



U.S. Department of the Interior
Bureau of Land Management

My Public Lands

Middle School Teaching Guide

**CLASSROOM
INVESTIGATION**

**Cadastral
Surveying:
Finding the
Boundaries
of U.S.
Public
Lands**



Dear Teacher,

Welcome to this Classroom Investigation Series unit about Cadastral Surveying on public lands. Students will apply cadastral surveying knowledge, history, and techniques to their school environment. From its three activities, students will:

- Describe how and why Congress developed the Public Land Survey System, define land tenure and public domain in the United States, and discuss how public domain, land tenure, and the Public Land Survey System shaped the United States.
- Understand the basic design of the Public Land Survey System, interpret aliquot descriptions of land, and map a location in their classroom using an aliquot description.
- Review surveying methods and tools, calculate acreages and angles using survey computations, and map an area at their school using survey computations.

Through this teaching guide, students will learn how the development of the Public Land Survey System was vital to the establishment of land ownership and government revenue in the early days of the United States. They will also learn how the survey system promoted European-American settlement in newly acquired areas of the country. The lessons will introduce students to public domain, the Public Land Survey System, and surveying methods and tools. Students will use surveying techniques to map their classrooms and to practice being a surveyor for a day. They will also complete calculations using measurements from the survey system.

Although designed for middle school students, the unit can be adapted for high school and upper elementary levels. Students engage in diverse cognitive skills such as speaking, drawing, interpreting graphics, problem solving, and teaching roles as they progress through the unit.

The unit supports innovative strategies in education, such as:

- Social and emotional learning: Students participate in small groups in which they work together, listen and speak to one another, and collaborate.
- Interdisciplinary instruction: As they progress through the unit, students define and discuss the historical background of the Public Land Survey System, interpret aliquot descriptions of land, and map an area at their school using survey computations.

The curriculum is flexible. It can be adapted so each activity in the unit takes one 45-minute class period, for a total of three class periods. The activities work best as a collective unit that progresses from Public Land Survey System development, to describing surveyed lands, to being a surveyor for a day.

Curriculum Connections

This unit addresses the following Next Generation Science Standards:

- MS-ESS3-3: Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
- MS-ETS1-1: Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

This unit also supports the following standards of the "College, Career, & Civic Life C3 Framework for Social Studies State Standards," published by the National Council for the Social Studies:

- D2.Geo.8.6-8: Human Population: Spatial Patterns and Movement. Analyze how relationships between humans and environments extend or contract spatial patterns of settlement and movement.
- D2.His.12.3-5: Historical Sources and Evidence. Generate questions about multiple historical sources and their relationships to particular historical events and developments.
- D2.His.12.6-8: Historical Sources and Evidence. Use questions generated about multiple historical sources to identify further areas of inquiry and additional sources.
- D2.His.16.3-5: Causation and Argumentation. Use evidence to develop a claim about the past.

The activities address the following essential understandings:

- The Public Land Survey System had a significant impact on the development of the United States.
- Land surveyors used maps and descriptions to define individual surveyed locations in the United States.
- Surveying methods, tools, and computations are applicable to our lives today.

About the Bureau of Land Management

The Bureau of Land Management (BLM) cares for about 245 million acres of federally owned public lands, mainly in the Western United States and Alaska. These lands, representing about one-tenth of the nation's land area, belong to all Americans. In addition, the BLM administers about 710 million acres of mineral estate across the entire country.

Public lands are used for many purposes. They support local economies, providing the United States with coal, oil and gas, forest products, livestock forage, and other commodities. As a haven for plants and wildlife, the lands play a critical role in habitat and resource conservation efforts, and they encompass important historical, archaeological, and paleontological sites. Open spaces on public lands offer places for people to play, learn, and explore. Some BLM lands are designated as part of the National Conservation Lands, a network of lands afforded special status and managed almost exclusively to conserve their scientific, cultural, educational, ecological, and other values.

The BLM is responsible for managing public lands under the principles of multiple use and sustained yield in a manner that best meets the current and future needs of the public. With so many resources and uses, the BLM's job is challenging. Thankfully, countless partners, volunteers, and communities provide invaluable support, helping the agency carry out its stewardship mission. To learn more about your public lands and how you can get involved, visit <http://www.blm.gov>.

The Importance of the Cadastral Survey Program

Robert Frost wrote, “Good fences make good neighbors.” How do landowners know where boundaries are to build a fence? When it comes to federal lands, the BLM relies on cadastral surveys and cadastral surveyors to know where the boundaries are. Cadastral surveys are the foundation for land ownership in many states.

The founders of the United States wanted Americans to be able to own land, which common people couldn’t do in England. The founders developed a system to survey the land, parcel it out, and sell it. This surveying system, named the Public Land Survey System, is still used to manage public land today.

BLM’s cadastral survey program maintains the Public Land Survey System.

An official cadastral survey provides legal evidence of federal land boundaries and federal subsurface interest such as minerals.

The BLM has specific authority to conduct cadastral surveys. So, the BLM conducts surveys for other federal organizations, federally recognized Tribes and their members, Alaska Native Corporations, Alaska Natives, and other landowners.

The BLM introduces the importance and history of the cadastral survey program as follows on its website (<https://www.blm.gov/programs/lands-and-realty/cadastral-survey>):

The BLM’s Cadastral Survey Program provides one of the oldest and most fundamental functions of the U.S. Government. Originating with the Land Ordinance of 1785, cadastral surveys create, define, mark, and re-establish the boundaries and subdivisions of the

public lands of the United States. (The word “cadastral” is derived from cadastre, meaning a public record, survey, or map of the value, extent, and ownership of land as a basis of taxation.) These surveys provide public land managers and the public with essential information needed to correctly determine ownership rights and privileges and facilitate good land management decisions.

As a young nation, the U.S. faced the daunting task of surveying over 1.8 billion acres of acquired public domain lands. Over the past two centuries, almost 1.5 billion acres have been surveyed into townships and sections and monumented. This represents the greatest land surveying project ever undertaken, requiring vast human energy for carrying heavy equipment, dragging chains, cutting trails, climbing mountains, placing monuments, digging pits, and blazing “witness” trees.

The BLM is the official record keeper for over 200 years’ worth of cadastral survey records and plats. In addition, the agency continues to complete numerous new surveys each year, mostly in Alaska. The agency also conducts resurveys to restore obliterated or lost original survey corners.

Today’s cadastral surveyors use updated technology to continue an important history of federal interest land management in the United States.

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Activity 1: What Shaped the United States?

Time Estimate

One 45-minute class period.



For the Teacher

This activity addresses the following essential understanding:

- The Public Land Survey System had a significant impact on the development of the United States.



Overview

This is the first of three activities that address the Public Land Survey System. This activity introduces students to:

- The Public Land Survey System's role in early United States development.
- Land tenure types and function in the early United States.
- Public domain land definition and significance.



Teacher Preparation

1. Read the "Background Information" and make a copy of it for each student.
2. Make copies of the group handouts. There are three versions, one for each small group.

Learning Objectives

Students will be able to (1) describe how and why Congress developed the Public Land Survey System, (2) define land tenure and public domain in the United States, and (3) discuss how public domain, land tenure, and the Public Land Survey System shaped the United States.



Procedure

1. Distribute the "Background Information" handout to all students.
2. Ask students to look at Figure 1 on the "Background Information." This is an aerial image from the middle of the country. Ask students "What do you observe about the aerial image in Figure 1?" and facilitate discussion regarding the network of square lines on the image.
3. Tell students they will investigate the Public Land Survey System, land tenure, and public domain in small groups.
4. Divide the class into three groups. For a large class, create additional groups and assign multiple groups the same topic. Assign each group a topic and distribute the three handouts accordingly. There is a distinct handout for each group. Ask students to research their topics using the "Background Information." Students will answer the prompts on their group handouts. Ask each group to select a spokesperson for a two-minute presentation. Provide about 15 minutes for the groups to prepare their report.
5. Circulate among groups to assist as needed.
6. Once the students have prepared their group reports, reconvene the class into one unit.
7. Whole-class discussion: Ask each group's spokesperson to report their findings on the assigned topic to the large group in two-minute presentations. After each group reports on their topic, ask the large group: What was the main idea of that report? How would you express that in your own words? How would you compare that group's definition with the "Background Information?"
8. Once all groups have reported, ask students to examine Figure 1 again. Ask the students: After researching your topic and hearing the other group reports, what can you infer from the lines on the aerial image now? What can you say about the survey system, land tenure, and public domain?



Assessment

Rove among groups during the small group activity and listen for students discussing the main ideas from the "Background Information." During the small group reports, ensure the spokesperson

addresses each talking point bullet in their handout, and the class is able to restate the main point in their own words.



Background Information Handout: What Shaped the United States?



Figure 1: Google Earth image of eastern South Dakota and southwestern Minnesota.

What would you do if you had land? Build a home on it? Plant crops to feed your community? Maybe you'd sell it to earn money. Nations and people in the early United States used land the same ways we do today; for shelter, food, and money.

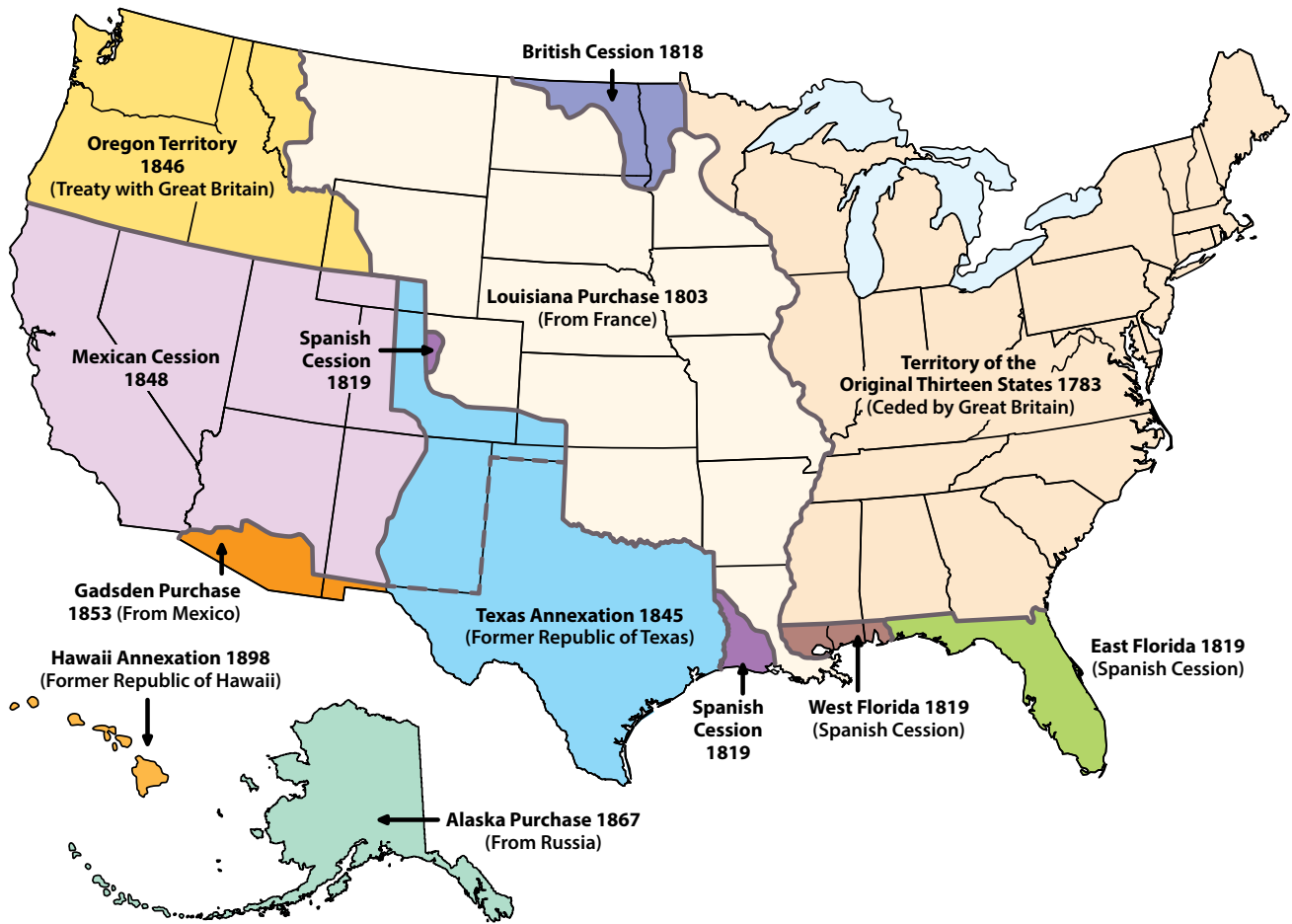
The way a society manages land is called land tenure. "Tenure" in land tenure means owning or holding land; like a tenant holds an apartment. Land tenure systems in the early United States changed depending on who owned the land at the time. Native American tribes, the British monarchy, Spain, France, and Mexico all held land in what became the United States.

