SURVEYING OUR PUBLIC LANDS

U. S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

1988

SURVEYING OUR PUBLIC LANDS

SINCE 1785

As the Nation's principal conservation agency, the Department of the Interior has basic responsibilities for water, fish, wildlife, mineral, land, park, and recreational resources.

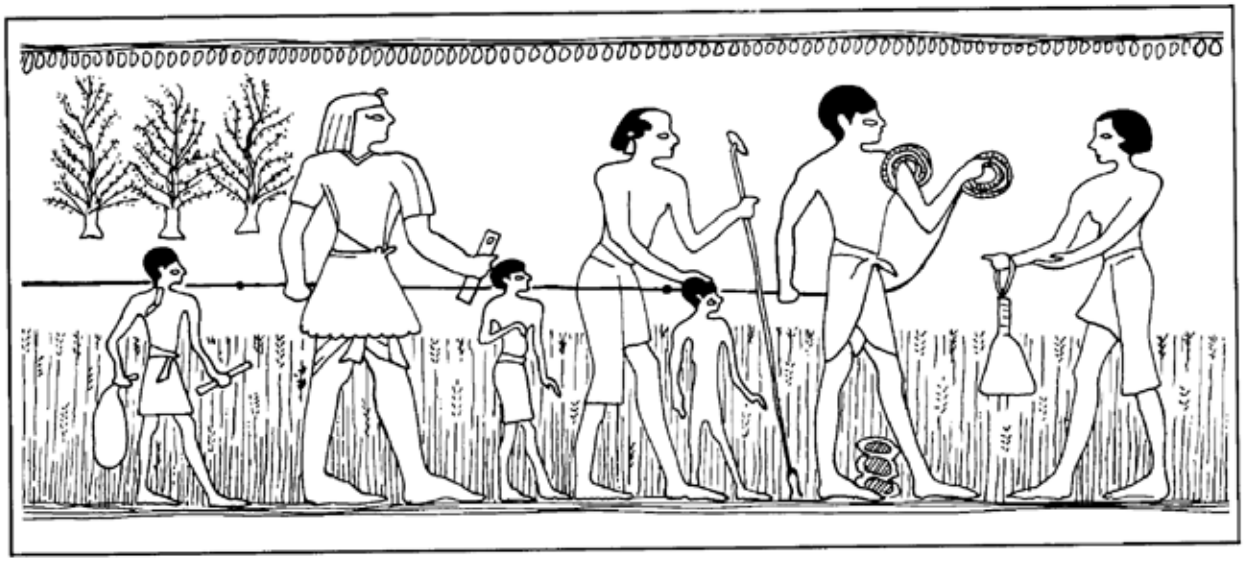
Interior, America's "Department of Natural Resources," works to assure the wisest choice in managing all of our resources so that each will make its fully contribution to a better United States — now and in the future.

The Bureau of Land Management (BLM) is part of the United States Department of the Interior. Its responsibilities encompass 272 million acres of public lands and administration and management of approximately 300 million acres of mineral rights. It also maintains the legal status for 331 million acres of reservations created from public lands, such as the national parks, national wildlife refuges, and national forests.

BLM was established on July 16, 1946, by the consolidation of the General Land Office (created in 1812) and the Grazing Service (created in 1934). Much of the history of the exploration and development of the public land states appears on the pages of BLM's records. As steward of nearly half of all federally)managed lands, BLM's primary purpose is wisely balancing the use of natural resources. To achieve this goal, BLM selectively disposes, conserves, enhances, and maintains the environmental quality of these public lands. These resources, besides the land itself, include minerals (oil and gas), forests, range, recreation, wildlife, and soil and water.

To manage these resources, the Bureau must be able to accurately identify and locate the increasingly valuable areas of land with which it has been entrusted.

BLM's Cadastral Survey Program is responsible for the creation, restoration, marking and defining the boundaries of these lands. Cadastral Survey is also responsible for the official boundary surveys for all federal agencies who together manage over 700 million acres of land.



History...

Land surveying dates back to ancient times. More than one civilization recognized the need for marking the boundaries of land for taxing purposes as well as for defining just where one ownership begins and another ends.

The Egyptians, with their great expertise and accuracy in building pyramids more than 7,000 years ago, must have possessed the techniques and instruments to perform surveys comparable in precision to present day requirements. In fact, the Egyptians were very much involved in property surveys since land boundaries along the Nile River were annually lost from flooding, and resurveys were constantly needed.

Most modern BLM monuments have an inscription which reads: UNLAWFUL TO DISTURB. Such warnings are really not new. Babylonian boundary stones set about 3500 years ago contained not only geographical information and the surveyor's name, but also numerous curses on anyone daring enough to move the monument!

There were several other notable surveying endeavors in earlier times including the Roman rectangular plots laid out with the four-armed groma instrument, William the Conqueror's land surveys of England with their resultant "Doomsday Book," and the pyramid, road, city, and bridge-related surveys of the 11th to 14th century Incas.

In early day America, several types of surveys were performed using state-of-the-art instruments, calling principally on mathematicians, astronomers, and navigators to perform as land surveyors. Most of these earlier surveys were of the metes and bounds type, meaning they were established by distances and directions which were not in accordance with a regular pattern.

Surveying was often listed among he accomplishments of notable scientific and/or public figures in late 18th century America. When the Penns and Calverts reached an impasse over the boundary of Pennsylvania and Maryland, they asked Britain's Astronomer Royal, to send "...some able mathematicians...of great integrity." If the Astronomer Royal did not confer immortality upon Charles Mason and Jeremiah Dixon, he conferred it upon the boundary they surveyed. David Rittenhouse, a largely self-taught mathematician, astronomer, and instrument maker was involved in half the boundary surveys of British America. When Thomas Jefferson came to draft the Land Ordinance of 1785, he brought not only his accomplishments in law, political philosophy, and architecture, he brought the heritage of his noted surveyor father, Peter Jefferson, and his own experience as a Virginia surveyor. Land holdings which

surveying fees had helped him acquire, made it possible for George Washington to serve as Revolutionary Commander-in-Chief and the nation's first president.

