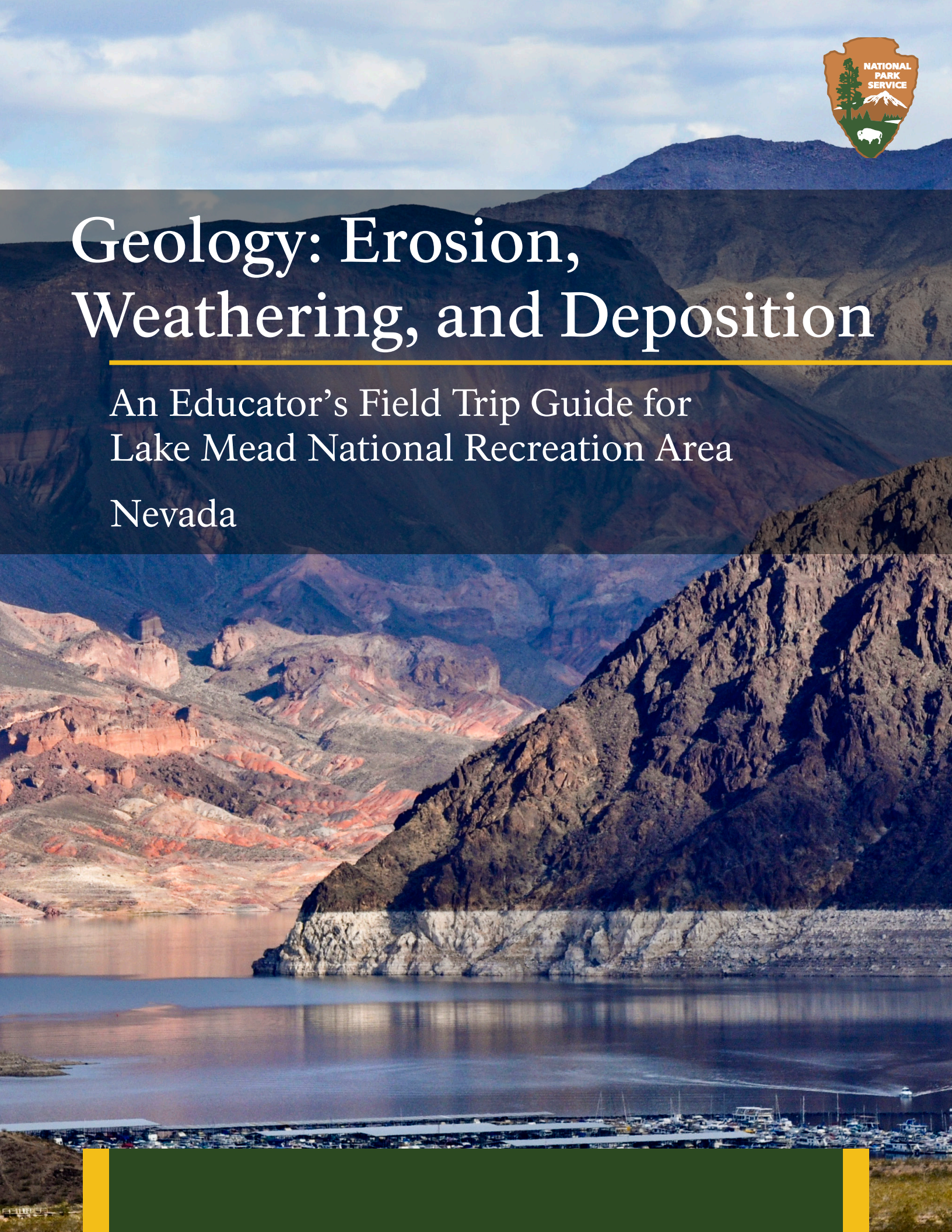

Geology: Erosion, Weathering, and Deposition

An Educator's Field Trip Guide for Lake Mead National Recreation Area

Nevada

This Field Trip Guide updated: July 2024

Cover Image: Boulder Basin at Lake Mead National Recreation Area (NPS Photo by Andrew Cattoir).

Southern Nevada Agency Partnership (SNAP) Accessibility Statement

The National Park Service (NPS) is committed to creating accessible content. It is our policy to ensure that everyone, including persons with disabilities, has full and equal access to our digital offerings. This document conforms to the PDF/Universal Accessibility (PDF/UA) (ISO Standard 14289) accessibility standards as required for Section 508 compliance.

Purpose of the Guide

The purpose of this guide is to support teachers in conducting independent field trips onto public lands, specifically the Bluffs Trail located outside of Las Vegas/Henderson/Boulder City, Nevada at the Lake Mead National Recreation Area.

This guide provides detailed information about what to bring, who to contact at the agency, and required forms to arrange a field trip. It also provides geology-based activities to conduct along the Bluffs Trail, as well as complementary pre- and post-field trip activities for the classroom to enhance student geography and geology knowledge and the field trip experience. The classroom-based activities are encouraged but not required to successfully conduct the field trip and its accompanying lessons.

The Lake Mead field trip content supports standards-based knowledge in geography, weathering, erosion, energy, and geology targeting grades 3-5, as well as extensions for grade 6 and beyond.

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Figure 1. Junior Ranger Day, Lake Mead National Recreation Area (NPS Photo by Andrew Cattoir)

Welcome

Welcome to the "Geology: Erosion, Weathering, and Deposition" educator's field trip guide for the Lake Mead National Recreation Area (managed by the National Park Service).

Figure 2. Southern Nevada Agency Partnership Logo

This is one of four field trip guides developed for educators to independently conduct field trips on public lands in southern Nevada. The other guides are for **Red Rock Canyon National Conservation Area** (managed by the Bureau of Land Management), **Spring Mountains National Recreation Area** (managed by the U.S. Forest Service), and the **Desert National Wildlife Refuge/Corn Creek** (managed by the U.S. Fish and Wildlife Service).

These guides were funded through an award from the Southern Nevada Public Lands Management Act (SNPLMA), which financially supports recreation, conservation, and education on public lands in southern Nevada. The award was given to a team representing five different agencies who are part of the Southern Nevada Area Partnership (SNAP): The Bureau of Land Management (BLM), the National Park Service (NPS), the U.S. Fish and Wildlife Service (USFWS), the U.S. Forest Service (USFS), and the Bureau of Reclamation (BOR).

SNAP was established in 1999 to address shared and common land management issues in southern Nevada, as well as to work with outside partners and community members to support education, interpretation, and research to advance conservation.

Thank you for your commitment to educating youth about our beautiful and unique natural areas in southern Nevada. We hope you explore all of the Teacher Guides and enjoy your time at Lake Mead!

Sincerely,

The National Park Service & the SNAP Team

How to Use This Guide

This guide is intended for use in conjunction with an educator-led field trip to the Bluffs Trail in Lake Mead National Recreation Area. The guide contains field trip specific activities addressing erosion, weathering, and deposition, as well as classroom pre- and post-field trip activities addressing geology and geography themes.

The guide has four sections: (1) About this Guide; (2) Field Trip and Onsite Activities; (3) Classroom Activities; and (4) Additional Background information and Resources.

The Background Information section provides content and context for the field trip experience and the classroom activities. The Field Trip and Onsite Activities section explains how to conduct a school field trip to the Lake Mead National Recreation Area and contains all educator instructions and student handouts for the Bluffs Trail Field Trip. The Classroom Activities section contains classroom-based pre- and post-field trip activities to prepare for, expand upon, and reinforce the field trip experience and content. Although complementary to each other, all activities can be implemented independently, allowing teachers to pick and choose.

Activities at a Glance

In the order presented in the guide: field trip activities are listed first, classroom (pre-field trip and post-field trip) follow.

Field Trip Activities

Onsite at the Bluffs Trail, Lake Mead National Recreation Area

Geology: Erosion, Weathering, and Deposition

- Overview: Using the landscape and visual cues along the trail, students learn about how weathering, erosion, and deposition contributed to shaping the land. There are a series of three activities that build upon each other with an optional, more advanced, fourth activity.
- Setting: Bluffs Trail
- Time: 1.5 - 2 hours (includes stopping at the amphitheater and walking 1-mile round trip along the trail)

Colors in Stone

- Overview: Individual watercolor painting activity which uses art to reflect on the natural world, in particular the geology of the natural world. It is a good way to help students slow down and connect with the landscape.
- Setting: Outside with landscape views
- Time 30 minutes (minimum)

Classroom Activity

Pre-Field Trip - Classroom

Topographic Map Scavenger Hunt

- Overview: Small group activity that explores and investigates topographic and geologic maps
- Setting: Classroom
- Time: 1 class period

Walk the Line

- Overview: Large group physical activity in which students make a human geologic time scale and learn about what was happening at Lake Mead in each of the eras.
- Setting: Schoolyard or classroom
- Time: 1 class period

Post-Field Trip - Classroom

WebQuest: Lake Mead's Geology from Different Angles

- Overview: Small group internet research activity that simulates a real-world geologic field experience
- Setting: Classroom, internet access
- Time: 1-2 class periods (depending on internet access and depth of research)

Applying Knowledge: Geologic Processes and Features

- Overview: Small group, picture sorting activity in which students use what they learned about the geologic features and processes and apply them to other places in the region and images from the Lake Mead Bluffs Trail.
- Setting: Classroom
- Time: 1 class period

Figure 2. Lake Mead National Recreation Area aerial (Photo by Michael Yantis on Unsplash).

Science Content Standards

This program is intended for students in grades 3-5, however there are extensions for students in grades 6 and above. It is integrated with content and activity connections to science, social studies, language arts, physical education/health, and art. Students will gain experience using fundamental skills and concepts such as observing patterns in nature; cause and effect; using systems and system models; analyzing stability and change in systems and examining the structure and function of elements in the natural world.

Activities have been created for the cognitive, social, emotional, and academic development of the intended age group. The following are connections to Nevada science content standards and beyond for activities included in this guide.

LAKE Teacher Guide Nevada Science Standards/NVACSS

2nd Grade: Earth Systems: Processes That Shape The Earth

ESS1.C: The History of Planet Earth - Some events happen very quickly; others occur very slowly, over a time period much longer than one can observe. (2- ESS1-1)

ESS2.A: Earth Materials and Systems - Wind and water can change the shape of the land. (2- ESS2-1)

ESS2.B: Plate Tectonics and Large-Scale System Interactions - Maps show where things are located. One can map the shapes and kinds of land and water in any area. (2-ESS2- 2)

ESS2.C: The Roles of Water in Earth's Surface Processes - Water is found in the ocean, rivers, lakes, and ponds. Water exists as solid ice and in liquid form. (2-ESS2-3)

3rd Grade – Forces And Interactions, Weather And Climate

PS2.A: Forces and Motion - Each force acts on one particular object and has both strength and a direction. An object at rest typically has multiple forces acting on it, but they add to give zero net force on the object. Forces that do not sum to zero can cause changes in the object's speed or direction of motion. (Boundary: Qualitative and conceptual, but not quantitative addition of forces are used at this level.) (3- PS2-1). The patterns of an object's motion in various situations can be observed and measured; when that past motion exhibits a regular pattern, future motion can be predicted from it. (Boundary: Technical terms, such as magnitude, velocity, momentum, and vector quantity, are not introduced at this level, but the concept that some quantities need both size and direction to be described is developed.) (3-PS2-2)
PS2.B: Types of Interactions - Objects in contact exert forces on each other. (3-PS2-1)

LS4.A: Evidence of Common Ancestry and Diversity - Some kinds of plants and animals that once lived on Earth are no longer found anywhere. (3-LS4- 1). Fossils provide evidence about the types of organisms that lived long ago and also about the nature of their environments.
(3-LS4-1)

RI.3.1: Ask and answer questions to demonstrate understanding of a text, referring explicitly to the text as the basis for the answers. (3-PS2-1), (3-PS2-3)

RI.3.3: Describe the relationship between a series of historical events, scientific ideas or concepts, or steps in technical procedures in a text, using language that pertains to time, sequence, and cause/effect. (3-PS2-3)

W.3.7: Conduct short research projects that build knowledge about a topic. (3-PS2-1),(3-PS2-2)

W.3.8: Recall information from experiences or gather information from print and digital sources; take brief notes on sources and sort evidence into provided categories. (3-PS2-1),(3-PS2-2)

RI.3.3: Describe the relationship between a series of historical events, scientific ideas or concepts, or steps in technical procedures in a text, using language that pertains to time, sequence, and cause/effect. (3-LS2-1), (3-LS4-1), (3-LS4-3), (3-LS4-4)

4th Grade – Energy, Earth's Systems: Processes That Shape The Earth

PS3.A: Definitions of Energy - The faster a given object is moving, the more energy it possesses. (4- PS3-1)

PS3.C: Relationship Between Energy and Forces - When objects collide, the contact forces transfer energy so as to change the objects' motions. (4-PS3-3)

ESS1.C: The History of Planet Earth - Local, regional, and global patterns of rock formations reveal changes over time due to earth forces, such as earthquakes. The presence and location of certain fossil types indicate the order in which rock layers were formed. (4-ESS1-1)

ESS2.A: Earth Materials and Systems - Rainfall helps to shape the land and affects the types of living things found in a region. Water, ice, wind, living organisms, and gravity break rocks, soils, and sediments into smaller particles and move them around. (4-ESS2-1)

ESS2.B: Plate Tectonics and Large-Scale System Interactions - The locations of mountain ranges, deep ocean trenches, ocean floor structures, earthquakes, and volcanoes occur in patterns. Most earthquakes and volcanoes occur in bands that are often along the boundaries between continents and oceans. Major mountain chains form inside continents or near their edges. Maps can help locate the different land and water features areas of Earth. (4- ESS2-2)

5th Grade – Earth's Systems

ESS2.A: Earth Materials and Systems - Earth's major systems are the geosphere (solid and molten rock, soil, and sediments), the hydrosphere (water and ice), the atmosphere (air), and the biosphere (living things, including humans). These systems interact in multiple ways to affect Earth's surface materials and processes. The ocean supports a variety of ecosystems and organisms, shapes landforms, and influences climate. Winds and clouds in the atmosphere interact with the landforms to determine patterns of weather. (5-ESS2-1)

ESS2.C: The Roles of Water in Earth's Surface Processes - Nearly all of Earth's available water is in the ocean. Most fresh water is in glaciers or underground; only a tiny fraction is in streams, lakes, wetlands, and the atmosphere. (5- ESS2-2)

Middle School Energy & Earth Science

PS2.A: Forces and Motion - For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction (Newton's third law). (MS-PS2-1) The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion. (MS-PS2-2)

PS3.A: Definitions of Energy - Motion energy is properly called kinetic energy; it is proportional to the mass of the moving object and grows with the square of its speed. (MS-PS3-1) A system of objects may also contain stored (potential) energy, depending on their relative positions. (MS-PS3-2)

PS3.C: Relationship Between Energy and Forces - When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the object. (MS-PS3-2)

ESS1.C: The History of Planet Earth - The geologic time scale interpreted from rock strata provides a way to organize Earth's history. Analyses of rock strata and the fossil record provide only relative dates, not an absolute scale. (MS-ESS1- 4) Tectonic processes continually generate new ocean sea floor at ridges and destroy old sea floor at trenches. (HS.ESS1.C GBE) (secondary to MS-ESS2-3)

ESS2.A: Earth's Materials and Systems - The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future. (MS-ESS2- 2)

ESS2.B: Plate Tectonics and Large-Scale System Interactions - Maps of ancient land and water patterns, based on investigations of rocks and fossils, make clear how Earth's plates have moved great distances, collided, and spread apart. (MS-ESS2-3)

Figure 3. Butterfly on a flower at Lake Mead National Park (NPS Photo).

ESS2.C: The Roles of Water in Earth's Surface Processes Water's movements—both on the land and underground—cause weathering and erosion, which change the land's surface features and create underground formations. (MS-ESS2-2)

ESS2.A: Earth's Materials and Systems - All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. This energy is derived from the sun and Earth's hot interior. The energy that flows and matter that cycles produce chemical and physical changes in Earth's materials and living organisms. (MS-ESS2-1)

ESS2.C: The Roles of Water in Earth's Surface Processes - Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land. (MS-ESS2-4) Global movements of water and its changes in form are propelled by sunlight and gravity. (MS-ESS2-4)

Section 2 – Field Trip and Onsite Activities

Figure 4. Students participating in an activity at the Lake Mead National Recreation Area (NPS Photo)

Recreate Responsibly

Whether exploring desert spaces or mountain places, remember to #RecreateResponsibly and follow Leave No Trace principles when you visit.

Know before you go

Check the status of the place you want to visit for closures, fire restrictions, and weather. Learn the rules and regulations for the site.

Plan and prepare

Reservations and permits may be required. Each location and agency has different field trip and entrance requirements (see Section 3 – Field Trip and Onsite Activities for specific details for this location). Make sure you have the gear you need (such as student medications, plenty of water and snacks, sunscreen, and clothing layers). Be sure to have a back-up plan.

Build an inclusive outdoors

Be an active part of making the outdoors safe and welcoming for all identities and abilities.

Respect others

There is space for everyone and countless outdoor activities. Be kind to all who use the outdoors and nature differently. Teach students basic trail etiquette – like step aside and let people pass, stay on the trail, use quiet voices and play music only in headphones. Students should be informed that loud noises scare off wildlife and other people go outdoors to relax and find quiet.

Leave no trace

Respect the land, water, wildlife, historic sites, and Native American communities. Follow Leave No Trace principles: stay on trails, pack out all waste, leave what you find (this includes rocks, plants, and historic remnants), minimize campfire impacts/determine if there are fire restrictions, never feed animals, control and clean-up after pets, and avoid wildlife during sensitive times.

Make it better

We all have a responsibility to sustain the places we love. Help clean up other's trash or volunteer.

Safety

Keep your distance from wildlife

Do not feed wildlife – it actually hurts them, either because human food can be toxic and/or animals become aggressive and have to be captured and moved or euthanized.

Be aware of your surrounding terrain

Stick to trails and stay on the safe side of barriers. Use extra caution on steep, loose, or rocky terrain. Stay away from ledges and drop-offs.

Wear hiking shoes or boots with sturdy soles

Bring water, food, medications, and clothing

A good rule of thumb is to bring one liter of water for every two hours (more when it's warmer). On a field trip, teachers and chaperones should carry a backpack with student medicines, extra food, extra water, and a first aid kit.

Be weather-aware

Avoid walking in washes when rain is nearby. (It can be raining in higher elevations miles away and water can flood the wash). Avoid hiking in high temperatures or exposed locations during lightning storms.