Before the United States was a country, the British recognized Native American land tenure with "Aboriginal title." Native American tribes

held title to the land, and King George III made treaties with tribes to gain their land. The King of England created the original 13 colonies with colonial land grants, another kind of land tenure.

Spain, Mexico, and France transferred land tenure to settlers with land grants. Later, these governments transferred land to the United States with treaties and purchases.

The United States also acquired land from Native American tribes through treaties and displacement. After the Revolutionary War, the federal government took ownership of land that Native American tribes had used for generations. The government often violated treaties to displace Native Americans from tribal land and promote European-American settlement.



U.S. Territorial Aquisitions map.

When the United States formed, the new government needed a way to raise money. Congress couldn't tax people yet, but the federal government owned a lot of land. Congress passed the Land Ordinance of 1785 to raise revenue by selling land to European-American settlers.

Before the government could sell land, they needed to know what they were selling. The Land Ordinance of 1785 created the Public Land Survey System. The survey system standardized methods to survey (or identify) and sell land. This encouraged European-American settlement and raised revenue for the new government.

The Public Land Survey System measured land into 6-mile-square townships, each divided into 36 sections. The survey system required

surveys using measurements in "chains" before settlement. Survey chains were 66 feet long and had 100 links. (We will learn more about measurements using survey chains in the third lesson.)

The survey system is the foundation for land title in most of the country. Thirty states use the Public Land Survey System. The other 20 states, territories, and Washington D.C. use other land tenure systems such as colonial land grants. Original surveys completed in the 1700s and 1800s are still used for property lines today.

When the government sells land, they "patent" it to the new owner. An example is the homestead patent, which is how many Americans established title to land.

Measurements of a Township and Adjoining Sections

36 80 ch.	31	32	33	34	35	36	31 80 ch.
1	1 mile 6	5	4	3	2	1	6
12	7	8	9	10	11	12	7
13	18	17	16	15	14	13	18
24	19	20	21	22	23	24	19
25	30	29	28	27	26	25	30
36	31	32	33	34	35	36	31
1	6	5	4	3	2	1	6

U.S. Theoretical Township Diagram.

Historic photo of a United States Land Office.



“Public domain land” is land that the government did not patent to anyone. The public owns public domain land, and the federal government manages it. Congress created the General Land Office in 1812 to manage public land sales. Congress moved the General Land Office from the Treasury Department to the new Department of the Interior in 1849. Later, the General Land Office combined with the United States

Grazing Service and became the Bureau of Land Management (BLM) in 1946.

Congress passed the Federal Land Policy and Management Act in 1976. This act changed the federal government’s role from selling public lands to conserving them. Today, the BLM manages public domain lands for the use and enjoyment of present and future generations.



Group 1 Handout: The Public Land Survey System

Select a scribe and a spokesperson. Use the "Background Information" to research this topic. Be prepared to report to the large group.

The Land Ordinance of 1785 is: _____

The Public Land Survey System was created to: _____

Land patents are used to: _____

How can you describe the Public Land Survey System in your own words? _____

Describe how the Public Land Survey System shaped the United States: _____

If you were in charge of government-owned land back then, what would you do differently? _____



Group 2 Handout: Land Tenure Definition and Types

Select a scribe and a spokesperson. Use the "Background Information" to research this topic. Be prepared to report to the large group.

Land tenure is: _____

Some types of land tenure are: _____

How can you describe land tenure in your own words? _____

Describe how land tenure shaped the United States: _____

If you were in charge of government-owned land back then, what would you do differently? _____



Group 3 Handout: Public Domain Lands

Select a scribe and a spokesperson. Use the "Background Information" to research this topic. Be prepared to report to the large group.

Public domain lands are: _____

The United States acquired public domain lands by: _____

How can you describe public domain lands in your own words? _____

Describe how public domain lands shaped the United States: _____

If you were in charge of government-owned land back then, what would you do differently? _____

Activity 2: Describing Surveyed Lands



For the Teacher

This activity addresses the following essential understanding:

- Land surveyors used maps and descriptions to define individual surveyed locations in the United States.



Overview

This is the second of three activities that address the Public Land Survey System. This activity introduces students to:

- The basic design of the Public Land Survey System.
- Aliquot descriptions and use in the survey system.



Teacher Preparation

1. Read the "Background Information" and make a copy of it for each student.
2. Make copies of the activity handouts. There are three handouts; each student will complete each handout.
3. Visibly mark the four cardinal directions in your classroom; post the compass points "north," "south," "east," and "west" on the four walls of your room.
4. Set up computer and projector to demonstrate a <https://glorerecords.blm.gov/> search.

5. Practice finding the section for your school's township using <https://glorerecords.blm.gov/LandCatalog/Catalog> and the directions in Handout 2.
 - a. **Please note:** if your school is not in the purple highlighted area on the map at <https://glorerecords.blm.gov/LandCatalog/Catalog>, disregard Handout 2.
6. At your discretion, set up student internet access for a <https://glorerecords.blm.gov/recordssearch>.

Time Estimate



One 45-minute class period. Handout 2 is optional according to your school's location; see Teacher Preparation for information.

Learning Objectives

Students will be able to (1) understand the basic design of the Public Land Survey System, (2) interpret aliquot descriptions of land, and (3) map a location in their classroom using an aliquot description.



Procedure

1. Distribute the "Background Information" handout to all students and give them time to review it.
2. Ask the students, "How can you describe an aliquot part?" and facilitate discussion regarding the definition

Handout 1 Procedure: Interpreting Aliquot Descriptions

3. Distribute copies of Handout 1 to each student.
4. Walk the class through the reference elements for this aliquot description: The east half of the south west quarter of section 18 of township 6 north, range 5 west, fourth principal meridian, Illinois.

Quarter-Quarter Section: . "east half"

Quarter Section: "south west quarter"

Section: "section 18"

Township: "township 6 north"

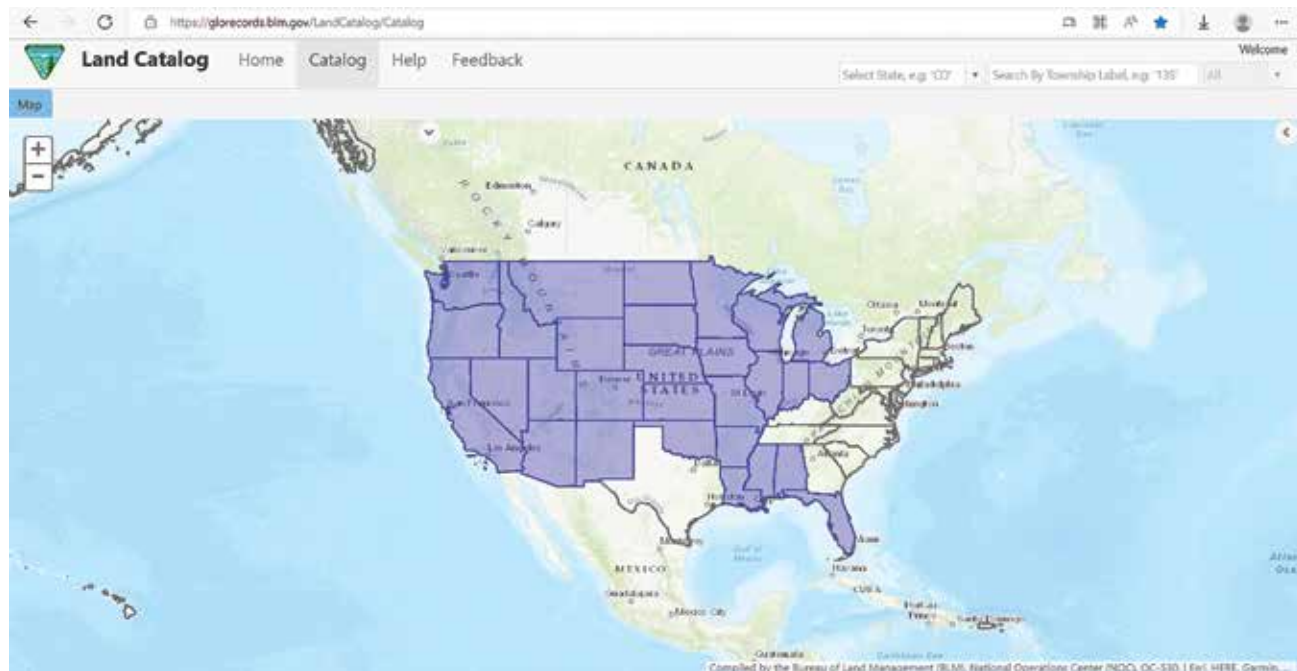
Range: "range 5 west"

Principal Meridian: "fourth principal meridian"

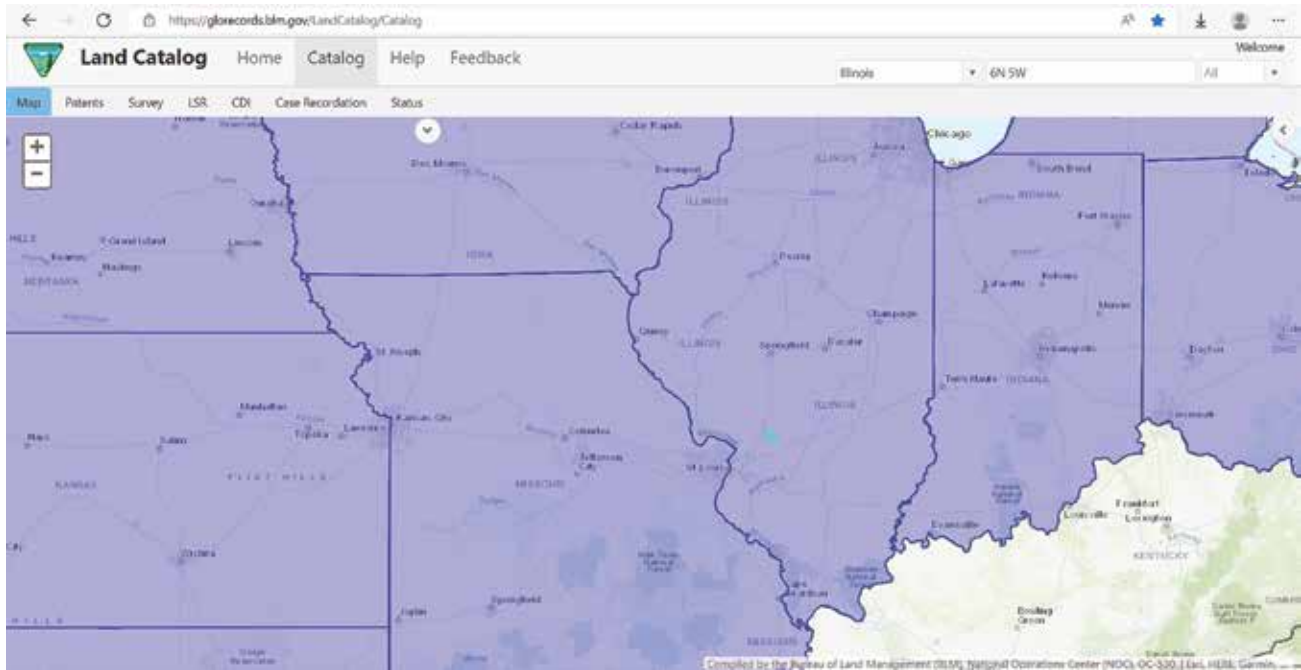
State: "Illinois"

5. Project your computer screen and navigate to <https://glorecords.blm.gov/LandCatalog/Catalog>. At your discretion, have students follow along on their own computers.
6. Use <https://glorecords.blm.gov/LandCatalog/Catalog> to walk students through the example aliquot description. Start with the largest reference element (state) and work through each one as the students follow along on their handout and circle the relevant locations.