It remained for the late 1700's of colonial America for the beginning of what was to become the most ambitious program of land disposal, ownership recording, and actual on-the-ground boundary marking which has ever occurred. Described as a "marvel of simplicity," the United States rectangular survey system was designed to lay out one mile square parcels over all of the federal land outside of the original thirteen colonies and their western territories. With modifications to Thomas Jefferson's original proposal for a rectangular survey, the Continental Congress enacted the Land Ordinance of 1785. It set in motion a sequence that tied the New England manner of rectangular survey to the southern penchant for individual settlement. Two military engineers, Colonel Henry Bouquet and Thomas Hutchins, were also among the contributors. Hutchins, as Geographer of the United States, in compliance with the ordinance, personally established the Point of Beginning where the west boundary of Pennsylvania crossed the north bank of the Ohio River (near present day East Liverpool, Ohio). Absolom Martin, of New Jersey, completed the first township in 1786.

Under the principles set forth in the Land Ordinance, 1.5 billion acres have been surveyed into 6-mile square townships, each with 36-mile square sections from East Liverpool to San Diego and from the Florida Keys to Point Barrow on the Arctic shore, resulting in easily understood land descriptions to expedite land transfers and promote security of title. The design is at once both complex and simple. The accomplishment is grand — 2.6 million section corners, each a mile apart, resulting from a vast cumulative expenditure of human energy in carrying transits, dragging chains, lifting stadia rods, cutting trails, scaling mountains, emplacing monuments, digging pits, and blazing witness trees.

The plan developed three new theories in land administration. First, the principle of "survey before settlement;" second, the principle of a mathematically designed plan to be followed throughout the entire area of the public domain; and third, the creation of a standard land unit, a section of uniform shape and area, with boundaries physically marked on the ground. These planned features were not used within the original colonies in America where land locations were made in irregular form, and without any orderly design.

In 1812, the General Land Office (GLO) was established by Congress as a bureau of the Treasury Department "to superintend, execute, and perform all such acts...respecting the public lands...." Before then, the public domain workload was handled by the Treasury Department, but it was recognized that a more focused land management agency was needed. However, the Surveyor General post, with responsibility for contracting surveys to private surveyors, remained independent of the GLO.

Edward Tiffin of Ohio was appointed the first commissioner of the GLO. Tiffin's contributions to land surveying were significant in consolidating and organizing land and survey records. Later as a Surveyor General, he designed a plan of correction lines to solve the troublesome problem of conforming a rectangular pattern to a round earth.

The first surveying was done on the lands between the Appalachian Mountains and the Mississippi River, an area which seven of the states had ceded to the new nation.

Growth of the Public Domain...

In 1803 President Thomas Jefferson arranged to buy a large amount of land from France. This is know as the Louisiana Purchase. It amounted to over 500 million acres and included most of the land from the Mississippi River west to the Rocky Mountains, except what is now the state of Texas. The Louisiana Purchase cost the United States about $23 million.

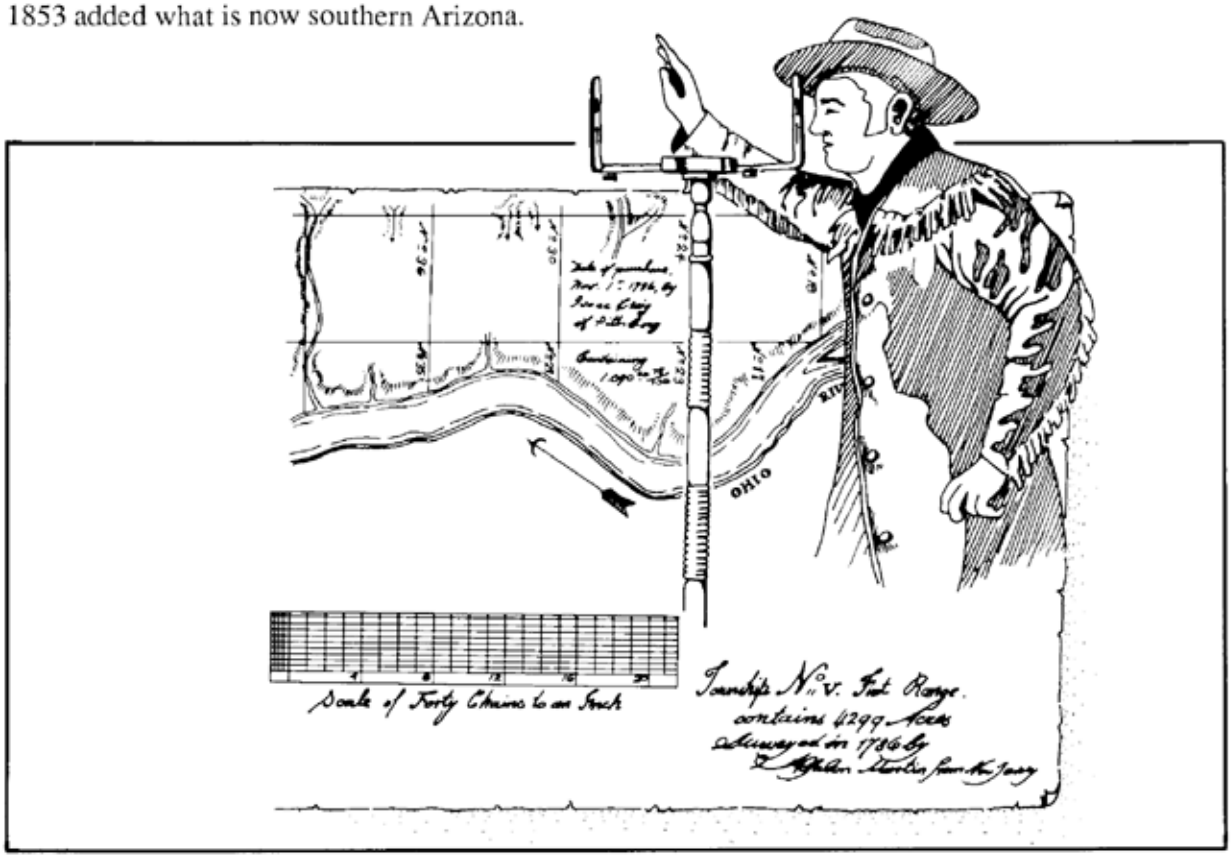
In 1819 the land that is now Florida became part of the United States. Texas became part of the U.S. in 1845. A year later the United States signed a treaty with Great Britain which added the area that is now the states of Oregon, Washington, and Idaho. This treaty is known as the Oregon Compromise.

