

EXAMPLE PHENOMENA AND CASE STUDIES

(Audience: formal and non-formal educators)

The following section contains examples of phenomena and case studies for potential inclusion in school curricula within Colorado. This includes considerations for locally and culturally-relevant phenomena. While many more resources exist, we added some initial resources on where to find more water phenomena, including images, video links, data links, news article links, etc.

The goal of these examples is to provide compelling anchor phenomena that could engage students from a variety of backgrounds at the beginning of a lesson or unit of study. These Colorado-specific examples could also be used in an assessment at the end of a unit. These are examples that could spark teacher/administrator interest in identifying locally-relevant water phenomena for their students.

The identification of example phenomena was a learning process as the task force discussed the most effective way to define, brainstorm and show results from the task of identifying example phenomena. Individual task force members contributed phenomena and case studies based on their expertise and interests. In addition, these examples include input from Water Education Colorado staff. These examples should be considered a first step with more work to build out this resource with support from the Water Educator Network and water educators from around the state.


Definition of Phenomena (from Colorado Department of Education):



Local, community-related phenomena engage students and make science meaningful, preparing students for life beyond school in college, in careers, and as citizens. A good phenomenon often has no one right answer, but is a specific event or connection within the natural or designed world, ideally that students can directly experience.

Consider:

- How do our example phenomena tell a bigger story?
- Whose story are we telling?
- In what ways are we incorporating connections to local and indigenous culture?
- Are we considering and elevating history?
- How and when do we introduce different topics (e.g. climate change)?
 - There are students, including very young students, who are living the reality every day (water scarcity, lack of access to water, poor water quality, impacts of climate change, etc.). These can be introduced earlier, but how they are introduced is important.

Example Phenomena and Case Studies by Critical Water Concept


CWC.I. The physical and chemical properties of water are unique and constant.		
Example Phenomena and Case Studies	Evidence Outcome (with GLE) <i>[see more Evidence Outcomes in Figures 7 and 8]</i>	Links or Other Resources
Ice dams breaking in spring	<p>Use senses to explore the properties of water by investigating changes in liquid water and solid ice when water is heated, cooled, combined etc. (SC.P.1.1)</p> <p>Develop a model that predicts and describes changes in particle motion, temperature, and state of water when thermal energy is added or removed. (SC.MS.1.1)</p>	https://youtu.be/F6_LRjBHGSU https://youtu.be/P2Qq9e2lI1o
<p>Place where water and wind went wild: Grottos, Paint Mines, Wheeler Geologic Area</p> <p>Local erosion (find a nearby spot with obvious water damage to soils)</p>	<p>Develop a model to demonstrate how water can change the shape of land. (SC.2.3.2)</p>	

<p>Aerial photos and drone footage of canyons and floodplains</p>	<p>Construct an explanation based on evidence for water's role in how geoscience processes have changed Earth's surface at varying time and spatial scales. (SC.MS.3.6)</p>	<p> https://www.moxiecranmedia.com/uploads/8/9/6/5/8965616/riogrande-june-19-2.jpg https://www.nps.gov/grca/learn/photosmultimedia/b-roll_hd08.htm https://vimeo.com/356739699 </p>
<p>Above suggestions plus Flooding - before and after shots (2013, 1965, 1933, 1864)</p>	<p>Construct an argument from evidence of how the properties of water and its effects on Earth materials and surface processes may alter dynamics within an ecosystem. (SC.HS.3.6)</p>	<p>Headwaters Magazine Summer 2014: Flooded. https://5008.sydneyplus.com/HistoryColoradoArgusNet_Final/Portal/portal.aspx?lang=en-US&p_AAEZ=tab2</p>  <p> https://5008.sydneyplus.com/HistoryColoradoArgusNet_Final/Portal/portal.aspx?lang=en-US&p_AAEZ=tab2 </p>  <p> https://www.westword.com/news/the-1965-flood-how-denvers-greatest-disaster-changed-the-city-6668119 </p>




Unique properties of water are utilized when treating water/cleaning water	Conduct an investigation to determine whether the mixing of two or more substances results in new substances by conducting water quality testing of a local waterway and observing reactions in test tubes. (SC.5.1.2)	South Platte Renew Video Tour: https://youtu.be/yX2-ZV4Cgbw Aurora Water Virtual Tour of Water Purification Facilities: https://storymaps.arcgis.com/collections/245f2bb7556a408fb24fd02842415b73?item=5 https://www.agclassroom.org/matrix/lesson/802/
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CWC.II. Water is essential for life, our economy, and a key component of healthy ecosystems.