Make sure people know where you are and when you will return

Make sure cell phone batteries are charged and GPS locators are on (which can provide a location to 911 in case of an emergency.)

Southern Nevada Federal Public Lands Field Trips

Places And Teacher Guides

The Las Vegas Valley is surrounded by amazing public lands run by different federal agencies including the National Park Service (NPS), the U.S. Forest Service (USFS), the Bureau of Land Management (BLM), and the U.S. Fish and Wildlife Service (USFWS). Each of these agencies has developed specific field trip activities to help you plan and implement a field trip that highlights unique experiences at each location and meets specific educational standards and topics.

Taking students on field trips to the public lands around the Las Vegas Valley is a very rewarding experience for students and teachers alike, but it takes planning to help the field trip go smoothly. Each land agency has different contacts and processes to make field trip arrangements. For example, some locations have entrance fees, so you will need to apply for a fee waiver, other locations are free, but have limited space, so you will need to obtain permission to visit with a group and know where and how to park the bus.

This document provide checklists and information you can use for field trips to any location, while subsequent pages provide specific steps, contact information, and links to forms (if needed, e.g. fee waiver forms) for planning the field trip associated with this specific location (Bluffs Trail, Lake Mead National Recreation Area).

The four federal agencies (BLM, USFWS, NPS, and USFS) developed detailed materials to help you conduct a field trip to a specific location/trail. Below is a summary of each field trip location, activity, and topics covered as part of the field trip.

Lake Mead National Recreation Area

NPS – fee area, fee waiver needed, limited parking space, coordinate with the agency ahead of time via lake_education@nps.gov.

- **LOCATION**: Bluffs Trail, Las Vegas Bay Campground
- **Field Trip ACTIVITIES**: ***Geology: Erosion, Weathering, and Deposition and Colors in Stone*** – The Bluffs Trail provides an incredible view of the mountains that surround the Las Vegas Valley and a front-row look at geological processes like erosion, deposition, and fault lines. Also, nearly every major category of rock is represented on this trail – volcanic, metamorphic, sedimentary, and conglomerate – which tells an amazing story about the geology of the Las Vegas Valley. Students stop at points along the Bluffs Trail to learn about these land-forming processes, then finish with a watercolor activity "Colors in Stone."

Red Rock Canyon National Conservation Area

BLM – Teachers are required to have attended a pre-approved training to conduct self-guided Field Trips, fee area, waiver needed, limited space, coordinate with the agency

ahead of time by calling (702) 515-5380 or get more information on their website at: https://www.redrockcanyonlv.org/educational-resources.

- **LOCATION**: Fire Ecology Loop Trail (Pine Creek pull out in the loop)
- **Field Trip ACTIVITY**: ***Bio Blitz Inventory*** – Students identify desert plants at specific stops along the Pine Creek Canyon trail on their way to the Fire Ecology Trail. At two points along the trail (one in the high desert and one along the creek) students work in pairs to conduct a "bio blitz inventory" to see how many different leaf arrangements and leaf shapes they can find in a square meter. Students compare the two areas and make decisions about biodiversity based upon the data they collected.
- **TOPICS**: Biodiversity/plant identification/data collection and analysis

Desert National Wildlife Refuge

U.S. Fish and Wildlife Service – free entrance, limited space, coordinate with the Agency ahead of time. Go to https://www.fws.gov/refuge/desert for information on how to coordinate a field trip.

- **LOCATION**: Desert National Wildlife Refuge Visitor Center
- **Field Trip ACTIVITY**: ***Habitats: Refuge Residents*** – Students are assigned a desert animal that lives at the National Desert Wildlife Refuge. As the class follows the trails near the visitor center, there are specific stops that highlight different habitats. At each stop students consider the availability of food, water, and shelter and record whether their assigned animal would live in that habitat.
- **TOPICS**: Habitats/animal and plants found in different habitats along the trail

Spring Mountains

Forest Service – free entrance, limited space, coordinate with the Agency ahead of time by emailing programs@gomtcharleston.com.

- **LOCATION**: Spring Mountains Visitor Gateway
- **Field Trip ACTIVITY**: ***Nature Detective*** – Nature Detective is an activity that connects students to their surroundings and allows them to practice observational skills. Students begin their observations on the ride up Kyle Canyon Road, learning about different life zones as they move from desert to pine trees. Once at the Spring Mountain Visitor Gateway they explore the nearby trails and record observations of nature, including evidence of insect and animal life. Students then take their observations and craft them into a poem.
- **TOPICS**: Life zones/evidence of plants and animals in nature/recording observations using their senses

General Checklists and Planning

STEP 1: FIELD TRIP DATES & PAPERWORK (minimum 1-2 months prior)

All of the agencies featured in this field trip guide require schools to schedule the field trip ahead of time.

- Select a field trip date , with at least 1 – 2 alternative dates. Some areas have limited space with schools vying for that space. The more optional dates you have the more likely you will easily be able to reserve your desired field trip spot. If your original field trip location is not available, consider going to one of the other three agency locations.
  - It is strongly recommended to plan at least 1-2 months out to allow time for the agency to process your paperwork. If your trip is less that one month away, be prepared that you may not be able to visit that location.
- Determine how the class will get to the location and reserve buses. Funds may be available to help pay for buses or even rent a charter bus. Get Outdoors Nevada is a non-profit organization that may be able to connect schools to mini-grants for buses. NOTE: There may be some restrictions for chartered buses at certain field trip sites, either for size or certain agencies have contractual agreements with specific companies. If you use a charter bus that is not on approved agency list, you may have to pay additional fees. Agency details are included in the specific agency field trip section in the specific Teacher Guide (this guide is for the Lake Mead Bluffs Trail.)
- Complete all paperwork needed for your school and/or school district (including obtaining permission slips, and ordering lunches and water ahead of time, etc.)

STEP 2: CONTACT THE AGENCY

- Refer to specific field trip activities for information about who to contact and the necessary forms required for the agency/location you are interested in visiting.
  - Read forms carefully and include all of the requested information. Missing information/documents will result in a delay. For example, in order to process fee waivers, some agencies require the teacher to complete and sign the form, provide proof of accreditation of the school, provide proof of non-profit status, and give a description of the educational activity and learning objectives for the activity. Just because you are using one of the lessons developed by the agency, do not expect the fees or front booth staff to know this information. Copy and paste descriptions and educational standards from the specific guide into specific paperwork or attachments as needed.
- Contact the agency at least 1 month prior to the requested field trip date, preferably several months prior.

STEP 3: PLAN THE ITINERARY

- Plan a detailed itinerary. A sample general itinerary is provided below. More specific itineraries are provided with the specific field trip information.

Itineraries will vary depending on the following factors:

- Distance from the school to the site. Use Google maps to estimate the time needed to travel from your school to the field trip location. Be sure to add in additional time for traffic and getting through fee booths.
- What time your school starts and ends.
- Whether you are using school buses or chartered buses. School buses often have to be back sooner.

Figure 5. Hiking at the Lake Mead National Park (NPS Photo).

- The number of students participating in the field trip and where you are going. If the group is large, your itinerary may need to include rotations. Suggestions for student group size and rotation times are included with each specific agency/location field trip. Sample Itinerary:
  - 9:00 -9:15 a.m. - Depart school
  - 10:00 a.m. - Arrive at field trip location
  - 10:00-10:15 a.m. – Restrooms (we highly recommend all students go to the bathroom before heading onto the trail)
  - 10:15-10:20 a.m. - Introduction
  - 10:20 a.m. – 12:00 p.m. – Trails and activities
  - 12:00 – 12:15 p.m. - Restrooms and load buses
  - 12:15 - Depart
  - 1:00 p.m. – Arrive back at school

STEP 4: DO A SITE VISIT (minimum of 1 week prior)

- **Visit the site ahead of time**. This will significantly increase your comfort level with conducting the field trip. Scope out where the bus(es) will park, bathroom locations, as well as the most direct and/or safest way to get from the bus to the trail. Print out a copy of the field trip activity and accompanying maps and bring them with you. Try a dry run by yourself or with friends or family, taking note of specific stopping points described in the activity.

STEP 5: GATHER SUPPLIES FOR YOUR Field Trip (1 week – 2 days prior)

- **Bring permission slips as needed/required by school or agency** - Make sure you are aware of medical concerns with students.
- **Distribute field trip supplies lists for students** – Each students needs to wear comfortable clothes, wear close-toed tennis shoes, bring a backpack, clothing layers/ jacket per season, water bottle, snacks, pen/pencil, medicines.
- **Prepare copies of activity handouts and any supplies for the field trip activity** (e.g. photo print-outs, pens/pencils). Activity supplies are listed at the beginning of the specific field trip.
- **Copy of approved Fee Waiver Form (if needed)** – Print out a copy of your ***agency-approved*** field trip fee waiver and bring it with you on the bus to show the entrance station. Field trips that will need fee waivers are: Lake Mead National Recreation Area and Red Rock Canyon.
- **Bring fully-charged cell phones** – All adult chaperones on the trip should bring fully charged cell phones in case of an emergency. Emergency phone numbers for each agency are provided on the agency-specific field trip pages. These numbers will get you the fastest response. Not all locations will have a strong cell phone signal and reception is better for some carriers than others depending on the area (e.g. Verizon, AT&T, T-Mobile). Having a variety of phones and carriers will increase the likelihood of cell signal.
- **Consider getting an emergency GPS locater/alert device such as SPOT or a Garmin InReach** – Emergency GPS locators are excellent safety devices to have on hand in case of an emergency when cell phones do not work. There are basic alert devices that do not require a subscription (no fee) and just send an alert and location to 911. Other devices allow texting-style communication with those on a contact list or, in an emergency, with the dispatch to provide details about the emergency. The more sophisticated devices with texting require monthly or limited plans. Outdoor stores are a good place to learn more about these device options. If a school plans to do self-guided field trips to public lands, the school might consider purchasing a device and allowing teachers to check it out.

- **Field trip teacher/chaperone backpa**ck – Assemble one or more field trip backpacks for teacher(s), group leaders, or chaperones with the following supplies:
  - **Field trip activity materials for each group leader** (e.g. handouts, data sheets, background information, etc. per the specific Field Trip activity instructions)
  - **Large and small trash bags** – Help students practice Leave No Trace principles by bringing both large and small trash bags with you. Small trash bags are helpful to bring on the trail and large trash bags are helpful if you plan to eat lunch on site. Some students really enjoy picking up trash found along the trail. You can give small trash bags (and possibly gloves) to students who get excited about contributing.
  - **Gloves** - Consider having some gloves for the students who are excited about picking up trash.
  - **Hand sanitizer**
  - **Spare water and snacks**
  - **First aid kit**
  - **Sunscreen**
  - **Student emergency medicine** (e.g. epipens, asthma inhalers, insulin, etc.)
  - **2 Wag bags** - Wag bags are emergency bathroom kits in case someone needs "to go" while out on the trail and cannot make it to a standard bathroom facility. Most outdoor stores sell wag bag kits (they can also be ordered online). These kits include instructions, toilet paper, hand wipe, anti-odor and absorbent materials, and multiple opaque bags to prevent spills or seeing the waste. NOTE: Students should not urinate in the bags, this is for feces.

STEP 6: CONFIRMATIONS (the day before)

- Confirm bus(es), student lunches, permission slips, student checklists, and all above supplies, as needed.

STEP 7: HAVE FUN AND FOLLOW-UP WITH THE AGENCY!

- Celebrate the joy the students experience while being out in nature and on our public lands!
- Follow up with the agency and let them know how the field trip went for you and the students. If you have suggestions about the field trip activity or materials, let the agency know and they will take notes for future revisions.

Conducting a Field Trip to Lake Mead

Below is a detailed description of the fee waiver/fee exemption process for Lake Mead National Recreation Area (the National Park Service). **This information is for 2024. Prices, forms, and details may change**. Remember, each agency has their own field trip processes and requirements.

CONTACT: lake_education@nps.gov and lake_fee@nps.gov

GENERAL NOTE: Due to specific regulations (National Park Service Regulation manual RM-22A), we are unable to use a "one-size-fits-all" approach for fee waivers.

Campgrounds/Camping Fees Group Campsites

Campground fees are not usually waived as camping is usually considered to be recreation. However, there are circumstances where the camping fees can be waived for educational activities such as symposia or teaching camping skills. On multi-day volunteer events either park entrance or camping is waived but often not both. That is determined on a case-by-case basis.

School Field Trips – Using School Buses

The entire school can be exempted from entry fees. Lake Mead NRA needs the following paperwork at minimum 4 weeks in advance to ensure all the documents are complete and correct.

- Lake Mead Fee Waiver Request form (email contacts above to request the form)
- Proof of Accreditation
- Proof of Tax Exempt Status
- Grading Criteria

Please note that each field trip – even if it is from the same school – requires these forms and an explanation of the educational purpose/curricular ties and how it relates to the Lake Mead NRA resource. The fee waiver form is for schools only (not non-profits).

Field Trips Using Chartered Coaches

If you use a company that is already on the Lake Mead fee waiver list (provided below), all fees will be waived for youth ages 15 and under. (NOTE: Buses that have contracts with Lake Mead may change from year-to-year. Be sure to let the person you are coordinating with know the bus service you are using.) Participants over the age of 16 (including chaperones) will have to pay $15 per person. The max charge from Lake Mead/NPS would be $150 (that is in addition to the chartered coach fees). The companies use a form that they will give to the station staff outlining how many people are on board that are exempt from fees.

Table 1. Lake Mead Transportation Fee Waiver List

Company Name	Contact Number
Royal Coach Tours	702-570-2390
CH Destination Inc, dba Canyon Coach Lines	702-933-1123
Holiday Motor Coach	208-821-1881
Triple J Tours	702-261-0131

Chartered coaches not on the fee waiver list will cost $150 – no fees are waived for riders 15 years and older. If it is a school group and the visit is educational, they can still apply for the educational fee waiver even if they enter in a rented motor coach. If it is an organized group not affiliated with a school, then the fee schedule above applies.

Entry Or Field Trips Using Vans Or Vehicles That Accommodate 25 Or Fewer People

NOTE: Entry prices are based upon vehicle type, not the number of people in the vehicle. If a mini-bus comes and only has 5 people, it will still be $60. Prices may change.

15-passenger Vans/Sedans/Minivans - $25 charge for the entire vehicle (as long as this is not a commercial van with a hired driver. Non-profit vans, such as the Boys and Girls Club, are not considered commercial and will only be charged the $25 fee). An America the Beautiful Pass can be used for this type of vehicle entry.

16-25 person minibus - $60 (unless they complete the above forms described under “school Field Trips using buses” to obtain the fee waiver). An America the Beautiful Pass CANNOT be used for this type of vehicle entry.

Volunteer/Service Project Entry

Volunteers get free entry when they volunteer for 2 or more hours. Fee waivers and all volunteer paperwork are coordinated through the Lake Mead National Recreation Area Volunteer Office.

Bluffs Trail Field Trip: Weathering. Erosion, and Deposition

Overview

This document is an educator's guide designed as a walk-thorough of student activities during field trips to the Las Vegas Bluffs Trail at Lake Mead National Recreation Area (LMNRA). The activities target grades 3-5 but can easily be adapted for other grade levels.

A note of caution – The land surfaces along the Bluffs Trail are made of loose gravel which has been undercut in areas, making it potentially unstable. Do not allow students to approach edges that slope downward steeply. Rocks may give away and cause injury.

Core skills that will be utilized are:

- Observation
- Description
- Critical Thinking
- Drawing

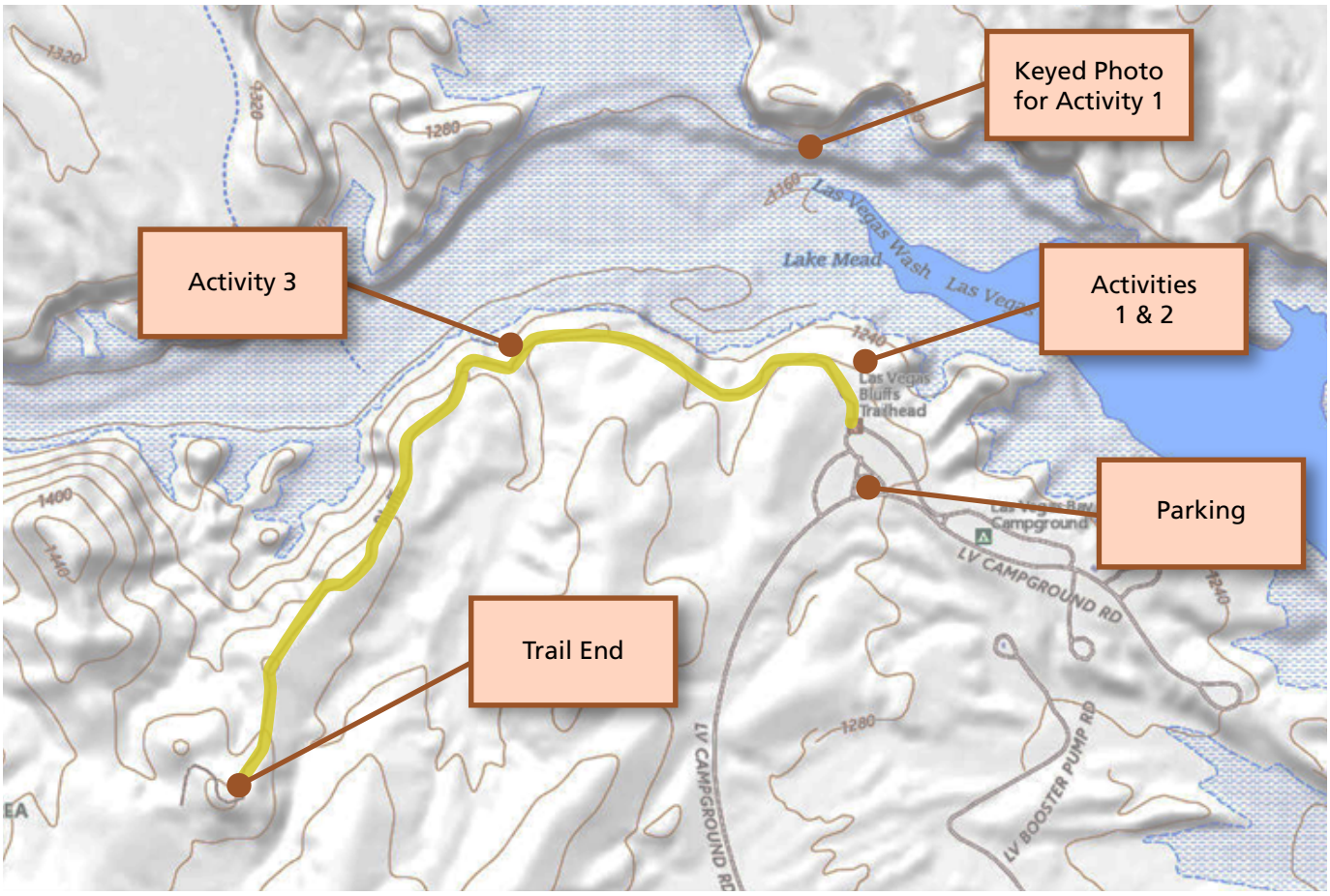


Figure 6. Map of the Bluffs Trail (source: National Map Viewer)

Materials (This is in addition to general field trip supplies for health and safety)

Copies of the student worksheets:

- Worksheets 1 & 2 on the same page
  - Weathering and Erosion example cards
  - Coloring pencils – (suggested limited set = Brown, Orange, Tan, Blue)
- Clipboards or other hard surfaces to write on.
- One or two filled water bottles for a demonstration.
- (Optional) A cup to pour water out of during an erosion demonstration.