In 1848, just one year before the discovery of gold in California, the United States obtained from Mexico the lands that are now the states of California, Nevada, Utah, and parts of Arizona, Wyoming, and Colorado. The Gadsden Purchase in 1853 added what is now southern Arizona.

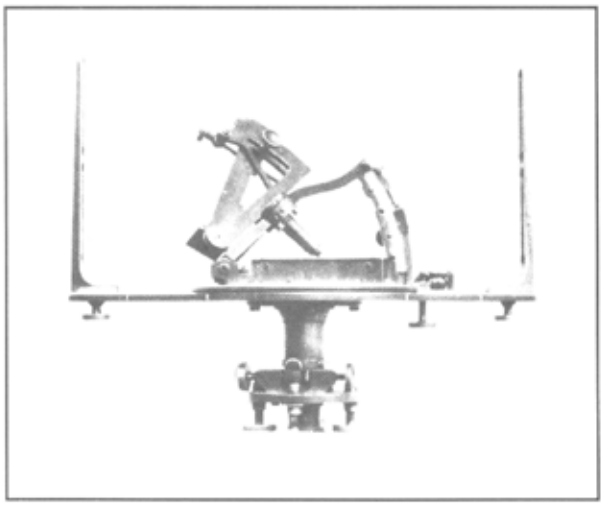
The last large addition to the Unites States came in 1867 when the United States purchased Alaska from Russia. The area of Alaska amounted to over 375 million acres (about one-fifth the area of the rest of the United States). It cost about $7 million.

With these additions, the public domain stretched from the west boundary of Pennsylvania to the Pacific Ocean, from the Canadian border to the Gulf of Mexico, and included Florida and Alaska. Altogether it embraced over one billion, 800 million acres.

A remarkable pioneer surveyor was William Burt who surveyed large areas of land in upper Michigan and Wisconsin in the mid) 1800's. Burt, who did not have much formal education, was the inventor of the solar compass which used the sun to maintain direction. His invention came of necessity from trying to use the magnetic compass and run lines in a region of vast iron deposits which



caused deviations of the compass needle.



The exploration and survey of the western lands continued with many verbal and written accounts by curious surveyors of colorful descriptions of the nature of a new land, and tales of hardship, misery, and financial loss. One 1852 field note record of an Iowa survey reads "...one of my men was accidentally shot yesterday and died almost instantly." The notes continue with bearings and distances to the stricken man's grave.

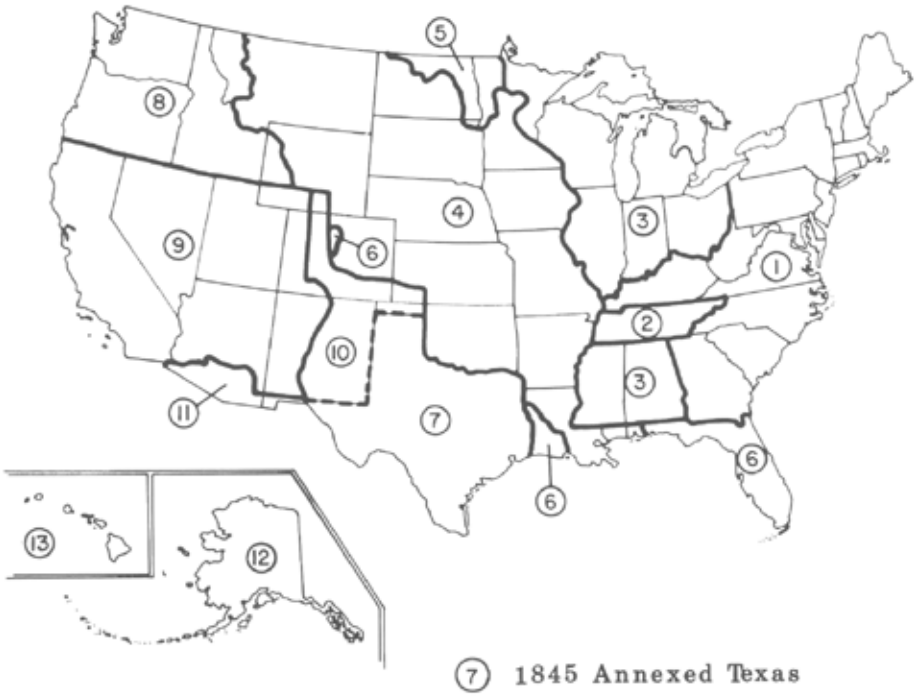
Until 1910, public land surveys were generally administered by federal surveyors-general in each state or territory who contracted with authorized deputy surveyors to perform the work. Sets of instructions to the deputies were often written by the survey general to specify the method of survey and the accuracies expected. However, it gradually became evident that a consolidation of officially authorized surveying procedures was needed. An Oregon Manual of Surveying Instruction was published in 1851, and a revision of this manual was published by the GLO in 1855 for national use. Subsequent manuals were issued in 1871, 1881, 1890, 1894, 1902, 1930, 1947 (BLM), and 1973 (BLM).

Toward the end of the 19th century, several signs pointed to the need for new management arrangements. Almost from the beginning, a U.S. Surveyor General was appointed for each territory and state. Under general instructions from the surveyor general in Washington, he contracted with deputy surveyors, often after competitive bid. The deputy surveyor general hired the crews, purchased the supplies, and supervised the field work.

When public land surveying covered prairies, open benchland, and other relatively accessible land, there was competition for such surveys. As surveying embraced fragmentary, rough, and isolated areas, contractors found it hard to bid within the statutory limits.