Example Phenomena and Case Studies	Evidence Outcome (with GLE) <i>[see more Evidence Outcomes in Figures 7 and 8]</i>	Links or Other Resources
<p>Side-by-side images of a dryland farm and irrigated farm (or xeriscape and irrigated lawn) or center pivot irrigation patterns and dry land.</p>	<p>Discuss how communities allocate water resources so that all members have access. (SS.2.2.2)</p> <p>Analyze how people use geographic factors in creating settlements and have adapted to and modified the local physical environment in order to use water resources through the development of irrigation ditches/acequias (to support food production) and hardrock mining. (SS.4.2.2)</p> <p>Construct an explanation based on evidence for how the availability of water (e.g. access to fresh water in rivers, lakes, and groundwater), occurrence of water-related natural hazards (e.g. floods, droughts), and changes in precipitation related to changes in climate have influenced human activity. (SC.HS.3.9)</p>	<p>Northern Water's Conservation Gardens:</p>  <p>To juxtapose local images, consider using collage maker websites, e.g.: https://www.kapwing.com/explore/side-by-side-collage-maker Or photo comparison slider website, e.g.: https://codyhouse.co/gem/css-jquery-image-comparison-slider</p>
<p>Observing organisms nearby: Water tiger (larvae of a predaceous diving beetle, a type of insect) found in a stormwater outfall</p> <p>Growing a classroom garden that also produces food</p>	<p>Describe how habitats provide for the basic needs of plants and animals, including water, to grow and survive by observing familiar living things (e.g. a classroom pet or a classroom garden that can also produce food). (SC.P.2.1)</p>	<p>https://drive.google.com/file/d/1-d97oBUEaLAp_alzblHFv_UcjQzpBAab/view?usp=sharing</p> <p>Resources on school gardens: https://www.agclassroom.org/matrix/search_result/?search=garden</p>

CWC.III. Water is a scarce resource, limited and variable.

Example Phenomena and Case Studies	Evidence Outcome (with GLE) <i>[see more Evidence Outcomes in Figures 7 and 8]</i>	Links or Other Resources
<p>What does it mean to be a “Headwaters State?” (Image of Continental Divide sign in CO covered in snow - displays CO is Headwaters state)</p> <p>Time series of snowpack in Colorado</p> <p>Comparing population and precipitation patterns: Colorado’s human population is more concentrated on the front range and average annual precipitation is much higher west of the Continental Divide.</p>	<p>Describe how the geography of Colorado and western states differ from other regions of the United States, including the role of snowpack as a main source of water, along with more limited average annual rainfall, versus the eastern United States region where average annual rainfall is generally more plentiful. (SS.4.2.1)</p> <p>Develop and use a model to describe how unequal heating, rotation of the Earth and geographic land distribution causes patterns of atmospheric and oceanic circulation that determine regional climates and precipitation patterns in regions of Colorado. (SC.MS.3.7)</p> <p>Use a model to describe how variations in the flow of energy into and out of Earth’s systems result in changes in climate and precipitation patterns in Colorado. (SC.HS.3.7)</p>	<p>https://satelliteliaisonblog.com/wp-content/uploads/2019/03/2018_2019_modis_trend.gif</p> <p>https://www.nrcs.usda.gov/wps/portal/nrcs/detail/co/snow/products/?cid=nrcseprd1432263</p> <p>Water Education Colorado Citizen’s Guideto Where Your Water Comes From</p> <p>Colorado Foundation for Agriculture’s Colorado Reader: Where Your Water Comes From</p>
<p>Measuring precipitation (CoCoRahs)</p>	<p>Construct an argument for how the quantity of water available for plants, animals, and humans varies by major river basin in Colorado and within river basins has resulted in similarities and differences seen today. (SS.3.2.2)</p>	<p>https://www.cocorahs.org/</p> <p>Colorado Foundation for Agriculture’s Colorado Reader: Where Your Water Comes From</p>