Background Information

Geology and History

Introduction: A Sense of Place

The Las Vegas Wash is one of the best locations in Southern Nevada to observe features of erosion in the visible landscape. The Las Vegas Wash is at the lowest elevation point

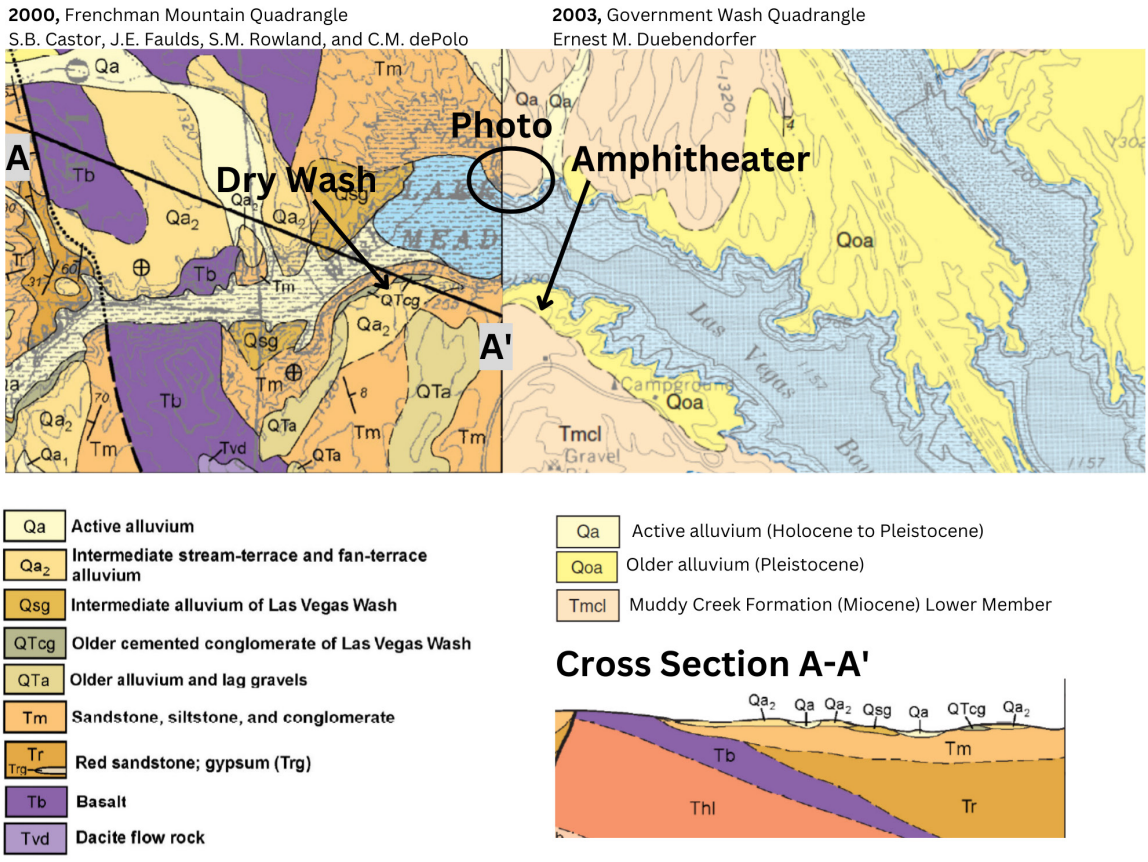


Figure 7. Example of a geological map comparing the 2000 Frenchman Mountain Quadrangle and the 2003 Government Wash Quadrangle.

of the entire Las Vegas Valley, which means that any water that falls in the mountains that surround the valley, or in the valley itself, will eventually discharge or drain through the Las Vegas Wash. That means that there is an almost continuous flow of water at this site. The historical, natural drainage, coupled with modern wastewater release has caused changes in the landscape which we will investigate in this lesson. Teachers and students will be investigating topics from geology including landscape features, erosional processes, and three of the "agents of erosion:" wind, water, and gravity.

Geologic map of the Las Vegas Bluffs Trail

A Geologic map is used to show the rock formations that are visible at the surface for a given area. Each Formation is colored and labeled based on the composition of the rock types and the age of the formation. (See page 35 "Vocabulary" for full descriptions of these formations)

Quaternary = In the Cenozoic Era, dating anywhere between now and 2.58 Million Years Ago (Ma) and including the Pleistocene and Holocene

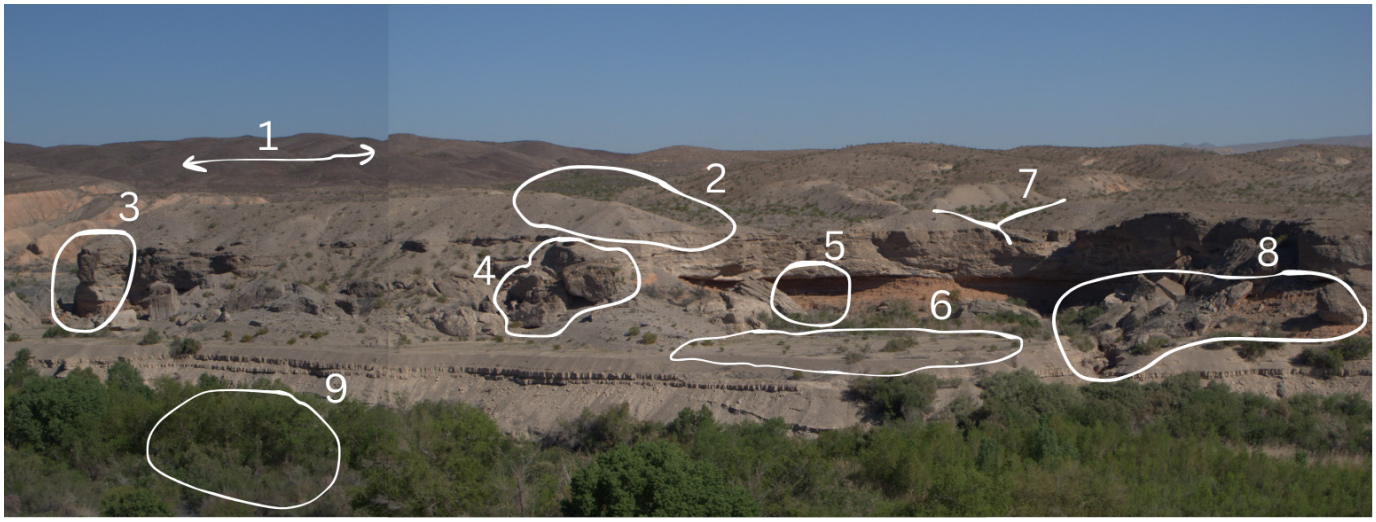
Tertiary = In the Cenozoic Era, dating anywhere between 2.58 Ma and 65 Ma. Begins after dinosaurs are extinct.

Field Trip Activity

Activity 1 – Introduction To Landforms At The Amphitheater

Location

Walk East, beyond the amphitheater towards an open area. Discussion and student completion of Worksheet 1 will take place here.



1. Surface
2. Slope
3. Block
4. Undercut
5. Bench
6. Drainage-Channel
7. Mass Wasting
8. Active Channel

* Arrow shows the direction of the above photograph, taken from the amphitheater.

Figure 8. Keyed photo and map of amphetheater found on the west walk for Activity 1.

Overview

Students will be able to look at the visible landscape and describe/identify key features of geology: Surfaces, Layers, Slopes, Cliffs, Drainage Channels, Undercuts, Blocks, Benches, and Active channels.

Materials

Worksheet 1: Exploring the Landscape

Time

Fifteen minutes

Procedure

- From the amphitheater, look across the wash to find the matching area shown in the keyed photograph (below).
- Use the keyed photograph and the images of hand motions to help identify and review the geology features with the students before they complete their worksheet. The numbers in the keyed photograph correspond to landforms with hand motions or to features that are discussed later in this activity guide.
- After each description and hand motion, ask the students to point to something that could match the land feature that was just described then have them complete Worksheet 1 on their own.

Hand Motions for Activity 1

After each action, ask the students if they can see something in the landscape that matches this landform.

0. **Erosion and Deposition** - mime scooping materials into your hand, transporting it across your body and then dumping it in a new location.

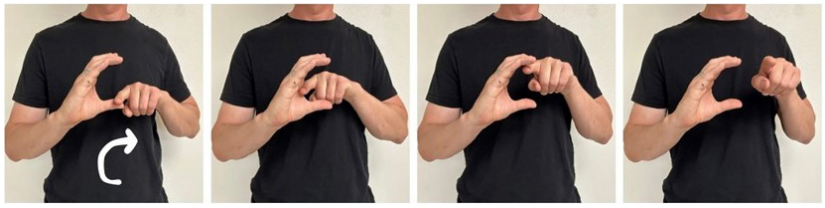
1. **Surfaces** - hands open, palms down, spreading side-to-side.

2. **Slopes** - hold your arm in front of your angled up and then slide your other hand from elbow to fingers to show motion as uphill. Repeat with arm angled downwards for downhill.

3. **Drainage Channels** - Make a "V" with your two hands, wrists touching. Then angle the "V" downhill and show that water would flow at the base of it (using your finger to represent water).

4. **Cliffs** - one hand open with fingers pointing up and palm facing to the side. Slide your other finger up and down your hand to show vertical motion.

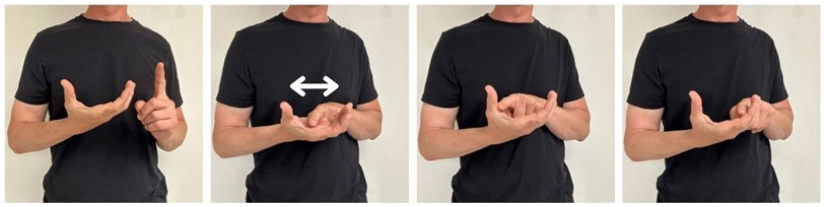
5. **Undercuts** - make a letter "C" with one hand. Trace the inside edge with a finger from the bottom of the "C" to the top of the "C" to show motion.



6. **Blocks** - make a fist and then grab it with your other hand to show that it is a single item, not attached to a layer.

7. **Benches** - arm flat, hand open with palm face down. Slide your other hand back and forth over the arm.

8. **Active Channels** - Make a wide "U" with one hand. Use a finger of your other hand to show a river in the middle of the channel. Now move your finger back and forth from one edge of the "U" to the other.



9. **Peeks** - Make an "A" with your two hands, fingertips touching.

Field Trip Activity

Activity 2 – Meet the Agents of Erosion Activity

Location

To be completed at the Las Vegas Bay Campground Amphitheater, gathered at the seats

Overview

Students will be able to:

- Identify three of the agents of erosion – wind, water, and gravity.
- Grasp the concept that weathering and erosion alter the landscape by removing material and transporting it to another location.
- Rank the agents of erosion according to their relative strengths to move sediment.

Materials

- Weathering and Erosion cards (ideally laminated or on durable cardstock)
- Worksheet 2: Exploring the Agents of Erosion

Time

Fifteen minutes

Procedure

Introduce the students to the concepts of weathering and erosion by using the weathering and erosion cards. Use the questions below to help guide the conversation with the students.

Weathering, Erosion, and Deposition (Use the weathering and erosion cards)

Introduction: *Have you ever looked at the land and wondered why it looks like that? Why are some parts hilly and others totally flat? The answer is that the earth is made of many layers that are stacked on top of one another. Some layers are hard and other layers are soft. Over time, these hard and soft layers get broken down by* ***weathering*** *and* ***erosion****. These processes shape the land by carving into old layers and by creating new land in other places through deposition of the material that has previously been weathered and eroded.*

1. **Show: Weathering Card**
    a. **State:** *Weathering is the action that breaks or loosens rocks and rock layers so they can be moved by erosion. Some rocks and layers are hard to break and others are*

easy to break. Forces of nature like water, wind, fire, and ice work to weather rocks and layers of the earth.

b. **Ask:** *Is it easier to break a sand castle or a brick house?*

c. **State:** *All rock layers can be described as hard or soft, based on how much they resist being weathered. If a layer is easy to weather, then it is called* ***soft*** *and if a layer is difficult to weather, then it is called* ***hard****.*

d. **State:** ***Soft layers*** *are often weathered and eroded into landforms like slopes, channels, and undercuts because they are easily eroded.* (Use the hand motions from page 4 to depict slopes, channels, and undercuts.)

e. **State:** ***Hard layers*** *usually form cliffs, blocks, and peaks because they do not break apart easily.* (Use the hand motions from page 4 to depict cliffs, blocks, and peaks.)

2. **Show: Erosion Card**

a. **State:** *Erosion is a process that moves loose materials and broken rocks from one place to another. Whenever erosion removes weathered material, there is an* ***agent of erosion*** *– either wind, water, or gravity – that does the work.*

3. **Show: Erosion Card, Focus On The Deposition And Layers**

a. **State:** *Eroded materials eventually get deposited when an agent of erosion runs out of energy. This makes a pile of new material. Over time materials that are deposited can get hardened into layers of earth.*

Meet the Agents of Erosion

Introduction: *Today we are going to look at the "Agents of erosion" – wind, water, and gravity – and how they work together to reshape the land around us. Each of these "agents" have different levels of strength and they shape the landscape in different ways too. Let us explore how the Agents of Erosion work."*

1. **Wind**

a. **Demo 1a:** Have the teacher or students pick up a mixed handful of dirt with large, medium, and small rocks in it. Hold it in an open palm or place it on the benches of the amphitheater.

b. ***Ask:*** *Do you expect that wind will be able to move these things?*

c. Demo 1b: While facing downwind, blow on the pile to simulate wind.

d. ***Ask:*** *What moved and where did it go? Hopefully, the students see that wind moves the dirt and sand easily, but cannot move the larger rocks.*

e. ***Show:*** *Point to the ground. Does everybody see that the ground is covered by loose rocks with varying amounts of dirt between them? This is a special kind of surface found in dry, windy environments called* ***Desert Pavement****. Desert pavement is made*

when wind carries away all the dirt that was around the rocks and leaves behind only the loose, larger rocks.

2. **Water**

   a. **Demo 2a:** Have the students or teacher place a bunch of dirt, pebbles, and rocks onto a bench. Make sure that there are some large rocks on the bench this time.

   b. ***Ask:*** *Do you think that wind could move this largest rock?*

   c. ***Ask:*** *Do you think that water could move these things?*

   d. **Demo 2b:** Drip some water on the pile (or pour carefully and slowly).

   e. ***Ask:*** *What moved and where did it go? Hopefully, the water moved only the dirt and small pebbles.*

   f. ***State:*** *"Water is weak when there is little of it. It can move some small sediments. And when it evaporates, it can leave behind a very hard, whitish, or tan material called CALICHE."*

   g. **Show:** Point out Caliche coatings on rocks nearby. Note that it is fine grained like dust and that it is on many of the rocks in the area.

   h. **Demo 2c:** Using the same pile of rocks, pour water forcefully onto the pile.

   i. ***Ask:*** *What moved and where did it go? Hopefully, the students see that water could move everything other than the very largest rocks.*

   j. ***State:*** *"When water collects in large amounts, it can be strong. Water flows downhill (gravity) and collects in drainage channels. Over time, water flowing in the channels can erode the ground so much that a whole layer may collapse in what is called a mass wasting event.*

   k. **Show:** Point out areas of mass wasting (collapsed blocks) and note that the collapse is usually at the end of a drainage.

3. **Gravity**

   a. **Demo 3a**: Now that the students have seen the potential strength of wind and water, it is time to explore gravity. Do this while either holding a very large rock in your hands or by placing it on the middle of a bench.

   b. ***Ask:*** *What is keeping this rock from falling to the ground?*

   c. Hopefully the students will answer "the bench" or "your hands"

   d. ***Ask:*** *What will happen if I take the bench or my hands away?*

   e. Hopefully, the students will answer, "It will fall to the ground."

   f. **Demo 3b:** Now put the rock really close to the edge of your hands or at the edge of the bench.

g. *Ask: Is this rock more or less likely to fall to the ground now?*

h. Hopefully, the students will say "yes, it is not balanced" or "there is not much holding it up.

i. **Demo 3c:** Drop the rock.

j. ***Ask:*** *What moved and where did it go?*

k. ***State:*** *"As an agent of erosion, gravity is always pulling material from high places to low places. It can move really big things, but it needs help. Also, you can think of gravity as a director, telling agents wind and water where they should put the materials that they erode."*

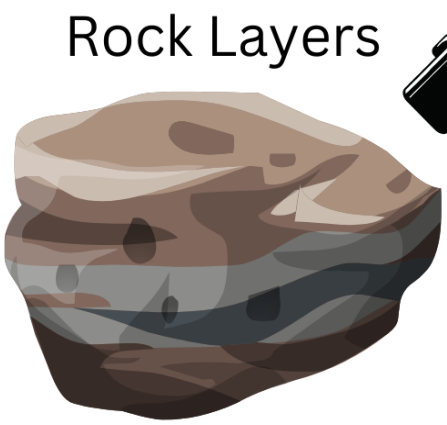
l. **Show:** Point out the large blocks that line the Las Vegas Wash. Note that they used to be connected to the cliffs above them. These blocks broke away and fell only after the softer orange material under them was removed by water.

Putting it together

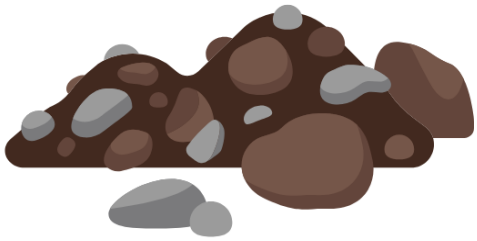
Now that we have seen the agents of erosion at work, have the students complete **worksheet 2A and 2B** to show us what you know.

