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Engineering in the Soil Conservation Service

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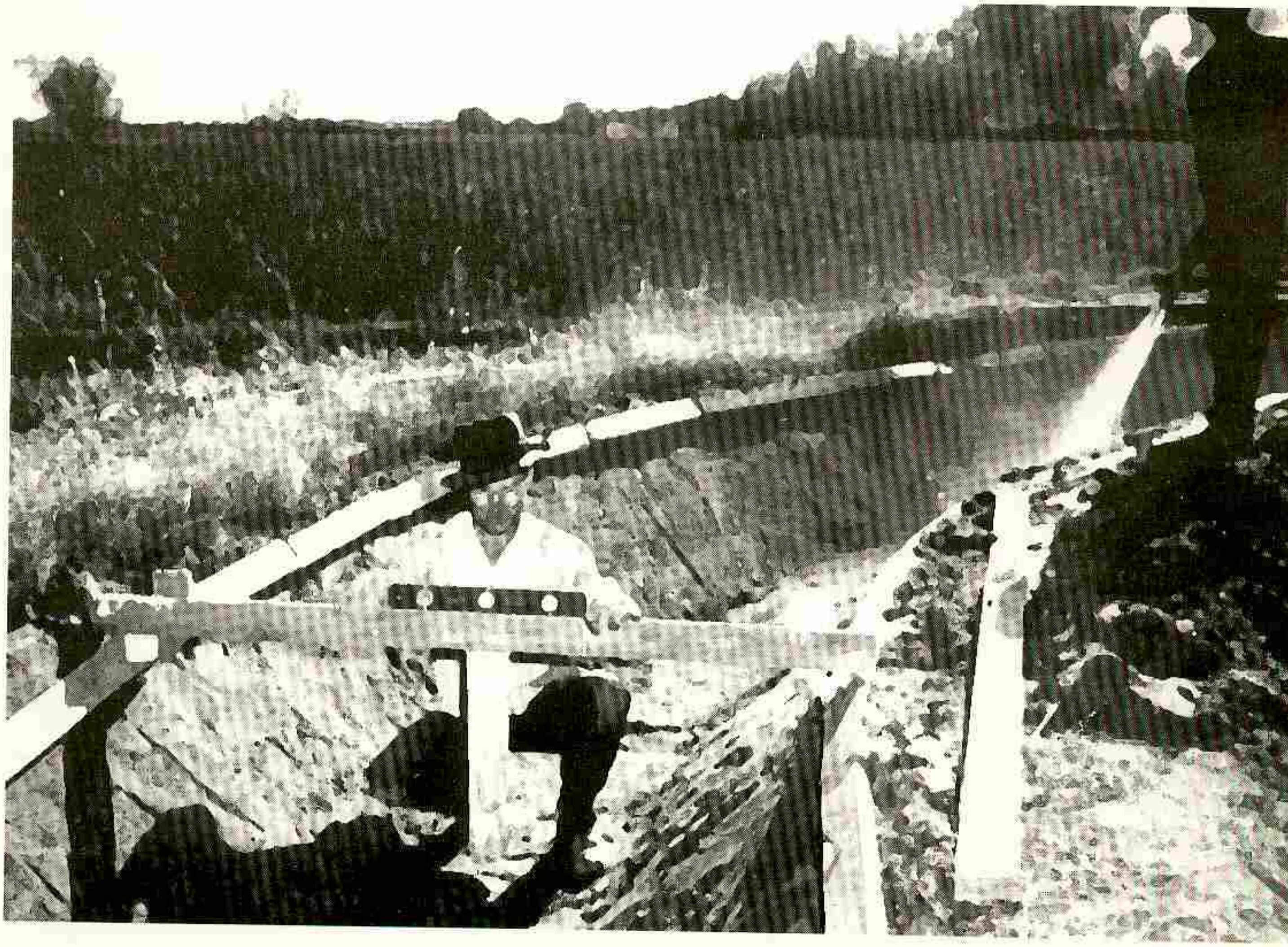

Cover: Spraying a mixture of cement, sand, and water on a prepared ditch bank with a Jetcrete hose and nozzle. Texas photograph number Tex-46608. Soil Conservation Service.

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Preface

The object of this paper is to document some of the developments that have brought the engineering profession in the Soil Conservation Service (SCS) to its present high level of competence and production.

There have been thousands of engineers, geologists, architects, technicians and others who, though unheralded, have contributed to the engineering proficiency of the Service.

This account is far from complete and many who deserve special recognition have been missed. We apologize for any errors. However, the authors hope that this will provide some help to others who someday will prepare a more comprehensive record.

Our thanks are due to Douglas Helms, SCS Historian, and to the retired and active members of the SCS family who have contributed memories, searched their files for old records, and generously contributed to the endeavor.

INTRODUCTION

The Soil Conservation Service (SCS), now as in the past, relies upon interdisciplinary cooperation among many professionals to accomplish its mission. Rather than being dominated by one discipline as was the case in other government agencies of the time, Hugh Hammond Bennett, creator of the agency, believed that the several disciplines needed to work together for the common goal of soil and water conservation. This emphasis upon a multi-disciplinary work force has proven to be the strength of SCS.

The authors of this study each served as director of the Engineering Division: John T. Phelan, 1971-1974 and Donald L. Basinger, 1984-1989. Their historical perspective on the development and contributions of engineering to the conservation effort is valuable to current employees in SCS. The Service thanks them for volunteering their time, effort, and experience in writing this volume. SCS also thanks J.D. Ross and Steve Phillips of the Economics and Social Sciences Division for their assistance in preparing this volume.

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ENGINEERING IN THE U.S. SOIL CONSERVATION SERVICE

*John T. Phelan and Donald L. Basinger**

TECHNICAL HERITAGE

Engineers in the Soil Conservation Service (SCS) have a rich and significant legacy. Though the agency and its predecessor, the Soil Erosion Service (SES), only date back to 1933, much valuable research, field trials, evaluations and studies had been conducted earlier. Many of these investigations were made by personnel in the Department of Agriculture, but other Federal departments, bureaus, State agencies, universities and private individuals and organizations also made important contributions. The work of these early scientists and engineers provided a solid foundation for conduct of an operations program when national concern with the soil erosion problem demanded action.

Observations and reports on the problem of erosion had been noted for centuries. In the United States, several perceptive observers in the eighteenth century wrote of the soil losses. But with new lands available to be broken in the west, farmers were not especially concerned. In fact some farmers spoke of having "worn out" one farm before they settled westward.

It should be noted that the Bureau of Public Roads and the Weather Bureau were initially agencies in the Department of Agriculture (USDA). While within the USDA, these organizations did important early work in the fields of hydrology, water supply, irrigation and drainage. The Bureau of Chemistry and Soils and the Bureau of Agricultural Engineering, some of whose functions are now with the SCS, also conducted programs and studies that still guide engineering design.

As early as 1862 the USDA demonstrated interest in landscape architecture. William Saunders was employed as a botanist and superintendent of propagating gardens and during his 38 years of distinguished service, he was responsible for such important works as the layout of Gettysburg Cemetery and contributed to the landscaping of the Capitol grounds and the streets and parks of Washington, DC. His photo is on the frontispiece of the 1900 Yearbook of Agriculture.

Probably the earliest responsibilities of federal engineers in the field of soil and water lay in their involvement with irrigation. Early Department work included "Irrigation Investigations" undertaken in 1898 and drainage studies instituted in 1902.[1] The settlement of the western states in the nineteenth century often dictated the development of irrigation projects, the construction of canals and laterals, the preparation of field surfaces, and an improvement in cultural and water application methods.

* Former Directors, Engineering Division, USDA Soil Conservation Service.

Many projects were constructed by private companies and groups. Construction of water supply and delivery systems by the Bureau of Reclamation, U.S. Department of the Interior (USDI) was authorized in 1902.

Since irrigation water is necessarily applied somewhat in excess of the amount that is used by the crop, waterlogging or ponding may occur when soil and slope conditions do not permit the excess water to escape. Irrigation intensified these problems on the new lands and drainage grew in importance. Similarly in humid areas, inadequate drainage was causing crop damage. Some limited technical guidance and assistance with their irrigation and drainage problems were available to farmers through state colleges and the Extension Service. The development of technical skills in the fields of water supply, water conveyance, application and disposal had been in process for centuries and refinements and adaptations provided the base for the programs of erosion control and flood control that came later.