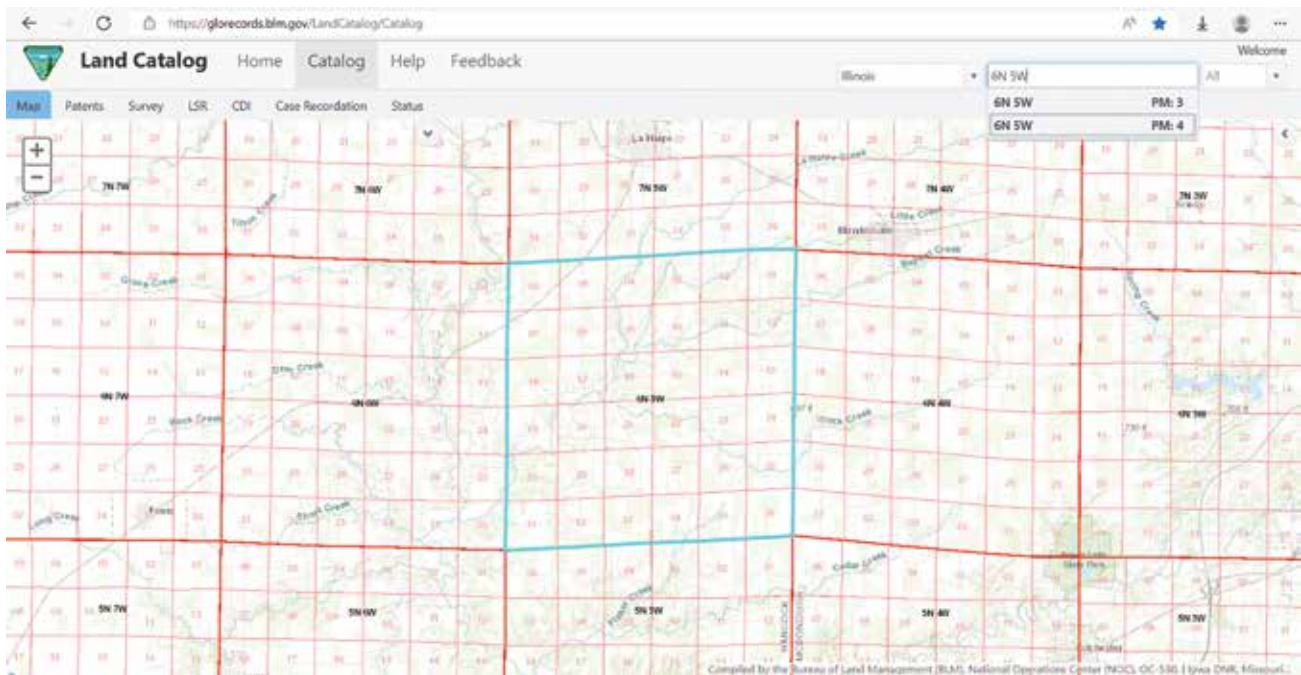
State: "Illinois"



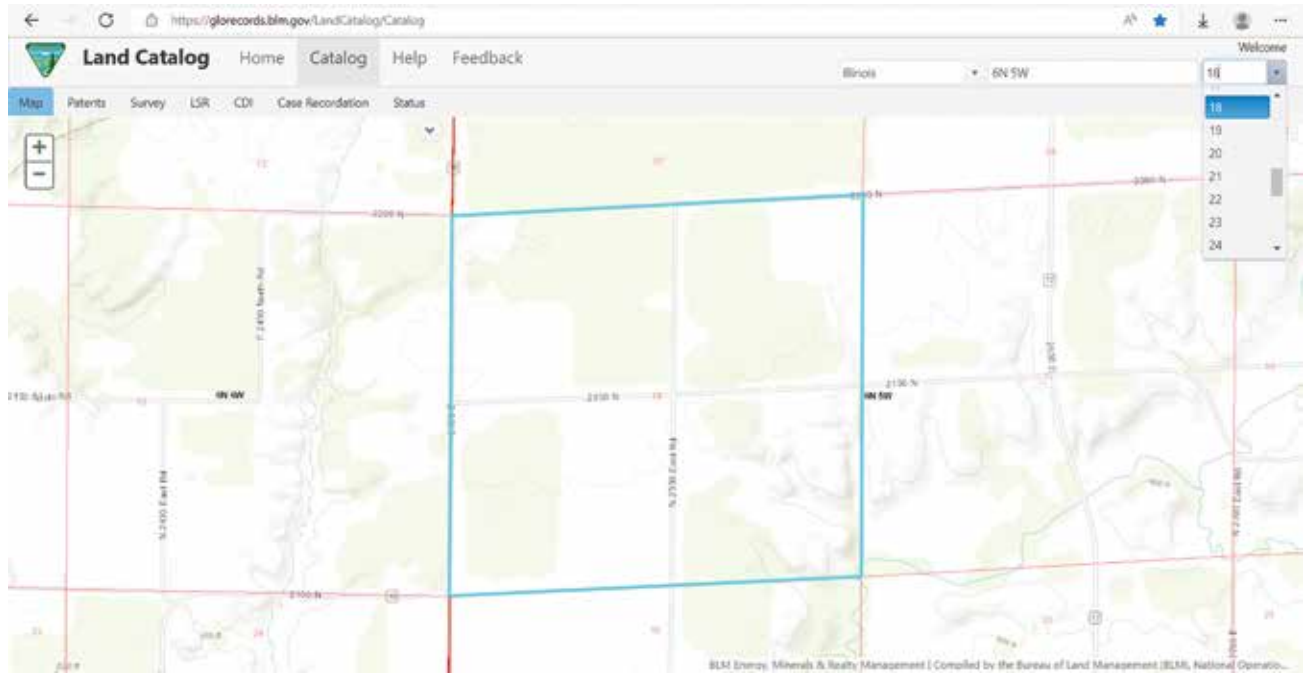
Principal Meridian: "fourth principal meridian" (this is not on the website map but it is on the handout; zoom in to the location shown)



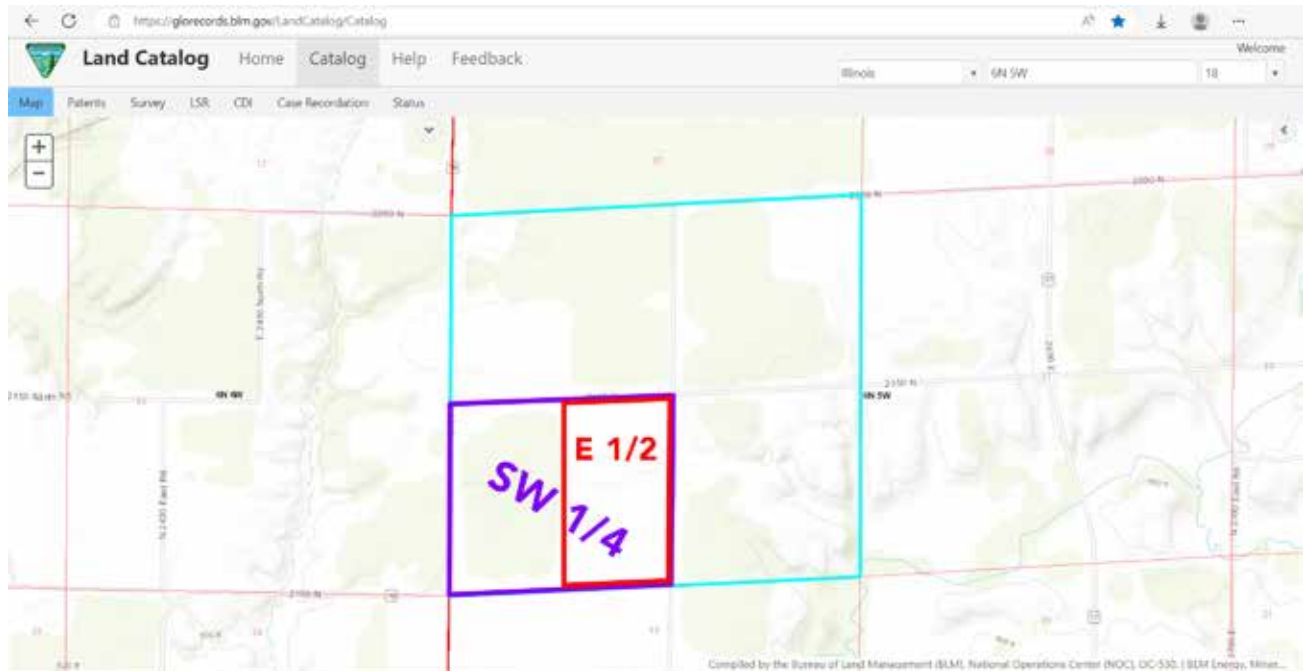
Range: "range 5 west" and **Township:** "township 6 north" (search for "Illinois" and "6N 5W PM:4")



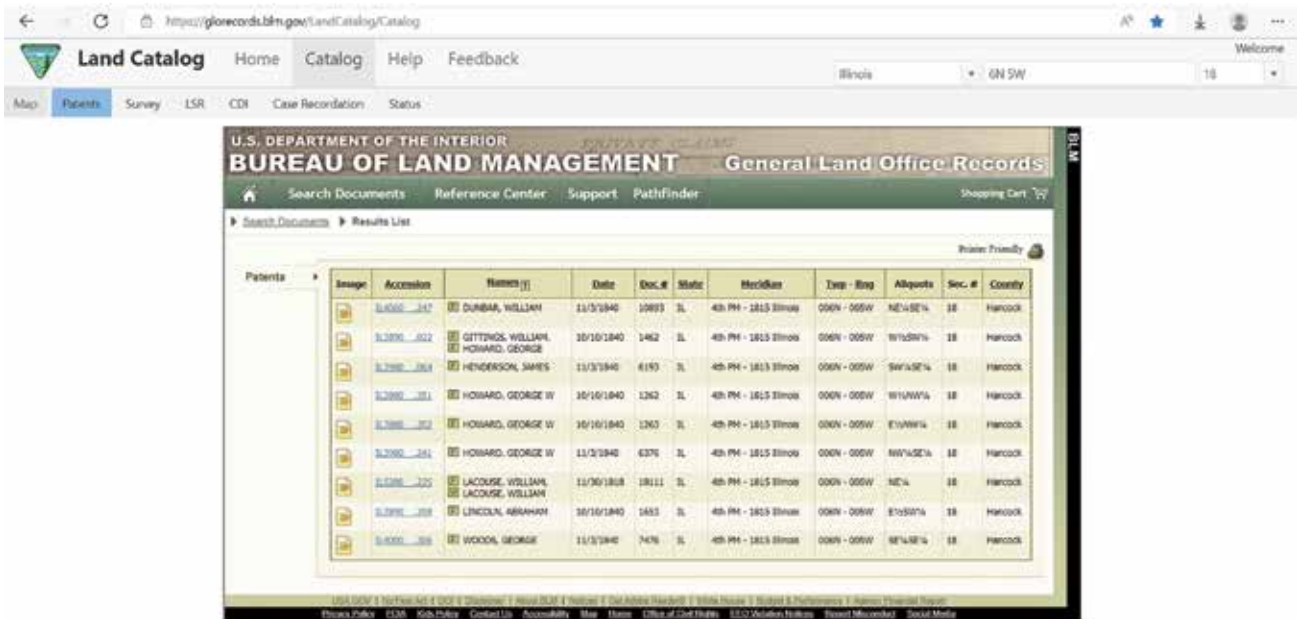
Section: "section 18"



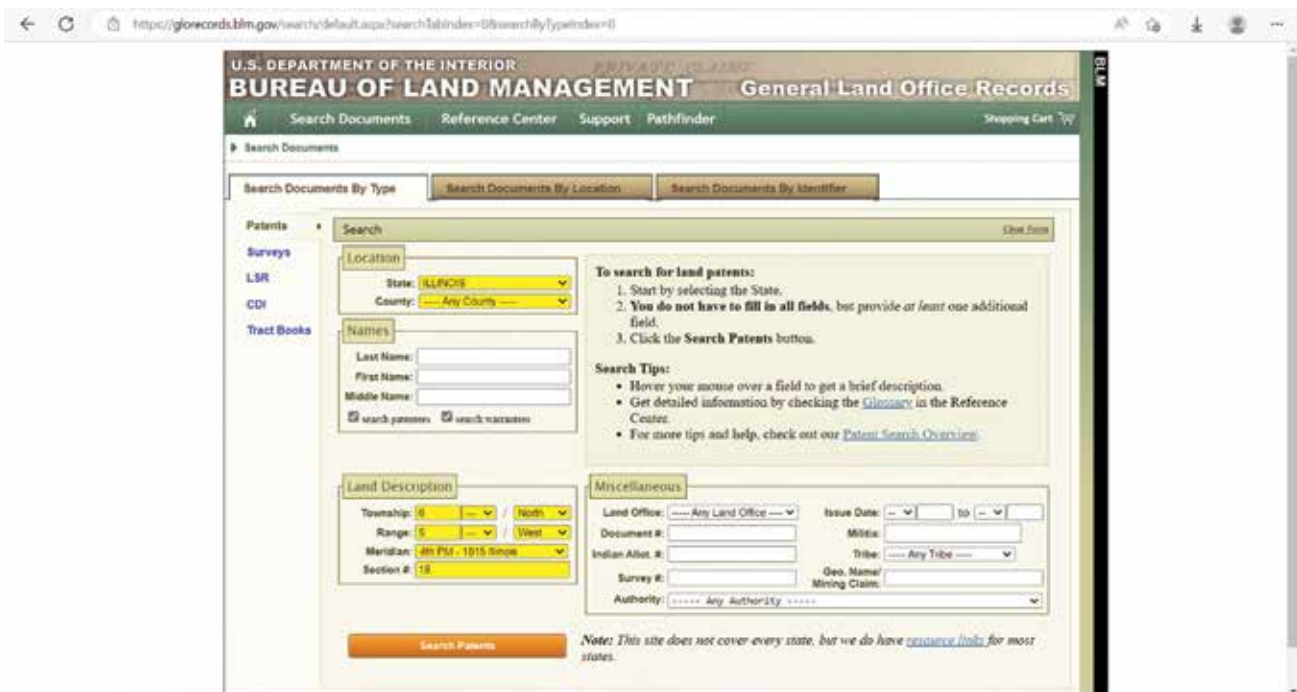
Quarter Section: "south west quarter" and Quarter-Quarter Section: "east half"



7. Select the "Patents" tab



8. **Optional step:** Demonstrate the search function on the website. Navigate to <https://gloreCORDS.blm.gov/>, select "Land Patents," enter the information from the aliquot description, search, and continue.



