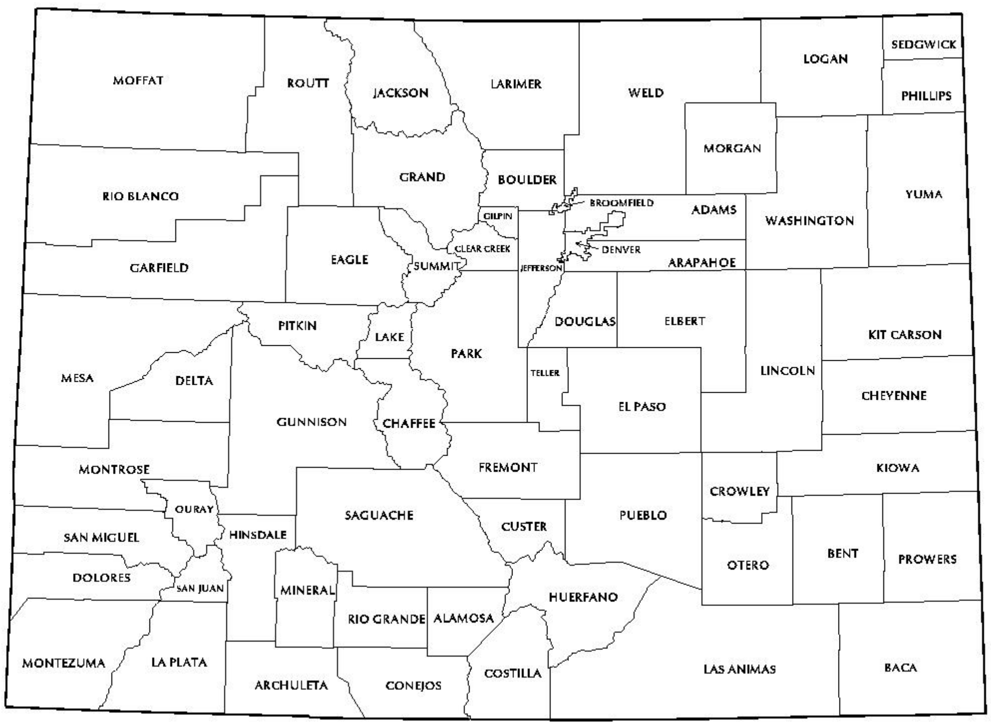
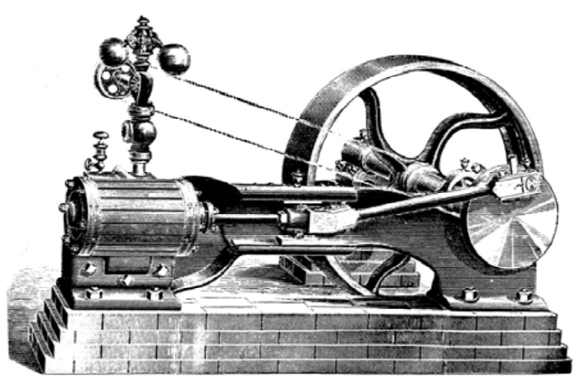
COLORADO ENGINEERING CONTEXT





OFFICE OF ARCHAEOLOGY AND HISTORIC PRESERVATION
COLORADO HISTORICAL SOCIETY

COLORADO ENGINEERING CONTEXT

JOSEPH E. KING

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OFFICE OF ARCHAEOLOGY
AND HISTORIC PRESERVATION
COLORADO HISTORICAL SOCIETY
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PUBLICATIONS IN THE RESOURCE PROTECTION PLANNING PROCESS (RP3) CONTEXT SERIES

Title	Number
Colorado Plateau Country	606
Colorado Southern Frontier	607
Colorado Mountains	608
Colorado Plains	609
Colorado Engineering	610
Colorado Urbanization and Planning	611

These publications are available from the Office of Archaeology and Historic Preservation or online at:
http://www.coloradohistory-oahp.org/publications/contexts.htm

Since the completion of the RP3 context series in 1984, a number of new regional and thematic contexts have been developed that expand on this Colorado Engineering Context document. These too are available from OAHP or online:

Title	Number
Highway Bridges of Colorado	632
Historic Resources of Marble	637
Metal Mining and Tourist Era Resources of Boulder County	623
Railroads in Colorado, 1858-1948	625
Routt and Moffat Counties Coal Mining Historic Context	620

PREFACE

The Colorado Historical Society, Office of Archaeology and Historic Preservation, is proud to present this set of historic contexts for the State of Colorado. The set includes regional historic contexts and also topical contexts which summarize and evaluate the history of the state from the earliest historic events up through World War II.

The four regional historic contexts include the Plains, the Mountains, the Southern Frontier in southeast Colorado, and the Plateau Country along the western edge of the state. For each of these regions, themes are based on socio-economic units of development in the region. These are presented in rough chronological order, but they are not strictly chronological units. They reflect the historic themes of development in each region and the historic properties associated with them.

Four "topical" contexts were developed: Engineering, Urbanization and Planning, Historical Archaeology and Architecture. The Engineering context is oriented toward a history of engineering technology. This context is organized by topics including Water Resources, Power Resources, Transportation, Industry, Mining, Communications, and Waste Disposal. Within each topic are themes for the various specific resources types. For example, the themes within Power Resources include Petroleum and Shale Oil, Natural Gas, Uranium, Electric Power and Coal.

The Urbanization and Planning context was developed to focus attention on the significance of town planning, layout and transportation modes, the latter including the Stage/Wagon Era, Rail Era and Auto Era. The themes within this context address town form or town function and selected aspects of towns during the transportation eras. Additional themes are presented for the three major urban centers in the state including the Central Business Districts, Residential Development, and Rail/Industrial/Warehousing Districts during the transportation eras.

For all of the historic contexts, the presentation of data for each theme begins with a narrative of the history and description of the theme. A chronology, description of the location of historic properties, and a list of cultural resource types are presented. Then the quality and quantity of existing data about the theme are evaluated. This includes an assessment of the historical documentation, number and location of sites, data gaps, future needs and important resources. Research questions and a guide to evaluation standards for physical condition are presented. References and a map are included for each theme.

The Historical Archaeology context is based on ten temporal units identified as socio-politically significant periods spanning the history of the state. For each unit the quality and quantity of past historical archaeology work is presented and research recommendations and identification and dating problems are considered. In addition, the context presents a research framework for future historical archaeology work in the state.

The architectural context for the project is presented as "A Guide to Colorado Architecture." The guide standardizes the terminology used for architecture styles in Colorado and presents pictures and descriptions of these styles.

The overall purpose of these reports is to provide a framework to identify and record the historical resources in the state and to provide research direction to analyze the significance and preservation of these resources. The contexts can provide guidance for state and federally mandated cultural resource management, as well as direction for pure research. We anticipate that the recording and evaluation of historic sites will benefit by using the combined contexts.

The reports were produced by the Colorado Historical Society with the assistance of a grant from the Colorado Commission on Higher Education. The development of these reports is a direct outcome of the RP-3 (Resource Protection Planning Process) effort led by Office of Archaeology and Historic Preservation Archaeologist Judith Halasi who provided research, coordination and editing for the project.

The editorial content of this publication was supported by a grant-in-aid through the funding provisions of the National Historic Preservation Act of 1966, as amended, which is administered by the National Park Service, Department of the Interior. The content and opinions do not necessarily reflect the views or policies of the Department of the Interior nor does mention of trade names or referenced publications constitute endorsement or recommendation by the Department of the Interior.

We hope that these volumes will stimulate an awareness of and appreciation for the historical resources of Colorado.

Barbara Sudler

Barbara Sudler
President
State Historic Preservation Officer

CONTENTS

ENGINEERING CONTEXT

1. DAMS

NARRATIVE

Dams are structures placed across a river to stop or divert the flow, to provide storage of the water in lakes or reservoirs, and to raise the water's surface. As generally used in the western United States, dams impounded water so that it could be used for water power, municipal water supply, hydraulic mining operations, irrigation, and similar applications. The design of the dam, along with the construction techniques and materials employed, depended upon complex variables, including the dam's function, the supply of water available, state of the art technology, the kind and quality of local building materials, geology, and topography. Although experts assert that no dam ever exactly duplicated any other because of these differing sets of variables at each damsite, there are many characteristic features of dams and dam construction materials.

In its simplest form a dam could be a crude combination of stones, branches, and tree trunks whose interstices had been chinked with sand, gravel, or clay. These brush dams, usually made in slow moving streams, were not ordinarily meant to be permanent structures, but rather to serve an immediate need--divert water for mining or irrigated agriculture. As a simple procedure using materials found along stream side, the brush dam has not been limited to a certain chronological period.

In forested regions where sawmills were located, a common structure was the timber dam, frequently regarded as a temporary dam because of its loose construction. Timber dams were built of logs, cribwork filled with stones, or framed timbers with the upstream face frequently covered with a sheathing of planks to minimize water seepage. Crib dams became popular because of their relatively low cost and their adaptability to most river bottoms. (For further information, see Edward Wegmann, The Design and Construction of Dams, 1927, Ch. 4)

Embankment dams, constructed of earth compacted into a watertight mass, had the advantage of relatively low cost, locally available building materials, simplicity of design, and they could be built to very large size. This combination of characteristics made earthfill dams particularly suitable for broad river valleys along the edge of the Great Plains, where they performed well for water storage. However, unless provided with a sufficient spillway or outlet, floodwaters can overtop this type of dam and wash it away. Most dams in Colorado are earthfill and most are used to impound water for irrigation purposes.

Western mining regions, particularly those in California, made a notable contribution to dam building in the middle to late 19th century with the rockfill dam. Frequently used to impound water for placer mining, this type of dam utilized loose rock rolled into place, creating a pile or embankment of stone, with the up river face made watertight by using masonry, wood, or metal. In mountainous regions, rock was abundant, concrete expensive to transport, labor costly, and water essential for successful mining operations, meaning the rockfill dam enjoyed a well-deserved popularity in the mining West. Western miners also practiced hydraulic mining, again probably first on the Pacific Coast, which directed a stream of water under great pressure through a nozzle to tear down hills, wash away sand, gravel, and rock, and uncover gold-bearing ground. From this mining method, begun in the mid nineteenth century, evolved an important technique to build earth and rockfill dams. The constructions materials were loosened, carried, sorted, and deposited by hydraulic force, thus making use of available water power and experience to save labor. Structures built by this method are called hydraulic fill dams. In Colorado, a significant example of this construction technology is the Terrace Dam on the Alamosa River near Monte Vista, completed in 1909 with the assistance of the renowned civil engineer James Dix Schuyler. The Santa Maria dam of 1910 near Creede was also made by hydraulic force.

In about the 1890s the availability of steel plates permitted engineers to use this material as a core wall or as facing on dams constructed of earth and rockfill. Though an expensive material to use and maintain, steel appeared in western dams to prevent leakage. The Victor or Skagway dam, erected by the Pike's Peak Power Company in 1901, represented an early use of steel plates on a rockfill dam; the high cost of the project warranted by the presence of rich gold fields at Cripple Creek.

Between the 1850s and the early twentieth century, the most substantial dams constructed in the United States were made of masonry. Ordinarily, masonry dams were built of cut stone (quarried locally), rubble (rough and irregular pieces of stone), or concrete, or a combination of these kinds of masonry. As major construction projects, masonry dams required careful planning and involved high costs for labor, materials, transportation, and engineering expertise. Thus, the appearance of these dams would indicate a region had attained a stage of development where demand justified and economic resources permitted the building of major water projects. The Cheesman Dam on the South Platte, built in 1900-1904 to supply water to Denver, is a fine example of masonry construction and illustrates sufficient population growth to support a work of this magnitude.

In the late nineteenth century theoretical studies and structural analysis combined with better building materials to advance the art of dam building. Greater use of concrete as a building material followed upon the introduction of portland cements in the 1870s, and with the passage of time, concrete dams appeared, primarily in the twentieth century. Gravity, arch, and buttress dams, or in combination such as gravity-arch, are generally constructed of concrete; the selection of dam type depending on engineering feasibility and cost. Gravity dams, which use great amounts of concrete, depend upon their weight and low center of gravity for stability. For building these dams, it is important to have the building materials close to the site. An arch dam is a complex structure that draws its strength from the arch form and its abutments. This type is often utilized in narrow, steep canyons where the bedrock and canyon walls can resist the load of stored water. When several contiguous arches are used for additional strength, the structure is called a multiple arch dam. Although many variations are possible, a buttress dam essentially consists of a series of upright concrete props supporting a slab of reinforced concrete. The buttress dam requires less concrete than a gravity dam, but involves greater expense for formwork and reinforced structures.

A movable dam is a structure outfitted with gates, shutters, or similar devices that permit a controlled flow over the dam. The earliest technology used wooden flashboards or hinged wickets that could be raised and lowered at the top of the dam, while later developments, such as the Taintor or radial gate of the nineteenth century, employed a pivoting, arc-shaped, metal gate to control flood waters. In the 1890s German engineers developed a movable dam that rolled an iron or steel pipe up masonry abutments, regulating the flow of water. The rolling crest dam near Grand Junction, Colorado, built by the U. S. Reclamation Service between 1913 and 1916, is one of the largest in the United States. The design was chosen to permit maximum storage of water for irrigation, but also to avoid flooding railroad tracks in the Grand Valley.

By erecting a barrier across a river valley and impounding the water, dams create artificial reservoirs. However, in mountainous regions, natural lakes and ponds exist that may have their natural outlets to a river closed by a dam and the water stored in this manner used to supply cities, mining operations, or water power projects. In some water supply systems, engineers utilize natural lakes in conjunction with man-made structures to control and direct water resources for a particular purpose. Primarily in the twentieth century as demand for water grew, new technologies evolved to make use of water in natural basins. One significant method, called "lake piercing", digs a tunnel to a lake bottom in order to draw off the water as needed. Although a complex procedure, it possesses advantages in high mountains where terrain and weather make dam building difficult and costly. Perhaps the earliest example of lake piercing in the United States occurred in Colorado in the 1890s near Telluride. A rockfill dam closed the outlet of Lake Hope and a tunnel pierced the lake to release water for hydroelectric plants at Ames and Illium, Colorado.

The purpose for which a dam is built and the design of the structure determine what appurtenant features are found at the dam site. A coffer dam is a temporary structure often used to direct water around the excavation for a dam. Fishways are ladders of pools and drops to permit the migration of fish around a dam. Spillways may consist of tunnels, pipes, or chutes and serve to release flood water and avoid overtopping of the dam. A "morning glory" spillway is a large inlet set in the reservoir itself to drain flood water by way of a tunnel. Penstocks are closed conduits to discharge water under pressure from a dam to a hydroelectric power plant. Control works are those facilities such as valves and gates that control the water flow from the reservoir over or around the dam. These facilities are usually operated from a control tower located upstream from the dam.

Dam building was a response to an increasing economic tempo in an area that sought to make greater use of its water resources for industrial, municipal, or agricultural purposes. These demands, which changed and blended together as time passed, were generally reflected in what group, company, or governmental agency undertook dam construction that usually represented a substantial financial commitment. In nineteenth century Colorado it appears that private companies in mining, irrigated agriculture, water supply, and water power built dams as did some municipalities. Notable examples are the Twin Lakes Dam near Leadville, built by a water and irrigation company around

1898, and the Castlewood Dam, built by the Denver Land and Water Company in 1890 for irrigation. Colorado also made a significant effort in the 1890s to construct state sponsored dams. Although the projects encountered political opposition, work did proceed on state reservoirs in Custer, El Paso, Saguache, Chaffee, and Las Animas counties.

In 1902 Congress passed the Newlands Act, creating the U. S. Reclamation Service, which opened a new era for dam building and reclamation in the West. Dozens of dams, affecting every major river in Colorado, have been built in the twentieth century, while building techniques have become routine and standardized. The Reclamation Bureau participated in most of the major water projects in the state to 1945, including the Gunnison River diversion to the Uncompahgre Valley, the Grand Valley Reclamation project, and during the Great Depression years the gigantic Colorado - Big Thompson project to bring Western Slope water to the front range.

CHRONOLOGY

1860s & 1870s	Small, temporary dams primarily used for mining and irrigation purposes.
1880s	Appearance of large dams of rock or earth fill. Hydraulicing used for dam building.
1890s	An important period in Colorado. Dam builders responded to the need for water storage and water diversion for power, municipal, industrial, and agricultural purposes. Earth and rock fill were still the principal types of dams, but the availability of concrete began to influence construction techniques.
c1891-1897	State efforts at dam building
1902	Newlands Act and U. S. Reclamation Service
1900-1915	An active period of dam building by irrigation commissions and cities.
1903	Gunnison - Uncompahgre Project
1905	Grand River Valley Project
1937	Colorado - Big Thompson Project

LOCATION

Dams and water control projects are found along every principal river in Colorado and many of their tributaries. Dams are associated with agricultural development, urban water supply, water power projects, mining, and other industrial operations. Map indicates principal dammed rivers.

CULTURAL RESOURCE TYPES

Dams

1. Building materials
   a. brush
   b. timber
   c. steel
   d. earthfill
   e. rockfill
   f. hydraulic fill
   g. masonry
   h. concrete
2. Types
   a. embankment
   b. arch
   c. gravity
   d. buttress
   e. movable
3. Reservoirs
   a. pierced lakes
4. Appurtenances
   a. coffer dams
   b. fishways
   c. spillways
   d. penstocks
   e. control works

THE QUANTITY AND QUALITY OF EXISTING DATA

Historical Documentation

A large amount of information is available on dams and dam building particularly the major structures, but one must be prepared to piece together data from various sources and to research diligently the lesser dams. A good general introduction to the subject is Norman Smith's A History of Dams. Older engineering treatises can be very helpful since they often provide historical examples. Daniel Mead's Water Power Engineering, published in 1920, is still useful.

For research on particular American dams, one should begin with T. W. Mermel's Register of Dams in the United States which provides basic data on type, purpose, construction, ownership and dimensions. Reliable information can be gathered from the periodic reports of the state engineer, engineering journals such as the Engineering News-Record, and books by civil engineer James Dix Schuyler and Edward Wegmann.

The construction of large dams has involved significant public policy decision making in the area of reclamation. As a result there is a growing body of literature in this field, notably Norris Hundley's Water and the West and Alfred Golze's Reclamation in the United States, the former containing an excellent bibliography. Because of the controversy sparked by dam building, care must be exercised in the use of polemical works for information on this subject.

Number/Condition

Since many small dams were constructed for temporary purposes, the number and type of resources that once existed or may have existed can not be accurately determined. The number and condition of large dams can be determined by a comprehensive site survey and field documentation. Some, such as the Cheesman Dam, have been well documented, while others, the Skagway and Terrace Dams for instance, need further attention. A site survey might also reveal evidence of temporary dams built for mining, timbering, water supply, and agriculture. Combined archival-library research and field documentation would provide an excellent data base on the state's dams.

Data Gaps

Representative dam design types.

Sites that represent a major engineering feat, unusual building materials, high degree of construction difficulty, or the work of an important dam builder.

Structures that made significant contribution to the state's historical development.

Representative temporary dam.

Future Needs

A comprehensive historic engineering site survey would identify the important dams in the state. Such a survey should have a high priority since engineering landmarks have been generally ignored yet they possess potentially great significance in the state's history. The survey should be conducted by a historian with research skills in the sources of historic engineering data.

Important Resources

Potentially all sites are significant. Dam building made an enormous impact on the economic development of the state, water supply for neighboring states, and settlement patterns in the region. Furthermore, dams are major construction projects often involving important techniques, high cost, public policy, and innovative methods. Thus, any site that contributes to our understanding of these aspects is noteworthy.

RESEARCH QUESTIONS

1. What resources in Colorado represent a departure from traditional dam building methods or materials?

2. Can cultural resources help us identify leading civil engineers and construction firms in western America?

3. What resources can lead to additional knowledge and new interpretations of water use in Colorado? How did mining, agriculture, and urban areas participate in dam building decisions?

4. Can cultural resources reveal the influence of hydraulic mining techniques on dam building?

PHYSICAL CONDITIONS

Dams: Any site with minimal modifications or with modifications that can be accurately dated. In the case of temporary dams, enough of the structure should remain to determine its function and it should be dated.

Reservoirs: Potential historic significance is likely to depend upon the dam structure or its place within an important water supply system. An example would be a pierced lake reservoir such as that at Lake Hope.

Dam Appurtenances: Should be in their original location and enough remain to determine their function in relation to a major dam structure.

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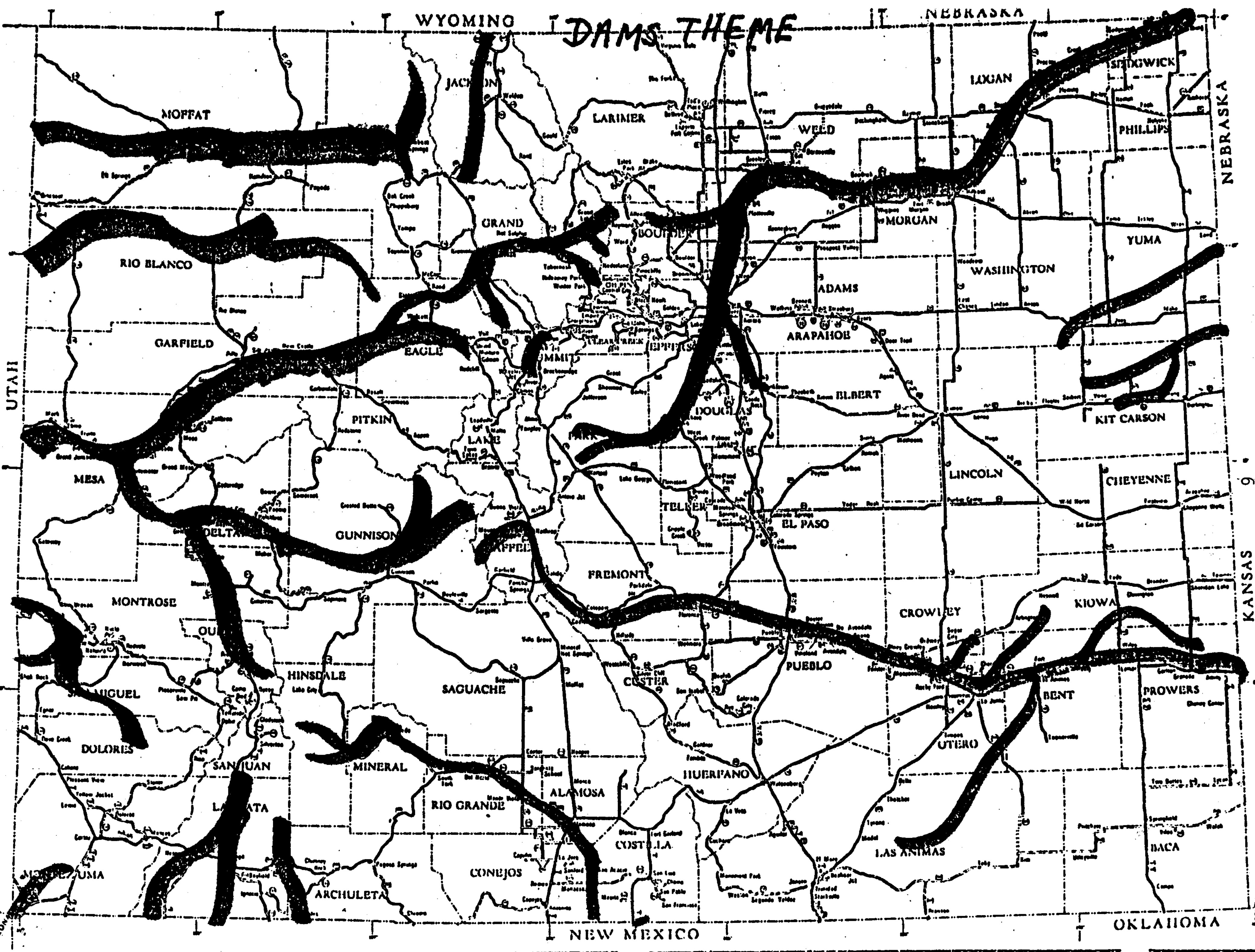

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EXHIBIT 2 FEDERAL AID SYSTEMS

3. WATER LIFTING DEVICES

NARRATIVE

Economic survival in arid and semiarid regions has depended upon the population's ability to make full and efficient use of the available water supplies. This involved utilizing techniques to elevate water from surface supplies, such as reservoirs and streams, and from underground sources in acquifers. Similar to other dry areas in the West, the western slope and eastern plains of Colorado had to adopt devices and machines to raise water from low lying sources to supply a growing population and a wide range of commercial activities. To the extent that these techniques were not used in Colorado as early as elsewhere seems due to the presence of rivers emanating from high elevations in the Rocky Mountains that made possible the movement and application of water by gravity feed. Thus, some of the considerations that encouraged water lifting were: the growth and spread of population away from readily secured water supplies; farms distant from gravity fed irrigation systems; farmers who wished to supplement surface water irrigation or who preferred an independent source; drouth conditions that diminished surface water; and, municipalities requiring greater flexibility and reliability from their water systems. While by no means an exhaustive list, these factors appear to have influenced the introduction of water lifting machines of various kinds.

In the early period pioneers generally relied on human and animal power to work devices, many of which had originated in antiquity, that raised water from streams, cisterns, and shallow wells. The task was made easier with a windlass, consisting of a hoisting rope attached to a wooden crank, or with a mot, whereby an animal hitched to a pulley could raise and lower a bucket by walking away from and then towards the well. Somewhat more complex was a small bucket wheel geared to enable a horse walking in a circle to turn the wheel and raise water. Farmers also used a simple hand-operated lift pump, sometimes called a pitcher pump, that raised and lowered a piston sucking water from a well. However, none of these mechanisms proved suitable for wells deeper than 20 feet or for large-scale irrigation projects. Rather they served the limited needs of pioneers moving into a new region and would be replaced when pumping demands increased and better technology became available.

The comparative simplicity of water wheels made them useful in western water projects prior to 1910. When facing the need to elevate water from a stream or a canal to irrigable land, farmers occasionally constructed current wheels. Built of wood, with paddles projecting into the water, these wheels revolved with the force of the current for irrigation or other uses. Small current wheels (about 4 feet in diameter) operated in irrigation ditches along the South Platte River near Denver in the late 1800s, while a wheel 34 feet in diameter raised water 30 feet to an orchard on the Grand Valley Canal at Grand Junction in the 1890s. The latter seems to have been the largest current wheel in the West.

Another device found in the early period was the hydraulic ram which elevated water through the power produced when moving water is suddenly stopped. Flowing water admitted to a valve box automatically closed a valve forcing the water upward into a delivery pipe. The loud banging noise resulting from this process accounts for the name "water hammer" sometimes used to describe the ram. Although very wasteful of water, this primitive pump was put to use on small farms to supply drinking water, in areas of abundant flowing water, and when a source of external power for pumping was unavailable. Consequently, a region in the early stages of economic development would likely adopt the hydraulic ram for pumping purposes.

By the 1860s steam power was being applied to reciprocating pumps in which a piston alternately drew water into the cylinder then forced it out. With one suction and one discharge valve on each cylinder, the pump is called "single acting; two sets of valves make the pump "double acting". Two cylinder pumps are called "duplex", while three cylinders are "triplex". Whatever the pump design, such steam powered pumping plants required a major investment of money, technical skill to operate and maintain, ready fuel supplies, and a constant demand for the water they delivered. As a result, steam driven reciprocating pumps (many of which were manufactured by the Worthington Company) generally were built as part of a larger municipal water supply system to elevate water from rivers, reservoirs, and wells. The expansion of cities in the late nineteenth century frequently led to the construction of steam pumping stations. In Colorado, where many cities and towns drew their water by gravity flow from the mountains and where fuel costs for steam power were high, the extensive development of steam driven pumps may have waited until the twentieth century and then frequently as boosters within the water works system. However, pumps of this type were often used in mining operations to remove water which entered the workings at lower levels.

A significant advance in pumping technology occurred with the introduction of the centrifugal pump in which rotating blades create suction that pulls the water up through the chamber for discharge. Although the principles involved had developed much earlier, the design of the centrifugal pump improved substantially in the late nineteenth century and continued to be modified in the twentieth century. When connected to electric motors or internal combustion engines (steam sometimes used in larger plants), these pumps provided reliable and efficient service at lower initial cost and proved adaptable for use in agriculture, industry, and municipal supply. A type of centrifugal pump called a deep-well turbine, introduced around 1900 and coming into general use in Colorado in the 1920s, consisted of serveral impellers on a vertical shaft which could be extended down a narrow well. The turbine saved on well construction costs and could be extended as the water level fluctuated, lifting water hundreds of feet. Until rural electrification in the 1930s, many farmers ran these pumps--and many still do--with internal combustion engines. Gasoline/diesel engines were chosen where electricity was unavailable, or when the pump was operated irregularly. Several firms manufactured pumps of this kind, with Worthington, Sterling, Peerless, and Fairbanks-Morse among the leaders.

CHRONOLOGY

1859-1870s	Primitive water lifting devices, i. e. windlass, mot, bucket wheel, pitcher pump.

1870s-1910	Current wheels
1870s-1945	Reciprocal action pumps. Large pumps powered by steam for municipal, industrial, and agricultural uses. Windmills used piston pumps.
1880s	Centrifugal pumps-electric and gasoline powered
1920	Deep-well turbines

LOCATION

Cultural resources can be found in all parts of Colorado. Water pumping and lifting are associated with agricultural, mining, and industrial activities as well as municipal water works. The map indicates cultural resources might be located in all parts of the state and notes several focal areas in which water lifting occurred for industrial, agricultural, and/or municipal purposes.

CULTURAL RESOURCE TYPES

Windlass

Mot

Bucket wheel

Hand-operated pitcher pump

Current wheel

Hydraulic ram (water hammer)

Reciprocal action pump

Centrifugal pump

Deep-well turbine

THE QUANTITY AND QUALITY OF EXISTING DATA

Historical Documentation

No general literary and interpretative source exists on this subject despite the obvious importance of water lifting to technology and the history of Colorado. To document this cultural resource will require considerable research effort and a measure of good fortune since the primary sources are scattered and often prove of minimal value in providing the kind of data necessary for full identification. Under the circumstances, published material--much of it aimed at imparting practical, "do it yourself" information for installing small pumping plants--represent the best available sources. Government agencies, among them the Department of Agriculture and the Geological Survey, have issued reports which can contain some valuable information. A section on local pumping practices appears in J. M. Dille's

Irrigation in Morgan County. The otherwise highly technical and abundantly illustrated Pumping Machinery by Arthur Greene contains a brief historical overview. Illustrations and technical data also make old catalogs from equipment manufacturers useful research tools on this subject. Advertisements and articles in the engineering and farm journals can be consulted; of course, care should be exercised in the use of advertising material in historical documentation. References found in the windmill and irrigation themes can supplement the list included here.

Number/Condition

The data are insufficient to determine the exact number of cultural resources that existed or may have existed. Some of the lifting devices may be components of larger preservation projects, for instance, a simple windlass, mot, or hand pump found on a farm. Similarly, the widescale use made of pumping by agriculture, industry, and municipalities may lead to cultural resources of satisfactory condition. The historical record indicates Colorado employed current wheels for irrigation projects, notably near Grand Junction and along the South Platte. While evidence of these resources would be significant, it is not likely many survived the ravages of time and wear. Powerful steam-driven reciprocal pumps utilized in industry and city water systems may remain, but would require a systematic field survey to locate them.

Data Gaps

Representative water lifting devices to show the evolution of technology in this area.

Representative resources for raising water from surface and underground water supplies.

Discernible evidence in place of the earliest efforts to raise water.

Future Needs

Much needs to be done in documenting and recording cultural resources. This is particularly so in the case of early twentieth century developments in pumping technology, a virtually unexplored topic. The chore would be difficult since few people would have attached importance to an old pump or hydraulic ram and retained one in good condition. Documenting what is located would also present problems because of the lack of sufficient data in libraries.

Important Resources

In comparison to large size current wheels and picturesque draw wells, the commonplace pump has been ignored. Yet its role in industry, municipal water supply, and especially in agriculture has been important to the state's economic growth. Resources that remain will have to be carefully dated and accurately identified.

RESEARCH QUESTIONS

1. Can cultural resources contribute to a better understanding of farming practices in the state and patterns of settlement?

2. What resources remain to document the changing technology of water lifting?

3. Can cultural resources aid in altering our current perceptions of water use technology on the plains and in the mountains?

PHYSICAL CONDITIONS

Windlass, Mot, Bucket Wheel, Pitcher Pump: Should be in place, clearly discernible as to function, and dated to the proper period.

Current Wheel: Enough should remain to determine its operation and accurately dated.

Hydraulic Ram: Enough of the equipment should remain in place to discern function and be dated as accurately as possible.

Reciprocal Action Pump, Centrifugal Pump, Deep-Well Turbine: Enough should remain to reveal function, be accurately identified and dated.

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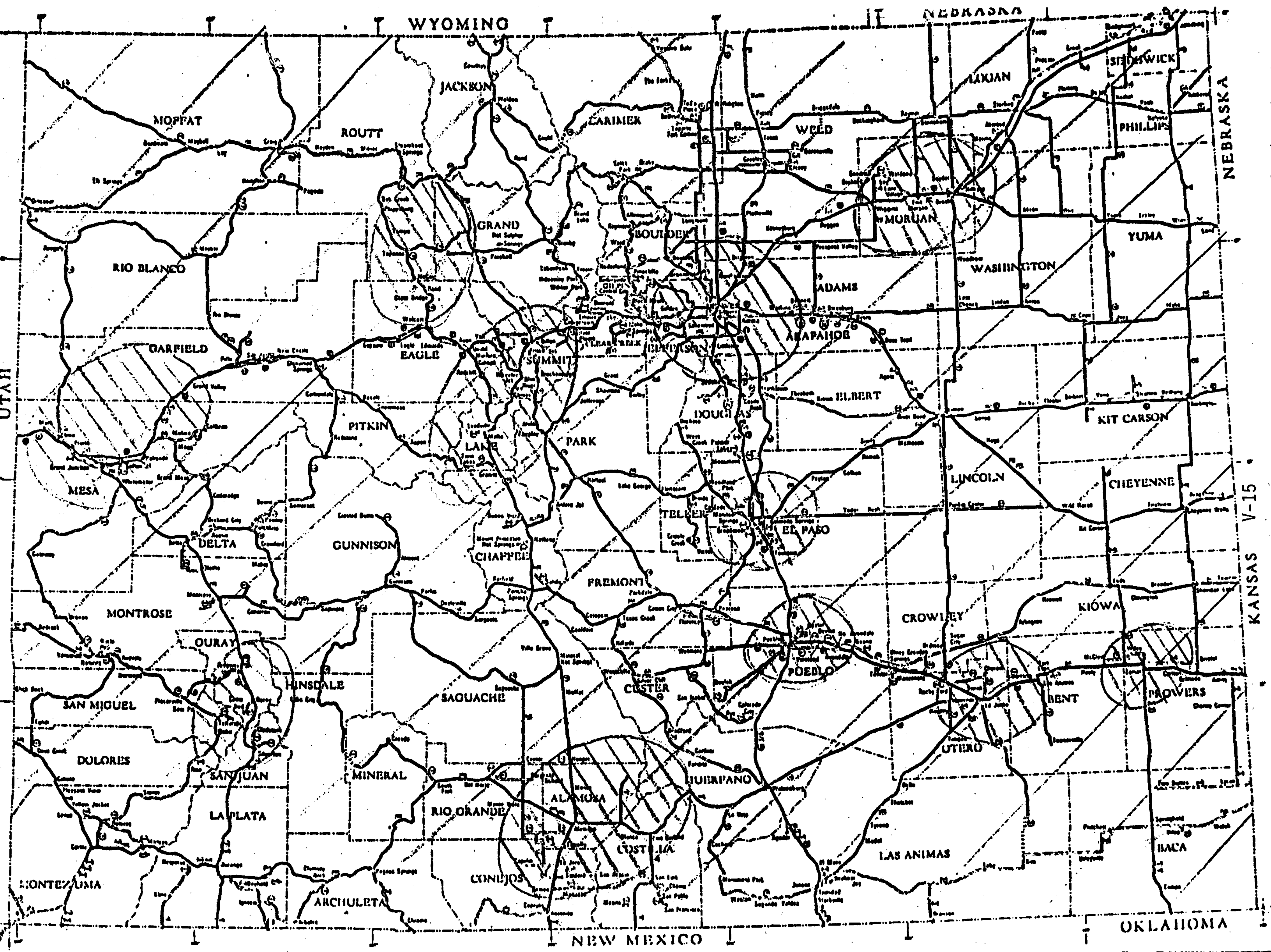

EXHIBIT 3 FEDERAL AID SYSTEMS *WATER LIFTING DEVICES*

3. WINDMILLS

NARRATIVE

Although the windmill is of European origin, probably dating to the twelfth century, its American version became synonymous with the efforts of western settlers to supply water to a parched land. From the 1860s through the 1930s, this machine which harnessed the energy of winds that blew across the plains, was often the salvation of upland farmers and cattlemen, who used it to power pumps for raising underground water. Thus, the windmill was particularly useful to farmers and stockmen who settled away from the river valleys. In Colorado, during the 1920s and 1930s, some irrigators installed pumps in the valleys to draw water from the gravel as a supplement to their surface water appropriation, and some windmills might have been employed for that purpose.

The amount of work performed by a windmill depended on the force of the wind, the size and construction of the wheel, and the location of the mill. Compared to steam-driven pumps in the nineteenth century, windmills were relatively low cost to purchase and operate (no fuel costs) and were fairly simple in design. Yet early models produced only a small stream of water, resulting in a flow that traveled only a short distance and was absorbed by the soil. Irrigators and ranchers had to construct earthen reservoirs, with wooden discharge gates, or position wooden tanks (bound by iron hoops) or metal tanks near the windmill to collect the water for later use. The tanks were often sold by the manufacturers of windmills.

Windmills ranged from crude, home-made contraptions to well-engineered, mass manufactured machines. Among the home-made models was the "jumbo", or ground tumbler, fashioned from scrap materials, with large wooden paddles, and placed in a box so that it operated like an overshot water wheel. Another, the "battle-axe" type, used wooden scraps for sails and usually included salvaged automobile parts. While these home-made devices may be found in any period of time, the major trend, beginning in the late nineteenth century, was toward improved factory-made windmills.

Two principal types of American windmills evolved between 1860 and the 1880s: the Halliday (made by the U.S. Wind Engine and Pump Company) with sectional wheels that collapsed or closed similar to an umbrella in high velocity winds, and the solid wheel (the Eclipse, later manufactured by Fairbanks, Morse and Company) that used a vane to turn the wheel away from winds high enough to damage the mill. Both types were made of wood, with some metal parts; the pump was a reciprocal stroke mechanism. One or both types of wheels, sectional and solid, were made by several manufacturers: Perkins, Star, Duplex, and Dempster represent some leading names. Builders of vaneless windmills attached counterweights of distinctive design, such as horses, roosters, and battleships, thus turning a necessity into a trademark.

The scientifically-designed steel windmill appeared in the 1880s (Aermotor Company), but it would not command the market until around the First World War. Wooden mills survived in arid areas and among farmers who believed that metal wheels would poison the wind. Hot-dip galvanizing protected these metal structures and later some of them were designed to tilt down for easier servicing. Around 1912, manufacturers (notably the Elgin "Wonder") introduced back-gearing and self-oiling type mills. Through back-gearing, the wheel could make several revolutions yet produce one stroke on the pump, thus making possible smoother operation of the system and avoiding damage to the pump from high winds. The oil bath lubricated important moving parts which on earlier models had been exposed to the elements. In addition to Aermotor, other manufacturers sold steel mills under the trade names of Dandy, Samson, Goodhue, Monitor, and Fairbanks-Morse.

"Power windmills" made between the mid-nineteenth century and about 1914, were geared for rotary motion in order to power grinders, saws, and drills on some farms. Farmers often mounted these windmills atop their barns for close proximity to their usual working area. However, these machines supplied power erratically and were eventually replaced by small gasoline engines.

During the depression years of the 1930s, some manufacturers produced small wind electric plants, using airplane-type propellars, to run generators. The energy was then stored in batteries to operate small electrical appliances or even some house lights. These windmills appealed especially to farmers living in isolated areas, until the arrival of rural electrification.

While farming and ranching constituted the major market for windmills, some town erected mills to supply municipal water the steam. Railroads frequently employed them to fill water tanks along the line. "Railway pattern" windmills carried huge wheels, measuring 16 to 30 feet in diameter, making them among the largest ever used in the nation. The Union Pacific Railroad owned such windmills in Colorado.

The prime years of the windmill on the plains extended from the 1880s to around 1920. By then, the windmill was facing stiff competition from pumps driven by electricity or gasoline engines; some windmill manufacturers themselves switched over to making the newer pumping systems. Yet windmills survived on remote ranches and farms where electrical wires might be destroyed by wind or ice.

CHRONOLOGY

1860s-1914	Wooden windmills of the sectional and solid wheel types.
1860s-1914	Power windmills that supplied rotary power.
1890-1945	Steel windmills
c1912	Back-gearing and oil-bath models
1930s	Small wind electric plants

LOCATION

Cultural resources of this kind are likely to be distributed through the farming and ranching areas of the state, particularly eastern Colorado, in or near small towns, and along railroad rights of way. The important sources of ground water are located east of the Continental Divide. Water bearing gravel extends from the South Platte River to the southern border of the state. In the eastern part of the state lies the Ogallala aquifer, although it requires deep wells to reach the water table. Shaded areas on the map denote potential location of this cultural resource.

CULTURAL RESOURCE TYPES

Wooden windmills

Early examples of sectional and solid wheel types

Power windmills

Wind electric plants

Counterweights used on vaneless wheels

Early steel windmills, prior to 1900

Water tanks and earthen reservoirs

Railway pattern windmills

Home-made windmills

The Quantity and Quality of Existing Data

Historical Documentation

Few structures have more forcefully symbolized the stubborn struggle to conquer the arid lands of the American West than the windmill. Despite this, the historical documentation on the windmill is small, very difficult to locate, and often devoid of interpretation and analysis. Most sources are old and primarily descriptive. The best analyses are A. Clyde Eide's article in Nebraska History and the fine piece by T. Lindsay Baker in Agricultural History; Baker is currently completing a field guide to American windmills. Besides offering some analysis, both articles are copiously footnoted with references to other resources.

The identification of specific windmills will greatly depend upon access to old manufacturers' catalogs which most libraries did not make an effort to collect. Though now elusive, the catalogs contain detailed information on parts, models, and designs. Beyond these, The Windmill as a Prime Mover by Alfred R. Wolff is a work of great value, but having appeared in 1885 its usefulness is limited to the early days. Under the circumstances, data will have to be pieced together from various sources. Government reports can fill some knowledge gaps, as can articles in engineering and farm journals. Windmill makers ran advertisements in these journals, but they must be viewed with care because of unsubstantiated claims for some machines. Archives and libraries may possess photographs helpful to the identification process. Verification of cultural resources will not be easy owing to the sparse and scattered historical sources.

Number/Condition

The data do not disclose the exact number of cultural resources that existed or may have existed. Certainly windmills were common on the eastern plains for agricultural and ranching operations and for supplementing surface water supplies. Yet the introduction of pumps powered by electricity or gasoline engines and the spreading net of rural electrification diminished the need for windmills. The condition of surviving cultural resources of an early date will vary greatly. Time and the elements appear to have taken a substanted toll of the windmill.

Data Gaps

Representative evidence of the major types of windmills, including home-made mills.

Representative agricultural/ranching site with windmill in place and with associated tank or reservoir.

Representative "railway pattern" windmill in situ.

Representative parts of windmills, such as wheel mechanisms and counterweights.

Future Needs

A statewide survey and inventory of this cultural resource should be undertaken. A similar effort ought to be made to compile technical data on windmills from manufacturer catalogs and related sources in order to assure accurate identification of resources. In the case of home-made mills and the small wind-electric plants of the 1930s, though of a relatively recent date, a special effort should be made to locate and document surviving examples, if any.

Important Resources

Windmills may be a cultured resource taken for granted. Studies by professional historians began to appear only about ten years ago. Consequently, cultural resources yielding important information about the technological evolution of the windmill in the West may still exist and can be regarded as potentially significant. Examples of the sectional wheel and the solid wheel types, in satisfactory condition, should be considered valuable. The distinctive counterweights of different makers represent an industrial art form while performing an essential function on certain wheels. Mills constructed out of salvaged parts and those made in the 1930s to generate electricity should not be ignored in view of the continuing interest in wind motors.

Research Questions

1. Can cultural resources expand our knowledge or alter our interpretation of agricultural and ranching activities in dry land areas?

2. What resources remain to demonstrate the changing technology in windmill construction?

3. Can resources clarify settlement patterns?

Physical Condition

Wooden Windmill: Enough should remain in place to discern its function and be dated to the proper period.

Section Wheel, Solid Wheel Type: Enough of the wheel mechanism should remain intact to show operation and be dated.

Power Windmill, Wind Electric Plant: Enough of the equipment should remain in place to demonstrate function and be properly dated.

Counterweight: Should be complete and dated as nearly as possible.

Home-made Windmill, Railway Pattern Windmill: Enough should remain in place to indicate purpose and be accurately dated.

Steel Windmill: Age and condition should be important considerations, in place, and dated.

Water Tank, Earthen Reservoir: In place and in association with a windmill.

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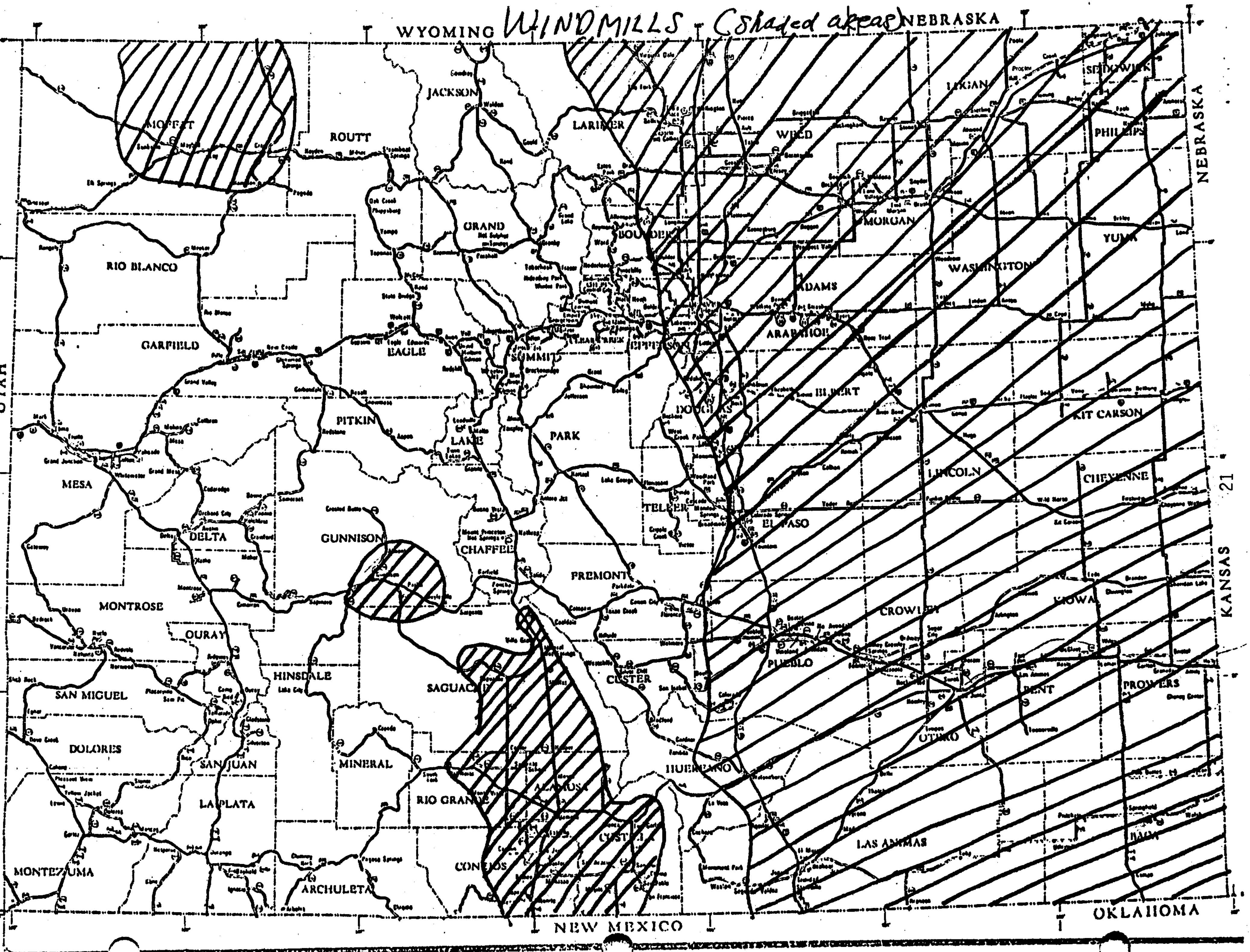

EXHIBIT 3 FEDERAL AID SYSTEMS

4. IRRIGATION

NARRATIVE

Irrigation is a system for bringing water to arid and semiarid lands for the purpose of raising farm corps. This has been accomplished in the American West by damming and diverting the flow of streams, catching and storing precipitation, and pumping ground water. Typically, the water is then fed by gravity through a series of channels and conduits as needed to irrigate field crops.