Responsibility for "Irrigation Investigations" was at first assigned to the Office of Experiment Stations, USDA, later to the Office of Public Roads and after several more organizational adjustments to the Division of Irrigation, Bureau of Agricultural Engineering in 1931.[2]

That the Secretary of Agriculture recognized the need for water supply investigations was apparent in his report to the President in 1909:

> *The study of snowfall conditions in the mountainous regions has been furthered by the establishment of a large number of observing stations in the more inaccessible sections of the country. The Weather Bureau has cooperated in this work with other Government bureaus engaged in irrigation and drainage projects. As the plans progress it is expected to complete a set of observations that will greatly increase the knowledge of the annual snowfall in those remote districts from which the western streams receive their water supply.*

In 1903, the Secretary recognized the greater breadth of the engineering function when in his annual report he recommended:

> *In order that the work of this Department in the lines of agricultural engineering other than irrigation may be more definitely recognized and organized on a more permanent and satisfactory basis, I recommend that Congress change the wording of the appropriation act so as to make the general title of this division of our work "Irrigation and Agricultural Engineering."*

An early mention of "soil washing" was included in the Secretary's report in 1903.[3] In 1907 Secretary Wilson wrote:

> *...it is a national duty to see that the soil is conserved and the farm improved for the immediate benefit of the farmer and the ultimate welfare of the country.*

Even before 1928 when the paper of Hugh H. Bennett, then in the Bureau of Chemistry and Soils and W. R. Chapline of the Forest Service[4] drew national attention to the soil erosion problem, engineering studies were being conducted through the Office of Experiment Stations. Erosion control efforts, especially in the South, had long been significant and in 1934, Secretary Henry A. Wallace wrote:

> *Some 15,000,000 acres of farm lands in the United States have been terraced during the past 15 years, largely in accordance with methods developed by Department engineers.*

Beginning in 1929, erosion control research was carried out jointly by the USDA and state experiment stations on 10 soil erosion experimental farms. USDA's responsibilities were carried out under the Bureau of Chemistry and Soils in cooperation with the Bureau of Agricultural Engineering. These and earlier studies in the fields of hydrology, hydraulics, erosion and sedimentation, agricultural equipment, and basic sciences all contributed to the store of knowledge that made it possible to rapidly initiate practical conservation programs.

The previously mentioned agencies within and outside of the USDA provided the basis for a soil and water conservation program. A listing of the titles of a few of the early papers that demonstrates the character and the breadth of the work can be found in Appendix A. As might be expected, engineering technology developed in small steps, sometimes refining ancient knowledge and practices.

THE SOIL EROSION SERVICE

Consider the problem of Chief Bennett on September 19, 1933, when he was the first and only employee of the newly established Soil Erosion Service, U.S. Department of the Interior. H. H. Bennett had been a career employee in the Bureau of Chemistry and Soils, USDA, and had long recognized that a multi-disciplinary approach to the erosion problems was essential. Though the new agency was in Interior, staff had to be recruited with skills in soils, agronomy, biology, forestry and engineering. An action program had to be devised, and personnel, including engineers, hired. A few experienced people were scattered in federal and state agencies and a fair nucleus was present on the experiment farms set up earlier under the USDA.

The original staff "included experts in technical fields drawn largely from the Department of Agriculture and land grant colleges."[1] Others had to be recruited and trained. Because of the severe depression in 1933, many technically trained individuals were available though they had little experience in erosion control work.

The responsibilities of the engineers were described:

> The engineers duties are to design and construct all erosion control structures including terraces, terrace outlet channels and terrace outlet protective structures; gully control structures including dams, baffles, head protectors, bank sloping and bank protection; contour furrowing in pastures; and the installation of measuring and sampling devices accurately to measure the soil and water loss from controlled experimental plots.[6]

Field work expanded almost immediately and by the end of November the Civil Works Administration (CWA) had provided emergency labor to the Service. Seven of the regularly established projects were assigned 1,835 men to assist with the work. An additional force of 1,036 was assigned to the Gila River Watershed in Arizona. The CWA program however was short lived and only continued until the middle of February.

The policy under which the work was done was reported:

> ...the Government provides the cooperator with the necessary seed, but the cooperator undertakes to plant the seed and protect the area in vegetation from overgrazing and fire. In other instances, it is necessary to treat large gullies with control structures or to build terraces. In these instances the farmer usually agrees to furnish the necessary horses and to move the earth needed to build the gully control structure, and also to complete the terraces by filling in the low places which may be left by terracing machinery. The Government, on the other hand, agrees to furnish the labor to build the gully structures and to supply equipment and part of the labor necessary to construct the terraces.
>
> Thus, the entire project is carried out on a cooperative basis. It is estimated that, on the average, the owners or operators contribute approximately 40% of the cost of the operation and the Soil Erosion Service or the ECW camps, operating under its direction, contribute the remaining 60% of the cost.[6]

Only 9 months later, on June 30, 1934, there were 2,200 persons employed in the Soil Erosion Service.[5] In the year and one half while under the SES, 37 demonstration projects involving private lands, three land-rehabilitation projects on Federal land, and about 50 Civilian Conservation Corps (CCC) camps were established for erosion control and staffed with the necessary engineering and other technical personnel. Since many of the field engineers had little or no experience in designing and applying conservation practices, they had to rely on instructions in scattered publications and advice from the few experienced personnel. It is a credit to the organizational skills of the leadership and the competence and adaptability of the new personnel that the work was successfully carried forward.

While under the Department of the Interior, principal staff of the Soil Erosion Service was:

Director .... H. H. Bennett
Vice Director .... Walter C. Lowdermilk
Chief of Operations .... Wm. Stephenson
Tech.Secretary .... Robert A. Winston
Chief Agronomist .... Lyman Carrier
Ch.Agr.Engineer .... James G. Lindley
Spec.in Erosion .... Glenn L. Fuller
Ch.Forester .... E. V. Jotter
Ch.Fiscal Officer .... Henry R. St. Cyr
Special Asst. .... Charles W. Collier*

During this same period the leadership in the USDA Bureau of Agricultural Engineering was:

Chief .... S. H. McCrory
Engineering Assistant to the Chief
.... George R. Boyd
Division Chiefs - Irrigation
.... W. W. McLaughlin
Drainage and Soil Erosion Control
.... Lewis A. Jones
Mechanical Equipment.... R. B. Gray
Structures .... Wallace Ashby
Plans and Services .... M. C. Bitts

Many of the individuals then in the Bureau of Agricultural Engineering were later prominent in the organization and work of the SCS.

The Department of Agriculture was not happy with what appeared to be an attempt to build up a duplicating organization within the Department of the Interior and Interior had some doubts as to the propriety and legality of furnishing direct government assistance to private landowners. A committee appointed by the Secretary Ickes of Interior studied the organization and their recommendations resulted in the transfer of erosion control research and operation on private lands to the USDA.[1]

* In a report prepared for the National Endowment for the Arts, April 1989, by Sally Schauman, mention is made that landscape architects were on the staff when the agency was formed in the 1930's. It is presumed but not verified that this referred to Charles W. Collier, B. Arch.

ESTABLISHMENT OF THE SOIL CONSERVATION SERVICE

On March 25, 1935, all funds, personnel and property of the Soil Erosion Service were transferred to the U.S. Department of Agriculture. Under the new organization, the Soil Erosion Service became responsible for the soil erosion investigations and regional experiment station functions which previously had been conducted jointly by the USDA's Bureau of Chemistry and Soils and the Bureau of Agricultural Engineering.[5] This brought a number of experienced engineers into close association with the operations staff and greatly strengthened the program. By the end of 1935 fiscal year, the total number of SCS employees totaled 6,622--95 percent of whom were in the field.

A few days later, on April 27, 1935, the Soil Conservation Service was established under the Secretary of Agriculture and was directed to include the activities formerly conducted by the Soil Erosion Service. The new agency moved from Interior offices and was first headquartered in the Standard Oil Building at 2nd Street and Constitution Avenue, NW. About 1938, the executive offices were moved to the South Building of the Department of Agriculture, but some of the personnel continued to be located at the Standard Oil Building until about 1942.

At the time of the transfer from Interior to Agriculture, there were 39 active erosion control projects with 51 Emergency Conservation Work (ECW) camps. Technical guidance for the ECW camps was provided by the personnel attached to the demonstration projects. Engineering staffing on the demonstration projects varied according to the need. Because of the labor and some materials provided through the projects and camps, the conservation work was applied at a reduced cost to the cooperating farmers. The installation of mechanical practices, i.e., terraces, waterways, gully control structures, farm ponds, etc., comprised a large part of the work effort.

