Logan: Environmental Planner
Career Pathway Lesson

Storm Water in the Community

Storm Water Career: Planner

All Careers Full- Course Lesson Plan #:
3 of 15

Next Lesson Plan Title (Full-Course):
Balancing Your Pollution Budget

Select Career Short-Course Lesson Plan #:
3 of 6

Next Lesson Plan Title (Short-Course):
Balancing Your Pollution Budget

SUMMARY

In this lesson, students will learn about watersheds and the ways in which land within a watershed affects storm water runoff.

FOCUS & GOALS

In learning about the relationship between land use and watershed health, students will:

- Describe the relationship between land use, storm water runoff, and watershed health
- Develop functional understanding of Geographic Information System (GIS) software and mapping tools

MATERIALS NEEDED

- Plain paper & water soluble markers
- Spray bottle with water
- Group Worksheet
- Land-Use Type Overlay Maps, printed on clear sheets
- Gridded Base Map, Satellite Map, & Hydrologic Map
- Calculator
- Large sponge, aluminum tray, small squares of duct tape, sand paper, & felt
- Straight pins
- PBL Track: Computer or device with internet connection to access ArcGIS Online; ArcGIS Online Student Guide; Zip files (Optional, accessible through the ArcGIS Online Student Guide)

LEARNING OBJECTIVES

- Identify the components of a watershed
- Identify and describe different land use types
- Demonstrate how land use type affects hydrology
- Evaluate the impacts of land use on watershed ecosystems

VOCABULARY

Geographic Information System (GIS) - The combination of recorded data with spatial information to produce visualizations that can be used to communicate data results, analysis, and ideas.

Land Use - The designated purpose for which an area of land is used.

Watershed - An area of land in which all water flows toward a common outlet, such as the ocean or a larger river.

Background

In our previous lesson, we explored how storm water runoff can contain a variety of pollutants, such as sediments and oil, and convey those pollutants into nearby waterways, degrading local water quality and harming aquatic ecosystems. We also discussed how urbanization exacerbates this issue because of the prevalence of impervious surfaces that prevent storm water from infiltrating into the ground. In this lesson, we focus on how Environmental Planners investigate different land uses impact storm water runoff and local water resources. These professionals map and assess land uses in our communities to adapt mitigation strategies that address unique storm water issues.

To analyze these systems, planners must first define the boundary of study: the watershed. A watershed is an area of land where all precipitation drains to a common outlet, directed entirely by the physical constraints of topography, elevation, and gravity. Mountain ridges and high points, such as the Koʻolau and Waiʻanae ranges on Oʻahu, act as natural topographical divides. Rain falling on one side of a ridgeline flows down into its respective basin, gathering into tributary streams before discharging at the watershed's lowest point. Understanding these boundaries is essential for regional planning, as any land-use activity or pollutant source within a watershed's physical boundary directly influences the water quality of its downstream receiving waters.

Once a watershed is delineated, planners must evaluate its land-use classifications, which represent designated purpose for which an area of land is used. The major categories of land use are typically urban (commercial, industrial, institutional, transportation, multi-family, single family, urban cultivated, vacant, open space), agricultural (cropland), rural (grassland and pastureland), and conservation (park lands, reserves, wilderness). Each land use type involves different kinds of activities and thus, the potential to generate different types of pollutants. Some of the main pollutants of concern in urban land uses, for example, are trash and sediment, while those for agricultural land uses include toxic chemicals and nutrients. An area's land use determines the types of pollutants that may be primarily produced and could potentially contribute to storm water pollution.

How water behaves when it hits the ground is determined by the permeability of these land-use surfaces, represented mathematically by a Runoff Coefficient, or Runoff Ratio, which is the percentage of rainfall that becomes surface runoff rather than infiltrating into the ground. In this curriculum, we simplify these into three primary land-use categories:

1. **Urban Land Use (90% Runoff Coefficient / 0.90)**: Comprised of commercial, industrial, residential, and transportation zones. These areas are heavily built out with impervious concrete, asphalt, and rooftops, which prevent infiltration and cause nearly all rainwater to immediately shed as high-velocity, high-volume runoff.
2. **Agricultural Land Use (30% Runoff Coefficient / 0.30):** Consisting of cultivated fields, crop farming, and pasturelands. While these unpaved soils absorb a significant portion of rainwater, tilled fields and compacted farm soils still generate moderate runoff, which often carries sediments, nutrients, and agricultural chemicals.
3. **Conservation Land Use (10% Runoff Coefficient / 0.10):** Encompassing state forests, natural reserves, and wilderness areas. These natural ecosystems act as giant organic sponges. Lush vegetation and undisturbed organic soils maximize infiltration, recharging local freshwater aquifers while generating minimal surface runoff.