9. After demonstrating the search to the students, ask the group, "What do you observe in the search results?"

10. Click the link in the search results to access the plat sold to Abraham Lincoln.

The screenshot shows the 'Land Catalog' website interface. The main header reads 'U.S. DEPARTMENT OF THE INTERIOR BUREAU OF LAND MANAGEMENT General Land Office Records'. Below the header, there are navigation tabs for 'Search Documents', 'Reference Center', 'Support', and 'Pathfinder'. The search results page displays the following information:

- Accession No: IL390...208
- Document Type: State Volume Patent
- State: Illinois
- Issue Date: 10/10/1840
- Cancelled: No

There are three tabs: 'Patent Details', 'Patent Image', and 'Related Documents'. The 'Patent Details' tab is active, showing a table with columns for 'Nature On Document' and 'Miscellaneous Information'. The 'Nature On Document' section lists 'LINCOLN, ABRAHAM'. The 'Miscellaneous Information' section includes fields for 'Land Office: Quincy', 'US Reservations: No', 'Mineral Reservations: No', 'Tribe: ---', 'Military Rank: ---', 'Authority: April 24, 1820: Sale-Cash Entry (3 Stat. 569)', and 'General Remarks: ---'. Below this, there are sections for 'Document Numbers' and 'Survey Information'. The 'Survey Information' section shows 'Total Acres: 93.00' and 'Survey Date: ---'. At the bottom, there is a 'Land Descriptions' table with columns for 'Map', 'State', 'Meridian', 'Twp - Rng', 'Alqpts', 'Section', 'Survey #', and 'County'. The table shows a single entry for 'IL 4th Pct - 1875 Illinois', '00N - 02W', 'E1/4SW', '18', and 'Hancock'.

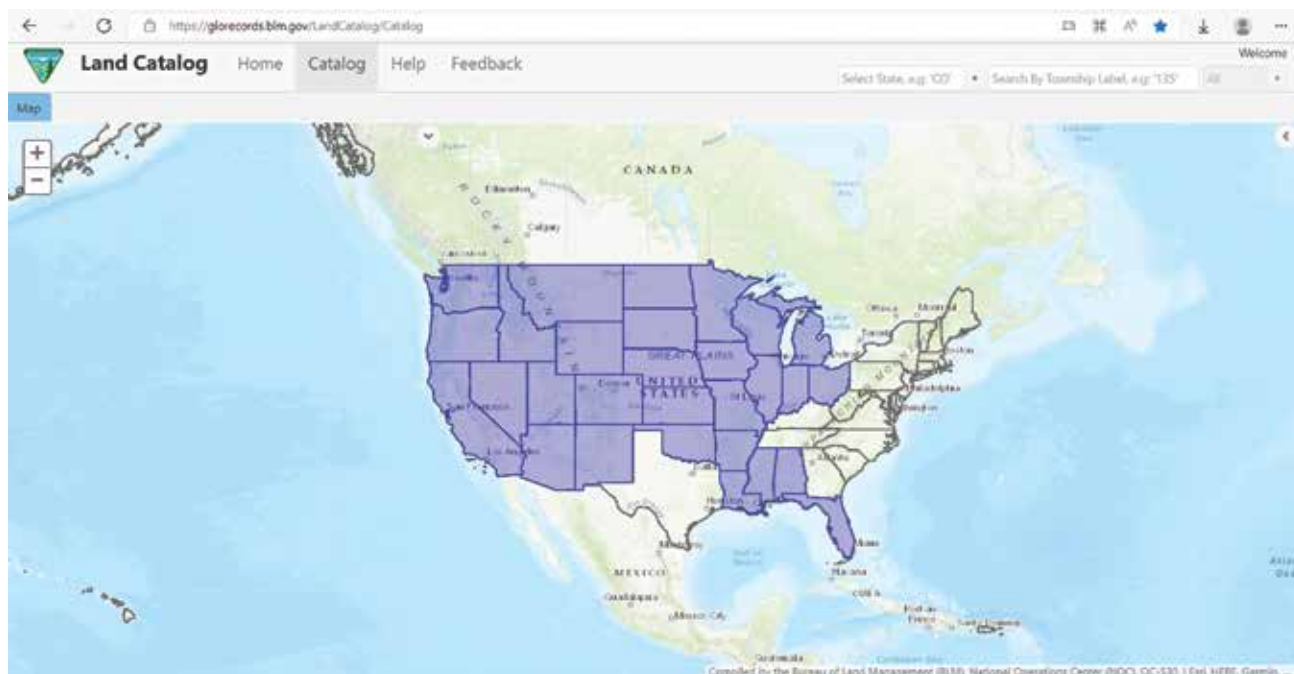
11. Click the "Patent Image" link at the top of the page to view the patent. Show the students the handwritten aliquot description that matches the description they just found, and points to one unique location in the United States: a land patent issued to the nation's 16th President.

The screenshot shows the 'Patent Image' tab selected. It displays a scanned image of a handwritten patent document. The document is titled 'THE UNITED STATES OF AMERICA' and is addressed to 'Abraham Lincoln of Hancock County Illinois'. The text of the patent reads: 'To all to whom these Presents shall come, greeting: WHEREAS Abraham Lincoln of Hancock County Illinois, has applied to the BUREAU OF LAND OFFICE of the United States, a Division of the DEPARTMENT OF THE INTERIOR, and it appears that full payment has been made by the said Abraham Lincoln, according to the provisions of the Act of Congress of the 10th of April, 1820, entitled 'An Act making further provision for the sale of the Public Lands,' for the East-half of the South-West quarter of Section Eighteen, in Township Ten North of Range Five West, in the State of Illinois, containing nearly three acres and fifty hundredths of an acre.'

12. Ask the students: How can you describe an aliquot description in your own words? What did you observe as we zoomed in from the United States to the quarter-quarter section?

Handout 2 Procedure: Locating Your School

13. **Note:** If your school's location is not in the purple highlighted portion of this map, skip Handout 2.



14. At your discretion, pair students and have them complete Handout 2 individually, or project your screen and complete Handout 2 as a large group.
15. Distribute copies of Handout 2 to each student.
16. Once Handout 2 is complete, ask the students: Think of how you would give a friend directions to our school. How would you compare the aliquot description we just completed with the directions you would give? What was different about them? Similar?

Handout 3 Procedure: Mapping Your Classroom

17. Place students in pairs if they are not already.
18. Distribute copies of Handout 3 to each student.
19. Instruct students that they will be mapping their classroom using aliquot descriptions, just like surveyors do. Each partner will give an aliquot description for an item in the classroom, and then the partners will swap handouts to find their partner's item.
20. Circulate among groups to assist as needed. Monitor time and announce when students have two minutes in the activity remaining.
21. Reconvene the class into one unit. Ask the students: Who navigated to the correct quarter-quarter? Did anyone guess their partner's object correctly? What did you observe when your partner used your description to navigate the classroom? What would happen if you weren't there to help? How would you write your description differently now?



Assessment

Ask the large group questions students can answer in their own words. Rove and listen to small groups. Spot check and verify that student

pairs give one another thoughtful answers to the aliquot description activity questions.



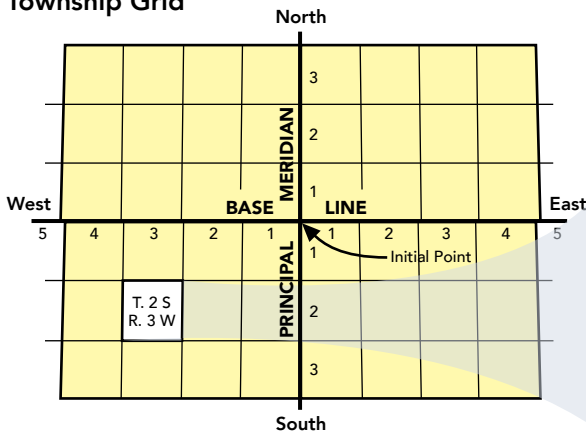
Background Information Handout: Describing Surveyed Lands

In the last activity, we learned that the United States developed the Public Land Survey System to map public land and sell it for revenue. Territories and states each had a surveyor-general, who hired deputy surveyors. Deputy surveyors and their crews traveled across unsurveyed areas, mapping 6-mile-square townships.

This style of surveying property boundaries in a square grid is called the “cadastral system.” First,

surveyors defined an initial point. Then, they ran two important lines: a north-south line called the “principal meridian” and an east-west line called the “base line.” Next, surveyors set township corners every six miles using the principal meridian and the base line. Finally, surveyors used the township corners to create grids of 6-mile-square townships. “Range lines” that ran north-south and “township lines” that ran east-west defined each township.

Township Grid



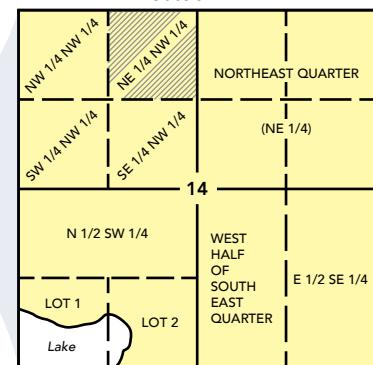
Working from a principal meridian and base line, surveyors marked township lines into 36-square-mile grids.

Township 2 south, range 3 west

6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	Sec 14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36

Surveyors further divided townships into 1-mile-square (640-acre) sections. Then, they numbered sections from 1 to 36.

Section 14



The survey system starts with big squares (townships), then breaks them down into equal, smaller parts. Townships are divided into 36 sections, sections into two half-sections, half-sections into four quarter-sections, and quarter-sections into four quarter-quarter sections. Each one of these equal, smaller parts of sections are aliquot parts. “Aliquot” means equal portions of a whole. For example, 3 is an aliquot part of 9, and a quarter-section is an aliquot part of a half-section. Surveyors always describe aliquot parts using the four directions: north, south, east, and west. Here’s an example:

The east half of the south west quarter of section 18 of township 6 north, range 5 west, fourth principal meridian, Illinois.

Written with abbreviations, that aliquot description looks like this:

$E\frac{1}{2}SW\frac{1}{4}$ sec. 18, T. 6 N., R. 5 W.,
fourth principal meridian

Each aliquot description, like the example above, is unique. It can only represent one location in the United States. The law required surveyors to describe each aliquot part precisely. What could happen if settlers arrived at a parcel of land that wasn’t described properly?

The aliquot descriptions from the original surveys are still used today. Surveyors, landowners, and students can research surveys and land patents on the General Land Office website.





Handout 1: Interpreting Aliquot Descriptions

As a large group, let's write out this aliquot description by short phrases, called reference elements, so you can see each step more clearly:

The east half of the south west quarter of section 18 of township 6 north, range 5 west, fourth principal meridian, Illinois.