The principal and engineering staff of the SCS in early 1935 at the Washington Office included:[7 8]

Chief	H. H. Bennett
Assoc. Chief	Walter C. Lowdermilk
Asst. Chief	Henry D. Abbott
Tech. Asst.	Robert A. Winston
Spec. Asst.	Charles W. Collier
Spec. Asst.	Henry H. Collins, Jr.
Liaison Officer (ECW)	J. G. Lindley

In the Division of Conservation Operations, the staff included:

Chief	Courtland B. Manifold
Section of Engineering	
Acting in Charge	T. B. Chambers
Assistant	Samuel B. Andrews
Asst.Agr.Eng.	R. L. McGrath
Section of Erosion Control Practices	
Acting in Charge	Ervin J. Utz
Section of Erosion Investigations	
Chief	R. V. Allison
Section of Sedimentation Studies	
Chief	Henry M. Eakin
Section of Watershed Hydrologic Studies	
Chief	C. E. Ramser
Section of Climatic & Physiographic Studies	
Chief	C. W. Thornthwaite

Other engineering personnel on the staff of the SCS in 1935 are shown in Appendix B. Many other engineers were employed with funds from the Emergency Conservation Works and served in CCC camps and other activities under the direction of the SCS. In 1938, the following were attached to the engineering division in the Washington Office: T. B. Chambers, N. R. Beers,

H. T. Cory, C. L. Hamilton, G. E. Ryerson, A. H. Davis and W. X. Hull.

Erosion Control Practices

The control of erosion on private lands was a major assignment and the cooperation of landowners was essential. In the projects and camps, terrace construction was generally accomplished with the farmers' own or hired labor, power and equipment. At some locations, local governments allowed landowners to hire their earth moving equipment and operators. Seldom could contractors be found to perform work. The SCS provided the planning, layout and inspection of construction and, as an incentive, took the responsibility to provide the terrace outlets. With labor provided by the ECW camps, and materials by the SCS, both vegetated and mechanical outlets were constructed.

For the construction of farm ponds and erosion control dams, the government provided the design, layout, and inspection. Through the ECW camps they also provided the needed labor and "fresnos" or slips to move the earth. Farm tractors or horses were customarily provided by the farmer and since the farm animals were fondly regarded by their owner, it was important that the enrollee teamsters be carefully chosen and trained. When structural elements such as trickle tubes or mechanical spillways were required, the farmer provided most of the materials.

Gully control work was a major task in the 1930's and required much CCC and Works Progress Administration (WPA) labor.* The smaller gullies could be controlled with a series of brush dams if followed with the establishment of vegetation. With some deep head cuts it was necessary to divert the runoff, slope the banks, and establish vegetative cover. On larger drainages it was sometimes necessary to install permanent structures, such as drop inlets or flume spillways. The farmer was expected to provide most of the materials for this construction.

Posts and wire for the construction of brush dams were furnished either by the farmer or government or both. Often the CCC enrollees or WPA laborers cut the posts from existing timber stands. Brush was cut wherever it could be found--usually on riverbanks. Trees or other vegetation were planted in the silt collected above the dams to permanently hold the soil in place.

Some county governments became interested in replacing some of the bridges that were being undermined with drop inlet or grade control structures. The farmer often cooperated in a joint effort, sharing the cost of the material and earthwork. The SCS provided the plans and the CCC or WPA the labor.

When fencing was required to protect new trees or other plantings, posts could sometimes be cut from woodlots or hedgerows on the farm. In other cases the fencing materials were provided by the farmer, the government or both, and

* E. B. Stauber, a pioneer settler, told that when he first came to Thayer County, NE, no one could drive across the county without encountering a gully. In the 1930's hardly a farm did not have one or more raw gullies that interfered with cultivation. During a recent tour of the area, scarcely a gully could be found.

the labor was provided through the camps or WPA.

Of course all structural installations were supported with vegetative measures, and seed collection and tree planting were tasks that seasonally took much labor.

Research Programs

Associate Chief Lowdermilk designed much of the early research work and became chief of the research division on April 24, 1937. Soil erosion investigations previously conducted by the Bureau of Chemistry and Soils became the responsibility of the SCS. In 1939, the work of the Divisions of Irrigation and Drainage of the Bureau of Agricultural Engineering relating to investigations, experiments, and demonstrations on the construction and hydrologic phases of farm irrigation and land drainage (including snow surveying responsibilities) was transferred to the SCS.[5] In the engineering field, this transfer brought a number of eminent engineers and scientists into the organization and provided a solid technical base for the development of an operations program.

Lowdermilk was followed by Dr. Mark L. Nichols who was widely known as the originator of the Nichols terrace. In 1934 he had been honored by the American Society of Agricultural Engineers (ASAE) with the Award of the McCormick Medal and in 1946 he was elected president of that organization.

C. Warren Thornthwaite, a geographer widely known for his development of the Thornthwaite procedure for estimating the consumptive use of vegetation from climatic data, was placed in charge of Climatic and Physiographic Investigations. Henry M. Eakin, an outstanding authority on sedimentation, headed the Sedimentation and River Hydraulic Investigations. C. E. Ramser, internationally known authority on the application of the sciences of hydraulics and hydrology and later winner of the ASAE John Deere Medal in 1944, directed Watershed Hydrologic Studies. R. V. Allison, a soil scientist, was charged with Erosion Investigations, and S. B. Detwiler, an agricultural chemist, provided the direction to Hill Culture Studies.

Other prominent engineers and scientists who came to the SCS operations program from research activities or from the Bureau of Agricultural Engineering included Lewis A. Jones, Farm Drainage; W. W. McLaughlin, Farm Irrigation; Gilbert C. Dobson, Sedimentation; George W. Musgrave, Infiltration; Russell E. Uhland, Soils; Carl B. Brown, Sedimentation; James H. Stallings, Agronomy; John J. Sutton, Drainage; George D. Clyde, Irrigation; and Gerald E. Ryerson, Conservation Equipment.

While under the administration of the SCS, significant progress was made with studies to understand soil and water relationships and climatic influences on both water and wind erosion processes. Hydrologic and hydraulic studies led to improved understanding and design of structures. The collection methods and analysis of snow survey data together with the dissemination of the forecast reports on the available water supply to state authorities and farmers were greatly improved. Progress was made in the development of over-snow vehicles to facilitate the collection of snow pack data--greatly influencing the later development of the popular snow vehicles by commercial sources. Procedures for evaluating irrigation methods and improving water conveyance and application were developed. Improved criteria for surface and subsurface drainage works were established.

Perhaps the greatest benefit from having some engineering research in the Service was the close working relationships that developed between the research and operations staffs. The field activities on the many cooperative farms provided a large and practical laboratory to supplement research studies. Field problems could be rapidly investigated and joint efforts led to timely and effective solutions.

In 1953 when all SCS research activities were transferred to the Agricultural Research Service, many of the personnel and others who had come to the Service from research agencies remained in the operations program. The snow survey program, which had been a part of irrigation research, remained with the SCS.

EMERGENCY WORK PROGRAMS

Civilian Conservation Corps

The Emergency Conservation Work Act of March 31, 1933 (ECW) was the basis for the establishment of the Civilian Conservation Corps (CCC) and the Civilian Conservation Corps Act of June 28 further clarified this authority. Congress passed the first bill a week after it had been requested by President Roosevelt and on April 5, 1933, the executive order was signed appointing a Director of Emergency Conservation Work to carry out the purposes of the Act. Six weeks later, more than 1,300 camps had been designated and were in the process of being built by the first recruits. Twenty-two camps were assigned to and commenced operations under the technical direction of the Soil Erosion Service on April 1, 1934. Shortly thereafter the SCS came into being and the number of camps assigned was raised to 204. By September 1935 there was a grand total of 2,427 CCC Camps, of which 500 were assigned to demonstrate erosion control practices to the farmers of the Nation.

Enrollees were unmarried male citizens between the ages of 17 and 23 years. Exceptions were made for a limited number of war veterans assigned to Veterans Conservation Corps camps (VCC). There were also a few camps for Indian enrollees, though in some areas, Indians were recruited along with other local personnel. Enrollment periods were for not less than 6 months and not more than 2 years.

Reserve military officers were responsible for housing, clothing, feeding, medical attention, pay and discipline of the enrollees. Usually the military camp staff consisted of a commanding officer, an assistant, a military or contract doctor, and an educational advisor. Enrollees were entitled to $30 per month, $25 of which went directly to the parents or family of the enrollees. Leaders and subleaders got a few dollars more. Camps usually had an authorized complement of 200 enrollees (not always maintained) and a considerable number were needed for camp operation and maintenance. An average of about 160 enrollees were available for conservation work and daily were turned over to the SCS for field work. The CCC camps had their technical backstopping from the staff of whichever of the 39 erosion control projects to which they were assigned. A few camps were assigned to SCS nurseries. Multidisciplinary teams including engineers, agronomists, soil scientists, foresters, and others regularly visited the camps to evaluate work and conduct training. Structural designs in use on the projects generally formed the model for similar work at the camps. A sort of job approval authority was in place and uncommon structural design was prepared by the camp engineer and submitted to the project director for approval.

The SCS technical staff at the erosion control camps often consisted of a superintendent, one or two engineers, an agronomist, and a soil scientist. Usually four foremen, one of whom usually doubled as forester or other needed specialty, supervised the work of the enrollees and were responsible for training them in construction skills. Beside the design, staking, and supervision of structural measures, other important and time consuming tasks for the engineers in the camps were farm mapping (before aerial photographs became available), assistance with farm planning, and the field layout of strip cropping and contour lines. Except during the tree planting season, most of the manual work was structural and the major responsibility for developing work schedules fell upon the camp engineers. A number of the enrollees were trained to conduct field surveys, draft plans, etc. Some of these later were employed by the SCS to serve as subprofessionals in the soil and water conservation district programs. A few went on to college and then returned to the SCS in a professional capacity.