Weathering

Rocks or
Rock Layers



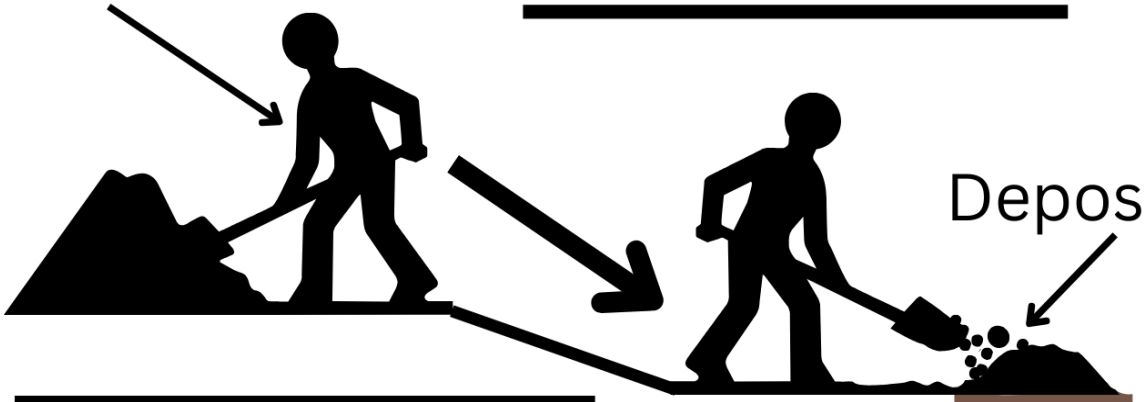
Sediment is a mixture of dirt, soil and rocks



Weathering breaks rocks into smaller pieces

Erosion

Agent of
Erosion



Deposition

Layers of sediment

Agents of Erosion

Wind

Water

Gravity

Erosion moves rocks and sediment (soil) from one place to another.

Field Trip Activity

Activity 3 – Investigating Drainages, Wash Deposits, and Mass Wasting

Location

To be completed at stop #3 on the Bluffs Trail (The Wash). You can recognize this area because the trail has a short step section with some "step downs onto rocks" into an obvious wash This is about 0.5 miles down the trail. Gather the students in the area just to the left of the trail, in the wash.

NOTE: Do not allow students to approach the edge of the wash towards the collapsed blocks. This area is undercut and there is danger that it will collapse at some point in the future.

Overview

Students will be able to

1. Define **alluvium**, **cement**, and **conglomerate**
2. Identify features of an active drainage channel
3. Recognize that **Mass wasting** often occurs when drainages carry water to and over the edges of cliffs, undercutting the lower layers of earth and allowing the upper layers to collapse

Materials

No student handout

Time

15 minutes (excludes hiking to and from the location. Add 30–45 minutes for hiking both ways and exploration in the wash)

Procedure

Introduce the students to the concepts of **alluvium**, **cement**, and **conglomerate** by showing them deposition layers in the wash. Use the questions below to help guide the conversation with the students.

Introduction: *We are standing in a type of drainage channel called a "wash." The walls and floor of this channel (point to them) are made of deposited material which hardened into something called a conglomerate. It is the same layer of rock that makes the collapsed blocks at the cliff edge (point to the area of mass wasting). We are going to investigate the why the rock wall layer breaks into large blocks rather than into loose gravel.*

1. **Recognizing fresh Alluvium**
    a. ***Ask:*** *Would you all agree that we are standing in a drainage channel?* (Use hand motion).
        i. Note that there are two slopes which meet here and go downhill towards the wash.
    b. ***State:*** *Active drainages commonly have loose gravel, sand, a few large rocks, and some debris scattered on the ground.*
    c. **Assign**: *Give the students a few minutes to look around to find some gravel, sand, and other loose debris within the wash.*
    d. ***Ask:*** *Did you find some? Is it all stuck together or is it loosely piled up?*
    e. ***Ask:*** *Are the piles of material mostly the same size or a jumble of different sizes?*
    f. ***State:*** *Rocks are easily eroded when they are loosely stacked with no glue holding them together. This type of deposit is called* ***Alluvium****. (Qa "active alluvium" on the geologic map)*
2. **Recognizing Conglomerate**
    a. Have the students gather near the rock wall on the east side of the wash.
    b. ***State:*** *This rock wall and the collapsed blocks at the end of this drainage are part of the same rock layer (QTcg on the geologic map). It forms a hard material that resists weathering and erosion. We need to find out why?*
    c. ***Ask:*** *When you look at this wall, are all the rocks the same size?*
    d. ***Ask:*** *Are these rocks loosely piled together?*
        i. Hopefully the students point out that the rocks are all stuck together.
    e. **Show**: Point out that the spaces between the rocks in this in the wall are filled in with a fine grained, tan/grey material.
    f. ***State:*** *This rock wall used to be made of loose alluvium like in the wash. Over time, the spaces between the rocks got filled in. This material between the rocks is called* ***cement****. It is very hard and it glues the alluvium together. Rock layers that are made of cemented alluvium are called* ***Conglomerate****.*
    g. **Assign**: *Let the students explore the wash again, looking for other areas where there is a lot of cement, between the rocks in the wall or all by itself in thin layers that make the floor.*
    h. ***Assign:*** *Let the students look for areas (the undercuts) where there is less cement between the rocks.*

3. **Putting it all together**

    a. ***State:*** *When water is flowing through this drainage, weathered rocks get eroded and deposited down in the active channel of the Las Vegas Wash. The water and debris cuts through this layer of conglomerate, pours over the side of the cliff, and erodes away the soft orange layer that is beneath our feet. This eventually makes an undercut that destabilizes the layer above it and eventually causes mass wasting like we see all along the Las Vegas Wash. While we walk back to the amphitheater, I want you to look for other areas of drainage, undercutting, and mass wasting.*

The Energy of Erosion Activity

This is a more advanced optional activity suggested for grades 6+.

Location

To be completed at stop #3 on the Bluffs Trail (The Wash). You can recognize this area because the trail has a short step section with some "step downs onto rocks" into an obvious wash This is about 0.5 miles down the trail. Gather the students in the area just to the left of the trail, in the wash.

Overview

Students will be able to

- Identify patterns of deposition in a large rock wall.
- Identify "packages" of deposited material (turbidites) left by each depositional event by noticing the existence of graded bedding as a repetitive pattern.
- Identify that some events have more energy than other events.
- Identify features like cementing of the rocks makes determines whether they will be HARD or SOFT against erosion.

Skills

Students will be measuring rocks, categorizing their sizes, and looking for patterns within the wash at stop #2.

Materials

Worksheet 3: Exploring a Dry Wash

Time

25 minutes (excludes hiking to and from the location. Add 30 -45 minutes for hiking both ways and exploration in the wash)

Procedure

Introduction: Now that you have identified landforms and know how the agents of erosion shape the earth by removing material. In this section, we will learn about how layers are made when eroded material gets deposited away from where it came from. We will learn that layers of the earth are often made by multiple events that each leave behind a deposit of material. Every deposit, described here as a "package" has its own unique set of characteristics that helps determine the way in which it formed. The layer of rock that we are going to investigate here is a conglomerate, part of an alluvial fan complex built up over a long period of time from many individual depositional events. It is now time to look

closely at those individual packages to find an important feature called **graded bedding**.

1. **The Energy of an event**
    a. ***State:*** *This rock wall is one layer of the earth, but it is made from many individual packages of deposits.*
    b. ***Ask: Do they see the pattern of repeated lines and swoops in the rock wall?***
        i. Have them trace in the air the direction of these layers with their hands.
        ii. Establish that this is a series **Repeated events** of deposition.
        iii. Hopefully, the students see some angled lines, some undercuts and that the wall is made of a lot of loose rocks.
    d. **Show**: Approach the wall and find an area with graded bedding – use the illustration on worksheet 3. Model the behavior of using your hands to bound the top and bottom of a package. Point out that the pattern inside this package has large rocks on the bottom and small rocks on the top.
    e. ***State:*** *This pattern is called Graded Bedding. It happens because every erosional event starts with high energy and ends with no energy. With high energy, an agent of erosion can carry large items. But as the energy of the event weakens, the agent cannot carry as much and it starts setting down the heaviest materials so that it can carry the rest a little bit further. The pattern of losing energy and setting down the heaviest thing being carried continues until the lightest material is dropped and the event runs out of energy.*
    f. **Assign**: Have multiple students approach the wall and put their hands on it to show the top and bottom of a few packages. Repeat several times.
    g. ***State:*** *Yes, these are all event packages, each topped with fine sediment*
2. **Worksheet 3B**
    a. ***State:*** *Now we are going to compare the strengths of several events by finding packages that are filled with mostly the same sized rocks.*
    b. **Assign**: Have the students find a high energy package with the biggest rocks in the wall.
        i. Using the ruler printed on their worksheet. Measure the size range biggest and the smallest of each category of rock and write it on the worksheet. (They may want to draw the smallest rocks)
    c. Repeat part B with the goal of finding packages dominated by medium rocks and then by small rocks.
    d. Repeat part B with the goal of finding only cement.
    e. **Putting it together**: Complete worksheet 3B

Fieldtrip Activities Vocabulary

Active Channel: Similar to a drainage channel, but with a continuously flowing body of water. Active channels are characterized by a meandering stream running through a wide channel with steep sides.

Agent of Erosion: Wind, Water, and Gravity as acting forces that can move sediment and rocks from one place to another.

Alluvium: A deposit of clay, silt sand and cobbles transported by water. Alluvium tends to be young and not consolidated into a rock unit.

Bench: A sedimentary feature characterized by a flat lying area bounded by slopes or cliffs. The benches at Bluffs trail are fluvial terraces which are remnants of the older flood plain of the Las Vegas Wash and were formed when the wash down-cut to its current active channel due to increased flow.

Blocks: Large rocks or sections of cemented sedimentary layers, usually from the edge of a receding cliff face, which have broken away from the cliff face and tumbled downwards, usually through mass wasting events.

Caliche: A hardened, fine-grained cement of light tan, white or pinkish color, made of calcium carbonate that forms through evaporation of water that binds silt, sand and gravel together into hard layer.

Cement: In sedimentary rocks, usually as a fine-grained material which fills the voids between rocks and cobbles. This material "glues" the rocks together, making them more resistant to erosion.

Cliff: A vertical section of exposed rock, usually created when portions of a rock layer break away and are carried downslope by gravity, such as in mass wasting.

Conglomerate: A rock which is made from many other rocks which have been cemented together, usually be caliche or another fine-grained material.

Contact: A distinct horizon, separating one formation from another. Usually horizontal, but may be tilted or offset if the layers of the formation have been altered by tectonic forces.

Deposition: A geological process where sediments, soil and rocks are added to a land area by an agent of erosion (wind, water, gravity) as the kinetic energy of that agent decreases, causing its carried load to be deposited.

Desert Pavement: A land surface, common in arid desert environments, characterized by loose rocks which are not buried in sediment. It is created slowly as wind removes sediment from between rocks at the surface.

Downcutting: An erosional process where flowing water creates a channel by removing sediment from its path. Downcutting occurs when the flow of a river increases.

Drainage Channel: Created by moving water and active only during rain events. Drainages are found where two or more slopes intersect. They are low spot on the land in which water flows downslope.

Erosion: The process of moving weathered material from one place to another, usually by wind, water, and gravity. This is the process that shapes the earth into landforms that are visible today.

Formation: A collection of rock layers that are distinct from adjacent rock layers and can be classified as a single body, based on age or lithology (what it is made of or how it was made). Formations must be thick enough and widespread enough to be included on a geologic map.

Layers: A normally horizontal section of the earth of varying thickness, composed of self-similar materials which can be differentiated from the earthen materials both above and below it. Created over time through deposition of materials by the agents of erosion.

Mass Wasting: The movement or rocks and soil down a slope under the influence of gravity. This is expressed at the Bluffs trail by collapsed blocks, concentrated at the terminus of drainage channels, and found all along the Las Vegas wash.

Sediment: Any unconsolidated (loose) material, derived weathered and eroded pieces of other, bedded rock units and layers.

Sedimentary: Pertaining to rock types and processes of erosion or deposition which feature sediments.

Slope: Any are of the land surface which angles downward, as in "downhill."

Surface: The exposed portions of the land where you would be able to walk.

Undercut: Usually caused by wind or water. This is an area where easily eroded material has been removed from under a more resistant layer of rock, causing the overlying material to become unstable.

Weathering: A process of breaking rocks and landforms into smaller pieces, usually by wind, water, ice, and tectonic activity (earthquakes etc.)

Geologic unit descriptions from the map Frenchman Mountain Quadrangle (2000) (left side of the map)

Qa2 – (Quaternary) Intermediate stream-terrace and fan-terrace alluvium (late Pleistocene) Alluvial surfaces forming an intermediate level of stream and fan terraces. Alluvial surfaces are present in the cobbly units but are smoothed from surficial reworking and eolian deposition. In pebbly deposits little or no surface may remain. Edges of deposits are commonly eroded or dissected. Pavements are well developed and rock varnish is moderately to strongly developed on siliciclastic, cherty, and granitoid rocks. Limestones and sandstones are moderately well to well etched. Soil development includes a 5- to 15-cm-thick eolian silt Av horizon overlying a reddish argillic horizon up to 80 cm thick, and a stage I to III calcic horizon or a gypsiferous horizon up to 40 cm thick at the base of the profile. Deposits are made up of sandy gravels to gravely cobbles. Deposits are moderately well indurated, poorly to moderately sorted, and poorly to moderately stratified. Clasts are angular to subangular. Deposit thicknesses range from 0.5 to 5 m.

QTcg – (Quaternary) Older cemented conglomerate of Las Vegas Wash (Quaternary or late Tertiary) Sandy pebble to cobble conglomerate composed of rounded and subrounded limestone, volcanic, granitic, and gneissic clasts cemented into a sandy calcareous matrix. Moderately to well sorted, generally well stratified with large-scale fluvial cross-bedding. The deposit is a well indurated, cliff-forming unit that is generally restricted to the channel walls of Las Vegas Wash, and is 10 m to 30 m thick. The deposit represents a paleochannel along Las Vegas Wash.

Tm – Muddy Creek Formation (Teritary) Sandstone, siltstone, and conglomerate Poorly to moderately sorted pale-reddish-brown and pale-red sandstone and siltstone with some interbedded pebble to boulder conglomerate. Locally, the unit is mostly coarse conglomerate. Fine-grained lithologies generally dominate in the east part of the quadrangle. Sandstone is generally fine- to medium-grained with subangular to subrounded grains, weakly indurated with calcite cement, and thinly bedded. Conglomerate generally contains subangular clasts and includes both matrix and clastsupported beds, but matrix-supported beds dominate. Bed thickness ranges from 2 to 30 cm. North of Sunrise Mountain in the Nellis Air Force Base, conglomerate gives way northward to limestone and gypsum (lacustrine facies) toward a depocenter near the north margin of the map area, here referred to as the Nellis basin. Near the Frenchman fault, Tm is dominated by thinly to moderately bedded, poorly to moderately sorted, matrix supported, weakly indurated (calcite cement), pale-brown or reddish-brown to light-gray conglomerate containing subangular clasts of Paleozoic lithologies ranging up to 50 cm. Where composed of sandstone and siltstone, Tm is difficult to distinguish from other redbed units, such as Tht and Tr (see below) but generally has flat-lying or gently dipping (less than 20 cm) bedding and commonly contains some gypsum.

Government Wash Quadrangle (2003) (right side of map)

Qoa – (Quaternary) Older alluvium (Pleistocene) boulders, cobbles, pebbles, sand, and silt present on elevated terraces and on inactive alluvial fans. Generally distinguished from modern alluvium by well-developed desert pavement and darker color on aerial photographs due to rock varnish. Generally poorly sorted, variably rounded, and ranging from unconsolidated to well cemented by caliche. Thickness ranges from 3 m to probably more than 20 m.

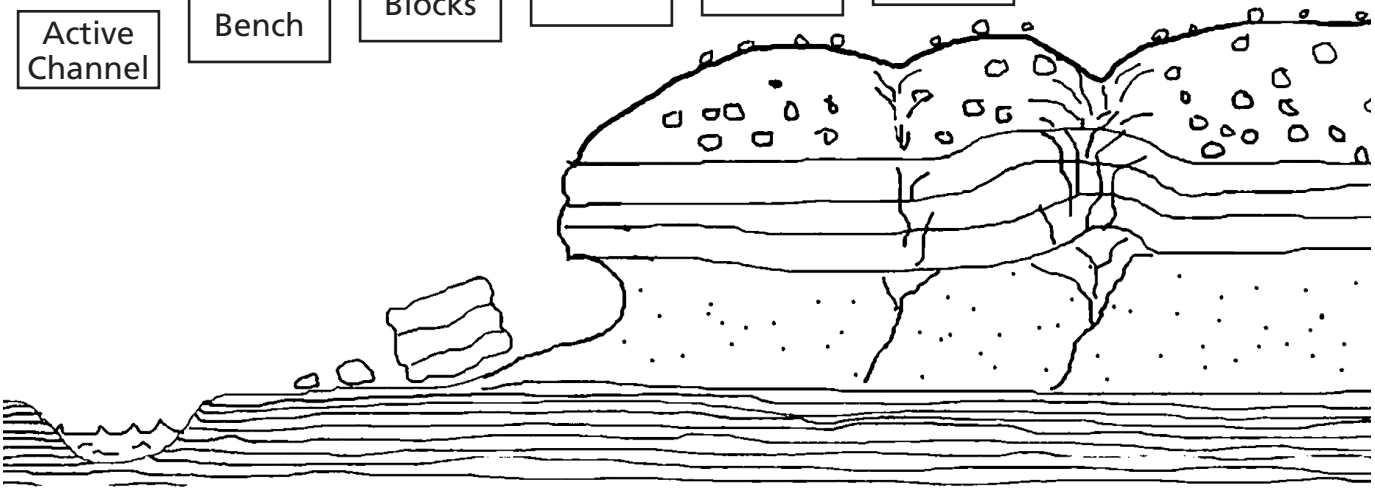
Tmcl – (Tertiary) Lower member Claystone, siltstone, gypsum, and gypsiferous siltstone, with minor sandstone and conglomerate. Claystone, siltstone, and gypsiferous siltstone is tan to light red or red-brown; sandstone and conglomerate are light tan. Unit tends to be more conglomeratic at base grading upward into gypsiferous sandstone and siltstone. In the western part of the quadrangle, the boundary between upper and lower Muddy Creek Formation (informal designations) is defined as the top of the extensive 3 to 10-m-thick white gypsum layer. There is a local angular discordance between the upper and lower members of the Muddy Creek Formation. The lower Muddy Creek Formation is present only in the western part of the quadrangle and south of the Las Vegas Valley shear zone. Thickness may locally be greater than 900 m (Bohannon, 1984).