Quarter-Quarter Section _____

Quarter Section _____

Section _____

Township _____

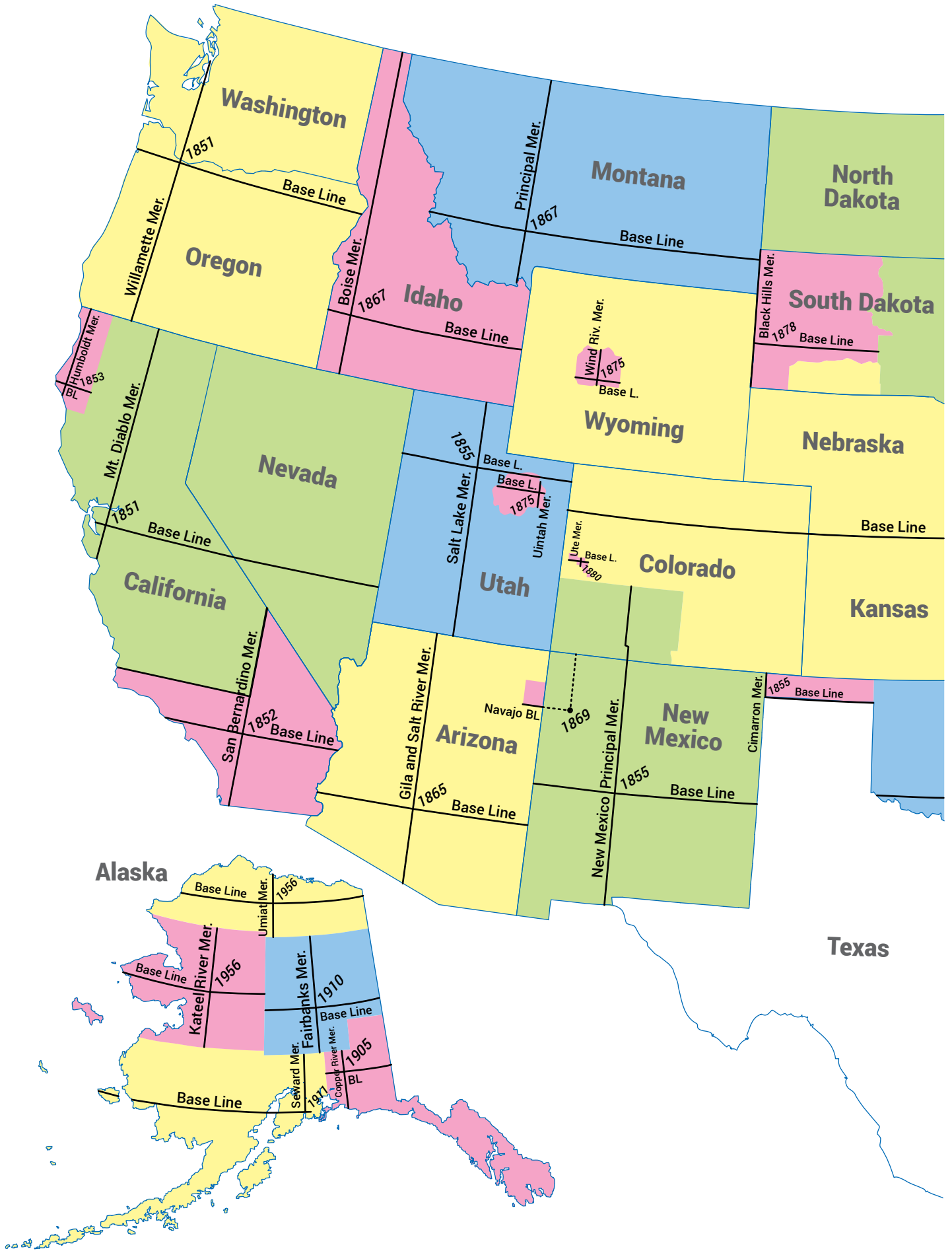
Range _____

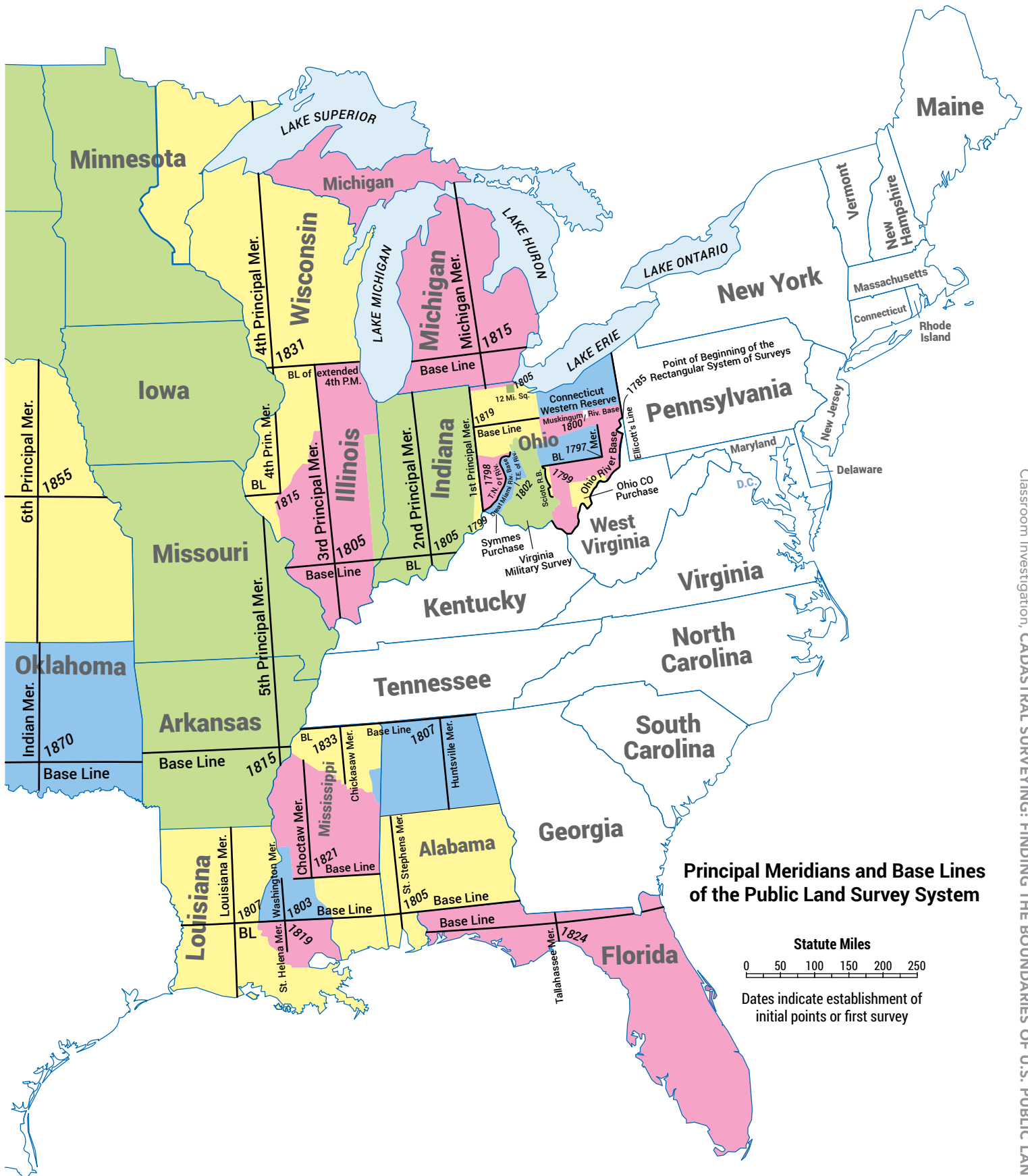
Principal Meridian _____

State _____

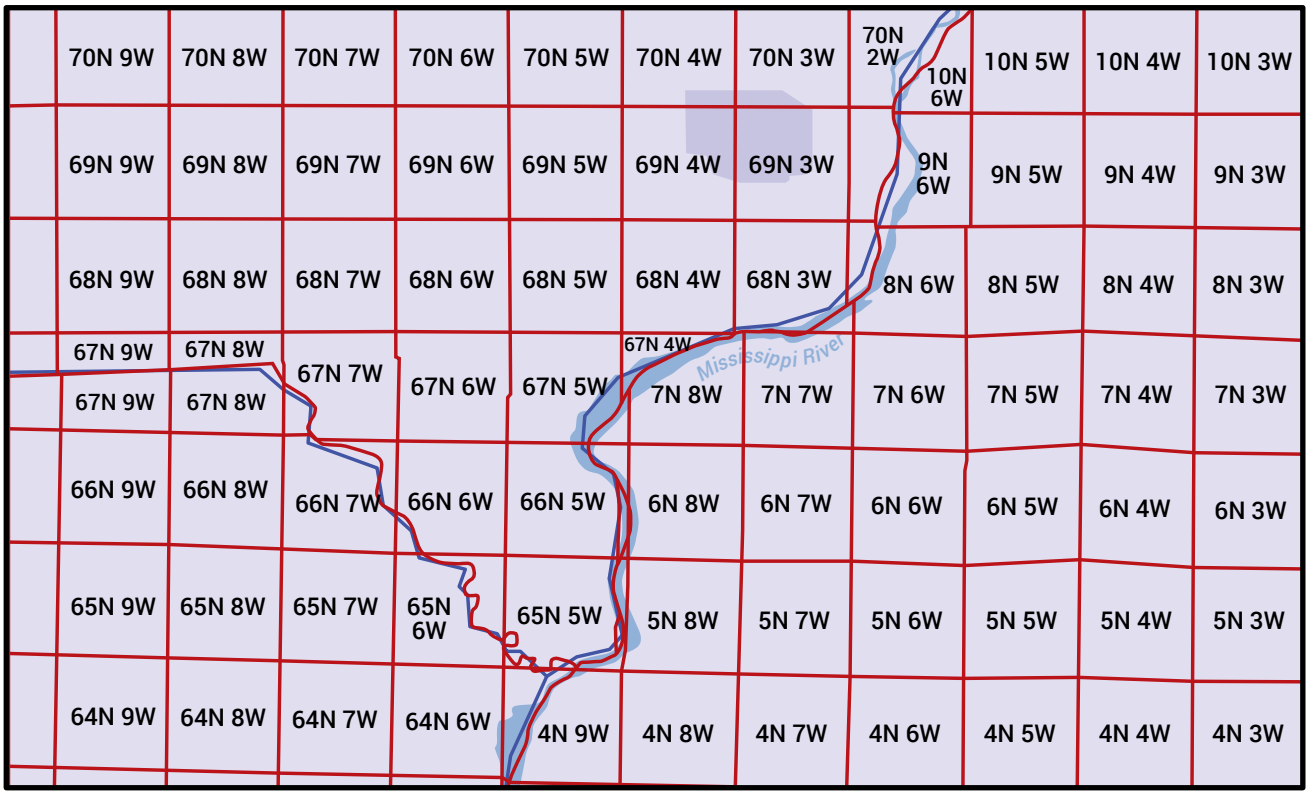
Let's find that together on the map on page 20 and 21 so we can see how this aliquot description uses reference elements to represent a unique location in the United States:

Circle the State _____ and Principal Meridian _____ on the United States map.

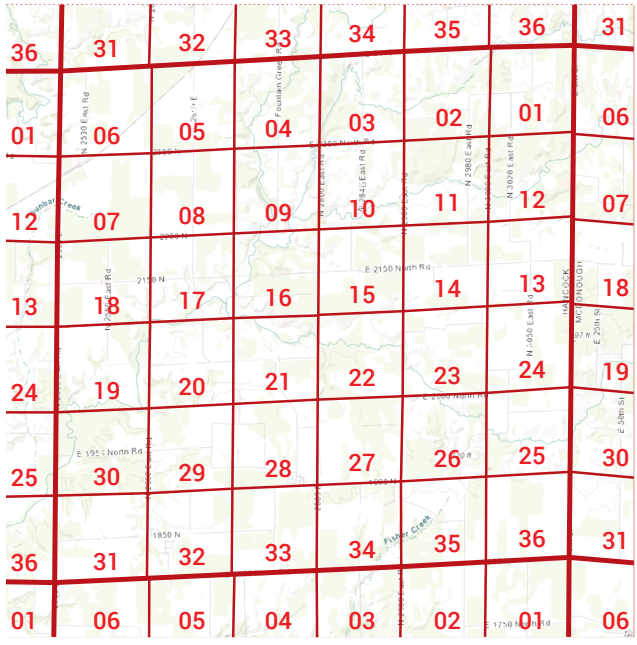




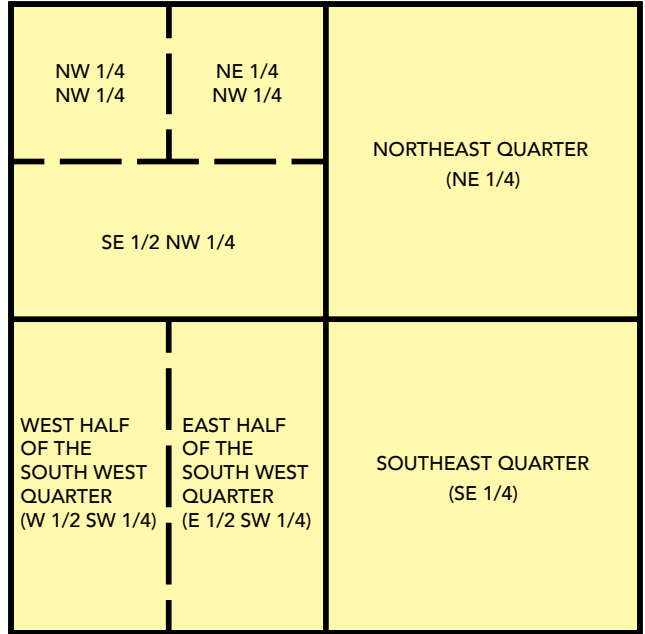
Circle the square for Range _____ and Township _____ on this map.



Circle Section _____ on the township map.