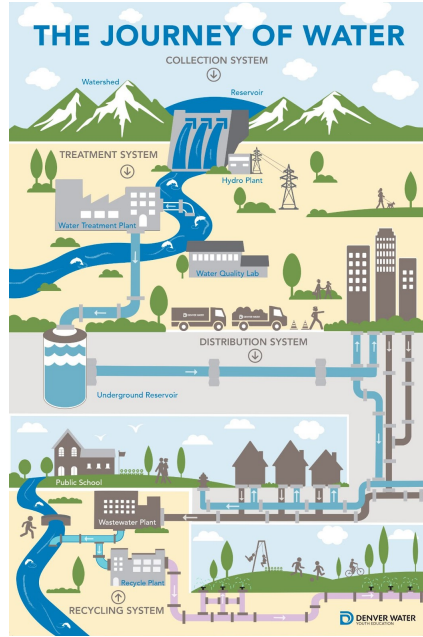
<p>Images of the Dust Bowl in Colorado</p>	<p>Explain how communities manage and use scarce freshwater resources and certain nonrenewable groundwater sources. (SS.2.2.2)</p> <p>Construct an explanation based on evidence for how the availability of water (e.g. access to fresh water in rivers, lakes, and groundwater), occurrence of water-related natural hazards (e.g. floods, droughts), and changes in precipitation related to changes in climate have influenced human activity. (SC.HS.3.9)</p>	 <p>Source: Headwaters Magazine, Spring 2019 (Science History Images/Alamy Stock Photo)</p>
<p>Video of the Colorado River and the many demands on this scarce resource. The first half of the video describes how many people and places rely on the Colorado.</p> <p>Storymaps that investigate the Colorado River and the degree to which human populations in the Western United States depend on its limited water supply.</p>	<p>Explain scarcity by giving examples of behaviors related to water and limited water (i.e., water restrictions). (SS.2.3.1)</p> <p>Determine the opportunity cost of different water allocation scenarios in Colorado, including among water users (such as agriculture, municipalities, industry, fish and wildlife, energy production, recreation, etc.). (SS.4.3.2)</p> <p>Identify, evaluate, and communicate strategies to respond to constraints placed on human systems by analyzing the scarcity and variability in available water resources in Colorado. (SS.HS.2.2)</p> <p>Explain the economic way of thinking: the condition of scarcity requires choice and choice has a cost (opportunity cost) by using Colorado's water resources as an example. (SS.HS.3.1)</p>	<p>Video: https://www.youtube.com/watch?v=mqYcC7jEe44</p> <p>Storymaps, e.g. The Hardest Working River in the West: https://storymaps.arcgis.com/stories/2efeafc8613440dba5b56cb83cd790ba?fbclid=IwAR1QxljetGs1vdLtPnOdhrEcOMFIJNjxmuntptQ9sc1ljhN-hJHZnnM3M9lw</p>



What can we learn from the people of Mesa Verde? <i>(and other regional water stories in Colorado)</i>	Explain, through multiple perspectives, how water use in each region have shaped the settlement of the state by using examples from American Indians, Spanish explorers, trappers/traders, and settlers in the mining, trading, agriculture, and industrial industries. (SS.4.1.1)	Citizen's Guide to Colorado Water Heritage "Harvesting Water" <i>(and other primary and secondary sources)</i> <i>From the same Citizen's Guide see also: "Sin Agua no hay vida" and "Mingled Waters"</i>
Where are families and communities experiencing water scarcity in Colorado and nearby?	Explain how communities manage and use scarce freshwater resources and certain nonrenewable groundwater sources (SS.2.2.2)	Roxborough Water and Sanitation District here - <i>it has enough water to supply only another 124 homes</i> Front Range housing boom sends water prices soaring (Arvada - <i>Arvada is close to maxing out its water supplies</i>). Hauling water in La Plata County - <i>In a La Plata district, 25 percent of residents have had to haul water.</i> Modern-day communal well in Ignacio: <i>Freshwater News</i> article Hauling water in the Navajo Nation .
What are some stories of water reuse that inspire hope?	Explain how communities manage and use scarce freshwater resources and certain nonrenewable groundwater sources.(SS.2.3.1) Explain how the uneven distribution of limited and variable water resources in the world can lead to conflict, competition, or cooperation among nations, regions, and cultural groups. (SS.HS.2.3)	WISE approach - effective way of making water go much further. Innovative use of water Denver developments: Use of greywater in Central Park Neighborhood Examples of water conservation in agriculture

CWC.IV Water cycles naturally through Colorado's watersheds, often intercepted and manipulated through an extensive infrastructure system built by people.


