A RESERVOIR SEDIMENTATION SURVEY INFORMATION SYSTEM -- RESIS

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ABSTRACT

All Reservoir Sediment Data Summary forms (SCS-ENG-034), Form 34's, on file through 1985, and a few surveys completed between 1986 and 1995, have been converted to electronic format and compiled into an INFORMIX database called RESIS, a Reservoir Sedimentation Survey Information System. The database was compiled through a joint effort of Natural Resource Conservation Service (NRCS) and Texas Agricultural Experiment Station (TAES) staff in 1994. It was used to study trends in reservoir sedimentation as part of the Sedimentation Subtopic in the third Resources Conservation Act (RCA III) analyses (Bernard et. al., 1995). Issues identified during the RCA III analyses include the decline in the number of surveys being made, some inconsistencies in data sheet numbering, the lack of detailed sediment dry weight information and the paucity of land use data for the periods surveyed. The database currently resides on a computer at the NRCS National Soil Survey Center in Lincoln, Nebraska and is being managed by the author. Long-term management responsibility is being studied.

INTRODUCTION

In 1994, the Natural Resources Conservation Service (NRCS) worked with the Texas Agricultural Experiment Station (TAES) to compile an INFORMIX database titled RESIS, the Reservoir Sedimentation Survey Information System. This cooperative effort was carried out as part of the third Resources Conservation Act (RCA III) activities of the NRCS.

RESIS is a relational database consisting of 14 tables. It contains records on 1,824 reservoirs and 4,141 individual sedimentation surveys. The data consists of electronic transformation of all Reservoir Sediment Data Summary forms (SCS-ENG-034), Form 34's, submitted for publication through 1985. The author has added a few survey records submitted from 1986 through 1995.

The sedimentation data on the Form 34's represents the cooperative effort of various U.S. government agencies over many years. The Subcommittee on Sedimentation of the Inter-Agency Committee on Water Resources (ICWR) has directed the collection and standardization of the data. NRCS worked with TAES in the development of the RESIS database.

NRCS acknowledges the assistance of Dr. Paul Dyke, and his staff, in compiling the database. Dr. Dyke is the Director of the Integrated Information Laboratory, Texas A & M University, at the Blackland Experiment Station in Temple, Texas. NRCS also acknowledges the assistance of Dr. Jay Atwood, an NRCS Agricultural Economist with the Natural Resources Inventory Division, who manages the NRCS economic modeling and database project at Texas A & M. Dr. Atwood designed the initial structure of the database and populated the tables utilizing ASCII text files of the original data on floppy

diskettes. Dr. Atwood also performed the initial queries utilized in the Sedimentation Subtopic analyses for RCA III.

BACKGROUND

Reservoir Sediment Surveys

Sedimentation surveys of existing reservoirs have provided the basic data that engineers and scientists have used historically to determine the volume of sediment storage required for new reservoirs. Large reservoirs trap almost all the sediment delivered to the pool so, over time, average annual rates (volume per year) of sediment accumulation can be determined by periodically measuring the changes in storage capacity of the reservoir. These rates can be compared to the watershed drainage area to develop a volume per year per square mile relationship. Historically, this information has been used to estimate sedimentation rates in other, similar areas.

Undisturbed samples of the sediment are collected during the sedimentation survey and analyzed to determine the dry unit weight of the deposits. This allows the volume (acre-feet) of sediment to be converted to weight (tons). The tons of sediment deposited, divided by the trap efficiency of the reservoir, converts the deposition to tons of sediment yield to the reservoir. Sediment yield can be divided by a sediment delivery ratio to estimate the tons of erosion from the watershed. Land use and sources of erosion can then be compared to sediment yield from one watershed to another.

Reservoir Sediment Data Summary Forms (SCS-ENG-034)

The value of reservoir sedimentation information led federal agencies to develop standardized procedures and data collection forms (Figure 1). The eight federal agencies on the Subcommittee on Sedimentation of the Inter-Agency Committee on Water Resources (ICWR) directed the collection and publication of all data sheets from all agencies. The sedimentation data has been published every five years through 1980 in "USDA Miscellaneous Publication No. 1362".

Analyses of the published sediment data was difficult due to the format and bulk of the data. The first attempt to convert the paper copies of the data sheets into an electronic format to facilitate analysis was made by NRCS in 1972. The conversion to a database management system on a dedicated central processing unit made some regional analyses possible but the data was not easily transportable to other systems so few researchers attempted to use it. The magnetic tape data was eventually converted by NRCS to ASCII files on floppy diskettes by 1992.