Circle the Quarter Section _____ and Quarter-Quarter Section _____ on the section map.



We just used an aliquot description to find a unique location in the United States. Nice work!



Handout 2: Locating Your School

Let's practice using the General Land Office website to write an aliquot description for our school.

If you were a deputy surveyor, how would you and your crew describe your school's location?

Use the map on page 24 to find the principal meridian.

Principal Meridian: _____

Next, write the state where your school is.

State: _____

Use the map at <https://gloreCORDS.blm.gov/LandCatalog/Catalog> to zoom in until you can see your school's township. The black letters on the township show the township and range.

Township: _____

Range: _____

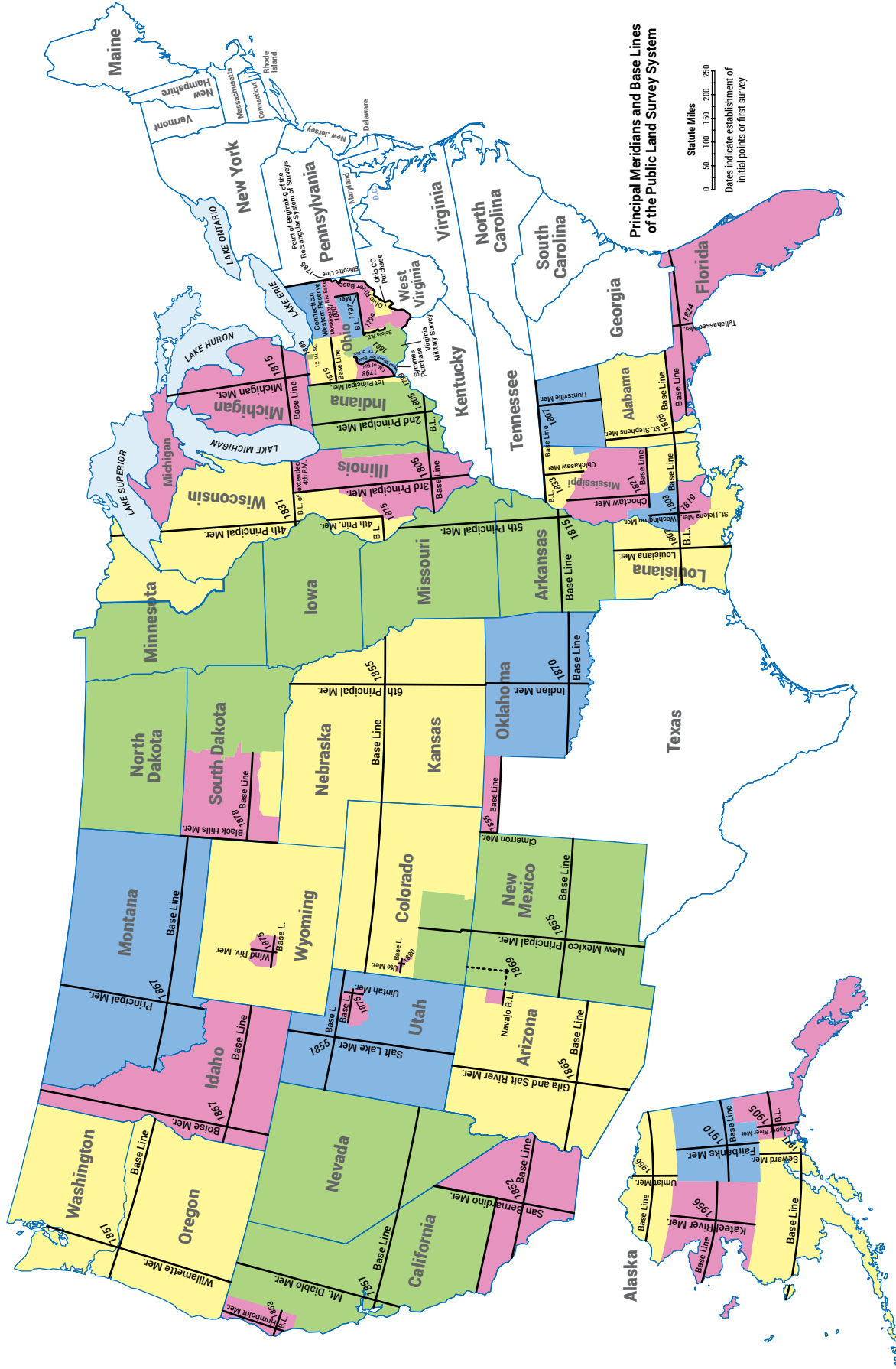
Keep zooming in until you can see your school's section in red numbers.

Section: _____

Your school should be highlighted in purple. Let's write the Quarter Section and Quarter-Quarter section on our own, by looking at the school's location within the section.

Quarter Section: _____

Quarter-Quarter Section: _____





Handout 3: Mapping Your Classroom

You've been hired as deputy surveyor of your classroom. For this activity, we are pretending your classroom is a section. Your teacher has labeled the cardinal directions (north, south, east, and west) on the walls of your classroom.

You will use what you have learned about aliquot description. You and a partner will work separately to write reference elements for a specific location in your classroom. Then you will swap descriptions and you will navigate using your partner's aliquot description.

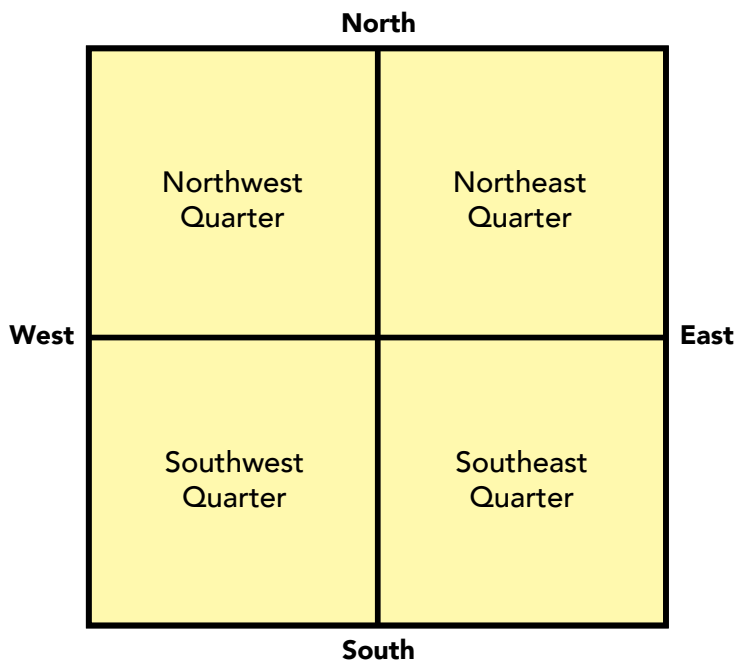
Let's get started!

First, think of an object in the room that you want your classmate to find. You can choose any object in your classroom: the pencil sharpener, your desk, the teacher's desk, just don't tell your partner yet.

Now, using the directions on the walls, write which quarter of the room that object is in:

_____.

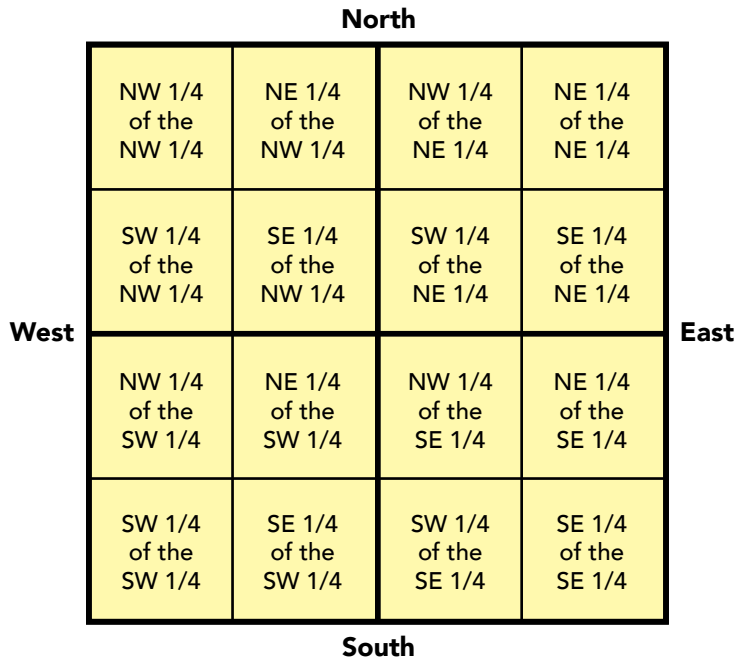
You can use this drawing to help:



Next, let's get even more precise. Still using the directions on the walls, write which quarter-quarter the object is in:

_____ of the _____.

You can use this drawing to help:



Copy your quarter-quarter reference element and write a hint for your partner under the dotted line.

When you're both ready, trade descriptions with your partner. Use your partner's description to navigate to their object in your classroom.

Once you've navigated to your partner's object, write down your guess.

My guess for my partner's object is: _____

.....

Description to give to your partner:

My object is located in the
 (quarter-quarter) _____
 of the (quarter) _____.

My object is _____ color and (circle one: bigger or smaller) than a basketball.

Activity 3: Surveyor for a Day



For the Teacher

This activity addresses the following essential understanding:

- Surveying methods, tools, and computations are applicable to our lives today.



Overview

This is the third of three activities that address the Public Land Survey System. This activity introduces students to:

- Surveying methods and tools.
- Survey computations and use in mapping.



Teacher Preparation

1. Read the "Background Information" and make a copy of it for each student.
2. Review the answer key. At your discretion, make a copy for each student or plan to review the answers as a large group.
3. Review the activity handout and make copies for each student.
4. Consider where you would like your class to complete Handout 1. An outdoor location is ideal, but indoor locations will work too. The best locations will have the "southeast corner" hidden from the students' starting point at the "southwest corner." The "southeast corner" can be hidden by a U-shaped hallway indoors, or an obstacle outdoors (such as a wall, fence,

or building corner). Walk through the activity yourself in the location you choose and modify the "township corners" in the activity as needed to fit your location.

- a. At your discretion, consider placing two false southeast corner monuments a small distance from the correct monument. This will confirm the students' measurements and azimuths as they complete the activity. If a group navigates to one of the false corners, lead a discussion of potential repercussions for landowners if surveyors marked corners incorrectly.
5. Cut lengths of string for each student. These strings will be the equivalent of 1 mile, or 80 chains. Choose a standard length of string that fits the location you've chosen for Handout 1. The students will be surveying the equivalent of a 6-mile-square township.
 6. Obtain hiking/orienteering compasses; at least one for each group but ideally one for each student. Consider asking students to bring theirs from home if they have them. Alternately, and at your discretion, consider directing students to use the compass application on their cell phones.
 7. Obtain rulers for each student.

Time Estimate

One 45-minute class period.



Learning Objectives

Students will be able to (1) review surveying methods and tools, (2) calculate acreages and angles using survey computations, and (3) map an area at their school using survey computations.



Procedure

1. Distribute the “Background Information” handout to all students.
2. As students read through the “Background Information” handout, circulate among the class. Consider reviewing the chain measurement and azimuth calculation examples as a large group.
3. When the class has read the “Background Information,” ask students “what would happen if a surveyor couldn’t find one of the corner monuments for a township?”
4. Tell students they will be surveyors for a day and they will find a lost corner monument. Divide the class into pairs or small groups at your discretion. Distribute copies of Handout 1 to each student. Students will work in groups; each student will complete their own handouts.
5. Stagger the group start times so they can’t see the path the preceding group is taking. Show each group the location you have chosen as the southwest corner monument; this is the starting point for the township resurvey.



Assessment

Ask the large group questions that students can answer in their own words. Move and listen to small groups during the activities. Verify that

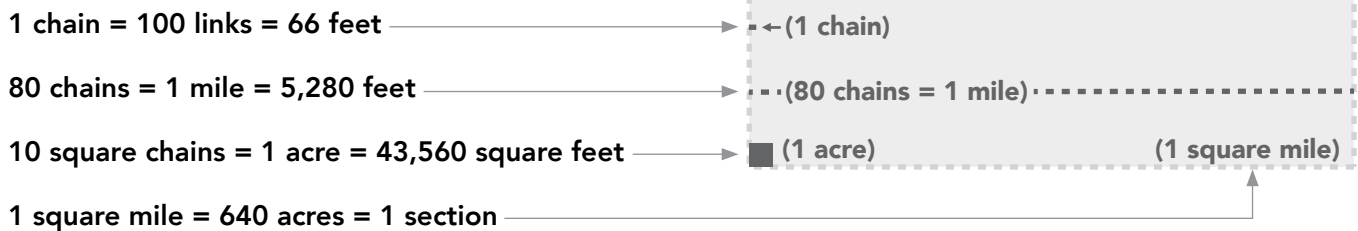
students arrive at the correct landmark for the first activity. Verify that distances and angles are correct on students’ maps.