Worksheet 1: Exploring the Landscape

Look across the wash to the north of the amphitheater to find an area that looks like this:

A: Label the picture below by drawing lines from each word to the feature that it represents.

Active Channel | Bench | Blocks | Undercut | Cliff | Slope | Drainage Channel | Surface



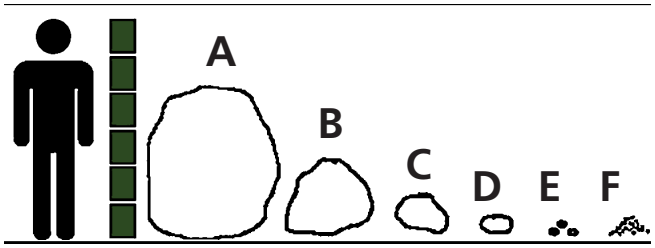
B: Color the layers with the colors that you see in the landscape.

Blue: Water and active channel **Tan**: Bench Layers **Brown**: Cliffs, Blocks and Surface **Orange**: Mud Layers

Worksheet 2: Exploring the Agents of Erosion

A: The Strength Of Erosion

It takes a lot of energy to move big things. Look at the rocks A-F drawn below. How much energy would it take to move each one of them? In the blank spaces of the table to the right, write the letters of the rocks that each of the agents of erosion can move.



Energy to Move	Letters of rocks in the picture
I can move	
Wind can move	
Water can move	
Gravity can move	

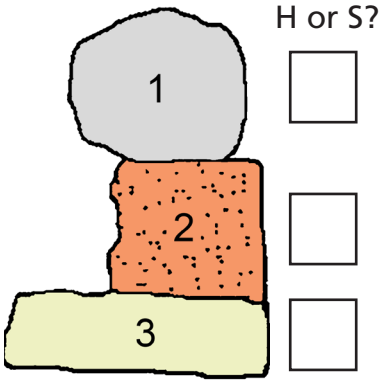
B: Agents Of Erosion At Work

Use the drawing of rock layers 1 - 3 to answer these questions:

1. Use the boxes next to the diagram to label rock layers 1, 2, and 3 as either "H" for hard or "S" for soft.
   Hint: Hard layers stick out and soft layers make underscuts.

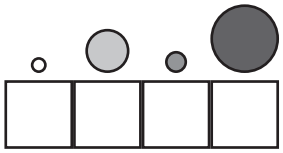
2. How can you make Block 1 touch layer 3? Circle your answers.

   Add to Layer 3 | Remove Layer 2 | Push Block 1

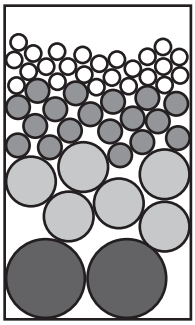


Worksheet 3: Exploring a Dry Wash

A: Just One Layer of "Package"



1. If all four of the dots to the right are being carried by an agent of erosion, which order will they be put down in as the agent runs out of energy? Enter a number for each in the boxes provided.



2. Right now, the rocks in the graded bedding diagram to the left are loosely piled up as alluvium. They are easily eroded when they are like this. How can you make them stronger? Circle your answer below.

Add more rocks **Fill spaces with cement**

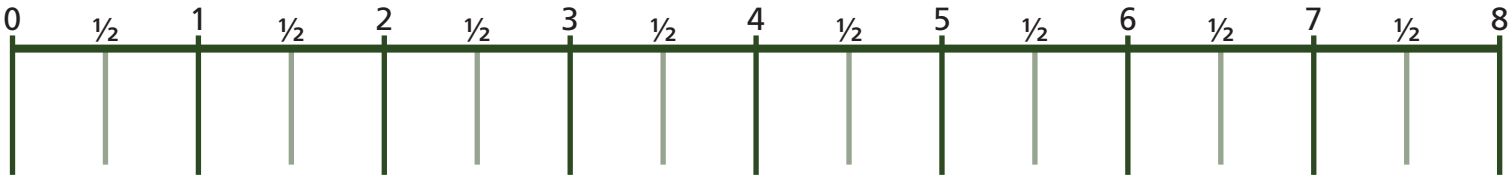
3. Now use your pencils to draw your answer to question 2 into the gradded bedding image to the left.

B: The Whole Wall

Look at the whole wall at stop 2. Find areas where most of the rocks are the same size. Use the ruler provided to measure the range of sizes in several of these "packages" and record your findings in the table to the right. The measurement is in inches.

Rock Sizes	Smallest	Biggest
Biggest Rocks		
Medium Rocks		
Smallest Rocks		
Cement		

▼Use this ruler to measure the size of the rocks.▼



Colors in the Stone

Location

Near the amphitheater at the Bluffs Trail at Lake Mead National Recreation Area.

Overview

In this activity, students will develop their skills of observation by examining and painting the landscape at Lake Mead National Recreation Area.

Students will learn rocks, minerals, soil, water, and light contribute to the colors we see. The many colors in the stones are a result of how the minerals, such as iron, in the rock and soil reflect light. Iron oxides may appear red or black, chlorite or copper-based materials appear blue or green, and calcium-dominated minerals can appear white.

Materials

- Watercolor paper - postcards size - 1 per student
- Watercolor set - 1 per student
- Dixie cup - 1 per student
- Napkins - 1 per student
- Clipboards (optional)
- Container of water - 1 per class
- Extra napkins
- Trash bag

Time

20-45 minutes (as time allows)

Procedure

1. Find a location where students can sit quietly and observe the landscape independently for a few minutes. The amphitheater at the start of the Bluff Trail is an excellent location. Here students can spread out and sit quietly, then come back together at the amphitheater seating to share and discuss the colors they observed in the landscape.

Ask probing questions including:

- Is the landscape a single color?
- Are there different shades of the same color?
- What do you think is making the landscape the colors we see?

Discuss what makes the various colors we see in the landscape. Explain that by using the skill of observation, we can see much more than simply glancing or quickly looking at a location. Colors can reveal much about the geology of an area. Geologists often use colors as one characteristic to identify the rocks in an area.

2. Students are given small postcard sized watercolor paper, clip boards, a watercolor set, paintbrush, and small container of water. Students should find a quiet place to view the landscape and paint what they observe. Particular attention should be paid to the colors. Take a few moments to help students understand some watercolor techniques which might make blending colors more successful.

Watercolor Technique

Figure 9. Watercolor examples using colors that you may find at the Lake Mead National Recreation Area.

Earth colors - Blends of yellows, oranges, and red will create earthy browns and add warm light to rock landscapes and distant cliffs and mountains. Blues, grays and violets will cool down your browns and earthy blends.

Water colors - The reflective quality of water makes it both difficult to paint and spectacular. Large bodies of water reflect the color of the sky. Greens, blues and grays will mix on wet paper to create beautiful colors of water. Use pinks and oranges for sunset and sunrise reflected water. Remember, landforms often take on a mirror image in calm water. Also remember to observe the direction the water is moving and use similar brush strokes.

Sky colors - At Lake Mead, the sky can offer an array of extreme colors from vibrant blues and ominous grays to soft pinks and reds. Use a wet-on-wet technique (paint with a wet brush on wet paper). Begin with a wet paper, load your brush with plenty of water and blue paint. Apply the paint in large horizontal brush strokes from one edge of the paper to the other edge. Add darker colors to create cloud shapes with soft edges.

Section 3 – Classroom Activities

Figure 10. Students participating in an activity at the Lake Mead National Recreation Area (NPS Photo).

Pre-Field Trip Classroom Activity

Topo Map Scavenger Hunt

Teacher Materials

Overview

This activity is designed to review and strengthen students' understanding of maps and map features, particularly, maps used by geologists. Students will investigate Lake Mead National Recreation Area using two types of maps: Topographic and Geologic Maps.

Materials

- Examples of maps (gathered from a variety of locations)
- Topographic map of Lake Mead (provided in Student Materials) - 1 per student or projected for class
- Yarn – students will use this to estimate mileage
- Scissors – to cut the yarn
- Geologic map of Lake Mead (provided in Student Materials) - 1 per student or projected for class
- Topo Scavenger Hunt (provided in Student Materials) - 1 per student

Topographic Map - A map which uses contour lines to show elevation as a way to visualize the surface of the earth.

Geologic Map – A map that shows the distribution of different types of rocks, as well as the locations of geologic structures such as faults and folds.

Procedure:

1. Students are shown samples of different maps (i.e. road maps, star maps, world maps, maps associated with new stories, etc.) and they brainstorm what information the maps are giving them. Facilitate a discussion about maps. Consider the following:

   - Why did people start creating maps?
   - Why do we have different kinds of maps for the same location?
   - Why can't a single map show all the information about a location?
   - What other things can be found on a map?

Students should conclude that different types of maps have advantages and disadvantages in giving information about a location. It is not possible to give all the information about a location on one single map.

2. Students are shown a topographic map of Lake Mead National Recreation Area. Students are asked what they think the map is showing. Topographic maps show three-dimensional features on a flat piece of paper or surface using contour lines. Contour lines reveal the elevation of a place. Lines close together show steep elevations (hills, cliffs, mountains) and lines further apart show a flatter elevation (fields, plateaus, mesas).

   - Point out key features of maps, including the key. Review the key for the Lake Mead Topographic maps, including what the arrow pointing up maps (north). Inform students they will be answering questions about this map and the Bluffs Trail shown on the map. Let students know the Bluffs Trail is the trail they will be visiting on their field trip. Also inform students they will be using a cut piece of yarn to measure the distance of the trail. Discuss why using yarn to measure distance might be better than a ruler (the trail is not a straight line and yarn will provide a more accurate answer. A ruler or straight line would provide a more general estimate.)

3. Introduce students to the map showing geologic features (types of rock). This is a good opportunity to review the three types of rock: sedimentary, metamorphic, and igneous. Geologic features are shown on maps as colors, lines, or special symbols.

4. Different colors might represent different types of rocks and rock ages. Geologists use geologic maps to help them understand the past, present, and future of land. Facilitate a discussion about geologic maps. Include the following:

   - How would you know by looking at rocks that a volcano had erupted in the area in the past?
   - How can knowing the age of rocks help you understand a location's past?
   - How might the identification of rocks in a location help land managers make decisions about land use?

5. Students are given a Topo Scavenger Hunt in which they work together to find topographic and geologic features on the map. Also distribute yarn and scissors so students can cut pieces to estimate trail distance on the map.
6. Students analyze topographic and geologic maps. Students draw conclusions about the elevation changes and geologic features of the trail in preparation for their field trip. Students make predictions about what they will see in the rocks on their trip. Students might sketch the landscape they predict based on their examination of maps of the area.
7. Conclusion, students brainstorm and present a list of ways topographic and geologic maps are useful.

Figure 11. Bowl of Fire in Lake Mead National Recreation Area (NPS Photo by Andrew Cattoir)

Sedimentary Rock – Rock that forms from the layers of the remains of once living things on the earth's surface which accumulate in layers over time.

Examples: limestone, sandstone and shale.

Igneous Rock – Rock that begins formation deep within the Earth where hot molten magma rises to the Earth's surface and turns to a solid.

Examples: basalt, granite and obsidian.

Metamorphic Rock – Rock that begin as other types of rocks such as sedimentary or igneous but then are changes due to heat, pressure and fluids rick in minerals

Examples: marble, quartzite and gneiss.

Student Handouts

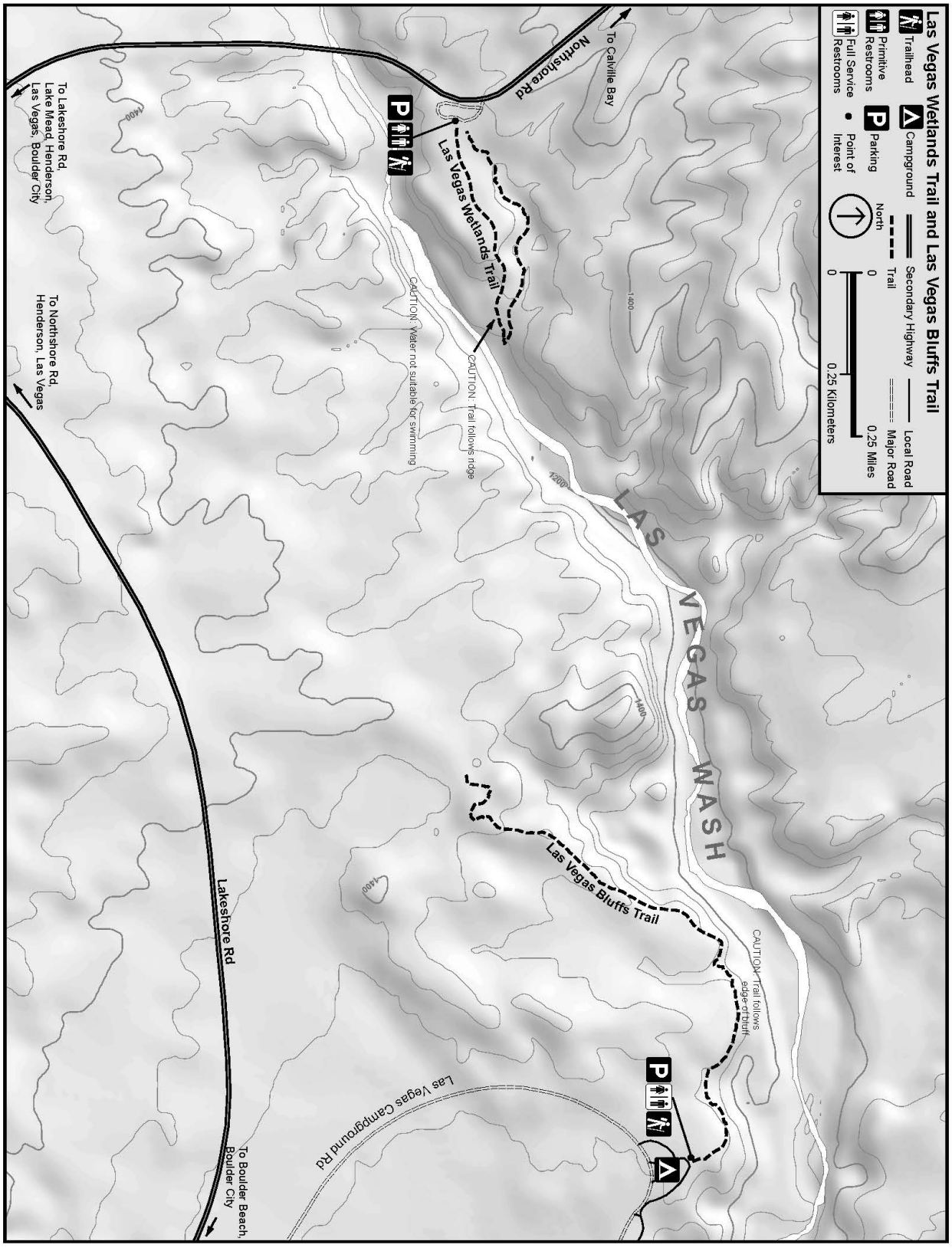


Figure 12. STUDENT HANDOUT - Las Vegas Wetlands Trail and the Ls Vegas Bluffs Trail Topographic Map courtesy of the National Park Service (NPS).

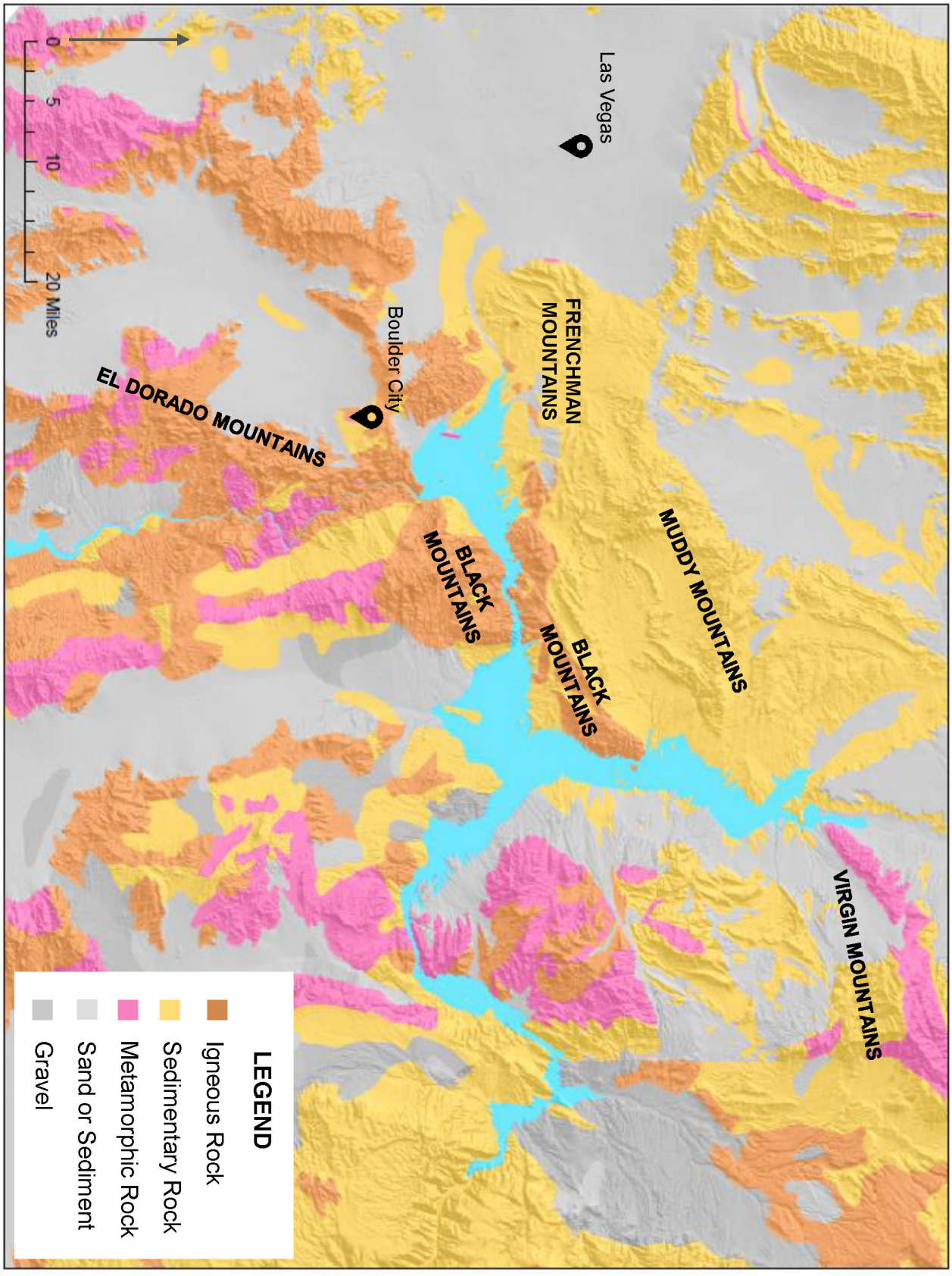


Figure 13. STUDENT HANDOUT - Geologic map of Lake Mead National Recreation Area (NPS).