RESERVOIR SEDIMENTATION SURVEY INFORMATION SYSTEM (RESIS)

Meetings of staff working on various studies as part of the third Resources Conservation Act in 1992 resulted in a collaborative effort between NRCS and the Blackland Experiment Station out of Texas A & M University to convert the ASCII files to a format compatible with the INFORMIX database management system. The conversion to INFORMIX was completed in January, 1994 and numerous queries were run to develop trends in reservoir sedimentation as part of the Sedimentation Subtopic analyses for RCA III.

Figure 1. SCS-ENG-034 Form: Reservoir Sediment Data Summary

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

RESERVOIR SEDIMENT DATA SUMMARY

SCS-ENG-034
02-85

NAME OF RESERVOIR _____ DATA SHEET NO. _____

DAM

1. OWNER	2. STREAM	3. STATE
4. SEC. TWP. RANGE	5. NEAREST P. O.	6. COUNTY
7. LAT. ° ′ ″ LONG. ° ′ ″	8. TOP OF DAM ELEVATION	9. SPILLWAY CREST ELEV.

RESERVOIR

10. STORAGE ALLOCATION	11. ELEVATION TOP OF POOL	12. ORIGINAL SURFACE AREA, ACRES	13. ORIGINAL CAPACITY, ACRE-FEET	14. GROSS STORAGE, ACRE-FEET	15. DATE STORAGE BEGAN
a. FLOOD CONTROL					
b. MULTIPLE USE					
c. POWER					16. DATE NORMAL OPER. BEGAN
d. WATER SUPPLY					
e. IRRIGATION					
f. CONSERVATION					
g. INACTIVE					

17. LENGTH OF RESERVOIR	MILES	AV. WIDTH OF RESERVOIR	MILES

WATERSHED

18. TOTAL DRAINAGE AREA	SQ. MI.	22. MEAN ANNUAL PRECIPITATION	INCHES
19. NET SEDIMENT CONTRIBUTING AREA	SQ. MI.	23. MEAN ANNUAL RUNOFF	INCHES
20. LENGTH MILES	AV. WIDTH MILES	24. MEAN ANNUAL RUNOFF	AC.-F T.
21. MAX. ELEV.	MIN. ELEV.	25. ANNUAL TEMP.: MEAN	RANGE

SURVEY DATA

26. DATE OF SURVEY	27. PERIOD YEARS	28. ACCL. YEARS	29. TYPE OF SURVEY	30. NO. OF RANGES OR CONTOUR INT.	31. SURFACE AREA, ACRES	32. CAPACITY, ACRE-FEET	33. C/I. RATIO, AC.-FT. PER AC.-FT.

26. DATE OF SURVEY	34. PERIOD ANNUAL PRECIPITATION	35. PERIOD WATER INFLOW, ACRE-FEET			36. WATER INFL. TO DATE, AC.-FT.	
		a. MEAN ANNUAL	b. MAX. ANNUAL	c. PERIOD TOTAL	a. MEAN ANNUAL	b. TOTAL TO DATE

26. DATE OF SURVEY	37. PERIOD CAPACITY LOSS, ACRE-FEET			38. TOTAL SED. DEPOSITS TO DATE, ACRE-FEET		
	a. PERIOD TOTAL	b. AV. ANNUAL	c. PER SQ. MI.-YEAR	a. TOTAL TO DATE	b. AV. ANNUAL	c. PER SQ. MI.-YEAR

26. DATE OF SURVEY	39. AV. DRY WGT., LBS. PER CU. FT.	40. SED. DEP., TONS PER SQ. MI.-YR.		41. STORAGE LOSS, PCT.		42. SED. INFLOW, PPM	
		a. PERIOD	b. TOTAL TO DATE	a. AV. ANN.	b. TOT. TO DATE	a. PERIOD	b. TOT. TO DATE

Figure 1. SCS-ENG-034 Form: Reservoir Sediment Data Summary (cont.)

26. DATE OF SURVEY	43. DEPTH DESIGNATION RANGE IN FEET BELOW, AND ABOVE, CREST ELEVATION											
	PERCENT OF TOTAL SEDIMENT LOCATED WITHIN DEPTH DESIGNATION											

26. DATE OF SURVEY	44. REACH DESIGNATION PERCENT OF TOTAL ORIGINAL LENGTH OF RESERVOIR													
	0-10	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100	-105	-110	-115	-120	-125
	PERCENT OF TOTAL SEDIMENT LOCATED WITHIN REACH DESIGNATION														

45. RANGE IN RESERVOIR OPERATION

WATER YEAR	MAX. ELEV.	MIN. ELEV.	INFLOW, AC.-FT.	WATER YEAR	MAX. ELEV.	MIN. ELEV.	INFLOW, AC.-FT.