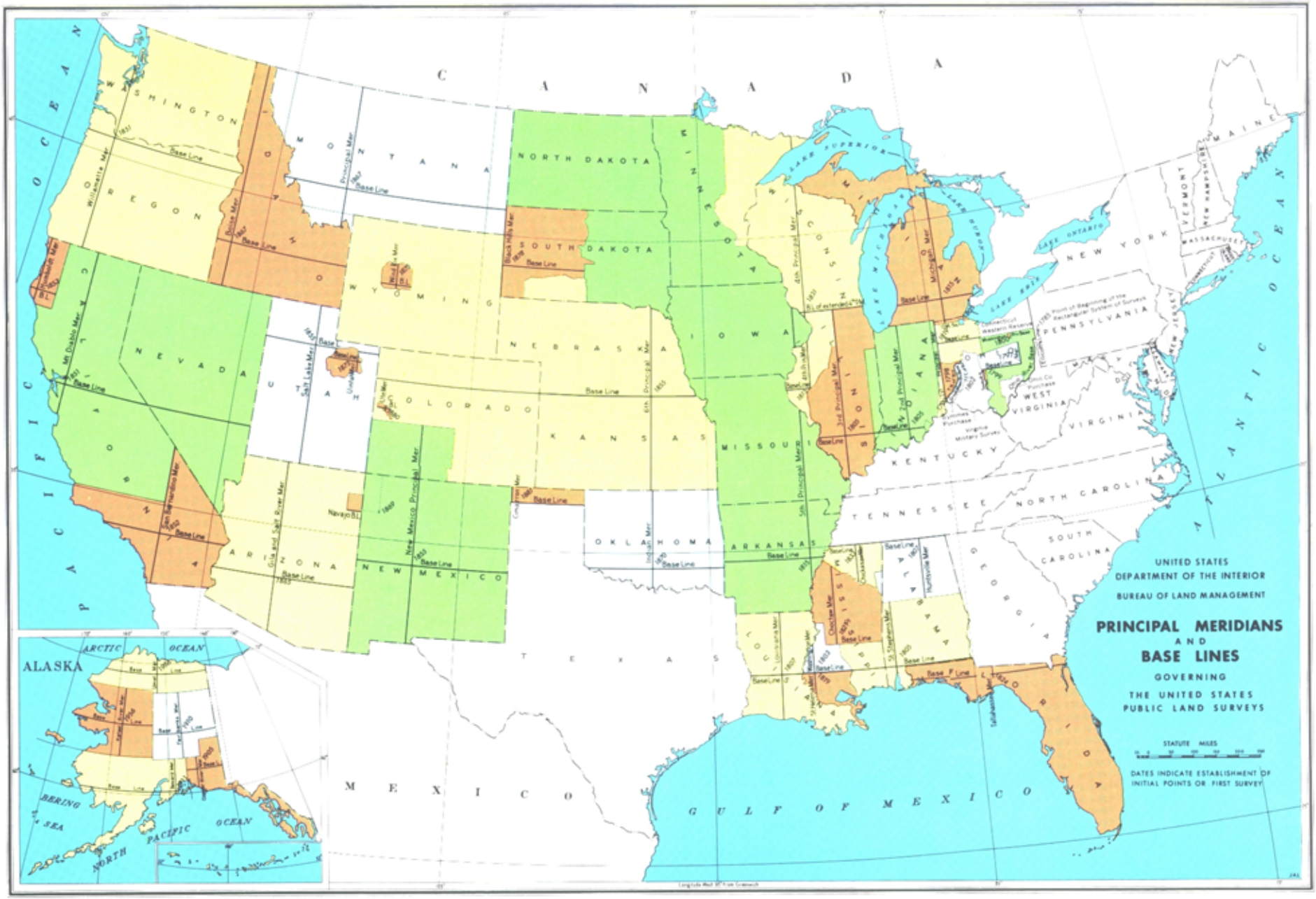
Resurveys became increasingly necessary as a growing proportion of careless, fraudulent, and sometimes practically mythical surveys surfaced as the public lands were occupied. Prospective contractors found it difficult to bid on resurvey work because it was hard to estimate the amount and character of the work. A change to contracting by the day brought some improvement, but ultimately the law was changed to provide for the direct hire of professional surveyors and their various kinds of assistants at a specified salary.

Stable pay and professional pride was thus substituted for contractors beginning July 1, 1910. Improved surveys at little extra cost soon justified those who advocated the direct hire of professionals in surveying.



1. The Original Thirteen States
2. 1790 North Carolina Cession
3. 1781-1802 State Cessions
4. 1803 Louisiana Purchase
5. 1818 Red River of the North
6. 1819 Treaty With Spain
7. 1845 Annexed Texas
8. 1846 Oregon Compromise
9. 1848 Mexican Cession
10. 1850 Purchased From Texas
11. 1853 Gadsden Purchase
12. 1867 Purchased From Russia
13. 1898 Annexed Hawaii

ACQUISITION OF THE TERRITORY OF THE UNITED STATES


UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT
PRINCIPAL MERIDIANS
AND
BASE LINES
GOVERNING
THE UNITED STATES
PUBLIC LAND SURVEYS
STATUTE MILES
DATES INDICATE ESTABLISHMENT OF
INITIAL POINTS OR FIRST SURVEY
CANADA
MEXICO
PACIFIC OCEAN
ATLANTIC OCEAN
GULF OF MEXICO
ALASKA
ARCTIC OCEAN
BERING SEA
NORTH PACIFIC OCEAN
WASHINGTON
OREGON
CALIFORNIA
NEVADA
IDAHO
MONTANA
WYOMING
UTAH
ARIZONA
COLORADO
NEW MEXICO
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
OKLAHOMA
TEXAS
MINNESOTA
IOWA
MISSOURI
ARKANSAS
LOUISIANA
WISCONSIN
ILLINOIS
MICHIGAN
INDIANA
OHIO
KENTUCKY
TENNESSEE
MISSISSIPPI
ALABAMA
GEORGIA
FLORIDA
SOUTH CAROLINA
NORTH CAROLINA
VIRGINIA
WEST VIRGINIA
PENNSYLVANIA
NEW YORK
VERMONT
NEW HAMPSHIRE
MAINE
MASSACHUSETTS
CONNECTICUT
NEW JERSEY
LAKE SUPERIOR
LAKE MICHIGAN
LAKE HURON
LAKE ERIE
LAKE ONTARIO
Base Line
Navajo B.L.