At all times, a number of variables, i.e. crop, soil conditions, available technology, economics, and water supply, determine the particular irrigation system constructed. The width, depth, and length of the main canals likewise vary, with those under ten feet in width generally classified as small canals. From the main supply canals, laterals or distribution ditches extend to the fields where water is delivered by flooding, through furrows, or by sub-irrigation. This last method, unusual in the West, has been practiced in the San Luis Valley of Colorado where soil conditions permit more efficient water usage. In sub-irrigation, the water is allowed to seep into the ditches, raising the water table and enabling the plants to draw the water through capillary action.

Into the nineteenth century, irrigation practices remained simple as settlers in the river valleys employed hand tools, shovels, scrapers, and plows along with animal power to dig ditches between nearby streams and their fields. To divert a stream for irrigation, a brush, mud, wood, or stone dam was built, directing the water into canals through headgates or regulators ordinarily constructed of wood and stone. Later in the century, headgates might include masonry or concrete construction with iron hardware (bevel gear lifter or windlass, for examples) and the regulator be either an overpour or undershot type. The overpour type helped prevent sediment from entering the canal, while the undershot delivered a steadier flow of water. Where canals needed to cross depressions in the terrain, irrigators used primitive canoas (dug-out logs) or rectangular wooden plank flumes elevated on trestles. A particularly deep depression, in which trestling would be difficult and expensive, would be crossed by a less costly inverted siphon of wooden stave pipe held by circular iron bands.

Irrigators installed additional appurtenances as required. If the gradient of a ditch produced high velocities causing erosion of the ditch bottom, a drop box to alleviate the problem was put in place. At points along the canal, measuring devices were used to determine the volume of water. One common way of doing this involved installing a section of wooden flume at the end of which was an aperture to measure the flow. Another was the weir, a board containing a rectangular notch which, when placed in a flowing canal, contracted the flow for measurement; a Cippoletti weir used a trapezoidal notch and was regarded as a reliable gauge. In the 1930s, a Colorado hydraulics engineer, R. L. Parshall, developed a successful sheet metal weir called the Parshall flume. In most cases the unit of measurement was the miner's inch of water, an amount that varied in different localities. For temporarily diverting lateral water to flood a small section of field, farmers frequently used a canvas or thin metal portable dam, called a tappoon in some places, to do the job.

The growth and expansion of irrigated agriculture in the late nineteenth and early twentieth centuries were accompanied by improved techniques and building materials. Temporary diversion dams were replaced by permanent earthen or rock fill or masonry dams, steel headgates appeared, and some canals were lined. Riveted iron, wood-banded, and concrete pipes found greater use, as did flumes of wooden stave, steel, and reinforced concrete. Tools and machines for digging canals also improved markedly. Powered ditching machines, clam-shell bucket cranes, and even specialized dredges reduced the extent of manual labor and permitted larger projects to be undertaken.

With the expansion of irrigation projects came changes in the organization of irrigation enterprises. Early projects were usually carried out by individuals or families or through partnerships formed by neighboring farmers. Although the number of individual enterprises for surface water irrigation declined after 1900, pump irrigation has kept this kind of organization viable in the twentieth century. From about the 1870s into this century, water users formed irrigation companies or associations to build larger systems. This classification would also include the community acequias organized by early Spanish American settlers in southern Colorado as well as the lateral companies that deliver water from a main canal. Cooperative associations were particularly active in Colorado.

During the 1880s and 1890s, commercial enterprises, some financed by foreign capitalists, constructed systems to supply water users at a profit. Most of them proved unprofitable, eventually selling out to user cooperatives, and all canals came under state regulation regarding common carriers.

Also in the late nineteenth century public involvement in irrigation began to emerge and increased steadily in the twentieth century. At the state level, laws provided for the distribution of water by public officials as the state was divided into water districts, and all landholders within a district had to share in the cost of irrigation projects. In the 1890s the state government of Colorado attempted a few reclamation projects at public expense, but these suffered from poor planning and bogged down in politics.

Initiatives by the federal government in reclamation had remained minor in deference to "state rights" and private enterprise. But in the 1870s, the central government began some irrigation projects on Indian lands (Point of Rocks on the Ute Reservation in Colorado), while Congress, in the 1870s-1890s, offered public land as an inducement for private and state directed reclamation projects. Direct federal involvement started in 1902 with passage of the Newlands Reclamation Act, creating a fund from the sale of public lands to finance reclamation and making possible water projects which had been beyond the means of state or private enterprises. Colorado was an early benefactor of this federal program. Shortly after it was created, the U. S. Reclamation Service diverted water from the Gunnison to the Uncompahgre River Valley and commenced the Grand River Valley project near Grand Junction; both projects assisting farmers on the Western Slope where irrigation development had been limited.

The activities of the Bureau of Reclamation along with the U. S. Army Corp of Engineers and the Bureau of Indian Affairs make the twentieth century the "federal era" in water development in the West with important consequences for irrigated farming.

CHRONOLOGY

c1787	Juan Bautista de Anza at "San Carlos de Jupes" near Pueblo, a small ditch
1846	John Hatcher Ditch on Purgatorie River near Trinidad to serve Santa Fe Trail
1840s	"The Pueblo". Trappers and mountain men may have built a small ditch at the mouth of the Fountain River
1852	San Luis Peoples' Ditch--oldest irrigation ditch in continuous service in Colorado.
1861	Baca Ditch, Trinidad. A large early irrigation project still in use.
1870s	Union Colony at Greeley. Impact of Anglo settlers from humid regions on western irrigation.
1877	Desert Land Act
1880s	High Line Canal--British commercial enterprise
1885	Montezuma Valley Irrigation Project. Water brought from the Dolores River
1894	Carey Act meant to foster state irrigation projects.
1902	Newlands Reclamation Act
1903	Gunnison-Uncompahgre Project--U. S. Reclamation
1905	Grand River Valley Project
1937	Colorado-Big Thompson Project

LOCATION

Irrigation has been pursued vigorously along the principal rivers of eastern Colorado, on the southern frontier, and in some areas of the Western Slope. The map locates focal areas of irrigation activity in the state.

CULTURAL RESOURCE TYPES

Canals

Ditches

Laterals

Diversion dams

Headgates

Canoas

Flumes

Pipes

Siphons

Drop boxes

Weirs

Parshall flumes

Tappoons

Ditching machinery

The Quantity and Quality of Existing Data

Historical Documentation

The importance of irrigated agriculture to the settlement and growth of Colorado is reflected in the impressive amount of historical documentation found in libraries and archives of the state. Also the coverage of the subject is broad, ranging from social and economic questions, to technological aspects and public policy issues. Frederick Newell's old Irrigation in the United States remains a superb introduction to the subject for its scope and clarity and it can be supplemented by the numerous reports and documents issued by federal agencies. The work of Arthur Powell Davis and Herbert Wilson and civil engineer B. A. Etcheverrey provide the researcher with comprehensive treatments of technical matters, including the variety of equipment and support structures used in irrigation.

The standard histories of the state treat the Colorado experience, notably LeRoy Hafen's multi-volume Colorado and Its People. For more detailed data on the subject, the History of Agriculture in Colorado by Alvin Steinel and A Hundred Years of Irrigation in Colorado are highly recommended. The library of Colorado State University at Fort Collins contains a great deal on agricultural and water engineering, and graduate theses produced at the state universities, such as Joseph Van Hook's study of the Arkansas Valley, are worth examination. Additional data can be gathered from the WPA field notes on irrigation in the 1930s at the State Historical Society Library and from the site files of the Colorado Preservation Office. Local and county histories can be good sources of detailed information, if not always interpretative in their treatment of subjects. The pages of Irrigation Age, the Engineering News-Record, and farm journals can be consulted on specific projects. As the breadth of these sources indicates, irrigation in Colorado can be amply documented and the technical achievements identified through research.

Number/Condition

The abundant historical documentation on irrigation can permit an exact determination of major irrigation sites and many of the lesser ones as well. The condition of the sites will have to be determined by field survey and careful examination of the location by professionals with the assistance of knowledgeable local people and irrigation specialists. Many historically significant sites have been recorded and recognized such as the San Luis Peoples' Ditch, the John Hatcher Ditch in Las Animas County, and the Gunnison Diversion Tunnel. The expansion and modernization of irrigation districts may have destroyed original sites and replaced older equipment and technology. The available data cannot supply an exact number of irrigation appurtenances, tools, and machines that existed or may have existed.

Data Gaps

Representative evidence of early irrigation methods and equipment.

A representative site complete with excavation tools, diversion equipment, and water conveying resources.

Evidence of differing irrigation methods due to soil condition, crops, farming practices, and cultural background of the irrigators.

Future Needs

Because of the quantity of historical documentation and other records, a lower priority can be assigned to survey work for the purpose of locating principal irrigation sites. However, this recommendation does not extend to tools, equipment, and machinery used in the construction and operation of irrigation projects. A historic engineering survey to identify and document these cultural resources should be undertaken. Also, much remains to be done in the area of historical interpretation. The available documentation supplies basic facts, but does little with comparisons, oral history, the philosophy of water use, or the cultural and environmental dimensions. Thus, further efforts at identification and interpretation should receive high priority among cultural resource projects.

Important Resources

Sites already recognized for their historic significance merit additional study of their structures and equipment. All resources are potentially significant since they could yield valuable information on the stages of technological development and perhaps a useful re-interpretation of water usage in the West. A historic engineering survey, emphasizing the cultural resources listed herein, may produce new and useful evidence about important agricultural practices.

Research Questions

1. Can cultural resources contribute to our understanding of farm practices and water use attitudes?

2. What evidence remains to document the evolution of technology in irrigated farming?

3. Can cultural resources expand our knowledge of Hispanic and Anglo irrigation practices?

4. Can resources substantiate the participation of private, state, and federal agencies in irrigated agriculture?

5. Can resources show differences between Colorado practices and the methods adopted in other western states?

Physical Condition

Canal, Ditch, Lateral: Should be clearly evident, not filled-in or substantially modified, and accurately dated.

Division Dam, Headgate: Enough should remain to disclose function intact, and dated.

Canoa, Flume, Pipe, Siphon: Should be *in situ*, discernible in function, and properly dated.

Drop Box, Weir, Parshall Flume, Tappoon: Enough of each device should remain to determine function and be properly dated.

Ditching Machinery: Enough should remain to disclose function, preferably on site, and dated.

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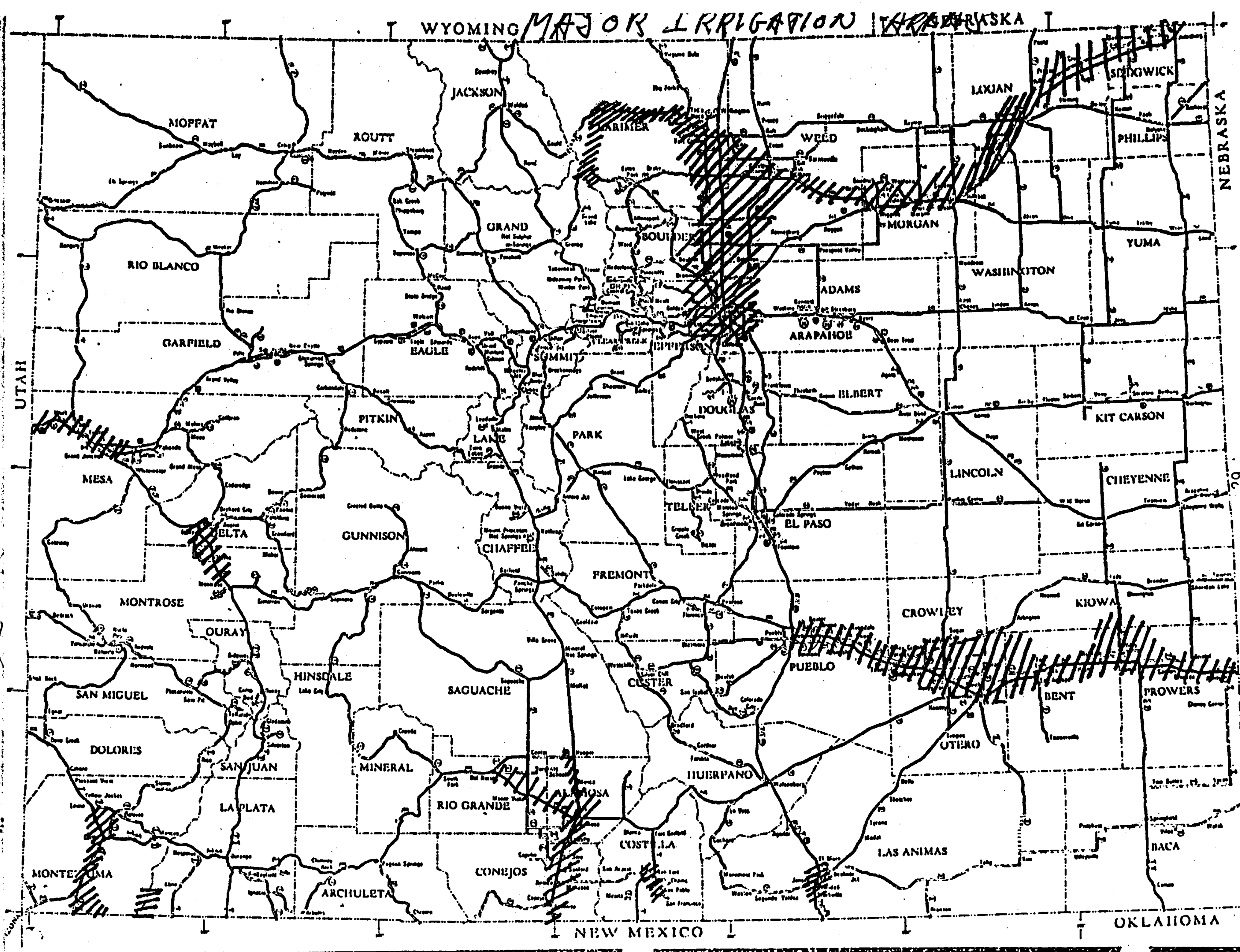

EXHIBIT 9 — FEDERAL AID SYSTEMS

5. COMMUNITY WATER SUPPLY AND SEWERAGE

NARRATIVE

Few issues were of greater importance to urban life and growth than a dependable supply of clean water. Most American cities reached a stage of their history when population growth exceeded the capacity of springs, wells, cisterns, and streams to supply good water and communities undertook the construction of sophisticated water works systems. These projects involved the collection of water from surface and underground sources and the building of a network of long conduits and pipelines to distribute the water to urban dwellers. Besides delivering clean drinking water, these systems provided water for fighting fire, sanitation, sewer flushing, and industrial uses. Water works thus proved a vital element in the social and economic growth of urban areas.

Early settlers in an area that later developed into a town or city obtained their water in ways essentially the same as pioneer farmers. Their water supplies came from springs or shallow wells (privately owned), or by collecting rainwater in homemade tanks or cisterns, or by drawing water from nearby streams. In some instances, a hand pumped public well might exist for use by all members of the community who would transport the water by bucket to their homes.

Population growth--and nineteenth century American cities grew rapidly, particularly after the Civil War--generally was the key determinant in communities acquiring an improved water supply system, whether publically or privately owned. In addition to the size of the city, climatic conditions and the extent and kind of industrial activities affected the demand for water. Some industries, such as paper producing, coking, steel making, electricity, and food processing among others, consumed large quantities of water. Likewise, the planners of early municipal systems tended to emphasize the amount of water obtained rather than its purity.

Although water works of the nineteenth century utilized relatively simple apparatus, the size and expense of the projects often reached great proportions and represented distinctive engineering achievements. Typically, early systems included steam or water powered pumping machinery to elevate water from lakes, streams, and wells, and, where topography permitted, to distribute the water through conduits by force of gravity. Machine bored wood pipe or lead pipe were frequently used until the 1840s and 1850s when cast iron pipe, treated with tar, became popular. Water not under pressure was conveyed in open channels or through brick or rubble aqueducts or vitrified clay pipe (as done at Florence, Colorado). Local conditions, such as the availability of construction materials, economic circumstances, and the magnitude of the works, affected decisions on the methods of construction.

Wooden pipe, widely used in the early days, regained popularity in the late nineteenth century, primarily in the West, where iron pipe was costly, water had to be moved long distances, and wood was readily available. Moreover, wood was durable and did not corrode. In the 1870s and 1880s westerners appear to have perfected the construction of wooden stave pipe in which staves, curved pieces of wood, were bound together by bands of iron or steel; the pipeline being built continuously in a trench. Denver made the most extensive use of this method in the 1880s in the municipal system built by the Denver Water Company. The company's chief engineer, C. P. Allen, patented the construction process which represented a major contribution to water supply technology. For construction material, engineers favored California redwood, Texas and Colorado pine, and Oregon fir.

The more sophisticated water works of the late 1800s and the twentieth century exhibited more complex engineering methods. Pumping increased (reciprocating pumps for high lifts, centrifugal for lower lifts), and electric motors joined steam turbines as power sources. For conveying water, engineers utilized trenches lined with concrete, called cut and cover conduits, gravity and pressure tunnels (example: pioneer bore of the Moffat Tunnel adapted in 1935 to carry water), and inverted siphons ("sag pipes") or pipelines used to cross a depression since bridges for aqueducts were expensive. To meet storage requirements, communities constructed dams and storage reservoirs and erected elevated reservoirs, called standpipes or water towers, consisting of either tall slim tanks on the ground or steel, wood, or reinforced concrete tanks supported on towers. Water meters appeared in the 1870s, but many cities chose to set a flat rate for domestic consumers until well into the twentieth century.

Securing an adequate supply of water was not the only problem confronted by city engineers. By the 1880s the cesspool and privy vault system for disposing of human waste along with the rising amount of industrial pollution contaminated water supplies and endangered the public health. The twin problems of providing safe drinking water and removing and purifying wastewater called for new technological solutions. Some cities responded by going further into the countryside to locate sources of clean water. Others constructed timber cribs or galleries beneath the gravel of riverbeds to serve as intakes for water which had been supposedly filtered by the river's sand and gravel. The slow sand filter, consisting of a large masonry bed filled with sand and graded gravel, proved slow and expensive but more effective in removing solid as well as organic and bacterial matter from flowing water. In the twentieth century, mechanical filters came into use; the raw water usually undergoing sedimentation, permitting the larger particles to settle, before being filtered. Modern systems also added various chemicals to the water. In 1914, the Public Health Service spurred on efforts at filtration by establishing the first national standards for drinking water supplies.

By the 1870s and 1880s American cities were facing the unfortunate consequences of the careless disposal of human wastes. Overflowing cesspools and privy vaults threatened urban life and health. Moreover, as city water supplies increased, households adopted water closets which worsened the problem of wastewater removal or sewerage. Drawing upon European examples, American cities began huge projects to construct sewer systems: lateral pipelines running from buildings to sub-mains connecting with large trunk line sewers that carried the sewerage to nearby streams or other bodies of water. Sewer pipe at first was commonly made of vitrified clay or wood stave (until about the 1930s), and later including iron, steel, asbestos-cement, and concrete pipe. While most of the wastewater ran to rivers or streams, some western areas, experienced in irrigated agriculture and more cognizant of the value of water, practiced sewage farming or broad irrigation in the 1880s and 1890s. By this method, cities arranged with local farmers to use sewerage to grow corps. In Colorado, farmers near Trinidad and Colorado Springs utilized sewage to raise alfalfa crops during the 1890s.

The considerable expense to build and operate a sewage treatment plant combined with disagreement among experts about the need to do so accounted for the slow adoption of such plants by American cities. However, in the 1920s and 1930s better information about the consequences of unchecked pollution encouraged communities to construct treatment plants. Many mechanical, biological, and chemical processes developed to purify wastewater. Settling tanks, intermittent sand filters, cage screens, grit chambers, and bar racks were used to remove solids. Both trickling filters and contact beds employed bacteria to consume the organic matter in sewage. After World War I. some cities used an activated sludge process, introducing aerobic microorganisms, with disposal of the sludge in landfills or in sludge incinerators.

Although privately-owned companies installed many of the early water works, the involvement of municipal, state, and federal government increased with the expansion of urban areas. In the twentieth century, the federal government made significant contributions to water supply and sewage treatment. The Reclamation Act of 1906 permitted cities to buy water from federal projects. During the Depression of the 1930s, the government developed a variety of programs that enabled cities to construct or improve water supply systems, sewers, and waste treatment plants. The Civil Works Administration, the Public Works Administration, and Works Progress Administration were among the principal New Deal agencies supporting hundreds of water projects during the Great Depression.

CHRONOLOGY

Pre-1850s	Bored wooden pipe
1850s	Cast iron pipe
1870s-1930s	Wooden stave pipe
1880s	Denver water system
1880s	Sewer pipelines
1880s	Sewage farming or broad irrigation
1890s	Concrete pipe
1906	Reclamation Act
1914	Public Health Service drinking water standards
1920s-1930s	Sewage treatment plants

1935-1936	Moffat water tunnel
1930s	Federal support for water projects

LOCATION

Cultural resources can be found in and around all cities and towns in Colorado and extending into the countryside for sources of water.

CULTURAL RESOURCE TYPES

Dams

Reservoirs

Pumps - reciprocal and centrifugal action

Cribs or gallery intakes

Aqueducts, channels, cut and cover conduits

Water tunnels

Water supply pipelines - various construction materials

Water towers and standpipes

Inverted siphons

Water meters

Water purification filters - slow sand filters and mechanical filters

Sewer pipelines - various construction materials

Cesspools and privies

Sewage farms

Sewage treatment plants - settling tanks, intermittent sand filters, cage screens, grit chambers, bar racks, trickling filters, contact beds, and sludge process

Landfills

Sludge incinerators

THE QUANTITY AND QUALITY OF EXISTING DATA

Historical Documentation

Persistent research reveals a solid, if not large amount of historical data on municipal water supply. While historians have become more active in this area in recent years, many of the primary sources and even earlier studies of water supply were produced by professional engineers and show the strengths and liabilities of their genre: richly detailed on technical matters and brief or devoid of a historical context. An exception is Schuyler's article on the Denver Water System. Helpful recent studies are The History of Public Works in the United States, 1776-1976 and Martin Melosi's Garbage in the Cities, the latter possessing a fine bibliography.

As with most engineering themes the researcher is advised to combine sources of a general technical nature with more detailed treatments of local projects. Reliable technical information can be drawn from engineering treatises such as Tarneaure and Russell's Public Water Supplies which explains the parts and functions of typical systems. For specific projects, turn to old water works manuals and directories, if possible, for they are difficult to locate. Engineering journals, state engineer reports, annuals of the engineering societies, and newspapers should be consulted. On occasion, utility companies and water boards will produce brief histories of their works and will make these available; they may also supply good photo-documentation from their files. On the whole, the documentation appears adequate on water supply (particularly of large cities such as Denver) but is minimal and scattered on smaller cities, wastewater, and relatively arcane subjects such as sewage irrigation.

Number/Condition

The data do not permit an exact enumeration of the cultural resources that once existed. This is partly due to the appearance and disappearance of mining towns that may have had primitive water supply systems, some elements of which may survive. Permanent towns and cities may have replaced and discarded significant parts of their water system in the process of expansion and modernization. What remains will vary greatly in condition, from large segments in satisfactory condition or perhaps still functioning to remnants in severely deteriorated condition. The Trinidad system still includes important physical remains of the city's original waterworks. Additional research and field surveys may identify others in similar condition. Historical documentation points to the existence of wastewater disposal and sewage irrigation around Trinidad and Colorado Springs. Twentieth century projects in supply and sewerage, often supported by government funding, can be readily documented and their condition recorded.

Data Gaps

Representative site of early water and/or wastewater systems in place.

Representative evidences of wood constructed water conveyances in place.

Representative structures associated with water supply and wastewater *in situ*.

Future Needs

The source of historical documentation needs to be expanded in combination with a comprehensive historic engineering survey. Sites must be accurately identified and marked and the physical remains recorded and preserved. Special attention is due sewage irrigation became of its relatively early appearance in Colorado. Much needs to be done on virtually all aspects of this cultural resource.

Important Resources

The earliest evidences of water supply systems in towns and cities and consequent efforts to handle wastewater are potentially significant resources. The urban character of many western states including Colorado makes resources associated with municipal water very important to researchers and planners. Civic works of this kind often became the pride of early town builders and represented large expenditures of money and important achievements in engineering and design. However, few integral systems may remain, meaning those that do should receive priority for location, identification, recording, and documentation. These resources can potentially communicate a great deal of data about technological change, settlement patterns, and urban growth in the region.

Research Questions

1. To what extent can resources add to our knowledge of urban growth in the state?

2. Can resources supplement the historical record on water use values and practices?

3. What resources can reveal similarities and differences in water supply techniques within Colorado and between Colorado and other areas?

4. Can cultural resources document innovations in water supply technology?

5. Can resources establish the role of important individuals and agencies in municipal water supply?

Physical Condition

Dam and Reservoir: See Dam theme.

Pump: See Water-Lifting Devices theme.

Aqueduct, Channel, Conduit, Tunnel, Pipeline: Enough should remain to discern function, in place and datable to the proper period.

Standpipe, Inverted Siphon: Enough should remain to determine function, in place and capable of accurate dating.

Meter, Filter, Treatment Plant, Incinerator: Must be clear as to function and dated to proper period.

Sewage Farm: Site should be accurately determined, enough equipment to reveal function, dated to proper era.

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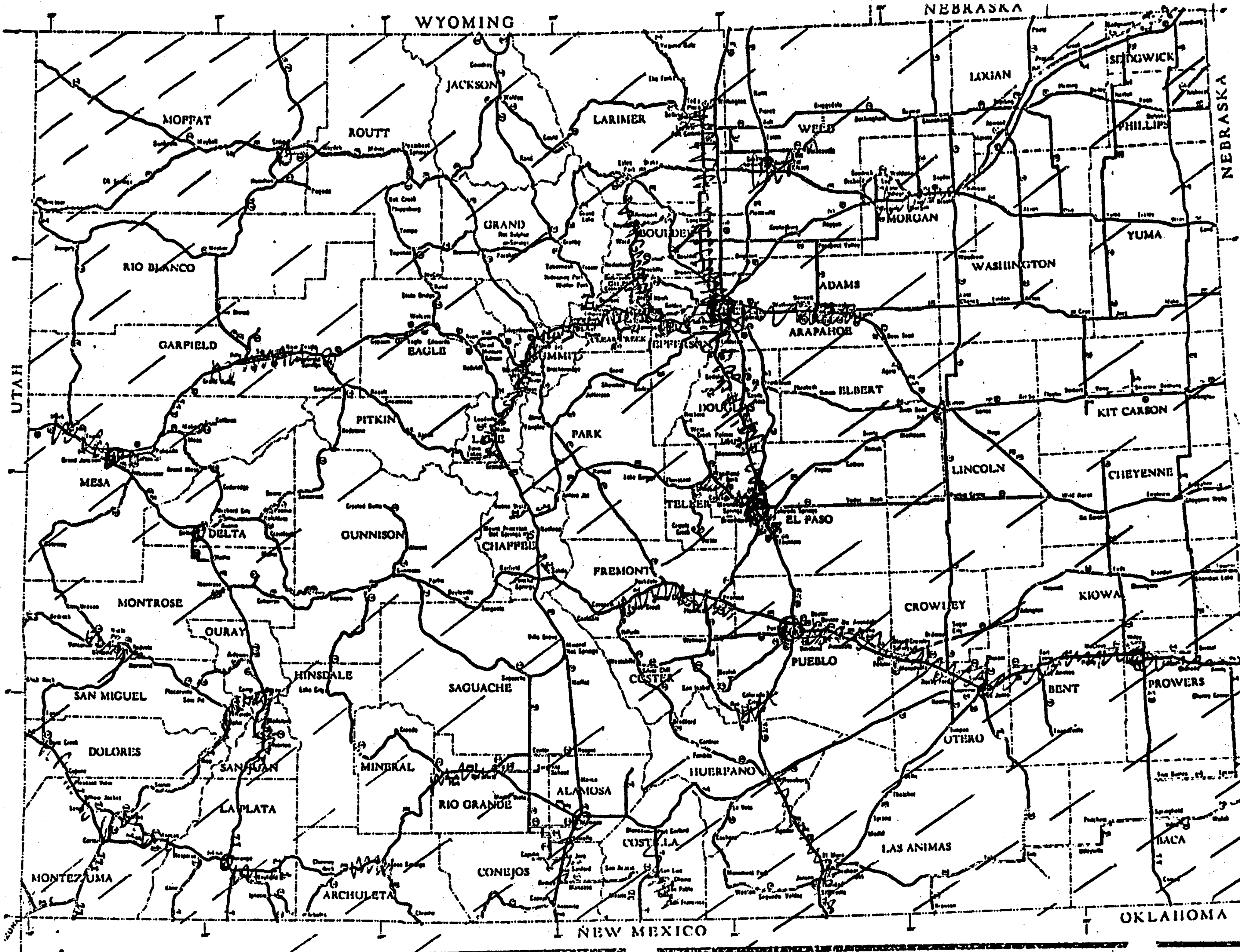

EXHIBIT 2 FEDERAL AID SYSTEMS COMMUNITY WATER SUPPLY AND SEWERAGE

6. HYDROPOWER

NARRATIVE

From colonial times to the early twentieth century, water power assumed an important place alongside farm land, timber, and mineral deposits as a vital natural resource to be developed by ambitious Americans. Prior to the arrival of the steam age in the 1850s, water power made possible much of America's industrial progress, particularly in New England, where the rivers supplied a sufficient head or fall of water to power water wheels that drove a variety of machines in factories and mills. The settlement of the mountain West in the middle and late nineteenth century revived interest in hydropower and spawned new developments in the field of water power engineering.

Hydropower depends upon a prime mover--a water wheel or a hydraulic turbine--and a water supply system. An important part of the system involves the selection of a stream site with adequate head of water, meaning the height water falls to generate power. A high head system usually requires less water volume to produce a given amount of power and thus reduces the size and cost of hydraulic facilities. Such sites are generally found in mountainous regions and in the upper sections of a river system, rather than the lower valleys. To regulate the water supply and gain additional elevation for a higher waterfall, a dam is frequently constructed and fitted with gates to admit water to a headrace, simply a waterway channel, or to a flume. The water flows to a point above the powerhouse where it fills a small regulating pond called a forebay, thence into a penstock, a pressure pipeline, for delivery to the wheel turbine. Once the water's energy is dissipated in turning the wheel, the water is directed back to the stream through a tail-race.

Before the development of hydraulic turbines in the middle decades of the nineteenth century, the early mills and manufactories of the United States utilized undershot, overhsot, and breast wheels as prime movers. These wooden wheels, with diameters ranging from eight to thirty feet, operated under low to medium heads of water directed against the paddles (impact type) or into buckets (gravity type) arranged on their circumference. In the undershot wheel, water flowed against paddles in the bottom quadrant of the wheel. In the overshot, water ran from a penstock to the top of the wheel on the down-stream side, filling the buckets and causing the wheel to revolve. The breast wheel was a more efficient type of overshot mechanism; among other advantages, it admitted water on the upstream side and so the wheel turned in the direction of the current. Its name derived from the use of an apron or breast that covered the lower section of the wheel and served to keep the water on the wheel. In practice, however, Americans tended to leave off the apron, perhaps out of greater concern for the additional cost of construction than the loss of efficiency. The simplest wooden wheel was the tub, or grist, mill. Looking like a wagon wheel with floats or buckets on the spokes, the tub mill revolved on a vertical axis to drive millstones for grinding grain. Too small and primitive for large commercial operations, this wheel supplied power in small frontier communities or even for individual families.

Major advances occurred in hydropower between the 1840s and 1900 with the development of hydraulic turbines. Characteristic of these new machines were their metal construction, greater efficiency, smaller size and higher speed. While much of the science behind this technology came from France, American engineers made significant contributions to the design of turbines. In fact, American designed and manufactured hydraulic turbines would be used throughout the world. Early efforts at developing a turbine centered on the reaction wheel, mounted on a vertical shaft and capable of operating under water, which was propelled by water pressure and the speed of the water's flow against a number of curved guides and vanes. Of the several types developed in the nineteenth century, the Francis or mixed flow turbine became the dominant design in the United States. Many firms manufactured this cast iron turbine; the leaders appear to have been the Stillwell and Bierce Company of Ohio, James Leffel and Company of Ohio, T. H. Risdon and Company of New Jersey, and the "American Turbine" by Stout, Mills, and Temple Company of Ohio (later the Globe Iron Works). The reaction turbine was well suited to the heavy stream flow but low to medium head conditions prevailing on the rivers and streams of the eastern United States.

Given a different set of topographical and climatic conditions, the miners in the mountain states of the West made several original contributions to water power technology. Mountain streams, typically having a low volume of water but very high heads (measured in hundreds of feet), provided a source of power to people experienced in using the kinetic energy of water in hydraulic mining. Also, the shortage of fuel in the mountains and the expense of hauling heavy machinery into the high country combined to limit steam power developments. Thus, California miners in the 1850s utilized water power to drive their hurdy-gurdy wheels, said to resemble in profile a circular saw with straight cut teeth. These wooden wheels, approximately ten feet in diameter and about one foot wide, contained shallow buckets or troughs against which a stream of water was directed causing the wheel to turn by force of the impact. Ordinarily water was conveyed to the wheel in ditches or flumes and into a wooden penstock, sometimes merely wooden boxes bolted together. A small hole bored in a wooden block directed a tangential stream of water at the wheel (a tangential water wheel). The power produced by the wheel could operate a derrick or run a stamp mill.

From the miner's hurdy-gurdy evolved the impulse turbine, an important hydraulic motor. The key change occurred in the 1870s when a California miner-mechanic named Lester A. Pelton designed a splitter bucket which divided the stream of water and, by avoiding the accumulation of dead water in the buckets, permitted much more efficient use of the water's energy. The Pelton wheel (patented in 1880) used replaceable iron buckets bolted to an iron wheel, required only a simple wooden mount, and demonstrated great versatility as a prime mover. Pelton-type wheels ranged from three inches to thirty feet in diameter, worked under heads from sixth to over two thousand feet, and powered hoists, stamp mills, air compressors, pumps, and electric generators. Thus, at the end of the nineteenth century when industrial power needs in the West were growing rapidly, the impulse turbine made possible a relatively low cost and flexible energy supply. Easy to transport into the mountains, even on muleback, the Pelton wheel quickly won favor among mining men as a solution to their power needs in deep-level mining operations. Among the major manufacturers of Pelton-type wheels were the Abner Doble Company, the Risdon Iron Works, and the Pelton Water Wheel Company, all located near San Francisco.

Although Francis-type turbines were rarely found in the West, the Pelton impulse wheel won wide acceptance. Its low cost, ease of installation, high head capability, light weight, and high power to weight ratio accounted for the Pelton's general use in the western mountains. Water reached the wheel from flumes and ditches connected to wooden or metal penstocks, finally issuing forth under great pressure from a needle nozzle. The jet of water hit the wheel at a tangent. Essentially the same construction technology would enable the impulse turbine to become the prime mover in hydroelectric projects that began to appear in the West by the end of the century.

CHRONOLOGY

1600s	Tub or grist mills
1700s-1850s	Undershot, overshot, and breast wheels
1840s	Francis-type mixed flow turbines
1870s-1880s	Pelton-type impulse turbines

LOCATION

Hydropower developments were possible along most streams with a dependable flow of water. Major power sites are apt to be found in mountain mining areas where the need for power was great. Hydropower has also been a part of multiple-purpose water projects. Focal areas of hydropower development are marked on the map.

CULTURAL RESOURCE TYPES

Ditches

Flumes

Penstocks

Forebays

Tailraces

Headraces

Tub wheels

Grist mills

Undershot wheels

Overshot wheels

Breast wheels

Reaction turbines

Francis-type mixed flow turbines

Hurdy-gurdy wheels

Pelton-type impulse turbines

Water jet nozzles

THE QUANTITY AND QUALITY OF EXISTING DATA

Until recently a reliable, general history of hydropower developments in the United States did not exist. That gap is now admirably filled by Louis Hunter's Waterpower, a social, economic, and technological history of waterwheels and turbines. The book contains an excellent section on technical innovations in the western states, but all parts of the study are informative on the evaluation of equipment and methods. Norman Smith's Man and Water contains a good chapter on American contributions to this technology. One should not overlook older books on waterpower written for professional engineers in the engineering journals, such as Electrical World and Cassier's Magazine, for both sources carried detailed data on significant hydropower projects. Similarly, the Transaction of the American Society of Civil Engineers can be very useful.

As is true of other technical subjects, sources of information on hydropower are not readily available and must be sought out by persistent research. State and federal government reports often contain specific data found no where else. Catalogs issued by machine manufacturers assist in the identification process. Water resources archives, such as that at the University of California, Berkeley, possess manuscript material and newspaper clippings as well as helpful staff members.

Number/Condition

The number and condition of cultural resources can be ascertained by field surveys and historical documentation. The mining industry's need for dependable sources of power in the high mountains stimulated the development of hydropower. However, the condition of sites will vary greatly, from ones totally obliterated through the passage of time to those with some remains at a near site. For instance, very little is left of the significant Ames Power Plant in San Miguel County. In the process of modernization power companies generally dismantled and scrapped earlier equipment. A Pelton-type wheel is located near McCoy, Colorado.

Data Gaps

Representative hydropower sites with sufficient evidence in place to discern the function of the installation.

Representative water wheels, impulse turbines, reaction turbines preferably in situ and capable of accurate dating.

Clearly discernible evidence of supporting equipment used at a hydropower facility. This could include flume, pipe, penstocks, and similar appurtenances that can be dated to the proper period and whose function within the system is made clear.

Future Needs

Insufficient attention has been given to cultural resources associated with hydropower development in Colorado. This is especially unfortunate because the state has an important history in this area of technology, which an engineering site survey could document. Because a variety of complex cultural resources may be encountered in the survey, a historian with expertise in water engineering and library resources on the subject should direct the project. A good chronology would reflect the changing technology in hydropower and the emergence of accurate energy sources.

Important Resources

Engineering works, with the possible exception of mining, await further identification and documentation. Original and undisturbed sites would be scarce, those marking what remains of early efforts in water power a high priority in cultural resource management. All early water wheels and hydraulic turbines are important resources, though they may not be especially notable in a natural concept, they may help illustrate a significant phase in the history of Colorado.

RESEARCH QUESTIONS

1. What resources can substantiate the relationship between mining technology and hydropower development?

2. Can resources help document technological innovation in the state?

3. Can cultural resources clarify the status of hydropower within a context of alternate power sources?

4. Can resources aid our understanding of the economic development of the state and the Rocky Mountain region?

5. What resources remain to prove or disprove the impact of technology and migration into the state?

PHYSICAL CONDITIONS

Ditch, Flume, Penstock, Forebay, Tailrace, Headrace: Enough in place to discern the function of each in relation to a waterpower site.

Tub Wheel, Grist Mill, Undershot and Overshot Wheel, Breast Wheel, Hurdy-Gurdy Wheel: Enough should remain to determine function and be dated to the proper period.

Reaction Wheel, Francis-Type Mixed Flow Turbine, Pelton-Type Impulse Turbine, Water Jet Nozzle: Proper dating is crucial since elements in the technology have remained essentially unchanged over times.

Preferably an original site to convey association with the water supply and support equipment.

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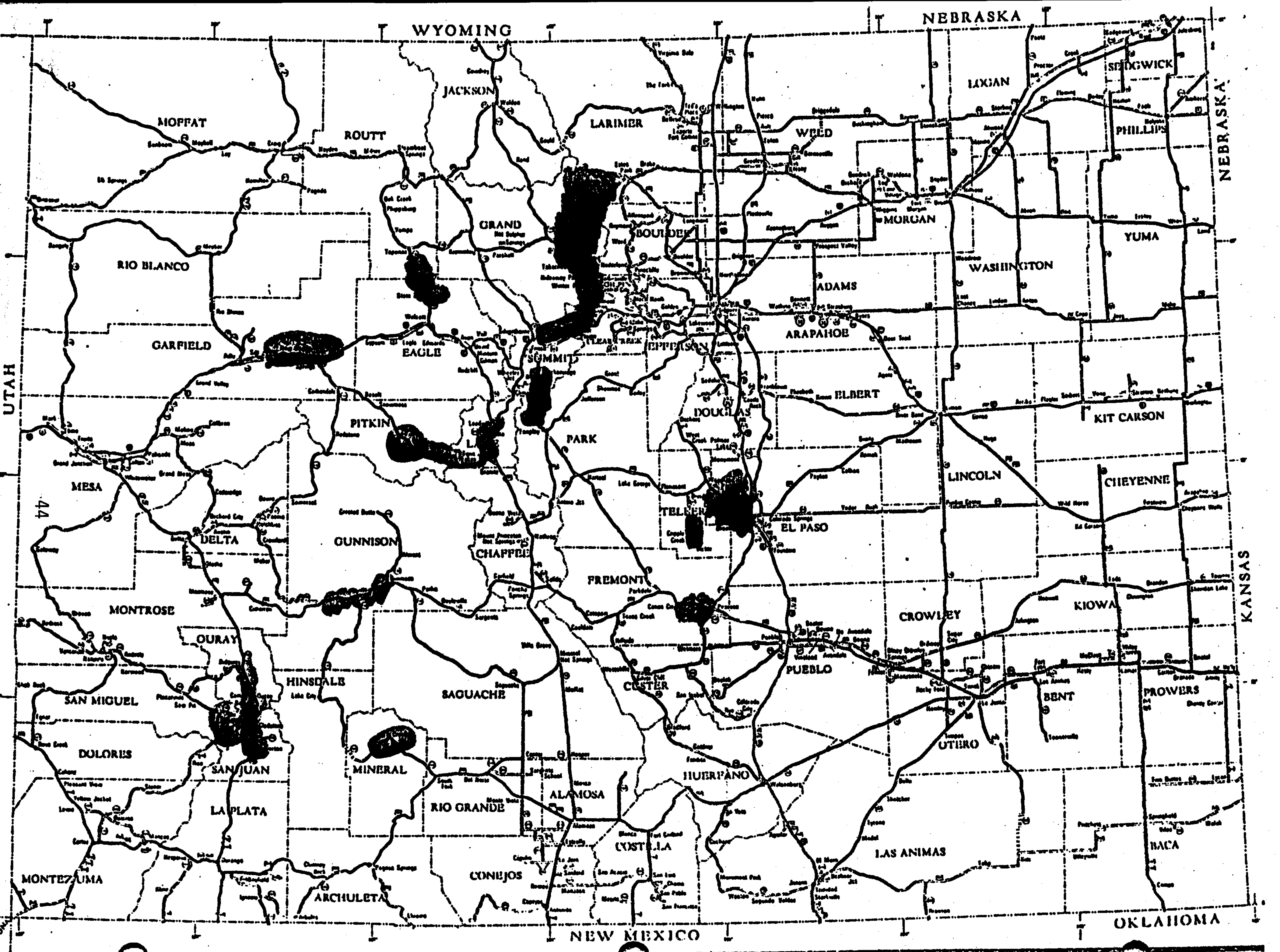

EXHIBIT 2 ~~FEDERAL AID SYSTEMS~~ HYDROPOWER THEME

7. PLACER MINING

NARRATIVE

While the old saying, "gold is where you find it", is undeniable, the prospectors who scoured western mountains looking for gold generally remained close to the stream beds. They understood that gold, though occurring in hard rock, can be eroded by the action of water and other weathering agents, carried away by existing or ancient streams, and eventually deposited on sand bars, gravel beds, or in pockets along the stream beds. Discovery of these alluvial deposits or placers, laid down by flowing water, incited many of the major mining rushes of the nineteenth century, including the California gold rush of 1849 to Sutter's Mill and the 1859 rush to the Colorado Rockies. From the placers, miners searched the neighboring hillsides for the source of the gold, often initiating underground mining operations in the area. The length of the placer period in a region depended on the local geology, the availability of capital investment and labor to conduct large-scale operations, and the development of suitable technology for surface and hard rock mining.

The object of placer mining is to separate the precious metal from the dirt and clay which is loosely mixed with it. The most primitive method to do this involves using a gold or prospect pan, a shallow pan 10 to 18 inches in diameter made of sheet iron. Partially filling it with water and dirt, the miner would remove pebbles, break up lumps of clay, and gradually swirl out the water and dirt until a residue remained in the pan. This washing process might leave a few specks of gold at the bottom. Although gold panning is associated with the early days of mining, the practice continued, particularly during times of economic distress, such as the 1930s. Similarly, considered "poor man's mining", panning was often left to the Chinese in the West where a day's work with the pan might yield no more than a few cents worth of gold dust.

Since gold panning was a slow, tedious, labor-intensive method, miners employed various devices to increase the amount of dirt that could be worked. One of these, a wooden cradle or rocker, similar to a child's cradle, contained a tray with a screen or perforated iron plate, called a riddle, on one end and on the other, open end, held a riffle bar. Water and dirt passing through the rocker resulted in gold collecting in the riffle. The long tom was a slanted wooden trough, 6 to 12 feet long, about 8 inches deep, and approximately 15 inches wide at the head and 30 inches wide at the foot. At the lower end was a sheet iron riddle, or a grizzly, a grid of iron bars. As water and dirt were run through the long tom the gold was separated and collected while the mud and debris flowed out of the lower end.

For larger-scale operations, involving greater quantities of sand and gravel and where a sufficient head of water existed, miners practiced sluicing. A wooden sluice box was a long, slanted trough, sometimes over 100 feet long, about 12 inches wide and 6 to 18 inches deep. The bottom contained riffles or cleats to catch the gold as water mixed with dirt rushed through the box. The ground sluice was a more primitive form. It consisted of a shallow trench dug by the miners who placed holes, rocks, and gravel bars at the bottom to act as riffles in collecting the yellow metal. Requiring planning and a considerable expenditure of labor, sluices ordinarily represented the collective effort of many miners to exploit a placer mine.

In the case of placers located a distance from running streams, miners undertook various construction projects to bring water to the sites. Ditches were dug to convey water, sometimes many miles such as the 12 mile long ditch made by Colorado miners between Central City and the Fall River in 1860. But ditches were not always practical; they were costly to construct and maintain and could not be used over broken terrain, in the high mountains, or in loose, sandy soils. Under these circumstances, miners constructed flumes: open wooden or metal channels supported above ground. Generally of rectangular cross section, wooden flumes, 6 to 10 feet wide, utilized local timber planks which were spiked together and erected on timber trestles. Intermittent use of these flumes caused the wood to swell and shrink resulting in leaks. This, however, may have posed more a problem for farmers, whose water needs were intermittent but long term, than it was for miners, whose placer operations were of shorter duration. Yet by the late nineteenth century, galvanized iron and steel plates were available to construct more durable metal flumes for placer mining.

Encountering low grade placers or finding insufficient water for sluicing, miners sometimes practiced "booming". In this method they temporarily dammed a stream (a boom dam) to collect a large volume of water which upon release washed away the dirt and freed the auriferous gravel. Although the dams were crudely constructed, some were fitted with automatic gates or self-shooters. When a box with a small hole filled with water, it automatically lifted the beam connected to the gate which then opened with a loud boom or crash of rushing water.

The same principle of using water under pressure to remove sand and gravel was considerably expanded in hydraulic mining. As developed in California during the 1850s, this method of placer mining involved conducting water from a high stream by means of a ditch or usually a flume to a point above the mine site. Here the water under pressure entered a closed wooden or metal conduit, called a penstock, then into a canvas hose (some times banded with iron hoops for additional strength) at the end of which was a metal monitor or nozzle that directed the jet of water. The Little Giant, developed in 1870, became the dominant manufactured hydraulic nozzle and the Risdon Iron Works of San Francisco became the leading manufacturer of this device. Bearing a great similarity to a piece of artillery with a 6 to 10 inch bore, the Little Giant's long snout, mounted on a movable base, could direct a powerful stream of water hundreds of feet to wash away a hillside. Although hydraulicing saved labor, it generally required an investment of capital for equipment and it had a destructive effect on the environment. As objections to the debris problem mounted in the late nineteenth century, some western states enacted legislation regulating the conduct of hydraulic mining. For low-lying placers, miners occasionally employed hydraulic elevators, directing a powerful jet of water below the surface through a heavy pipe in order to dislodge gold bearing gravel and flush it to the top. This method apparently was used near Breckenridge, Colorado, at the turn of the century.