46. ELEVATION–AREA–CAPACITY DATA

ELEVATION	AREA	CAPACITY	ELEVATION	AREA	CAPACITY	ELEVATION	AREA	CAPACITY

REMARKS AND REFERENCES

48. AGENCY MAKING SURVEY

49. AGENCY SUPPLYING DATA

50. DATE _____

RESIS is a relational database consisting of 14 tables that contain all the information on all Form 34's on file through 1985. A few additional records from 1986-1995 have been added. RESIS has records for 1,824 reservoirs and 4,141 individual sedimentation surveys. Table 1 is a short description for each table and it shows the distribution within the tables of the numbered blocks of information from the Form 34's. Each table contains the data sheet number for each reservoir. This is the primary sorting key that connects all the data in each table to the pertinent reservoir. The principal secondary sorting keys used in querying the database include the pool identification and the date of each survey.

The "rsedrca_reg" and "rsed_damlnk" tables were added to the database to more accurately locate each reservoir. Some reservoirs had section, township, range location recorded on the Form 34's and some also included latitude and longitude. However, most reservoirs only included a county and a nearest post office as location information. In order to use most of the data in the RCA III analyses, it was necessary to put as many reservoirs as possible into a Major Land Resource Area (MLRA) and a four-digit hydrologic unit. The "rsedrca_reg" table was created to accomplish this task.

Other databases had matched the alphabetic abbreviation for each county in the United States to MLRAs and four-digit hydrologic units. This matching list became the "rsedrca_reg" table. Each reservoir in RESIS is matched to a unique MLRA and a unique four-digit hydrologic unit through this table.

The "rsed_damlnk" table was added later to increase the number of reservoirs with latitude and longitude information for GIS analyses. All the records in the National Inventory of Dams (NID) database include latitude and longitude information for each reservoir. RESIS and NID were compared and 900 common dams were identified. Physical description data from NID is referenced by data sheet number in the "rsed_damlnk" table for future applications.

USES TO DATE

The primary use of RESIS to date has been to complete analyses of reservoir sedimentation trends for RCA III (Bernard, et. al., 1995). The analyses were done at the four-digit hydrologic unit and Major Land Resource Area levels. RESIS data is also being used to help validate the sediment yield predictions generated by the Hydrologic Unit Model for the United States (HUMUS) and the Soil and Water Assessment Tool (SWAT) analyses being made for RCA.

Some minor database queries have been performed to generate information for researchers. Individual state reports have also been compiled and distributed to each NRCS state office. These reports list descriptive information and summarize the sedimentation data for each reservoir. The state reports have also been grouped by NRCS regions and each of the six new regional offices have been sent a copy.

ISSUES

RCA III analyses highlighted a number of issues relative to the data in RESIS. One issue involves the lack of recent data. Table 2 indicates that the number of reservoir sediment surveys reported on Form 34's has been dropping since 1970. This trend may be

Table 1. Overview of the RESIS database tables.

Table	Form 34 Blocks	Description
rsed01_descrip	1-9, 15-25	Details the ownership, location, top of dam and spillway crest elevations, dates of operation, drainage area and climate of reservoir drainage.
rsed02_respurp	10-14	Gives the pool elevations, surface area, and capacities of the pools by purpose of operation.
rsed03_period	26-28	For each survey on each reservoir, the elapsed time since the previous survey is recorded.
rsed04_surv-def	29-32	For each survey date on each reservoir, the survey method and scope is detailed.
rsed05_precflow	34-36*	Precipitation and water inflow for each survey period are recorded for each reservoir.
rsed06_deposits	37-42	Aerated, submerged, and total sediment deposits, sample number, and average dry weight estimates are given for each survey date.
rsed07_depth_def	43	Defines reservoir pool layers denoted by elevation for areal sediment distribution.
rsed08_depth_sed	43	For each survey, the percentage of sediment deposits occurring in each depth layer.
rsed09_reach_sed	44	For each survey date, gives the percentage of the sediment deposits occurring by distance segment and reach for each reservoir.
rsed10_range_opr	45	Water inflow and maximum and minimum reservoir elevations are given by water year.
rsed11_elev_cap	46	For each reservoir, the storage capacity by elevation stage is given (may have multiple dates).
rsed12_remarks	47	Footnote explanations and other remarks.
rsed13_agency	47	Agencies collecting and reporting data.
rsedrca_reg	---	For each reservoir, the associated county, Major Land Resource Area (MLRA), and 4-digit hydrologic unit area are recorded for use in RCA III queries.
rsed_damlnk	---	Matches reservoirs in RESIS with National Inventory of Dams database records.