Trucks transported the enrollees to the field--leaving about 7:30 a.m., and the work assignment was 6 hours, 5 days a week. The military provided a noon meal, sometimes hot, at the field locations. Returning to the camp in middle or late afternoon, the enrollees were provided recreational and educational opportunities. Under the auspices of the civilian camp educational advisor, SCS technical personnel often conducted classes in the evenings on subjects requested by the enrollees.

Some camps supervised by the SCS had been given specialized assignments. In Kansas, the CCC constructed a series of lakes in state parks in cooperation with the Kansas Forestry, Fish and Game Commission. CCC crews made a large contribution in the SCS nurseries producing plant materials. The technical staffs at these locations were organized according to the work requirements.

One important product of the ECW work in the projects and camps was the opportunity to determine the amounts of labor, materials, equipment required and the cost of installing conservation measures. Detailed time and cost records were kept and reported to regional authorities who then were able to assemble data used in promoting conservation measures.

The ECW and the CCC programs were gradually phased out and eliminated early during World War II. Beginning in 1941 and continuing till 1947, Civilian Public Service Camps were established as part of a program of employing conscientious objectors. The Selective Service allotted as many as 15 of these camps to the SCS for erosion control work.

In 1941 upon the occasion of the eighth anniversary of the CCC, Chief H. H. Bennett wrote:

> *Possibly this generation will never fully appreciate what the C.C.C. is doing to build the internal strength of America. So many things of immediate magnitude are taking place every day that we are likely to overlook some of the long-time gains being made in our time. But the C.C.C. is making history, and as history is written in the future it will record that in the 1930's and 1940's the C.C.C. made an invaluable contribution to the conservation of America's most vital natural resource - its soil.*
>
> *I doubt seriously whether the importance of the C.C.C. contribution to soil conservation in the United States can be over evaluated.*

Works Progress Administration Participation

At some SCS activities, the WPA provided labor for work on government lands and projects. The WPA was a work relief program that provided emergency employment for local citizens. A local representative of the WPA managed the operation in accordance with an approved plan. The SCS planned and supervised the installation of the conservation measures. In 1936 the peak of WPA relief employment was reached when 23,709 workers were on the payroll for SCS work. It was phased out early during World War II.

In some areas, the great need to provide work relief led some local organizations to sponsor WPA programs of a quasi-conservation nature. Often these involved the construction of dams, generally small farm ponds, but sometimes of a size or hazard that would classify them as important structures. Local surveyors and engineers were hired to provide the plans and supervise construction and the pressure to provide work sometimes led them to approve questionable projects. Generally the WPA work was good but in some instances could be considered substandard and some confusion with respect to the quality of "government" work resulted. At some locations, this led to a competitive attitude between the WPA and SCS that lasted for a couple of years.

Related Conservation Programs

A companion agency authorized in 1933 was the Agricultural Adjustment Administration (AAA), a program to reduce acreage in return for government payments. With the assistance of county extension staffs, local associations of producers were organized to administer the program. This program was invalidated by the Supreme Court in 1936. Less than two months later, the Soil Conservation and Domestic Allotment Act of 1936 was passed to:

> *...promote the conservation and profitable use of agricultural land resources by temporary Federal aid to farmers and by providing for a permanent policy of Federal aid to States for such purposes.*

Several new conservation programs including the Agricultural Conservation Program (ACP) ultimately were established under this authority. The ACP permitted payment to farmers for the establishment of conservation practices.

NEW AUTHORITIES

In the 1930's, a number of new programs were authorized which expanded the responsibilities of the SCS and allowed the Service to include flood control, irrigation and drainage works in operation programs and truly fully embrace the soil and water conservation functions.

Flood Control and Watershed Protection

The Flood Control Act of 1936 for the first time recognized the importance of providing watershed protection and flood prevention as complements to the downstream flood control program of the Corps of Engineers. Prior to 1937, SCS was not authorized to provide technical or other assistance for water conservation measures.

The Acts of 1937, 1938, 1939 and 1940 authorized the USDA to work on the uplands of the same streams that Congress had authorized for work by the Corps. In August 1937 the first allotment of flood-control funds was approved for SCS--transferred to the USDA from the War Department. In November 1938, SCS was given the responsibility for flood control operations on lands which were predominately agricultural. Preliminary examinations followed by detailed surveys resulted in the authorization for operations on eleven watersheds by the 1944 Flood Control Act.

In 1953 the Secretary of Agriculture assigned the responsibility for administration of all of USDA's flood control and river basin activities to SCS. A "Pilot Watersheds Program" followed, and by the end of 1953, 62 pilot projects were selected to demonstrate the practicability of complete watershed protection to reduce flood and sediment damage, associated problems, etc., and to evaluate hydrologic effects and economic benefits.

Finally on August 4, 1954, the Watershed Protection and Flood Prevention Act (P.L. 566) was approved authorizing a nationwide program to provide technical and financial assistance to local groups for upstream watershed conservation and flood control. The size of upstream watersheds was limited to 250,000 acres. River basin investigations also were authorized. This Act repealed the authority for flood prevention measures under the Flood Control Act of 1936 except for the programs authorized on 11 major watersheds.

Watershed planning and operations programs expanded rapidly and led to the establishment of a new position, Deputy Administrator for Watersheds, with Watershed Planning, Watershed Operations, and River Basin Divisions. In addition to the large number of engineers, geologists and engineering-related professionals required to provide assistance, many engineers were assigned to administrative functions because of the quasi-technical nature of the positions. The design and construction responsibility for watershed structures remained with the Engineering Division.

As the organization pattern of the Service evolved over the years, engineers continued to play an important part in administrative as well as technical positions.

Of the 1,494 projects approved for operation under P.L. 566, 712 are now completed. The works installed include over 6,000 dams and over 10,000 miles of improved channels. The Federal input into this program exceeded 3 billion dollars and an additional 2 billion was provided by local governments, agencies and organizations.

Water Facilities Program

The Water Facilities Act of August 28, 1937, authorized the Secretary of Agriculture to plan and construct agricultural water storage and utilization projects in the arid and semiarid areas of the United States. In 1938, the Secretary assigned the responsibility for the Water Facilities Act of 1937 to the SCS. This included the "construction and installation of water facilities, development of conservation management plans for farms and ranches where the work was carried on, and the rendering of technical advice on water-facilities matters."[1] In the Water Facilities Program, the USDA's Bureau of Agricultural Economics had the responsibility for advising on the selection of project areas and the preparation of an area plan, and USDA's Farm Security Administration was responsible for making and servicing loans for the farm or group installations, while the SCS prepared the conservation and engineering plans and supervised construction. Mostly the work consisted of the planning and development of available groundwater and surface water supplies for farm and domestic use and constructing and rehabilitating small irrigation and water-spreading projects. At some locations where contract services were not available, the Service had earth-moving and other construction equipment available to perform the work. At the local level, this program demanded especially good relations and close coordination with the Farm Security Administration since representatives of both agencies were dealing with the landowner or farmer.

In 1942 the program was transferred to the Farm Security Administration, and in 1954, the Water Facilities Act was amended extending the loan program to the whole nation. The SCS cooperates in the technical aspects of the program but does not have responsibility for operations.

Land Utilization Projects

Also in 1938, responsibility for a part of the Land Utilization Program (LU) was assigned to the SCS. Initiated in 1935, the program had successively been in the Resettlement Administration, Farm Security Administration and Bureau of Agricultural Economics.[10] In these projects large areas of submarginal private lands were purchased by the government with the intent of assisting farmers and ranchers stranded on poor land to get a new start elsewhere. Over seven million acres were placed under SCS administration. The number of farm or ranch operating units was reduced to the number that the area would support, unnecessary farm headquarters eliminated, needed conservation practices applied, vegetative cover improved, and strict grazing controls enforced.

The principal engineering operations on the LU projects were the development of new and the rehabilitation of old farm ponds, dugouts, springs and wells to provide water for the grazing animals. Some small irrigation and water spreading projects were installed to increase feed supplies. Another major task for the engineers was the location of the government property boundaries and the construction of the necessary fencing. And of course, all project personnel were charged with the prevention and suppression of prairie and timber fires.

In 1953, responsibility for the administration of LU lands was transferred to the Forest Service. Some of the original LU projects have since been incorporated as "National Grasslands."

Wheeler-Case Projects

Senator Bert Wheeler of Montana and Congressman Francis Case of South Dakota introduced an act in 1939 with the avowed intention of requiring the Departments of Interior and Agriculture to work together in the planning and development of small water projects. The act authorized the U.S. Bureau of Reclamation (USBR) to establish small water conservation and utilization projects in the Great Plains and other arid areas of the west. These projects were to be partially paid for by labor and supplies from the WPA and CCC since it was accepted that the cost of irrigation was too great to be fully repaid if undertaken under reclamation law. It was further provided that the Department of Agriculture would participate in the planning and development of the project lands.