Example Phenomena and Case Studies	Evidence Outcome (with GLE) <i>[see more Evidence Outcomes in Figures 7 and 8]</i>	Links or Other Resources
<p>Historical images of different examples of humans modifying their environment in Colorado. Mesa Verde, People's Ditch in San Luis Valley, CO-Big Thompson Project, etc.</p>	<ol style="list-style-type: none"> 1. Explain that people settle in certain areas because of the need to access freshwater. 2. Explain how access to freshwater affects a community's ability to thrive. 3. Identify examples of how water draws people and wildlife to particular areas. (SS.2.2.2) 	<p>https://waterknowledge.colostate.edu/water-history/</p>
<p>Grand Valley Ditch, including the story of immigrant/migrant labor (Japanese and Mexican laborers) <i>Note: Grand Valley Ditch is a good hike for kids, too.</i></p> <p>Trans-basin diversion of water from the Dolores River to irrigate the Montezuma Valley: Students can learn how this project provides water security to the Montezuma Valley and explore impacts to the down-river ecology below McPhee dam to understand the true cost to the environment and recreation.</p>	<p>Explain how altering the environment by altering water supplies has brought prosperity to some places and created environmental dilemmas for others by examining differences between tribal nations and nontribal communities, consequences of poverty on access to clean drinking water, rural versus urban access to water, immigration/settlement and its impact on access to water resources, etc.). (SS.HS.2.2)</p> <p>Give examples of professions/jobs in the local community where individuals help plan, build and maintain water infrastructure (e.g. for producing food, cleaning and delivering drinking water, cleaning water after human use, maintaining parks and recreation opportunities, etc.). (SS.1.3.1)</p>	<p>https://publiclands.colostate.edu/digital_projects/dp/poudre-river/moving-storing/ditches-dams-diversions/grand-river-ditch/</p> <p>High Country News: Water Across the Divide</p> <p>The Dolores Project (U.S. Bureau of Reclamation): https://www.usbr.gov/projects/index.php?id=453</p>

<p>Use a pedal to pump water ("It takes work" - collaborative) and/or students can work together to set irrigation tubes</p>	<p>Design, build, and refine a device that models a watershed or municipal drinking water system to convert one form of energy into another form of energy. (SC.HS.1.9)</p> <p>Develop a model illustrating how energy (e.g. the sun and gravity) is exchanged to power the water cycle and move water from one location to another. (SC.MS.1.6)</p>	<p>https://www.denverwater.org/tap/craftsmen-pedal-journey-of-water-to-schoolkids</p>
<p>Students draw what it takes for drinking water to get to them, then see a real water system map.</p>	<p>Discuss how water contributes to the interaction of a community with their environment. (SS.2.2.2)</p> <p>Use maps to trace the paths of rivers and streams to the oceans and to identify where man made structures (cities, reservoirs, etc.) are located in relation to natural features. (SS.1.2.1)</p>	 <p>The infographic, titled "THE JOURNEY OF WATER", illustrates the water cycle in a community. It starts with a "Watershed" at the top, showing mountains and a "Reservoir". Water flows into a "TREATMENT SYSTEM" which includes a "Water Treatment Plant" and "Water Quality Labs". From there, it goes to a "Hydro Plant" and then to a "DISTRIBUTION SYSTEM" featuring an "Underground Reservoir". The water is then delivered to various locations: a "Public School", "Homes", a "Wastewater Plant", and a "Recycling Plant". The "RECYCLING SYSTEM" is shown at the bottom, with water being recycled back into the system. The Denver Water logo is in the bottom right corner.</p> <p>Example: Denver Water Education Poster Citizen's Guide to Where Your Water Comes From (HS-level resource)</p>


CWC.V. The quality and quantity of water, and the timing of its availability, are all directly impacted by human actions and natural events.