Mass production methods came to placer mining in the 1890s with the introduction of gold dredging. Originating in New Zealand but being adapted and refined in California, this technique worked best on low value placers in relatively level terrain, such as river valleys. The dredge was a combination excavating machine, treatment plant for gold bearing dirt and gravel, and tailings stacker built on a shallow-draft, flat-bottomed barge. Typically, it excavated by means of an endless chain of digging buckets that reached pay dirt as much as 50 to 100 feet below the surface. The dirt was then treated on board the dredge to remove the gold, while the mud was pumped out and the stones sacked astern by a conveyor belt. Winching moved the vessel forward and huge wooden or metal spuds lowered into the stream bed permitted the machine to pivot in place. Most often dredges were assembled on the site and made of wood and metal. Steam power drove most of the early gold dredges, with electricity gaining popularity in the twentieth century. The major manufacturers of the heavy machinery in gold dredges were the Risdon Iron Works, Bucyrus, Marion Steam Shovel, Yuba Industries, and Link Belt Machinery Company.

Dredge mining had a long term impact on the environment. The buckets chewed away at the ground, creating a pond for the dredge as it advanced, and leaving behind large mounds of washed stone and gravel. When operations ceased, dredgemen commonly stripped off the machinery for future use and abandoned the hull and superstructure which may still be seen in some places.

CHRONOLOGY

1858	Discovery of gold in Colorado
1859	Gold rush to Colorado
1860s	Gold panning and sluicing
1860s-1880s	Hydraulic mining
1870	Little Giant hydraulic nozzle developed
1879	Major hydraulic mining operation at Alma, Colorado
1890s	Hydraulic elevators in use
1890s	Gold dredging
1898	Gold dredging begins in Summit County, Colorado
1930s	Great Depression revives gold panning

LOCATION

Placer mining was the first mining activity at most gold camps in Colorado. Major placer mining operations developed in Summit, Park, Clear Creek, Boulder, and Gilpin counties. The areas of this activity are marked on the map.

CULTURAL RESOURCE TYPES

Gold pans (also called prospect pans)

Rockers

Long toms

Sluice boxes

Ground sluices

Water supply ditches

Wooden and metal flumes

Metal pipes

Boom dams

Penstocks

Canvas hose

Little Giant hydraulic nozzles

Hydraulic elevators

Continuous bucket gold dredges

THE QUANTITY AND QUALITY OF EXISTING DATA

Historical Documentation

The mining history of Colorado has generally focused on deep-level mines rather than the earlier and relatively brief episodes of placer mining. Yet there is an abundant literature on placer mining in the West and these sources can be drawn upon to clarify the Colorado experience. Otis Young's Western Mining is a reliable source on technical developments and Rodman Paul's study of mining frontiers presents a helpful overview and a thorough bibliography. The histories of Colorado by Percy Fritz and Robert Athearn should be consulted on mining in the state and for references to more detailed works. Archival collections, college theses, and government documents such as Henderson's Mining in Colorado can be excellent sources of additional data.

Scant attention has been given to hydraulic and dredge mining. Robert Kelley has written a study of hydraulicing in California that explains basic techniques and explores the legal ramifications of this mining method. Clark Spence's article on dredge mining is a brief though informative introduction to that subject. Beyond these sources, newspapers, government reports, old catalogs of machine manufacturers, and particularly the engineering and mining periodicals represent the best sources for documenting hydraulic and dredge mining operations.

Number/Condition

The existing data does not allow an exact accounting of cultural resources. Certainly many hundreds of placer mines were recorded and operations initiated, but most of these sites have disappeared or been substantially modified. Some information on placer mining sites can be gathered from the inventories located at the Colorado Preservation Office. In dredge mining the operators commonly dismantled the boat upon completion of an operation and moved the equipment to a new site. An effort should be made to identify the hardware used in hydraulic and dredge mining.

Data Gaps

Representative hydraulic mining site in place and undisturbed since operations ceased.

Representative machines, equipment, and supplies marking the hydraulic and dredge mining eras.

A dredge mining site in undisturbed condition.

A boom dam provided that its function is clearly discernible and can be accurately dated.

Future Needs

Since the early phases of placer mining have been well recorded and documented, the emphasis should be placed on identifying, documenting, and interpreting hydraulic and dredge mining activities. These types of mining have not enjoyed the same degree of interest or documentation as deep-level mining in Colorado. The identification of cultural resources combined with additional historical documentation can add an important dimension to the state's engineering history. A comprehensive historic engineering site survey and inventory is advisable.

Important Resources

One measure of the significance of placer mining is the way miners utilized water resources in their operations. Consequently, the equipment and tools, including nozzles, hoses, hydraulic elevators, and flumes can supply useful information to reconstruct the significant role water played in the development of the mining industry. Similarly, the interplay between placer mining technology and other technical developments in water engineering might be better established through cultural resources and historical documentation.

RESEARCH QUESTIONS

1. Can cultural resources advance our knowledge of the development of water engineering and technology?

2. What resources remain to illuminate the relationship between Colorado mining development and mining trends elsewhere in the West and the world?

3. Can cultural resources clarify the impact of mining on the environment?

4. What resources remain to verify the historic evolution of placer mining to more modern surface mining techniques?

PHYSICAL CONDITIONS

Gold Pan, Rocker, Long Tom, Sluice Box: They should be in satisfactory condition to explain their function and be dated to the correct historical period.

Ground Sluice and Water Supply Ditch: Historical evidence and adequate remains *in situ* to determine with precision the purpose and date of the resource.

Flume, Pipe, Penstock, Canvas Hose: Enough of the equipment must remain to determine function and the relationship to other facets of mining activity on the site.

Boom Dam: Enough should remain in place to convey purpose and be dated to the proper historical period.

Little Giant Hydraulic Nozzle, Hydraulic Elevator: Enough of the equipment should remain to clearly discern its function and be accurately dated.

Continuous Bucket Gold Dredge: Enough of the hull and machinery on board should remain in place to determine the dredge's function. Preferably in place in a dredge pond the cultural resource can reveal its operating procedures and the consequent effect on the environment.

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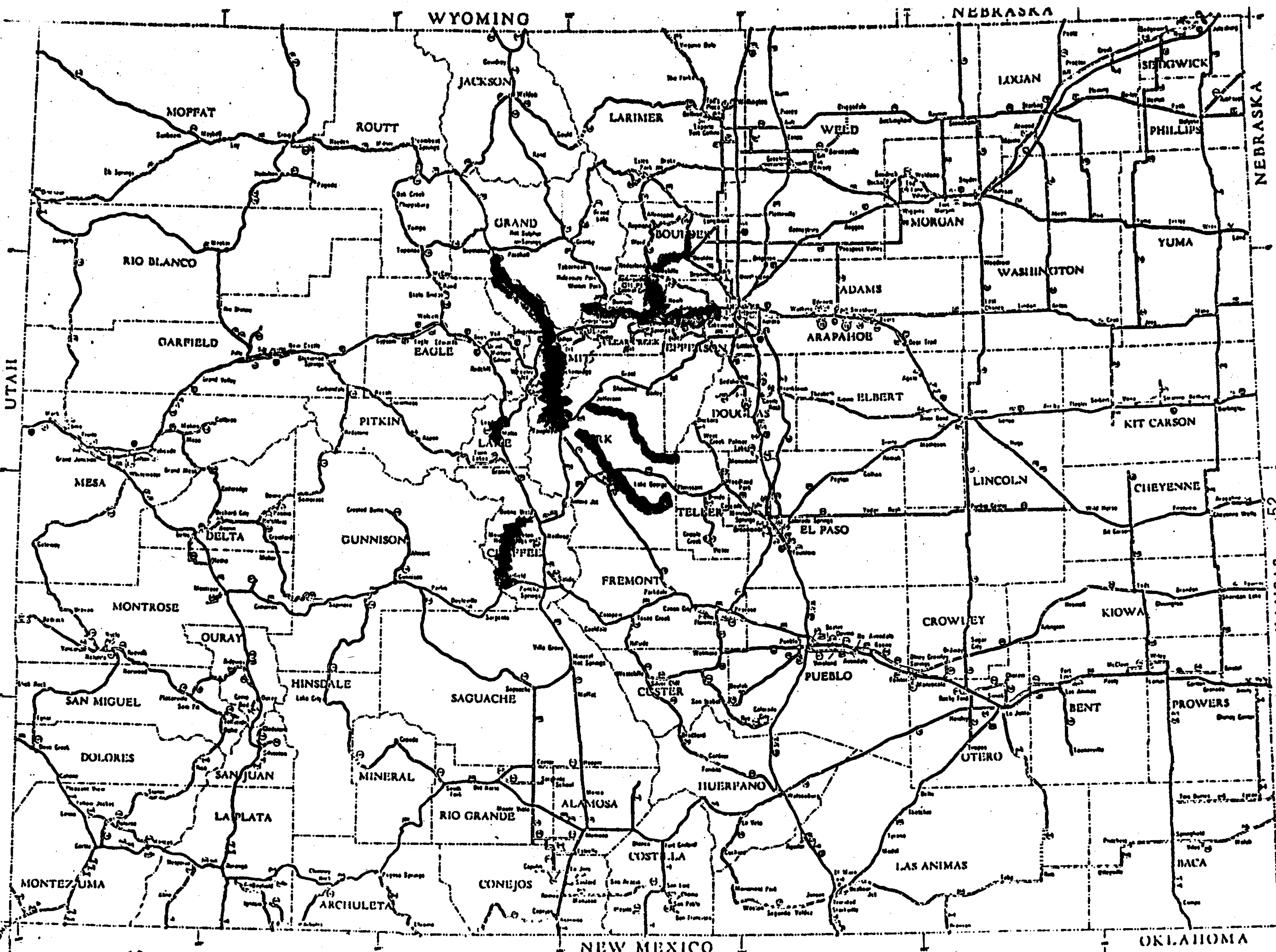

EXHIBIT 2 FEDERAL AID SYSTEM

PLACER MINING

8. PETROLEUM AND SHALE OIL

NARRATIVE

The development of the first successful oil well in western Pennsylvania in 1859 began the petroleum industry in the United States. At first valued as an illumination, oil quickly established new markets in a modern, industrial America for its lubricating, energy, and chemical properties. The growing demand spurred exploration into all parts of the nation, resulting in the discovery of major oil fields in the West and Southwest during the twentieth century. Colorado possessed important oil resources and supplied refining facilities for oil produced in neighboring status, primarily form the large fields in Wyoming. Until the construction of adequate transportation facilities, much of Colorado's oil land remained inaccessible and distant from major markets.

Oil well drilling borrowed much of its early technology from water well boring. A shaft was dug to bedrock and lined with wooden planks called conductors. In the early 1870s cast iron pipe began to replace the planks. This casing kept the well free of debris and mud. Over the well site, drilling constructed a wooden derrick or drilling rig, its height and design depending on the depth of the well. From Pennsylvania days to the 1930s, when generally replaced by the rotary drill developed in the 1880s-1890s, the drill utilized was a cable tool or impact type. Attached to a hemp rope (wire rope introduced in the early 1900s), a string of tools, including a fish tail drill bit, was repeatedly lowered into the hole with a twisting, driving action to chew away at the dirt and rock. In the 1890s rotary drilling made its appearance in the oil fields. Distinguishing this system was the revolving table on a drilling platform that gripped a pipe to which a bit had been fastened to the end. Conical shaped, steel bits developed in the early 1900s cut faster and more evenly than the cable tool. Drillers used special muds to cool the bit, flush out fragments of rock and sand, and to reduce the danger of blowouts in the well.

The drilling apparatus was supported by a derrick consisting of four wooden legs with criss-cross bracing and sometimes rising to a height over 100 feet. Between 1910 and the 1930s wooden derricks gradually gave way to metal ones fabricated of tubular steel or angle iron. The cable tool rig was readily identified by its large wooden bull wheel that wound the cable, the walking beam which operated the percussion drill, and the large band wheel which moved the walking beam. In the 1920s-1930s, the spudding machine, a type of impact drilling rig without, the extensive rigging of a derrick, came into wide use. Up to the 1920s, the usual source of power for drilling came from single or twin cylinder stationary steam engines using locomotive-type boilers. After World War I, internal combustion engines fueled by gasoline or well gas began to appear in the oil fields.

Once oil was reached in a non-flowing well, the walking beam became a pump, operating wooden (later metal) rods connected to suckers or pump valves. This "standard rig front" remained dominant until the early 1920s when the industry developed beam pumping units that have evolved into the familiar "horsehead" pumps of today. Storage facilities at the well also improved. In their haste to produce as much oil as possible, early operators dug holes in the ground or erected earthen reservoirs (sumps) to store the crude. Otherwise wooden or riveted iron tanks served for storage into the-mid 1920s when replaced by covered welded steel tanks.

Early devices to separate gas, called gas traps, were fashioned out of wooden barrels and tanks and used specific gravity for separation. Yet greater demand for natural gas for fuel in the twentieth century encouraged the development of complex separators which could supply high pressure gas to transmission pipelines. The addition of various valves and fittings atop a well to regulate the flow of oil and diminish blowouts resulted in the Christmas tree mechanism found in the oil fields.

Two principal means of transporting crude to refineries in distribution centers emerged in the late nineteenth century: railroads and pipelines. In the 1870s railroads replaced their open wooden tub-like tank cars with horizontal metal cylinder tanks resting on flat cars. To this day, this type of tank car transports crude oil and refined petroleum products. However, as early as the 1870s, the industry found it cheaper and faster to pump oil via pipelines. Feeder lines gathered oil from the fields to a central shipping point, while main lines or trunk lines, often interstate, moved oil to refining centers. Wrought iron pipe of various diameters was commonly used. Shortly before World War I diesel pumping stations began to replace the large steam driven stations first used.

Early refineries were primitive and hastily built structures that resembled simple stills. Oil was heated by fire or steam allowing the various fractions in the crude to vaporize separately. The gases were piped through water cooled coils that liquified the vapors. At an acidizing tank, sulphuric acid treated the oil to remove much of the ill-smelling sulphur. Prior to 1900, the principal product to emerge from this process was kerosene to be sold as an illuminant. Around the turn of the century, two developments -- the expansion of electric lighting and the introduction of the automobile -- deeply affected the refining industry. The increasing demand for gasoline coupled with the rise of petrochemical technology transformed the oil refineries into modern, multiple product manufacturing plants. A notable innovation in 1910-1013 was the Burton still that cracked hydrocarbon molecules into lighter fractions for greater gasoline output.

Though never in the front rank of oil producing states, Colorado can claim one of the first producing wells west of the Mississippi River. In 1862 a migrant from the Pennsylvania fields discovered a well near Canon City that stirred some interest in oil exploration in this area. With the exception of an important field near Florence which went into production in 1876, little activity occurred partly because of the state's distance from major markets and adequate supplies oil elsewhere in the nation. In 1901-1902 oil fields opened around Boulder and Rangely (not fully exploited until the 1940s) and additional fields produced in the 1920s, principally in Moffat and Larimer counties. Continental, Union, and Marland (absorbed by

Continental) were among the most active and successful oil companies in the state. Refineries were often erected near the major fields, such as Florence, but by the 1930s Denver emerged as the state's refining center mainly due to the laying of petroleum pipelines from Wyoming fields, for instance, the Rocky Mountain Pipe Line from Cheyenne.

Oil shale, a soft sedimentary rock from which oil and gas are extracted, remains an enormous mineral resource in Colorado and other parts of the West. Scotland developed a shale oil industry as early as the 1850s, but America's vast petroleum reserves limited interest in the "rock that burns" until World War I oil shortages spurred exploration and experimentation. Between 1915 and 1930 feverish activity occurred in shale oil as dozens of companies formed, issued stock certificates, raised capital, and located mining claims. Colorado was a focal point of this frenzy, particularly the Grand Valley - Debeque area in the northwestern part of the state.

In the long run, success hinged on the development of an efficient and reliable process to extract oil from the rock. Scottish-type retorts were found wanting because of differences in the composition of western shale. Other processes followed. The shale was crushed and heated to a high temperature in brick retorts which collected the vapors for condensing. Many retorts of this kind were built, and in 1925-1926 the Bureau of Mines erected a pilot retorting plant at Rulison. Despite private and public efforts, the boom collapsed in the late 1920s and 1930s. High costs, technological failure, and especially the flood of oil from wells in California and east Texas doomed the oil shale business. New developments in Colorado shale awaited the 1940s.

CHRONOLOGY

1859	Pennsylvania oil discoveries mark beginning of the oil industry in the United States.
1860s-1930s	Percussion or cable tool oil drilling.
1860s-present	Development of feeder and trunk line pipes to transport oil.
1862	Discovery of oil well near Canon City, Colorado.
1872	Oil Placer Act provided for subdivision of shale oil lands.
1876	Florence, Colorado, field opened.
1880s-1890s	Development of rotary drilling techniques.
1901	Spindletop gusher, near Beaumont, Texas.
1900-1910	Development of steel bits for rotary drills.
1900-1920	Wire rope gradually replaces hemp for deep well drilling.

1910-1913	Burton still improves refining.
1915-1930	Boom in western oil shale.
1920	Minerals Leasing Act required government leases on shale lands.
1920s	Beam pumping units developed.
1925-1926	Bureau of Mines Rulison pilot plant for retorting shale oil.
1930s	Opening of major East Texas oil fields.
1930s	Extensive adoption of rotary drilling methods.

LOCATION

Shaded areas on the map indicate major oil producing fields in Colorado. Cross hatching marks the areas of oil shale mining and refining.

CULTURAL RESOURCE TYPES

Sites Include: oil fields, wells, sumps, shale land claims.

Oil Field structures and equipment include:
- Derricks
- Drilling rigs
- Casing pipe
- Drill bits
- Steam engines and boilers
- "Christmas tree" well head valves and fittings
- Separators and gas traps
- Well pumps
- Storage tanks
- Pipelines
- Pumping stations

Refineries
- Stills
- Acidizers
- Storage tanks

Oil Shale
- Crushers
- Retorts
- Tanks

THE QUANTITY AND QUALITY OF EXISTING DATA

Historical Documentation

An extensive literature exists on the history of the production and use of petroleum in the United States. The two volumes by Harold Williamson will challenge the reader with their detailed treatment of the industry's growth, but contained therein is a wealth of useable data on business, geological, technological, and consumption patterns. Rundell's lavishly illustrated history of Texas oil successfully introduces the subject to the novice and its brief narratives and captions contain a surprisingly large amount of information which help identify oil machinery and methods. If not intimated by its length (1,241 pages) or confused by its poor organization, one can find most answers about petroleum technology in the History of Petroleum Engineering. The technology of oil to 1906, including standard American practices, is plainly described by English engineer Sir Boverton Redwood. For additional engineering data, consult government and industry reports and equipment catalogs.

The history of Colorado oil has yet to be written and general sources devote slight attention to the state. Thus, the researcher must examine a variety of sources: company histories (exercise care with self-congratulatory in-house publications), state and federal documents, and newspapers. The Oil and Gas Fields of Colorado by Jensen and others briefly treats the major issues in the state's oil history and locates the oil fields with a description of their geology. Local histories, such Vandenbusche and Smith's on the Western Slope, are reliable sources of information and can lead one to more specialized studies. The library at the Colorado School of Mines in Golden is an excellent resource. The subject of shale oil receives competent coverage in the Russell book, including a list of Colorado companies formed during the boom years, but the study falls short on contextual framework and historical interpretation. In summary, the story of Colorado oil has been overshadowed by the state's mining history.

Number/Condition

The available historical documentation on oil in Colorado will permit an exact determination of major oil related sites. The data cannot supply precise numbers of structures, equipment, and machines that existed or may have existed. It is doubtful that many cultural resources of the early days have survived because of the tendency in the industry to dismantle and relocate structures or to scrap out-of-date equipment. A cooperative effort with oil pioneers in the state, perhaps as part of an oral history project, might yield additional data on cultural resources.

Data Gaps

Representative evidence of early oil field drilling, production, refining, and shale oil projects.

Complete identification and documentation of important oil fields and shale projects.

Future Needs

The historical data are sufficient to locate the principal sites of oil activity. However, an effort needs to be made to inventory and document any surviving structures, equipment, and machinery from historic periods in the state. A comprehensive historic engineering site survey would accomplish this task. Furthermore, a project should be initiated to narrate the Colorado historical experience with an eye to national developments, to gather oral history evidence, and to analyze and interpret the state's role in the evolution of the Rocky Mountain oil industry.

Important Resources

Sites, structures, equipment, and machinery merit additional study and full documentation. The earliest oil activities in Colorado, coming so soon after the Pennsylvania discoveries, make them significant to the history of oil in America. The same is true of early shale oil projects. Colorado's focal role in the boom between 1915 and 1930 makes cultural resources associated with this episode a primary concern to historians and resource managers.

RESEARCH QUESTIONS

1. Can cultural resources expand our knowledge of oil field methods, technology, and culture?

2. What evidence remains to document the pattern of oil exploration and development?

3. Can cultural resources reveal differences/similarities between Colorado practices and those adopted in other oil-producing states?

4. To what extent can resources delineate the role of Colorado in regional oil developments?

PHYSICAL CONDITIONS

Oil Field: enough structures of all types (housing, commercial, and technical) should remain in place to convey purpose of the site. Dates must be accurately determined.

Oil Field Equipment and Machinery: ideally located on original site, but all must be identified as to function and manufacture and dated to the correct historical period.

Refinery: enough of the equipment, structure, and machinery should remain in place to discern its function and to show relationship of parts to the whole. Date properly.

Shale Oil Operation: enough of the structures and machinery must remain in place to determine the site's function and be accurately dated.

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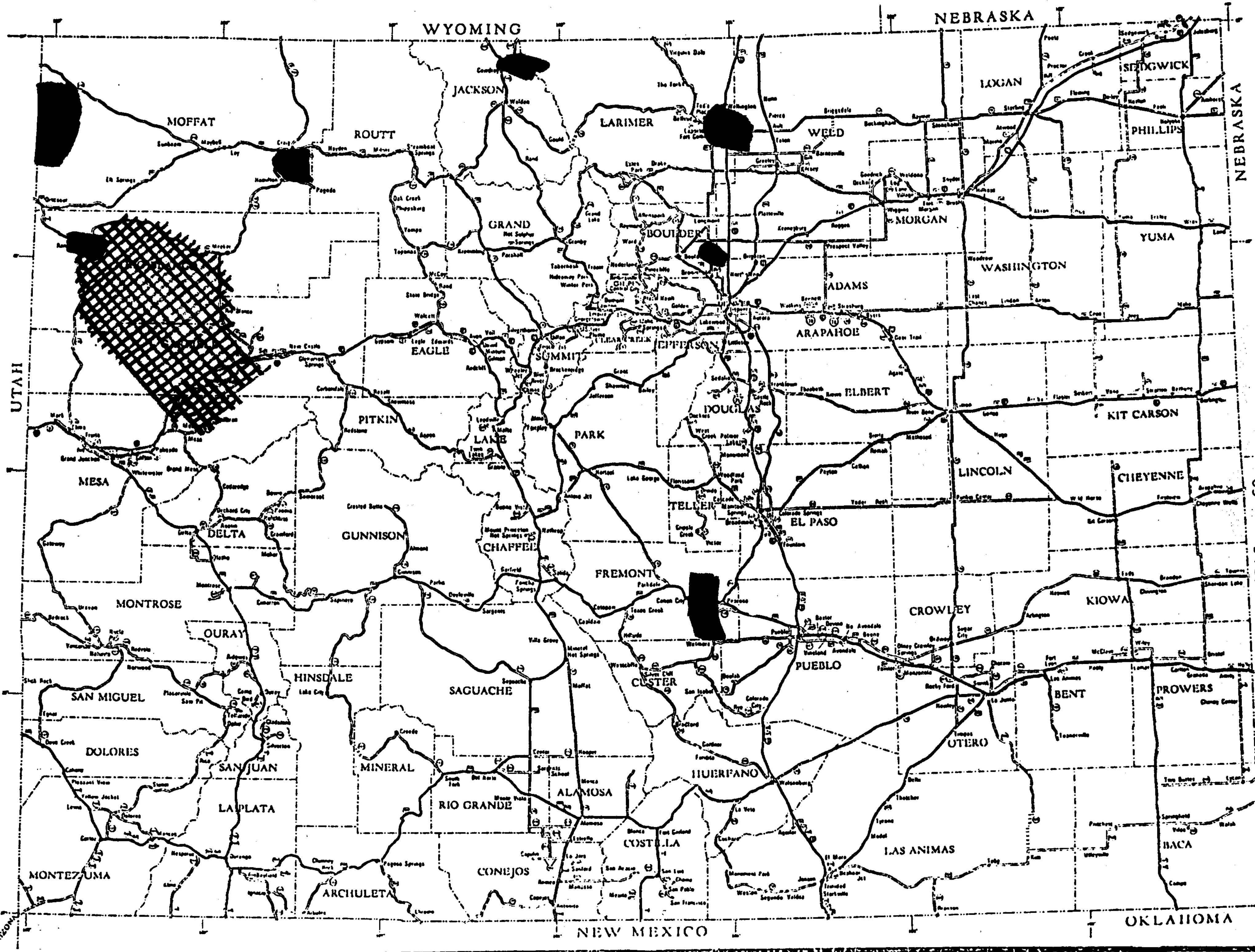

Petroleum ■ Shale ▩

9. NATURAL GAS

NARRATIVE

Natural gas did not become a major source of energy in the United States until the twentieth century, comparatively late among the fossil fuels. Its development was delayed by the availability of abundant supplies of low cost alternatives, by technical problems that hampered gas transmission over long distances, and by wasteful practices at the wellhead that characterized the early decades of oil and gas drilling. In the 1920s the industry confronted and overcame many of these problems and it aggressively established new markets for its product. Natural gas benefited from the rapidly rising energy demands of a nation undergoing transformation into a modern, high-energy consuming, urban and industrial society.

The natural gas industry was born in the United States, though it made little progress in the nineteenth century. A shallow well located near Fredonia, New York, in the 1820s reportedly produced enough gas to light streetlamps in the town and to encourage some local exploration for other gas deposits. However, more familiar and readily adaptable illuminants existed to dissuade large-scale commercial development of natural gas. Chief among the established competitors was manufactured gas derived from heating coal and drawing off the lighter fractions. Baltimore chartered the nation's first gas company in 1816 and the company's success spawned similar ventures in other eastern cities. By the 1860s approximately 300 gas companies existed, but they faced stiff competition after the Civil War from kerosene distilled from petroleum and from the electric lamp (invented in 1879) whose cool, flameless light would dominate the market in the twentieth century. Manufactured gas gradually turned to the industrial fuel and heating markets and expanded its production until the late 1940s when replaced by natural gas. Thus, some of the current natural gas companies trace their origins to the days of manufactured gas.

In the period 1880 to 1910, coal, gas, and electricity vied for a share of the market in the growing cities and this led to intense, often chaotic, competition but also to technological innovation. The Welsbach incandescent gas mantle, which greatly increased the illuminating value of gas, was quickly adapted by manufactured gas companies in the 1880s to meet the competition of electricity. Beginning in the early twentieth century, gas distributors promoted new markets in space heating, water heating, cooking stoves, as well as industrial use of their product. The result of this aggressive marketing campaign and the introduction of new technology was to bring about major physical, social, and economic changes in the cities, such as Denver, which modernized on a foundation of cheap and reliable energy.

Natural gas awaited an opportunity to enter the burgeoning market for energy in the cities. For several decades after the discovery of petroleum in Pennsylvania (1859), drillers regarded gas found in association with oil as a nuisance, either venting it into the air or flaring (burning) it off. (The methods and technology for drilling gas and oil are the same. See Petroleum theme.) Gas, being a volatile fraction in petroleum, was not needed for kerosene production. Oilfield laws that encouraged the rapid pumping out of crude--even if it had to be stored in open pits in the ground--before other drillers tapped into the pool worsened the problem of gas wastage. To a limited extent gas found with oil was used for fuel in drilling engines and sometimes gas was shipped to a nearby city via wooden or wrought iron pipelines. While the industry grew more aware of the value of gas in the early twentieth century, the newly opened oil fields of the Southwest and West proved too far from major markets to risk the construction of long, leak-prone pipelines.

Large-scale commercial development of natural gas began in the 1920s. The nation experienced serious fuel shortages between 1916 and 1923 largely caused by problems in the production and shipment of coal, difficulties magnified by our involvement in the First World War. With new attention focused on natural gas as a sleeping giant in energy, companies rushed to build long distance transmission pipelines using large diameter welded steel pipe capable of carrying gas under high pressure. There had been a few long pipelines earlier in the East and Midwest that utilized wrought iron pipe with screw couplings. First of the new welded steel pipe appeared in a line constructed between Beaumont, Texas and northern Louisiana in 1925. Later in the 1920s the Colorado Interstate Gas Company laid a pipeline from the Texas Panhandle to serve Pueblo, Colorado Springs, Denver, and Boulder. In addition to welded steel pipe, other technical innovations of the 1920s and 1930s facilitated gas transmission: pipeline ditching machines, improved gas separation in the oil fields, better storage tanks, and compressors to propel the gas over long distances. Carbon black plants, which usually located near the gas fields, also became an important industrial consumer of natural gas by the 1920s. Rubber companies, supplying the thriving automobile industry, utilized carbon black to reinforce rubber tires.

The network of natural gas pipelines expanded during the Second World War and particularly in the postwar period as energy demand continued its upward spiral. Colorado emerged as an important gas producing state in the years since World War II. Prior to the 1940s, vast coal resources, gas wells distant from major markets, and the availability of low cost gas from neighboring states in the Southwest kept Colorado's natural gas industry relatively small. Important gas deposits were opened in the state during the 1920s and 1930s, a period of heightened gas activity nationwide, and some fields, for example, that in Larimer County, produced fuel for nearby towns.

CHRONOLOGY

1817 First natural gas well, Fredonia, N.Y.

1821 Gas Light Company of Baltimore-manufactured gas industry begins in the United States.

1859 Petroleum discovered in Pennsylvania.

1879	Thomas Edison's incandescent electric lamp.
1880s	Welsbach incandescent gas mantle.
1890s	Screw couplings development to connect high pressure gas pipelines.
c1898	Gas field discovered in Las Animas County, Colorado.
1916-1923	Natural fuel shortages.
1923	Opening of Fort Collins gas field.
1925	First long distance welded steel gas pipeline.
1927	Texas to Colorado pipeline (340 miles long).
1931	1,000 mile gas pipeline from Texas to Chicago.
1938	Natural Gas Act places interstate transmission of gas under federal regulation (Federal Power Commission).

LOCATION

Green shaded areas on the map mark gas field development in Colorado. Major gas pipelines are shown in red. Cultural resources associated with natural gas may exist in these areas.

CULTURAL RESOURCE TYPES

Sites Include: Gas and oil fields.

Structures and Equipment Include:

- Drilling rigs
- Gas Separators
- Gas storage tanks
- Pipelines
- Trenching machines
- Compressor stations.

THE QUANTITY AND QUALITY OF EXISTING DATA

Historical Documentation

Natural gas is an untapped field of historical research. One might speculate that its relatively recent development into a major energy resource has not given historians adequate perspective on its growth and that its status as a less glamorous by-product of petroleum production may account for this fact. Consequently, no comprehensive historical study exists on natural gas development. Peebles' Evolution of the Gas Industry devotes a single sketchy chapter to gas in the United States, while the volume by Leeston, Crichton, and Jacobs presents a historical introduction to what is otherwise a contemporary survey of the industry in the early 1960s. Natural Gas: A Study in Industry Pioneering contains some useful graphics but the narrative is undependable for the historian. The best sources of historical data will be found through research in federal and state government reports and in older volumes of industry periodicals, such as Gas Age and the Oil and Gas Journal. The technology of gas production and distribution may be documented from equipment manufacturers' catalogs, though difficult to locate, and industry handbooks published in various years, one of which appears in the list of references. Check the documentation and reference section of the Petroleum theme as well.

Documentation is scanty for Colorado gas. Fortunately, the article by Rose and Clark provides a thought-provoking and analytical framework for studying energy use in Denver and contains a fine bibliography. The libraries at the Colorado School of Mines and the University of Colorado are likely to hold additional documentation in the form of geological reports, local history, and student theses.

Number/Condition

The sites where gas was produced in Colorado can be accurately determined, but the number of structures, equipment, and machinery that existed or may have existed cannot be determined from the available data. With few exceptions, activities were confined to the 1920s, 1930s, and 1940s in both the production and transmission of natural gas. The condition of cultural resources may vary greatly. As with petroleum, producers commonly moved and/or discarded equipment as new technology was made available.

Data Gaps

Representative evidence of early gas field drilling and production methods.

Representative evidence in place of early pipelines and distribution systems for natural gas.

Future Needs

Sufficient information about natural gas development can be found in literary sources such as government documents, newspapers, and periodicals, but cultural resources remain to be recorded and documented. An effort should be made to compile the historical data into a usable and interpretative framework in combination with a historic site survey and inventory of cultural resources. Both aspects of this project would require the skills of a historian familiar with the sources of documentation for engineering works and with the technology employed by the industry. Contacts should also be made with companies and individuals active in the state's gas production and transmission industries.

Important Resources

So little has been done on this subject from a historical as well as a cultural resource perspective that all sites are potentially significant to state and local history. Gas and oil simply have not attracted the attention accorded to other mineral resources in Colorado. The relatively small number of production sites and major pipelines should make it possible to survey and inventory cultural resources with a minimal level of effort. The Texas to Colorado pipeline of 1927 represented a major engineering achievement and needs to be studied and documented further. Likewise, efforts to distribute gas in cities and towns from local fields in the early twentieth century are notable.

RESEARCH QUESTIONS

1. What evidence remains to document the pattern of gas exploration and development?

2. Can cultural resources increase our knowledge of gas methods and technology?

3. Can cultural resources expand our understanding of the competition between natural and artificial gas and between gas and alternative fuels?

4. What evidence remains to reveal the strategy of pipeline systems and to document the changing technology of pipeline construction?

5. Can cultural resources verify the wasteful practices of early oil and gas field development?

PHYSICAL CONDITIONS

Gas Field: enough structures of all types (housing, commercial, and technical) should remain in place to convey purpose of the site. Dates must be accurately determined.

Gas Field Equipment and Machinery: ideally located on original site, but must be identified as to function and manufacturer. Dated to correct historical period.

Pipeline and Distribution System: enough of the pipeline and supporting equipment must remain in place to discern function and be accurately dated.

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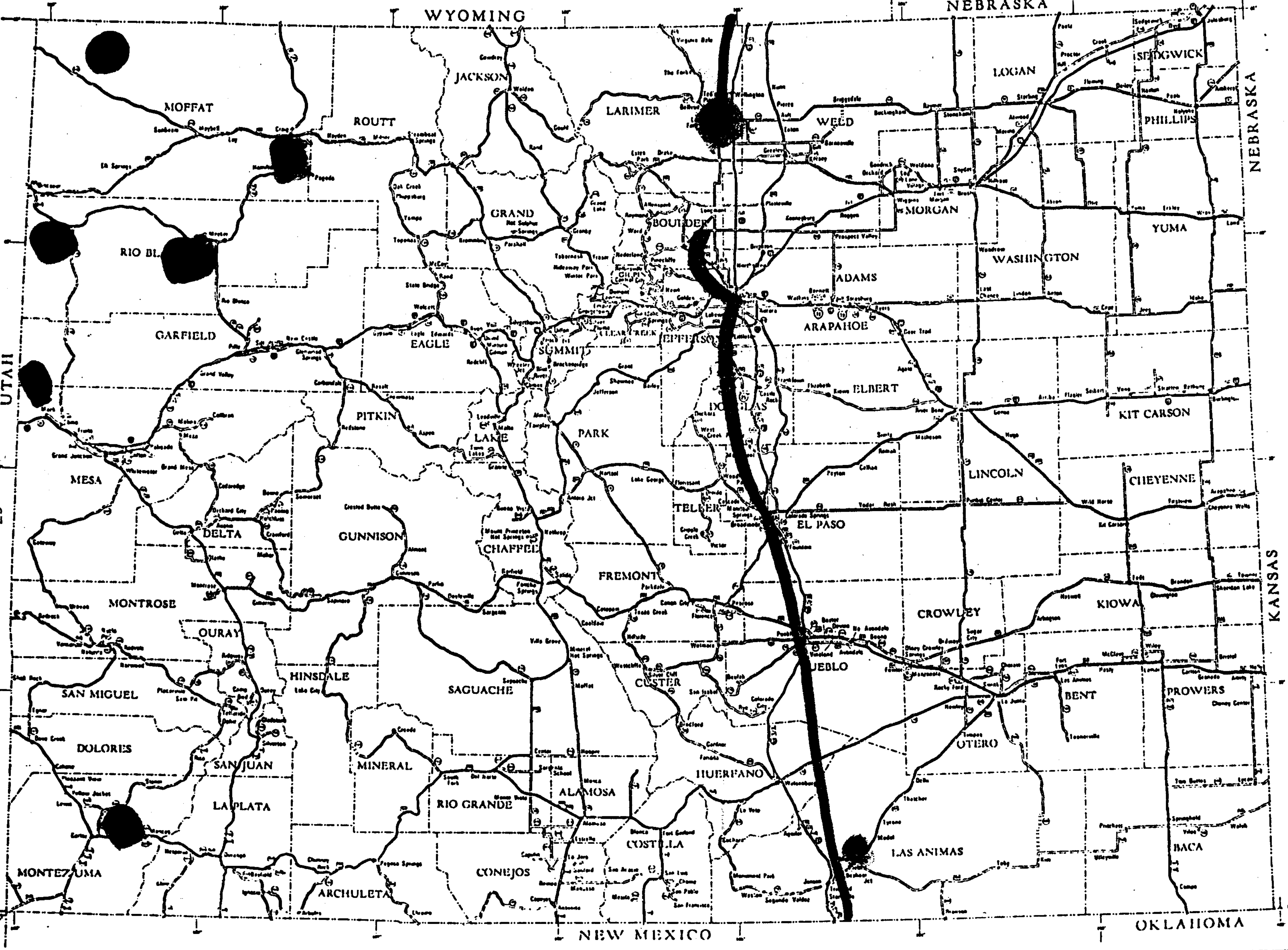

NATURAL GAS

Gas Fields ▬ Gas Pipelines ▬

10. URANIUM

NARRATIVE

Uranium is a radioactive metal generally found in very small quantities in such minerals as pitchblende and carnotite. Although uranium was discovered in the 1780s, little was known about its properties until the 1890s when discovery of its radioactivity led to a surge of scientific research. Numerous medical experiments followed upon the discovery by physicists Pierre and Marie Curie that radium, found in uranium ore, possessed intense radioactivity. In 1942 Enrico Fermi used uranium to produce a controlled nuclear chain reaction that opened the way for the development of both the atomic bomb and nuclear power as a new source of energy.

Colorado assumed an important place in the earliest efforts to produce uranium ores. Around 1871 miners working gold mines near Central City discovered pitchblende. Through the end of the century Colorado shipped many tons of pitchblende to Europe for treatment and for use in scientific experiments, although it does not appear that the Curies isolated radium from a batch of Colorado ore. However, the radium discovery stimulated uranium exploration in the state (new finds were made in Montrose Country) and encouraged efforts to improve recovery methods, with several new processes being developed and patented by individuals in Denver.

Interest in Colorado uranium reached a peak in the period 1907 to 1917. Prospectors in the remote and parched Paradox Valley of Montrose County discovered deposits of a yellow-colored ore called carnotite that contained radium and vanadium. The ore's radium content induced the Standard Chemical Company of Pittsburgh to build a mill and concentrator at a place called Coke Ovens (today's Uravan) in the Paradox Valley. The operation became the largest radium producer in the nation, utilizing heat from the ovens, water hauled by mule from the San Miguel River, and hydrochloric acid to treat the ore. The radium, worth about $40,000 a gram, was used for medical purposes, and for making luminous paint. The establishment of the National Radium Institute in Denver in 1914 significantly boosted these developments. The Institute represented a joint effort by cancer specialists who had experimented with x-ray therapy and the U.S. Bureau of Mines to produce radium. The Institute established a station (called the doctor's camp) in Long Park in Montrose County near the Crucilble Steel Company's operation and a plant in south Denver to treat the ore with nitric acid. Having produced sufficient quantities of radium, the Institute closed in 1917. World War I ended the Colarado radium boom; after the war, lower cost uranium from mines in the Belgium Congo (now Zaire) dominated the market.

By 1927 no ore was being mined in Colorado for uranium. Rather, on a sporadic basis, attention shifted to the vanadium element in carnotite as an alloy for strengthening steel. Vanadium plants operated at several locations, including Rifle and Naturita, during the 1920's, but most mines and mills shut down during the Great Depression. The United States Vanadium Corporation constructed a large mill and company town at Uravan (combination of uranium and vanadium) in 1936 which contributed to Colorado leading the nation in vanadium production in the 1940s.

The devastatingly successful project to develop an atomic bomb during the Second World War revived Colorado's uranium industry. The federal government began an inventory of strategic metals and experimented on Colorado ores. Recognizing the importance of the state's uranium resources, the government, acting through the Atomic Energy Commission created in 1946, ushered in the atomic age and a new era for Colorado uranium.

CHRONOLOGY

1780s	Uranium discovered by German scientist
1871	Pitchblende found near Central City
1890s	Carnotite discovered in the Paradox Valley
1898	Radium isolated by the Curies
1903-1917	Uranium boom in Colorado
1910	Standard Chemical Company plant built in the Paradox Valley
1914-1917	National Radium Institute in Colorado
1917	Brief uranium flurry in Boulder County
1923	Belgium Congo establishes dominance in uranium production
1936	Uravan plant erected
1940-1945	Manhattan Project to develop an atomic bomb
1942	Fermi produced a controlled nuclear chain reaction at the University of Chicago
1945	Atomic bomb dropped on Japan
1946	Atomic Energy Commission created

LOCATION

Resources associated with uranium production may exist in the Central City area and in various places on the Western Slope and in southwestern Colorado. The map denotes principal areas of uranium mining prior to 1945. It is important to note that the most vigorous period of uranium exploration and mining occurred after World War II.

CULTURAL RESOURCE TYPES

Sites include:
- Mine shafts, adits, and inclines
- Mining camps and towns
- Milling sites
- Tailing dumps

Structures include:
- Hoist house
- Trestle
- Bins
- Mills
- Tool Shed

Equipment includes:
- Drills
- Mine cars
- Ore crushers
- Roasting furnaces
- Leaching tanks

THE QUANTITY AND QUALITY OF EXISTING DATA

Historical Documentation

Few sources exist to detail the history of uranium mining and processing. The small quantity of literature reflects the marginal importance of uranium until the 1940s, a period too recently in the past to generate much in the way of reliable historical information. Recent studies that claim to have a historical basis are sometimes flawed by a highly partisan position on the issue of nuclear power. Fortunately, the main trends in early uranium development can be pieced together through research into a variety of sources. Kathleen Bruyn's Uranium Country is the best place to start since she provides a solid historical narrative, maps, and a good working bibliography. Yet her book is nearly thirty years old and needs to be supplemented from other sources. Vandenbusche and Smith's A Land Alone and Smith's Colorado Mining contain a few paragraphs on uranium. Government reports should be consulted, particularly the reports of the United States and the Colorado geological surveys and the U.S. Bureau of Mines. Contemporary mining journals, for instance the Mining and Scientific Press, are worth examining, as are newspapers. Archives in the state may possess promotional brochures and report on companies started during the "uranium fevers" in the State. In brief, much remains to be done in gathering and interpreting the history of uranium before World War II.

Number/Condition

The data are insufficient to determine the exact number of cultural resources that once existed or may have existed. The historical documentation can serve as a guide to the principal locations of uranium mining, but it is likely that more recent activities have destroyed older sites and dismantled or removed earlier equipment and structures. Uranium prospectors were a mobile group who built camps, then removed them as they moved off in search of more profitable diggings. These factors combined would tend to diminish the number and condition of resources associated with this theme.

Data Gaps

Representative campsite of a uranium prospecting party clearly discernible in place.

Representative remains of mining tools, equipment, and machinery.

Clearly discernible evidence of early mining efforts at locations that later became uranium mining centers.

Fuller historical documentation of Colorado's uranium mining industry.

Future Needs

Because of the paucity of historical documentation on this theme, a cultural resources survey and inventory should receive high priority. It seems likely that resources will add to our understanding and knowledge of uranium mining and processing. Moreover, much work remains to be done in gathering historical data, interpreting it, and making it available to researchers. Restrictions may be encountered in conducting research and surveying due to continuing national security considerations about uranium production.

Important Resources

Because uranium mining has been generally neglected by the cultural resources process, what sites, structures, and equipment survive from the early years are potentially significant and instructive. Colorado attained an early and important place in this national theme, meaning that cultural resources may have a significance beyond the state or regional level. Resources associated with what Kathleen Bruyn calls in her book the "radium era" between 1903 and 1923 may yield useful data about the progress of experience and technical know-how in handling uranium ores. Important resources may also include individuals in the state with direct knowledge about early uranium activities, and an oral history might be conducted.

RESEARCH QUESTIONS

1. What resources remain to establish and clarify patterns of uranium prospecting and mining in Colorado?

2. Can cultural resources document the changing technology of uranium mining and processing?

3. What evidence reamins to verify the early and important part played by the state in uranium development?

4. What resources remain to link uranium with the larger mineral resources development of Colorado?

5. Can cultural resources connect state mining activities with scientific advances at the national and international level?

PHYSICAL CONDITIONS

Mine shaft, adit, and incline: Should be clearly discernible as to function and should be datable beyond a reasonable doubt.

Mining Camp: Enough structures of all types should remain so that their function is clear. Should be dated and identified.

Structures: Enough should remain in place to reveal their function in uranium mining or processing. Dated to the appropriate historical period.

Equipment and Machinery: Function and operation should be clear and accurately dated to the proper historical period.