The USDA's responsibility was initially assigned to the Farm Security Administration and about seventeen projects were initially authorized for study in the states of Idaho, Colorado, Montana, North Dakota, Nebraska, South Dakota, Texas, Utah and Wyoming.

On the larger projects, the Farm Security Administration (FSA) in cooperation with the Bureau of Reclamation evaluated the lands to be irrigated, acquired the land needed for project purposes, and was responsible for the development of theland and its resettlement. The farms were intended to be of subsistence size for a farm family. The Bureau of Reclamation was responsible for the development of the water supply, construction of the needed distribution system and major drainage works, and, upon completion of the project, transfer of the operation and maintenance of the project works to a local organization.

Some of the smaller projects were completed prior to World War II, when all work on the projects was suspended. After the war, it was decided that even though the projects underway could not be economically justified, the projects should be completed and the completely developed farms sold to veterans on favorable terms at a subsidized price that would establish an economically justified farm unit. Competition for these developed units usually required that the new settlers be selected by drawings after eligibility standards had been met.

In 1945, the duties of the Farm Security Administration in connection with these projects were transferred to SCS. Major work on about six of these projects remained to be done. Prior to the war, the needed land had been acquired and project plans developed. Immediately after the war, the FSA had reinitiated the work and the projects were in various stages of completion. The projects on which the SCS made a major impact were:

Buffalo Rapids Project I	Montana
Buffalo Rapids Project II	Montana
Buford Trenton Project	North Dakota
Mirage Flats Project	Nebraska
Angostura Project	South Dakota
Eden Valley Project	Wyoming

The engineering functions on these projects included the planning of the farm sizes and boundaries based upon the topography and classes of soil. A system of roads was an essential part of the planning. This was a cooperative endeavor with the USBR and local authorities so that water deliveries could be efficiently made to each farm and an infrastructure provided. The necessary land leveling and construction of the on-farm irrigation and drainage facilities was performed by the SCS using either contract or force account procedures. Several of the projects were tens of thousands of acres in size.

After the land development was completed, the engineers made metes and bounds surveys of the farm boundaries and wrote legal descriptions to permit sales to the selected veterans. Work on the Wheeler Case projects was concluded in 1960.

ORIGINAL TECHNICAL ORGANIZATION THROUGH 1953

Washington Office

The organization of the Washington Office in 1939 included Chief H. H. Bennett and a number of assistant chiefs. Technical operations was under Assistant Chief Courtland B. Manifold, and the chiefs of the divisions were:[5]

Agronomy	Charles R. Enlow
Biology	Ernest G. Holt
Engineering	Thomas B. Chambers
Agr. Eng.	T. B. Chambers (Acting)
Construction Section	John S. Grant
Drainage & Irrigation Section	John G. Sutton
Equipment Section	Gerald E. Ryerson
Hydrology Section	T.B. Chambers (Acting)
Farm Planning & Mgt	N. Robert Bear
Forestry	John F. Preston
Nursery	Harry A. Gunning
Range Conservation	F.G. Renner

There was also an Assistant Chief for Research, Mark L. Nichols, and the chiefs of the divisions were:

Climatic & Physiographic	C. Warren Thornthwaite
Conservation Economics	Walter J. Roth
Cons. Experiment Stations	Alva E. Brandt
Farm Drainage	Lewis A.Jones
Farm Irrigation	W.W. McLaughlin
Hillculture	Samuel B. Detwiler
Hydrologic	Charles E. Ramser
Hydraulic Sect.	Howard L. Cook
Sedimentation Studies	Gilbert C. Dobson
Reservoir Sedimentation	Carl B. Brown

In July 1949, an Engineering Standards Unit (ESU) was established to provide in brief and usable form information on the application of engineering principles to the problems of soil and water conservation. An Engineering Council made up of the regional engineers and the chief of the Engineering Division in Washington provided general guidance to the Unit staff. First located at Lincoln, NE, the Unit staff headed by Melvin M. Culp developed standard procedures, designs, and technical materials for the use of SCS engineering personnel. The Unit was staffed with design engineers, hydraulic engineers and geologists. The first National Engineering Handbooks were prepared by this Unit.

On January 11, 1952, when a Design and Construction Division was established in the Washington Office, the ESU was redesignated as the Design Section (DS) and the personnel from the ESU were moved to Beltsville, MD.

Regional Offices

Starting in 1935 the SCS had adopted a regional type organization and by the end of fiscal 1936, the SCS had 11 regional offices, 147 demonstration projects, 48 nurseries, 23 Experiment Stations, and 454 ECW camps. ECW and SCS full-time employees totaled 10,394. As time went on, the numbers and boundaries of the regions were adjusted to better reflect work loads and maintain operation efficiency. In 1940, regional headquarters were at Upper Darby, PA (1); Spartanburg, SC (2); Dayton, OH (3); Fort Worth, TX (4); Milwaukee, WI (5); Amarillo, TX (6); Lincoln, NE (7); Albuquerque, NM (8); Spokane, WA (9); and Berkeley, CA (10).

A regional office was under the direction of a regional conservator who was responsible for administration and program operations in the region. He had a number of assistants, one of whom was the chief of Operations, who was responsible for the technical divisions. The chief of the Engineering Division typically was assisted by a couple of specialists, often a design engineer, an irrigation and drainage engineer or agricultural engineer or other specialist according to the need.

The original Regional Engineers in 1936 were:

Region 1, Williamsport, PA.............C.A. Frye
Region 2, Spartanburg, SC...............John T. McAlister*
Region 3, Dayton, OH......................Earl C. Johnson*
Region 4, Fort Worth,TX.................Howard O. Matson
Region 5, Milwaukee, WI.................R.W. Oberlin
Region 6, Amarillo, TX....................Edwin C. Kinnear*
Region 7, Salina, KS.........................John S. Glass
Region 8, Albuquerque, NM...........F.D. Matthews
Region 9, Rapid City, SD.................Lionel C. Tschudy
Region 10, Berkeley, CA..................John G. Bamesburger
Region 11, Spokane, WA.................Clarence C. Johnson*

After several reorganizations, the Regional Engineers in 1953 were:

Region 1, Upper Darby, PA............Walter S. Atkinson
Region 2, Spartanburg, SC...............Arvy Carnes
Region 3, Milwaukee, WI.................Edwin Freyburger
Region 4, Fort Worth, TX................James J. Coyle
Region 5, Lincoln, NE......................C.J. Francis
Region 6, Albuquerque, NM...........John G. Bamesburger
Region 7, Portland, OR....................Francis K. Muceus

The Chiefs of the Water Conservation Divisions were:

Region 1, Upper Darby, PA............John H. Wetzel
Region 2, Spartanburg, SC...............Harry G. Edwards
Region 3, Milwaukee, WI.................John S. Glass
Region 4, Fort Worth, TX................Howard O. Matson
Region 5, Lincoln, NE......................Kirk M. Sandals
Region 6, Albuquerque, NM...........Harold B. Elmendorf
Region 7, Portland, OR....................Frederick A. Mark

Each region was divided into zones. Zones were established without considerations of state boundaries and represented areas of roughly similar farm conditions. Zone teams consisting of an engineer and vegetative specialist routinely visited the soil conservation districts and other field activities to provide training to the field technicians and program evaluation. "Zoners" reported back to the state conservationist and the regional chief of Operations with their recommendations for program improvements. In their visits, they represented all the technical divisions and they brought reports of successful techniques or deficiencies to the attention of the division directors.

State, District, and Work Unit Offices

Each state has a state coordinator who maintains relations with state agencies and a state conservationist who provides administrative and logistic support to the field offices. Within each state were a number of districts, each with a district conservationist who supervised the work unit offices and other SCS activities.

The rapid growth of the numbers of soil conservation districts immediately after World War II greatly expanded the influence of the SCS. The names of the district offices and work units were changed to area offices and districts respectively.

* These individuals were Chief Agricultural Engineers but their assignment as Regional Engineers has not been positively determined.

TECHNICAL ORGANIZATION DEVELOPMENT

From the inception of the Service, controversy existed as to the role of the Federal government in soil conservation. The Federal and state extension services had been the principal contact between the government and the farmers. When Secretary Henry Wallace, in 1936, decided to implement his authority through units of government organized under state law, the colleges and Extension Service felt that their authorities were undermined. As the soil conservation districts came into being, the technical assistance provided by the SCS expanded with little input from the state agricultural authorities. In particular the zone teams, because of their multistate authorities, were not popular with the state agricultural colleges and extension personnel. Pressures were brought to effect a change.

On Monday morning, November 2, 1953, the regional offices were abolished and a system of state offices established. The regional office personnel were temporarily transferred to the staff of the Administrator while the establishment of a new personnel organization took place.