STUDENT HANDOUT - Topo Map Scavenger Hunt

Directions

Use the Topographic map of the Bluffs trail and the Geology Map of Lake Mead National Recreation Area to answer the following questions. Use yarn to measure distances.

Topographic Map

(Note: Each contour line represents 40 feet)

1. Using the map's contour lines, what is the highest elevation near the Bluffs trail?
2. What is the lowest elevation near the Bluffs trail?
3. What is the difference in feet between the highest and lowest elevation?
4. When the trail ends, are you further away or closer to the Las Vegas Wash?
5. About how many miles long is the Bluffs trail? If you hike to the end and back, how many miles will you have traveled?
6. In what direction does the Las Vegas Wash go? East/West OR North/South
7. Where do you see the most climb in elevation?
    a. At the trailhead
    b. At the end of the trail
8. What is the elevation when the trail follows the edge of the bluff?
9. On your way back to the trailhead, is the Las Vegas Wash to your North, South, East, or West?
10. How many trails are shown on the map? What is/are the name(s)?

Geology Map

1. How many types of rock are represented on the geology map?
2. What type of rock primarily composes the Black Mountains?
3. What rock types do you find in the El Dorado Mountains?
4. What two ranges are primarily composed of sedimentary rock?
5. What rock types surround Boulder City?
6. What two rock types do we find North of Las Vegas?
7. What range appears to have no metamorphic rock?

ANSWER SHEET - Topo Map Scavenger Hunt

Directions

Use the Topographic map of the Bluffs trail and the Geology Map of Lake Mead National Recreation Area to answer the following questions. Use yarn to measure distances.

Topographic Map

(Note: Each contour line represents 40 feet)

1. Using the map's contour lines, what is the highest elevation near the Bluffs trail?
   - Students may need to be shown where to find the elevation numbers (1200 feet and 1400 feet) on the topo map. Discuss as needed what the 1200 feet and 1400 feet mean (number of feet above sea level).
2. What is the lowest elevation near the Bluffs trail?
   - 1160 feet
3. What is the difference in feet between the highest and lowest elevation?
   - 240 feet (these contours are near the wash water line. Students will have to follow the line that says 1200 feet and see if there is anything lower. 1400 feet - 1160 = 240 feet)
4. When the trail ends, are you further away or closer to the Las Vegas Wash?
   - Further away
5. About how many miles long is the Bluffs trail?
   - About 1 mile (there may be some variability in this answer).

   If you hike to the end and back, how many miles will you have traveled?
   - About 2 miles.
6. In what direction does the Las Vegas Wash go? East/West OR North/South
   - East/West
7. Where do you see the most climb in elevation?
   - At the end of the trail. Most of the trail follows a single contour line, which means it is mostly flat. At the end of the trail it goes between several contour lines (those contour lines are far apart, which indicates a slow rise).
8. What is the elevation when the trail follows the edge of the bluff?
   - 1280 feet (students may need help identifying and following the contour line)

9. On your way back to the trailhead, is the Las Vegas Wash to your North, South, East, or West?

   - North – it is always to the north of the trail no matter which direction you are headed.

10. How many trails are shown on the map? What is/are the name(s)?

    - Two. Las Vegas Bluffs Trail and Las Vegas Wetlands Trail.

Geology Map

1. How many types of rock are represented on the geology map?

   - Three - This is a tricky questions because sand/sediment/gravel are not types of rock. They are usually mixes of rock. The three types of rock are igneous, sedimentary, and metamorphic.

2. What type of rock primarily composes the Black Mountains?

   - Igneous

3. What rock types do you find in the El Dorado Mountains?

   - Igneous and Metamorphic

4. What two ranges are primarily composed of sedimentary rock?

   - Frenchman and Muddy Mountains

5. What rock types surround Boulder City?

   - Sedimentary and Igneous

6. What two rock types do we find North of Las Vegas?

   - Sedimentary and Metamorphic

7. What range appears to have no metamorphic rock?

   - Muddy Mountains

Pre-fieldtrip Classroom Activity

Walk the Line

Teacher Materials

Overview

In this activity, students take up positions in a line to create a geologic timeline for southern Nevada and the Lake Mead National Recreation Area.

Materials

- Rock Types (1 per student - students will bring this page on the field trip with them. May be helpful to laminate)
- Geologic Time Scale Cards - 1 set per group of 12 students
- Timeline (8.5"x11" version - either print as many copies as there are groups and tape to the wall or project for all the students to see)

Background Information

Geologic History

The rock formations that surround lakes Mead and Mohave tell the story of spectacular geologic events. These stories are revealed as if in chapters in a book, each one building on the last and leading to the next. From shallow seas that covered today's dry and barren desert to cataclysmic volcanic activity, this land has been transformed by stretching, pulling, and cutting to create the landscape we see today. It was also these events that set the stage for a river to be born. While mountain building and volcanic activity have ended, geologic processes such as erosion and deposition continue to transform the landscape.

The geologic story of the landscape surrounding lakes Mead and Mohave began more than a billion years ago when this area was a shallow sea.

Sediments from this ancient ocean were invaded and contorted by molten rock, some of which made it to the surface as lava flows. The mix of molten rock, sediments and lava cooled to become the 1.7-billion-year-old gneiss, schist, and granite as seen at places like Saddle Island. These are among the lake's oldest rocks, forming the bedrock upon which all future deposits occur. When considering the geologic history as a book with chapter, this "bedrock" history marks the long prelude to chapter one in the geologic story.

Ancient Seas and Ancient Sands – Chapter 1

In the Precambrian era (4 billion years ago to 570 million years ago) our planet looked quite different. The region just to the west of Lake Mead was the edge of the continent of what would eventually become North America. Southern Nevada was covered by a shallow sea, there was only rock and sand in varying forms, plants and animals were yet to exist. The coast would have looked like barren sand where it meets the seas.

By 650 million years ago most of North America had been planed off through erosion to a nearly flat surface with some areas of gently rolling hills. Over the next 250 million years, this sea expanded and retreated move than times in the area where Lakes Mead and Mohave now lie, creating what would eventually be the sedimentary rocks and strata we see today.

Figure 14. Basin and Range. (Photo by NASA)

About 560 million years ago, as the shoreline moved eastward, the water in the Lake Mead region became deeper and deeper allowing finer and finer sediments to deposits. This Tapeats beach sand was eventually covered with fine silt and clay that later hardened to siltstone and shale. Off-shore shoals and reefs became home for the teeming plant and animal life that were established in the Lake Mead region. During these sea level changes countless calcium carbonate skeletons accumulated layer upon layer on the sea bottom. The gradual sinking of the sea bottom kept pace with skeletal accumulation, so the sea remained shallow while the sediment pile below got thicker and thicker. Burial converted the calcium carbonate skeletons to layered limestone and dolomite rock which is up to 2,000 meters (more than 6,000 feet thick) at Lake Mead.

260 million years ago, plate tectonics affected all land masses. Evidence for this plate tectonic upheaval is recorded in the rocks formed during the Permian Period at what was to be Lake Mead National Recreation Area. Mountains formed when South America and Africa collided with North America, lifting the land so that the shallow seas that had covered the west for much of the previous 300 million years receded. Sediment eroded from the newly uplifted ancestral Rocky Mountains was deposited in this area by a large system of rivers.

Over the next 200 million years, marine conditions eventually gave way to continental forest, river, mud flat, flood plain, lake, and dune environments. Gravel, sand, and silt deposited in these environments eventually hardened to form conglomerate, sandstone, and siltstone. Volcanic ash preserved in these sedimentary rocks provides evidence of explosive volcanic eruptions associated with plate collision continuing to the west. The

region must have been covered by great forests during the time these sediments were deposited because certain layers contain petrified wood nearly everywhere they are found.

As the climate became increasingly arid, some of the sediment was transported from the riverbeds by wind and deposited as large dune fields. Minute quantities of iron in these stream and dune deposits gradually oxidized, turning them a distinctive brick-red color - geologists call these 'red beds'.

Remnants of the red dunes can be seen today in the magnificent and brightly colored Aztec sandstone seen in the Bowl of Fire, Red Stone Picnic Area, and other formations dotting the lake's landscape.

Stretch – Chapter 2

About 50 million years ago a widening deformation, called the Basin and Range province, began stretching this area, eventually doubling its size. Imagine slowly pulling apart a ball of pizza dough until the middle eventually drops down creating a "valley." The thinning and cracking nearby eventually caused splitting of the Earth's crust and enormous blocks began to break off, rotate, and slide along faults. Over a period of millions of years, various north/south fault lines came and went, creating the unique and plentiful north-south oriented mountain ranges in Nevada we see today.

Figure 15. The stretching of the land can be compared to the stretching of pizza dough. Some parts may get thin wand form a "hole" where magma can push through.

Some of these fractures became paths for hot magma to rise and what happened next would be the most dramatic yet.

Boom! – Chapter 3

Volcanic activity in the area began slowly about 20 million years ago. The frequency of eruptions increased with the thinning caused by the "stretching" and extensions of the crust. About 13 million years ago volcanic activity in southern Nevada literally exploded, forming the volcanic landscapes of Lake Mead NRA. The stretched-thin crust allowed magnesium-rich magma and basalt to pour to the surface, creating the prominent, dark basalt-capped mesas of Fortification Hill and Callville Mesa.

Also in that era, magma pushed the Colorado Plateau to its highest point and a giant volcanic caldera erupted near present-day Hoover Dam, contributing to the rhyolitic ash-flow tuffs that can be seen as pinkish, bubbly rock forming the sides of the Black Canyon along Lake Mohave and scattered along the Bluffs Trail.

Over time, this dramatic chapter of land formation quieted, paving the way for water to cut through cliffs and collect, forming small lakes or playas in low-lying areas. This would change the terrain forever.

Figure 16. This image shows the Miocene-age basalt flows that form the Black Mountains and the Boulder Basin of Lake Mead (Fortification Hill is in the middle). These volcanic flows occurred before the modern Colorado River (Grand Canyon) drainage system.

The Birth of a River – Chapter 4

As described in "Stretch – Chapter 3" above, much of the topography we see today is a result of the Basin and Range deformation, which is a wide-rift that contains many different valleys within the rift.

Although the Colorado Plateau began rising about 50 million years ago, it reached its highest point about 5 million years ago when the magma gave a final push upwards. As the deformation ended, water collected in low areas to form small lakes, which filled and spilled over, ran down along fractured areas, and into the next basin, resulting in down-cutting, until a uniform river gradient was achieved. Eventually, the Colorado River began a steady directional flow towards the Pacific Ocean.

The constant wearing down of the rock by this ancient river removed basin sediments, further exposing millions of years of geologic history. This process of erosion formed the Grand Canyon (the southern-most tip of which touches Lake Mead National Recreation Area), and many other canyons along the way including Boulder Canyon (a canyon that divides the Black Mountains of Nevada and Arizona, located above current day Hoover Dam and is now covered by Lake Mead) and the Black Canyon (located below the modern-day Hoover Dam, which is an incredible place for kayaking).

This ushered in an era of cutting down the terrain and eroding away the land.

Epilogue

The long geologic history of the area surrounding lakes Mead and Mohave is not yet a complete story – as long as the earth exists, the story will continue. Although faults continue to shape the land, today, erosion and weathering are dominate forces, cutting down the landscape. Students can see these forces in action as they visit the Bluffs Trail at Lake Mead.

New variables are also always being introduced, such as human impact and climate change. These additions will likely complicate the tale of our landscape. Only time will reveal the new chapters which will be written in the stone.

Timeline

Ancient Seas & Sands
(Chapter 1)
500 MYA – Shallow seas deposited sediments to eventually form limestone, shale, and sandstone.

Stretch
(Chapter 2)
17 MYA – Basin and range formation stretched out, many fault lines also formed pushing up mountains in a N-S orientation.

Boom!
(Chapter 3)
13 MYA – Ongoing stretching thinned the crust and allowed magma to reach the surface as well give a final push up of the Colorado Plateau.

Birth of a River
(Chapter 4)
5 MYA – Water accumulated in small lakes, overflowed, ran downhill, and combined, eventually forming the Colorado River.

Epilogue
Modern Day
Although there are still active fault lines pushing land upwards, erosion is a dominating force in today's landscape.

Procedure

1. Tape onto the wall or project the 8.5" x 11" version of the Timeline so all students can see it. Review the geologic history of Lake Mead with the students. They are reminded that the Lake Mead area's geologic story is nearly two billion years old. Evidence of past climates and environments are hidden in the multicolored rocks that surround them in the landscape. Ask the students to consider How you can tell a rock's age? How can you tell a person's age?

   There are different cues you can use, and sometimes one method is more accurate then another. More than one method is typically used to triangulate or confirm information. For example, if you stand a child next to their grandparent, you know the child is younger relative to their grandparent through different clues: often (but not always) the child is shorter, often the child has less wrinkles, the child's voice sounds different (higher pitch), and the words the child uses are less mature.

   Scientists use a variety of different clues to date rocks as well. One way is by comparing rocks that are adjacent or nearby. Since earth's material forms rock over time, the rock builds up in layers. Therefore, the older rocks are often (but not always) on the bottom of the layers and the younger rocks, the rocks that have formed more recently, are on top of the older rocks. This geologic concept is called relative dating.

   Geologists can also use radiometric dating – which is looking at the presence of radioactive isotopes in the rocks. The isotopes decay or break down in a predictable way, which can be used to help determine age. But, like our analogy of comparing a child to an adult, factors can impact accuracy. For example, fault zones and crumpling of the earth's crust can place an older layer above a younger layer, so the relative dating would be inaccurate in that example. Or, rocks can be pushed down into the mantle and reform or re-emerge, which can alter the presence and proportion of radiometric isotopes.

   Other common methods geologists use include faunal succession, when the presence of certain fossil species is used to date rocks, paleomagnetism, which looks at the changes in magnetic polarity (currently the earth's magnetic polarity causes compasses to point to magnetic north, but the earth's magnetic polarity has flipped and shifted in the past).

   Using a combination of methods gives geologists a general idea of how old rocks are in a location. Geologists know that the landscape surrounding Lake Mead is approximately 1.7 billion years old.

2. Students are given cards or lanyards with a specific geologic timeperiod within a range of 1.7 billion years ago (BYA) to 5 million years ago (MYA) and a description of their timeperiod. There are 12 cards, so break students into groups of 12. If there are fewer students per group then some students can read more than one card. Tell the students to orient themselves in time. Once the human timeline is created, students read their cards out loud. : When their card asks what kinds of rocks are being formed, students

can refer to the geologic map from the Topo Map Scavenger Hunt and/or the Rock Types hand out. The Rock Types handout will help familiarize the students with the rock types they will see on the Bluffs Trail and can be used on the field trip. Students continue reading their cards until the newest timeperiod is read.

3. Students can speculate about what happened before this range in time and what might happen in the future, geologically.

4. Have students refer to the geologic map from Activity 1 "Topo Map Scavenger Hunt." Have each of them identify which rock and Lake Mead land formation their time period most likely formed. You may want to write the following information on the board:

   + sedimentary rock (formed in ancient oceans) = limestone & sandstone

   + metamorphic rock (formed under great pressure underground) = schist & gneiss

   + igneous rock (formed from molten lava) = basalt & granite.

Student Handouts – Timeline

Ancient Seas & Sands

(Chapter 1)
500 MYA –
Shallow seas deposited sediments to eventually form limestone, shale, and sandstone.

Stretch

(Chapter 2)
17 MYA – Basin and range formation stretched out, many fault lines also formed pushing up mountains in a N-S orientation.

Boom!

(Chapter 3)
13 MYA –
Ongoing stretching thinned the crust and allowed magma to reach the surface as well give a final push up of the Colorado Plateau.

Birth of a River

(Chapter 4)
5 MYA – Water accumulated in small lakes, overflowed, ran downhill, and combined, eventually forming the Colorado River.

Epilogue

Modern Day
Although there are still active fault lines pushing land upwards, erosion is a dominating force in today's landscape.

Student Handouts – Rock Types

Basalt - Ingeous

Granite - Igneous

Gneiss - Metamorphic

Sandstone - Sedimentary

Limestone - Sedimentary

Student Handouts – Walk the Line

(Student Geologic Scale Cards – print on cardstock, laminate, if possible, cut along dotted lines)

Precambrian (4.6 billion years ago - 570 million years ago)

Earth's atmosphere and oceans begin to form

Unicellular and multicellular life forms in the oceans.

Q: What's happening at Lake Mead?

A: Southern Nevada is covered in a shallow sea. (What types of rocks are being formed and where are they showing up on the Geologic Map of Lake Mead?)

Paleozoic (570 million years ago - 245 million years ago)

- Life flourishes: first invertebrates, then fish, amphibians, and reptiles
- Fungi appears
- Land plants and insects
- Pangaea forms

Q: What's happening at Lake Mead?

A: The shallow sea covering southern Nevada expands and retreats several times. (What types of rocks are being formed and where are they showing up on the Geologic Map of Lake Mead?)

Triassic (245 million years ago - 208 million years ago)

- Beginning of the Mesozoic - Age of Reptiles
- 1st dinosaurs appear and then dominate
- Pangaea begins to crack
- 1st mammals appear

Q: What's happening at Lake Mead?

A: The shallow sea is retreating and forming the western edge of North America. Shallow rivers, ocean shorelines, and distant volcanoes dot the landscape. The limestone and shale formations we see today are created as the remains of plants and animals that lived and died on the sea's shores are mixed with sediments eroded from older rocks. (What types of rocks are being formed and where are they showing up on the Geologic Map of Lake Mead?)

Jurassic (208 million years ago - 144 million years ago)

Dinosaurs continue to dominate 1st birds appear Continents break apart and begin to drift

Q: What's happening at Lake Mead?