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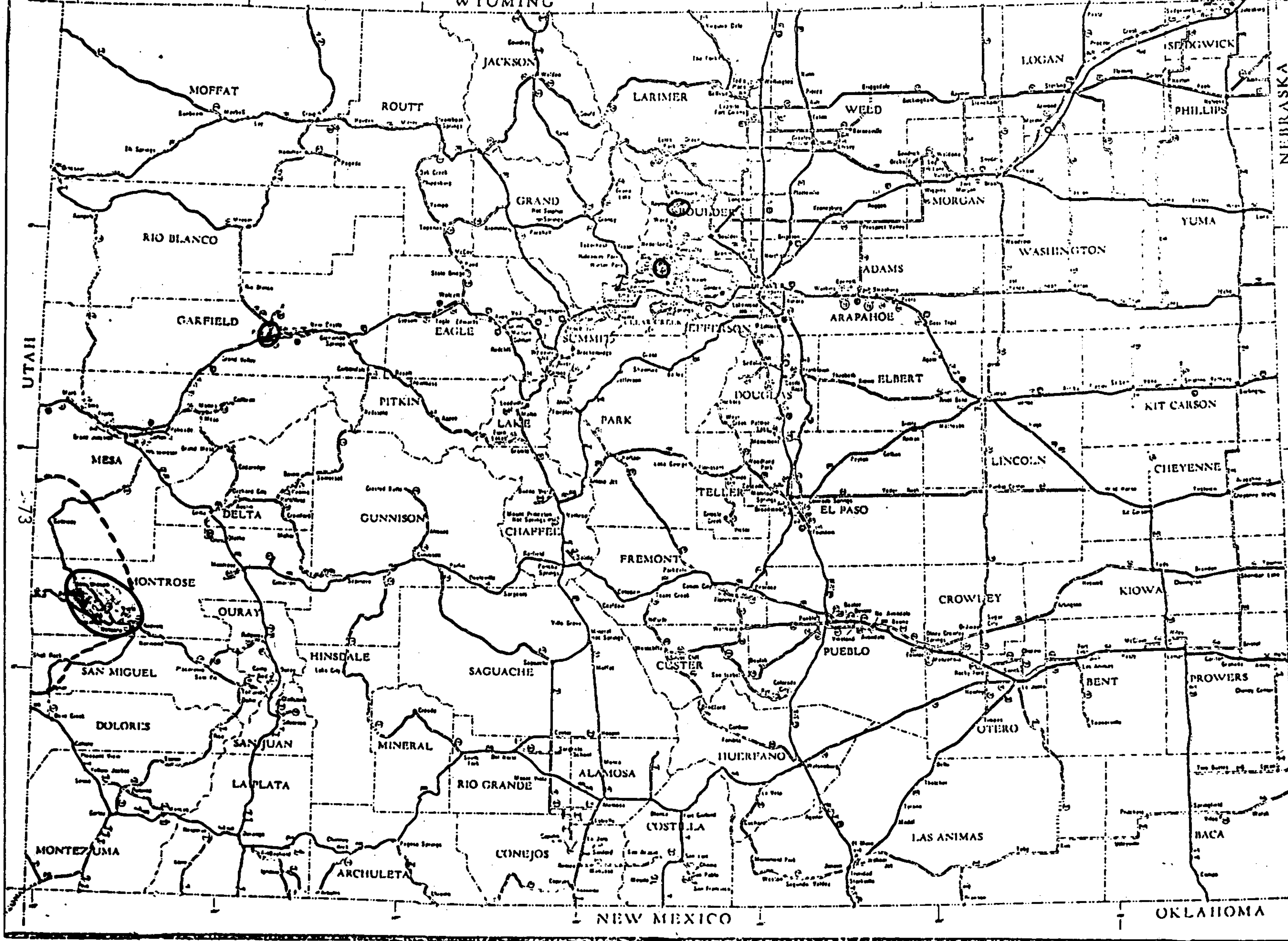
WYOMING
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ADAMS
GARFIELD
EAGLE
SUMMIT
JEFFERSON
ARAPAHOE
ELBERT
KIT CARSON
PITKIN
DOUGLAS
LAKE
PARK
MESA
LINCOLN
CHEYENNE
TELLER
EL PASO
DELTA
GUNNISON
CHAFFEE
FREMONT
MONTROSE
OURAY
CROWLEY
KIOWA
HINSDALE
SAGUACHE
CUSTER
PUEBLO
SAN MIGUEL
BENT
PROWERS
DOLORES
SAN JUAN
MINERAL
HUERFANO
OTERO
LA PLATA
RIO GRANDE
ALAMOSA
COSTILLA
MONTEZUMA
ARCHULETA
CONEJOS
LAS ANIMAS
BACA

URANIUM

11. ELECTRIC POWER

NARRATIVE

The generation and distribution of electric power began a revolution in American social and economic life at the end of the nineteenth century that continues today. Electricity changed cities by supplying a cheap, smokeless, and safe means for lighting streets, homes, and factories and by providing industry with a flexible new source of energy to run equipment and machinery. Centralized generators connected to long transmission lines successfully delivered power to remote areas where farmers, ranchers, mine operators, and others benefitted. By producing a steadily changing technology and aggressively marketing new uses for electrical power, the electrical manufacturers ranked as one of the leading industries in the country.

The commercial development of electric power began in the late 1870s and 1880s. In 1877 Cleveland, Ohio erected several carbon arc lights on a public square (Denver installed 64 arc lights in 1881). While these lights represented a major technical advance, their hazardous open flame and high intensity made them unsuitable for interior illumination. Experimenters, recognizing that the gas companies' best market was interior lighting, focused their efforts on developing an incandescent lamp for homes and factories. Thomas Edison invented such a lamp in 1879 and immediately started to develop the commercial potential of electricity. Edison built the nation's first central electric generating station in New York City in 1882. The same year a small hydroelectric plant began operations in Appleton, Wisconsin.

Edison's direct current was most efficient when transmitted short distances in densely populated areas where the high cost of copper conductors could be shared among many users. George Westinghouse's introduction of alternating current in the mid-1880s provided a superior alternative. Alternating current generated in central stations could be transmitted at high voltage over long distances to transformers that stepped down the voltage for individual consumers. Thus, an alternating current system realized its greatest advantage in economical transmission to customers distant from the central station and to low population areas, i.e., city suburbs, small towns, and industrial operations. Bare or insulated copper wires were strung on wooden or metal poles or buried beneath ground (urban areas) in wrought iron pipes to transmit the power.

Electric power made rapid strides beginning in the 1890s, a vigorous and prolific period. General Electric and Westinghouse emerged as the giants of the electrical manufacturing industry. They sold new and complex machinery to private, investor-owned utilities and municipal electric systems. Large scale power generation is generally thought to have started with the construction of a huge hydroelectric plant at Niagara Falls, New York in 1896. By the 1920s this trend enabled large private companies using big turbogenerators and interconnected transmission networks to dominate the industry. The number of small and municipal owned power plants began to decline in that decade.

Industrial demand for electricity provided an important impetus for growth. The development of the Sprague electric motor in the 1880s gave industry a more efficient source of power than steam and an excellent substitute for human or animal power. The adaptability of electric motors meant they could run a variety of machines, from drills and lathes to elevators. They also found wide use in public transportation. Electric motive power could replace horse-drawn streetcars and steam-powered locomotives, both of which dirtied the urban environment. In 1887 the large streetcar system of Richmond, Virginia was electrified.

The electrical industry met the growing demand with larger, more efficient equipment. Around 1900 central stations began to replace their large and slow reciprocating steam engines, which drove the generators, with high-speed steam turbines. These turboalternators generated enormous amounts of energy; by the mid-1930s, some produced 200,000 kilowatts of electricity. One consequence of this development was greater reliance on central power stations and fewer independent power plants in mills, mines, and factories.

The rapid expansion of the electric power industry combined with harmful speculation in the industry during the 1920s encouraged efforts at government regulation and federal power development in the 1930s. Franklin Roosevelt's New Deal created the Tennessee Valley Authority in 1933 to build dams and produce cheap electricity in several southern states. The Rural Electrification Authority, formed in 1935, offered low interest loans to rural electric cooperatives. Electricity reduced much of the drudgery of farm life and introduced many city conveniences to the countryside.

Colorado played a historic role in the development of electric power in the United States. In 1890-1891 at Ames near Telluride, L. L. Nunn used experimental equipment from the Westinghouse Company to transmit high voltage alternating current 2.6 miles to operate a mill at his Gold King mine. His successful project predated a similar and world famous experiment in Germany. The Ames plant became a kind of laboratory for commercial electrical experiments and led to important discoveries in lightning protection for high transmission lines.

Colorado mines, such as Nunn's, adopted electricity because of the high cost of transporting coal into the mountains for steam engines, the need to operate a wide variety of equipment and machinery, and the availability of mountain streams to run generators. The requirements of miners often acted as the catalyst for the early introduction of electric power into remote areas of the state. Hydroelectric developments at both Aspen in the mid-1880s and near Victor in 1899-1901 illustrate this aspect. Mining operators utilized electricity in many different ways. They applied it to run drills, air compressors, hoists, pumps, ventilating fans, haulage locomotives, and aerial tramways. Lower energy costs and greater mechanization doubtlessly extended the life of many mines in this period which were excavating lower grade and therefore less profitable ores.

Colorado kept pace with electric power developments nationwide. In the early 1880s Denver and Leadville installed arc lighting systems, followed by the introduction of incandescent lamps and larger generators. The first decade of this century saw many power plants established in the state, among them a steam generator at Lafayette in 1906 that used equipment exhibited at the St. Louis World's Fair and the Shoshone-Denver system that used A-frame towers to carry high-altitude transmission lines from a hydroelectric plant near Glenwood Springs. These and similar projects make the period 1900-1912 significant in the state's electrical and engineering history.

The presence of mountain water power, remote industrial (mining) operations with large energy demands, and the mountainous terrain made Colorado a challenge and an opportunity for electrical producers. Pioneer developments in the state contributed to the experimental stage of electricity and to its acceptance across the country.

CHRONOLOGY

1877	Cleveland installed arc lights for street lighting.
1879	Edison invented incandescent lamp.
1881	Denver installed arc lighting system.
1882	First central power station, New York City.
1882	Hydroelectric plant started in Wisconsin.
1880s	Sprague electric motor developed.
1885	Aspen hydroelectric system for lighting began operations.
1888	Tesla invented induction motor.
1890-1891	Nunn's Ames plant erected.
1892	General Electric Company formed.
1895-1896	Commercial turbogenerators developed.
1896	Niagara Falls large scale hydro project.
1896	Westinghouse Electric Company formed.
1907-1909	Shoshone-Denver system constructed.
1920	Federal Power Commission created by Congress.

1933 Tennessee Valley Authority created.

1935 Rural Electrification Authority created.

LOCATION

The adoption of electricity in Colorado was rapid and widespread. Major cities, towns, and mining areas in the mountains were the first to electrify. The map denotes areas of significant early electrical developments in the state.

CULTURAL RESOURCE TYPES

Structures:

- Central power stations
- Relay stations

Equipment and Machinery:

- Turbines
- Generators
- Alternators
- Transformers
- Transmission lines, poles, and towers
- Insulators
- Electric motors

THE QUANTITY AND QUALITY OF EXISTING DATA

Historical Documentation

The story of electricity's development and adoption in the United States is well documented in a variety of sources. The late nineteenth century, an important formative period in the technology and economics of electricity, is analytically treated by Passer's *Electrical Manufacturers* and by MacLaren's study of the industry's origins; both authors succeed in simplifying complex issues and assessing the impact of this new energy source. The forthcoming book (as well as the article cited in the reference section) by the masterful historian of technology Thomas Hughes promises to provide an interpretative framework for understanding the electrification of the western world. The chronology of electrical development published in 1946 by National Electrical Manufacturers Association should not be overlooked when trying to tie down a precise date. Additional historical information can be garnered from technical journals, such as *Cassier's Magazine*, *Electrical World*, and the transactions of the professional engineer societies. In brief, a major university library or a large public library should supply the researcher with a number of good historical sources on this subject.

Documenting electrical development in Colorado will require greater effort. The older histories of the state, such as Stone's, provide only bare facts about early projects in Colorado. Fortunately, a more recent work, that by Lawrence Robertson in the *Power Engineering Review*, expands our knowledge of technical advances. Good primary and secondary sources exist on L. L. Nunn's electrical project at Ames in the early 1890s. Further data can be gathered from research into engineering journals, government reports, newspapers, and archival materials. Public utilities in the region, particularly the Public Service Company of Colorado and Utah Power and Light, might supply information on specific sites.

Number/Condition

It is not possible from the available data to determine the exact number and type of resources that once existed or may have existed. In-depth research into the historical documents may produce a fairly complete list of sites where electrical power was generated, though not likely a full picture of the equipment, methods, and machinery employed. For instance, it appears that little remains of Nunn's pioneering operation at Ames except for one piece of machinery--the armature--which is kept in a Telluride museum. Generally, electrical producers functioned in a rapidly changing technological environment whereby old equipment was quickly replaced by the new in order to increase output or achieve greater efficiency. Modernization and expansion may have removed evidence of earlier operations. Thus, the number and condition of cultural resources need to be established by a survey and inventory.

Data Gaps

Representative evidence of early hydro and steam powered electrical stations.

Clearly discernible evidence of early transmission systems for commercial and residential use.

Representative equipment and machinery, particularly from the early days of electricity.

Future Needs

A historic engineering site survey and inventory, including electrical power developments, is highly recommended. States which have conducted such surveys in the recent past, for instance Arizona and Nevada, have located important cultural resources, particularly in hydroelectricity. The historical evidence indicates that Colorado's potential in this regard is as high as those other states. Furthermore, a great deal remains to be done in analyzing and interpreting the state's experience with electric power. At the present time only a skeletal view of electricity can be gained from the sources.

Important Resources

The early enthusiasm for electrical power in Colorado, especially in the mining industry, was an important historical development. The Ames plant of L. L. Nunn is of national even international significance, yet it has not achieved a prominent place in the standard studies of electrical power systems. Electricity was a major innovation in mining, one of the foremost industries in the state, but relatively little is known about this facet of Colorado history. Any site which would substantiate the state's role in introducing electricity to the Rocky Mountain region or to the mining industry would be an important addition to the historical record.

RESEARCH QUESTIONS

1. What resources remain to provide information on the historical development of electrical power?

2. Can cultural resources substantiate the challenges and successes of generating and distributing electrical energy in a mountainous region?

3. What evidence survives to expand or alter our understanding of the link between mining and electrical developments?

4. Can cultural resources document the changes in social and economic life caused by the introduction of electricity?

5. What resources remain to document engineering achievements in water or steam powered electrical generation?

PHYSICAL CONDITIONS

Central power station, relay station: Enough of the structure should remain in place to understand its function and its relationship to a power system. Should be dated to the appropriate historical period.

Machinery and equipment: Should be accurately dated and identified as to manufacturer, if possible. Enough of the object should remain intact to discern its function and its relation to the larger system of production and distribution of electric power.

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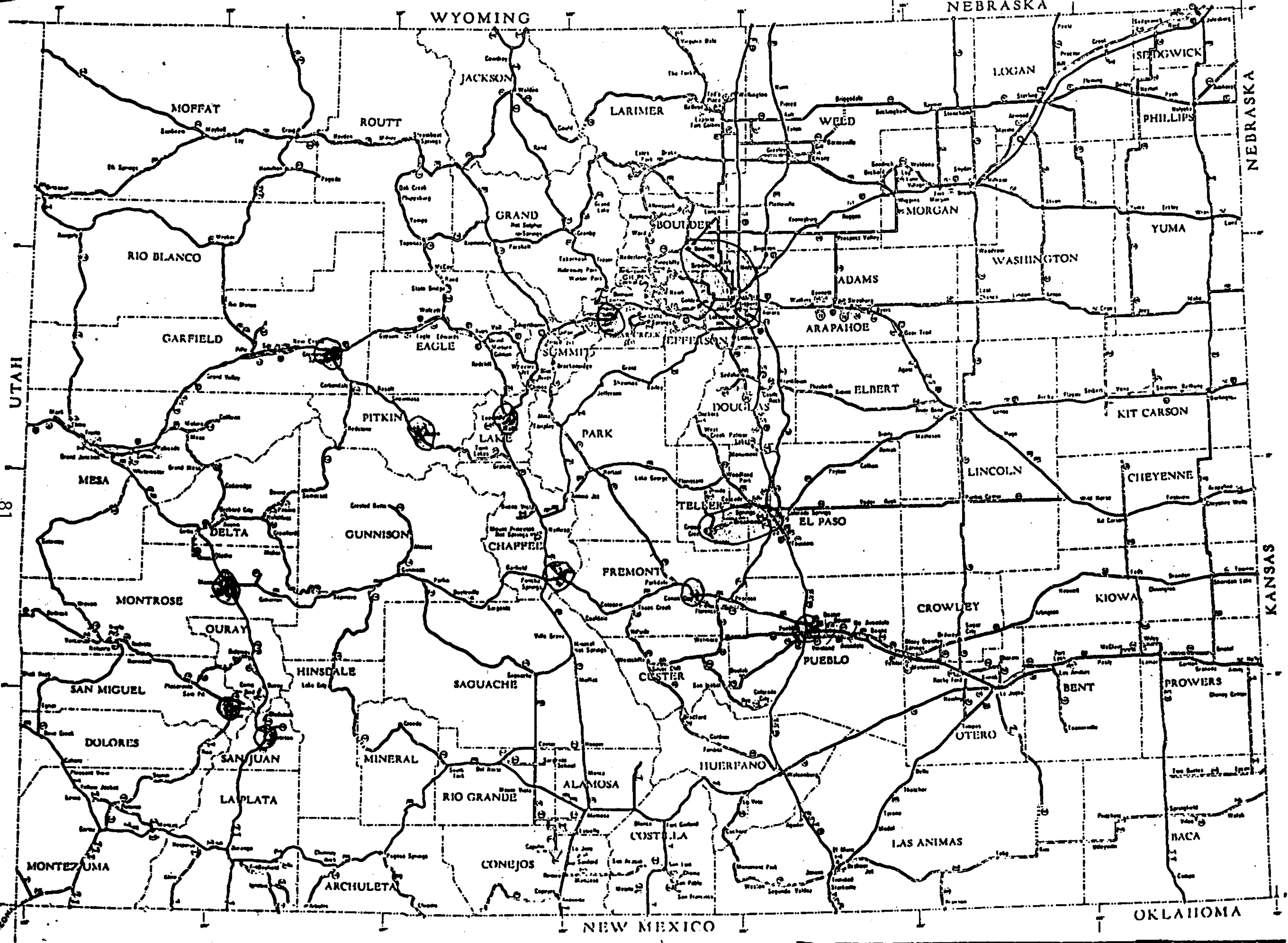

EARLY ELECTRIC POWER SITES

12. COAL

NARRATIVE

Coal was fundamental to American industrialization. In the middle decades of the nineteenth century coal began to replace wind, wood, and water as the nation's principal source of energy and the change made possible the rise of a modern factory system featuring machine production and the expansion of a railroad network using steam powered locomotives. The manufacture of iron and steel, another hallmark of an industrial society, also owed its growth to metallurgical coke used in the smelting of iron.

The significant period of coal mining in America extended from the 1830s-1840s to the late 1920s, peaking at the time of the First World War when coal supplied about 75% of the nation's energy. Anthracite (hard) coal, though the least plentiful, was extensively developed in Pennsylvania during the nineteenth century to provide fuel for homes and industry. By the 1870s, however, the rising price of anthracite encouraged greater ~~utilization~~ of the abundant deposits of bituminous (soft) coal which became the chief fuel for industry, including electric generating plants, and the sole source for coke making. Particularly in the later years of the century, the railroads accounted for much of the industry's growth. Besides being major consumers of coal and even developing coal lands, the railways provided essential transportation between producers and their markets, meaning that the success of many mining operations depended on economical freight rates. Rate considerations, intense competition between many small operators, high production, and similar factors led to low profits and considerable instability in the industry by the late nineteenth century. These economic conditions forced changes on the way coal was mined and in turn altered the life of the coal miner.

Until the late 1800s coal was dug by miners using simple tools such as picks, augers, and shovels and it was brought to the surface in mule or horse drawn mine buggies. Between the 1890s and the 1940s coal mining technology greatly changed in an effort by the industry to limit labor costs and to compete with alternative fuels. Mechanization of coal mining involved the introduction of compressed air and electric powered drills (1890s), the Jeffrey "breast machine" to undercut the coal wall or "breast" (1890s), electric or battery powered mine locomotives (1900-1912), the Joy mechanical loader that swept coal onto a conveyor belt (1920s), and the "continuous miner" developed in the 1940s. At the surface coal mines were characterized by a wooden or steel head frame or "gallows frame" for hoisting and a coal tipple where mine cars dumped (tipped) the coal for handling. Inside the tipple, coal was screened, sometimes washed, and fed into railway hoppers for shipment. Reputedly one of the first reinforced concrete coal tipples was built at Leyden, Colorado in 1912.

Until the twentieth century, almost all coal produced in the United States came from underground mines. In shaft mines, the passage to the coal bed is dug straight down from the surface; in slope mines, the passage is dug on a slant usually at the angle of the coal seam; and in drift mines, the passage enters a seam of coal on a hillside. Because American coal seams are thick and generally close to the surface, miners have used the room and pillar method to extract coal. A network of passages and rooms are cut in the seam, while thick pillars of coal are left to support the roof of the mine. Extensive underground development was made possible by this technique.

Working conditions in the mines were harsh and dangerous and wage rates were low. The isolation of most mines together with the necessity of a large work force fostered the development of company owned towns in which miners bought from the company store, rented a company house, and were even buried in a company graveyard. Labor-management disputes plagued the industry. Labor conflict touched every major coal mining region in the country, including Colorado, where strikers and National Guardsmen clashed in the "Ludlow Massacre" of 1914.

By the turn of the century miners had opened vast fields of bituminous coal in Colorado. Until the 1870s the major impetus for coal digging came from the rapid depletion of timber lands for fuel by the expanding precious-metals mining frontier. These early, small operations yielded to large scale mining enterprises as steam powered railroads entered the state and as the smelting industry demanded increasing amounts of fuel for their furnaces. Colorado's central location for transcontinental railroad service and its own internal rail network led to a great involvement by railroad companies in the development of coal mining. The Union Pacific, Santa Fe, and most notably the Denver and Rio Grande railroad produced coal through mining subsidiaries in the state during the 1880s and 1890s. William J. Palmer and other officials of the Rio Grande founded the Colorado Fuel and Iron Company (eventually controlled by the Rockefeller family, 1903-1944) that operated large coal mines in several counties. It was the leading producer of coking coal, some from a mine at Florista, which at 10,000 feet may have been the world's highest coal mine. Much of the company's coal and coke went to its own iron and steel plant opened at Pueblo in the 1880s.

The industry of coke making assumed an important place in Colorado by 1900. Coke, used by the smelting and iron and steel industries had to be imported from Pennsylvania until the 1880s when coke works were established at El Moro (1879). Coke was made by baking crushed coal at extremely high temperatures in brick beehive ovens, so called because of their dome-shaped portals. Loaded from above by mule drawn hoppers or lorries, the ovens burned night and day to produce almost pure carbon coke. Early in the twentieth century, the industry introduced the by-product oven that captured coal residues for use in making asphalt and other products.

Coal's decline as a major industry began in the 1920s. Labor strife, shortages, competing fuels, and the impact of the Great Depression of the 1930s hobbled the industry. Production picked up during World War II, but ahead lay diminishing markets as the nation's railways dieselized and steel-makers needed less coal to produce a ton of metal.

CHRONOLOGY

1860s	Coal first mined in Colorado.
1879	Coke works established at El Moro.
1880	Colorado Coal and Iron Company incorporated.
1883	John C. Osgood, a leading coal mine developer in the state, organized the Colorado Fuel Company.
1883	Coal Mining Act passed in Colorado.
1890	Founding of the United Mineworkers Union.
1890s	Compressed air and electric powered drills for coal mining.
1900-1912	Electric and battery powered mine locomotives introduced.
1914	The "Ludlow Massacre".
1920s	Joy mechanical coal loader.
1920s	Coal mining considered a "sick" industry.
1940s	Development of the "continuous miner".

LOCATION

Cultural resources related to the coal mining and coke making industry exist in various parts of the state. Primary locations are marked on the map which shows the major areas where coal mining occurred prior to 1945. Continuing mine development has tended to alter or destroy many original mining sites and others have been closed off because of their obvious hazards.

CULTURAL RESOURCE TYPES

Sites include: mine shafts, slopes and drifts. Mining camps and towns.

Structures include:

- Company houses
- Company stores
- Company offices
- Head frames
- Hoist houses
- Coal tipples
- Coal washeries

Beehive coke ovens
By-product ovens

Machinery and equipment include:

Drills
Coal cutting machines
Conveyor belts
Coal loaders
Mine locomotives
Mine cars

THE QUANTITY AND QUALITY OF EXISTING DATA

Historical Documentation

Coal mining has not generated the quantity or the quality of historical writing that exists on the precious metals. This is particularly so in regard to western coal mining. The standard source on the industry's history remains Howard Eavenson's study published in 1942, but it touches only lightly on Colorado and the other western states. The book successfully conveys the early history of coal and supplies a good context for further research in this field. One should not overlook the many governmental reports on various facets of coal or the coal mining journals, such as Coal Age. Technical information on mining methods and machinery is more difficult to find. Stack's Handbook is very helpful with its narrative of machine development and its many photographs, but introduction dates for new machines and principal manufacturers are not always given. Ketchum's book on mine structures is highly recommended. Do not expect historical interpretation of the impact of new technology from books of this kind.

Because of the company's central role in coal development in the state, Lee Scamehorn's Pioneer Steelmaker in the West is the best source of information on Colorado. He covers in detail the many coal mining operations of CF&I as well as the numerous permutations in the company's organizational structure. A fine bibliographical essay will steer you to other primary and secondary sources. Reliable information can also be gathered from the reports of the state mining inspector, publications of the Colorado School of Mines, and U.S. Geological Survey reports on Colorado coal fields. Duane Smith's book highlights major coal activities within an overview of the state's mining history.

Number/Condition

The data are insufficient to determine the number and types of resources that once existed or may have existed. From the historical documentation one can ascertain most of the coal mining sites in the state, but they are not likely to yield many resources due to the continuance of coal mining development and the tendency of the industry to replace old equipment with new technology. Only a survey and inventory can determine what remains in the state from the early periods of coal mining.

Data Gaps

Representative example of an early coal mine.

Representative remains of early coal mining tools, equipment, and machinery.

Representative example of early coal mining town with houses, stores, and business structures.

Full historical documentation of Colorado's coal mining history.

Representative evidence of coke making in beehive ovens.

Future Needs

A high priority should be given to a comprehensive historic engineering site inventory of which coal would be a major part. A prime focus should be on locating and documenting the changing technology of coal mining and handling. The importance of domestic coke works to the economic growth of precious metal smelting and the iron and steel industry means this aspect of coal merits special attention by cultural resource researchers. An interpretative treatment of Colorado coal also needs to be done.

Important Resources

So much remains to be done on Colorado coal mining that any early sites or structures associated with the industry are potentially significant. Coal helped establish an early and broad industrial base in Colorado that made the state exceptional in the Rocky Mountain region. The contributory role played by coal in railroad developments in the state is significant as are the social and cultural contributions of the multi-ethnic work force attracted to the mining camps. Any site or structure that can verify these facets of the state's history is important. Few, if any, beehive coke ovens are functioning in the United States today and those that remain should be identified by the cultural resources process.

RESEARCH QUESTIONS

1. Can cultural resources contribute to our understanding of coal mining methods and technologies?

2. What resources remain to clarify the differences/similarities between western coal mines and their generally earlier eastern and midwestern counterparts?

3. Can resources add to our knowledge of coal's economic role in Colorado history?

4. Can resources document the cultural impact of specific ethnic groups drawn to the coal mining work force?

5. What resources remain to link coal mining with the large mineral development of the state?

6. Can resources substantiate the evolution and impact of large scale coal mining enterprises in Colorado?

PHYSICAL CONDITIONS

Coal mine: Any early site that shows minimal disturbance is considered important for research and interpretative purposes.

Coal mining structures: Should be in place, with few modifications and be dated accurately. Their function in relation to mining activities should be clear.

Equipment and machinery: Function and operation should be clear and dated to the proper historical period.

Coke making: Enough of the beehive ovens should remain to convey function and be dated accurately.

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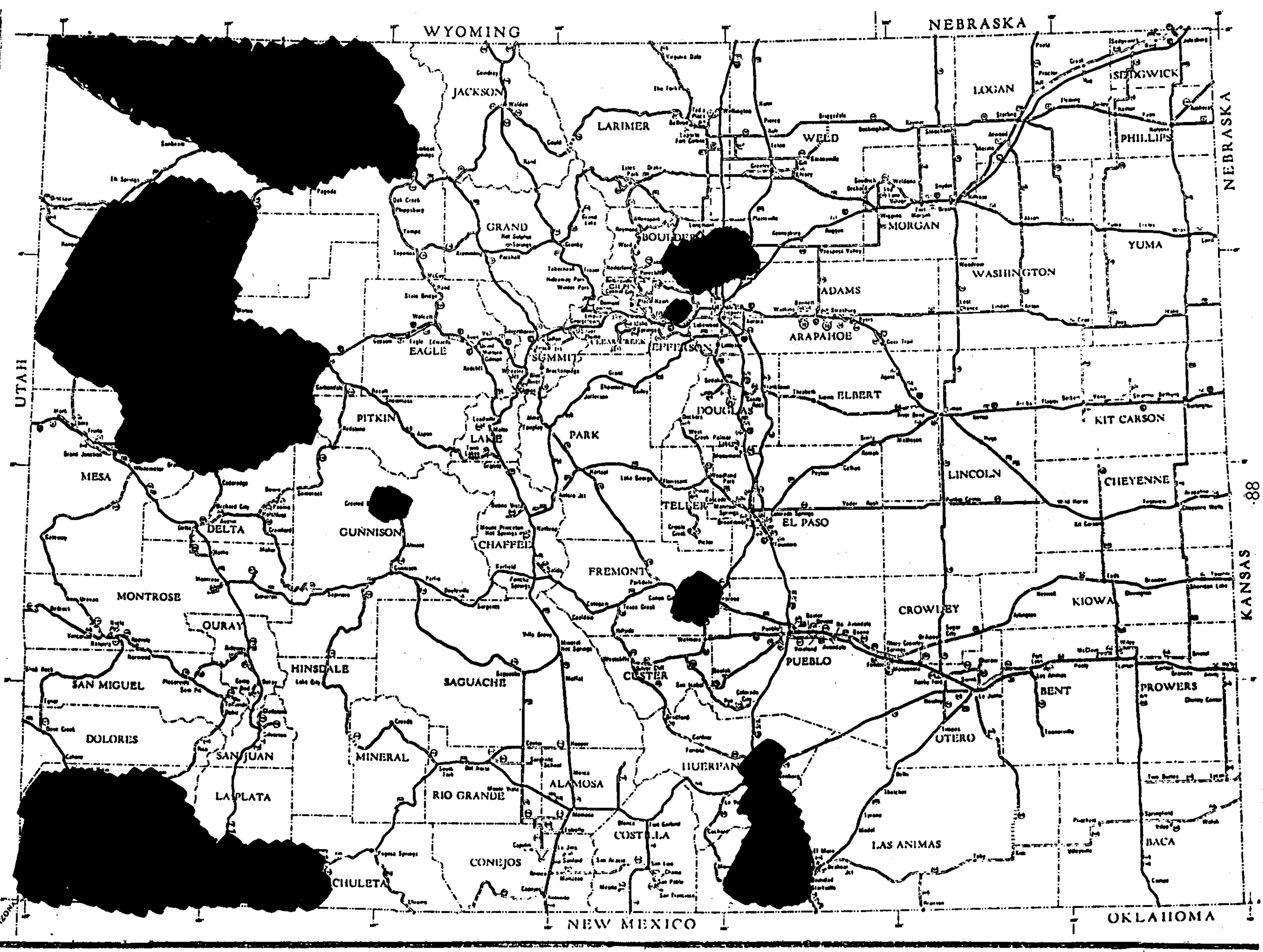
WYOMING
NEBRASKA
UTAH
KANSAS
NEW MEXICO
OKLAHOMA
ARIZONA
JACKSON
LARIMER
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PHILLIPS
GRAND
BOULDER
MORGAN
YUMA
WASHINGTON
ADAMS
GILPIN
CLEAR CREEK
JEFFERSON
ARAPAHOE
EAGLE
SUMMIT
ELBERT
DOUGLAS
PITKIN
LAKE
PARK
KIT CARSON
LINCOLN
CHEYENNE
MESA
TELLER
EL PASO
DELTA
GUNNISON
CHAFFEE
FREMONT
MONTROSE
CROWLEY
KIOWA
OURAY
CUSTER
PUEBLO
HINSDALE
SAGUACHE
SAN MIGUEL
BENT
PROWERS
DOLORES
OTERO
MINERAL
SAN JUAN
HUERFANO
ALAMOSA
RIO GRANDE
LA PLATA
COSTILLA
LAS ANIMAS
BACA
CONEJOS
ARCHULETA

COAL MINING

13. WATERBORNE

NARRATIVE

The Rocky Mountains presented a physiographic barrier to every method of travel and transportation. The history of transportation in the Trans-Mississippi West, from the overland trails to early aviation, is marked by the way the mountains deflected the movement of people and goods to easier passages north and south of the Rockies. Even the many rivers, which rose in the mountains and were navigable in their lower reaches, were unsuited to waterborne transportation in Colorado. Although early explorers and settlers to the state followed the river routes into the mountains, the streams were too narrow, shallow, rocky and treacherous to permit the development of safe and reliable transportation by boat. Instead Coloradans chose to use their valuable water resources for irrigation, water supply, hydropower, and recreation. No evidence remains of an extensive water transportation system in the state.

The absence of large-scale waterway traffic does not preclude the possibility that the state's streams transported people and goods in various places and at various times. Canoes and flat-bottomed, timber rafts frequently provided early trappers and traders with a simple means to move furs and other light cargos downstream. In like manner the wooden raft could serve as a ferry when fording a river was not possible. By rigging a rope or a cable across a stream, a raft could be pulled between the banks by a horse or a windlass. The landings used by such current ferries were rarely more than a convenient log, rock, or an overhang of land. Timbermen commonly chained logs together into a raft which could be floated down river to a sawmill.

Colorado rivers could not accomodate the steamboat that operated on western rivers and provided an important means of transportation during the middle and late nineteenth century. With their side or stern paddle wheels, shallow hulls, and steam boilers mounted on the main deck, river steamboats plied the Mississippi, Missouri, Red, Rio Grande, Colorado, and Arkansas rivers, but evidently never entered the borders of Colorado. For instance, the head of navigation on the Arkansas is Tulsa, Oklahoma. Beginning with the California gold rush of the 1850's, steamboats ran on the lower Colorado River, even extending as far north as Moab, Utah, but resulting in no permanent water transportation system. One of the most striking demonstrations of the steamboat's durability and versatility occurred on the Missouri River as vessels pushed inland as far as Fort Benton, Montana in the 1860's carrying mining and military supplies to the northern Rockies.

The standard sources of information on river transportation in the West present no evidence of any activity on Colorado rivers. The state's early economic growth coincided with, and to a great extent was made possible by, the railroad whose technology overcame the difficulties of narrow passes and high elevations. Elsewhere in the United States the arrival of railroad service decreased and often times destroyed the competing steamboat trade. In Colorado, the availability of rail and road transportation made waterborne commerce unnecessary, even if the natural obstacles could have been overcome. Thus, cultural resources for this theme will be negligible or non-existent.

In view of this analysis, a statement on resources, location, documentation, and the other elements in the RP-3 process is not in order. However, a list of references is included to support the conclusion reached in the narrative.

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14. AVIATION

NARRATIVE

The First World War (1914-1918) gave aviation a great boost by proving the usefulness of aircraft in combat, transportation, and reconnaissance. At the start of the war, American factories produced a total of 49 planes per year, while in 1918 production exceeded 14,000. The large number of surplus military aircraft available at the end of the war provided the basis of aviation's expansion in the postwar period. Aided by various federal government programs, aviation passed through its pioneering stage in the 1920s and emerged in the 1930s as an important American industry.

At first using planes and pilots from the War Department, the Post Office introduced Air Mail between major eastern cities in 1918 and started transcontinental service in 1920. Planes from New York flew west to Cleveland, Chicago, Omaha, and San Francisco, skirting Colorado because of the Rocky Mountains, but stopping at Cheyenne, Wyoming. In 1924, night flights began between Chicago and Cheyenne, which had an important impact on the development of landing and navigation systems. Besides fitting planes with landing lights similar to automobile headlamps, the Post Office illuminated landing fields with flood lights and rotating beacons developed by General Electric and Sperry Gyroscope. The system also included intermediate landing fields, spaced about 30 miles apart, and flashing acetylene gas beacons to signal pilots. With this expansion, federal air mail operations ceased. The Air Mail Act of 1925 required that the Post Office contract with private carriers for air mail service.

Federal mail contracts encouraged the growth of commercial aviation and the development of organized systems. Route 12 from Pueblo, Colorado Springs, and Denver to Cheyenne went to Colorado Airways Corporation of Denver, which utilized surplus war aircraft to inaugurate its service. Hogan Airdrome in east Denver was used for the first flight in May 1926. Passenger service also began during this time as carriers purchased larger, enclosed airplanes. Several new companies, such as Western Air Express and United States Airways, using the newly-constructed Denver Municipal Airport (Stapleton Field today), opened new routes in Colorado and to the Middle West and Southwest. To promote and regulate these developments, the Air Commerce Act of 1926 created an Aeronautics Branch within the Department of Commerce. This office had the authority to license carriers and to construct lighted airways and install navigational devices. The federal government based its role in aviation on its participation in supporting waterborne commerce; airports or docking facilities were to be provided by private business or local government, while the central government assisted navigation. Consequently, airport facilities varied greatly. Grass or gravel landing strips were commonplace, along with crude wooden buildings and metal hangars. Larger airports generally had a communications shack containing a radiotelephone.

Determined to eliminate alleged fraud and collusion in the granting of air mail contracts, Congress enacted the Air Mail Act of 1934 that cancelled all contracts, and President Roosevelt ordered the Army Air Service to fly the mail. The results were disastrous. This action disrupted regular service, raised costs, and led to the death and injury of inexperienced army pilots. Private contracts returned. Under these circumstances, more established carriers, such as Continental and United air lines, entered Colorado, while air service expanded in all sections of the country. Important government assistance appeared in the Civil Aeronautics Act of 1938, creating permanent passenger routes and granting such generous air mail subsidies that airlines were guaranteed a profit. Enjoying financial security, airlines invested in larger transport planes, particularly the Boeing 247, the first modern airliner, and the DC-3, introduced in 1935. Beginning in the mid 1930s, major airports received government-built airway traffic control centers (Denver in 1942) to aid navigation in poor weather.

The faster and heavier airplanes required airports with long and hard runways. State and local authorities would have to wait until after World War II to receive substantial federal support for airports. However, various New Deal measures designed to reduce unemployment caused by the Great Depression aided public works, including airports. The Civil Works Administration, Public Works Administration, Works Progress Administration, and other agencies constructed and improved airports between 1933 and 1941. Geared to "make work," these New Deal airports provided many minimal facilities that reverted to grass in later years. An important change in government thinking occurred in the late 1930s when the Civil Aeronautics Administration (which became the Civil Aeronautics Board in 1940) accepted responsibility for constructing and improving airports. World War II delayed expenditures, but the Federal Airport Act of 1946 provided federal funds for construction.

Military installations of all kinds appeared across the nation and in Colorado during the Second World War. The Army Air Force used Lowry Air Base, opened in 1938 near Aurora for aerial photographers, and it trained bomber crews at Peterson Air Field near Colorado Springs and at LaJunta Army Air Field. Although civilian aviation lost planes and staff to the war effort, military activities resulted in many gains to the industry after the war. Radar, more powerful engines, larger aircraft, and better landing fields are a few. In the Defense Landing Area program, for instance, the government spent heavily on constructing and improving public airports to handle military traffic. At the end of the war the aviation industry was poised for another period of rapid growth.

Chronology

1903	Wright Brothers flight.
1907	First airplane manufacturing begins in the U.S.
1914-1918	World War I.
1918	Post Office air mail.
1920	Transcontinental air mail service begins.

1924	Night flights.
1925	Air Mail Act (also known as Kelly Act)--mail contracts to private carriers.
1926	Air Commerce Act--federal aid to navigation.
1927	Charles Lindbergh's flight across the Atlantic.
1933-1941	New Deal public works programs.
1934	Air Mail Act--Army briefly carries the mail.
1935	DC-3 introduced.
1938	Civil Aeronautics Act--federal regulation of commercial aviation.
1946	Federal Airport Act.

Location

The map locates the cities served by the first air mail flights to Colorado in 1926. The information available is insufficient for recording other sites that existed or may have existed.

Cultural Resource Types

Sites include: Air fields, landing strips.

Structures include: Hangars, terminals, communication buildings, offices, radio towers.

Equipment includes: Beacons, markers, radiotelephones, teletype machines, aircraft.

THE QUANTITY AND QUALITY OF EXISTING DATA

Historical Documentation

Aviation is still a relatively new field for the historian. In such cases, the first studies tend to be broader surveys which outline the major themes and key issues while encouraging additional research on more specified topics. The development of aviation in the United States is treated in several fine historical surveys which introduce the researcher to this subject. John Rae's Climb to Greatness examines the technical and economic growth of the aircraft manufacturers, and the studies by Charles Kelly, Jr. and Carl Solberg trace the evolution of commercial aviation. Besides shaping the historical context of this theme, these books possess excellent bibliographies. Safer Airways, by Donald Whitnah, is a detailed treatment of an important facet of government's involvement in aviation and directs the researcher to a multitude of government publications on the subject. Government reports and documents are essential sources for specific research tasks. Gathering data about pre-1945 airports requires examining local materials: local histories, newspapers, and the records of municipal airport authorities. The best overview on ground facilities is a chapter in the History of Public Works in the United States, 1776-1976.

The scholarly work on aviation in the state by Professor Lee Scamehorn of the University of Colorado is very good, but concerned more with the early airlines and their equipment than ground facilities or navigation aids. The more recent histories of the state, such as A Colorado History (1976) by Carl Ubbelohde, Maxine Benson, and Duane Smith, contain some information on military activities during World War II.

Number/Condition

The data do not allow an exact determination of the number or type of resources that existed or may have existed. However, major airports and most secondary ones that remain are readily located and the condition of their cultural resources ascertainable. Some early "airports" were no more then than grassy fields or pastures with a temporary building or two, and, as late as the 1930s, New Deal work programs produced only temporary facilities leaving little on-the-ground evidence. Some early equipment associated with this theme may survive.

Data Gaps

*Representative early air field with discernible runways and support buildings.

*Representative equipment for marking airways and landing fields.

*Representative communications equipment from the early days of flying.

Future Needs

A need remains for gathering historical documentation on pre-1945 developments in the state and for analytical studies of aviation's impact on transportation in Colorado. This effort should extend beyond commercial aviation to study general aviation (privately-owned aircraft and ground facilities) and military aviation. An oral history program is advisable in view of the relatively recent character of this theme. Lastly, an historical engineering site survey should be undertaken which includes aviation within the goals of the project. The rapidly changing technology of this industry at all levels means that most cultural resources which may remain are at risk until a survey begins.

Important Resources

The earliest sites, structures, and equipment are the most important. Aviation is significant in the state's history because of Colorado's distances, mountain divides, rugged terrain, and remote settlements, which had restricted other methods of transportation. Industries related to natural resource development improved their range and mobility through aviation. Denver's emergence as a principal air travel center is additional evidence of this theme's importance. Any site which adds to our knowledge of these developments is potentially significant.

RESEARCH QUESTIONS

1. Can cultural resources provide information on the historical growth of aviation in the state?

2. Can resources document the changing design and technology of ground facilities and air navigation?

3. What resources survive to demonstrate the early contributions of government, at all levels, and private business to the introduction of aviation into Colorado?

PHYSICAL CONDITIONS

Air field: Any site that dates to an early period and shows no more than slight disturbance can be important to research.

Hangars, terminals, offices, towers: Must be in place and dated to the appropriate historical period. Function and relation to other resources on the site must be clear.

Equipment: Enough should remain intact to convey function ~~and should~~ be dated and identified.

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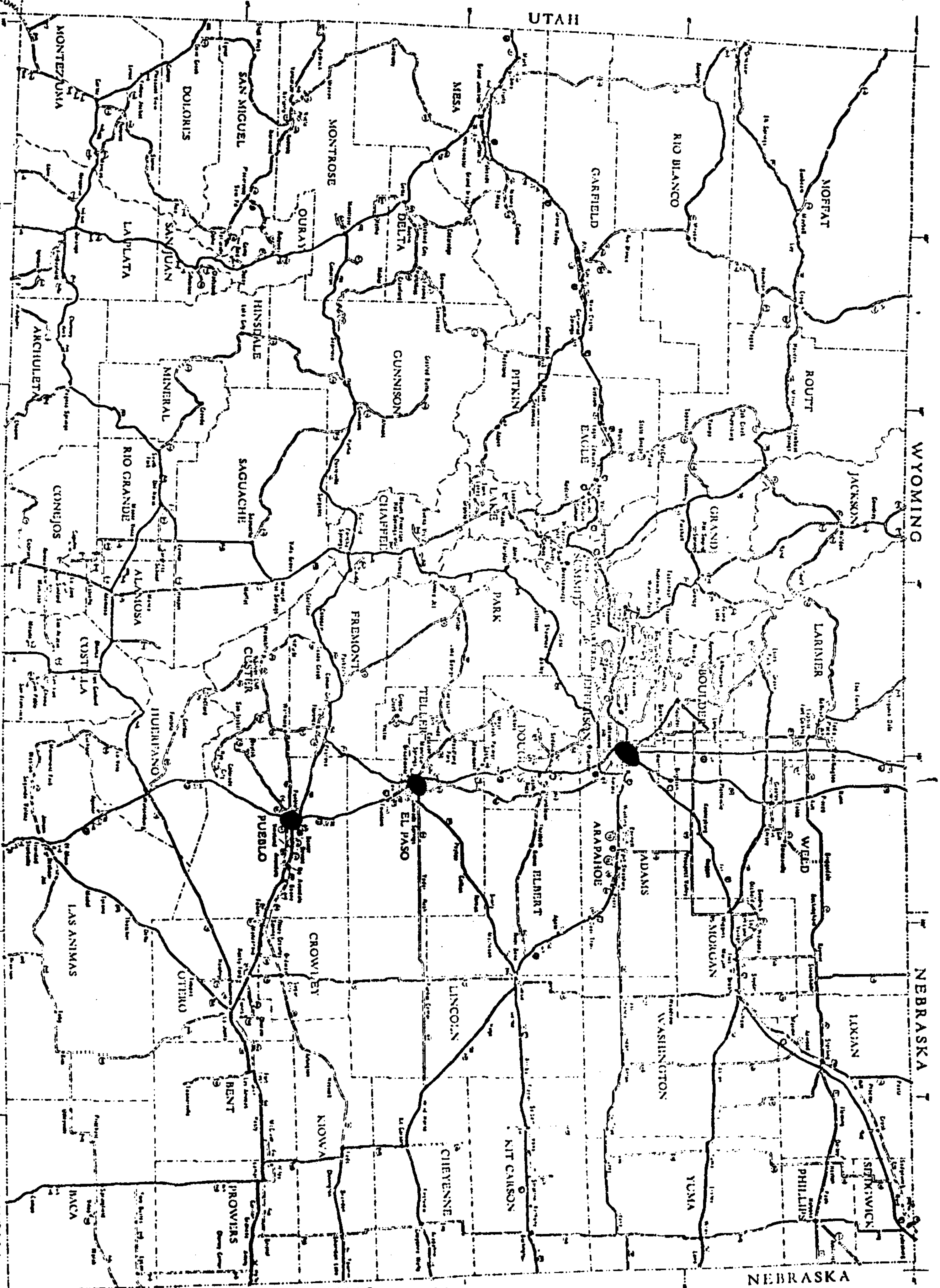

AVIATION (FIRST CITIES WITH AIR MAIL SERVICE)

15. RAILROADS

NARRATIVE

The period 1830 to 1920 belonged to the railroad. During this time the American railroad evolved from a few horse drawn carriages on wooden rails to a steel and steam transportation network that spanned the continent and helped transform the nation into a modern urban and industrial society. Its impact was broad and pervasive: the railroad was a source of technological change that affected many other industries; it was the nation's first "big business" and a major employer; in the form of interurbans and trolley lines, it provided mass transit and contributed to the rise of the suburb; and, the railroad served as the catalyst for increasing governmental regulations of the economy. Railroad expansion peaked between 1865 and 1915 when mileage grew from 35,000 to one- quarter of a million miles. The first transcontinental railroads were built across the West in this period, and construction crews followed miners into the Colorado mountains to provide the state with a cheaper and more dependable way of transporting goods and people than the horse and carriage.

Colorado railroad building, from its start around 1870 through the end of the century, reflected national trends, including haste and waste. Dozens of companies sprang into existence, surveyed routes to the mining camps and hurriedly laid tracks to outmaneuver the competition and seize a strategic advantage. This kind of struggle in Colorado is illustrated by the 1897-1898 "war" between the Santa Fe and the Rio Grande railroads to control Royal Gorge as a passageway to Leadville. Under these circumstances, early lines were built quickly rather than well, necessitating rebuilding and adding permanent facilities at a later time. Timber trestles served as temporary structures, and looping circles of track to scale the mountains helped to avoid the expense and delay of boring a tunnel. The Colorado Central's Georgetown Loop and the Rio Grande Southern's Ophir Loop are well known examples.

While some narrow-gauge railroads were built in the East during the 1870s, Colorado was first and led all other states in narrow-gauge mileage (about one-third of the state's total railroad mileage). Its lower cost and advantages in negotiating mountain curves made narrow-gauge lines popular. Instead of a standard gauge of 4 feet, 8½ inches (many railroads eventually added a third rail, making a dual gauge that permitted interchanging), William J. Palmer chose a three foot gauge for his Denver and Rio Grande Railroad in 1871, figuring to save money on rail, equipment, and maintenance and to make sharper turns in the mountains with his lighter, smaller equipment. Purchasing English made 30 pound iron rail and English steam locomotives, Palmer's railroad became the first north-south railroad west of the Mississippi River and it began to snake its way into the mountains to reach the new mining camps (in 1887 the Colorado Midland became the first standard gauge railroad to cross the Rockies). Not having federal land grants, the Rio Grande laid out new townsites, such as Colorado Springs, to increase traffic on the road.