Example Phenomena and Case Studies	Evidence Outcome (with GLE) <i>[see more Evidence Outcomes in Figures 7 and 8]</i>	Links or Other Resources
Colorado's variable geology, hydrology and climate have created distinct differences in water availability and crops grown. Students can investigate the maps to find trends between geologic features and how we have utilized the land and water.	Construct an explanation based on evidence for how the availability of water (e.g. access to fresh water in rivers, lakes, and groundwater), occurrence of water-related natural hazards (e.g. floods, droughts), and changes in precipitation related to changes in climate have influenced human activity. (SC.HS.3.9)	<ol style="list-style-type: none"> 1. Colorado water source distribution 2. Colorado Cropland Map or https://nassgeodata.gmu.edu/CropScape/ 3. https://efotg.sc.egov.usda.gov/references/public/CO/CMZPrecip_1981_2010.pdf or 4. Storymap of the Gunnison River: https://storymaps.arcgis.com/stories/196d3c8b23624530b1d7b3ff9935f258
<p>This video highlights how land cover and management (particularly fire mitigation) impact water quality and quantity. Fire causes rapid land changes and has big consequences for water users. Students can use this as a jumping off point for how natural phenomena (drought, fire, disease) impact each other and who is most vulnerable.</p> <p>Grizzly Creek (Glenwood Canyon), Cameron Peak, and East Troublesome fires with recovery efforts.</p>	Analyze geoscience data to make the claim that one change to Earth's surface (loss of ground vegetation from fire, flood, aridification, etc.) can create feedbacks that cause changes to other Earth systems (increase in water runoff and soil erosion or changes in food production). (SC.HS.3.7 and SC.HS.3.4)	<p>https://vimeo.com/406250886</p> <p>Freshwater News: Glenwood Canyon fire https://www.youtube.com/watch?v=cJ4FObWWs4U</p> <p>Freshwater News Article: East Troublesome fire https://www.watereducationcolorado.org/fresh-water-news/squeezed-between-two-megafires-the-race-to-save-lake-granby/</p> <p>Northern Water: 1 year recovery efforts of East Troublesome Fire https://www.youtube.com/watch?v=Pz9Ha203hck</p>

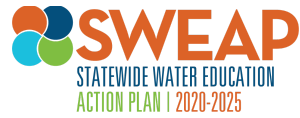
NASA Images of Change as seen from space.	See <i>example objective above</i> (SC.HS.3.7 and SC.HS.3.4)	Arapaho Glacier (up to 2003) https://climate.nasa.gov/images-of-change/?id=556#556-arapaho-glacier-melt-colorado Snow drought in the Rockies (2016 vs. 2018) https://climate.nasa.gov/images-of-change/?id=640#640-snow-drought-in-the-southern-rockies San Luis Valley stream change (1987-2011) https://climate.nasa.gov/images-of-change/?id=470#470-san-luis-valley-stream-change-colorado
Picture/video of youth involved in a stream or wetland restoration project.	Discuss how water contributes to the interaction of a community with their environment. (SS.2.2.2)	Fountain Creek Week
Side-by-side images of different farming practices (e.g. regenerative agriculture, agroforestry, traditional agriculture, etc) - connects the food we eat to water	Analyze how people use geographic factors in creating settlements and have adapted to and modified the local physical environment. This includes the development of irrigation ditches/acequias (and return flows of irrigation water to streams), farming and ranching practices, and hardrock mining in order to use, conserve, and protect water resources. (SS.4.2.2)	Activity list provided by CO Ag in the Classroom https://www.agclassroom.org/matrix/search_result/?search=garden

<p>Two Forks Dam case study: a 539-foot reservoir proposed in Cheesman Canyon at the confluence of the north and south forks of the South Platte River. <i>Note: in 1990, the Environmental Protection Agency vetoed the construction of the Two Forks Dam.</i></p>	<p>Analyze how cooperation and conflict influence the division and control of Earth by using examples from the development of Colorado's extensive water infrastructure and management systems. (SS.HS.2.3)</p> <p>Identify physical water features (e.g. transbasin diversions, irrigation canals and mountain snowpack) and the positive and negative impacts on human systems in different regions. (SS.6.2.2)</p> <p>Engage in civil discourse regarding balanced water solutions by discussing how current water issues demonstrate that the sustainability of water in quality and quantity is essential for life and our economy. (SS.HS.4.1)</p>	 <p>Two Forks Retrospective (audio)</p> <p>[Other examples around the state found in Citizen's Guide to the Environmental Era, HEADWATERS Winter 2016 or other source]</p>
<p>Algal growth in a reservoir or nearby lake (cyanobacteria)</p>	<p>Design, evaluate, and refine a solution for reducing the impacts of human activities on (and potentially providing benefits to) water quality/quantity, the environment and biodiversity (including food production, urbanization, dam construction, and dissemination of invasive species). (SC.HS.2.6)</p>	<p>https://www.watereducationcolorado.org/fresh-water-news/in-brief-high-temperatures-toxic-algae-killing-fish-in-denver-metro-area/</p>

CWC.VI. Water is a public resource governed by water law.