The Rectangular Survey System...

Our present system of public land survey still retains the basic elements set forth in the Ordinance of 1785, with subsequent legislation and regulations adding refinements.

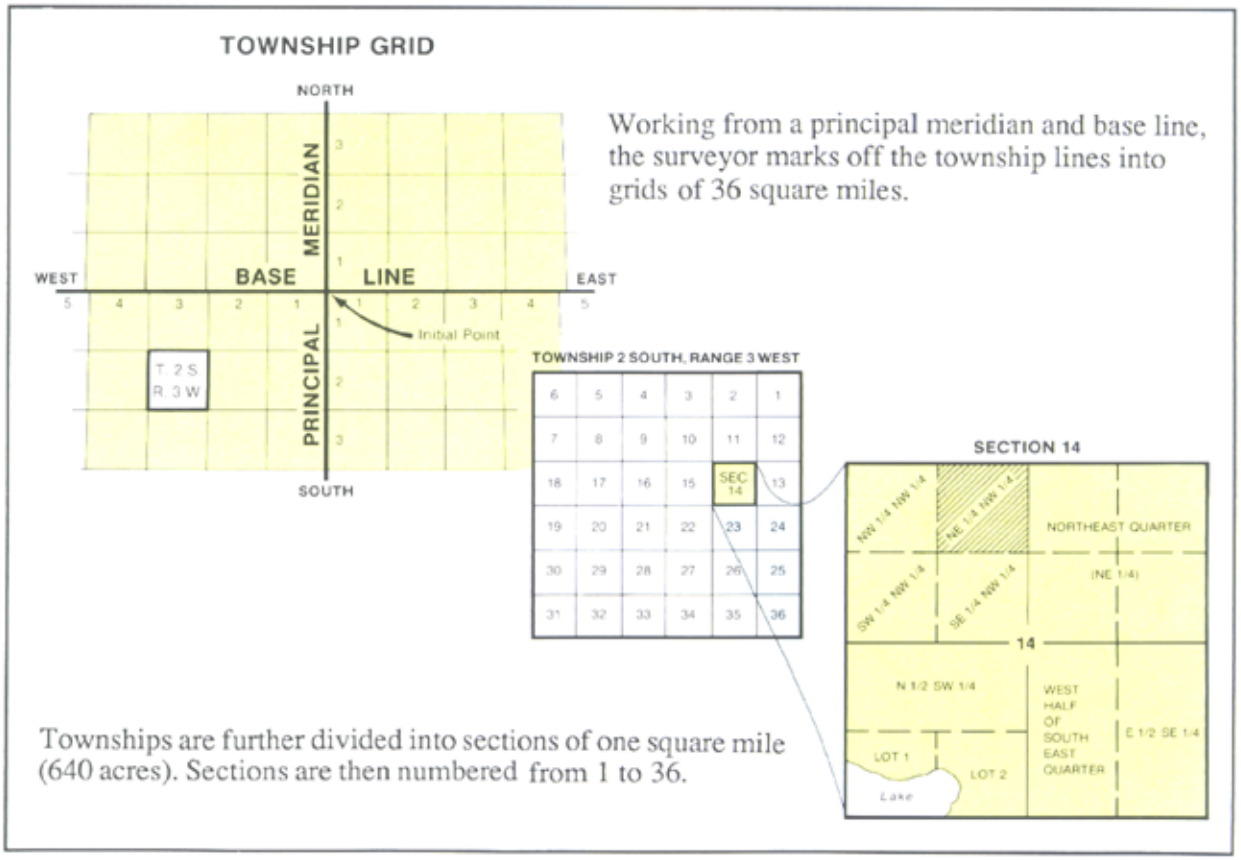
Under the cadastral system, the public domain is plotted into a grid of squares, each approximately 6 miles to the side, called "townships."

Before any measurement can be made, the surveyor must define an initial point where the exact latitude and longitude is known. From that initial point two lines are run, one north-south, the other east-west. The north-south line becomes a principal meridian and is identified by a name — the Salt Lake Meridian, for example, which intersects its baseline at the southeast corner of the Mormon Temple Grounds in downtown Salt Lake City. The east-west line becomes the base line for the meridian (see map, page 6).

Working along the principal meridian and the base line, the surveyor sets township corners at 6-mile intervals, and then, by extension, the tract is marked off into a grid. Each of the 6-mile squares is a township of 36 square miles, or approximately 23,040 acres. Any specific township can then be located according to its relationship to the appropriate principal meridian and the base line.

Because of the shape of the earth, principal meridians come closer together as they extend toward the North Pole. To adjust for this, correction lines are run every 24 miles.

The township is further divided into sections of one-mile squares containing 640 acres. Individual sections are identified by a numbering system that starts with section 1 in the northeast corner of the township and ends with section 36 in the southeast corner.



Working from a principal meridian and base line, the surveyor marks off the township lines into grids of 36 square miles.

Townships are further divided into sections of one square mile (640 acres). Sections are then numbered from 1 to 36.

The section can be further sub-divided into quarter section of 160 acres which became the basic unit under the Homestead Act of 1862. Quarter sections can be divided into half-quarter sections of 80 acres or into quarter-quarter sections of 40 acres, etc.

From the settler's point of view, the rectangular system forced them to take undesirable land along with that deemed most desirable. However, this disadvantage may have been more than offset since there was less chance of boundary disputes and fewer cases of expensive litigation than there would have been under a system of metes and bounds.

Under the rectangular survey system it is very easy to describe and locate any one parcel of land. There cannot be another parcel of land with the same identification. In order to avoid writing out a lengthy description, a shorthand method of describing has been devised.

For example, in the illustration on page 7, the sample township is located two townships south of the base line and three ranges west of the principal meridian. In short, from the location of the township, it would be written "T. 2 S., R. 3 W." In formal land descriptions it is also necessary to include the name of the principal meridian.

The example section on page 7 would be described as "Sec. 14, T. 2 S., R. 3 W" and the name of the principle meridian. Although the name of the state is not required, it is usually added for convenience. One of this system of land description is that the method allows land to be described by very small legal subdivisions without an actual detailed field survey.