The spreading railroad system of the late nineteenth century adopted technological innovations, many to keep up with the development of heavier and faster trains, and also erected on assortment of specialized buildings and structures. Standard roadbed consisted of wooden crossties embedded in a gravel base, and the railroads gradually converted from iron rail to more durable steel rail, particularly in the 1880s and 1890s. The weight of the rail (measured in pounds per yard) also became heavier. In the 1870s electrically operated block signal systems and switch controls appeared which led to automatic train controls in the 1920s. Wooden, brick, and stone buildings (many of standard design) performed various functions along the right of way. Lesser structures included watchmen's shanties, flag depots, ice houses for supplying passengers and refrigerated cars, sand houses where greater friction was needed on steep or slippery grades, and oil storage and mixing houses. Among the medium sized buildings were small town depots, loading platforms, section houses for employees, signal towers, coaling stations, and freight houses. Major structures, generally found in railroad yards and cities, included passenger terminals, car barns, and locomotive roundhouses. The great water requirements of steam locomotives were met by water tanks and pumps placed at five to twenty mile intervals along the route. If the water supply was above the line as was often the case in the mountains, a gravity flow system carried the water to reservoirs or settling tanks stationed near the tracks. Steam railroads also located ashpits in yards and sidings and occasionally on a main line for dumping the contents of locomotive fireboxes.

Colorado's geography and climate influenced railroad engineering. Faced with steep grades and heavy snowfall in the mountains, railroad men accepted the necessity for tunnel building. Boring tunnels through hard rock required skill, labor, capital, technology, and explosives. The methods of tunnel making in the late 1800s were greatly influenced by the construction of the Hoosac Mountain railroad tunnel in Massachusetts during the 1860s and 1870s. Tunnelers there used a central CORE method--driving a pioneer bore from both sides of the mountain to guarantee alignment and to test rock characteristics. The Alpine railroad tunnel at Altman Pass in 1880-1881 and the monumental Moffat Tunnel at Rollins Pass, completed in 1928, were built on a pioneer bore. A major engineering feat, the Moffat Tunnel opened northwestern Colorado for development. Under unusual circumstances, a railroad near Victor in 1898 constructed a steel tunnel above ground to shield its track from a growing mine dump. To reduce the effects of snow accumulation, mountain railroads tended to build on the north side of a valley for maximum exposure to the sun. They also constructed hundreds of snowsheds consisting of round or square timber bents covered by plank roofing and siding (galvanized iron was also used). Designs varied, depending on the physical features of a location, but the two main types were valley sheds used on hillsides and gallery sheds erected on level ground. The latter, similar to a wooden tunnel, protected against heavy snowfalls in open areas.

The railroad also changed transportation in urban areas. The electric interurban railway filled an important transitional state between passenger railroads for short distances and the adoption of the automobile. From 1890 to 1915 many interurban lines were built to connect major cities with their suburbs and outlying small towns. Primarily running single car trains, these systems initially generated their own electricity with steam turbines and distributed power to the cars through trolley wires strung over the track. Five lines operated in Colorado: two in Denver, and one each in Cripple Creek, Trinidad, and the Grand River Valley. The Denver and Intermountain Railroad (part of the Denver Tramway) provided service to Golden and the suburbs, while the Denver and Interurban Railroad (1908-1926) ran to Boulder. The Grand River Valley Railroad (1910-1935), known as the Fruit Belt Route, operated between Grand Junction and Fruita, carrying passengers along with fruits and vegetables. All of these lines wrestled with automobile and bus competition, and most succumbed in the 1920s and 1930s.

New technology altered street railways in most major cities, including Denver, in the 1880s. Although horse cars continued to run, the Denver Tramway Company, organized in 1886, began cable car service in 1888, utilizing a moving steel cable buried in an underground conduit. The cable was gripped by grooved steel bars brought together by the gripman who operated the car. Denver's seven mile long cable (owned by the Denver City Cable Railway) in 1890 was reputed to be the longest single cable in the world. (By way of contrast, the Durango Railway and Realty Company, which owned a two mile line between Durango and Las Animas, may have been the shortest street railway in the nation). During the 1890s the Tramway converted to electric streetcars. The company built car barns, power stations that consumed coal from its mines near Leyden, and purchased trolley cars from the Woeber Carriage Company in Denver. In 1940 Denver Tramway introduced trackless trolleys or trolley buses, foreshadowing the demise of trolley. Yet the streetcars impact on cities had been enormous: it had extended the suburbs, strung out shopping areas, created shopping centers away from downtown, and fostered amusement parks, ballparks, and other urban diversions to insure traffic on the weekends.

By the 1930s the railroad's place in American transportation was being superceded by automobiles, buses, and airplanes. The Second World War revived the railroads to meet the great demand for moving troops and war materiel, but passenger service resumed its decline after the war. New technology, notably dieselization and piggybacking of truck trailers, were attempts to keep the railroads competitive in the postwar period.

CHRONOLOGY

1828	Start of railroad building--Baltimore and Ohio
1850-1872	Federal land grants to railroads
1865	First domestically produced steel rails
1869	First transcontinental railroad completed
1870	Kansas Pacific reached Denver and Denver Pacific opened to Cheyenne
1871	Horse drawn streetcars appeared in Denver. Denver and Rio Grand--first narrow gauge railroad in U.S.
1877-1878	Royal Gorge "war"
1880-1882	Peak years of Colorado railroad building

1885	Colorado begins railroad regulation
1888	Rock Island is last transcontinental railroad to enter Colorado. Cable cars introduced to Denver
1890-1915	National enthusiasm for electric interurbans
1890s	Denver Tramway converts to electric trolleys
1906	Argentine Central Railroad's scenic route to Mount McClellan at Silver Plume--highest railroad in America
1913	Colorado Public Utilities Commission created
1916	National railroad mileage peaks at 254,000 miles
1927	Centralized traffic control developed
1928	Moffat Tunnel completed

LOCATION

Maps for virtually all lines that operated in the state can be located in historical sources.

CULTURAL RESOURCE TYPES

Major Types Include:

Standard gauge
Narrow gauge
Dual gauge

Railroads Include:

Trunk lines
Feeder lines
Industrial railroads
Interurban railroads
Cable railroads
Trolleys
Cog railroads
Inclined-plane railroads

Equipment Includes:

Steam, electric, diesel locomotives
Passenger and freight cars
Roadbed
Track
Iron and steel

Signal systems
Wire and switches
Turntables
Trolley wires and poles

Structures Include:

Depots
Control towers
Water tanks
Coal tipples and chutes
Tool, sand, and oil sheds
Section houses
Snowsheds
Car barns
Roundhouses
Power houses and relay stations
Platforms
Bridges and trestles
Tunnels
Terminals

THE QUANTITY AND QUALITY OF EXISTING DATA

Historical Documentation

Professional historians and amateur enthusiasts have produced an enormous amount of information about railroads both nationwide and in Colorado. A major university library and large public libraries will contain the standard sources as well as many of the regional and local studies. John Stover's American Railroads remains the best introduction to the subject before one attacks the more detailed histories of major lines, such as the excellent histories of the Rio Grande or Union Pacific by Robert Athearn. His books offer comprehensive treatments and useful bibliographies. Regional publishers, such as the Colorado Railroad Museum and Pruett Press, have regularly issued fine books on Colorado railroading. Particularly notable is Tivis Wilkins' Colorado Railroads for its chronology, detail, and photographs. Abundant primary materials also exist in the form of company papers, journals and newspapers, and government documents, for example, the annual reports of the Colorado railroad commissioner.

Interurban and trolley systems have not been so extensively and lavishly treated. George Hilton's studies of the cable car and electric interurban are highly-regarded standard sources, and each covers developments in Colorado along with good maps. Though George Miller's Fares Please! is old and popular, its overview is still a solid and readable introduction to an important topic. Mile-High Trolleys by Jones, Wagner, and McKeever presents a sparse narrative, but a superb photographic record of Denver streetcars.

Despite the vastness of railroad material, little attention has been directed to structures and buildings, with the exception of depots. One must dig for data on railroad practices in this area. Walter Berg's Buildings and Structures of American Railroads is of great value, but it does not refer to specific Colorado lines. However, just as Berg wrote for the benefit of railroad managers, so also did the Association of American Railroads, the journal Railway Age, and the American Railway Engineers Association which issued maintenance manuals on track, equipment, and buildings to assist the professional. The researcher should consult these publications for contemporary practices and for the names of major manufacturers and suppliers.

Number/Condition

The data are not sufficient to determine the number and types of resources that once existed or may have existed. However, there are many resources within this theme that have been well documented, preserved, and interpreted. Particularly significant is the cooperative effort by New Mexico and Colorado to preserve the scenic Toltec and Cumbres Railroad. Files at the Colorado Preservation Office contain additional information on sites and structures in this theme.

Data Gaps

Representative railroad buildings and structures.

Representative buildings and structures of interurban and street railways.

Future Needs

A specific survey to locate and inventory evidence of railroad building in Colorado is not recommended. Railroads have enjoyed considerable attention from such groups as the Colorado Railroad Museum in Golden, and have been the subject of major restoration projects, the Georgetown Loop for example, which indicate a high-level of preservation interest and accomplishment. However, when the state undertakes its overdue historic engineering site survey, railroads must be included and a systematic approach taken to field surveying for railroad resources. Surveyors should be especially mindful of buildings and structures, which have received less attention than moving equipment.

Important Resources

Although many important resources have been recognized by the cultural resources process, the tremendous importance of the railroad to the state's development and the extensiveness of the railroad network means that other sites, structures, and equipment may be historically significant. This theme is by no means exhausted. Any site or building that lends further substantiation to the railroad's impact are worth documenting and inventorying.

RESEARCH QUESTIONS

1. Can resources verify engineering methods adopted for a maintainous environment?

2. What evidence remains to document the construction strategy of railroad companies in the state?

3. Can resources demonstrate the changing technology of railroad, interurban, and street railway systems?

4. To what extent can resources show the influence of national technological trends on practices and developments in Colorado.

PHYSICAL CONDITIONS

Right of way, track: Must be discernible, accurately dated and documented, and show minimal surface distrurbance.

Equipment: Must be accurately dated and documented. Its function should be made clear.

Structure: Enough should remain to understand its function and be documented and dated to the appropriate historical period. With a few exceptions, i.e. bridges, structures should be in their original location.

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16. ROADS

NARRATIVE

The history of roads in America can be divided into four major phases: (1) late eighteenth century to about 1850, enthusiasm for internal improvements resulted in several efforts at road construction in the eastern states; (2) 1850s to 1890s, the "dark ages" of road building due to a national emphasis on railroads; (3) 1890s to about 1920, the bicycle and automobile generated a strong "good roads" movement; and (4) since 1920, the era of scientific road building. As late as the early twentieth century, poor planning, primitive construction, and a general state of neglect characterized American roads. A prime reason for this state of affairs was the practice of placing responsibility for roads with local officials who usually lacked resources for the task.

Various factors influenced road building during the nineteenth century. Common roads were made by hand labor using farm implements along with a few specialized tools such as wooden scoops and drag scrapers. Dusty or muddy most of the year, these roads barely proved adequate for horse and wagon traffic. Near larger settlements, gravel or the improved stone surface advocated by Englishman John McAdams (a macadamized road was made of broken and compacted stones) afforded better weather resistance. The search for an improved surface included the use of wood. In swampy areas, saplings laid side-by-side formed a corduroy road, and wooden plank roads appeared in the 1840s (planks laid end-to-end were sometimes used for automobiles in desert areas of the west); all wooden roads were expensive to construct and maintain. Faced with growing populations and heavier wheeled traffic, American cities helped introduce new methods and technology for road building. Rock crushers, steam driven road rollers, and mortar mixers mechanized building projects, while new materials such as bituminous cement hardened surfaces.

With few reasons to construct national or even extensive state road systems prior to the automobile, roads remained essentially a local matter. County officials generally built and maintained roads through the corvée system in which personal labor on the roads served in lieu of taxes. Besides resulting in poorly built roads, this method often saw roads made along the land section lines to avoid disputes with land owners, but oblivious to natural obstacles or purposeful planning. Political and constitutional concerns limited federal government involvement in road building for most of the century, notable exceptions being the National Road between Maryland and Illinois and wagon and military roads in western territories.

Beginning in the 1890s both federal and state governments responded to calls for better roads. Bicyclists, acting through the League of American Wheelmen based in the northeast, joined by growing numbers of automobilists and by farmers who resented dependence on the railroads exerted pressure for road improvements. These elements helped create the National League for Good Roads in 1892 that became a focal force for change. In the 1890s an Office of Road Inquiry was formed within the U.S. Department of Agriculture to study road building, the Post Office started Rural Free Delivery which encouraged federal participation in road issues, and several states set up highway departments. Further federal support came in the creation of the U.S. Bureau of Public Roads in 1902 and in the enactment of the important Federal Aid Road Act of 1916. The latter left road decisions in the states, but provided matching funds for building rural roads and ordered federal inspections. Subsequent legislation also provided incentives for making state road systems.

Twentieth century road developments have been linked to the rapid and widespread adoption of the automobile, leading to what one historian has termed America's "car culture." The auto's higher speed and rubber tires rendered obsolete the dirt and gravel roads once sufficient for horse and wagon. Greater use of asphalt, Portland cement, brick and other hard pavements accommodated the automobile. Transportation bottlenecks during World War I spurred plans for a national network of good roads. As early as 1911 the Lincoln Highway Association, a private group, promoted a coast to coast highway. During the 1920s some eastern states constructed parkways and New Deal relief programs of the 1930s stressed local and state projects rather than a national system. World War II interrupted most road projects. Thus, a program for long distance express highways waited until 1956 when the Federal Aid Highway Act began construction of the present interstate highway system.

In its formative era Colorado, like eastern states around 1800, made use of privately built toll roads. While settlement patterns did not produce a broad population base for public roads, mining towns required improved roads for moving heavy machinery and ore wagons. Private roads filled these purposes. During the 1880s companies headed by Otto Mears, acknowledged as the "Pathfinder of the San Juans," built several toll roads in the rugged country of southwestern Colorado to reach isolated mining camps. One of Mears' major achievements was constructing a toll road along the perilous cliffs of Uncompahgre Canyon to link Ouray with Red Mountain.

The advent of the automobile in Colorado increased government participation in road projects. Beginning in 1899, with a road between Pueblo and Leadville, the state employed convicts to construct and maintain roads; convict labor completed the scenic Royal Gorge road around 1911. As happened elsewhere in the early twentieth century, various "good roads" organizations in Colorado favored a state highway commission which was formed in 1909. Support for better roads also came from the emergent auto tourist industry. In 1919 the state enacted a gasoline tax to finance road building and participate in federal aid programs. Road building also occurred under the auspices of federal agencies in the many national forests and parks in the state.

CHRONOLOGY

c1820s	John McAdams principles influence road making.
1850-1890s	National transportation dominated by railroads.
1858	Invention of Blake steam-powered rock crusher.
1880s-1900	Colorado's Internal Improvement Fund, based on revenues from land sales, used for roads and bridges.
1880s	Otto Mears' toll roads in San Juan region.
1890s	Bicycle craze promotes better roads.
1890s-1910	Beginning of the automobile age.
1890s	Start of "good roads" movement.
1899	Start of convict labor road program in Colorado.
1902	U.S. Bureau of Public Roads created.
1909	Colorado Highway Commission formed.
c1910	Portland cement used for roads.
1916	Federal Aid Road Act
1919	Colorado gasoline tax.
1920s	Begins scientific road building.
1930s	New Deal programs include public roads.

LOCATION

Several maps are appended to illustrate the expansion of a Colorado road system between 1911 and 1948.

CULTURAL RESOURCE TYPES

Sites include:
- Dirt roads
- Timber and wooden plank roads
- Asphalt roads
- Brick roads
- Concrete roads
- Toll roads
- Turnpikes

Road building tools and equipment include:
- Scrapers and graders
- Rollers
- Mortar mixers
- Rock crushers

THE QUALITY AND QUANTITY OF EXISTING DATA

Historical Documentation

An extensive amount of historical literature can be found on roads and road building in America. The best interpretative studies have been done by John Rae, The Road and Car in American Life and Labatut and Lane, Highways in Our National Life, which view roads in a historical context of technological, economic, and cultural change. Detailed information about the impact of government participation in roads is available in the Federal Highway Administration's account of federal aid programs. Both Wixom's and Allhands' books rely on photographs to convey changing methods and machinery for road building, making them useful for identification purposes. Utilizing all of these sources, one can reliably date and authenticate most major developments in road history. Additional data can be taken from trade journals, government reports, and publications of the professional engineering societies.

Locating specific information on Colorado roads presents a more difficult problem. In many cases local developments followed national trends, thus making general historical sources useful for research on the state level. Most of the standard histories of the state contain some references to roads, and Colorado Magazine contained several useful articles. Government documents, particularly reports by the state engineer, are essential tools for the researcher. Private roads may be documented from the incorporation files at the state archives and in local libraries. Newspapers, county histories, and the publications of private automobile and road associations should also be consulted. Exercise care, however, in using any promotional materials.

Number/Condition

Sites can be identified on reliable maps such as the U. S. Geological Survey Quadrangle maps. While the original route followed by a road may not have changed, the condition of the road will likely reflect the passage of time and various changes brought on by widening, repairing, and repaving. Original road surfaces will rarely be encountered.

Data Gaps

Representative examples of early road building tools, machines, and equipment.

Representative evidence of early roads displaying various surfaces and engineering techniques.

Future Needs

A need remains to identify and document early roads built in the state. Roads may merit recognition in the cultural resources process for a variety of reasons: early date, builder, difficulty of construction, building materials, design, importance to an area's historical development, and similar considerations. Making an assessment of this kind will require considerable research into documents as well as a comprehensive site survey directed by a professional who is knowledgeable of transportation developments in the state and the technical stages of road building.

Important Resources

Most roads in the state should not be considered significant. Important ones can be identified by careful research in archival and library materials and through a field survey. Roads can help clarify patterns of expansion and settlement and reveal the growth of agricultural, mining, manufacturing, and tourist industries in the state. The road projects of Otto Mears in southwestern Colorado are important, but additional work is needed on the history of private roads in the state, particularly those constructed in the 1860s.

RESEARCH QUESTIONS

1. Can cultural resources either expand our knowledge or alter our interpretation of transportation developments in the state?

2 What was the relationship between roads and other means of transportation?

3. Can cultural resources verify technical changes in road building?

4. What evidence remains to clarify patterns of settlement and the growth of major economic activities in Colorado?

PHYSICAL CONDITIONS

Road: Enough of the original should remain in undisturbed condition to reveal an early building technique.

Equipment and Machinery: Should be identified to the correct historical period and should be in condition to reveal its function and operation.

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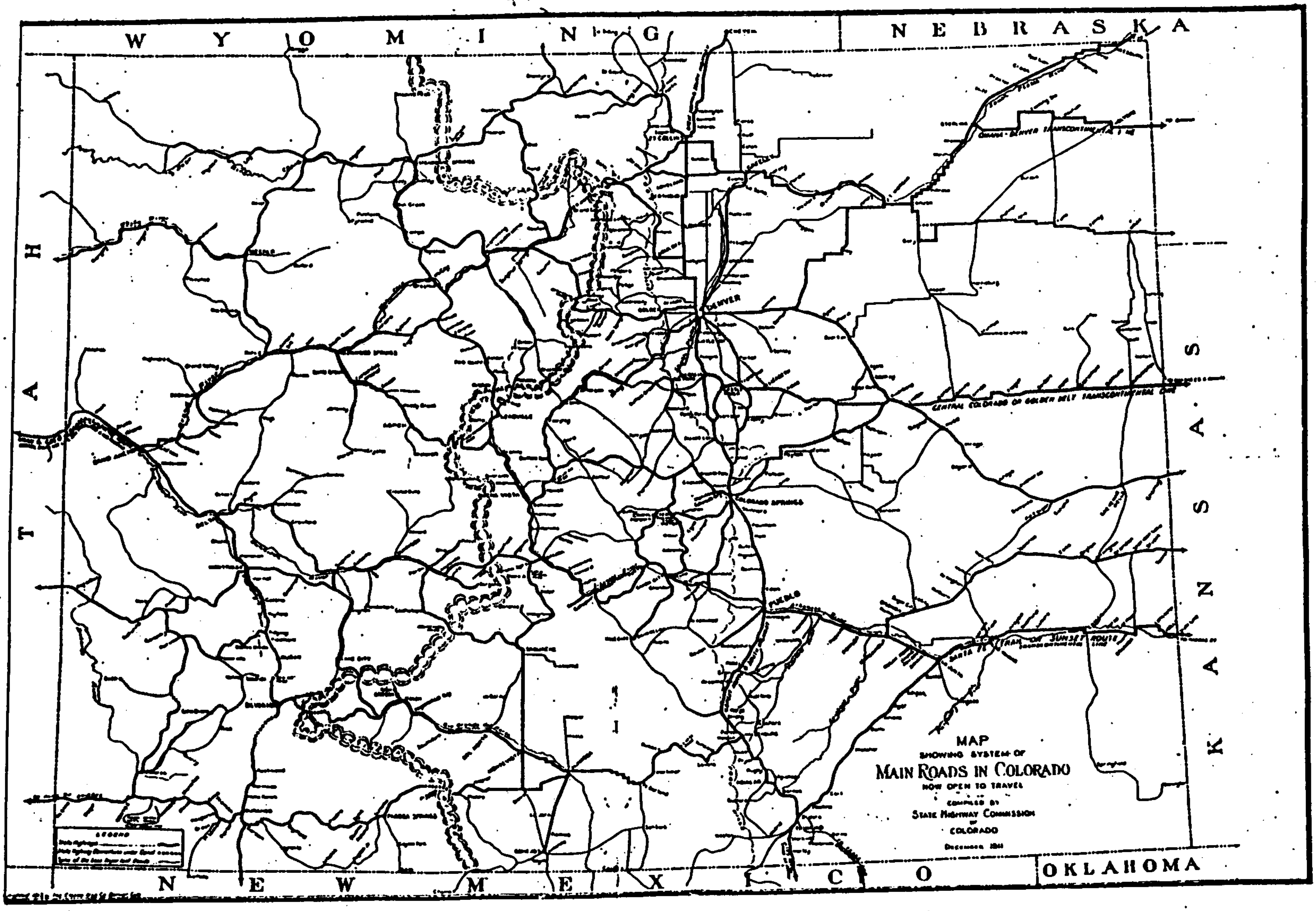
Figure 1. Colorado Wagon Roads Designated as State Highways by 1911.



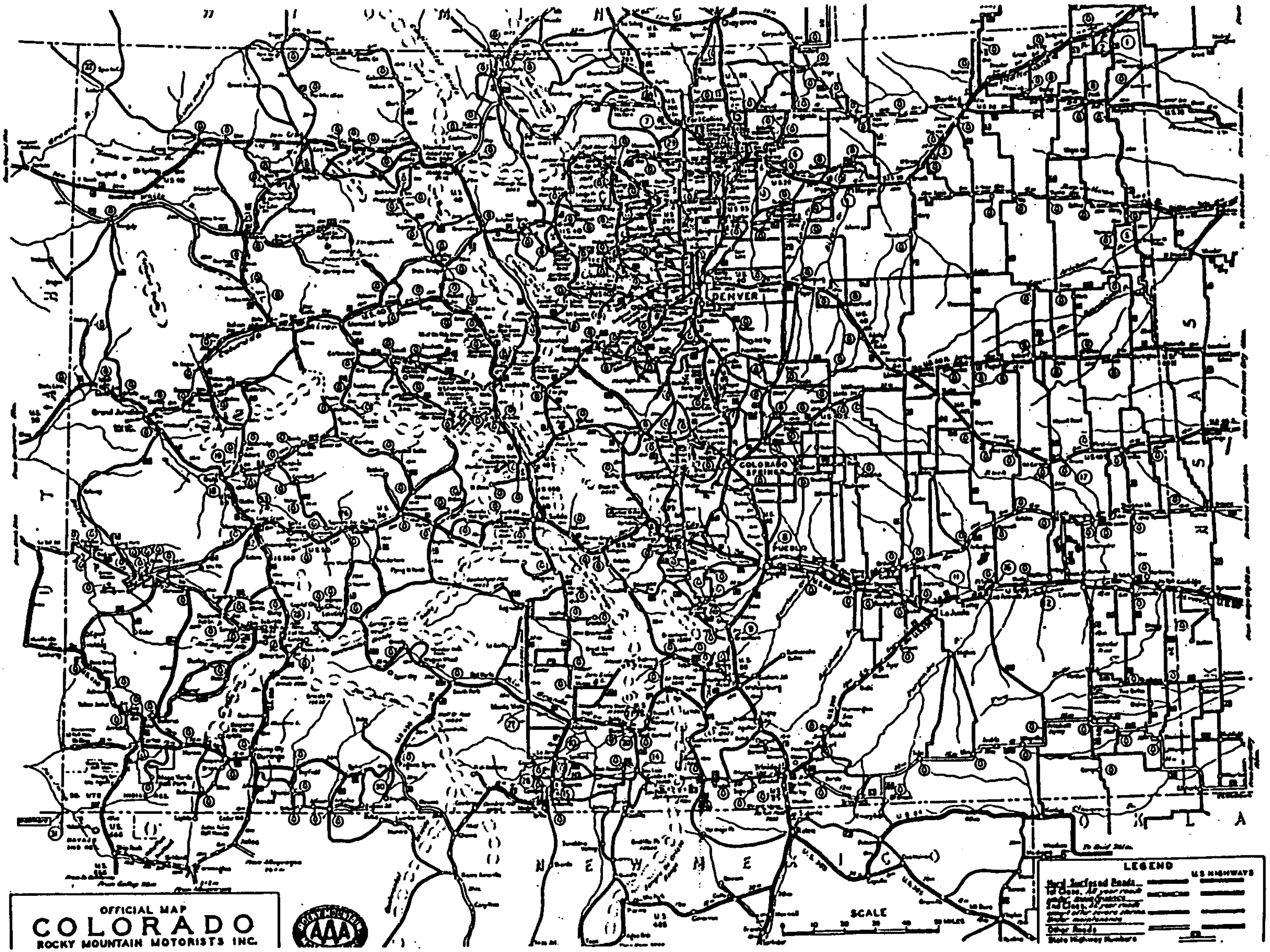


Figure 2. Colorado Auto Roads, Ca. 1928

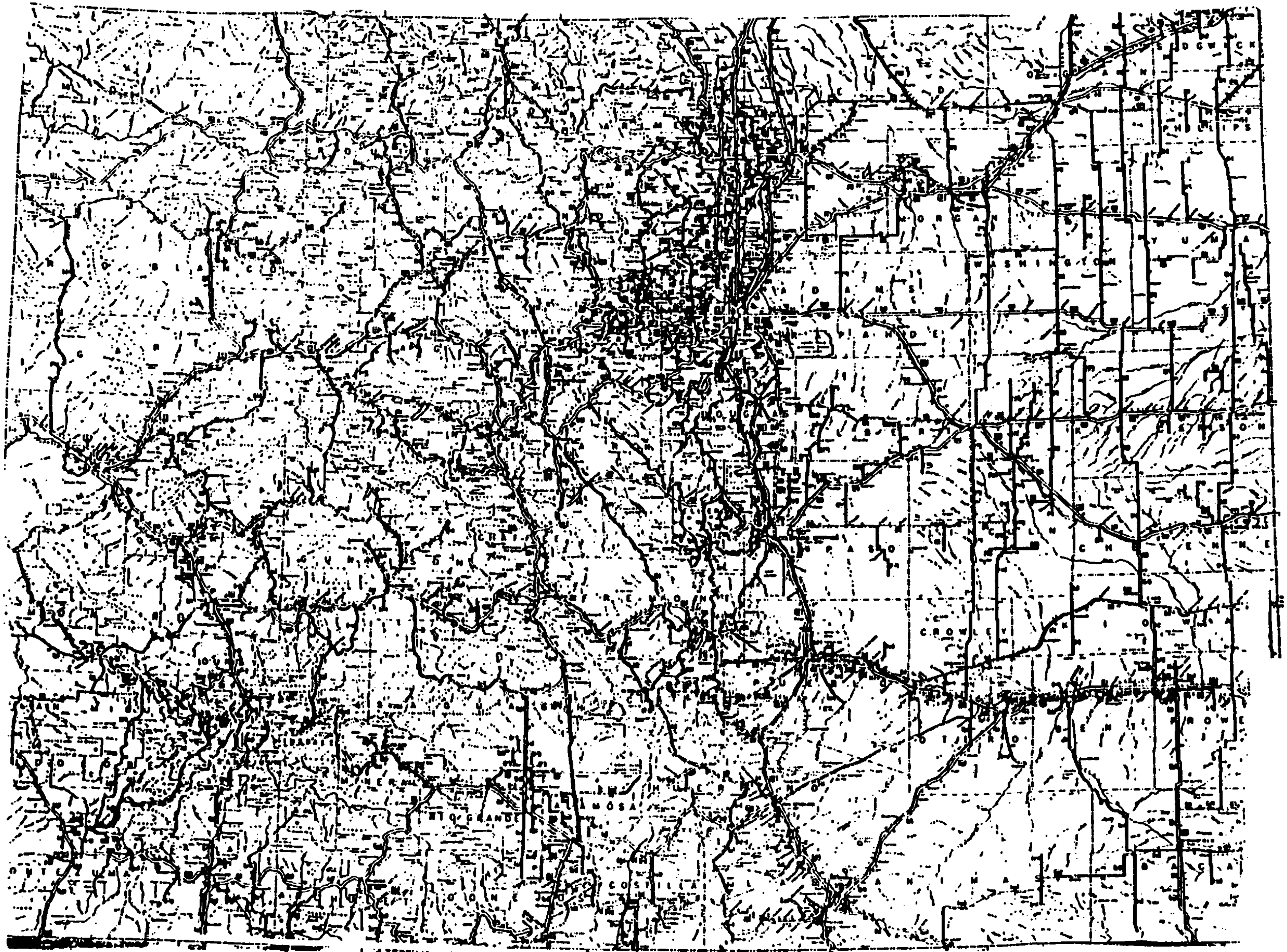


Figure 3. Colorado Auto Roads 1948.

17. BRIDGES

NARRATIVE

American bridge building in the nineteenth century ranged from traditional techniques, such as the simple log placed across a stream and more sophisticated masonry arches, to important new developments in the construction of truss bridges. New England carpenters employed trial and error methods in the early 1800's to build wood frame bridges of greater strength and durability by using triangular designs. The resulting truss bridge, executed in many different patented designs and materials, became the dominant structure of the nineteenth century and represented a major American contribution to bridge engineering. A through truss bridge carries traffic level with its bottom chords. The pony truss contains no bracing between its top chords. In the deck truss the supporting structure is below the traffic level. Since all trusses consist of many structural members in either tension or compression, different design arrangements are possible as is a combination of the truss with an arch. By the mid nineteenth century truss designing emerged from the empirical period to enter a more scientific era where better understanding of mathematics and stress forces permitted improved designs.

Colorado's settlement and growth during the second half of the last century coincided with a prolific period of bridge building principally stimulated by the demands of an expanding railroad network for structures capable of carrying faster and heavier trains. Bridge builders responded with an impressive variety of truss designs. (Appended to this theme are two pages illustrating principal truss designs, their names, and general dates of utilization. The pages are reproduced from T. Allen Comp and Donald Jackson, Bridge Truss Types: A Guide to Dating and Identifying. Technical Leaflet no. 95. Nashville: American Association for State and Local History, 1977.). William Howe's truss design of 1840 combined wood with wrought iron in tension and his structure could be rapidly erected, a foremost consideration to railroad men throughout the period. While the Howe truss continued to find use into the twentieth century as a highway bridge, railroads gradually turned to all metal structures for greater strength. Because cast iron possessed limited strength under tension and wrought iron was costly, steel came into greater use as its price declined due to more efficient methods of production. Steel's suitability in bridge building was demonstrated by major structures built over the Mississippi and Missouri rivers in the 1870's. Utilizing iron then steel, railroads began to build Pratt trusses, including numerous variations, and Warren trusses, whose diagonals are alternately placed in either tension or compression. Their strength, versatility, and speed of construction made the Pratt and Warren trusses the most popular designs on the railroads by the turn of the century and a standard type for highway bridges until the mid 1920's.

As eastern areas converted to metal bridges, several factors kept wooden structures in use on western railroads: their later development, access to abundant timber, concern for cost and speedy construction, and adjustment to topographic features. Mountain railways generally tried to avoid major cuts and fills, to use climbing loops rather than tunnels, and to follow easy grades and broad curves. High labor costs and the expense of metal bridges were major determinants. Under these circumstances, the wooden trestle, a series of bridges supported by piers called bents, frequently served to carry a railroad across wide, low places, over rivers, and even along mountainsides (called side trestles) to provide a safer ledge for a roadbed. The pile trestle consisted of four to seven wooden piles driven into the ground which ordinarily supported a simple beam bridge, while a framed trestle, generally used for greater heights, was made of several stories of framed timber structures supporting a beam (stringer) bridge. Later, particularly in the 1930's with better earthmoving equipment available, many of these trestles were filled with earth to provide a permanent structure. Trestles utilizing steel towers and bents as well as concrete ones appeared in the twentieth century. A cruder form of the wood trestle found in Colorado and elsewhere was the timber crib made of stacked logs. Most of these were replaced by earth fills containing a metal pipe or a concrete box culvert to pass a small stream or a drainage ditch under a railroad or a highway.

By the late 1800's and early 1900's both railroads and highways drew upon the same pool of basic designs, technical information, and construction materials, yet they diverged in important respects. As big businesses, railroads employed professional engineers who designed and supervised the construction of high-quality bridges and the companies contracted with major national bridge building firms, such as the American Bridge Company (a division of U.S. Steel Corporation). For greater strength in their structures, railroads phased out the old pin connected spans for more rigid riveted structures. By comparison, highway bridges were primarily provided by local and county governments until the development of state highway departments in the twentieth century. Often poorly informed about bridges and ordinarily dealing with meager funding, county officials met the need for bridges as cheaply as possible, sometimes accepting outmoded truss bridges from the railroads. When acquiring a new bridge, they contracted with bridge fabricators using patented designs and mass produced parts. Bridge fabricators varied in skill and integrity, but in most states a group of reliable regional firms, along with others from the middle west, assumed a dominant position. In Colorado, the Charles Sheely Company of Denver, the Denver Steel and Iron Works, and the Pueblo Bridge Company were successful and prominent. As a general rule, the development of state highway departments standardized bridge building and introduced more competent engineering.

In the twentieth century steel and concrete altered bridge building. Improvements in rolling steel made possible the plate girder bridge consisting of vertical steel plates reinforced by angles at top and bottom. Girder bridges reduced labor and engineering costs. While steel and steel cable permitted the construction of suspension bridges, their cost limited their application to major projects and railroads required greater rigidity than provided by suspension structures.

Colorado's only suspension bridge is at Royal Gorge and was built in 1929. Despite its lesser aesthetic qualities, concrete for its cost and structural advantages gained a larger role in the 1920's and 1930's as reinforced concrete slab bridges and as box girders.

Around the time of World War I, the key influences on bridge building shifted from the railroads to the automobile. The ubiquitous automobile spurred greater participation by state and federal government in road and bridge building. In 1910 the U.S. Office of Public Roads created a Division of Highway Bridges and Culverts that supplied engineering expertise to the states for surveying and for bridge inspections. The Federal Aid Road Act of 1916 led to design standards and financial assistance for bridges. Under these influences, highway bridge building expanded in the 1920's and dramatically improved due to better engineering criteria and new technology. These trends ushered in the modern age of bridge building in America.

CHRONOLOGY

1790-1830	Carpenters build wooden trusses, ie. Ithiel Town's lattice truss of 1820.
1840	William Howe patented his truss.
1844	Pratt truss patented.
1847	Bridge engineer Squire Whipple wrote first American treatise on bridge building.
1848	Warren truss patented.
1856	Bessemer process developed for making steel.
1850-1925	Era of metal truss bridges.
1874	Eads Bridge at St. Louis demonstrated value of steel for railway bridges.
1883	Roebling's Brooklyn Bridge opened.
1890's-1920's	Introduction of reinforced concrete bridges.
1910	Division of Highway Bridges and Culverts formed in the Office of Public Roads.
1916	Creosoted pilings for timber trestles.
1920's	Increasing use of steel plate girder bridges.
1929	Royal Gorge suspension bridge completed.

LOCATION

No single map can locate all bridges that existed or may have existed in Colorado. Bridges can be located in transportation corridors throughout the state.

CULTURAL RESOURCE TYPES

Sites Include:

Function

- Railroad
- Highway
- Pedestrian
- Utility

Type

- Beam bridge
- Arch bridge
- Truss bridge--through, pony, and deck. Pin connected or riveted. For some major truss designs see Comp and Jackson's Bridge Truss Types: A Guide to Dating and Identifying.
- Cantilever bridge
- Movable bridge
- Girder bridge
- Trestle

Construction Material

- Stone
- Wood
- Iron, cast and wrought
- Steel
- Concrete

THE QUALITY AND QUANTITY OF EXISTING DATA

Historical Documentation

Extensive and reliable documentation in the form of primary and secondary sources is available for this theme. Technical data can be found in the older treatises written by eminent bridge engineers such as Theodore Cooper and J.A.L. Waddell and in the engineering journals of the day and the publications of the American Society of Civil Engineers. These sources present state of the art practices and often contain information on specific bridges. David Plowden's Bridges: The Spans of North America is the best recent study. It details important trends and the changing nature of building materials and should be consulted for its vast information, useful bibliography, and excellent photographs. Bridges and Men by Joseph Gies offers a fine overview of the subject along with insightful comments that help the researcher establish an historical context.

Within the last ten years the activities of the Society for Industrial Archeology and the Historic American Engineering Record have fostered great interest and enthusiasm about bridges as historic structures. At the same time the Federal Highway Administration has urged the states to inventory their historic bridges for planning purposes. These developments have important implications for the bridge researcher. Many states have produced excellent historical surveys and experts have composed helpful guides for the study of bridges. In the latter category, the Technical Leaflet by T. Allen Comp and Donald Jackson is a superb example. Although David Weitzman's Traces of the Past contains many useful bridge drawings and diagrams, its text is not error free.

Researching particular bridges in Colorado will require examining newspapers, county histories, and state reports, particularly those issued by the state engineer's office. Records of bridges built and maintained by the state are located in the highway department, while the minutes of county commissioners may contain data on county-owned structures. Railroad records, some of which have been placed in public archives, usually include bridge books which supply information on specific railroad structures. For example, the records of the Denver and Rio Grande Railroad are housed at the Colorado Historical Society. One should not ignore railroad hobby publications, such as Model Railroader magazine, as sources since they frequently carry detailed drawings and specifications of historic railway structures. Paul Mallery's handbook, though a modeler's guide, is informative on bridges and trestles.

Number/Condition

The number and condition of surviving historic bridges can only be determined by a historic bridge survey and inventory. The Colorado Department of Highways is currently conducting a survey of its historic bridges.

Data Gaps

Representative examples of early railroad and highway bridges.

Representative examples of historic bridge types, particularly truss designs.

Future Needs

While the historic highway bridge survey in progress appears to be meeting one need, it also accentuates the need to conduct a comprehensive engineering site survey that will include local bridges and privately-owned structures, most notably the railroad structures. Railroads shaped early bridge building in this country, yet no systematic effort has been made to document remaining examples of early railroad bridges. Furthermore, historic bridges can also be found on ranches and farms, and in cities where they are maintained by municipal authorities.

Important Resources

Historic bridges can be determined by a numerical evaluation system that assigns a point value to age, size, design, and similar criteria. However, the importance of these resources should also be judged by the role a bridge played in the social and economic life of a region, be it a state or a county. Railroad timber trestles represented important engineering achievements, but few survived the ravages of time or railroad improvements. Any remaining in largely original condition may be deemed significant.

RESEARCH QUESTIONS

1. Can cultural resources add to our understanding of the state's growth and its transportation system?

2. Can resources document the technological evolution of bridge building?

3. Can resources show regional variations in railroad and highway bridge building?

4. What evidence remains to illustrate the impact of important bridge building firms and bridge engineers?

PHYSICAL CONDITIONS

Bridge: The structure should be in place, substantially unaltered, and dated accurately. Because truss bridges were often moved to lighter load duty, fine examples of these bridges should certainly be considered as significant despite their removal from an original site.

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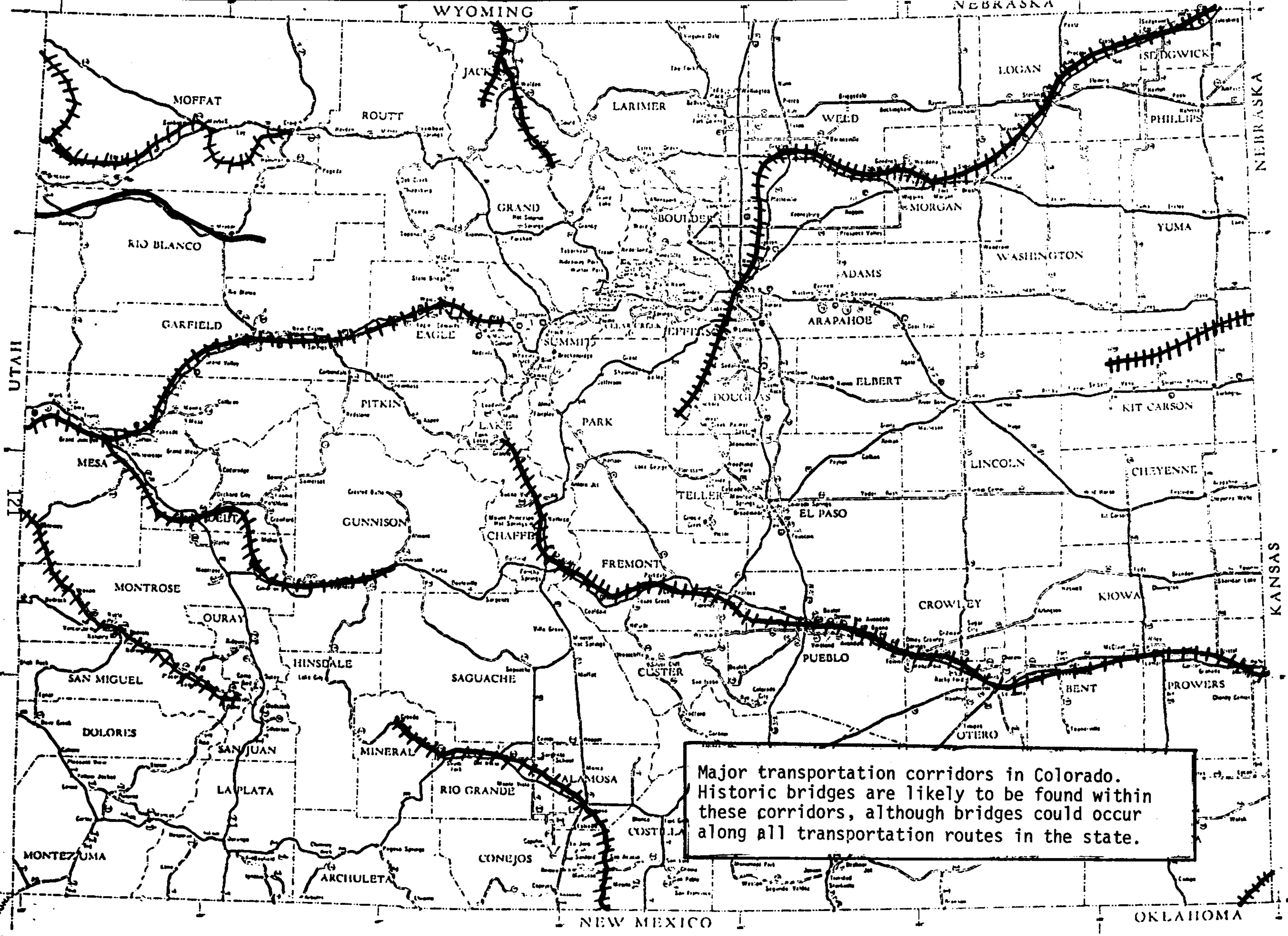

Major transportation corridors in Colorado. Historic bridges are likely to be found within these corridors, although bridges could occur along all transportation routes in the state.

18. TRAILS

NARRATIVE

Trails constituted the earliest and most primitive stage in the evolution of an overland transportation system. Each new frontier opened for settlement in North America depended on rudimentary paths and tracks, some initially formed by the movement of herd animals, others blazed by Indians, explorers, and traders/trappers who preceded the general advance of population. The many navigable rivers east of the Mississippi River formed a natural network of transportation arteries, but once pioneers moved deeper into the interior trails became essential. Daniel Boones' Wilderness Road through the Appalachians was no more than a rude trail when it opened Kentucky to settlement in the 1770s. With few navigable streams, those who pushed across the plains and into the mountains depended on overland routes.

Until the gold rush of the late 1850s, few major trails entered Colorado. The Spanish were the first Europeans to traverse the region beginning with Juan de Rivera's expedition of 1761-1765 and they continued to explore and patrol the area until 1820. With no large permanent settlements in Colorado, supply trails did not exist. However, the Old Spanish Trail, part of which was opened by the Escalante-Dominguez expedition of 1776-1777, crossed southwestern Colorado connecting Santa Fe to Los Angeles. A branch of the Santa Fe Trail, established by Missouri traders in the 1820s, followed the Arkansas River to Bent's Fort and through Raton Pass. American military expeditions began with Zebulon Pike's journey into southern Colorado in 1806, followed by Major Stephen Long's exploration of the Platte and Arkansas river valleys in 1820. John C. Fremont attempted to locate western mountain passages in the 1840s and 1850s and Captain John Gunnison of the U.S. Topographical Corps was killed by Indians in 1853 while searching for a usable railroad route. These expeditions confirmed the common view that the Colorado mountains were a barrier to western migration.

By the 1850s the principal route west, the Central Overland Trail (also known as the Oregon Trail), passed north of Colorado through South Pass. Like other major trails, this one followed the watercourses and generally was a zone, rather than a road, several miles wide, whose surface was compacted by wagon wheels and tramping men and animals. The army used the trail for military purposes and helped to maintain its condition. Other trails appeared with the discovery of gold in Colorado. Gold seekers left the Central Overland Trail at Julesburg to follow the South Platte Trail into Colorado, while others branched off the Santa Fe Trail near Bent's Fort to follow the Arkansas River route (also called the Cherokee Trail). In addition, the Republican River Trail across northern Kansas to Denver and the Smoky Hill River Trail became significant freight and stagecoach routes to Colorado.

Until the advent of the railroads, wagon freighting companies hauled goods over hundreds of miles of western trails from supply towns located on the Missouri River. The firms of Russell, Majors and Waddel, D.A. Butterfield Company, and others operated trains of wagons that transported military and civilian goods during the 1850s and 1860s. By 1865 Denver was receiving about one hundred million pounds of goods by wagon. The short-lived Leavenworth and Pike's Peak Express Company largely marked out the Republican River Trail for its stagecoaches in 1859; hundreds of independent teamsters also filled the trails into Colorado. One of the largest transportation outfits was commanded by Ben Holladay who benefited from U.S. Mail contracts to operate over 3000 route-miles in the West (Holladay sold out to Wells, Fargo and Company in 1866). Stage and freight lines erected stations along the trails to accommodate passengers, change draft animals,and make wagon repairs. Once freight reached a central point, it was ordinarily transferred to pack trains which followed mountain trails to the mining camps. The arrival of the railroad in the 1870s diminished the need for long-haul freighting firms, but trails and wagons continued to serve as feeder lines into the twentieth century.

Trails of another sort served the early western cattle industry. After the Civil War the demand for beef in eastern cities spawned the "long drive" in which thousands of head of cattle moved northward out of Texas along various trails to meet railheads in Kansas and Missouri. The Sedalia Trail ran from South Texas to Missouri, the Chisholm Trail to Abilene and the Western Trail to Dodge City, Kansas. The cattle trails were wide routes that shifted to reflect grazing conditions and usable river fords along the way. The mining camps, high grasslands, and construction of the railroad attracted cattle drives to Colorado during the 1860s and 1870s. The Dawson Trail entered Colorado along the Arkansas Valley and further west the Goodnight-Loving Trail stretched from Texas through Trinchera and Raton passes north to Cheyenne. Among the largest Colorado cattle raisers was John W. Iliff, who ran cattle along the South Platte and sold his beef to the miners and railroad construction gangs. By the 1880s the railroads largely ended the need for long drives and cattle raising settled into ranching on reserved grazing lands.