A: A sea of sand now covers the region and howling winds lift that sand into the air, blow it around, and create enormous dunes. Remnants of the dunes can be seen today in places such as the Bowl of Fire and other formations dotting the Lake's landscape.(What types of rocks are being formed and where are they showing up on the Geologic Map of Lake Mead?)

Cretaceous (144 mys - 65 mya)

- Large dinosaurs roam the earth
- Extinction event

Q: What's happening at Lake Mead?

A: Sand and rock continue to build up the landscape. (What types of rocks are being formed and where are they showing up on the Geologic Map of Lake Mead?)

Paleocene (65 mya - 57 mya)

Begins the Tertiary Period of the Cenozoic Era: the "Age of Mammals" - this is the Era we are in today.

Q: What's happening at Lake Mead?

A: Sand and rock continue to build up the landscape. (What types of rocks are being formed and where are they showing up on the Geologic Map of Lake Mead?)

Eocene (57 mya - 36 mya)

Mass extinction event

Q: What's happening at Lake Mead?

A: Sand and rock continue to build up the landscape. (What types of rocks are being formed and where are they showing up on the Geologic Map of Lake Mead?)

Oligocene (35 mya - 23 mya)

Mammals continue to dominate the planet

Q: What's happening at Lake Mead? (What types of rocks are being formed and where are they showing up on the Geologic Map of Lake Mead?)

A: Sand and rock continue to build up the landscape.

Miocene (23 mya - 5 mya)

Grasses begin to cover the surface of Earth

Q: What's happening at Lake Mead? (What types of rocks are being formed and where are they showing up on the Geologic Map of Lake Mead?)

A: Around 17 mya the earth's crust begins to stretch and thin. Rocks slide along large faults, mountains are lifted up while valleys drop down, forming the familiar basin and range topography we see today. Some of these fractures become paths for hot magma to rise up and... BOOM! Volcanoes erupt for thousands of years again changing the landscape.

Pliocene (5 mya - 1.6 mya)

1st hominids

Q: What's happening at Lake Mead? (What types of rocks are being formed and where are they showing up on the Geologic Map of Lake Mead?)

A: As the dramatic episode of volcanoes and fractures quiets, a last layer of hot magma spreads across the landscape creating the iconic dark basalt-capped mesas of Fortification Hill and Callville Mesa. This rock layer paves the way for water to cut through cliffs and collect in small lakes. As these lakes fill and spill over, they run down along fractured areas, and into the next basin until a river wears a path through the rocks. The birth of the Colorado River marks the end of a long era of building up the mountainous landscape and has ushered in a time of cutting down the terrain and eroding away the land.

Holocene (.01 mya– Today)

Humans continue to dominate the planet

Q: What's happening at Lake Mead? (What types of rocks are being formed and where are they showing up on the Geologic Map of Lake Mead?)

A: Today, weathering continues to cut down the landscape and erosion further breaks down the earth's crust. New variables are always being introduced, such as human impact and climate change. These additions will likely complicate the tale of our landscape and only time will reveal the new chapters which will be written in the stone.

Pleistocene (1.6 mya - .01 myaie10,000 years ago)

- 1st humans
- Ice Age begins

Q: What's happening at Lake Mead? (What types of rocks are being formed and where are they showing up on the Geologic Map of Lake Mead?)

A: The Colorado River continues to weather and erode the land as it makes its way to the sea.

Post-fieldtrip Classroom Activity

WebQuest: Lake Mead's Geology from Different Angles

Overview

This is an inquiry-oriented activity designed to introduce students to geology, landforms, geologic processes, and geology careers through an online web-quest. Students work in groups of four with each team consisting of a cartographer, geologist, and geomorphologist.

Geologist - A scientist that studies the Earth, the materials it is made of, and the processes that build up, break down, and change those materials. Geologists are also interested in how Earth's materials, structures, processes, and organisms have changed over time.

Geomorphologist - A geologist that studies Earth's landforms and is interested in how Earth's surface is changed by rivers, mountains, oceans, air, and ice.

Cartographer - A cartographer uses multiple disciplines such as art, math, and science to graphically represent an area on a flat surface such as a map. Modern cartographers rely heavily on satellite images and aerial data (like infrared or LIDAR) to depict a place on a map or chart.

Materials

- Job Descriptions - 1 per team
- WebQuest Task Cards - 1 per group
- Access to internet

Procedure

Students are put into teams of three and are told they will be going on a WebQuest in which they will gather information about the geology, landforms, and geologic processes at Lake Mead National Recreation Area (NRA) in preparation for their upcoming field trip. For the WebQuest, each team will be given a task in which they are given a geologic feature or landform at Lake Mead NRA to research.

1. Each member of the team will assume the role of a geology professional (specialist): Cartographer, Geologist, Geomorphologist. Students should read through the job descriptions to see what job best suits them.

2. Distribute 1 task card to each team.
3. Team members use the internet to complete their task.
4. Teams present their findings.

Student Handouts – WebQuest: Lake Mead's Geology from Different Angles

Job Descriptions

Geologist

A scientist that studies the Earth, the materials it is made of, and the processes that build up, break down and change its surface features. Geologists are also interested in how Earth's materials, structures, processes, and organisms have changed over time.

- Is this the specialty for you?
- Geologists love to collect rocks and minerals, are curious about phenomena such as volcanoes and earthquakes and are not afraid to play in the dirt and mud. Geologists are interested in past life such as dinosaurs.

Geomorphologist

A geologist that studies Earth's landforms and is interested in how Earth's surface is changed by rivers, mountains, oceans, air and ice.

- Is this the specialty for you?
- Geomorphologists, like all geologists, love to collect rocks and minerals, are curious about phenomena such as volcanoes and earthquakes and are not afraid to play in the dirt and mud. Geomorphologists also find themselves watching the weather channel and are fascinated by weather events such as floods and natural disasters such as earthquakes.

Cartographer

A cartographer uses multiple disciplines such as art, math, and science to graphically represent a geographic area on a flat surface such as a map. Modern cartographers rely heavily on satellite images to depict a place on a map or chart.

- Is this the specialty for you?
- Cartographers are creative. They would rather sketch than write words and sentences. They have a keen sense of direction and tend to pay attention to details. Cartographers might see maps as artwork and have fun playing on google Earth and are comfortable using map apps and the computer for drawing.

WebQuest - Task Cards

Each task is a location at Lake Mead National Recreation Area with a particular geologic significance. Students will research their task location. Each specialist will have a task associated with their location.

Task #1 Redstone

Geologist

- What is it?
- Describe what it looks like. Sketch its major features.
- What is made of? What color is it? Why is it that color? Describe the composition.

Geomorphologist

- How did it form?
- How old is it?
- What processes are in play which may change its features?
- Describe what it looks like. Sketch major features that show processes that shaped it.

Cartographer

- Where is it located?
- Draw a map with its location and other major landforms, roads, trails, and locations near it.

Task #2 Fortification Hill

Geologist

- What is it?
- Describe what it looks like. Sketch its major features.
- What is made of? What color is it? Why is it that color? Describe the composition.

Geomorphologist

- How did it form?
- How old is it?
- What processes are in play which may change its features?
- Describe what it looks like. Sketch major features that show processes that shaped it.

Cartographer

- Where is it located?
- Describe what it looks like. Sketch its major features.
- Draw a map with its location and other major landforms, roads, trails, and locations near it.

Task #3 Lava Butte

Geologist

- What is it?
- Describe what it looks like. Sketch its major features.
- What is made of? What color is it? Why is it that color? Describe the composition.

Geomorphologist

- How did it form?
- How old is it?
- What processes are in play which may change its features?
- Describe what it looks like. Sketch major features that show processes that shaped it.

Cartographer

- Where is it located?
- Describe what it looks like. Sketch its major features.
- Draw a map with its location and other major landforms, roads, trails, and locations near it.

Task #4 Las Vegas Wash

Geologist

- What is it?
- Describe what it looks like. Sketch its major features.
- What is made of? What color is it? Why is it that color? Describe the composition.

Geomorphologist

- How did it form?
- How old is it?
- What processes are in play which may change its features?
- Describe what it looks like. Sketch major features that show processes that shaped it.

Cartographer

- Where is it located?
- Describe what it looks like. Sketch its major features.
- Draw a map with its location and other major landforms, roads, trails, and locations near it.

Task #5 Muddy Mountains

Geologist

- What is it?
- Describe what it looks like. Sketch its major features.
- What is made of? What color is it? Why is it that color? Describe the composition.

Geomorphologist

- How did it form?
- How old is it?
- What processes are in play which may change its features?
- Describe what it looks like. Sketch major features that show processes that shaped it.

Cartographer

- Where is it located?
- Describe what it looks like. Sketch its major features.
- Draw a map with its location and other major landforms, roads, trails, and locations near it.

Task #6 Saddle Island

Geologist

- What is it?
- Describe what it looks like. Sketch its major features.
- What is made of? What color is it? Why is it that color? Describe the composition.

Geomorphologist

- How did it form?
- How old is it?
- What processes are in play which may change its features?
- Describe what it looks like. Sketch major features that show processes that shaped it.

Cartographer

- Where is it located?
- Describe what it looks like. Sketch its major features.
- Draw a map with its location and other major landforms, roads, trails, and locations near it.

Applying Knowledge: Geologic Processes and Features

Overview

In this activity, students apply what they have learned about interpreting geologic processes and identifying geologic features in other landscapes and from their fieldtrip to the Bluffs Trail.

Materials

(We recommend laminating these for re-use. The Bluffs Trail can also be laminated and students can use dry erase markers to write the numbers on the card.)

- Applying Knowledge Photograph Cards (1 set per group)
- Applying Knowledge Descriptor Cards (1 set per group)
- Bluffs Trail Formations Matching (1 card per group)
- Dry erase marker (1 marker per group)

Procedure

1. Working in small groups of 2-3, students are given a set of cards and a copy of the Bluffs Trail Formations handout (the Bluffs Formations handout can also be projected for all the students to see). Each card has a photograph of a regional landscape or geologic feature with a description of the location. Each photograph also has a matching descriptor card. The depicted features match something students have observed or learned about at Lake Mead National Recreation Area.
2. Students work together to match the photograph with the descriptor cards that best match. They will also match an agent of erosion/weathering with the photograph cards (there are multiple correct answers). Next students will write the number of the land formation in the blank square on the Bluffs Trail Formations Card.
3. When all the cards have been matched and numbers entered, students share their results and defend their matches. In some cases there are multiple answers. The answer key below has an asterisk next the “best” match. The answer key for the Bluff’s Trail Formations Card is also provided below.

Answer Key - Applying Knowledge Photograph Cards

Valley of Fire State Park – Weathering, primary agent wind (erosion and water also work here but wind and weathering are the best match)

Bryce Canyon National Park – Erosion, primary agent water (includes snow/ice) (weathering and wind also work here)

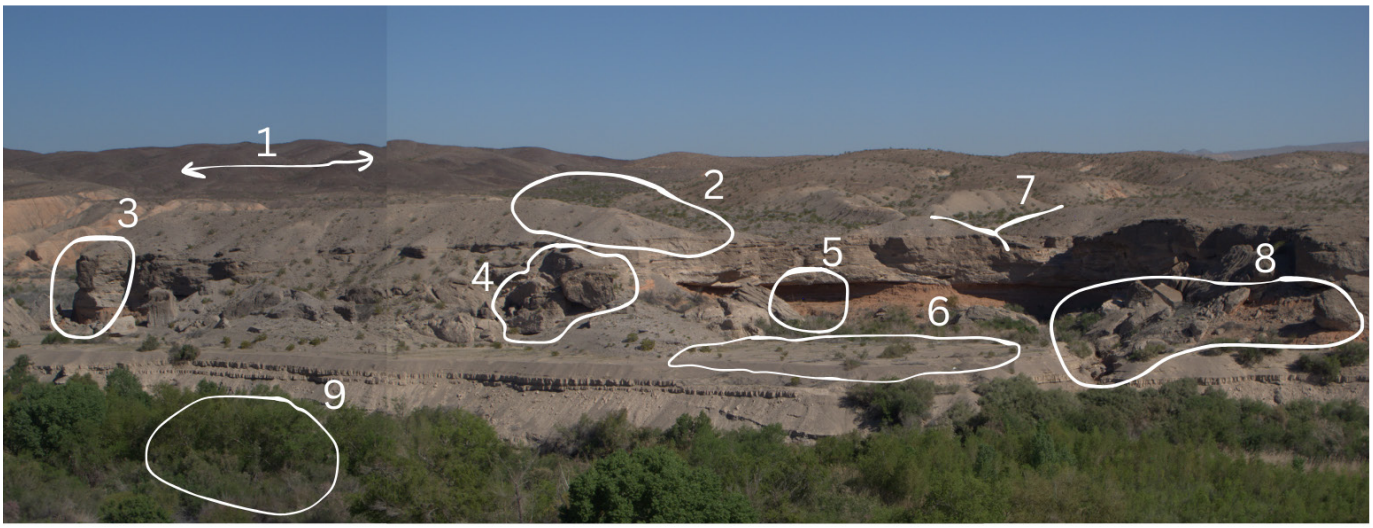
Grand Canyon National Park – River cut canyon, primary agent water (erosion and weathering are forces that are constantly acting on this too)

Oceanside, California – Mass wasting, erosion, primary agent gravity* (water also plays a role since the soil get saturated and loose)

Red Rock Canyon National Conservation Area – Dry wash, alluvium, primary agent water

Answer Key - Bluffs Trail Formations Matching

(Note: Each contour line represents 50 feet)



1. Surface
2. Slope
3. Cliff
4. Black
5. Undercut
6. Bench
7. Drainage Channel
8. Mass Wasting
9. Active Channel

* Arrow shows the direction of the above paragraph, taken from the amphitheater

Student Handouts – Applying Knowledge Activity

Photograph Cards

Valley of Fire State Park

Nevada

Bryce Canyon National Park

Utah

Grand Canyon

Arizona

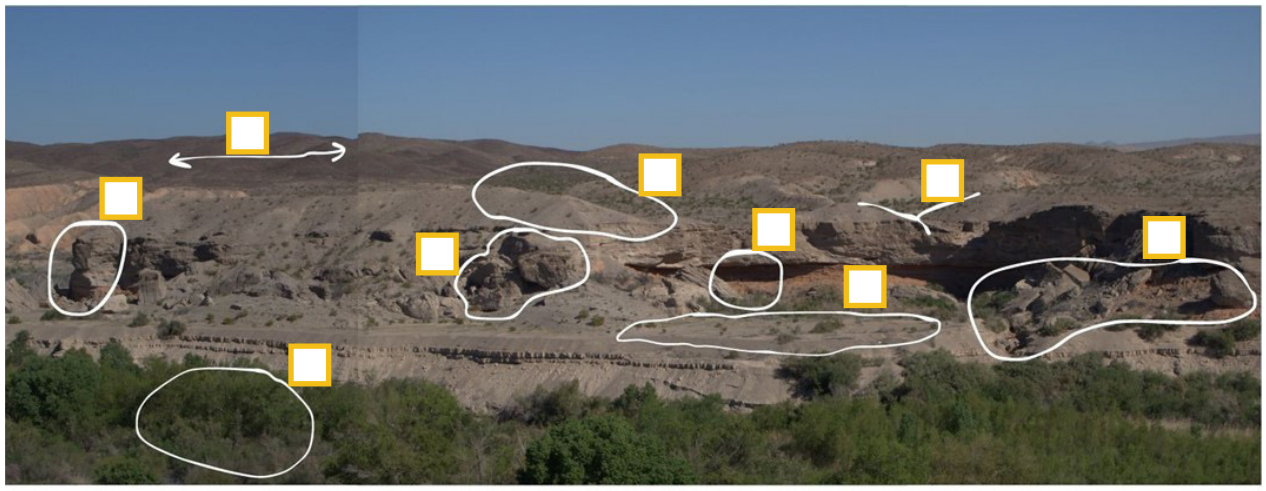
Oceanside

California

Red Rock Canyon

Nevada

This is a view of the field trip to the Bluff's Trail at Lake Mead National Recreation Area. Write the number 1-9 in the white square that corresponds with description. Numbers are repeated.



1. Surface
2. Slope
3. Cliff
4. Black
5. Undercut
6. Bench
7. Drainage Channel
8. Mass Wasting
9. Active Channel

* Arrow shows the direction of the above paragraph, taken from the amphitheater

Student Handouts – Descriptor Cards

Erosion

Sediment and rocks are moved by wind, water, and gravity and carried to a new location.

Weathering

Rock is broken down by wind, water, ice, plants, animals, and tectonic activity.

Mass Wasting

The movement of large slabs or pieces of rock and soil down a slope under the influence of gravity, water, ice, or erosion.

Dry Wash

A drainage area lacking water most of the year but subject to periodic flooding, intense erosion and weathering, and spectacular vegetation.

River-cut Canyon

Water creates a gradient in the land which slowly breaks down the rock creating a path which forms a river with rock and sediment walls on either side of the river's path.

Alluvium

Loosely stacked rocks with no cement or "glue" holding them together. This is common in the bottom of washes

Agent of Erosion/Weathering - Wind

Agent of Erosion/Weathering - Water

Agent of Erosion – Gravity

Slope, cliff, block, undercut, bench

Section 4 – Additional Background Information and Resources

Figure 17. Black Canyon Wilderness Area. (Photo credit NPS)

Land Acknowledgement

Lake Mead National Recreation Area occupies the ancestral, traditional, and contemporary lands of numerous Native American Tribes, who have lived on this land since time immemorial.

In the United States there are 574 federally recognized Tribes, all uniquely different, and all having sovereign status.

In Nevada, there are 27 federally recognized Tribes and 22 federally recognized Tribes in Arizona.

Many Tribal Nations are comprised of separate reservations, bands, colonies and community councils.

The Colorado River area is important to many Tribal Nations and Lake Mead NRA currently consults with 18 different Tribes. These Tribes fall under several different language groups including:

- Numic – including the Southern Paiute and Chemehuevi dialects
- Yuman – including the Mojave, Hualapai, and Yavapai
- O'odham
- Navajo (Diné)

Lake Mead NRA recognizes Native Nations, historic Indigenous communities on these lands, Indigenous individuals and communities who live here now, and those who were forcibly removed from their homelands.

Public Lands

"Public lands" is a broad term used to describe the lands and waters that are owned collectively by the citizens of the United States. These areas are managed by either federal, state, or local governments. There are also other lands beyond "public lands" that are available for public use, such as private lands that are accessible by special conservation easements or hunting/fishing permits.