Background Information Handout: Surveyor for a Day

Think back to the Land Ordinance of 1785 that we studied in the first activity. The ordinance created the Public Land Survey System and standardized the methods surveyors used to survey land. One of the measurements that the ordinance standardized was distance; surveyors measured land using a "chain" and a compass. A chain is a unit of measurement and an actual physical item. Surveying chains are 66 feet long and made up of 100 links.

The survey system's measurements are:



Remember that surveyors measured land into 6-mile-square townships. They divided each township into 36 1-mile-square sections. Since 10 square chains are equal to 1 acre, surveyors could easily calculate the distances as they surveyed vast areas of land.

Let's look at this with an example calculation of 40 acres, or a quarter-quarter of a section.

First, try doing this math in your head using feet as the measurement.

How many acres are in a 1,320-foot square?

1. Multiply 1,320 feet by 1,320 feet. $1,320 \text{ feet} \times 1,320 \text{ feet} = \underline{\hspace{2cm}}$ square feet
2. Divide $\underline{\hspace{2cm}}$ square feet by 43,560 square feet to get acres
(Remember that 10 square chains = 1 acre = 43,560 square feet)
 $\underline{\hspace{2cm}} \text{ square feet} / 43,560 = \underline{\hspace{2cm}}$ acres

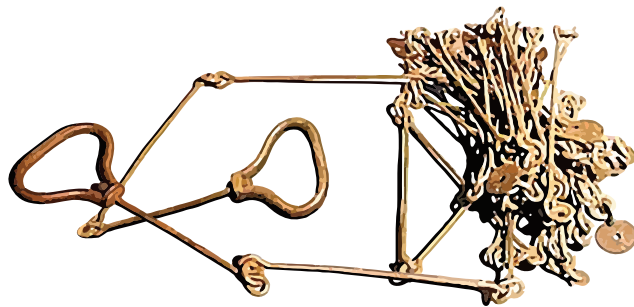
That's difficult! Now let's try the same calculation using chains.

How many acres are in a 20-chain square?

1. Multiply 20 chains by 20 chains. $20 \text{ chains} \times 20 \text{ chains} = \underline{\hspace{2cm}}$ square chains
2. Divide $\underline{\hspace{2cm}}$ square chains by 10 to get acres
(Remember that 10 square chains = 1 acre = 43,560 square feet)
 $\underline{\hspace{2cm}} \text{ square chains} / 10 = \underline{\hspace{2cm}}$ acres

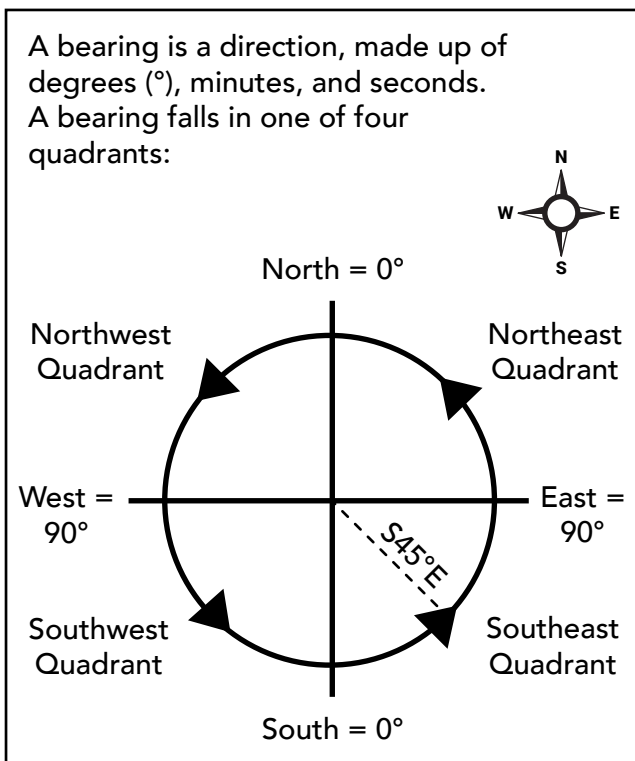
Since we used chains as the measurement instead of feet, we can do the math without using a calculator. That's why surveyors used this system.

Surveyor's chains weren't just a convenient shortcut for math. They were also physical chains that surveyors and their crews would lay down on the ground to measure distances directly. Chains were made of heavyweight wire, to withstand harsh terrain and years of use.

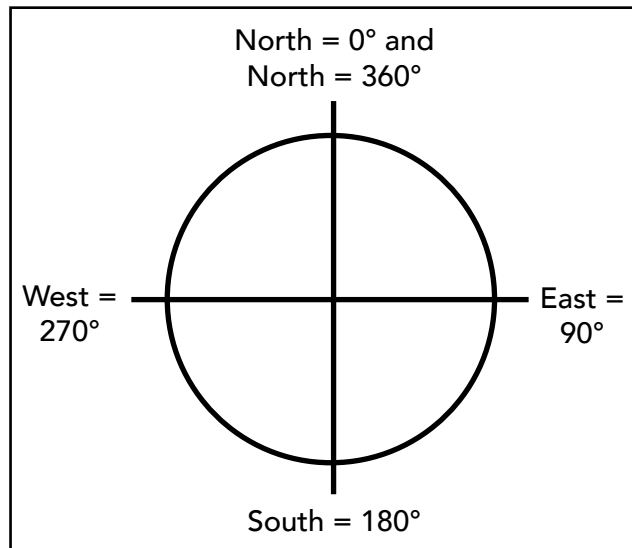


Surveyors used chains to measure distance and compasses to measure direction. They recorded directions in "bearings" or "azimuths."

Bearings break down the four cardinal directions into quadrants.

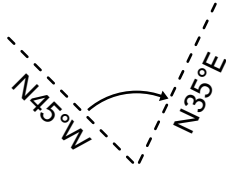


An azimuth in surveying means a direction. Azimuths are recorded as degrees on a circle. Azimuths begin at 0° (north) and continue clockwise until ending at 360° (north). East is 90° , south is 180° , and west is 270° .



An angle is the difference between two bearings or azimuths. Angles are written as either right or left. If you rotate right (clockwise) from the first to the second azimuth, that's a right angle. If you rotate left (counterclockwise), it's a left angle.

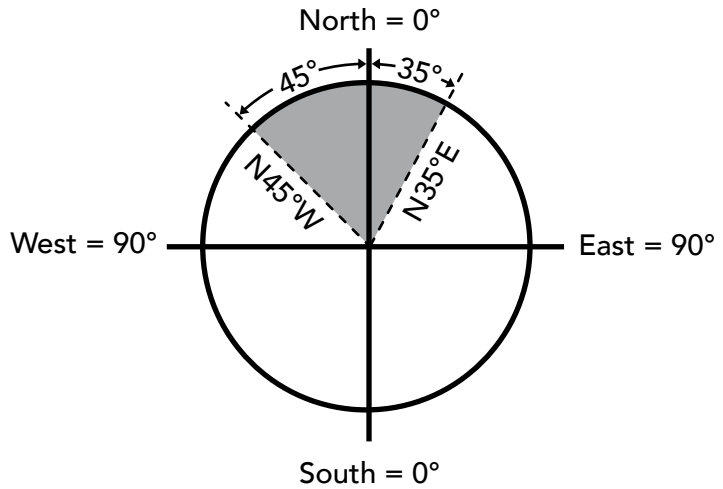
An angle is the difference between two bearings or azimuths.



To calculate bearings, we add or subtract known parts of the 360° pie.

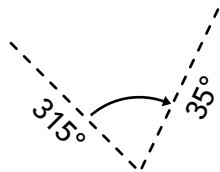
$$45^\circ + 35^\circ = 80^\circ$$

This depicts an angle of 80°

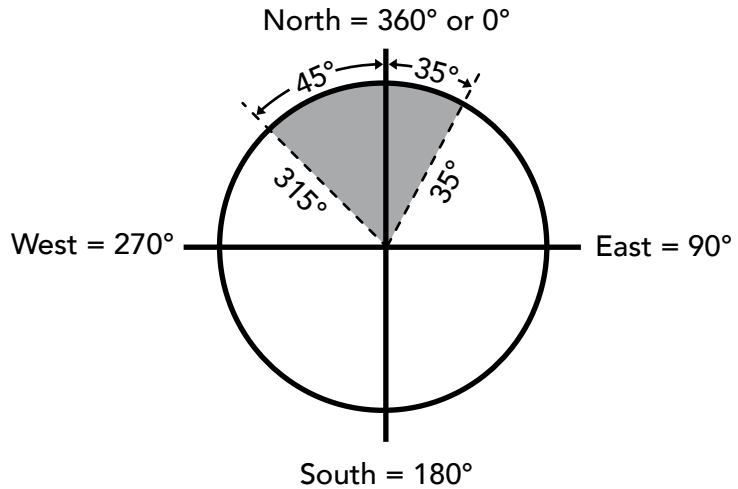


This also depicts an angle of 80°

Azimuths work the same way.



$$360^\circ - 315^\circ = 45^\circ + 35^\circ = 80^\circ$$

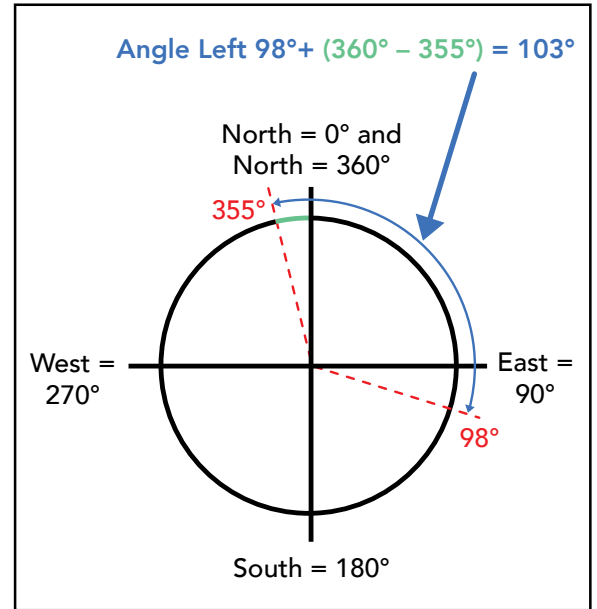


We're going to use azimuths in the handout, so that's what we will practice with. You can use your compass to follow along with these two examples." be in one column, above the two examples?

What is the angle?

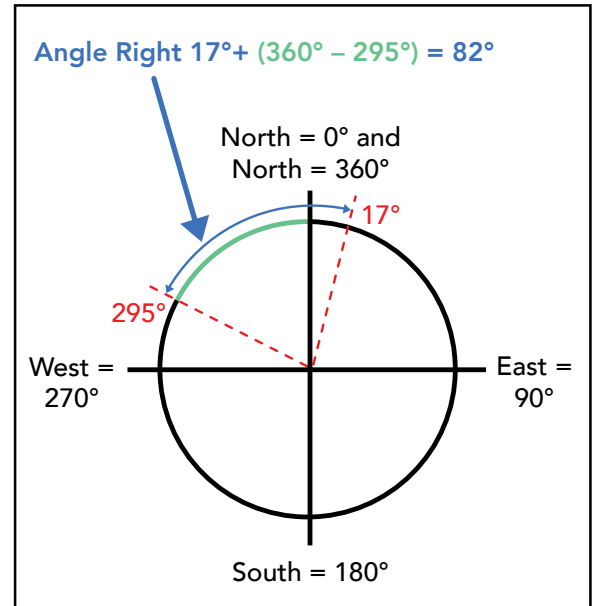
Begin at 98° and angle left to 355°

1. Find the difference between 360 degrees and the second azimuth $360^\circ - 355^\circ =$ _____ $^\circ$
2. Add the result to the first azimuth $98^\circ +$ _____ $^\circ =$ _____ $^\circ$



Begin at 295° and angle right to 17°

1. Find the difference between 260 degrees and the first azimuth $360^\circ - 295^\circ =$ _____ $^\circ$
2. Add the result to the second azimuth $17^\circ +$ _____ $^\circ =$ _____ $^\circ$



Surveyors calculated distances using chains and angles using azimuths or bearings. As we learned in the first activity, surveyors divided land into sections and townships. Once they had measured a township by calculating distances and angles, they marked the township's corners using a "monument." Monuments could be a slash in a tree's bark, a wood stake, or a chiseled stone.



Background Information Answer Key

Example area calculation answers:

How many acres are in a 1,320-foot square?

1. Multiply 1,320 feet by 1,320 feet
 $1,320 \text{ feet} \times 1,320 \text{ feet} = \mathbf{1,742,400 \text{ square feet}}$
2. Divide 1,742,400 square feet by 43,560 square feet to get acres
(Remember that 10 square chains = 1 acre = 43,560 square feet)
 $\mathbf{1,742,400 \text{ square feet} / 43,560 = 40 \text{ acres}}$

How many acres are in a 20-chain square?