The days of the great transportation trails for moving people, freight, and animals were generally over by the end of the nineteenth century. Their role was replaced by the railroads and improved roads, both of which were often constructed over the same route followed by the trails. Yet smaller trails continued to serve as feeder lines and, more importantly, to provide recreational opportunities in the Colorado mountains. Hunting, hiking, and skiing trails appeared in the early days, but more formal and extensive recreational activities emerged in the twentieth century. The railroad and automobile simultaneously made the major trails obsolete and enabled more people to reach recreational trails in the state. Ski trails developed at Steamboat Springs and Hot Sulphur Springs in the 1920s and at Aspen in the 1930s attracted winter vacationers. During World War II the U.S. Army trained its mountain troops at Camp Hale near Leadville, producing new ski courses and giving the sport a great boost in the postwar years. Hiking trails also proliferated in the many parks and forests administrered by the federal government.

CHRONOLOGY

1721-1820	Spanish expeditions into Colorado.
1806	Pike's expedition.
1810-1830s	Fur trappers/traders active in Colorado.
1820	Long's expedition.
c1822	Start of Santa Fe trade.
1840s	Land rush to Oregon over the Central Overland Trail.
1840s-1850s	Fremont and other military expeditions into the Rockies.
1857	Start of Post Office appropriation for Overland Mail Service.
1859	Gold rush to Colorado.
1860s	Smoky Hill Trail to Colorado.
1850s-1870s	Introduction of Texas cattle into Colorado.
1870s	Railroad building in Colorado.
1890s	Efforts for "good roads" begin.

LOCATION

The map delineates principal trails used for freight, people, and cattle. No single map can include all of the trails that existed or may have existed in the study area. Mountain passes can be expected to show trails developed at various periods in the state's history.

CULTURAL RESOURCE TYPES

Sites include:
- Trails
- Campsites

Structures include:
- Forts
- Way stations
- Corrals

THE QUALITY AND QUANTITY OF EXISTING DATA

Historical Documentation

The fundamental importance of western exploration and trade to our national and state history as well as the great professional and popular interest in the frontier era have combined to produce a vast amount of data on this theme. Much of the literature focuses on the human experience of traveling westward, rather than the physical properties of the trail. However, from these sources, the researchers can achieve a degree of accuracy in tracing or plotting the route of major trails. Many original documents from both the Spanish and American periods of exploration have been printed and should be consulted. Josiah Gregg's Commerce of the Prairies, about the Santa Fe Trail, and other diaries and memoirs of overland travelers are readily available.

William Goetzmann's Exploration and Empire and Army Exploration in the American West are splendid introductions to the role of the federal government in sponsoring expeditions in the West. His maps and bibliographical essays are very helpful. W. Turrentine Jackson's Wagon Roads West remains the best source on government participation in surveying and maintaining roads for military purposes. The Transportation Frontier by Oscar Winther is narrow chronologically (1865-1890) but broadly interpretative, and the book succeeds in explaining the interrelatedness of transportation developments.

There is little scholarly work on trails in the twentieth century. With due caution, some basic information can be drawn from hiking and skiing guides or popular literature about jeep trails. A fine source is Sprague's The Great Gates which, among its many assets, lists all of the Colorado mountain passes with a brief note about each. His observations are keen; for instance, pointing out that animals and men avoided the high passes and chose those possessing grass, water, and trees. Site files at the state preservation office contain some information on trails and related matters.

Number/Condition

The data are insufficient to determine the number and types of trails that once existed or may have existed. Literary sources document the major trails, at least in general terms, but physical traces have been obliterated by time and development. It is important to note that good trails for men and animals became good routes for the railroads and the automobiles. Cattle trails were ordinarily so wide that they left few permanent marks upon the land.

Data Gaps

Clear evidence showing the route followed by exploration, travel, cattle, or recreation trails.

The physical remains must be corroborated by other evidence and full documentation.

Future Needs

Since sufficient documentation exists on the principal trails, additional effort in this area should be assigned a low priority. It seems unlikely that field surveys would advance the state of knowledge about this theme and would require a substantial commitment of time and funds. However, recreational trails have received scant attention. Though realizing the inherent problems in documenting such resources (should they exist), the area should be investigated. In addition, the subject deserves more historical scholarship, particularly if the work would give a better focus to the cultural resource efforts.

Important Resources

The value of trails as the state's first transportation system means that any site has potential historic significance. The trails bound a frontier province to the settled areas in the east and made possible the flow of people, goods, and equipment that built the early mining industry. Cattle trails fostered a ranching economy in eastern Colorado, while recreational trails furthered the tourist trade and mountain sports which today represent a sizable source of state income.

RESEARCH QUESTIONS

1. What resources remain to document the existence of important trails in Colorado?

2. Can resources add to our knowledge of early explorations in the state?

3. Can cultural resources explain or illuminate the reasons for choosing certain trail routes?

PHYSICAL CONDITIONS

Trail: Markers or evidence of a trail must be in place, undisturbed, and documented to the correct historical period.

Way station: Must be in place with enough structure remaining to show function. Dated accurately.

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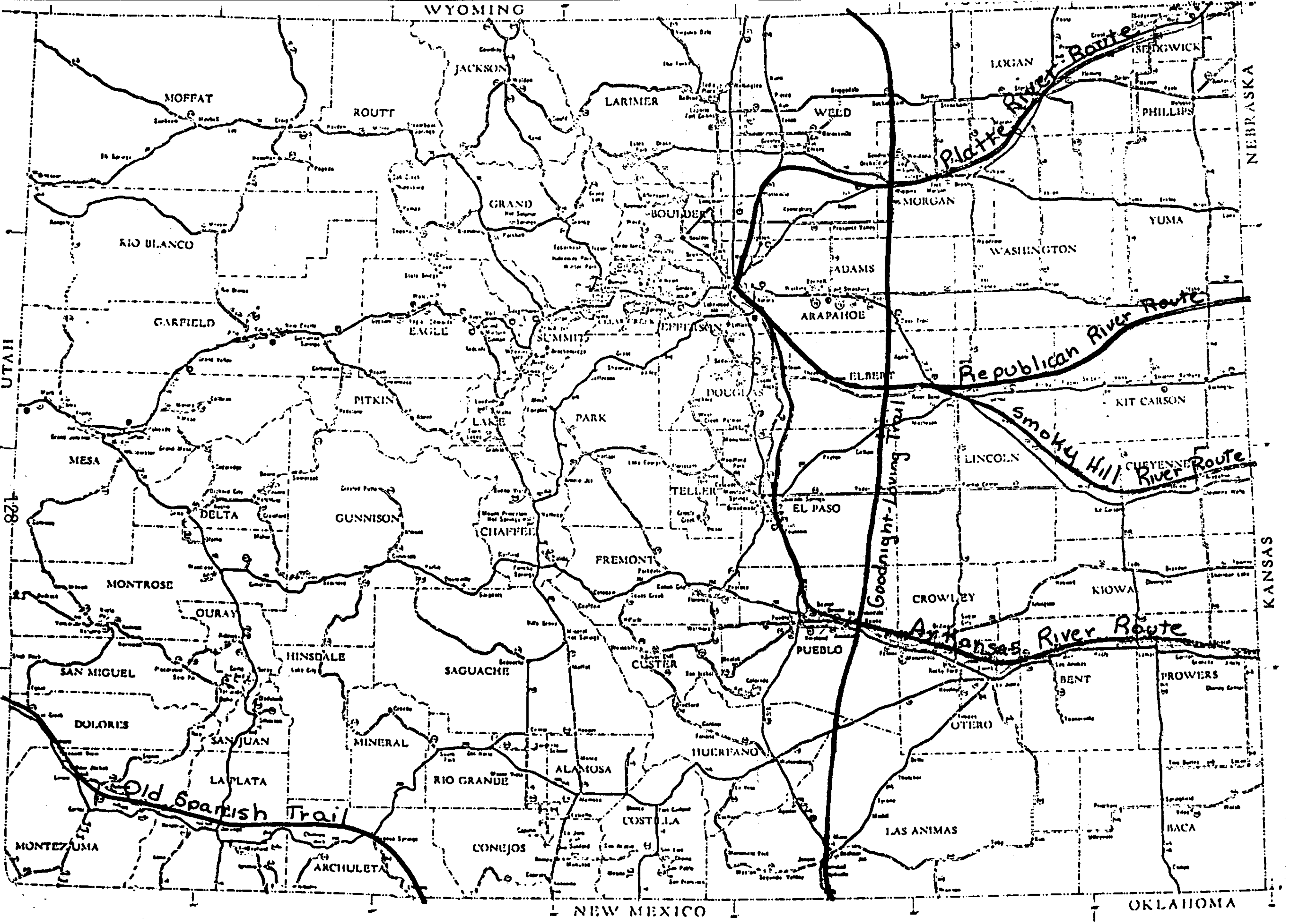
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RIO BLANCO
GRAND
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WASHINGTON
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ARAPAHOE
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EAGLE
SUMMIT
JEFFERSON
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KIT CARSON
PITKIN
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LINCOLN
CHEYENNE
MESA
DELTA
GUNNISON
CHAFFEE
TELLER
EL PASO
MONTROSE
FREMONT
CROWLEY
KIOWA
OURAY
HINSDALE
SAGUACHE
CUSTER
PUEBLO
SAN MIGUEL
BENT
PROWERS
DOLORES
SAN JUAN
MINERAL
HUERFANO
OTERO
LA PLATA
RIO GRANDE
ALAMOSA
COSTILLA
LAS ANIMAS
BACA
MONTEZUMA
ARCHULETA
CONEJOS
Platte River Route
Republican River Route
Smoky Hill River Route
Arkansas River Route
Goodnight-Loving Trail
Old Spanish Trail

TRAILS

19. TELEPHONE

NARRATIVE

The communications revolution, begun earlier in the century by the telegraph, accelerated and became pervasive with the invention of the telephone in 1876. The instrument designed by Alexander Graham Bell translated sound waves into electrical impulses that were sent along a wire to a receiver where corresponding sound waves were transmitted to the listener. Attesting to the importance of this invention, more than six hundred legal suits were brought against Bell's patents before his claims were secured. By 1880 efforts were under way to improve the technology, create a distribution system, and demonstrate the advantages of instant and direct communications for both individuals and business concerns. The first commercial exchange opened in Connecticut in 1878 and initiated the development of switchboards, one of the most complex and essential technologies in the organization of a telephone system. Early switchboards used a cross-bar device in which the operator dropped a metal plug(sometimes called a "pumpkin seed") at the appropriate intersection to complete a circuit.

Under the leadership of Theodore N. Vail, the telephone became big business in the late nineteenth century. Vail's American Bell Telephone Company organized a nationwide communications system by licensing local operating companies, tying the parts together with long distance service (American Telephone and Telegraph Company was formed in 1885 and absorbed American Bell in 1889), and supplying new equipment from the Western Electric Manufacturing Company of Chicago. However, the expiration of American Bell's last basic patent in 1894 led to a flurry of new competition from independent companies responding to the public demand for more telephone service at lower rates. Along with commercial companies, the new competition included a number of mutual systems in small towns and rural lines in farm country, areas neglected by American Bell. Between 1895 and 1907, the number of telephones increased rapidly.

Vail, an occasional investor in Colorado mines, became president of AT&T in 1907, and the company, with financial help from Wall Street banker J. Pierpont Morgan, embarked on a new effort to control the industry under the slogan, "One Policy, One System, Universal Service." The corporation agreed to governmental regulation in return for the right to operate as a "natural monopoly." By 1920 this arrangement resulted in a quasi-monopoly for AT&T by virtue of its control over long distance service and whole or partial ownership of state/regional Bell operating companies(the Bell System). AT&T controlled about 75% of the nation's telephones and ranked as one of the world's largest private corporations.

The potency of AT&T as a business enterprise was in part due to the rapid technical progress of the telephone. The "hellogirls", as early telephone operators were called, used manual switchboards well into this century, but the first automatic switchboard, known as the step-by-step system, appeared in the 1890s. Automatic switching together with dial telephones were introduced in the 1920s to meet the growing volume of telephone calls. Other changes focused on the telephone wires. Like the telegraph, the telephone at first used iron wire, changing to hard-drawn copper wire for better conductivity. Early telephone systems filled city streets with a bewildering maze of overhead wires strung from trees, high timber poles, and the roofs of buildings. Some poles carried 12 to 30 crossarms, each strung with multiple wires attached to glass insulators or porcelain knobs. The lines were eyesores, dangerous, and vulnerable to the weather, leading to the development of underground lines for the cities during the 1890s. Dry core cables, so named because of their paper insulation, proved best for underground work.

In a gradual process, long distance service spread across the nation: New York to Chicago in 1892, to Denver in 1911, and to California in 1915. Loading coils, invented in 1900, when placed at one mile intervals along the wire, prevented a weakening of the signal as they permitted use of thinner, cheaper wire. Lee de Forest's invention of the triode in 1906, which also contributed to the radio, proved a major innovation for the telephone. His three electrode valve(at first called an audion) amplified sound waves, making possible coast to coast telephone conversations. These innovations impressed upon AT&T the value of scientific research and development, and the corporation created Bell Telephone Laboratories in 1925.

The rapid expansion of the telephone continued between the world wars as the public came to regard the instrument as more a necessity than a luxury. Greater convenience and style were considerations when Bell introduced in 1927 the "French phone" which combined transmitter and receiver in a handset. Despite the presence of the Great Depression, the telephone industry achieved important technical breakthroughs during the 1930s. In one area radiotelephony extended the range of telephone service and reduced some rates, while in another the telephone truly entered the age of modern telecommunications when engineers in the mid-1930s combined high-fidelity sound reproduction with large capacity coaxial cables to dramatically improve long distance. The same coaxial cable became a major force in the development of television.

The telephone arrived in Colorado in 1879 when F. O. Vaille gained financial backing from Henry R. Wolcott to open an exchange on Denver's Larimer Street. Several businesses quickly responded to the new technology, particularly the Colorado Fuel and Iron Company which installed a private line for its Denver offices. During the 1880s a number of cities, flush with the profits of a mining boom, set up telephone exchanges for local use, but faced technical problems and high costs in starting long distance service. By mid decade, however, telephone lines extended from Denver to Georgetown, Golden, Boulder, and as far away as Pueblo.

Few towns exceeded Leadville in its enthusiastic reception of the telephone. The timing was nearly perfect: the telephone reached Colorado just as Leadville opened some of the richest silver mines discovered in the state. Mining millionaire Horace Tabor organized the Leadville Telephone Company in 1880 and quickly strung iron wires from poles and buildings to connect the mines, smelters, hotels, and businesses of the city. The Leadville exchanges were purchased by the Colorado Telephone Company in 1888 and it immediately began an ambitious project to supply Leadville with long distance service to Denver. Encountering great difficulties with the mountainous terrain and harsh weather, the company constructed a telephone line over Mosquito Pass and across South Park to Fairplay, Como, Morrison, and Denver. Since neither heavy wooden poles nor insulated wire laid on the ground survived the elements, company engineers placed the line in a trench covered with dirt and rocks. A major technical achievement, the Leadville "toll line" appears to have been the first across the Continental Divide and its success demonstrated the feasibility of extending telephone service throughout the high country.

CHRONOLOGY

1863	Telegraph connections to Denver.
1876	Alexander Graham Bell invented the telephone.
1878	First commercial telephone exchange opened.
1879	Denver exchange established.
1883	Extruded copper wire developed.
1888-1889	First long distance line across Continental Divide.
1889	AT&T absorbed the Bell Company
1894-1907	Appearance of many independent telephone companies.
c1895	Public telephone booths introduced.
1900	Loading coil aided long distance transmission.
1901	Successful demonstration of wireless by Gugliemo Marconi
1906	Invention of the triode--beginning of electronics in telephone industry.
1910	Mann-Elkins Act placed telephone under federal regulation by the Interstate Commerce Commission.
1911	New York-Denver long distance line opened.
1915	Transcontinental telephone service initiated.
1920s	Introduction of automatic switching and dial telephones.
1930s	Development of the coaxial cable.

LOCATION

Cultural resources associated with this theme may be found in every part of the state. All cities and towns have a "telephone history." No map could adequately detail the telephone systems that exist or may have existed. Thus, the attached map indicates the approximate location of the famous Leadville to Denver toll line constructed in 1888-1889.

CULTURAL RESOURCE TYPES

Structures include:
  Exchange buildings

Telephone offices
Public telephone booths
Towers

Equipment and apparatus include:

Iron and copper wire
Cable
Timber poles
Insulators
Switchboards
Telephone instruments

THE QUANTITY AND QUALITY OF EXISTING DATA

Historical Documentation

The centennial of the telephone's invention in 1976 brought forth a spate of historical studies concerning technical, social, and business aspects. Much of the best work focused on the social and cultural impact of this technology, for instance, Pool's The Social Impact of the Telephone which examines the subject from a variety of thought-provoking perspectives. Historians are still coming to grips with the enormous business and legal implications of the Bell System, particularly in light of recent anti-trust actions, but the best early treatment of the industry remains the book by Arthur W. Page(a company executive), while The Telephone: The First Hundred Years by John Brooks brings the story up to date in a popular, polished way. Researchers are fortunate to have masterful biographies of two inventors--Alexander Graham Bell and Thomas Edison--whose careers intersected, by Robert Bruce and Matthew Josephson respectively. Although one can gather reliable information about technical changes from all of these books, the early equipment of the telephone industry is described, with detail if not clarity, by Frederick L. Rhodes' study published in 1929. The promise that technological studies of the telephone can reveal important historical dimensions is shown in the excellent article by John V. Langdale in the Journal of Historical Geography.

Local and state histories, especially the earlier ones, contain helpful information on the telephone in Colorado. Newspapers of the era are valuable since the advent of the telephone was a major event for most cities that this technology as more than better communications, but as a harbinger of modern civilization. Because many prominent Coloradans became involved with the telephone business, the manuscript collections at the Colorado Historical Society, Denver Public Library, and University of Colorado should be consulted. The powerful influence of the Bell Company and AT&T on the course of this industry requires consideration of local activities against a background of national trends and events. This also means that general studies can be useful in more specific research projects on the state.

Number/Condition

The number and condition of cultural resources related to this theme are unknown. Many of the devices of early telephony have been saved by AT&T, notably the Western Electric division, and museums around the country.

It is unlikely that equipment, such as that used in long distance, would have survived constant technological change in the industry. However, cultural resource surveys in urban areas frequently identify early telephone structures, which sometimes have been adapted to new uses.

Data Gaps

Representative examples of early telephone equipment and apparatus.

Representative early telephone structures.

Representative evidence of early long distance projects.

Future Needs

A historic engineering survey of the state, which is highly recommended, should target telephone systems along with other important technological developments. Existing county and city surveys should be examined for information on telephone structures and the data gathered together for reference purposes. Any survey project undertaken on this theme must include a historian familiar with the technology, the literary sources, and field techniques.

Important Resources

The enormous strides being made by today's telecommunications industry coupled with the importance attached to better communications by early Coloradans make cultural resources in this theme significant and worth identifying. Until we have a national inventory of historic telephone equipment, regard all properly dated and documented resources valuable. At the state level, material evidence of early long distance projects, particularly in the mountains, demands careful consideration. This is also true of early independent telephone companies and rural systems.

RESEARCH QUESTIONS

1. Can resources document and explain the problems of building of telephone systems on the western frontier?
2. Can resources demonstrate special adaptations of the telephone to mountain conditions?
3. Can resources enlarge or alter our understanding of urban-suburban growth patterns?
4. What resources remain, if any, to explain the evolution of the telephone industry in Colorado?
5. Can resources contribute to our knowledge of this technology's impact on business, life and society, and cultural affairs?

PHYSICAL CONDITION

Structures: Should be well maintained, and should convey the building's function and relationship to the system's operation.

Equipment, Apparatus: Must be recognizable as to function, accurately dated to the appropriate historical period, and, when possible, related to the other elements of a communications system.

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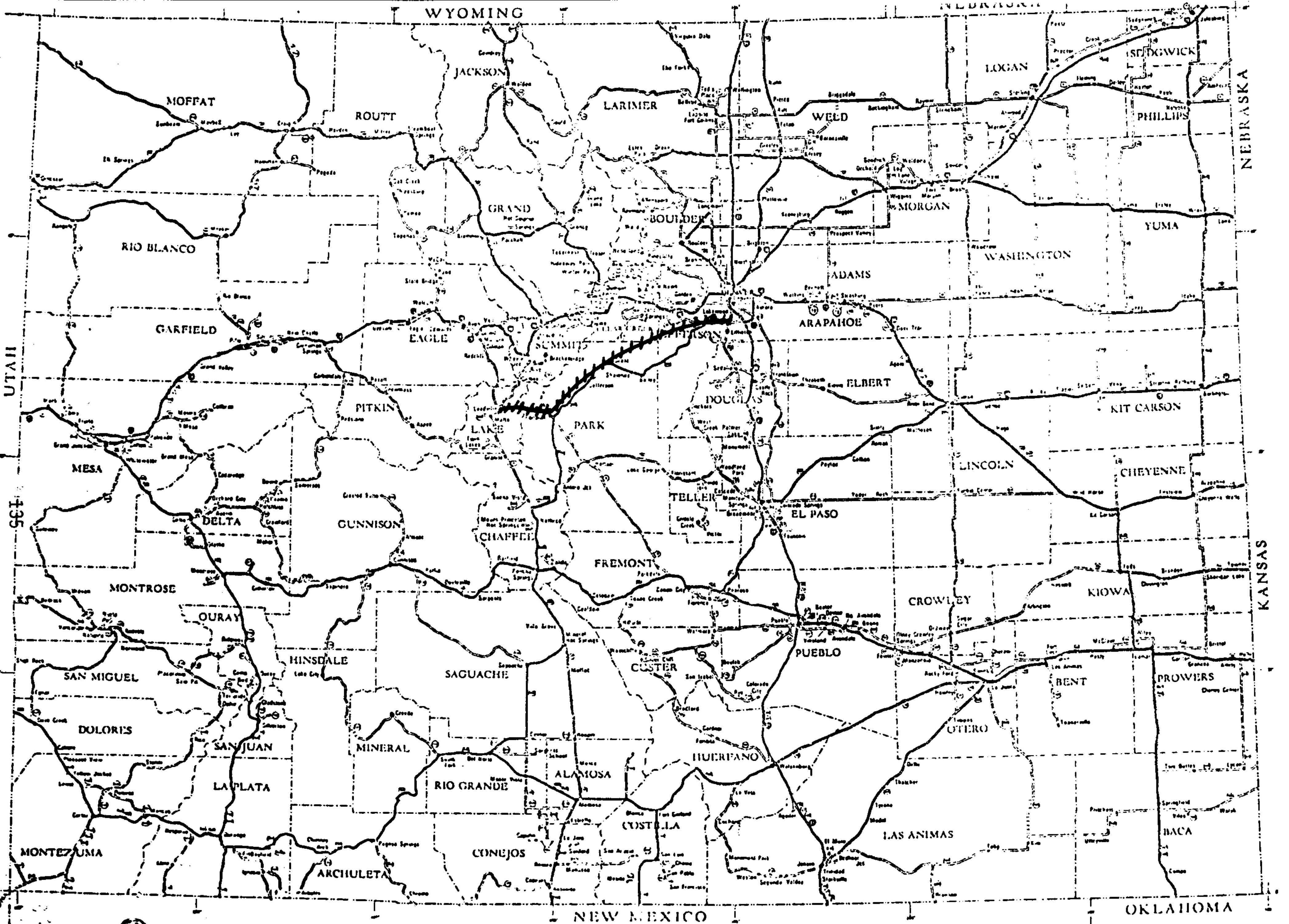

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LEADVILLE-DENVER TELEPHONE LINE, 1888-1889

20. TELEGRAPH

NARRATIVE

The telegraph revolutionized communications during the nineteenth century by providing a means of transmitting messages by electricity. This technical innovation increased the speed, reliability, volume, and flexibility of communication and greatly benefited transportation, journalism, and business and industry. It also initiated a series of scientific experiments and technical developments that produced the telephone and the radio. In view of its wide-ranging impact, the first commercially successful telegraph, invented by Samuel Morse in 1837, was a relatively simple apparatus. Morse used a set of electromagnets to send and receive signals transmitted along a wire. The switch or key sent electric impulses to a receiver(sounder) that clicked out the message. The Morse code utilized a system of dots and dashes for conveying the message to the receiving operator.

By the time of the Colorado mining rush of 1859, ~~a privately-owned~~ telegraph sytem had developed in the eastern and middle western states, and consideration turned to the building of a telegraphic connection with the Pacific Coast. The federal government, having financed a test line between Washington, D.C. and Baltimore in 1844, had decided against controlling the telegraph as a government property similar to the post office and left private companies to spread the new technology. Prior to the Civil War, dozens of telegraph companies appeared, but a small group led by the Western Union Telegraph Company dominated the industry. Wanting to establish better communications with the West on the eve of the Civil War, Congress enacted the Pacific Telegraph Act in 1860 subsidizing the construction of a telegraph line to California. The law authorized two construction companies--the Overland Telegraph Company to build east from California and the Pacific Telegraph Company(affiliated with Western Union) to build west from Omaha, Nebraska. This transcontinental telegraph, completed in late 1861, ran north of Colorado through South Pass, although a station was established at Julesburg which sent messages <u>via</u> the Pony Express to Denver.

Construction gangs on the transcontinental telegraph dug holes, set timber poles(using local timber when available), and attached galvanized iron wire to glass insulators. Iron wire was cheaper than copper and proved more durable under a variety of weather conditions. A tough rubber-like substance called gutta-percha provided insulation for submarine wires extended across rivers. Service on the transcontinental line was often interrupted by lightning that struck and melted the wires and by buffalo which knocked over the poles.

At the conclusion of the Civil War the telegraph system rapidly expanded in the West. Denver, which had been joined to the transcontinental line in 1863 by a wire strung through Fort Morgan to Julesburg, became the center of a telegraphic network that extended to new towns in Colorado and reached into neighboring states. In 1868 several prominent businessmen in Denver, including Benjamin Woodward(builder of the Julesburg line), Horace Porter, and William Byers of the Rocky Mountain News, formed a company that constructed a telegraph line between Denver and Santa Fe, New Mexico. In the same year another company linked Denver with Cheyenne, Wyoming. However, these lines and others built in this period quickly became the property of the Western Union Company which achieved a near-monopoly over the nation's telegraph industry in 1866. In 1890 the construction of a wire between Denver and Kansas City by the Postal Telegraph-Cable Company began a period of new activity by that company in Colorado. The Postal built along the right-of-way of the Santa Fe Railroad, providing telegraph service to the many farm towns along the Arkansas River. The firm also strung telegraph wires into Leadville and Cripple Creek and opened lines to Texas and southern California. The Postal reputedly introduced copper wires and used electric generators rather than batteries for transmitting its signals. Thus by the early 1900s Denver enjoyed improved telegraphic service supplied by two competing companies.

In general practice the telegraph expanded alongside the railroad, using the railroad's right-of-way to set its poles and establishing offices in train stations. This relationship solved the telegraph's problem of acquiring land while it gave the railroad the advantage of improved communications for maintenance, despatching, and management. By using the telegraph, the railroads could control the flow of information about trains and freight over hundreds of miles and reach their many employees in a rapid and reliable way. During the 1870s better and faster service resulted from the introduction of multiplex system that could carry several messages over one line at the same time.

During the twentieth century the telegraph remained an important communication device. While the telephone supplied instant communications for growing numbers of private individuals and businesses and the radio emerged as a popular entertainment medium, the telegraph continued to perform many functions in the business community. For transmitting large amounts of information swiftly and inexpensively, such as on the stock market ticker and the news service teleprinter, the telegraph had few competitors.

CHRONOLOGY

1837	Morse demonstrated successful telegraph.
1844	Government sponsored experimental telegraph line between Washington and Baltimore.
1856	Western Union Telegraph Company formed.
1861	Transcontinental line completed--end of the Pony Express.
1863	Telegraph connection to Denver.
1866	Cyrus Field laid transatlantic cable.
1875	Multiplex telegraph system developed.
1876	Telephone invented.

1890	Postal Telegraph-Cable Company expanded into Colorado.
1890s	Increasing use of copper wiring.
1901	Marconi demonstrated wireless transmission.
c1927	Teleprinters appeared in use.
1945	Western Union began sending messages by radio beam.

LOCATION

As a general rule telegraph wires were strung along railroad rights-of-way and other transportation corridors.Lines constructed prior to the building of a railroad--and this happened in the West where towns grew rapidly and vied for transportation and communication services--were frequently removed at a later date and placed on railroad property.

CULTURAL RESOURCE TYPES

Poles
Insulators
Wires
Relays
Generators
Sending and receiving apparatus
Stations

THE QUANTITY AND QUALITY OF EXISTING DATA

Historical Documentation

The importance of the telegraph to the evolution of a modern communications system in the United States is not reflected in the quantity of historical literature. Robert Thompson's study is still the single most detailed and analytical treatment of the telegraph, yet it does not extend beyond 1866 and offers little on western developments beyond a generalized discussion of the transcontinental line. *Echoes from the Rocky Mountains* by John Clampitt contains a discursive chapter on the transcontinental telegraph. Clearly the best historical treatments focus on Samuel Morse and the early days of telegraphy as presented, for example, in Roger Burlingame's old but useful *March of the Iron Men*.

Researchers will need to piece together the story of telegraph developments in Colorado, relying on older general studies of the state, such as Wilbur Stone's, and examining a variety of historical sources. Government documents, local histories, railroad studies, technical journals, and newspapers may contain helpful information. The papers of Colorado entrépreneur Horace Porter, a telegraph builder, are available in the Western Business History Records Center at the Colorado Historical Society. Records of the Colorado Fuel and Iron Company of Pueblo might also be consulted since the firm at one point owned the Colorado and Wyoming Telegraph Company.

Number/Condition

The data do not exist to determine the number and type of resources that once existed or may have existed. The ravages of time and weather along with constant technical improvements in the telegraph systems would have destroyed virtually all of the original equipment. Furthermore early telegraph sysyems would have left few if any permanent changes on the land.

Data Gaps

Representative examples of early telegraph equipment and devices.

Clearly discernible path used by an early telegraph system.

Representative example of an early telegraph office, whether located in an independent structure or part of a railroad station,business office, etc.

Future Needs

A survey conducted specifically to locate evidence of early telegraph systems is not recommended. However, high priority should be given to a historic engineering site inventory of the state to include resources associated with this theme. An initial effort should be made to identify and gather historical documentation on the telegraph in Colorado. Perhaps railroad companies in the state and Western Union can be helpful in supplying data on early developments.

Important Resources

The telegraph was a most significant innovation in communications and a major influence on the railroading industry. Better communication and transportation broke down the isolation of small communities dependent on mining and agricultural activities and fostered the development of an integrated state economy. The contribution of the telegraph to this process is apparent and makes all early sites and equipment potentially valuable historical resources. Early settlers in Colorado realized the advantages in rapid and reliable communications and devoted considerable efforts to obtaining them. An important factor in Denver's rise as a major city is its vigorous campaign to build a communications network.

RESEARCH QUESTIONS

1. What resources, if any, remain to document the early development of the telegraph in Colorado?
2. Can resources provide information on the peculiar problems of constructing telegraph systems in mountainous areas?
3. Can cultural resources add to our knowledge and understanding of the close working relationship between the railroad and the telegraph or, more broadly, between transportation and communication?
4. Can resources supply additional evidence of the impact the telegraph is thought to have had on specific industries, ie. mining stock exchanges, newspapers, shippers, and others?

PHYSICAL CONDITION

Station, Office: Enough of the structure should remain to understand its function and dates of construction should be ascertained.

Equipment, Apparatus: Enough should remain to determine purpose and operation and should be dated to the appropriate historical period.

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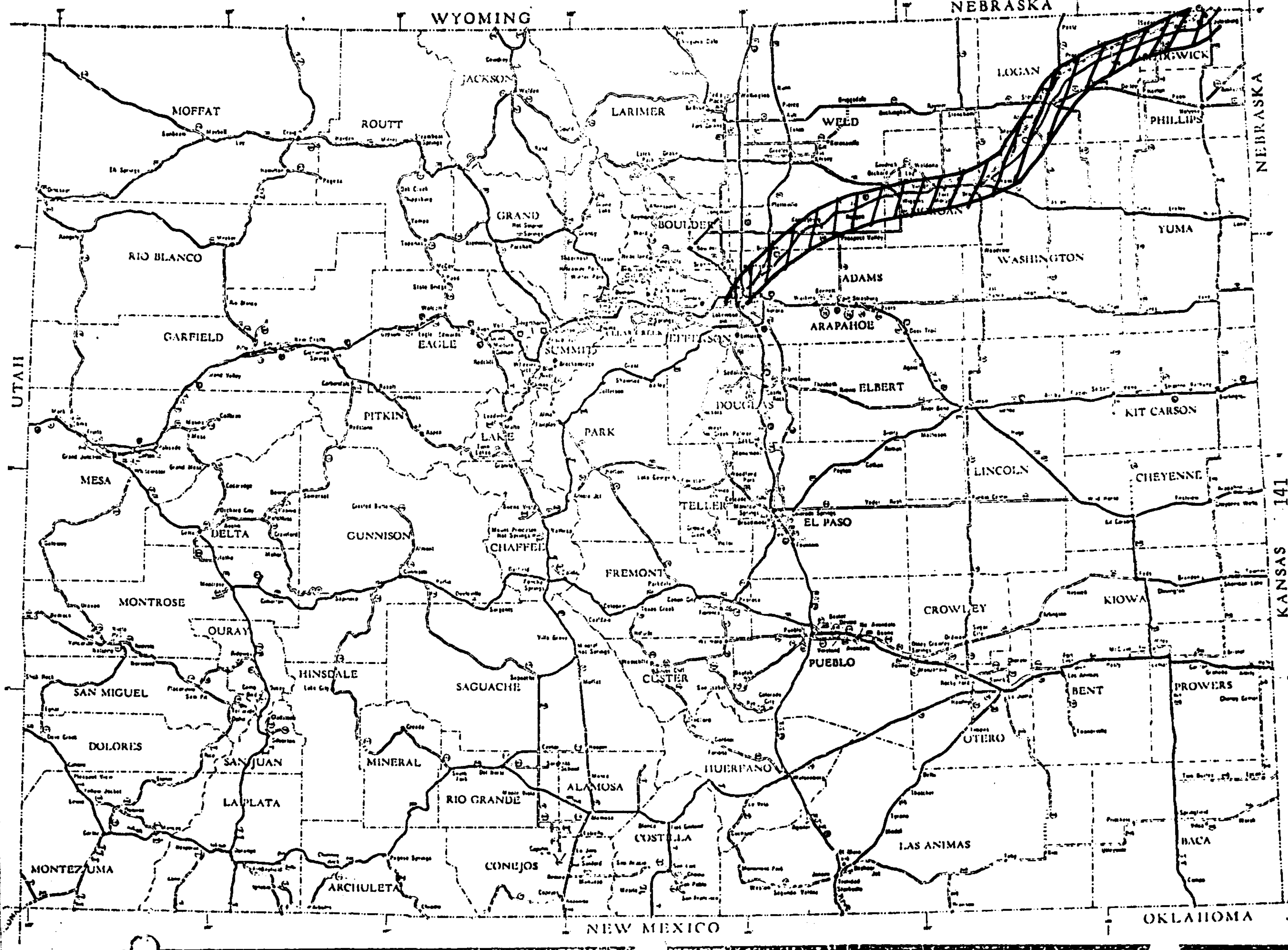

APPROXIMATE ROUTE OF FIRST TELEGRAPH LINE TO DENVER 1863

21. RADIO

NARRATIVE

Guglielmo Marconi impressively demonstrated the practicality of radio as a means of long distance communication when his wireless telegraph transmitted a message across the Atlantic Ocean in 1901. Based on the knowledge that electromagnetic waves(radio waves) can carry a signal through space until intercepted by a receiver which changes the waves back into their original sounds, Marconi's wireless began a period of rapid progress in both the technical development of radio and the growth of the broadcasting industry. Lee de Forest's invention of the triode(audion) in 1906 represented a major technical advance for it improved the effectiveness of amplifiers and detectors. Prior to the triode, de Forest had been associated with a highly speculative effort to promote the sale of some wireless stocks through the mining exchanges of Colorado. Between 1904 and 1907 the American de Forest Wireless Telegraph Company erected a chain of stations in Denver, Boulder, Fort Collins, Cripple Creek, Altman, Leadville, Trinidad, Pueblo, and Colorado Springs to transmit business messages and demonstrate the value of wireless telegraphy. (A wireless station on the Denver, Lakewood, and Golden Railroad was named De Forest, Colorado). The failure of this fraudulent enterprise did not diminish the exuberance over the wireless that existed prior to the outbreak of World War I.

America's involvement in the First World War(1917-1918) had an important impact on electrical communications. By ordering the mass production of electronic equipment to serve a wide range of military needs, the federal government encouraged new applications of the radio, made many new people in the armed forces proficient in the use of radio technology, and invited established electrical equipment manufacturers, such as General Electric and Westinghouse, into a new market as producers of radio tubes and other materials. The war years also tended to widen the gap between wireless telegraphy and the radio: the wireless was more concerned with achieving long distance transmission of signals for military and navigational purposes, while the radio moved toward communicating news, weather, and entertainment.

Radio made spectacular progress in the decade after the war. During the 1920s, amateur radio operators fashioned receiving sets and antennas out of any available parts and materials, while several large business firms tried to gain dominance over the new industry. In 1919 Westinghouse, General Electric, and American Telephone and Telegraph combined to create the Radio Corporation of America to share patents and to bestow upon each participant certain "exclusive" rights within radio. For instance, under the complicated and controversial agreement, RCA sold parts and receivers made by General Electric and Westinghouse and AT&T manufactured transmitters. To increase public demand for its equipment, Westinghouse started broadcasting from station KDKA in Pittsburgh in 1920, and broadcasting stations began to appear across the country. Requests to the U. S. Department of Commerce for operating licenses came from department stores, newspapers, colleges, and from a marble company which set up station KHD in Colorado Springs. In 1924 General Electric opened station KOA in Denver. Although AT&T left radio in 1926, it had introduced both the concepts of "toll broadcasting", or commercially sponsored programs, and network programs through a chain of stations. The latter innovation was carried forward by the National Broadcasting Company(a part of RCA) which controlled both a Blue and a Red network in the late 1920s.

Changes in radio technology also came swiftly in the 1920s. Radio receivers advanced beyond the crystal sets that used mineral crystals to detect radio waves, to the tube sets such as RCA's Radiola, to the tubeless radio powered by household current, such as the Zenith set. Short wave transmitters proved capable of sending signals very long distances and opened up another area of investigation. Congress responded in 1927 to the burgeoning development of radio as business and technology by creating the Federal Radio Commission(later becoming the Federal Communications Commission) and charged the agency with assigning frequencies to radio stations and preventing monopoly practices in the industry.

The Great Depression of the 1930s did little to slow down radio's "golden age." In fact, Franklin Roosevelt's "fireside chats" from the White House effectively communicated the President's New Deal messages via radio into parlors and living rooms across the country. Since most of the major technical developments had taken place earlier, the depression years witnessed new competition from producers like Philco, Zenith, and Emerson who stressed lower prices and vigorous advertising campaigns. Among the new products introduced were battery-operated portable radios, combination radio-phonographs, and automobile radios. A significant event occurred in 1933 when scientist E. H. Armstrong of Columbia University demonstrated the feasibility of FM transmissions which possessed a number of technical advantages. For the most part, however, television rather than radio was captivating researchers on the eve of the Second World War.

CHRONOLOGY

1901	Marconi's wireless transmission across the Atlantic.
1902	Lee de Forest forms the American de Forest Wireless Telegraph Company which becomes active in Colorado.
1906	de Forest invented the triode tube.
1912	Radio Act required federal licenses for operators.
1919	Radio Corporation of America created.
1920	Station KDKA began broadcasting in Pittsburgh. Radio station started in Colorado Springs.
1921	Station KLZ began operations in Denver.
1922	AT&T started "toll broadcasting" in New York City.
1924	General Electric opened KOA in Denver.
1926	National Broadcasting Company formed. AT&T left radio.

1927	Columbia Broadcasting Company formed. Radio Act created the Federal Radio Commission.
1933	Frequency Modulated successfully demonstrated by E. H. Armstrong.
1934	Communications Act created Federal Communications Commission. Mutual Broadcasting System established.
1942	Government ordered end of civilian radio production because of World War II.
1943	American Broadcasting Company organized.

LOCATION

Radio stations were and are located in cities and towns throughout the state. The map denotes the location of de Forest's early wireless stations and also the sites of the earliest radio stations in Colorado. Radio stations may have been located in any building, even residences, and transmitting towers may have been placed on the top of tall buildings and on the edge of populated areas to avoid interference. By 1940 Colorado reputedly had 15 radio stations.

CULTURAL RESOURCE TYPES

Structures include:
- Radio stations
- Towers

Equipment and apparatus include:
- Antennas
- Receivers
- Transmitters
- Alternators

THE QUANTITY AND QUALITY OF EXISTING DATA

Historical Documentation

Radio's far reaching impact on the social, cultural, and economic life of the United States has been chronicled and analyzed by many scholars. While intending to be national in scope, the major studies, notably Archer's History of Radio to 1926 and Barnouw's essential A Tower in Babel, devote considerable attention to pioneering activities in the eastern and middle western states and offer far less on the expansion of radio into the West. Consequently, the researcher is well informed about important business and technical trends, but must research elsewhere for data on specific developments in states such as Colorado. Dunlap's Radio and Television Almanac is a very helpful chronology of major events to 1950, and the study by W. Rupert Maclaurin remains the best treatment of the technological and commercial evolution of radio, including the persistent battles over patent rights. More specific information can be found in local newspapers, the published reports of the Federal Communications Commission and the Federal Trade Commission, as well as several trade journals, among them Radio World and Radio Retailing. The Denver Public Library, Norlin Library on the University of Colorado campus, and other major state libraries and archives may have manuscript collections and company records relating to this theme.

Number/Condition

The data are insufficient to determine the number and condition of resources that existed or may have existed. Research into the historical documentation currently available can reveal many of the early radio stations and they should be recorded on state inventories. As major stations expanded and improved their facilities, it is likely that much of the older equipment was discarded and destroyed. Cultural resources in original condition may be exceedingly difficult to find.

Data Gaps

Identification and documentation of significant people and events associated with the radio industry in Colorado.

Identification and documentation of sites related to broadcasting in the state.

A complete radio station or studio in one location.

Representative examples of radio transmitting and receiving equipment.

Future Needs

A statewide survey of cultural resources in this theme in conjunction with a project on all communications, or perhaps as part of a larger historic engineering site inventory, is justified and recommended. At the same time oral history techniques, research into state and local records, and scrutiny of Colorado newspapers should be undertaken to gather reliable data on the formative years of radio in the state. Further delay in this area should not be permitted, since pioneering individuals, if any, will not survive much longer and since one can already expect keen competition from antique collectors and radio buffs for materials remains from the early years.

Important Resources

Despite the relative youth of radio, any representative resources associated with its early history are significant. It is worth repeating that transportation and communication were vitally important to Colorado in view of its rugged terrain and scattered population centers. Yet by the 1920s , when radio began to flourish, Colorado had become fully integrated with the nation technically and economically so that much of the radio technology which may have survived will reflect on developments nationwide.

RESEARCH QUESTIONS

1. Can cultural resources provide new information on the growth of communications in Colorado?
2. What resources remain, if any, to illustrate the emergence of radio technology from wireless telegraphy?
3. Can material remains show the relationship between radio, telegraphs, telephones, and newspapers?

4. Need to identify important people and events in Colorado radio history.

5. Can resources clarify the impact of national patterns in technology, broadcasting practices, and business developments on Colorado?

PHYSICAL CONDITION

Structures: Should be in original location, generally in an unaltered state of condition, accurately dated, and identified as to function.

Equipment and apparatus: Enough should remain to discern its function and its role in a radio system should be determined. Accurate dating is necessary, and an effort should be made to identify the manufacturer. Some objects may be restorable.

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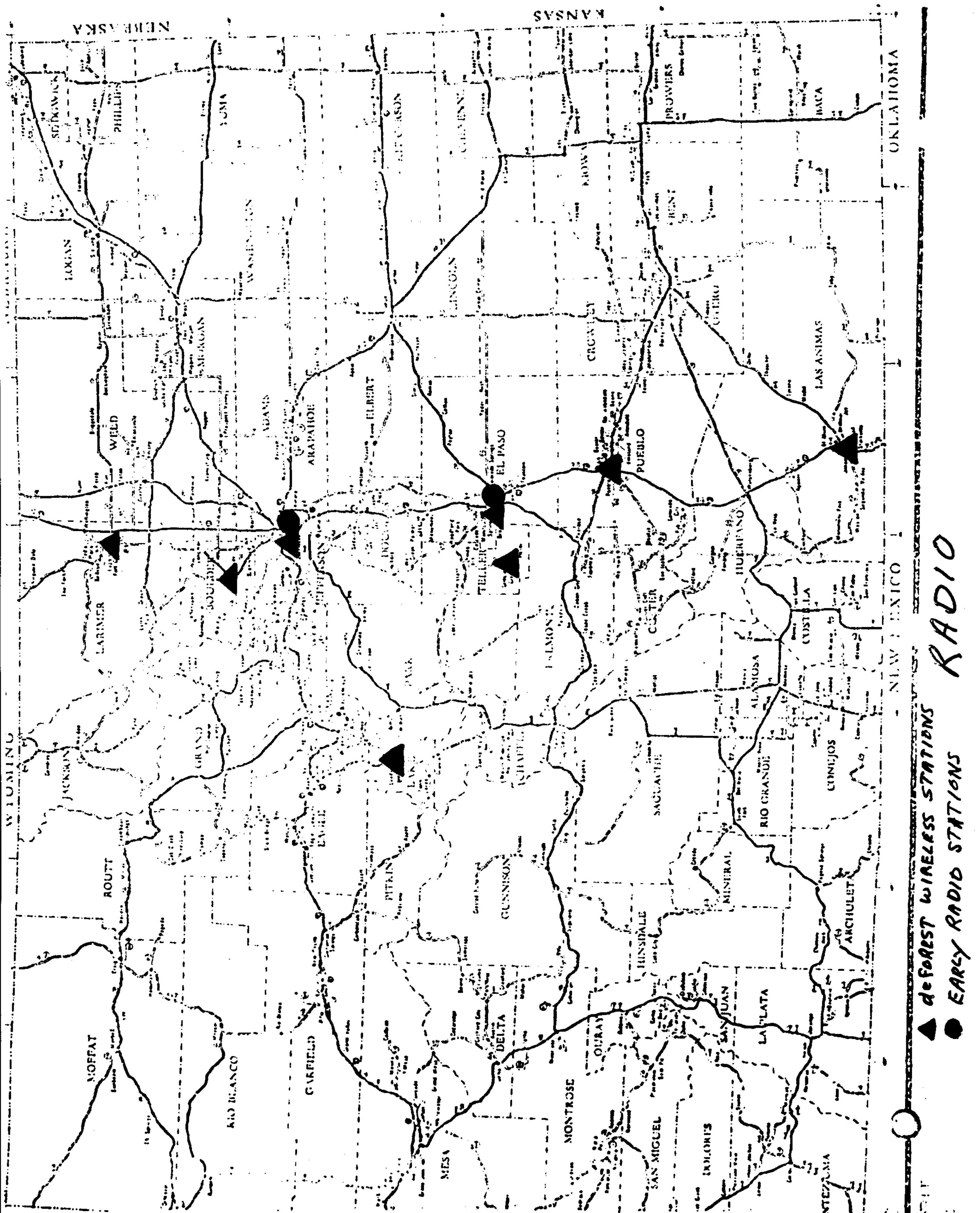
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HUERFANO
COSTILLA
ALAMOSA
CONEJOS
RIO GRANDE
MINERAL
ARCHULETA
LA PLATA
SAN JUAN
HINSDALE
SAGUACHE
GUNNISON
DELTA
OURAY
MONTROSE
SAN MIGUEL
DOLORES
MESA
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22. MUNICIPAL REFUSE

NARRATIVE

For the most part Americans ignored the mounds of garbage they produced until late in the nineteenth century when the rapid growth of large industrial cities dramatized the problems stemming from limited space, dense population, poor sanitation practices, and the spread of disease. Refuse materials of all kinds(a classification list is in Armstrong et al., 1976) filled vacant lots and open dumps and littered streets and alleys. Horses, the principal motive power in the cities into the twentieth century, deposited so much fecal matter and urine on the streets that many people regarded the appearance of the automobile as a technical triumph over a leading source of urban pollution. Colonel George E. Waring, Jr., street cleaning commissioner of New York City in the 1890s, became the leading proponent of sanitary reform and he promoted scientific and professional responses to the problem of municipal waste. His influence was felt in the early 1900s as improvements in the collection and disposal of municipal refuse often became a part of the progressive reform movement to engineer the "city beautiful" and to restructure urban life and politics. At least in larger cities waste management became a major concern for municipal and sanitary engineers who experimented with a variety of collection and disposal methods.