Quarter divisions of a section of land are known as "aliquot parts." An aliquot part is always described in relation to the four points of the compass. In the lower illustration on page 7 the hatched portion would be described as the "northeast quarter of the northwest quarter (NE1/4NW1/4) Sec. 14, T. 2 S., R. 3 W," and the name of the principal meridian.

BLM has sometimes found it necessary to approve uses of land tracts before actual survey has been performed. These administrative requirements are handled by a system of "protracted surveys" — lines drawn on maps that informally extend the public land survey system, even though the boundaries have not yet been laid out on the ground. Protractions help in locating oil and gas leases and provide a means for recording actions dealing with public lands.

Protractions will not take the place of the final official survey but they do provide a present basis for many types of land management.

The Federal Land Surveyor...

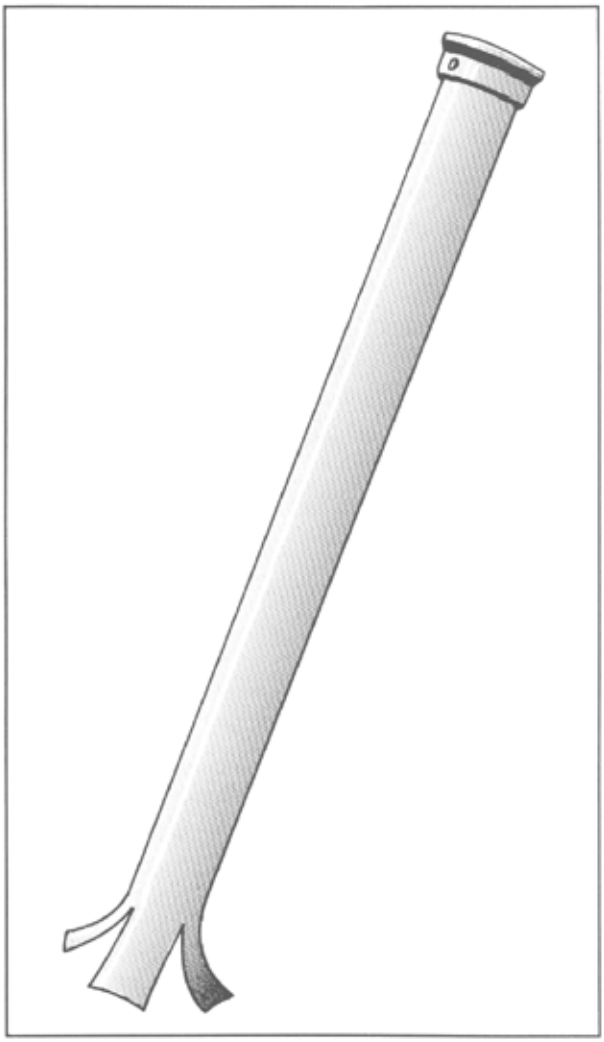
Surveyors are usually within one of three groups — geodetic surveyors measure the shape and size of the earth; topographic surveyors locate and map the earth's features including its contours, water bodies, roads and buildings; cadastral surveyors lay out and mark property boundaries according to legal requirements and doctrines.

Today, in the BLM, there are about 280 permanent cadastral surveyors to augment this corps of professionals, BLM employs seasonal survey aids who operate surveying instruments, cut brush, climb hills, maintain equipment, and set permanent monuments. There are also professional cadastral surveyors employed by several other government agencies for specialized purposes such as land line location and boundary management in the U.S. Forest Service.

Travel and long stays away from home offices are commonplace for BLM field surveyors. A good degree of self-reliance is a desirable attribute of surveyor party chiefs since independent decisions on both technical and crew management matters are frequently needed. Personnel management and logistical abilities are sometimes critical (such as for a six month Alaskan field camp operation).

BLM surveyors go to and from work sites on just about anything that moves, including by foot, horseback, four-wheel drive vehicle, helicopter, and boat. Survey work is carried on any where in the United States — from the Arizona deserts to the Alaskan tundra, along the edge of a large water body, or in a dense forest on the sides of a western mountain. Cadastral surveys fall into two main categories — original surveys and resurveys. Since the majority of the land in the lower 48 states has already been originally surveyed, most original survey work today is carried on in Alaska, quite often in remote, roadless areas.

Resurveys have always been necessary in marking the public lands in order to restore obliterated or lost original survey lines. Statutory authority for resurveys was given by Congress in 1909. Resurveys now compose the most challenging and complex projects for BLM surveyors.



Corner Monument. The exact location of the corner is stamped on top. The bottom is spread out to prevent pulling the post from the ground. Congress authorized the use of metal monuments in 1908. Stone monuments were principally used before then.

However, it is legally stipulated that no resurvey can impair the bona fide land rights of affected claimants. Corners established in original cadastral surveys are forever fixed in position even though they may not fall precisely at a stated bearing and distance from a previous point. Today's cadastral surveyor must weigh many

kinds of evidence in order to ensure the protection of private rights.

In recent years, modern technology has replaced the traditional "chain" measuring tape with electronic instruments. Microwave, light wave, laser beam, photogrammetry, and gyroscopic orientations are among the scientific mediums integrated in the cadastral surveyor's array of working tools.

New, highly sophisticated surveying techniques range from "Total Station" concepts where all azimuthal and distance data are automatically recorded for later computer processing, to inertial guidance systems which give continuously updated coordinates of airborne positions. BLM in Alaska use this "black box" system to rapidly meet the survey demand of millions of acres of land scheduled for transfer under the Native Claims and Alaska Statehood Acts.

Computer aided drafting has replaced the traditional manual methods of platting the boundaries that were measured by the surveyor. computers also provide the capability to calculate coordinates, or latitude and longitude, for survey corners. These coordinates are incorporated in the BLM's Public Land Survey System/Geographic Coordinate Data Base and allow the PLSS to be displayed on maps using automated methods rather than manual copying techniques. The PLSS/GCDB is the foundation for legal parcel based Land Information System which will allow mapping and analysis of resource and cultural information which relates to the land. "Field to finish" will no longer end at the survey plat, but at any map which shows the PLSS.