* Block 33 not included

continuing today based on experience within NRCS. It appears that surveys have not been a high priority task for federal agencies starting in 1980. About 45 percent (1,853) of all surveys recorded in RESIS were actually done between 1965 and 1980. There were 947 surveys completed from 1965 to 1970 and 916 surveys completed from 1971 to 1980.

Table 2. Number of Reservoir Surveys by Time Period

Period		Number of Surveys by Period
1904-1930		19
1931-1950		871
1951-1970		2,257
1971-1985		945
1986-1995		49
	Total	4,141

The RCA III analyses required data to be reported at the MLRA and four-digit hydrologic unit level. This type of identification is not recorded on Form 34's. The majority of reservoirs in the database also do not have latitude and longitude information. However, all the reservoirs did have a county location noted. The "rsedrca_reg" table was constructed to match the alphabetic abbreviation for each county with MLRA and hydrologic unit data.

Data from the National Inventory of Dams (NID) was matched to data in RESIS to increase the number of reservoirs in RESIS with latitude/longitude references. The RESIS/NID link is made in the database table titled "rsed_damlnk". Latitude and longitude for the center point of the dam creating a reservoir is needed for every reservoir in RESIS for georeferencing. Without this level of location information, the database cannot be easily used in any GIS application.

Since the data sheet number is the primary sorting key in the database, it is important that each reservoir have its own unique number. Current instructions for completing Form 34's indicate that the first two digits of a reservoir's data sheet number should be the two digits denoting the river basin map number in the hydrologic atlas compiled by the Subcommittee on Hydrology of the ICWR. The number following the two digits is supplied by the Subcommittee on Sedimentation when the data is published. Since it is possible to update RESIS more often than the historic publication dates for ICWR, there will be a need to coordinate with the Subcommittee on Sedimentation to insure continuity for numbering data sheets.

One of the more difficult tasks associated with sediment surveys is the collection of undisturbed samples for determining the dry unit weight of the deposits. Enough samples should be collected to adequately define both the areal and vertical distribution of sediment volume weights throughout the reservoir. Very few surveys contain adequate sampling information. Too many surveys show assumed dry densities. The average dry density of the sediment deposits is used to convert the volume (acre-feet) of deposits to weight (tons) for comparison with erosion, suspended sediment measurements or sediment budget data. A comparison of changes in reservoir sedimentation rates with erosion reductions due to land treatment programs will not be accurate without accurate determinations of the dry unit weight of the sediment.

The last issue involving RESIS records is the paucity of land use data reported with each survey. Scientists in the United States have been examining the relationships between land use and sediment yield since the advent of water resources planning. The lack of land use records for the period of time between sediment surveys limits the usefulness of RESIS for further defining, or possibly quantifying, the land use/sediment yield relationship.

FUTURE PLANS

The RESIS database is currently being used, maintained and managed by NRCS. A number of tasks need to be completed prior to the release of the database to other public and private entities. A user's guide needs to be completed. The database needs to be error-checked and missing latitude and longitude information should be added. Queries to generate standard reports, like a new version of the Form 34, also need to be completed. The format for the standard reports should be reviewed and approved by the ICWR Subcommittee on Sedimentation. The future location for RESIS, a sponsoring agency and the extent of public use is still under consideration at this time.

NRCS is pursuing the application of computers, sonar and Global Positioning Satellite (GPS) technology to reservoir sediment surveys. Stage storage relationships in a reservoir can be generated electronically using this type of technology mounted in a boat (Texas Water Development Board, 1994). The amount of staff and time required to complete a reservoir sediment survey time is greatly reduced with this technology. The initial cost of such a system is high but it is still cost-effective. The Texas Water Development Board's Hydrographic Survey Team was able to complete eleven surveys at less cost with the new system than it would have cost to do three surveys using traditional methods (Brazos Basin Update, 1995).

REFERENCES

Bernard, J. B., Iivari, T. A., and Steffen, L. J. 1995. Has the US sediment pollution problem been solved? Proceedings Sixth Federal Interagency Sedimentation Conference (In progress).

Texas Water Development Board. December 16, 1994. Volumetric survey of Belton Lake. Hydrographic Survey Group. PO Box 13231. Austin, Texas 78711-3231.

Brazos Basin Update. Spring, 1995. Lake sedimentation surveys using new technology increase yield by more than 38,000 acre-feet of water per year. Issue #4. Brazos River Authority. Po Box 7555. Waco, Texas 76714-7555.