The majority of public lands are managed by four federal agencies: National Park Service (NPS), U.S. Forest Service (USFS), U.S. Fish and Wildlife Service (USFWS), or Bureau of Land Management (BLM). The focus and mission of each of these agencies differ and subsequently affect the way they manage the lands. The Bureau of Reclamation manages land primarily along waterways for which it is responsible.

Bureau of Land Management – The Bureau of Land Management's mission is to sustain the health, diversity, and productivity of public lands for the use and enjoyment of present and future generations

National Park Service – To preserve unimpaired the natural and cultural resources and values of the National Park System for the enjoyment, education, and inspiration of this and future generations.

U.S. Fish & Wildlife Service – To work with others to conserve, protect, and enhance fish, wildlife, and plants and their habitats for the continuing benefit of the American people.

U.S. Forest Service – To sustain the health, diversity, and productivity of the nation's forests and grasslands to meet the needs of present and future generations.

Bureau of Reclamation – To manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

How lands are managed is dependent on the agency managing those lands, the mandates set for that land, and the type of land designation defining the scope and breadth of the use and protection. For example, some lands are preserved for wildlife (e.g. refuge or wilderness), while others may allow commercial activities such as mining or grazing.

The percentage of federal lands in each state varies, with the western states having higher percentages than eastern and midwestern states. Nevada has the highest percentage of federal land in all fifty states. Of Nevada's 70 million acres of land, 56 million acres or 80.1% of Nevada is federal lands.

For more information about our nation's public lands visit https://www.doi.gov/blog/americas-public-lands-explained.

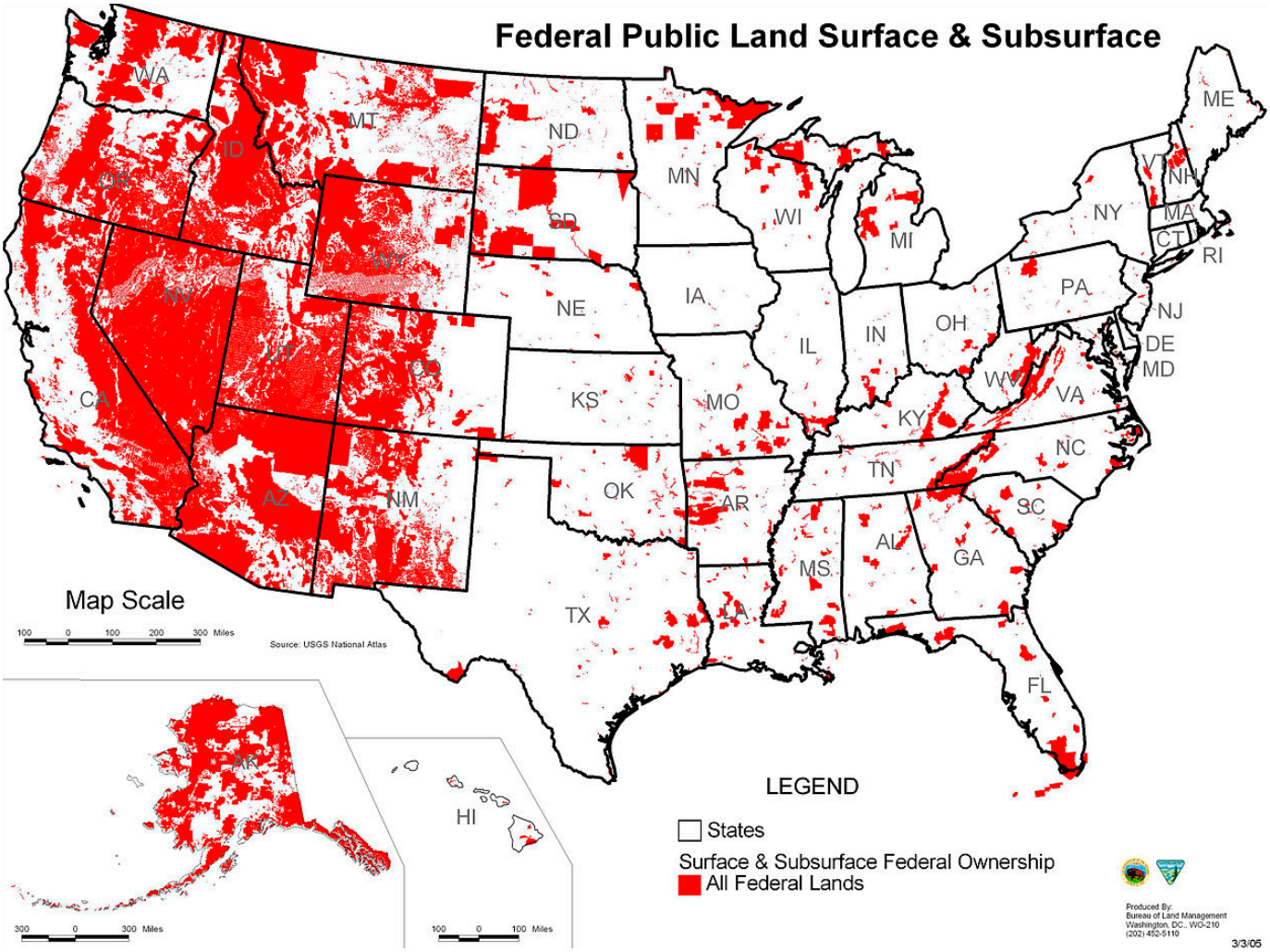


Figure 18. Map of the Federal Public Lands in the United States. (Image Courtesy of Bureau of Land Management –http://wilderness.org/blm-lands, Public Domain, https://commons.wikimedia.org/w/index.php?curid=26857120)

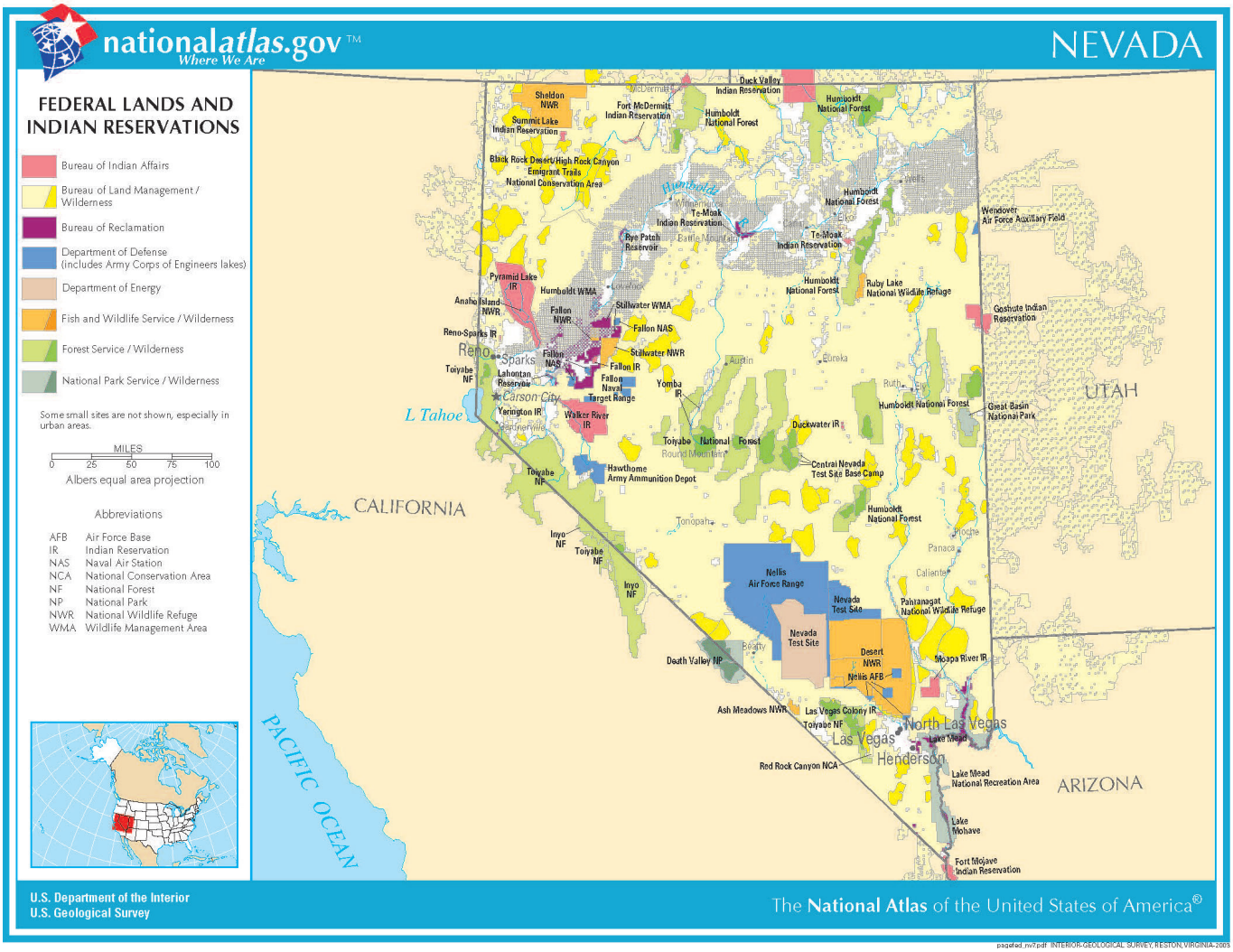


Figure 19. Map of the Federal Public Lands in Nevada (nationalatlas.gov)

Lake Mead National Recreation Area

Located east of Las Vegas, the Lake Mead National Recreation Area is a 1.5- million-acre National Park Service (NPS) site that stretches across the border of Nevada and Arizona along the Colorado River. Created in 1936 as the Boulder Dam Recreation Area, the name of the area was changed in 1947 to the Lake Mead National Recreation Area.

This man-made reservoir was formed by the creation of the Hoover Dam on the Colorado River [The Hoover Dam and the releases of water from the dam are managed by the Bureau of Reclamation (BOR)]. Lake Mead is the largest reservoir in the United States and when full, covers approximately 247 square miles with over 550 miles of shoreline.

The creation of the dam was an effort to "tame the river," providing hydroelectric power, a consistent water supply for human consumption, agriculture, and recreation, and to reduce the impacts of spring flooding due to snow thaw further upstream.

Early settlers along the river had wanted to use the river as a mechanism for moving goods from place to place, similar to how the Mississippi River was utilized. Large steamboats

Figure 20. Lake Mead National Recreation Area (NPS Photo by Andrew Cattoir). To learn more about the Lake Mead National Recreation visit: https://www.nps.gov/lake/index.htm.

attempted moving along the river with limited success. The variable water levels and rough terrain weren't suitable for using the river in this way.

In 1951 the Davis Dam (which is also managed by the BOR) was built near present-day Laughlin, Nevada and Bullhead City, Arizona, forming Lake Mohave. Lake Mohave is the second lake in Lake Mead National Recreation Area and is created from the crystal clear and cold water flowing out from the depths of Lake Mead via the Hoover Dam into the Black Canyon.

Today Lake Mead supplies water for 25 million people in Nevada, Arizona, California, and Mexico. The lake is a critical water resource for the greater Las Vegas community with over 2 million residents and nearly 43 million visitors.

Habitats

America has four desert ecosystems and three of the four meet here in the boundaries of Lake Mead National Recreation Area – the Great Basin, the Mojave, and the Sonoran Desert. At a staggering 1.5 million acres, the park hosts a wide variety of habitats and subsequently a wide variety of species. The Park has over 900 plant species, 500 animal species, 25 threatened or endangered species, and 9 wilderness areas.

Check out some of the species that call Lake Mead home:

1. In the winter months high cliffs along Lake Mead and Lake Mojave provide nesting spots for the Bald Eagle. This high vantage point provides a good view of the surrounding area as well as a close proximity to the fish they feed on. (Image from the 2014 Lake Mead NRA Eagle Survey.)
2. The chuckwalla lizard prefers the rocky, boulder laden areas of the park where they can duck quickly under or between rocks for protection (Image courtesy of Dr. Jim Boone, birdandhike.com.)
3. The Las Vegas Bearpoppy prefers the gypsum-rich soils around the Las Vegas Valley and in the Lake Mead area. Known for its hairy blue-gray leaves and bright yellow flower, this plant lives only this is area of the world and is protected by state law. https://www.nps.gov/lake/learn/nature/las-vegas-bearpoppy.htm (Image courtesy of Dr. Jim Boone, birdandhike.com.)
4. Water erosion over time has cut the narrow canyon along Lake Shore Drive known at White Owl Canyon. Here Barn Owls make their nests along the high, narrow canyon walls. https://www.nps.gov/lake/planyourvisit/hiking.htm (Image courtesy of Dr. Jim Boone, birdandhike.com.)

Figure 21. Plants and wildlife of Lake Mead National Recreation Area.

Deserts: https://www.nps.gov/lake/learn/nature/deserts.htm

Geology: https://www.nps.gov/lake/learn/nature/geology.htm

Wilderness: https://www.nps.gov/lake/learn/wilderness.htm

Wildlife: https://www.nps.gov/lake/learn/nature/wildlife.htm

Plants: https://www.nps.gov/lake/learn/nature/plants.htm

The Human Story

Indigenous Homelands

The vast and varied landscape now encompassed by the Lake Mead National Recreation Area boundaries are ancestral homelands to many Numic and Yuman speaking peoples. Spirit Mountain (Avi Kwa Ame), a sacred site to some indigenous peope, rises in the southern part of the park. Since time immemorial, these communities have used, and continue to use, the local natural materials. For example, yucca and other plants were used

to make baskets, shoes, and ropes. Other natural materials were gathered to build dwellings. And, mesquite beans and prickly pear cactus fruit were, and still are, collected for food, alongside farming.

New People

By the 1700s, Native Americans began encountering European Americans, including fur traders, explorers, and settlers who established small towns along the Colorado, Virgin, and Muddy Rivers. In 1849, the Mormons arrived and, shortly thereafter in 1867, there was the rush for gold and silver, prompting more town growth. By the early 1900s, settlers wanted protections from the Colorado River floods and a dam was proposed to regulate river flow, generate electricity, and provide water for drinking and irrigation. When Boulder Dam, later renamed Hoover Dam, was completed in 1936, many of these settlements were submerged by water. By 1941, Lake Mead reached full water pool (1,221 feet in elevation) and in 1951 Lake Mohave was formed from Davis Dam. A new generation of tourists and locals from the Las Vegas valley embraced recreation at Lakes Mead and Mohave, and a 1950s recreational "boom" began.

Shrinking Lake, Emerging History

By the year 2000, the desert Southwest began experiencing record setting droughts from climate change. While the supply of water decreased, the demand for water has increased, resulting in rapidly dropping lake levels over the past two-plus decades.

These drops have revealed remnants of historic settlements, such as St. Thomas, along with artifacts (anything over 50 years old) that range from old beer cans tossed over the side of a boat to Native American relics thousands of years old. This emerging history is giving park archeologists the opportunity to study what would have otherwise been lost. Although covered by water for many years, the critical information an object can provide remains – especially if it is not moved. For Native Americans, the sacredness of a historic site still holds strong. Thus, park visitors should leave all historic objects in place and take only pictures. This not only allows other park visitors to directly experience history, but it also enables that history to be researched and told for years to come.

The shrinking lake has also impacted access to the water and motorboat recreation. In the quest to get to the water, people drive vehicles to the new shorelines creating a crisscross of unapproved roads. Not only is this risky for the driver, as vehicles get stuck in the soft or water-saturated silt, it can also significantly disturb and damage hidden historic sites or sensitive plants and animals trying to re-establish themselves. To preserve this areas' incredible history and resources, vehicles need to remain on approved roads.

Additional Historical Resources:

History and Culture: https://www.nps.gov/lake/learn/historyculture/index.htm

Hoover and Davis Dams: https://www.nps.gov/lake/learn/historyculture/hoover-and-davis-dams.htm

Dam Workers: https://www.nps.gov/lake/learn/historyculture/damworkersandfamilies.htm

Lost City: https://www.nps.gov/lake/learn/the-lost-city.htm

Early Explorers and Settlers: https://www.nps.gov/lake/learn/historyculture/early-explorers-and-settlers.htm

Mining: https://www.nps.gov/lake/learn/historyculture/mining-history.htm

Steamboats on the Colorado River: https://www.nps.gov/lake/learn/historyculture/steamboats-on-the-colorado-river.htm

Figure 22. The old St. Thomas School House near the remnant steps that have re-emerged as the lake water levels have dropped. (Photo credit NPS)

The foundation of the St. Thomas School House, which once looked like the black and white photo, sat underwater for many years after Lake Mead filled. Due to declining water levels, the town resurfaced in 2002 (NPS Photo). For more information watch this video about St. Thomas: https://www.nps.gov/lake/learn/nature/st-thomas-nevada.htm.

Educator Resources

Ancient Seas: https://www.nps.gov/lake/learn/ancient-seas.htm

Curriculum Materials: https://www.nps.gov/lake/learn/education/classrooms/curriculummaterials.htm

Fossils: https://www.nps.gov/lake/learn/historyculture/fossils.htm

Junior Ranger program https://www.nps.gov/kids/junior-rangers.htm

Lake Mead Videos: https://www.nps.gov/lake/learn/photosmultimedia/index.htm

Soundscape: https://www.nps.gov/lake/learn/nature/soundscape.htm

Surface Project: https://www.nps.gov/lake/learn/surface-project.htm

Virtual Museum: https://www.nps.gov/lake/learn/lake-mead-virtual-museum.htm

Glossary

Sedimentary rock -Rock formed from fragments of other rocks or the remains of plants or animals.

Erosion - An act in which earth is worn away, often by water, wind, or ice.

Weathering - The breaking down or dissolving of the Earth's surface rocks and minerals.

Igneous rock - Rock formed by the cooling of magma or lava.

Metamorphic rock -Rocks that start as one type of rock and—with pressure, heat, and time—gradually change into a new type of rock.

Cartographer - A person who collects, measures, and interprets geographic information in order to create and update maps.

Mass wasting - The movement of rock and soil down slope under the influence of gravity.

Relative dating - A method of dating which estimates whether an object is younger or older than other things found at the site.

Geology - The study of the physical history of the Earth, its composition, its structure, and the processes that form and change it.

Geomorphologist - A scientist interested in the geographic features of the landscape and the forces that create them.

Geologic time - The extensive interval of time occupied by the geologic history of Earth beginning when the earth is formally recognized to have formed, 4.6 billion years ago.

Topographic map - Map showing natural and human-made features of the land, and marked by contour lines showing elevation.

Geologic map - A geologic map is a special-purpose map made to show various geological features such as rocks and minerals layers.

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