The physical challenge to the cadastral surveyor of laying boundaries across the terrain remains. The mental challenges are increasing. The future survey of our public lands will call for technically adept surveyors who are willing to integrate the wisdom and experience of their predecessors with the expanding knowledges and uses of both the scientific and managerial regimes.

SHORT LIST OF SURVEYING TERMS

Bearing Tree — A marked tree used as a corner accessory; its distance and direction from the corner being recorded. Bearing trees are identified by prescribed marks cut into their trunks; the species and size of the trees are also recorded.

Corner — A point on the earth, determined by the surveying process, which defines an extremity on a boundary.

Field Notes — The official written record of the survey, certified by the field surveyor and approved by proper authority. Originally, field notes were prepared by hand, but are now typewritten.

Meander Line — A traverse of the margin of a permanent natural body of water.

Monument — The physical object which marks the location of a corner point.

Original Survey — A cadastral survey which creates land boundaries and marks them for the first time.

Plat — As used technically by BLM, a graphic representation drawn to scale depicting the actual survey as described in the official field notes.

Resurvey — Cadastral survey to identify and remark the boundaries of lands which were established by an earlier survey.

Traverse — A sequence of lengths and directions of lines connecting a series of stations.

Witness Corner — A monumented point usually on the true line of the survey near a corner point which cannot be physically occupied or which falls at a place subject to destruction by the elements. The witness corner is then a reference to the true corner point.

E. on a random line
bet. secs. 25 & 36.
Va. 14° E.

10.50 Leave timber & enter Park.

40.00 Set temporary 1/4 sec. cor.

79.52 Intersect E. boundary of
Sp. 64 lks. N. of cor. to secs.
25, 30, 31 & 36.

Thence I run
N. 89° - 33' W.
on a true line.

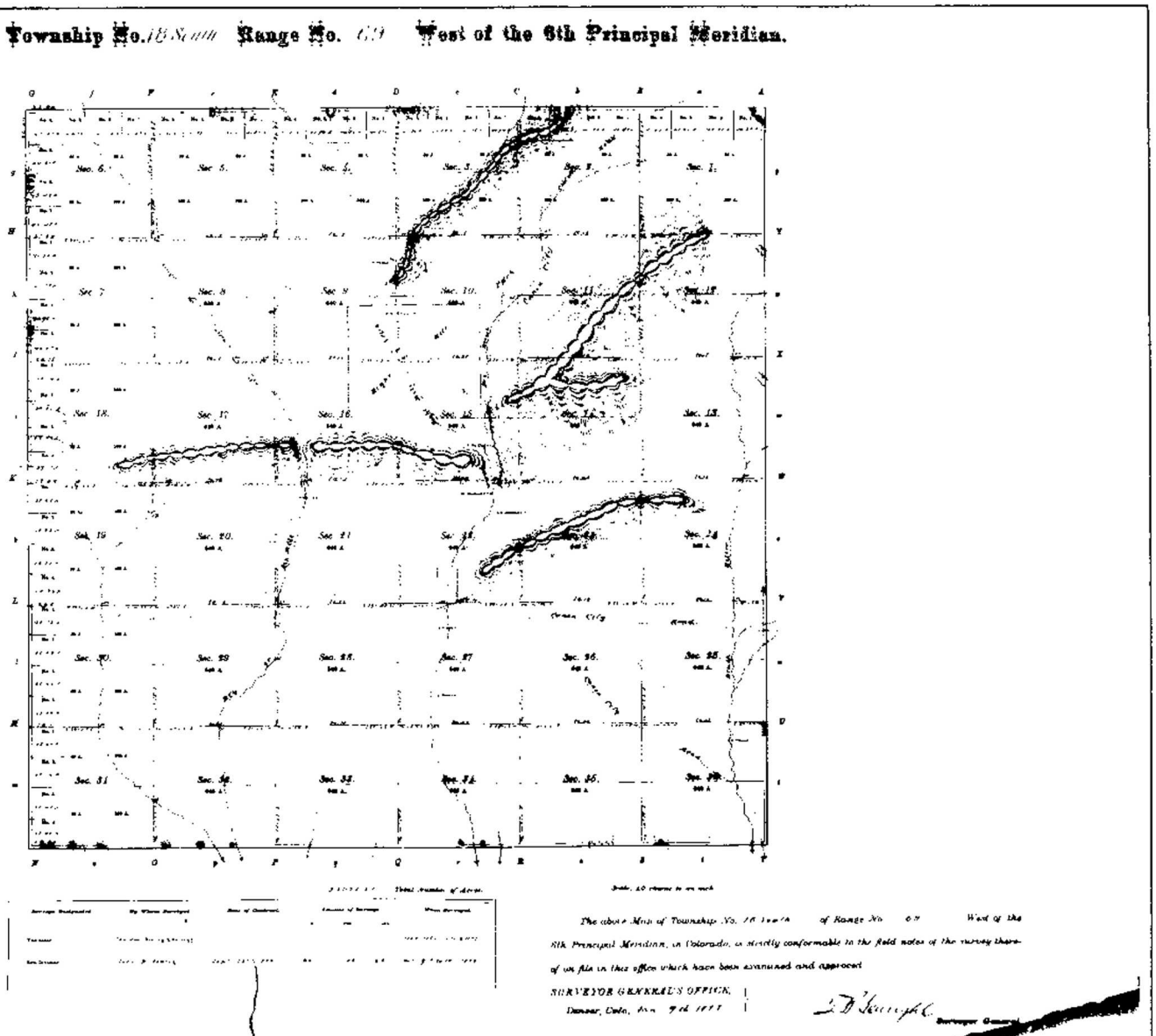
39.76 Set sandstone 14 x 12 x 6
marked 1/4 in mound of
stones for 1/4 sec. cor.

79.52 At cor. to secs. 25, 26, 35
& 36.

Oct. 10 1880.

Surface mountainous.
Soil 2nd rate
Veg. buffalo grass.
Pine & quaking asp timber

Handwritten field notes of an original cadastral survey in Colorado (1872).



