. The initial first step towards meeting water quality standards is to substantially reduce the amount of sediment that will be delivered in the future. The information available clearly shows that that goal has already been accomplished in the majority of the watershed. The next step is to continue to assess conditions to support or to modify these initial targets. Yellow Smoke Lake will continue to be monitored under the Clean Lakes Study started in 2000 through the 2004 season. Part of the phase II of this TMDL will be to evaluate that data and determine if any further actions need to be taken.

The major impact to the fishery in this lake has been sediment deposition in critical habitat areas. Once the sediment target level has been achieved it is likely that further actions will be necessary. They could include reclaiming and reestablishing the spawning area in the east arm by removal of the sediment already there, and continued efforts to create new areas.

12. Public Participation

Public meetings regarding the procedure and timetable for developing the Yellow Smoke Lake TMDL were held on January 17, 2001, in Des Moines, Iowa; and on January 23, 2001 at Yellow Smoke Lookout Shelter near Denison, Iowa. Another meeting was held at the same location in Denison October 30, 2001, at 7 PM to discuss the draft document. Comments received, where appropriate, were incorporated into this document.

13. References

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14. Appendix I

PREDICTING RAINFALL EROSION LOSSES, THE REVISED UNIVERSAL SOIL LOSS EQUATION (RUSLE)

The equation is expressed as follows: A = RKLSCP where:

A = average annual soil loss from inter-rill (sheet) and rill erosion caused by rainfall and its associated overland flow expressed in tons/ac/yr,

R = the factor for climatic erodibility,
K = the factor for soil erodibility measured under a standard condition,
L = the factor for slope length,
S = the factor for slope steepness,
C = the factor for cover-management, and
P = the factor for support practices.

Example calculation from Yellow Smoke Watershed:

A= ?
R= 145 rainfall factor
K= 0.30 erodibility factor (by soil type)
LS= 2.23 length / slope
C= 0.08 cropping factor
P= 0.83 practice factor (ex: 90% reduction, therefore 10% of load)

A= (145) (0.30) (2.23) (0.08) (0.83)
= 6.4411 t/a/y
= 6.4 t/a/y

GULLY EROSION

Approximate Unit Weight1

Soil Textural Class	Dry Density (Lb/ft.3)
Silt Loam	85

Gully erosion formulas:

Data and estimates from published soil surveys, laboratory data, and soil interpretation records are to be used where available. Parent materials, soil consistency, soil structure, pore space, soil texture, and content of coarse fragments all have influence on unit weight.

Where A = top width
B = bottom width
C = depth
D = length
E = soil unit weight
F = head ward advancement
G = average annual rate of sloughing or recession
H = number of years

Gully development and volume computations are as follows:

$$\frac{(A + B) \times C \times D \times E}{2 \times 2000 \times y} = \text{tons of eroded material}$$

$$\frac{(6+9+6)(0.5)(500)(85)}{2000} = 225 \text{ tons/yr}$$

15. Appendix II

Figure 1
Yellow Smoke Subwatersheds