As cities grew larger they generally addressed first the problem of sewage, then street cleaning to keep main-travelled arteries functional and attractive, and finally residential solid wastes. Meanwhile garbage piled up in any convenient open space, with many cities letting pigs and even vultures roam freely to feed on the refuse. A strong inducement to change these practices came from scientific theories that traced the spread of disease to poor sanitation. Gradually cities responded by contracting with private scavengers or providing municipal collection and by establishing public dumps on the edge of town or in some cases depositing the garbage in rivers, lakes, or at sea. Until the 1920s, when trucks appeared in large numbers, garbage was hauled in horse drawn wagons or carts.

Technology introduced in the last twenty years of the nineteenth century aimed at reducing the volume of garbage, disinfecting it, and extracting useful by-products. Crematories or incinerators, ordinarily constructed of brick and using ducts, valves, and blowers to supply oxygen, destroyed the waste through combustion. Many of the first American incinerators borrowed designs from Europe where waste control became a problem much earlier. The first American incinerator was built by the U. S. Army on Governors Island, New York, in 1885, and cities around the nation quickly began to construct garbage furnaces. The Engle Sanitary and Cremation Company of Des Moines became a major manufacturer of these devices. Portable incinerators, mounted on wooden wagons and drawn by horses into neighborhood alleys, also appeared in some cities. The same time period produced a rival and more complex technology known as the garbage reduction plant which was a privately-owned enterprise but authorized by a municipality. These plants commonly cooked the garbage, moved it on conveyor belts, and then squeezed the refuse under heavy hydraulic presses. This extremely malodorous process extracted from the garbage several useful by-products, including grease used for cheap soaps and oils and tankage used in fertilizers. Due to the costliness of reduction, it was limited to the larger urban areas; Denver apparently had a reduction plant in the 1890s. However, even as these technologies developed, most big cities utilized a combination of disposal methods, a practice continued to the present time.

The strength of traditional disposal methods was demonstrated by the number of cities that organized systems to feed raw or cooked garbage to pigs on nearby farms. Denver in 1908 contracted with the Hog Ranch Company to collect municipal refuse for delivery to a large complex of company swine feeding pens outside the city. The Food Administration boosted this practice during World War I as a quick and efficient way to reduce waste and simultaneously increase the nation's supply of fresh meat. Not until the 1930s did scientific studies conclude that raw ~~garbage fed to pigs~~ accounted for the presence of parasitic worms(trichinae), harmful to humans, in undercooked pork.

Several factors influenced the issue of solid wastes in the period after the First World War. With the automobile accelerating the expansion of suburbs, cities were forced to locate garbage dumps further away from the source of supply. This development neccessitated better planning to meet future needs of growing metropolitan areas and it also hastened the adoption of motor trucks to haul refuse greater distances. During the 1920s the nature of garbage changed as Americans enjoyed the beginnings of a consumer revolution. Supermarkets, as one example, made grocery shopping more convenient and faster by "pre-packaging" goods in paper, cellophane, and other materials that eventually became garbage. An important new way to deal with the increasing diversity of garbage was the sanitary landfill, developed in Great Britain in the 1920s and arriving in America during the 1930s. The sanitary landfill utilized compacted layers of garbage and earth and became a popular technique for reclaiming ravines, quarries, and other land depressions.

At the end of the nineteenth century cities were able to supplement their force of pushbroom and shovel street cleaners with horse pulled rotary sweepers in the battle against manure and litter. The manure was sometimes sold to farmers for fertilizer. As paved streets became more common in the twentieth century, motorized mechanical sweepers, squeegee scrapers, and street flushers were introduced. This pattern of seeking technological answers to the problems of street cleaning and the other aspects of municipal solid waste control continued after World War II.

CHRONOLOGY

1869	Massachusetts became first state to create a state board of health.
1880s	Horse drawn rotary street sweepers introduced.
1887	American Public Health Association began nationwide fact-finding on refuse collection and disposal methods.
1880s-1920s	Peak years for garbage reduction plants.
1895-1897	George E. Waring, Jr., street cleaning commissioner of New York, New York.
1890s-1930s	Peak years for adoption of garbage incinerators.
1908	Denver contracted to feed garbage to pigs.
1914-1930	Major developments in motorized street cleaning equipment.
1920s--	Sanitary landfills established.

LOCATION

Resources associated with this theme can be found in and around all cities and towns in Colorado. Denver is particularly important because of its early development into a regional center, the annexation of contiguous areas, the expansion of suburbs, and for its methods and technology of handling municipal refuse.

CULTURAL RESOURCE TYPES

Sites include:
- Garbage dumps
- Ashpits
- Clinker dumps
- Manure pits
- Swill yards
- Sanitary landfills
- Compost heaps

Structures include:
- Reduction plants
- Incinerators

Equipment include:
- Garbage wagons and carts
- Portable incinerators
- Mechanical street sweepers

Street flushers
Truck haulers
Wheeled can carriers for street sweepers

THE QUANTITY AND QUALITY OF EXISTING DATA

Historical Documentation

Society's growing concern for environmental issues has spawned a few historical studies about municipal solid wastes, but analytical treatments of the subject remain meager. The leading expert in the field is Professor Martin Melosi of Texas A&M Univerity whose book on Garbage in the Cities is the only full-fledged historical study, offering not only a helpful discussion of leaders, theories, and technologies, but also a superb bibliography which should be consulted by any beginner in this field of research. The History of Public Works in the United States contains a good overview of the subject.

Sanitary engineers and reformers produced a number of treatises and reports beginning in the 1890s that detailed new technology, promoted new methods, and compiled information on practices in European and American cities. These constitute good primary sources on techniques and on occasion they convey references of a historical nature on specific cities. A fine example of this kind study is the Collection and Disposal of Municipal Refuse by Hering and Greeley. Additional information can be garnered from the reports of public agencies, engineering trade journals, municipal publications, and magazines such as the American City. Since editorialists sometimes focused public attention on issues of sanitary reform, newspapers may be a good source of information about local directions and attitudes regarding municipal wastes.

Number/Condition

The data are not sufficient to determine the number, type, and condition of resources that existed or may have existed. Open dumps in many abandoned mining camps have been picked over by souvenir hunters and bottle collectors, while other dumps have been buried and probably built upon. Structures associated with the theme may vary in condition from still in use to badly deteriorated. Much of the historical equipment is likely to have been scrapped and replaced by modern tools and machinery.

Data Gaps

Accurate location of municipal refuse sites.

Representative examples of early garbage handling tools and equipment, including street cleaning devices.

Accurate data on the ways and means Colorado cities handled solid wastes.

Future Needs

Documentary research is needed to gather historical information on this theme in Colorado. Field surveyors should be advised of the cultural resource types that may be encountered and they should be urged to locate and identify surviving examples. Pertinent data amassed in the course of previous projects, particularly in the Denver area, should be identified for future reference. Finally, a comprehensive historic engineering site survey should be undertaken by the state and this theme designated in the scope of work.

Important Resources

Without a comprehensive inventory for this theme, representative resource types that can be accurately dated and identified should be considered significant. Early efforts by Denver to collect and dispose of refuse materials need to be recorded, especially experiments with garbage reduction plants and swine feeding programs.

RESEARCH QUESTIONS

1. What resources remain to provide information on early efforts at collecting and disposing of municipal refuse?
2. What can material remains tell researchers about earlier attitudes regarding the urban and natural environment?
3. Can cultural resources shed new light on the subjects of municipal reform, civic pride, and life styles at earlier times?
4. Can resources document the changing methods and technologies involved in the management of municipal refuse?

PHYSICAL CONDITION

Site: Should be undisturbed, identified as to purpose, and accurately dated.

Structure: Should be in place and enough interior machinery should remain to make the purpose and method of operation readily apparent.

Equipment: Should be complete and in good or repairable condition; should be dated and identified as to function.

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23. LUMBER

NARRATIVE

From the founding of the colonies, Americans made a practice of using the woodlands, often in careless and wasteful ways, to supply their needs for building material and fuel. The pattern continued into Colorado where the earliest settlers introduced traditional methods of felling trees and producing lumber in crude sawmills. Even though a number of factors, including remoteness from major markets, strong local demand, and the steep mountainous terrain, kept Colorado from becoming a leading producer in the Rocky Mountain region, the state did develop many commercial operations, particularly in response to the growing demands of the railroad and mining industries. The railroads consumed vast amounts of wood for crossties, trestles, and structures and the mines required round and square-sawed timber to shore up their underground workings and lumber to construct surface buildings; as late as 1911 the mines consumed about 23% of the timber produced in Colorado. To these usages were added the requirements of telegraph, telephone, and electric power industries for wooden poles and the wood cutting activities of charcoal makers who sold fuel to the smelting and refining plants in the state.

Logging activity reached a peak in Colorado during the last thirty years of the nineteenth century, a time when lumbermen had available both new and old methods for harvesting trees. The specific tools and techniques varied, depending on the size and specie of trees, topography, the nature of the final product, and similar considerations. Typically, logs were removed in stages: the felling of the trees, skidding the logs to a central yard, and transporting the timber to a sawmill or other destination. The felling axe was essentially an American tool, which, by the late 1800s, had evolved into single and double bitted, cast steel models that were mass manufactured by the "axe trust", the American Axe and Tool Company, and a few others. Lumbermen relied on axes, wedges, hooks, and jacks to do their job, and beginning in the 1880s, they made use of the new two-man crosscut saws manufactured of tempered steel. The American trait of seeking labor-saving devices extended to logging as well. Between 1905 and 1930 saws powered by compressed air and electricity were developed; the important breakthrough coming in 1927 when German inventor Andreas Stihl introduced a portable, gasoline powered chain saw.

Moving the fallen trees proved the most difficult and costly aspect of logging. Woodsmen took advantage of water and gravity whenever possible, but they rarely avoided the necessity of hauling or skidding the logs to a central yard. In general they depended on oxen and horses to pull heavy wagons or, in winter, sleighs, with such additional equipment as "big wheels", two large wheels connected to a long tongue, that dragged the logs by one end, or "steam donkeys", consisting of stationary steam engines and spools that pulled the logs across the ground by means of rope or steel cable. In the twentieth century these techniques gradually gave way to gasoline powered crawler tractors, trucks, and cranes, along with improved devices to haul the logs.

Most lumbering operations utilized a clearing(on a stream bank if water was being used for transportation) in the woods where some on-site processing of the logs could take place. Workers using bucksaws cut the logs into smaller, more easily handled sizes and trimmed away branches before shipping the timber to mills. Railroad crossties(railroads used about 3000 per mile of track) and many mine timbers could be hewed in the woods, until both industries began requiring more creosote treated timbers in the twentieth century. A sign of this development appeared in 1925 when the National Lumber and Creosoting Company established a pressure-treatment creosote plant in Salida.

The industry employed several methods to transport raw timber from forest to sawmill. By blocking streams with temporary dams, called splash or flooding dams, enough water was accumulated, usually by the spring of the year, to float the logs downstream. Diverting high-country streams into wooden flumes was another way to convey logs down steep hillsides, while oxen and horses remained valuable for hauling heavy wagons to the mills. Although experiments began in the 1850s to construct logging railroads, Colorado appears to have had the first steam driven logging railroad using iron rails. This occurred in 1868 when the Arapahoe, Jefferson, and South Park Railway carried timber to Denver for the construction of the Denver Pacific Railroad. Conflicts with farmers over water usage and the unsuitability of some mountain streams to carry logs encouraged the building of logging railroads at the turn of the century. A most important technical advance was the development of small, powerful logging locomotives,notably the Shay and the Heisler, which could negotiate the sharp turns and steep grades in the timberlands.

After the Civil War, steam began to replace water as a source of power in sawmills. Steam also permitted mills to become portable and move with the cutting operation, although the mills generally remained close to the streams and railroads. The circular saw, in widespread use by the 1830s, was the basic machine in most sawmills, while larger mills often contained gang saws and band saws as well. The early Colorado mills produced rough-cut lumber which satisfied the immediate needs of new towns and industries for building materials.

Lumber companies in Colorado operated under few restrictions until the federal government established forest reserves in the 1890s. The Forest Reserve Act of 1891 created five reserves in the state, totalling over three million acres of forest land, and required user permits. President Theodore Roosevelt set aside eleven more reserves in Colorado by 1909. These actions by the federal government touched off acrimonious debates throughout the West between conservationists and anticonservationists. Smale-scale logging operators were adversely affected by the imposition of federal controls that hampered their "cut and run" practices in the forests. At the same time, however, the permit system presented larger companies with new opportunities, for example, the New Mexico Lumber Company that built a logging railway and carried on extensive cutting operations in the Montezuma National Forest in the 1920s. With few exceptions, the Colorado industry underwent a general decline after 1910. Large corporations working in the abundant timberlands of the northern Rockies and the Pacific Northwest enjoyed cost advantages and could reach Colorado consumers by rail. Furthermore many of the commercially-valuable forests in the state had been exhausted at earlier dates with no provisions made for reforestation. Thus, by the Great Depression of the 1930s, the industry was left mainly in the hands of small operators supplying wood to specialized or local markets.

CHRONOLOGY

1865-1900	Active period of timber cutting to supply the requirements of the mining industry for underground props.
1867-1868	Crosstie cutting in northern Colorado and construction of first logging railway using iron rails.
1870s-1880s	Appearance of tempered steel crosscut saws.
1880-1900	Development of steam driven logging locomotives.
1891	Forest Reserve Act began federal regulation of forest resources.
1895-1907	Active period of logging in southwestern Colorado, including the construction of logging railroads.
1920s	Introduction of many gas powered machines and equipment in logging and milling operations.
1927	Development of portable, gasoline powered chain saws.
1924-1933	New Mexico Lumber Company harvested timber in the area around the company town of McPhee, Colorado.

LOCATION

Resources associated with this theme can be found at various places in the mountains and plateau regions of the state. While loggers spread throughout the forested areas, sawmills, even the portable ones, tended to locate near streams, railroads, and towns. The map outlines the major timber areas in Colorado.

CULTURAL RESOURCE TYPES

Sites include:
- Sawmill complex
- Camps
- Gathering yards
- Cutting zone
- Chip pile
- Roads
- Logging railway route
- Log ponds

Structures include:
- Splash or flooding dams
- Sawmill
- Drying kilns
- Charcoal ovens
- Flumes
- Incinerators

Tools, equipment, and machines include:
- Axes - single and double bitted

- Wagons
- Sleighs
- Big wheels
- Hoists and loaders
- Logging railway cars and locomotives
- Bucksaws
- Crosscut saws
- Chain saws
- Gang saws
- Jacks
- Steam donkeys
- Powered log haulers

THE QUANTITY AND QUALITY OF EXISTING DATA

Historical Documentation

The secondary literature presently available on lumber and the forest products industry can be described as broad and shallow. Histories of specific firms, important individuals, and regional developments range from uncritical, authorized pieces and picture books to scholarly studies. There are a number of technical works dealing with various facets of timber use. Some of the most dependable sources having a technical bent were written by ~~Nelson C.~~ Brown, whose Timber Products and Industries provides a helpful overview. In 1983 the Forest History Society compiled an Encyclopedia of American Forest and Conservation History that is an excellent source of up-to-date information on many familiar as well as new topics pertinent to this theme. In addition to articles written by experts, it contains bibliography, maps and charts, a useful index, and appendices on national forests and federal legislation. Some of the essays relevant to this theme are: "Colorado Forests" by G. Michael McCarthy, "Logging Technology and Tools" by Thomas R. Cox, "Lumber Industry: Rocky Mountain Region" by Jay. M. Hammond, "Mine Timber" by Joseph E. King, and "Railroads and Forests" by Roy V. Scott.

The history of lumbering in Colorado can be gathered from several secondary sources, particularly Wroten's dissertation on tie hacking, and from county histories, newspapers, manuscript collections, and both federal and state government publications. The records and histories of mining and railroad companies often include information on wood usage. The Forest History Society, the American Forest Institute, and the U. S. forest Service have documents and photographs useful to researchers. At the state level, the Norlin Library at the University of Colorado, the Denver Public Library, and the Colorado Historical Society possess a variety of printed and manuscript materials pertinent to this theme.

Number/Condition

The data are insufficient to determine the number of resources that existed or may have existed. Subsequent use of forest areas for other purposes and the ephemeral nature of most logging operations have resulted in the disappearance of an indefinite number of resources. Technological changes accounted for the replacement and removal of many early machines and equipment, although many tools of an earlier date remain remarkable unchanged. U. S. Forest Service inventories contain some information on resources in this theme.

Data Gaps

Representative examples of early lumbering operations.

Representative tools, machinies, and equipment related to all aspects of the forest industries.

Records of sawmills and logging companies.

Further documentation of important people, places, and events in the history of Colorado lumber.

Future Needs

A field survey, perhaps as part of a more comprehensive effort, should be initiated in the near future. Likewise, a need remains to examine and appraise previous survey materials and to collect additional historical documentation. Technology performed an important role in this industry's development, so a special effort should be made to identify and preserve examples of early equipment and machinery. Historians and archaeologists should jointly participate in the field survey.

Important Resources

The timber industry's early growth and sometimes devastating impact in certain areas of the state are sufficient reasons to regard all resources valuable. Yet the industry must also be seen as an essential support to the development of mining and railroads in Colorado, reinforcing the significance of resources in this theme.

RESEARCH QUESTIONS

1. Can resources document the technology and the evolution of technology in the lumber industry of Colorado?
2. Can resources reveal the connection bewteen lumbering and the state's mining, railroad, and urban development?
3. Can material evidence expand or modify our understanding of historical attitudes toward the environment and natural resources?
4. Can resources clarify some of the issues debated by conservationists and anticonservationists in the past?

PHYSICAL CONDITION

Sites: Must be clearly discernible and dated to the appropriate historical period. Connections to other activities and sites should be established.

Structures: Should be in historic use location and retain sufficient integrity to identify purpose.

Tools, Machinery, Equipment: Should be intact or enough should remain to permit restoration. Purpose, mode of operation, and historical importance should be made clear. Manufacturer and approximate date of use should be ascertained, if possible.

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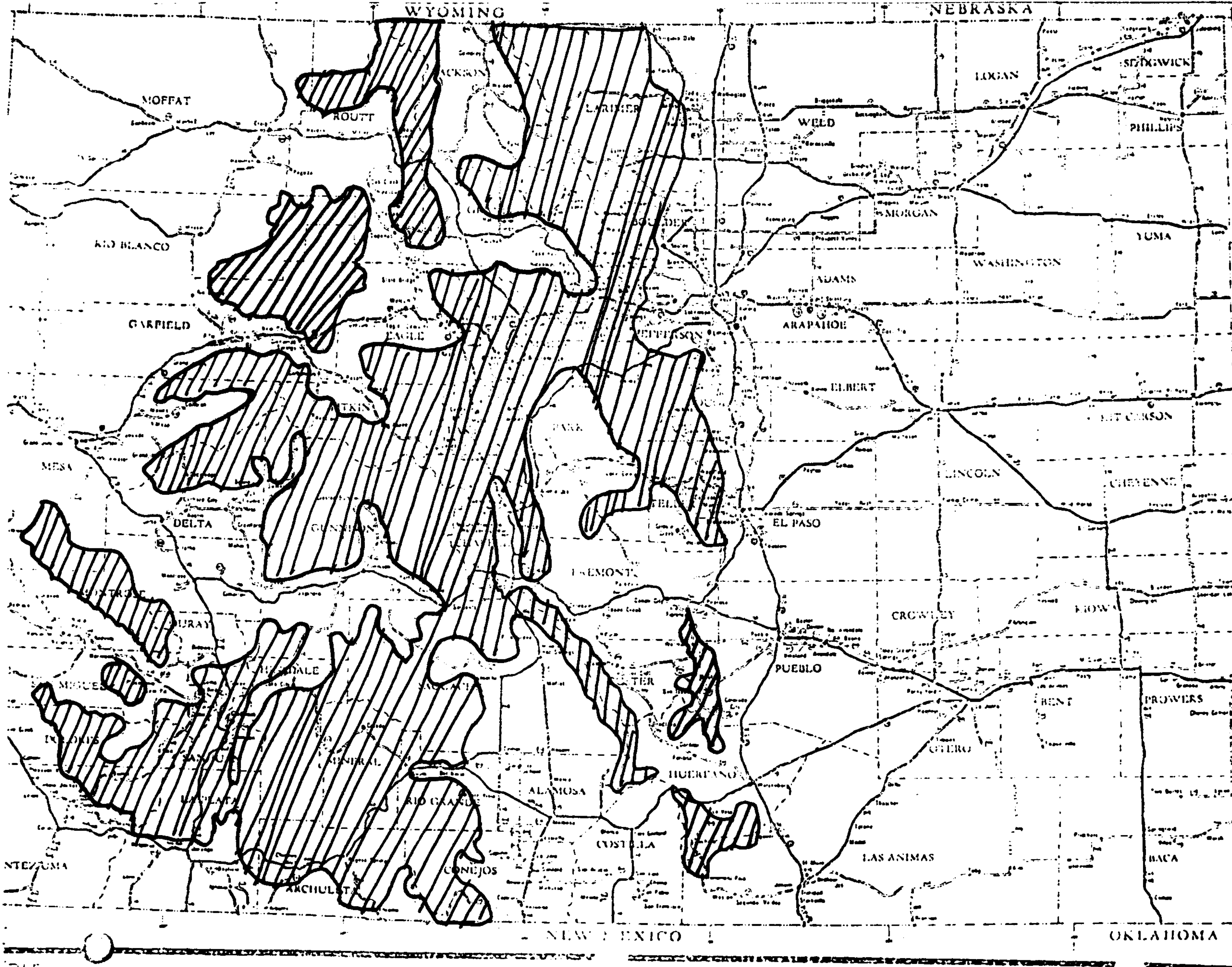
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WASHINGTON
ADAMS
GARFIELD
EAGLE
JEFFERSON
ARAPAHOE
ELBERT
KIT CARSON
PARK
MESA
LINCOLN
CHEYENNE
DELTA
GUNNISON
EL PASO
FREMONT
CROWLEY
KIOWA
PUEBLO
HINSDALE
BENT
PROWERS
OTERO
HUERFANO
ALAMOSA
RIO GRANDE
MINERAL
COSTILLA
LAS ANIMAS
BACA
CONEJOS
NEW MEXICO
OKLAHOMA
KANSAS

LUMBER

24. SMELTING

NARRATIVE

The industrial development of gold and silver deposits in Colorado relied upon constant improvements in the science and technology of ore reduction. This crucial partnership between mining and processing became evident early in the state's history. Miners in the 1860s found that ore taken at greater depths defied traditional methods of extracting the gold by milling and amalgamation with quicksilver. The chemical complexity of the ores, "refractory" said the miners, touched off a process mania between 1864 and 1867 as a host of experiments, from the sensible to the ridiculous, tried to unlock the secret of better gold recovery. The solution came from Brown University chemist Nathaniel P. Hill who smelted the ore in a furnace according to a process he witnessed in Swansea, England. Beginning in 1868, Hill's smelter at Black Hawk, built with eastern capital, produced gold on copper mattes which were shipped to England for final processing. The union of science, technology, and business acumen, successfully formed at Black Hawk, would largely characterize the rise of a smelting industry in Colorado.

Mineral developments in the central Rockies during the late 1870s and 1880s, especially at the the rich silver camp of Leadville, prompted a surge in smelting enterprises. Businessmen and metallurgists, such as August Meyer, James Grant, Edwin Harrison, and Anton Eilers, erected smelters at Leadville to treat silver carbonates. Most plants installed Piltz or Raschette furnaces (often manufactured by Fraser and Chalmers in Chicago), each lined with firebrick, which were loaded with ores, fuel, and flux. From the molten ore, workers drew off slag(sometimes utilized for road building) and silver-lead bullion, the lead acting as a collector for the silver. At greater depths the mines produced ore with a high sulphur content necessitating technical changes at the smelters. Starting in the 1880s some plants added reverberatory furnaces to roast the ores, burning off some of the sulphur, as a preliminary treatment. Pyritic smelters, large furnaces designed to ignite the sulphides and use less coal, appeared in the 1890s in response to lower grade ores.

As illustrated by Leadville, early smelters built near the mines to reduce the costs of freighting ores a long distance; some mines established their own smelters for this reason and others. Yet this initial advantage began to disappear as a railroad network grew in the state and region, permitting smeltermen to select central locations with rail service in many directions. Centrality became particularly important as smelters needed a steady flow of mixed ores, flux, fuel, and supplies from all parts of the state and region. Leadville smelters, for example, were hurt when local mines produced "dry" ores(less lead), requiring them to import lead ores from distant points, even Mexico. Denver and Pueblo primarily benefited from the relocation of smelters. Hill shifted his operations from Black Hawk to Denver in 1878, constructing the Argo smelter, and was followed by the Grant smelter, and the huge Globe Smelting and Refining Company plant in the early 1890s.

Pueblo, at the foot of the Arkansas Valley, was an attractive site with its nearby coal fields. The so-called "valley smelters" at Denver and Pueblo dominated the Colorado industry by the early 1890s, their economies of scale and transportation facilities unmatched by the somewhat isolated mountain smelters.

During the late nineteenth century the industry exercised a strong influence on the state's economy and society. Smelting channeled large sums of developmental capital into the region from eastern investors and regularly induced some of the best trained engineers and scientists, many educated in the European metallurgical academies, to plants in the state. Several leading figures in the industry became political forces in Colorado, such as James Grant and Nathaniel Hill, while others achieved enviable reputations worldwide as businessmen and engineers. The technology of ore reduction was altered in countless ways by individuals associated with the Colorado industry; one example being Arthur Wilfley whose concentrating table became standard throughout the world. Finally, the construction of large smelters in Denver and Pueblo helped shape those urban environments, from air and water pollution to the immigrant workers attracted to the factory jobs.

By the turn of the century smeltermen were following the path of other industries in the United States toward greater consolidation and integration. Many companies owned mines, sampling works, several smelters, and refining plants. Among the largest operators in the nation were the United Smelting and Refining Company(Pueblo), the Omaha and Grant Company(Denver and Durango), Consolidated Kansas City(Leadville), and the Philadelphia Smelting and Refining Company(Pueblo). Troubled by weak and unsteady prices for silver and lead, the smelters gave more attention to the base metals, such as copper and zinc, by introducing new processes and technologies. Good prices for copper between 1896 and 1914 hastened the adoption of electrolytic copper refining, while zinc concentrators and smelters appeared in the early 1900s when that metal's value increased.

The greatest change occurred in the organization of the industry. In 1899 leading entrepreneurs within the industry, including Colorado capitalists Dennis Sheedy, David Moffat, and James Grant, with assistance from the New York banking community, formed a giant combination called the American Smelting and Refining Company(ASARCO) that controlled roughly two-thirds of the nation's smelting and refining capacity and was quickly dubbed the "smelter trust." However, poor management and a strike led by the Mill and Smelterworkers Union left ASARCO in need of new investment. Financial help came from the Guggenheim family, owners of the Philadelphia smelter at Pueblo and early investors in Leadville, who gained control of the combination in 1901. One of the first steps taken by ASARCO was to open a new plant at Blende, near Pueblo, to produce zinc spelter. The declining quantity and quality of smelter rock persuaded the company to reorganize its Colorado operations and gradually shift production out of the state. ASARCO closed the Denver and Pueblo smelters soon after World War One, the Durango plant in 1930, and left the Leadville smelter in partial operation until its closing in 1961.

CHRONOLOGY

1864-1867	Process mania to reduce "refractory" ores.
1865-1880	Development of various processes to smelt ores in hearths, roasters, and blast furnaces.
1868	Nathaniel Hill's successful Swansea process for smelt-ores is used at his Boston and Colorado smelter in Black Hawk.
1876-1880	Rapid expansion of smelters at Leadville.
1878	Hill built Argo smelter. Closed in 1910.
1880-1900	Shift of smelters to plains cities of Denver and Pueblo.
1890s	Depressed prices of silver.
1891-1892	Introduction of pyritic smelters at Leadville.
1895-1920	New mechanical and chemical procedures to reduce lower grade ores.
1899-1901	Organization of ASARCO and control over the firm gained by the Guggenheims.
1918-1921	ASARCO closes smelters at Pueblo and Denver.

LOCATION

Resources associated with the smelting industry are primarily located in the mountainous areas of the state and in the plains towns of Denver and Pueblo. Early smelters set up operations as close to mining sites as possible, but, with the development of better transportation and the need for ore and fuel from distant areas, the industry became more centralized. In the mountainous areas, valley locations were preferred so that ore could move down to the smelters.

CULTURAL RESOURCE TYPES

Structures include:
- Smelting plants
- Sheds
- Offices
- Mills
- Smokestacks

Machinery and equipment include:
- Hearths
- Reverberatories
- Blast furnaces
- Rock crushers
- Concentrating tables
- Chemical treatment vats

THE QUANTITY AND QUALITY OF EXISTING DATA

Historical Documentation

James Fell's Ores to Metals is an excellent scholarly treatment of this subject with particular emphasis on the business aspects of smelting and primarily focusing on Colorado. The book's bibliography will introduce the researcher to the variety and extent of secondary and primary printed materials on smelting as well as important collections of manuscripts on companies and individuals in the industry. Fell's study will suffice for most issues raised by the Colorado experience in ore smelting. Marcosson's volume, on the other hand, is worth consulting mainly because it is the only attempt at a company history of ASARCO, which has not made its records public, although the book is out of date and contains errors and apocryphal stories. Careful study is required to gain even a modest understanding of the complex technology of smelting and the metallurgical problems wrestled with by the industry. Clark Spence's Mining Engineers and the American West helps to identify the many contributions of mining engineers to the industry and provides a sophisticated analysis of the impact of scientific knowledge and methods on western mining. Older technical treatises on many aspects of ore dressing and reduction are available to researchers who wish to examine a specific process or technique. Jay Niebur's Arthur Redman Wilfley is a useful study of an important and neglected inventor. Additional information can be gathered from the periodicals Mining and Scientific Press(San Francisco) and the Engineering and Mining Journal(New York). Researchers will also benefit from the publications of the American Institute of Mining and Metallurgical Engineers and the Colorado School of Mines.

Number/Condition

The data base needs to be reviewed, revised, and expanded to provide an accurate number of sites that exist or may have existed. The condition of sites vary from intact to demolished. Many sites have deteriorated due to vandalism, souvenir hunting, weathering, and salvaging. At the time of abandonment, machinery and equipment were often removed for installation elsewhere or sold for scrap.

Data Gaps

Representative examples of early smelting technology.

Representative examples of the changing methods and practices in ore reduction.

Full identification and recording of smelter sites in the state.

Future Needs

Despite its close and crucial association with mining, the smelting industry has not received the same degree of attention. The amount of historical documentation currently available should permit a complete inventory of sites and surviving structures. A greater effort will be required to survey and inventory the technology of ore reduction because of the variety and complexity of equipment and apparatus. Both a full review of the present data base and a field survey of surviving resources deserve high priority. These tasks will require the skills of a historian knowledeable of mining developments in Colorado, smelting technology, and the cultural resource process.

Important Resources

Until existing data are reviewed for thoroughness and accuracy and upgraded by additional research and field work, all resources related to this theme should be considered important. Resources pertinent to the industry's efforts at treating base metals, such as lead, copper, and zinc, that have been generally ignored, are also historically significant. Likewise, cultural resources related to the impact of smelters on urban and neighborhood development must be regarded as important.

RESEARCH. QUESTIONS

1. What resources remain to show the evolution of smelting technology in Colorado?
2. Can resources document inventions and innovations ascribed to the Colorado industry?
3. What resources remain to clarify the association and interrelatedness of mining, smelting, and the railroads?
4. Can resources add to or alter our understanding of the business organization of smelting?
5. Can resources in the state substantiate the regional and even international dimensions of the smelting industry?
6. Can resources help explain the environmental impact of this industry?

PHYSICAL CONDITION

Structures: Should be in place and with sufficient integrity to reveal their function. Smelters should retain structural integrity and contain enough machinery to disclose the purposes and methods of operation.

Machinery, Equipment: Should be intact or enough should remain to disclose its purpose and operation. Should be dated to appropriate historical period. If possible, it should be identified for its historical location and for its manufacturer.

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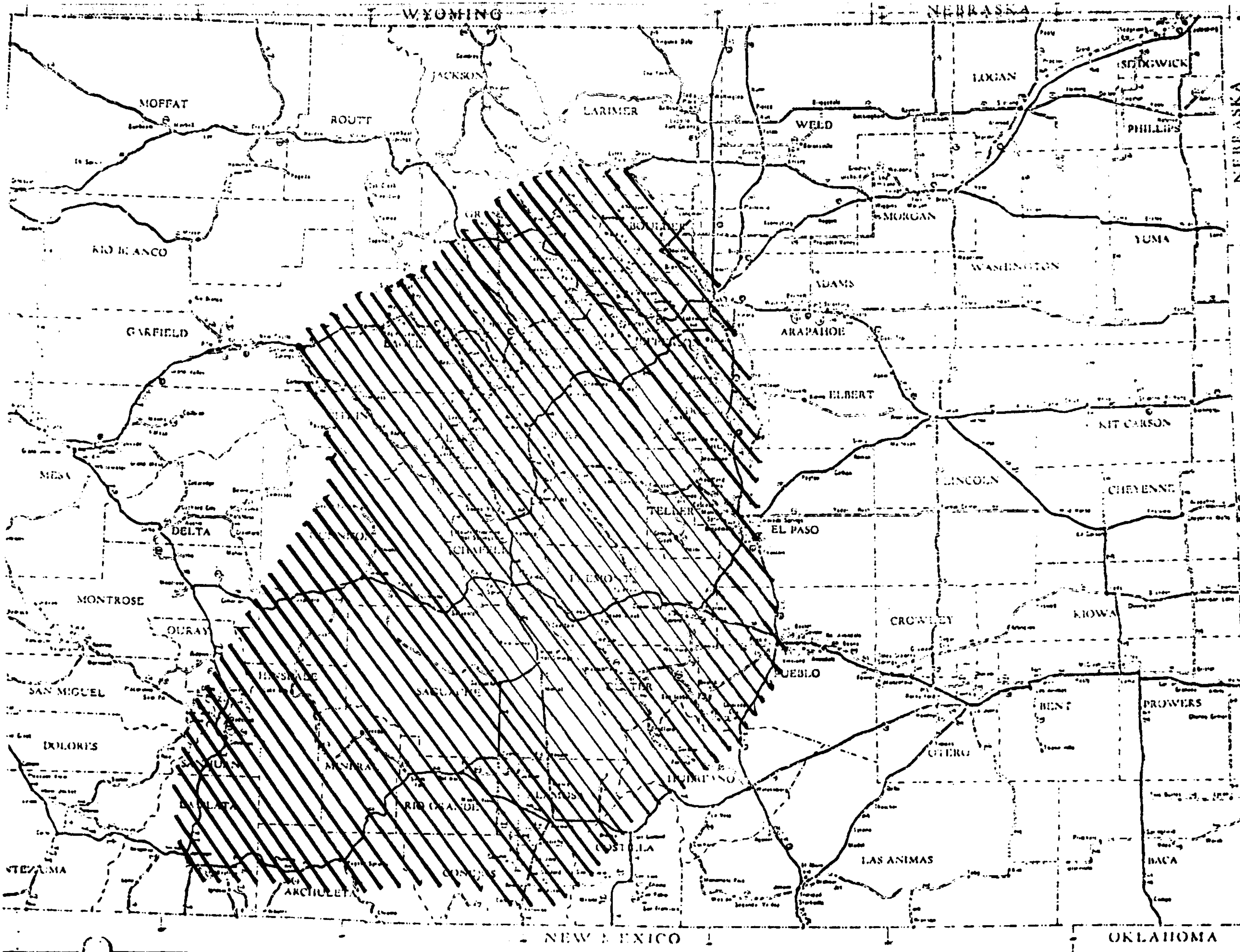
WYOMING
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MORGAN
YUMA
WASHINGTON
ADAMS
GARFIELD
ARAPAHOE
ELBERT
KIT CARSON
MESA
LINCOLN
CHEYENNE
DELTA
TELLER
EL PASO
KANSAS
MONTROSE
CROWLEY
KIOWA
OURAY
PUEBLO
SAN MIGUEL
SAGUACHE
BENT
PROWERS
DOLORES
OTERO
RIO GRANDE
COSTILLA
LAS ANIMAS
BACA
ARCHULETA
NEW MEXICO
OKLAHOMA

SMELTING

25. FOOD PROCESSING

NARRATIVE

Science, technology, and business organization combined, under the stimulus of improving transportation and growing cities, to make food processing a major American industry during the nineteenth century. Traditional methods, reliant on drying, pickling, salting, and similar preservation techniques, gradually gave way to large-scale commercial operations which mechanized production. The Civil War spurred on these developments through its enormous demand for processed foods to feed the armies in the field. The middle and late years of the century witnessed numerous technical and economic innovations that ushered in the modern age of food processing.

Improved methods and new technologies are said to have revolutionized the business of flour milling, primarily during the 1880s-1890s. At mid century the typical grist mill was a small, locally-owned enterprise that depended on either water or steam power to turn its large millstones for grinding wheat and corn. Most of the early mills in Colorado, including those built by Hispanic settlers in the San Luis region, were of this type. The so-called "American" mills that arrived with the goldseekers often utilized bolting cloth to separate the finer flour. However, urbanization, greater mechanization of agriculture, and the introduction of hard spring wheats altered milling practices in the late nineteenth century. Most notable was the development of better ways of purifying the flour, first with sieves then with streams of air. At about the same time steel rollers were introduced(rolling mills) that cracked rather than ground the grain, resulting in a more desirable product. These changes also made mass production feasible and several large-scale milling companies emerged, principally around Minneapolis. Beginning in the 1880s John K. Mullen of Denver organized the Colorado Milling and Elevator Company which owned about eighteen mills in the state by the time of the First World War and constructed numerous grain elevators on the plains in eastern Colorado and western Kansas. Continued expansion made the firm one of the largest processors in the region.

The evolution of a successful canning industry encouraged farmers to expand their production of perishable commodities and enabled urban consumers to purchase a variety of foods throughout the year. In the last thirty years of the nineteenth century technical advances focused on the mass manufacture of tin cans and better sealing procedures, mechanized preparation of the product, and more reliable methods of pressure-cooking canned foods. In pea canning, for example, the invention of automatic pea podders and pea viners in the 1880s reduced the amount of hand-labor, often performed by women and children from nearby farms, thus lowering the price of the final product. Mechanical means of cutting and peeling fruits and vegetables also resulted in additional savings. Canners generally set up their factories close to the fields that supplied their commodities. One of Colorado's early and large canneries was established by John Empson at Longmont and Fort Lupton during the 1880s and 1890s to produce canned peas, tomatoes, and currant jelly(reputedly made in silver kettles). In the 1920s Empson sold out to another early canner in the state, the Kuner Pickle Company of Denver.

In the period after the Civil War, some of the most dramatic changes in the food processing industry concerned meat packing, the first processors to organize on a national scale. To compete with the small and local slaughter-houses, there developed a highly centralized meat packing industry in Chicago headed by Gustavus Swift and Philip Armour. These packers achieved substantial cost savings by purchasing cattle in quantity, slaughtering in one place, and shipping dressed meat to eastern cities in refrigerated railway cars. The size of their operations further permitted them to manufacture numerous by-products from the animal, such as fertilizer, glue, and soap, that were not economically feasible for smaller companies. As with other food processors, the meat packers introduced an array of innovative processes and mechanized methods that disassembled each carcass. Many Colorado ranchers, who had begun by supplying cattle to butchers in the mining camps, eventually shipped shipped large numbers of animals by rail to the Chicago packers. However, in the twentieth century, the industry gradually decentralized operations; packing plants were established in the West closer to the points supply.

Between 1900 and 1945 food processing incorporated many new methods and techniques, some brought about by the demands of two world wars, and others by the rapid growth of supermarkets, especially during the 1920s. In the earlier years of the century, a method of cold packing(slow freezing) fruit was developed which helped growers in the western states reach eastern markets with fresh fruit. H. S. Baker reportedly conducted the first success-experiments in cold packing in Denver in 1908. Late in the 1920s Clarence Birdseye demonstrated that many foods could be quick frozen. Greater use of these processing techniques depended on improvements in mechanical refrigeration for industry and homes.

CHRONOLOGY

1819	Commercial canning started in America.
1840s	Tin cans came into widespread use.
1856	Gail Borden developed process for condensing milk.
1874	Retort invented for pressure cooking canned foods.
1870s	Development of the refrigerated railway car.
1870s-1880s	Formative period of the Chicago meat packing industry.
1880s	New mechanical processes for milling grain.
1882	Kuner Pickle Company organized in Denver.
1885	Empson Packing Company started in Longmont.
1887	Colorado Milling and Elevator Company created by John K. Mullen.
1906	Congress passed Pure Food and Drug Act to regulate the food industry.

1920s	Rapid expansion of supermarket chains.
	Greater use of cold packing for fruits and vegetables.
1929	Quick freezing foods successfully demonstrated.

LOCATION

Food processing plants can be found in all parts of the state, but principally on the eastern plains, in cities along the front range(especially Denver), and on the western slope. Availability of transportation and proximity to the source of supply were important determinants in location, while urban areas facilitated direct marketing to consumers. Because of the diverse resources treated in this theme, no map is attached.

CULTURAL RESOURCE TYPES

Structures include:
- Mills
- Canneries
- Slaughterhouses(packing plants)
- Dairies
- Cattle pens
- Stock yards
- Storage bins
- Bottling plants
- Grain elevators

Equipment and apparatus:
- Numerous specialized machines and techniques depending on the product.

THE QUANTITY AND QUALITY OF EXISTING DATA

Historical Documentation

Over the last twenty years historians have devoted little attention to the food processing industry. Since no general history exists, one must turn to specialized studies of particular industries, innovators and inventors, and individual companies. Yet the researcher must exercise caution in using many of these works since they are far out of date, were carelessly researched and written, or sponsored by a company or industry as a public relations effort. Given these deficiencies, the available secondary sources can be useful in tracing technical changes and for determining approximate dates for the introduction of new machinery and processes.

In his History of Agriculture in Colorado Alvin Steinel did not directly address the subject of food processing, but his discussion of agricultural developments in the state provides valuable background information on this theme. The same is true of the publications of the Colorado Agricultural Experiment Station. Manuscript collections and other documents found in the state university libraries, the Colorado Historical Society, the Denver Public Library, as well as the state archives might prove helpful. Local business directories and newspapers might yield additional information. The inventory files at the Colorado Preservation Office should also be consulted.

Number/Condition

The presently available data are inadequate to determine the number or type of resources that once existed or may have existed. The condition of surviving structures is likely to vary greatly. As with other industries, food processors tended to scrap older equipment when new machinery and processes became available.

Data Gaps

Representative early food processing facilities.

Accurate location and identification of food processing operations in Colorado.

Records of food processing firms.

Future Needs

A special effort to identify resources in this theme is not recommended at this time. However, food processing should be included within larger inventories concerned perhaps with historic engineering, industrial, or agricultural activities in Colorado. An important need remains to gather basic documentary evidence on this multi-faceted industry and to develop an interpretative framework for assessing its resources.

Important Resources

All aspects of the food supply system that developed in Colorado to support the activities of early miners and railroad builders are historically important. This consideration, along with our scanty knowledge of resources remaining in this field, makes all surviving physical remains significant. Once a more complete inventory of resources is available, the task of selecting representative types can proceed.

RESEARCH QUESTIONS

1. What resources remain to document the changing technology of food processing?
2. Can cultural resources help explain the relationship between agricultural developments, including food processing, and the mining industry, railroads, and urban growth in the state?
3. What resources remain to document the extent of food processing in Colorado?
4. Identify and document leading individuals and companies in food processing.
5. Can resources increase our knowledge of the social and economic impact of the processing industry at the state and local levels?

PHYSICAL CONDITION

Structures: Should retain enough physical integrity to show the buildings' function and operation. Should be accurately dated.

Equipment and apparatus: Should be intact or enough should remain for restoration. Should be dated accurately and identified for function and

and method of operation. If appropriate, its function within a system of processing should be clear.

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26. BEET SUGAR

NARRATIVE

The commercial development of sugar beets began in Europe in the early 1800s through the efforts of Napoleon to find a substitute for cane sugar during his long wars with the British. The achievements of the French and Germans in cultivating the beets and processing them for sugar attracted the attention of individual and government promoters in the United States. The U. S. Department of Agriculture and several state agricultural experiment stations, including the one in Colorado, tested seed, soils, climatic conditions, and farm implements and urged farmers in many areas to plant sugar beets. The reluctance of western farmers to try the new crop greatly diminished after a serious depression in the 1890s and after the appearance of a few successful beet sugar factories in the West. The first successful factory was built at Alvarado, California in the 1870s, and other plants opened in that state and in Nebraska during the 1880s. Most impressive to farmers in the Rocky Mountain states was the construction of a factory by the Mormon Church at Lehi, Utah in 1891. The first to use American made machinery as opposed to European imports, the Lehi plant quickly proved successful and showed the way for others in the region. Mining entrepreneurs John F. Campion and Charles Boettcher built Colorado's first sugar factory at Grand Junction in 1899.

Between 1898 and 1913 enthusiasm for sugar beets became almost feverish in the West. The reasons appeared to be good ones: beet production blended well with other established crops; both beet tops and beet pulp from the mills could be fed to beef cattle and sheep; and, beet factories added an industrial base to farming communities, all of which were important considerations to westerners. The Newlands Reclamation Act of 1902 added a further incentive by providing federal financing of irrigation projects. Under these favorable conditions, the processing industry and sugar beet cultivation expanded rapidly. While the Lehi plant became the nucleus for the much larger Utah-Idaho Sugar Company, Colorado experienced its own spurt in factory building, particularly in towns along the South Platte and Arkansas rivers. The American Beet Sugar Company, owned by the innovative Oxnard family of California, erected plants at Rocky Ford(1900), Lamar(1905), and Las Animas(1907), and the Holly Sugar Company built at Holly(1905), Swink(1906), and Delta(1920). The Campion-Boettcher group organized the Great Western Sugar Company in 1900 and proceeded to erect a string of factories in Loveland, Greeley, Eaton, Fort Collins, Longmont, Windsor, Sterling, Brush, and Fort Morgan between 1901 and 1906. A major part of the expansion in Colorado and elsewhere was made possible by a large capital investment in sugar beets by the often criticized "sugar trust", the American Sugar Refining Company headed by Henry Havemeyer of New York, which also sent west highly-trained engineers, chemists, and agronomists to provide technical assistance.

Extracting sugar from the beets involved a complex process, mostly originated in Europe with American adaptations. Initial steps required washing the beets, slicing them into strips called cossettes, and soaking the strips in hot water diffusing machines. At this stage the pulp was drawn off as cattle feed, while the sugary juice was processed further with limestone for purification and in steam-heated evaporators. Boiling in vacuum pans produced a thick mixture called fillmass that was poured into centrifugal machines, operating at high speeds, to make sugar crystals. Beyond a reliable supply of beets from local farmers, the factories needed limerock for the precipitation process and coal to fire the boilers. The value of dependable transportation was demonstrated by the Great Western Sugar Company which operated its own railroad between factories and supply stations in the countryside. Early in the twentieth century sugar companies reduced their imports of European machinery and bought from American manufacturers, such as the E. H. Dyer Company and the Kilby Company in Cleveland, Ohio; Stearns-Roger Company of Denver became active in the industry about 1906.

The beet sugar industry made an impressive contribution to Colorado's economy, emerging as it did after the depression of the 1890s and upon the general decline in mining activities. Yet the industry was not without its own problems. Farmers, finding it difficult to hire field labor, recruited Japanese, German-Russians, Mexican-Americans and Mexicans who were as a rule shunted into an inferior social and economic status (see also the regional history contexts). The industry also followed an erratic economic course, the fluctuations due to changing world conditions, tariffs and other regulatory measures, and the usual uncertainties in agriculture. World War I brought prosperity to the industry as European production was interrupted, but the expansion in America left many farmers overextended and processors facing excess capacity at the end of the war. Economic instability and overproduction haunted the industry throughout the 1920s, only to become worse in the Great Depression of the 1930s.

New Deal agricultural programs brought relief to sugar beet growers in the 1930s. The Jones-Costigan Act of 1934 paid farmers to reduce their acreage in production and it also set conditions on wages and hours for field laborers. World War II restored economic health in the industry at the same time it depleted the supply of farm workers. The combination of economic incentives and a labor shortage led farmers to intensify mechanization during the war. In 1942 a harvester that loosened the beets from the soil, cut off their tops, and loaded them into wagons made its appearance and heralded the arrival of several new machines and techniques that altered the industry in the postwar period.