At the same time soil conservation research was transferred to the Agricultural Research Service (ARS) and at his own request, Robert M. Salter, Chief of SCS, was transferred as Chief, ARS. Donald A. Williams, an SCS engineer who had temporarily been assigned as chief of the Agricultural Conservation Program, was appointed to succeed Dr. Salter.

Special note should be made of the problems facing Administrator Williams as he took this assignment. Morale at the Washington, regional and state levels plunged, especially among the technical staff who anticipated undesired transfers, assignments or separation. It was necessary to quickly devise an organizational pattern that would satisfy SCS's critics and yet would permit the effective operational program to proceed. The Administrator and his top assistants immediately traveled to each regional headquarters, met with the regional staffs, quickly selected the leadership for the individual states and developed the pattern that continues with only slight adjustment to the present.

Washington Headquarters

Gladwin E. Young was designated Deputy Administrator; J. C. Dykes, Assistant Administrator for Field Services; C. E. Kellogg, Assistant Administrator for Soil Survey; and W. R. Van Dersal, Assistant Administrator for Management.[12] The Administrator also had field representatives, each responsible for liaison with state and E&WP unit and field specialists in an assigned group of states.

The principal staff under the Assistant Administrator for Field Services were:

Planning Division	Carl B. Brown
Farm & Ranch Plan'g Branch	Alfred M. Hedge
Cons. Needs & Records Branch	Ethan A. Nortan
Watershed Planning Branch	John H. Wetzel
Engineering Division	Karl O. Kohler
Hydrology Specialist	Harold O. Ogrosky
Sedimentation Specialist	Louis C. Gottschalk
Infiltration Specialist	George W. Musgrave
Ag. Engineering Specialist	James J. Coyle
Irrigation Eng. Specialist	Tyler H. Quackenbush
Drainage Eng. Specialist	John G. Sutton
Cons. Equipment Specialist	Gerald E. Ryerson
Design & Construction Branch	Chester J. Francis
Plant Technology Division	Edward H. Graham
Agronomist Specialist	Grover F. Brown
Range Conservation Specialist	Fredric G. Renner
Forester Specialist	Courtland B. Manifold
Biologist Specialist	Lawrence V. Compton
Plant Materials Specialist (Vacant)	

National Specialized Engineering Units

About the same time but not necessarily related to the abolishment of the regional offices, a National Soil Mechanics Laboratory (SML) was established at Lincoln, NE, to provide technical guidance and design assistance. This laboratory was an outgrowth of the soil irrigation and drainage work pioneered in the Albuquerque, NM, Fort Worth,TX, and Spartanburg, NC, regional offices. The SML was under the direction of the Director, Engineering Division.

In cooperation with the engineering geologists, the Soils Mechanics Laboratory continued to provide national leadership in the investigation of foundation conditions, in the classification, testing and design of soil materials. The SML provided advanced testing capability of soil materials beyond the facilities available in the states and the Engineering and Watershed Planning Units. About 1973, the SML was attached to the Regional Technical Service Center for administrative purposes.

The existing Design Section (DS) continued in operation and was located at Beltsville, MD. In 1963 they were moved to Hyattsville, MD and in 1964 were renamed the Design Unit (DU). A new unit, the Central Technical Unit (CTU), was established on June 8, 1954, and was located alongside the Design Section with the mission of extending, developing, testing, and evaluating applied techniques in the field of hydrology, and sedimentation.

Their charge was to develop and recommend new methods and procedures to be used in carrying out the hydrologic and sedimentation work of the Service. The CTU became responsible for some of the functions previously carried out by the Design Section.

The CTU and DS were located together at Beltsville, MD. Both were regarded as field units. The CTU was under the direction of the Chief, Hydrology Branch, Engineering Division, while the Design Section remained with the Design and Construction Branch. In 1963 both were moved to Hyattsville, MD and in 1967 relocated to Lanham, MD.

In 1979, a National Engineering Staff was established to include the Design Unit, the Central Technical Unit and others. Their duties were expanded to accommodate all the technical needs of the Engineering Division as determined by the director and his national staff. The CTU was renamed the Hydraulic Unit.

In 1982 the Units became a part of the Engineering Division though still located at Lanham, MD. Their function continued to grow with the added responsibilities of the Service and especially with the advent of computers and computer-aided engineering. Under the direction of an assistant director, Engineering Division, they now support all SCS programs for the conservation and protection of soil and water resources and the protection and enhancement of the environment. They provide assistance to the leaders in the national engineering and geologic disciplines, the National Technical Centers and the states in developing technology which includes the development and maintenance of engineering computer software models, data bases, engineering standard procedures and technical materials. In 1983 they moved to the Cotton Annex, USDA, Washington, DC, and are now known as the National Engineering Technology Development and Maintenance Staff under an Assistant Director, Engineering Division.

Engineering and Watershed Planning Units

Following the abolishment of the regional offices, a new office, an Engineering and Watershed Planning Unit (E&WP Unit), was devised and located at the previous regional locations. The staff at the E&WP Units received their technical guidance from their counterpart in the Washington Office and the head of the E&WP Unit was administratively and technically responsible to the Director of the Engineering Division.

The original Heads of the E&WP Units were:

Upper Darby, PA ..... Fred Larson
Spartanburg, SC........ Thomas B. Chambers
Milwaukee, WI.......... C.E. Ghormley
Lincoln, NE............... Dwight S. McVicker
Fort Worth, TX......... Howard Matson
Portland, OR............. Ellis Hatt
Albuquerque, NM .... J.G. Bamesberger

The staff attached to each E&WP Unit varied according to work load and initially represented the following disciplines: watershed planning, hydrology, geology (watersheds), geology (sedimentation), agricultural economics, design, construction, irrigation, drainage, and erosion control. In addition there were aides, draftsmen, stenographers, and clerks to support the technical staff. A few E&WP Units had one or more additional specialists to handle problems important to their work area. As an example, the Albuquerque E&WP Unit had a soil materials engineer and laboratory and the Portland E&WP Unit had a soil mechanics laboratory.

As time passed, the number of the E&WP Units was reduced to six, then to four; the states served were adjusted; and additional disciplines were added to satisfy the ever changing work load.

Related Technical Support Units

Cartographic Units were usually located in the same cities as the E&WP Units to provide drafting and duplication services for all SCS offices in the states for which they were responsible. For the most part these units employed professional engineers and aides but were under the supervision of the Assistant Administrator for Soil Survey. As other reorganizations occurred, these facilities were consolidated and relocated.

Soil, plant, and biological specialists provided technical assistance to the state and field units. They were based at scattered locations and were not necessarily assigned to the same areas as the E&WP Units. Until the establishment of the Regional Technical Service Centers, these specialists reported directly to their counterpart in the Washington office.

Technical Centers

In 1965 Regional Technical Service Centers (TSC) were established to coordinate the technical expertise in assisting the states and to keep the technical specialists advised of program developments, policy changes, new procedures, and problems facing the service. Four TSC's were established and located at Upper Darby, PA (Northeast); Fort Worth, TX (South); Lincoln, NE (Midwest); and Portland, OR (West). The TSC staff was under the direction of a field representative who reported to the Administrator. Field representatives were staff officers who maintained a close working relationship with the states and the Washington office. Technical personnel at the centers continued to be members of the staff of the division from which they received guidance. Accordingly the E&WP Units at the Regional Technical Centers continued to look to the Engineering and Watershed divisions in Washington, DC for technical direction and support.

Initially the E&WP Units retained the same disciplines within the Technical Service Center. Over the years these units became large because of the disciplines needed to assist states in project planning, operations and maintenance. In 1977 a reorganization abolished the E&WP Units and placed all the technical disciplines on other staffs, and the Technical Service Centers were renamed National Technical Centers (NTC). Each technical discipline continued to provide the same technical help to the states, but through staffs that were more interdisciplinary in nature.

In 1989, a National Water Quality Technology Development Staff was organized and located at Fort Worth, TX with a coordinator at each of the four National Technical Service Centers. The staff includes engineers, geologists, soil scientists and other specialists to meet thechallenge of improving water quality. This staff was located at the South National Technical Center and instructed to devote full time to development of needed technical materials and not to be involved in assisting states in routine technical assistance.

State Offices

Within a couple of weeks after the abolishment of the regional offices, selections of state staffs were essentially complete. State offices were enlarged, files assembled from the regional materials, and personnel transfers effected. Since it was impractical to place complete staffs for complex works in every state office, the E&WP Unit staff and specialists in the agronomic and soils disciplines were responsible for technical support. The new state conservation engineer position carried considerable responsibility and effective working relationships between the state and E&WP Unit staffs quickly developed. The original state conservation engineers and their successors are listed in Appendix C.

Field Offices

A system of work units and district offices (later renamed district offices and area offices respectively) existed under the state office. Most area offices were staffed with area engineers who provided field support to the districts. Engineering problems beyond the capability of the local staff were referred to the state conservation engineer for assistance. He/she, in turn, solicited help from engineering specialists to resolve complex problems.