Example Phenomena, Case Studies, and/or Introductory Activities	Evidence Outcome (with GLE) <i>[see more Evidence Outcomes in Figures 7 and 8]</i>	Links or Other Resources
<p>Dolores Project (McPhee Reservoir) and the Animas-La Plata Project offer a cross-cultural perspective on water issues. Both projects were strongly tied to the settlement of treaty-based water rights with the Ute Mountain Ute and Southern Ute tribes.</p> <p>Specific environmental justice-related magazine or newspaper articles.</p>	<p>Research and interpret multiple viewpoints on issues that shape policies and programs for water resource use and explain how the management of water supplies has brought prosperity to some places and created environmental dilemmas for others by examining Colorado examples (e.g. differences between tribal nations and nontribal communities, consequences of poverty on access to clean drinking water, rural versus urban access to water, immigration/settlement and its impact on access to water resources, etc.). (SS.HS.2.2)</p>	<p>"Ute Water" (HEADWATERS)</p> <p>Animas-La Plata Project</p> <p>Article from Durango Herald</p> <p>"When Water Justice is Absent, Communities Speak Up" (HEADWATERS)</p> <p>"Plumbing Poverty" (HEADWATERS)</p>
<p>Image of "sweeping" the river - a senior water right holder may have the right to divert the entire flow of a stream or river at a specific location.</p>	<p><i>See example objective above</i> (SS.HS.2.2)</p>	 <p><i>Burlington Ditch sweeping the South Platte River</i></p>

Explore the use of water by miners to obtain products for human use. Consider the pros and cons of mining as a way to bring prosperity that also presents environmental dilemmas.	<i>See example objective above</i> (SS.HS.2.2)	<p>The story of John Hamilton Gregory. He searched the creeks, rivers, and streams of the Front Range and eventually found gold in what is now Gilpin County:</p> <p>https://www.coloradohistoricnewspapers.org/?a=d&d=STP19430211.2.106&e=-----en-20-1--img-txIN%7ctxCO%7ctxTA-----0-----</p> <p>This article talks about the sluice method of mining, which is what Gregory used: https://www.unco.edu/hewit/doing-history/pdf/essays/miners.pdf</p>
Early conflict between Greeley and Fort Collins over water. Greeley (downstream) was cut off from water by a new diversion for Fort Collins (upstream). The downstream user advocated for rights that the upstream user had impaired.	Analyze how cooperation and conflict influence the division and control of Earth by using examples of Colorado's water administration and treaties/interstate compacts over water resources as an example. (SS.HS.2.3)	Water War and Law (Cache La Poudre National Heritage Area)
Role-play activity	<i>See example objective above</i> (SS.HS.2.3)	<p>Example: H2O Outdoors at Keystone Science School:</p> <p>https://www.watereducationcolorado.org/publications-and-radio/headwaters-magazine/8030-2/nextgen-collaborators/</p>



<p>What does a boat ramp have to do with having enough water for fish? The genesis of instream water rights.</p> <p>Additional introductory activity: "Pass the Jug," Project WET Curriculum and Activity Guide 2.0</p>	<p><i>See example objective above (SS.HS.2.3)</i></p>	<p>Technical resources:</p> <p>https://www.watereducationcolorado.org/fresh-water-news/bill-to-expand-colorados-innovative-instream-flow-program-advances/</p> <p>https://cwcb.colorado.gov/focus-areas/ecosystem-health/instream-flow-program</p> <p>https://www.americanrivers.org/2020/04/we-are-rivers-episode-24-understanding-colorados-instream-flow-program/</p> <p>Activity Idea:</p> <p>"Pass the Jug," Project WET Curriculum and Activity Guide 2.0</p>
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