CHRONOLOGY

1811	Napoleon ordered commercial development of sugar beets.
1870s	First successful beet sugar factory began operations in California.
	Some sugar beet planting took place in Colorado
1891	Mormons constructed factory at Lehi, Utah, using American machinery.
1892	Convention held in Denver to promote sugar beet industry.
1899	Grand Junction became the site of Colorado's first sugar beet plant.
1900-1913	Excitement over sugar beets led to rapid expansion of the industry in Colorado and elsewhere in the West.

1901-1906	Active period of factory building by the Great Western Sugar Company.
1902	Newlands Act began federal aid to irrigation.
1920s	Overproduction and lower prices hurt the industry.
1934	Jones-Costigan Act helped stabilize the sugar beet industry.
1942	Appearance of sugar beet harvesting combines.

LOCATION

Resources associated with this theme have been and can be recorded in drainage areas of the Arkansas and South Platte river valleys, in Mesa and Delta counties, and to a lesser extent in the San Luis region. The map denotes the major sugar beet growing areas; beet sugar plants are located or were located in the towns within these areas.

CULTURAL RESOURCE TYPES

Structures include:
- Processing plant
- Storage sheds and bins
- Warehouses
- Trestles
- Kilns
- Water towers
- Flumes
- Steffen house(molasses processing)

Equipment, machinery, and apparatus include:
- Beet pilers
- Beet washers
- Beet slicers
- Conveyor belts
- Boilers
- Diffusers
- Filters and purifiers
- Evaporators
- Centrifugal machines
- Pumps
- Vacuum pans
- Granulators

THE QUANTITY AND QUALITY OF EXISTING DATA

Historical Documentation

A recent and comprehensive history of the beet sugar industry in the United States or in the western states does not exist and would appear to be a most worthy topic for scholars. However, it is possible to achieve a fair overview of this subject by making use of a variety of published materials: technical studies issued by trade associations, histories of individual firms(although "authorized" histories must be used with caution), and published reports of federal and state government agencies. Beet Sugar Technology by R. A. McGinnis supplies a clear description of technology and processes, but it unfortunately does not provide a historical context or chronology for changes in the industry. The article by Wayne Rasmussen in Agricultural History is concerned with agricultural technology of sugar beet cultivation not with the processing end. The researcher in this theme must consult the work of Leonard Arrington whose article cited in the References is essential to understanding the historical stages in the beet sugar industry and whose book on the Utah-Idaho Sugar Company is informative and insightful on the economic history of sugar beets in the West.

A great deal of information, some it yet undigested, exists on the subject of sugar beets in Colorado. William May's 1981 doctoral dissertation (University of Colorado) on the Great Western Sugar Company is valuable as is his article in Colorado Magazine on the Grand Junction factory. The Bulletins of the Colorado Agricultural Experiment Station are very informative despite their boosterism in the early years. Colorado State University at Fort Collins possesses a superb collection of historic materials on agriculture in the state, but additional documentation is available at the Colorado Historical Society, the University of Colorado Library, the Denver Public Library, and many local public libraries. Newspapers, promotional literature, and early trade publications, such as The American Sugar Industry & Beet Sugar Gazette, can be very useful sources to the researcher.

Number/Condition

The approximate number(22) of sugar processing plants built in Colorado prior to 1945 and their location can be ascertained from the available data. The types of additional resources, particularly equipment and machinery, that existed or may have existed cannot be determined. Condition can be expected to vary from currently operating to deteriorated and demolished.

Data Gaps

A complete inventory of processing plants and related facilities in the state.

A representative beet sugar processing factory.

Representative examples of early processing equipment and machinery.

Records of beet sugar companies and farmers in Colorado.

Future Needs

A survey and inventory of resources associated with sugar beets, both from an agricultural and an industrial perspective, should be given high priority. The rapidity of modern technological change is such that delay in doing this only endangers what few resources may remain. The survey should be conducted by a historian familiar with the farming and industrial dimensions of this theme. An effort should also be made to solicit the aid and cooperation of sugar companies in the state, particularly Great Western and Holly, for oral history, records, and artifacts.

Important Resources

All resources associated with this major industry in the state should be judged important until a complete inventory permits greater selectivity. The processors of agricultural goods have been generally ignored by historians and by the cultural resource process, yet the industry played a vital role in the region's economic development, especially after the heyday of precious-metals mining had passed.

RESEARCH QUESTIONS

1. What resources remain to document the changing technology of beet sugar processing?
2. Can resources reveal any innovations attributable to the Colorado industry?
3. What resources remain to clarify the relationship between growers and processors of sugar beets?
4. What resources remain to show the impact of European methods and machines on the American industry?
5. Can resources add to our knowledge of the economic relationship between the industry in Colorado and that in neighboring states, ie., Nebraska, Kansas, and Utah?

PHYSICAL CONDITION

Structures: Should be in place and with sufficient integrity to reveal their function. Relationship to other facilities in a plant complex should be clear.

Machinery, Equipment, Apparatus: Should be intact or enough should remain for restoration. Must be identified as to purpose and mode of operation, and be dated to the proper historical period. If equipment was moved from another factory, an effort should be made to determine original location.

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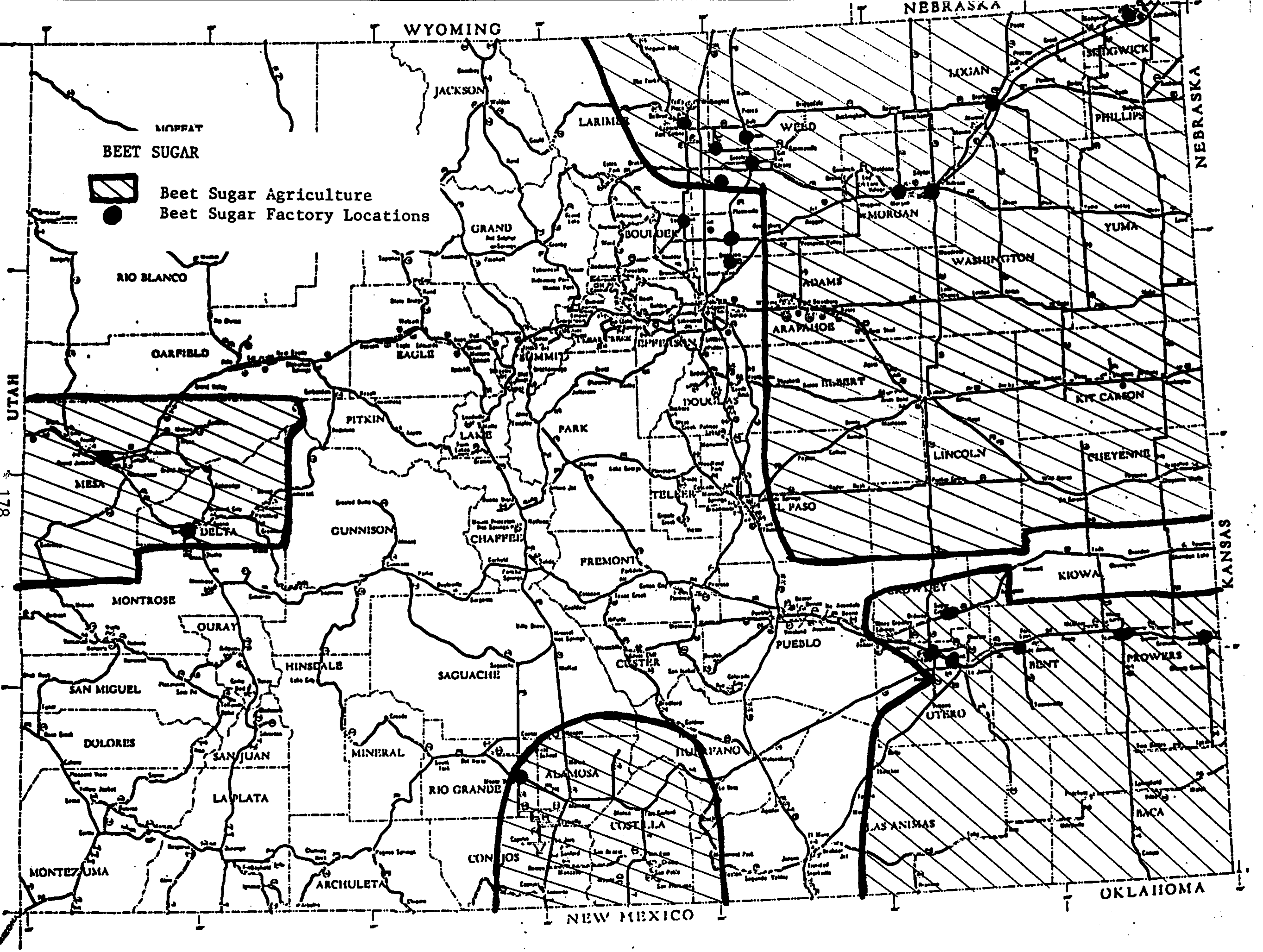
BEET SUGAR
Beet Sugar Agriculture
Beet Sugar Factory Locations
WYOMING
NEBRASKA
KANSAS
OKLAHOMA
NEW MEXICO
UTAH
JACKSON
LARIMER
WELD
LOGAN
SEDGWICK
PHILLIPS
MORGAN
YUMA
WASHINGTON
GRAND
BOULDER
RIO BLANCO
ADAMS
ARAPAHOE
GARFIELD
EAGLE
SUMMIT
JEFFERSON
ELBERT
KIT CARSON
PITKIN
LAKE
PARK
DOUGLAS
LINCOLN
CHEYENNE
MESA
GUNNISON
TELLER
EL PASO
DELTA
CHAFFEE
FREMONT
KIOWA
MONTROSE
CROWLEY
OURAY
HINSDALE
SAGUACHE
CUSTER
PUEBLO
BENT
PROWERS
SAN MIGUEL
OTERO
DOLORES
SAN JUAN
MINERAL
HUERFANO
RIO GRANDE
ALAMOSA
LA PLATA
COSTILLA
LAS ANIMAS
BACA
MONTEZUMA
ARCHULETA
CONEJOS

27. IRON AND STEEL

NARRATIVE

Much of America's industrial vitality in the late nineteenth century derived from the progress made in iron and steel production. The ancient craft of iron making had passed through a series of technical changes that enabled producers to smelt the ore in blast furnaces using mineral fuel and to roll the iron into semifinished and finished products. The requirements of a rapidly expanding railroad system for track, bridges, car wheels, and much more spurred on many of these changes in both the quantity and methods of iron initially and later steel production. The key technical breakthrough occurred in the 1850s with the Bessemer-Kelly process for making steel. A charge of hot air blown through the molten pig iron in a pear-shaped Bessemer converter reduced the impurities in the iron and produced the stronger, more durable metal steel at lower costs than previous methods. Thus, in the period after the Civil War, steel was no longer an expensive metal only utilized in small amounts to make fine cutlery and tools, but became readily available for constructing the nation's railroads and cities.

The master of the American steel industry was Andrew Carnegie whose large-scale, fully integrated company centered in Pittsburgh became a symbol of big business in this era for both critics and admirers. His concern over reliable supplies of the raw materials to make steel led him to acquire iron ore deposits and coal reserves and to operate his own railways and steamships for moving these goods. He constantly modernized his facilities around Pittsburgh to improve their efficiency and lower costs and to produce those items most eagerly sought in the marketplace. Carnegie dominated the American industry and his innovations influenced practices at every steel mill in the nation. Banker and business consolidator J. Pierpont Morgan purchased Carnegie's firm in 1901 and made it the nucleus for forming the United States Steel Corporation, the first billion dollar corporation in our history.

The Bessemer process, which proved successful in making steel rails between 1870 and 1910, faced competition from new techniques that possessed greater flexibility to manufacture steel to more exacting standards. The open hearth(Siemens-Martin) method, developed in the 1860s and widely accepted in the 1890s, used exterior heat, permitting better temperature control, and a mixture of pig iron and scrap metal to make a superior steel. During the 1920s the industry began to adopt electric furnaces(electricity becoming more available at lower cost) that further improved regulation of the heating of the furnace charge. The electric furnace was particularly useful in manufacturing alloy steel required by the automobile, food processing, and aviation industries. However, prior to World War II, American companies generally relied on the Bessemer and open hearth processes to produce their steel.

The versatility of iron and steel, used in making nails and wire to huge structural beams, was reflected in the complex assortment of buildings, material handling equipment, and technologies found at a steel mill. At the core of a steel works was the battery of blast furnaces, converters, and open hearths that produced ingots for further finishing in bloom, slab, and billet mills. The shaping process continued in other mills that made rails, light and heavy plates, beams, tubes, wire, and an array of specialized products. (The books in the Reference list included with this theme should be consulted for detailed discussion of the numerous processes).

The availability of raw materials in south central Colorado, especially the presence of coking coal, and the possibility of selling rails to the growing railroad system in the mountains encouraged William J. Palmer and other entrepreneurs to organize the Colorado Fuel and Iron Company(the name adopted in 1892) at Pueblo during the 1880s. The first mill of its kind west of the Mississippi River, it reflected on a smaller scale Andrew Carnegie's efforts at full integration, that is, controlling the ore, limestone flux, and mineral fuel necessary for making metal, manufacturing semifinished and finished products, and operating an intracompany railway, the Colorado and Wyoming line. Using standard technology of the time, Colorado Fuel and Iron often encountered stiff competition in the rail market from larger, more aggressive eastern producers. Frequently the company's fuel sales, particularly coke to the precious-metal refiners in the state, proved the most profitable activity, but in 1903 financial difficulties compelled the sale of the firm to John D. Rockefeller, Jr. and his associates. The Minnequa Works, built at Pueblo in 1903, consisted of blast furnaces, Bessemer converters, open hearths, and several mills to manufacture a variety of products.

The rise of a mass consumption society in the twentieth century kept iron and steel prosperous. Expansion in the automotive, road building, aviation, electrical, and petroleum industries along with construction of "skyscrapers" in the cities accounted for steel's profitability until 1929. It was the Second World War that finally revived the industry after the long and debilitating depression of the 1930s.

CHRONOLOGY

1840s-1850s	Expansion of iron production primarily for railroad construction.
1855-1860	Bessemer-Kelly process for making steel developed.
1870-1910	Major era of Bessemer-made steel.
1870s	Carnegie built iron and steel mills at Pittsburgh.
1880	Colorado Fuel and Iron Company organized.
c1883	Railroads shifted to steel rails.
1880s	Introduction of many labor-saving machines to handle materials at steel mills.
1890s	Wide-scale introduction of open hearth methods.

1890s	Depression in this decade led to industrial consolidations.
1901	United States Steel Company organized.
1903	Colorado Fuel and Iron's Minnequa Works opened.
1915-1929	Increased production of alloy steels--vanadium, molybdenum, chromium, manganese, and others added to steel for strengthening.
1918-Present	Adoption of electric furnaces(initially used for non-ferrous metals in the 1880s).
1920s	Continuous rolling mills developed to supply the durable goods industries.

LOCATION

The historical evidence indicates that foundries and mills existed in Denver, Lake City, Golden, and Boulder as early as the 1870s, probably small-scale operations and perhaps engaged in rerolling iron rails. The map locates the heavy industry operations of Colorado Fuel and Iron at Pueblo, but does not denote the many sites controlled by that company to mine coal, coke coal, remove limestone, or similar support activities for the integrated mill at Pueblo. The vast holdings of CF&I are detailed in Scamehorn, Pioneer Steelmaker in the West.

CULTURAL RESOURCE TYPES

Structures include:
- Mills(designated by their product ie. wire, bloom, merchant, spike, etc.)
- Offices
- Trestles
- Shops
- Storehouses
- Sheds
- Coke ovens
- Forges
- Foundries

Equipment and Apparatus include:
- Blast furnaces
- Open hearths
- Hot air stoves
- Tuyères(hot air pipes)
- Bessemer converters
- Electric furnaces
- Slag and hot metal ladles
- Molds(pigs and ingots)
- Skip hoists
- Cupola roasters
- Soaking pits(control temperature of ingots)
- Pickling pits(acid cleaning)
- Charging lorries
- Saws and shears

THE QUANTITY AND QUALITY OF EXISTING DATA

Historical Documentation

An abundant secondary literature exists describing and analyzing all phases of the iron and steel industry, a business of special significance in the economic history of the United States. Often the best scholarship is biographical, focusing on the innovators and business leaders, such as Andrew Carnegie, and studies of this kind should be consulted for they offer insights on many economic and technical issues that shaped the industry. The more strictly technical side of the industry can be followed in the concise and interpretative Iron and Steel in America by W. David Lewis or the more detailed, but uncritical Epic of Steel by Douglas Fisher. The complexity of the industry's technology and its specialized processes for handling ore types and for manufacturing numerous shapes/products means that the researcher will need to examine technical manuals, such as The Making, Shaping and Treating of Steel by Camp and Francis. U. S. Steel's pictorial volume of 1939 is very helpful for its photographs of older equipment at work. Finally, consult the book by W. K. V. Gale for the industry's sometimes colorful but almost always confusing variety of terms for equipment and methods.

H. Lee Scamehorn's solid study of Colorado Fuel and Iron unfortunately does little with the period after 1903. While the company papers were available only to Scamehorn, the bibliography in his book cites many sources open to researchers at public libraries and archives as well as graduate theses, government documents, and newspapers. The trade publications Coal Age and Iron Age should not be overlooked as sources of technical data and for information on important trends within the industry.

Number/Condition

The data are insufficient to determine the number and types of resources that existed or may have existed. However, the historical documentation in Scamehorn's Pioneer Steelmaker in the West provides the number and location of facilities operated by Colorado Fuel and Iron. With the cooperation of the company, it may be possible to inventory older equipment and determine its condition. It seems likely, however, that much of the older equipment has disappeared in modernization efforts at the plant.

Data Gaps

Representative examples of early and innovative iron and steel making processes.

Identification of important people and events in the history of Colorado iron and steel.

Identification of non-Colorado Fuel and Iron activities in the state, particularly small forges and foundries.

More complete data on Colorado Fuel and Iron's impact on architectural resources in Pueblo and in its many company towns.

Future Needs

The Colorado Preservation Office should undertake a historic engineering survey. Such a project would identify iron and steel technology, review existing data files for completeness and accuracy, and apply the historical documentation already available to specific sites, structures, and apparatus. The principal investigator for the project should be a historian knowledgeable of the changing and diverse technology in the industry and familiar with cultural resource surveys. A thematic or possibly a multiple resource National Register nomination seems desireable in this area.

Important Resources

The significance of Colorado Fuel and Iron as the first steel mill west of the Mississippi, its origins with railroad builder William Palmer, the association of John C. Osgood and the Rockerfellers and the company's prolific activities and social and economic impact upon the state make the iron and steel industry in Colorado important. All resources associated with this historical development clearly merit state and regional consideration, if not also national attention. Any physical remains that can reveal and substantiate this theme are significant. Yet justifiable concern with the importance of Colorado Fuel and Iron in the state should not diminish the contribution of eastern iron and steel mills to Colorado's built-environment. The railroads transported large amounts of materials made elsewhere into Colorado for fabrication.

RESEARCH QUESTIONS

1. What resources remain to document the development of an iron and steel industry in Colorado?
2. Can resources reveal the migration of technology, processes, and business methods to Colorado from the East or Europe?
3. Can resources show any special economic or technical problems affecting the Colorado industry? Any innovations in Colorado for these reasons?
4. Can material remains clarify the relationship between the iron and steel industry and the railroads or precious-metal mining and refining?
5. What resources remain to substantiate the participation of ethnic groups in the Colorado iron and steel industry?

PHYSICAL CONDITION

Structures: Should be in place and possess sufficient integrity to reveal their function and role in a steel plant. Mills should retain structural integrity and contain enough machinery to disclose purpose and methods of operation.

Equipment and Apparatus: Enough should remain to be restored or to disclose its function and operation. The resources should be accurately dated and identified for their role in the system of production.

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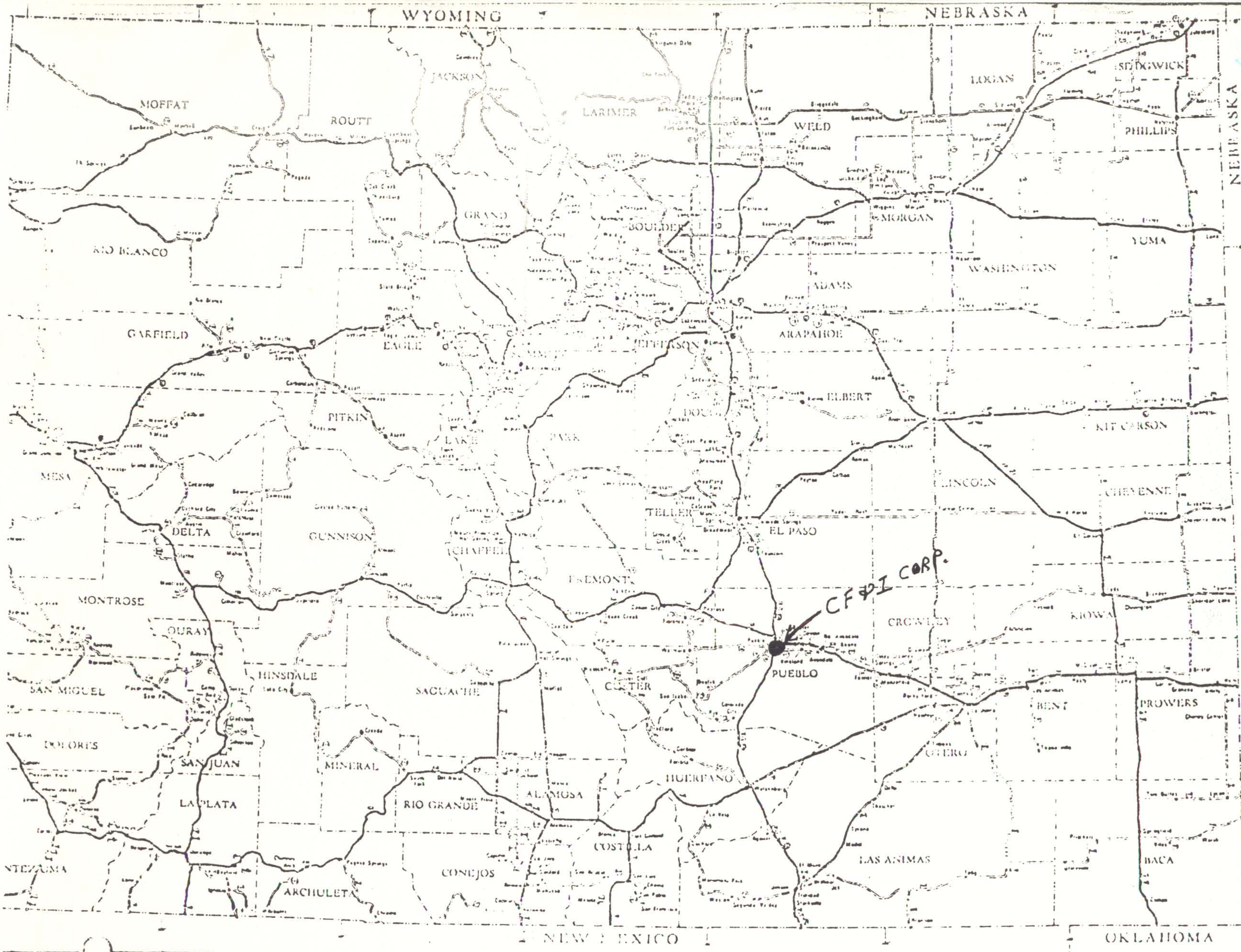

IRON AND STEEL INDUSTRY

28. CEMENT

NARRATIVE

Between the 1820s, when utilized by engineers building the Erie Canal in New York, and the late nineteenth century, cement rock found in natural deposits provided the binding element in concrete construction in the United States. This natural cement, crushed under millstones and burned or calcined in vertical kilns, had its limitations. In an environment abundant with timber and stone building materials, the cement rock was not to be found everywhere(the best came from the Rosendale district of New York) and its processing was slow and expensive; the concrete made from it required months even years to acquire full strength. Despite these drawbacks, the demand for strong, watertight construction material encouraged the establishment of natural cement manufacturing plants in many parts of the country. The discovery of cement rock at Canon City, Colorado led to the opening of a mill in Denver in the early 1880s.

The failure of natural cement to satisfy the needs of an expanding urban and industrial society after the Civil War created a favorable environment for new developments. Portland cement, a mixture of lime and clayey materials invented in 1824 by an Englishman who thought it resembled the stone found near Portland, England, quickly proved its superiority in the United States during the last decades of the century. At first, European imports entered the country, but high tariffs imposed in the 1890s and the expense of transporting the heavy, bulky material overland encouraged the rise of a domestic industry. Portland cement from the first American factory, opened in Pennsylvania in 1871, proved successful in the construction of large jetties on the Mississippi River.

American manufacturers introduced a number of cost-saving technical changes between the 1880s and 1910 that moved portland cement ahead of the competition. As a first step, new and more powerful grinding machines crushed the hard limestone taken from quarries in vicinity of the mill. This crushed rock, in both the wet and dry methods of processing, entered huge cylindrical rotary kilns, introduced in the 1890s, which heated the charge to extremely high temperatures, producing a cement clinker. Rotating cylinders loaded with steel balls then pulverized the clinker into the fine powder of portland cement. The rotary kiln, made of steel and lined with fire brick, was the key technology in the plant. While it consumed great amounts of fuel(coal and other fuels were abundant and cheap at the time), the kiln substantially reduced the time and labor(a major expense) required for production. Future technical changes focused on building bigger kilns, with some of the largest designed by Thomas A. Edison, to a point in the 1930s when some kilns were over 400 feet long. Rotary kilns thus represented some of the largest moving machinery in American industry. Major manufacturers of cement plant equipment included Allis-Chalmers of Milwaukee, Traylor Engineering and Manufacturing Company of Allentown, Pennsylvania, and F. L. Smidth of New York.

Economic growth in the early twentieth century continually produced new uses for concrete. Office buildings, sidewalks, streets, highways, bridges, and dams consumed vast amounts of portland cement; reinforcing concrete with metal rods for added strength provided engineers and architects with a versatile building material. Cement makers responded by establishing plants across the country, selecting locations for their proximity to raw materials, reliable transportation, and growing markets. Because the industry employed a standard technology and made a generally uniform product, competition often led to heavily-financed business consolidations. After 1910, dominance of the industry rested in the hands of several large manufacturers operating many plants, among them Universal Atlas(a subsidiary of U. S. Steel), Alpha, Lehigh, International, and Penn-Dixie.

The Ideal Cement Company of Denver, organized in 1927, expanded from a strong regional base in the Rocky Mountains. Entrepreneur Charles Boettcher began producing cement from a plant he purchased at Portland, near Florence, in 1901 and operated under the name Colorado Portland Cement Company. While the cost of long distance freight kept outside competition to a minimum, the company swiftly gained control over a large territory, supplying cement(under brand name Ideal) for beet sugar factories, reclamation and irrigation projects, roads, and commercial buildings. Boettcher demonstrated the strength of concrete by constructing the first multi-story reinforced concrete building in Denver in 1908. The Ideal Building, at 17th and Champa streets, served as company headquarters until 1975, although Ideal sold the building in 1928 to the Denver National Bank. Between 1908 and 1917 the United States Portland Cement Company, affiliated with the Coors family, operated a plant at Concrete near Portland, but the mill became a Boettcher property until the late 1920s, when an antitrust prosecution forced its closing. In 1928 Ideal built a plant at Boettcher, near Fort Collins, that took both limestone and shale from a neighboring quarry. By the 1930s Ideal ranked as a major national producer of portland cement, with factories in Colorado, Utah, Montana, Nebraska, Oklahoma, and Arkansas.

CHRONOLOGY

1818-1820s	Natural cement made by engineers building the Erie Canal across western New York.
1824	Invention of portland cement in England.
c1870-c1890	Widespread use of imported cement in the United States.
1871	First portland cement factory in the United States - Pennsylvania.
c1881	Natural cement plant erected in Denver.
1880s	Development of heavy steam-powered rock crushing machines for the cement industry.
1890s	Introduction of rotary kilns for producing cement.
1899	First portland cement plant in Colorado, subsequently purchased by Boettcher.
1900 - present	Widespread use of reinforced concrete.
1901	Boettcher and associates began the Colorado Portland Cement Company.

1909	First concrete highways built in the United States.
1927	Ideal Cement Company organized.
1928	Ideal constructed plant near Fort Collins.

LOCATION

The map denotes the location of three sites associated with this theme. Entry into the industry was limited by high capital investment and some anti-competitive practices.

CULTURAL RESOURCE TYPES

Sites include:
- Cement plant complex
- Quarries

Structures include:
- Cement mills
- Raw material storage bins
- Cement silos
- Elevators
- Office buildings
- Tanks
- Stacks

Machinery, equipment, and apparatus include:
- Rock crushers
- Hammer mills
- Tube mills
- Ball mills
- Conveyor belts
- Rotary kilns
- Clinker coolers
- Boilers
- Vibrating screens

THE QUANTITY AND QUALITY OF EXISTING DATA

Historical Documentation

Cement making has not attracted much scholarly interest and no general history of the industry exists after 1924. Instead the researcher will encounter an assortment of industry/company sponsored works and technical publications that offer sketchy or unreliable historical introductions. Robert W. Lesley's History of the Portland Cement Industry in the United States is a richly detailed account of early business and technological developments, but the book is not documented, ends its story in the early 1920s, and was written by an early promoter and manufacturer of portland cement. Although cement is discussed only as a component in concrete, Carl W. Condit's American Building is a superb study of the impact concrete made on building designs and methods of construction. The development of the Ideal Cement Company is adequately treated in the biography of Charles Boettcher by Geraldine Bean, who made extensive use of the Boettcher Papers in the Colorado Historical Society. Other materials on cement production in Colorado may be found in the Norlin Library of the University of Colorado, the state archives, and the Denver Public Library. Additional sources of general information are the publications of engineering societies, handbooks and advertising pamphlets issued by manufacturers of machines and equipment for the industry, and the trade journal Pit and Quarry.

Number/Condition

The historical documentation appears sufficient to establish the number of cement plants that exist or once existed in the state. Technical changes have undoubtedly altered in many respects the historical condition of these sites. The data do not reveal the number or condition of machinery and other apparatus that existed or may have existed in and around these sites.

Data Gaps

Representative examples of early cement making technology.

Identification and documentation of early and significant structures built with Colorado cement.

Additional recording of important people and events in the history of the Colorado cement industry.

Future Needs

The limited number of resources associated with this theme encourages one to include cement within a larger effort to survey and inventory industrial developments in the state. Colorado should give high priority to a comprehensive historic engineering site survey that could include cement. Further efforts should be directed to gathering documentation on cement, particularly an oral history project. Finally, consideration should be given to identifying examples of the early use of concrete construction in Colorado, especially in commercial buildings and public projects.

Important Resources

The relatively small number of resources in this theme should be considered important, at least until an inventory permits greater selectivity. The great size and weight of many of the machines used in this industry will pose problems to preservation efforts. Photodocumentation and scale drawings may be reasonable alternatives. Early concrete structures should also be regarded as significant resources related to this theme.

RESEARCH QUESTIONS

1. What resources remain to document the history of cement production in Colorado?
2. Can resources disclose the changing technology of production and society's increasing dependence on concrete construction?
3. What resources remain, if any, to show the impact of national trends in business and technology on the Colorado industry?
4. Can resources reveal important connections between cement technology and urban, agricultural, and industrial developments in the state?

PHYSICAL CONDITION

Sites: Must be clearly discernible and dated to the appropriate historical period. Connections to other activities and sites should be established.

Structures: Should be in place and retain sufficient integrity to reveal function.

Machines, Equipment, Apparatus: Should be intact or enough should remain to permit restoration. Purpose and method of operation should be made clear. Should be accurately dated and, if possible, the manufacturer identified.

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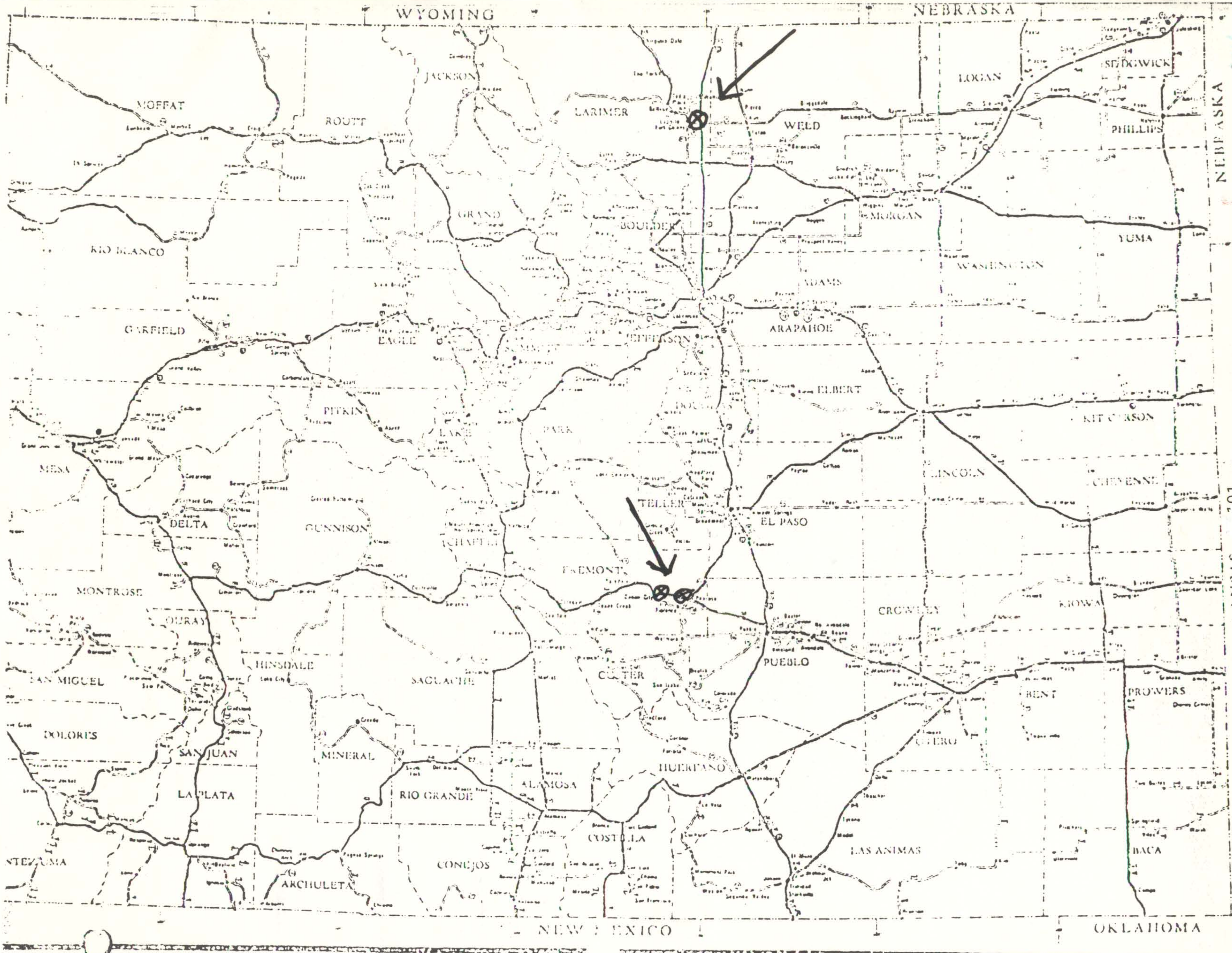

PORTLAND CEMENT PLANTS ⊗

29. STONE QUARRYING

NARRATIVE

America's rapidly developing urban and industrial society between 1870 and 1920 relied upon an increasing output of both new and traditional building materials. Stone, an ancient material, appealed to architects and engineers who sought an abundant, strong, durable, and attractive material to build the structures of the modern age--factories, civic buildings, railroad depots, hotels, bridges, dams, and similar projects that represented progress, permanence, and stability to a society going through fundamental changes. The technology of the period, particularly steam and electric powered machines, made it easier to produce dimension stone (cut to a desired shape or size) from the numerous granite, limestone, marble, and sandstone deposits that existed across the country. In addition to building stone, these resources produced crushed rock for roads and railway roadbeds, curb stone and cobbles for city streets, ornamental stone for monuments, grindstones, and fluxing material for the smelting and refining industry.

Stone quarries were generally open at the surface, but employed different methods of development depending on the geological character of the deposit, available technology, kind of product, and similar considerations. Some stripping of the overburden was usually necessary to expose the rock, which was then removed by cutting shelves or ledges into a hillside deposit or opening a pit below ground level. On occasion, operators used an undercutting method that combined both surface and underground mining techniques.

Quarrymen separated large blocks of stone from the mineral mass by using a variety of machines, methods, and tools for cutting. A traditional technique, known as plug and feather, involved drilling holes into which workers drove wooden wedges(plugs) and half-round metal bars(feathers) to crack the stone into blocks ready for further fabrication at a mill or by hand labor. A faster method filled the drill holes with black powder and by means of slow-burning fuses or battery charges blasted out the stone into workable sizes. Some quarries operated steam, compressed air, or electric powered channelers(manufactured by Sullivan, Ingersoll-Rand, and Wardwell) that moved along a two rail track while their chisels cut into the rock. The steam driven channeling machines fitted with upright boilers often resembled small locomotives at work in the quarry. The wire saw, consisting of an endless wire rope rigged to a driving wheel and pulleys, was introduced into some quarries in the 1890s, including one in Colorado. Other equipment commonly found in quarries included animal or steam powered hoist derricks(stiff-leg derricks), flat, low wheeled wagons for hauling stone, and inclined tramways.

Some quarries shipped their stone to mills in cities where fabrication for specific building projects took place; stone masons at the construction site added final touches. Finishing mills or dressing plants housed several different kinds of machines that prepared the stone for market. Gang saws, consisting of many saws attached to a single frame, sliced the stone into several slabs in one operation. Planers shaped the stone, and rubbing beds polished the product. Some mills also contained circular diamond saws and guillotines for cutting and shearing the stone.

The economic fortunes of the quarrying industry rested on a number of factors. The weight and bulk of the product meant that many quarries survived only as long as they could deliver stone to nearby towns, and when the building boom ended, they were abandoned or reduced to supplying custom orders. Even larger operations possessing valuable mineral deposits depended heavily on the railroads to build sidings near the pit in order to reduce handling costs and to provide entry into more distant markets through low cost freight rates. Some railroads, the Union Pacific, for example, which had a Stone Department, owned or leased quarries to supply stone for their own buildings, towns along their system, and crushed rock for roadbeds. Besides critical concerns about transportation, most operators of quarries, being small, local businessmen, needed skilled quarrymen and masons who, occasionally, were induced to emigrate from Europe. Yet the greatest threat to the industry came in the early twentieth century from increasing competition by alternative materials, especially concrete.

Colorado contained extensive deposits of stone, some became nationally known producers, others served only local and regional markets, and still others went undeveloped because of their remote location. From the 1890s to 1941, quarries around the town of Marble near the Crystal River produced Colorado Yule, a handsome stone streaked with yellow bands that compared well to Italian Carrera marble, that was used in the Tomb of the Unknown Soldier, the Lincoln Memorial, and many significant public structures. Travertine, a distinctive tan and brown marble, went from quarries near Salida into the construction of government buildings in Washington, D.C. and Denver. The rapid urbanization of Colorado from 1870 to 1915 kept many quarries busy supplying building stone. The notable Denver masonry construction firm of Geddes and Serrie used Colorado stone on several important projects, including granite from Aberdeen, near Gunnison, for the State Capitol, native red sandstone for the Brown Palace Hotel, and local granite for the Cheesman Dam, a storage reservoir for the Denver Union Water Company. Quarries also provided track ballast for the state's growing railroad system and industrial materials, such as the limestone flux taken from quarries near Pueblo and Canon City by the Colorado Fuel and Iron Company for its blast furnaces.

Building stone quarries in Colorado and the nation were adversely affected by both world wars. Regarded as non-essential industries, many quarries ceased operations during World War I never to resume production because of the availability of cheaper building materials. A short-lived revival occurred in the depression era of the 1930s when New Deal programs made possible the construction of many civic buildings. World War II, however, resulted in further closings throughout the industry.

<u>CHRONOLOGY</u>

1858	Invention of a steam powered rock crushing machine.

c1870-1917	Peak period of stone quarrying in Colorado.
1880	Introduction of powered channeling machines.
1890-1910	Increasing use of electric and pneumatic powered equipment in quarrying.
1890s-present	Concrete becomes more important and widespread as a building material.
1890s-1941	Quarrying operations at Marble, Colorado.

LOCATION

Resources associated with stone quarrying are scattered throughout the north central and central parts of the state, mainly in the mountain and plateau regions. Generally the more developed mineral deposits in this theme are located along the Front Range because of the higher development of transportation and urban markets. The map indicates primary areas for quarrying limestone, marble, sandstone, and granite. More detailed maps showing geological formations are readily available.

CULTURAL RESOURCE TYPES

Sites include:
- Quarries
- Pits
- Dumps
- Roadbeds

Structures include:
- Finishing mill
- Powder and tool sheds
- Employee housing
- Blacksmith shop
- Tram shed
- Derrick
- Crushing plant

Machinery, equipment, and tools include:
- Power and hand drills
- Augers
- Channelers
- Tramways
- Rock crushers
- Cranes
- Circular saws
- Wire saws
- Guillotines
- Planers
- Rubbing beds

Gang saws
Chisels
Picks and shovels
Feathers
Air compressors

THE QUANTITY AND QUALITY OF EXISTING DATA

Historical Documentation

Quarrying has not been the subject of in-depth historical studies at either the national or regional levels. Articles in the Colorado Magazine and Vandenbusche and Myers' book on Marble are helpful on specific operations, but fuller-scale treatments will have to be prepared from extensive research into primary materials available from several sources. The best of these sources are the publications of the U.S. Bureau of Mines, the U.S. Geological Survey, and state agencies concerned with the mineral industries. Reports from agencies in New York, Vermont, and Indiana, states whose quarries assumed greater importance than in Colorado, can be helpful in researching the state of the industry as well as mining practices and technology. For Colorado, the publications of and the library at the School of Mines in Golden should be consulted for data pertinent to this theme. However, the information contained in most government reports is rather narrow; good on geological, some technical, and statistical matters, but usually devoid of historical analysis or context. The trade journal Pit and Quarry and its various handbooks reported on the development of tools and machinery as well as carrying advertisements of the major equipment manufacturers; information of this kind can help with problems of identification. Lastly, refer to county histories and newspapers when undertaking research on a specific quarry and the individuals who operated it.

Number/Condition

The data are not sufficient to determine the number of sites that existed or may have existed. Removing stone for local projects was such a common and widespread practice that it seems unlikely all sites could ever be recorded. In addition, many quarries have been put to other uses, covered over, or reclaimed. The quarrying town of Stout located near Fort Collins now lies beneath the waters of Horsetooth Reservoir. Doubtlessly much of the earlier quarrying equipment has disappeared in technological change, scrap drives, decay, souvenir hunters, and vandals.

Data Gaps

A representative example of an early quarry.

Representative evidence of early quarrying tools and equipment.

Historical documentation for and accurate locations of stone quarries.

Identification of major structures built with Colorado stone.

Recording of important people and events in the history of Colorado stone quarrying.

Future Needs

High priority should be assigned to identifying, inventorying, and documenting resources in this theme. An appropriate first step would be to conduct a historic engineering site inventory that would target quarrying operations and be directed by a mining historian familiar with the specialized tools and practices of a stone quarry. An effort is also needed to gather and examine printed materials, archival holdings, oral history, and government reports pertinent to this theme. More information is needed on the activities of the Colorado chapter of the Quarrymen's National Union of America, the masonry construction firm of Geddes and Serrie, and the apparently high proportion of Swedish and Italian workers in the quarries and the stone trades.

Important Resources

So little attention has been directed to stone quarrying--in part due to the more important economic role and romanticism of precious-metal mining in the state-- that all resources which can reveal and substantiate this theme are important. Clearly we have more successful in recognizing historic structures and their builders than we have in studying the people, process, and places that supplied the distinctive building materials. The highest importance should be placed on representative sites, structures, and equipment.

RESEARCH QUESTIONS

1. What resources remain to document the development of quarrying in Colorado?
2. Can cultural resources reveal any technological connections between quarrying and precious-metal mining in the state?
3. What material evidence remains of the ethnic groups which contributed to the quarrying industry?
4. Can cultural resources contribute to our understanding of earlier building technologies and to the value system of early town builders?

PHYSICAL CONDITION

Pit, Quarry: Should not be filled-in, and its function should be apparent. Any original scaffolding, hoists, tracks should be intact, accurately dated, and identified.

Structures: Should be in place and with sufficient integrity to reveal their function. Mills should retain structural integrity and contain enough machinery to disclose purposes and methods of operation.

Machinery, Equipment, Tools: Should be intact , accurately dated, and discernible as to function.

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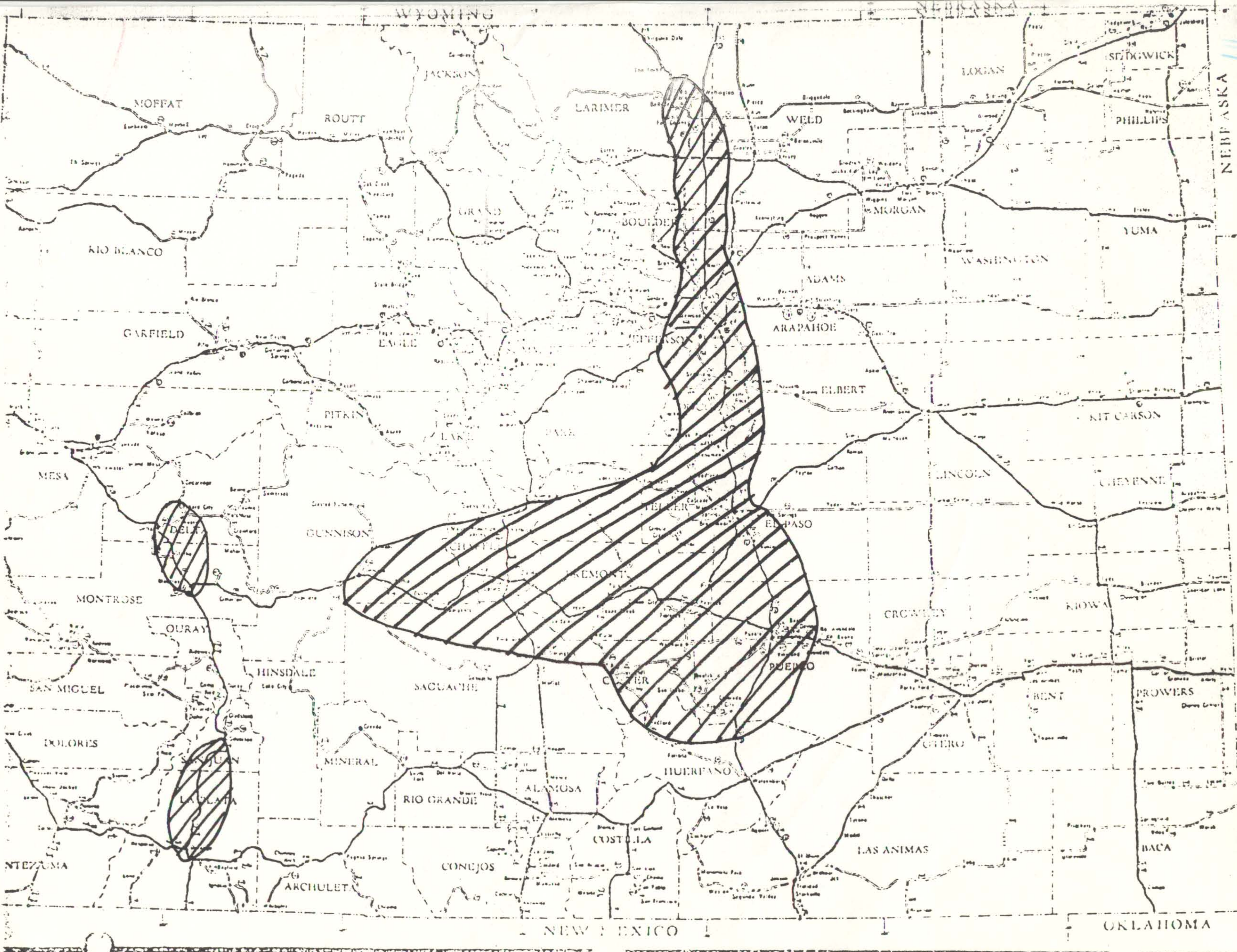

STONE QUARRYING