ENGINEERING DELIVERY

At the inception of the Soil Erosion Service, the top engineering staff was faced with a serious problem of training the many new employees that were recruited to perform the engineering work. USDA bulletins were available, some of which had been previously authored by the top engineering staff members and other helpful information had been published by the land-grant colleges. Operational time constraints did not permit formal training and many new employees were placed in position, technically qualified but with little previous experience in the work.

Because of the nature of the multi-disciplinary work of the Soil Conservation Service, engineers made important contributions to a number of programs. The section in the Soil Survey publications on the engineering properties of soils was a collaborative effort between the soil scientists and the engineers. The conduct of the flood control and water development projects utilized many engineers in program and contract administration. Some engineers served in the Cartographic Units. Numbers of engineers moved into various nonengineering positions such as State Conservationists, Field Representatives, Administrative Officers, etc. and contributed to the overall conservation effort.

SCS has developed a unique and very successful engineering delivery system. Some have questioned the number of engineers in the organization, but in fact the number is very small when one considers the billions of dollars worth of engineering conservation practices installed on the lands of the United States. Important elements of this system include handbooks, standard plans, practice standards, an engineering job approval authority system, and the help from nonengineering and nonfederal personnel.

In 1978, an SCS policy was established requiring professional engineering registration for the Director of Engineering, the heads of engineering staffs at the four National Technical Centers and all state conservation engineers. This policy was established with the full knowledge that federal employees are exempt from state registration laws. The purpose was to assure a high level of engineering professionalism for the three levels of engineering approval authority and to promote high respect for SCS leadership by various professional engineering societies and peers. A high percentage of engineers in the Soil Conservation Service are now licensed or registered professional engineers.

Engineering Handbooks

The first "handbook" that came to the attention of the author (1935) was a mimeographed publication put together by C. E. Ramser which summarized the most important procedures for the guidance of new and junior engineers. The method of estimating peak flood flow using the rational formula, $Q = CIA$; gully control with diversions and brush dams; criteria for the grades, spacing and length of terraces; and simple hydraulic design of waterways were included. This was supplemented with bulletins that the individual engineer acquired from the government, university and commercial sources. Junior engineers who had their first assignment on the demonstration projects had on-job training from the senior staff. Others, especially new engineers in the CCC camps, were thrust into the work immediately.

The development of engineering handbooks became a primary job of the regional engineering staff and in many regions these became available in the late 1930's. In September 1948 J.C. Dykes, Assistant Chief, SCS, appointed a committee to "prepare a handbook setting forth service-wide guides covering design criteria, design procedures, standard plans, standard specifications and contract procedures." On February 15, 1951, Memo 1278 was issued by the Secretary directing the development of a guide for use by technicians in carrying out the Service responsibilities in connection with permanent types of conservation work.

The first work in preparing the National Engineering Handbook (NEH) was done in the ESU and later by the DU and CTU. Great impetus to their preparation was provided when the Engineering and Watershed Planning Units were established and specialists became available to assist with the outlines established in the Engineering Division.

National handbooks must undergo rigorous and detailed technical examination to meet the requirements of the many climatic, geologic, agricultural, and cultural areas of the nation, so they take considerable time to complete. The engineering staffs at the states, regions, and Washington headquarters all participated in their development. To provide immediate, and sometimes tentative, information to the field on new techniques, materials, and procedures, a system of Engineering Technical Releases and Engineering Notes was devised with the intention that this information, if found adequate, would eventually be incorporated in the National Engineering Handbooks. Some releases have survived several decades pending handbook revision.

The first section of the NEH, "Hydraulics," was issued in 1951. Occasionally sections have been prepared and released on a chapter by chapter basis. Special note should be made of the recognition that the engineering profession has given these publications. One handbook section, "Drainage," was reprinted in its entirety in 1973 by the Water Information Center, Inc., "to make it available to all persons and organizations interested in the management of water resources for the benefit of man." Commonly, the handbooks are listed as references in textbooks and technical papers and journals published by national technical societies. In 1961 the Bureau of Reclamation published the procedure developed by SCS for estimating rainfall runoff from soil and vegetative cover data in their publication "Design of Small Dams." Consultants around the world have requested copies of the SCS handbook sections.

Many states have also prepared state engineering handbooks to cover local procedures for the selection, design, layout and inspection of the most common conservation measures applicable to the area. In these, the design elements can be more narrowly focused toward the field conditions present in the state. State handbooks also can specify recording requirements and define any more restrictive state practice standards.

The continuing development of handbooks reflects new and improved technical information useful to the field personnel in the fulfillment of their old and new responsibilities.

Standard Plans

From the first days of the Service, many individuals began to develop standard plans for their own and associates' use. The engineers in the demonstration projects often developed standard plans to facilitate the work of the junior engineers in their project or the CCC camps that they supervised. Typical of these were plans for the construction of brush dams and small drop structures. Later, the regional engineers included some elements of standard plans in the engineering handbooks that were developed to facilitate the work in their area of responsibility. Many state conservation engineers, with the help of engineering specialists in the E&WP Units, developed manuals of standard plans to be used by field personnel for such installations as erosion control drops, irrigation structures, drainage structures, pipelines, etc.

A major advance in the development of standard plans came with the work of the ESU. Further emphasis was provided by the requirement of standards for approval of Agricultural Conservation Program (ACP) practices entitling the cooperator to Federal payments. In many technical areas, cooperation between research personnel and SCS engineers made it possible to define field problems and lead to a solution which often could be incorporated in a revised standard plan.

As time went on, improvements were made in many small steps. With the advent of electronic processing and communications, standard plans adapted to meet special conditions can now be made readily available to the field with a minimum of delay.

Engineering Practice Standards

Though standards for engineering practices had always been known through handbooks, standard plans, memos and personal communications, it became important that these be formally established when the SCS became responsible for the certification of practices installed by the farmer with financial assistance from the ACP. A National Handbook of Conservation Practices was prepared which established official names, definitions, national standards and specifications and guides to specifications for the practices commonly used in soil and water conservation programs. These standards are included in the local technical guides of each Soil and Water Conservation District and often are supplemented with more restrictive provisions as deemed necessary by local conditions.

Many of the engineering standards have been developed with the assistance of many professionals in other Federal and state agencies and research and university personnel. Often committees in professional engineering societies have participated and adopted identical standards in their literature. Standards undergo frequent review to keep them current with modern conditions and technology.

Job Approval Authorities

From the very first days of the Service, some form of authority for the approval of conservation work was present. Initially these were informal in nature and were largely defined by an engineer's supervisor. As might be expected, some restrictions quickly came into play, often because of less than fortunate experiences. When the certification of

ACP practices for Federal payments became the responsibility of field engineers, it became mandatory that a system of job approval authority based upon an individual's experience and competence be established.

Beginning in the 1950's, SCS field engineers provided direction to non-engineers to help plan, design, lay out, and check out engineering conservation practices. A formal engineering job approval authority system was developed and implemented. In 1968 the system assigned approval authority to all the field engineers and allowed about 8,000 to 9,000 nonengineer SCS employees to participate in the SCS engineering delivery system. The key has been the concept that the area engineer is responsible for, and provides guidance to, the engineering work done in the field offices within his or her area. Thus, with area engineer oversight, non-engineers such as District Conservationists, soil conservationists, and conservation technicians who have been trained, are able to plan, design, lay out and check out the more simple engineering practices.

Use of Nonfederal Personnel

The SCS has always encouraged land owners and others to participate in the layout and check of engineering practices. In the 1970's and 1980's, many conservation district technicians were hired to assist in conservation application. Because the technicians were under the technical direction of the SCS district conservationist, they were trained and given job approval authority for simple engineering practices. However, district employees are not federal employees and therefore are not exempt from state engineering registration laws. In 1985, SCS engineering policy required each state conservation engineer to review the approval authority given to the conservation district technicians. The purpose was to limit the technician's approval authority to work that does not constitute the practicing of engineering without a license.

In 1986 the Engineering Division provided direction to increase the use of conservation contractors to assist in providing engineering assistance and documentation for conservation practices. Most states have participated in this effort, and as of July 1989, it is estimated that over 400,000 hours per year for construction layout and checking are being provided by conservation contractors.

DEVELOPMENT OF ENGINEERING TECHNOLOGY

For the most part, the first engineers employed by the Service came from research and university backgrounds and the leadership was skilled in a number of professional fields of importance to the conservation program. There were no established curricula for soil conservation at that time. The junior engineers were technically trained but were thrust into new tasks with little on-job training.

In conducting the early programs, field engineers utilized elements of planning, design, hydrology, job organization, and construction techniques. They needed to acquire some familiarity with soil capabilities and recommended vegetative programs. The title "Soil Conservationist" came into use and for a period there was a movement to apply that appellation to everyone employed by the SCS. It was not long, however, before administrative purposes made it necessary to supplement the title with "(Eng)" or other parenthetical designation. Gradually more specific titles returned to use. Since every engineering specialist uses some elements of others, work loads and organizational needs often dictated that an individual, skilled in several fields, had to carry a couple of assignments. As the complexity increased, some specialties became narrower. For purposes of this discourse, an arbitrary listing of specialties is the basis for discussion.