1. Multiply 20 chains by 20 chains
 $20 \text{ chains} \times 20 \text{ chains} = \mathbf{400 \text{ square chains}}$
2. Divide **400 square chains** by 10 to get acres
(Remember that 10 square chains = 1 acre = 43,560 square feet)
 $\mathbf{400 \text{ square chains} / 10 = 40 \text{ acres}}$

Example angle calculation answers:

Begin at 98° and angle left to 355°

1. Find the difference between 360 degrees and the second azimuth
 $360^\circ - 355^\circ = \mathbf{5^\circ}$
2. Add the result to the first azimuth
 $98^\circ + \mathbf{5^\circ} = \mathbf{103^\circ}$

Begin at 295° and angle right to 17°

1. Find the difference between 260 degrees and the first azimuth
 $360^\circ - 295^\circ = \mathbf{65^\circ}$
2. Add the result to the second azimuth
 $17^\circ + \mathbf{65^\circ} = \mathbf{82^\circ}$

Some of the monuments are missing because surveyors first placed monuments more than 100 years ago. Surveyors today have to use distances and azimuths to find where missing monuments were, just like a scavenger hunt!





Handout 1: Finding a Lost Corner Monument

You are a surveyor for a day! Your team's job is to resurvey an imaginary township that is missing a corner monument. The imaginary township has a huge swamp in the middle of it, and the missing corner monument is on the other side of a dangerous ravine. Your team can't walk across the swamp, and you can't cross the ravine, so you need to go around the perimeter. You'll need to use distances and angles to make sure you correctly locate the missing corner monument.

Our starting point at the imaginary township's southwest corner monument is

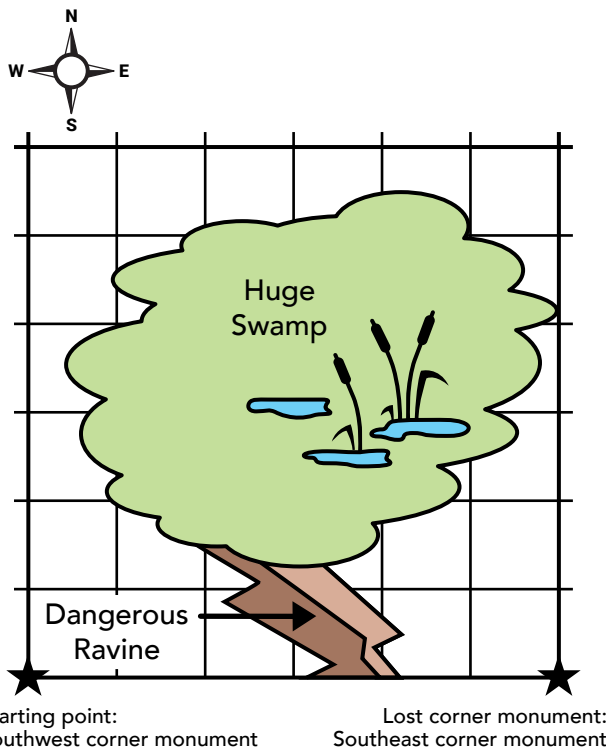
_____ (the identifying landmark our teacher showed us).

We will travel using our strings (the equivalent of one mile) and our compasses.

We learned in the first activity that townships are _____ miles on each side.

Townships are square, so we need to angle _____ degrees from each corner before starting to walk to the next corner.

Use the township map on the next page to take notes during the activity. Write down and/or draw details about the township, the distances, and the angles as you navigate the township perimeter.



Your starting point is at the southwest corner of the township. The missing monument is on the southeast corner of the township. You have your measuring tape (the string from your teacher, which is scaled to a mile for this activity) and your compass. Working in groups, use your string and your compass to walk from the southwest corner to the southeast corner. Make sure you reach each corner monument along the way.



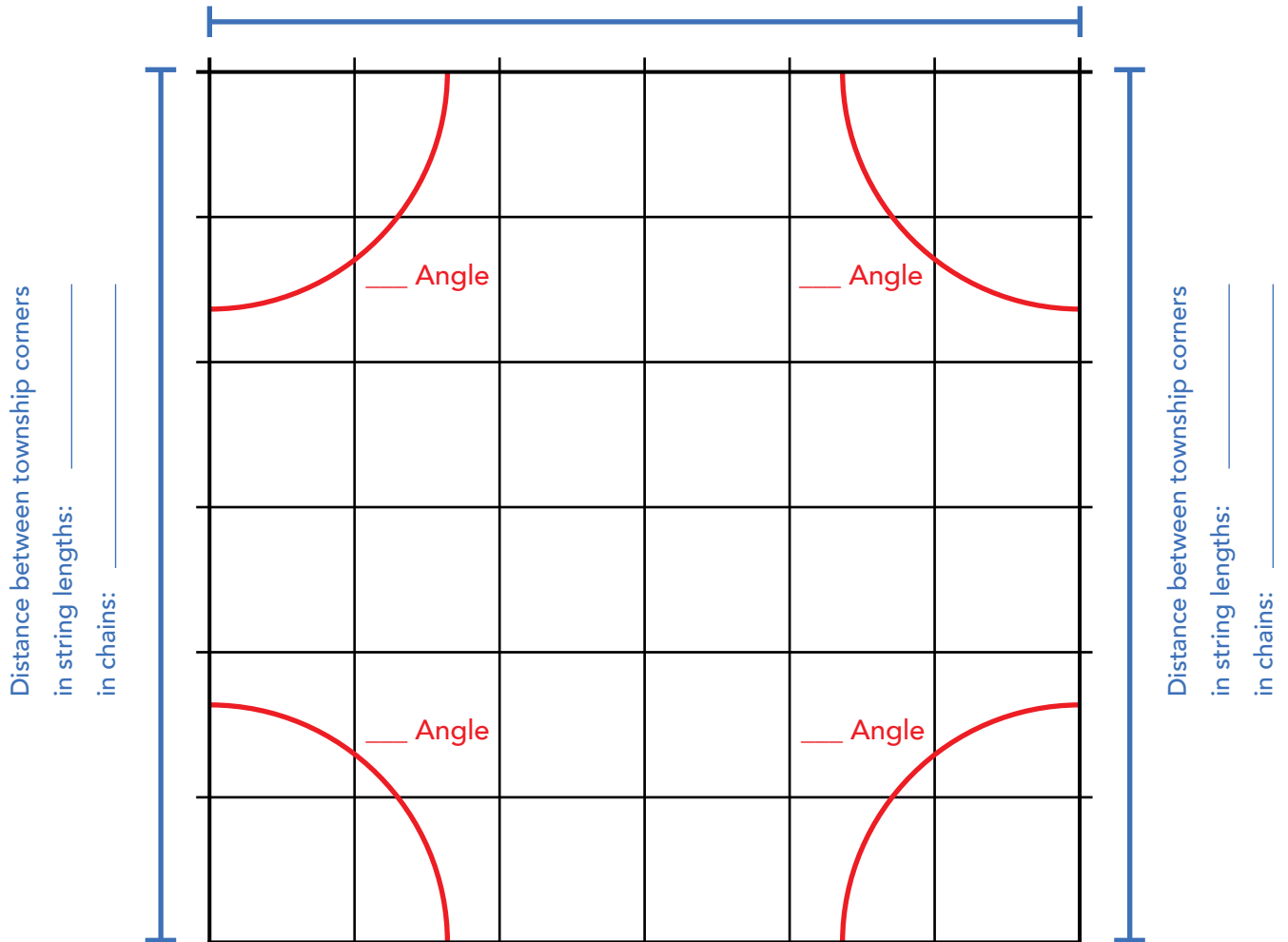
Northwest corner monument:

Distance between township corners

Northeast corner monument:

in string lengths: _____

in chains: _____



Southwest corner monument:

Southeast corner monument
(missing):

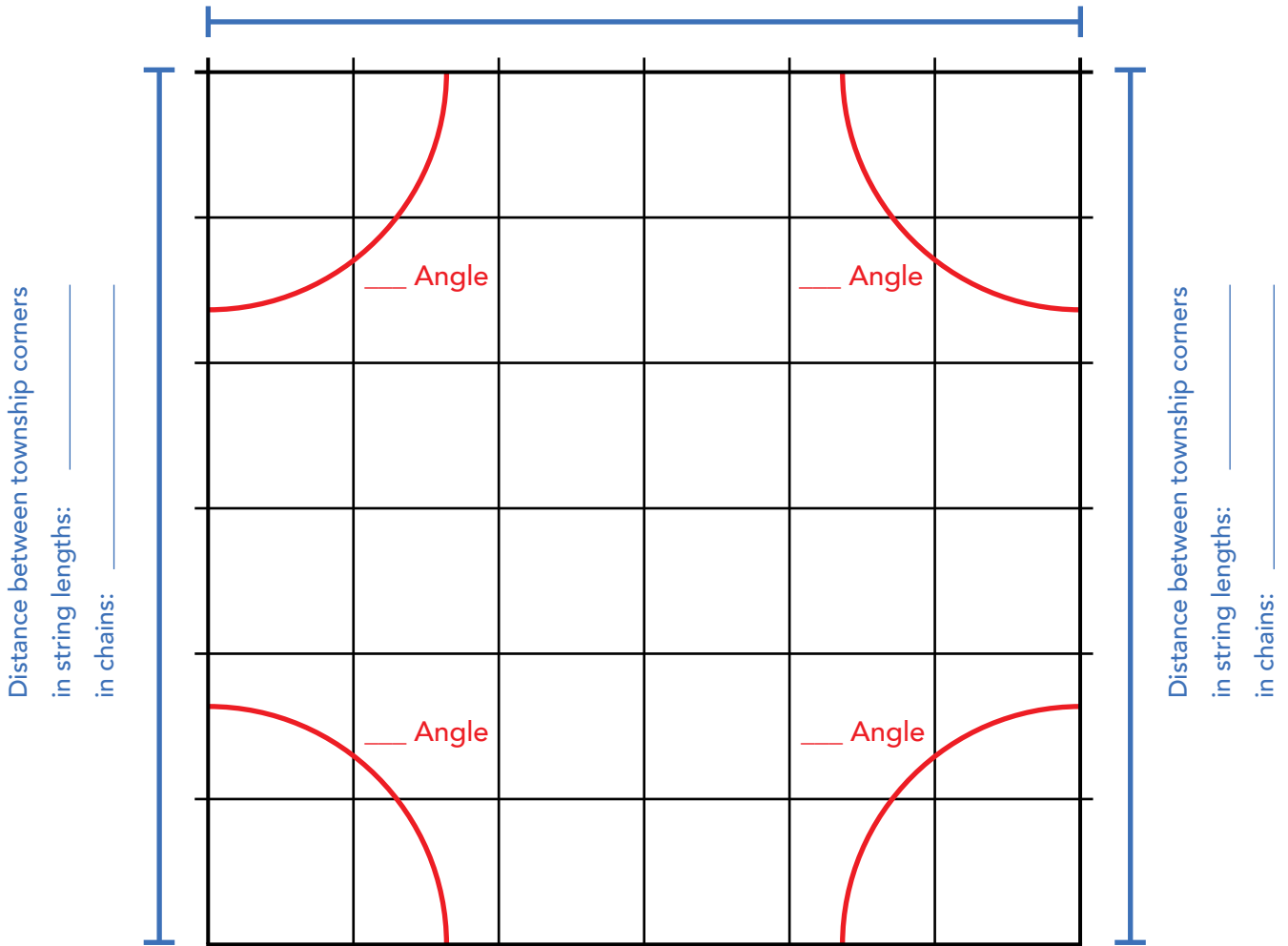
Township Illustration for Handout 1: Finding a Lost Corner Monument



Northwest corner monument:

Distance between township corners
 in string lengths: _____
 in chains: _____

Northeast corner monument:



Southwest corner monument:

Southeast corner monument
 (missing):

Township Illustration for Handout 1: Finding a Lost Corner Monument

For Further Research

Cadastral Survey Program:

<https://www.blm.gov/programs/lands-and-realty/cadastral-survey>

The Federal Land Policy and Management Act of 1976, as amended:

https://www.blm.gov/sites/default/files/AboutUs_LawsandRegs_FLPMA.pdf

Manual of Surveying Instructions:

https://www.blm.gov/sites/blm.gov/files/Manual_Of_Surveying_Instructions_2009.pdf

Specifications for Descriptions of Land:

For Use in Land Orders, Executive Orders, Proclamations, Federal Register Documents, and Land Description Data Bases: https://www.ntc.blm.gov/krc/uploads/940/2017_SpecificationsForDescriptionsOfLand.pdf

Surveying our Public Lands:

<https://www.ntc.blm.gov/krc/uploads/538/SurveyingOurPublicLands2002.pdf>

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