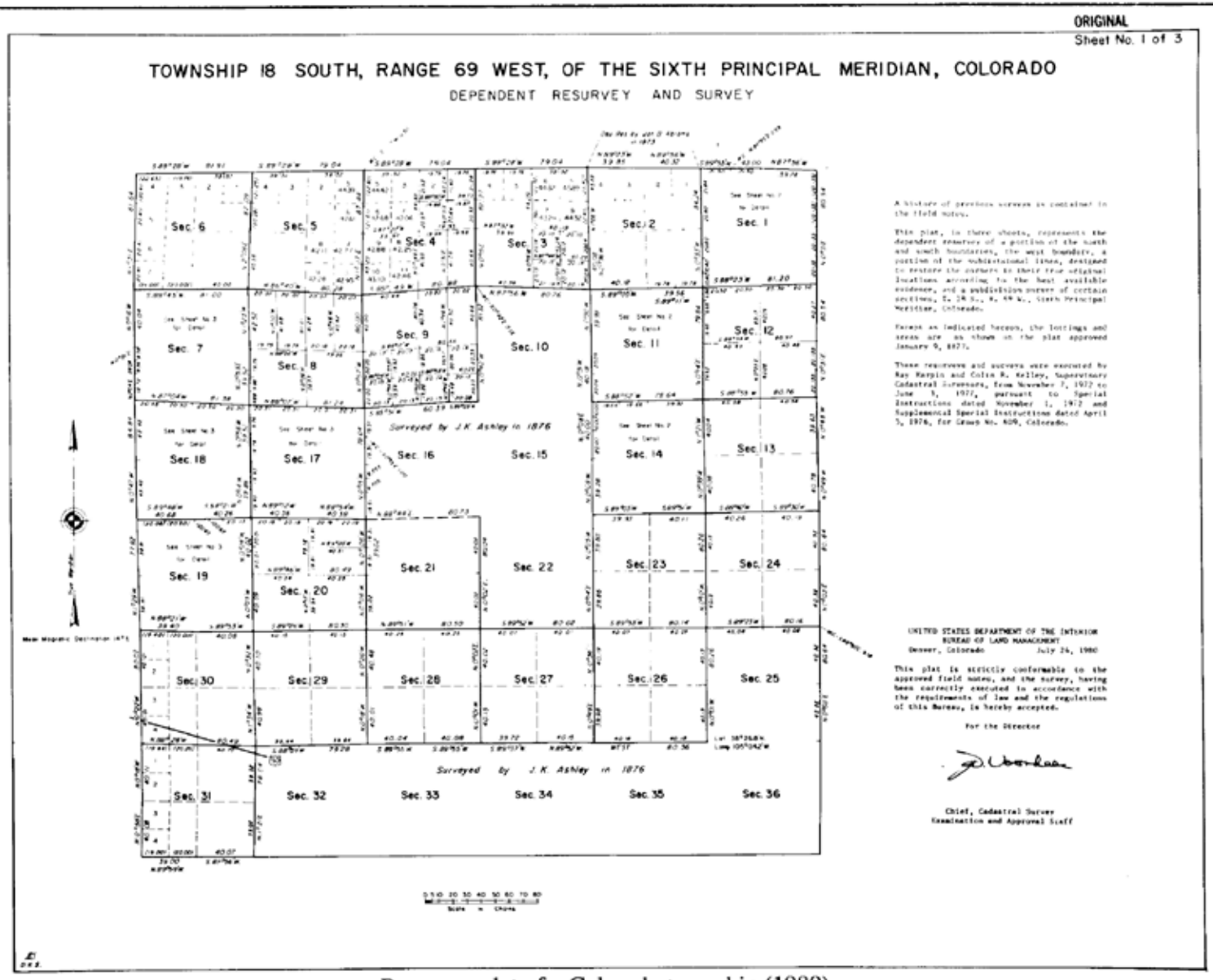
Original survey plat of a Colorado township (1877).

Dependent Resurvey of the W. Bdy.,
T. 18 S., R. 69 W., Sixth Principal Meridian, Colorado

CHAINS	
	Set an iron post, 28 ins. long, 2½ ins. diam., on solid rock, supported in a mound of stone, 5 ft. base, to top of brass cap mkd. S 1/16 S12|S7 1976
28.08	The N-S 1/64 sec. cor. of secs. 7 and 12, identical with cor. 6, M.S. 14374, Alabaster Placer, monumented with a sandstone, 24x8x6 ins., firmly set 16 ins. in the ground, mkd. with a X (cross) on top, and 6 14374 on the E face. At the corner point Set an iron post, 28 ins. long, 2½ ins. diam., 24 ins. in the ground, with brass cap mkd. N-S 1/64 S12|S7 |COR 6 |MS 14374 1976 Bury the mkd. stone alongside the iron post.
	N. 0° 21' E., beginning new measurement. Continue descent.
8.10	Powerline, bears ESE. and WNW.
9.38	The ¼ sec. cor. of secs. 7 and 12, identical with cor. 1, M.S. 14374, Alabaster Placer, monumented with a sandstone, 22x12x5 ins., firmly set 8 ins. in the ground, mkd. 1 14374 on the E face. At the corner point Set an iron post, 28 ins. long, 2½ ins. diam., 22 ins. in the ground, with brass cap mkd. T18S R70W R69W ¼ S12|S7 |COR 1 |MS 14374 1976 Bury the mkd. stone alongside the iron post. The cor. is located in a fence extending N. and S.
	N. 0° 16' W., beginning new measurement. Over rolling hills, through scattering juniper and pinon.

Form 9600-10 (June 1978) (formerly 9180-7) USDI—BLM FIELD NOTE PAPER

Field notes of a resurvey in Colorado (1979).



Resurvey plat of a Colorado township (1980).

The chain is the unit of linear measurement for the survey of the public lands as prescribed by law. All returns of measurement in the rectangular system are made in the true horizontal distance in links, chains, and miles. The only exception to this rule are special requirements for measurement in feet in mineral surveys and townsite surveys.

LINEAR MEASUREMENT

1 Chain = 100 Links or 66 Feet
1 Mile = 80 Chains or 5,280 Feet
1 Mile = 1.61 Kilometers

AREA MEASUREMENT

1 Acre = 10 Sq. Chains or 43,560 Sq. Feet
1 Square Mile = 640 Acres
2.47 Acres = 1 Hectar