Hydrology

Initially, the greatest technical need was an improvement in the procedures for estimating the peak flows and volumes from small watersheds. These estimates are required in preparing a sound plan forthe application of soil and water conservation measures. In the 1930's, the "Rational" formula was the state of the art for estimating peak flows from small watersheds. This formula, $Q=CIA$, expressed the flow, Q, in cubic feet per second, when the rainfall intensity, I, in inches per hour and the drainage area, A, in acres were known. A coefficient, C, corrected for the rainfall that infiltrated into the soil and its value was estimated from the slope, vegetative cover, and soil condition. The rainfall intensity was taken from weather records as the rainfall that could be expected during the time needed for flow to accumulate from all parts of the drainage area at the frequency assumed in design.

A conservative use of this formula gave values of peak flow that were satisfactory for sizing spillways on small earth dams and in the design of vegetative waterways and drop structures. However, no good procedure was available to estimate the volumes of flow that might be expected. This information was needed to effect refinements in the design of structures with large drainage areas. The expected volume of runoff was especially needed to properly size flood irrigation systems in arid climes where floodwaters were diverted to treated areas to increase production. The best information available came from gaging records on small streams when reduced to runoff volumes per square mile of drainage area.

Research in the field of hydrology had a high priority from the very first days of SCS. In 1936 C. E. Ramser was put in charge of hydrologic studies and later was in charge of the hydraulic laboratories at Spartanburg, SC, Minneapolis, MN, and Stillwater, OK, and directed the collection of hydrologic and hydraulic data on over 60 field projects. Many researchers were primarily concerned with uncovering the fundamental principals of hydrology. SCS engineers were mostly interested in developing working tools for field use. As the research information became available, SCS engineers developed increasingly accurate and practical field procedures and promulgated their use in the field offices.

In 1954 the hydrology research program was transferred to the Agricultural Research Service (ARS), and in 1956 the SCS, in cooperation with the ARS, began the development of standardized hydrologic procedures for small, ungaged, agricultural watersheds. This led to the publishing of Section 4 of the National Engineering Handbook in 1964. Incorporated were several new and important hydrologic concepts. These concepts include (1) a system for grouping soils according to their infiltration capacity, (2) a standard system of determining the runoff potential of watersheds according to soils and land use, and (3) the use of a dimensionless unit hydrograph in estimation of peak rates of runoff. This was followed with a release for procedures to be used in urban areas for evaluating and mitigating the impact of urbanization.

SCS hydrologists have also provided leadership in the development of channel routing techniques and incorporating kinematic wave concepts for overland flow.

The SCS predictive methods have been adopted by many engineering organizations, both governmental and private. The principles have been incorporated into handbooks for several foreign countries, including India, The Gambia, and North Africa.

Snow Survey

Even before 1900, it was recognized that a measurement of the snowpack in mountainous regions would be helpful in determining the seasonal water supply that downstream irrigation farmers might expect. As early as the winter of 1908-09, the University of Nevada and the Agricultural Experiment Station developed a snow sampler and scale to determine the water equivalent of snow on the ground and began to measure pressure, temperature, humidity, wind movement, precipitation, and sunshine at the sampling sites. The data collected were correlated with the rise and fall of the water level in Lake Tahoe.

In 1917 California established its first snow survey project and in 1929 established the activity as a permanent program. Nevada established their cooperative snow survey program in 1919 and Utah followed in 1923. It is of interest that in the early 1920's, George D. Clyde of Utah Agricultural College (later SCS Director of Engineering) developed the snow sampler that subsequently was adopted throughout the West. In 1935 the Federal-State Cooperative Snow Survey was established and the USDA Bureau of Agricultural Engineering was charged with coordinating the work. W. W. McLaughlin, then Chief of the Division of Irrigation, Bureau of Agricultural Engineering (BAE), and later on SCS's national staff, is credited with the successful establishment of the cooperative survey.

By 1936, the snow survey system was extended throughout the West. Studies continued to perfect the correlation between the snowpack measurements and the runoff yield. Starting in January

1951, snow survey and water supply reports for the principal western drainage basins were issued on a monthly basis through the winter season.

The data collected by the cooperative snow survey are used by the SCS to forecast the quantities of water available for irrigation and by other agencies to forecast flood potential and to manage the water resource.

Initially, snow surveys had to rely on ski or snowshoe travel and sometimes overnight trips to reach the remote snow courses to manually collect the data. Personnel were drawn from colleges, the ranching community, state and federal agencies and from the SCS. Many SCS work unit employees played an important part in this program. Because of the hazards involved, SCS research embarked on a program to develop an over-snow vehicle, and by contracts with several western universities, several models were designed, constructed, tested and evaluated. The first machine financed by the SCS, known as the "Frandee" (after its builders, Roy France and Emmett Devine), was developed at Utah State and was the forerunner of a machine later mass-produced by Morton Thikol in Brigham City, Utah. A second snow machine development project was with Montana State, where Ashton Codd developed and built a "Sno-Bug," the predecessor of the many small machines now on the market.

Modernization of data collection techniques continued, first concentrating on communications between the snow surveys and the base stations and later on the development of remote sensors and communication relays to provide the data to the base station without travel to the snow course. SCS engineers guided the developments that led to the collection of data from remote snow courses in real time without leaving the base station.

Under the leadership of Robert Rallison, Chief, Hydrology Branch, Engineering Division, this automated system developed still further utilizing meteor burst communication. This, the largest meteor burst communication system in the world, was completed and became operational in 1980. The snow survey program was transferred to the Inventory and Monitoring Division for program direction in 1980 but the national hydraulic engineer, Engineering Division, continues to have technical responsibility for hydrologic procedures used within the program.

Hydraulics

When the Service first started, several of the SCS leadership had performed valuable work in the field of hydraulics. Fred Scobey's work on the flow of water in pipes is an example. While all SCS engineers had training in hydraulics, its application to the design of erosion control practices needed further examination.

Section 5 of the National Engineering Handbook (NEH), "Hydraulics" was first issued in the early 1950's by the Engineering Standards Unit to provide basic information on the application of engineering principles to the problems of soil and water conservation. It largely consisted of a compilation of known axioms put in a usable form for easy use. It's preparation also served to highlight the field conditions which needed additional research and study. Section 11, "Drop Spillways" and Section 14, "Chute Spillways" of the NEH followed soon thereafter to provide the hydraulic design of these specialized structures.

A special problem existed in selecting the proper flow coefficients for use in the design of vegetated waterways. Most of the flow design criteria had been drawn from investigations on irrigation and drainage canals which were not fully applicable. William O. Ree conducted valuable research on this problem which culminated in a procedure that has been adopted worldwide.

In 1939 field engineers reported that some of the "trickle tubes" that had been installed on steep grades were flowing full contrary to the then accepted hydraulic theory. This was called to the attention of a regional engineer, who in turn referred it to research personnel at St. Anthony Falls, MN. Investigations there and at Oregon State College led to the development of a hood inlet for pipe spillways that would reliably cause full pipe flow, thereby increasing the flow capacity. Hooded inlets are now widely used--another example of an SCS solution widely applicable to other government and private use.

The hydraulic characteristics of many of the mechanical structures commonly used, drop inlets, chutes, drop structures, energy dissipators, etc., were greatly refined by the close collaboration between the SCS research and operations engineers. Research was performed in a dimensionless manner which permitted application to field installation without individual site laboratory testing. The work of Fred Blaisdell at the St. Anthony Falls Hydraulic Laboratory and William O. Ree at the Stillwater Outdoor Laboratory was especially valuable.

The SCS developed a program for the computer hydraulic proportioning of dams and reservoirs along with the linkage of several retarding measures within a drainage network. As the watershed programs grew in complexity, the use of computers provided the opportunity to evaluate the hydraulic effects of a number of planning approaches and select the optimum solution.

Engineering Geology

Earth materials are widely used in soil and water conservation measures. Probably the earliest structural use of earth by the SCS was the construction of farm ponds, terraces, and water conveyance channels. The responsibility for evaluating site conditions was initially the responsibility of the field engineer and since the works were of a minor nature, no specialized attention was necessary. However, with the advent of larger water-impounding structures, many built on yielding foundations, it became important that foundations and construction materials be thoroughly described and evaluated to provide a basis for design. Geologic investigations also became important in the planning and design of stable channels. And still later, geologists carried the major responsibility for groundwater investigations.

There was some scattered geological expertise within the SCS (mostly not in the engineering organization). Chief H. H. Bennett had some training in geology having been made aware of the soil survey work in USDA by Collier Cobb, his geology professor at the University of North Carolina. It was not until the establishment of the Engineering and Watershed Planning