Analyzing how storm water flows across various land-use surfaces into regional waterways is critical for identifying localized pollution sources and mitigating community flood risks. Geographic Information Systems (GIS), such as ArcGIS, are indispensable tools in this analysis, combining location data and environmental attributes into layered maps using points (exact locations like cities), lines (linear data like streams), and polygons (area boundaries like counties). By layering datasets, such as stream networks over land-use zones, analysts can easily evaluate how developed areas contribute to runoff pollution, directly informing municipal policy and storm water management regulations.

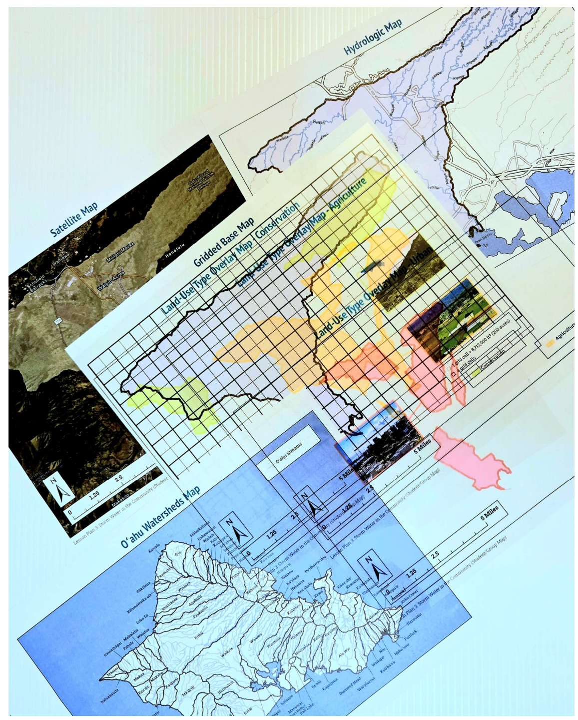
In this lesson, students bridge physical geography and mathematical modeling by exploring these spatial relationships both through an analog classroom simulation and digital mapping tools. In the classroom, students simulate professional computational modeling by stacking transparent, gridded land-use sheets over base maps to calculate the total storm water runoff for the Waikele watershed. For those continuing with the Project-Based Learning Track, this analysis expands into a hands-on investigation of their own neighborhoods. Utilizing a custom-made map and a step-by-step student guide, students will navigate GIS software to evaluate the specific land uses in and around their chosen community project site, calculating localized runoff impacts to design targeted environmental solutions.

NOTE: *The land use types of urban, rural, agricultural, and conservation given here are simplified in order to reinforce the basic concepts of land use. In reality, designating land use can be more complicated and intricate, as zoning laws and land use designation procedures vary from state to state.*

I. What is a Watershed? Activity

1. Demonstration: take a piece of paper and crumple it up into a ball, then partially un-crumple it. The peaks and valleys created by the folds will represent a mountainous landscape.
2. Use a dark-colored water-soluble marker to trace the highest peaks and connecting ridge lines on the paper. Explain that these ridge lines act as geographic boundaries that determine which way water will flow, effectively defining the edges of a watershed.
3. Use different colored water-soluble markers to color various sections of the slopes and valleys on the paper model. Explain that these different colors represent various land use types within the watershed (e.g., red for urban development, green for agriculture, blue for conservation).
4. Using a spray bottle, lightly mist the paper model with water to simulate a rainstorm.
5. Instruct students to watch how the "rain" flows down the slopes from the ridge lines, converging into common valleys and receiving waters at the bottom. Have them observe how the different colors bleed and flow into the water bodies. Discuss how this visualizes the way runoff picks up pollutants or materials from different land use types and carries them into our shared waterways.
6. Following the demonstration, share the Oʻahu Watersheds Map with the students. Guide them in navigating the map to find and identify the specific watershed where their school, facility, or home is located.

II. Exploring Runoff Activity



1. Divide students into groups of 3 to 6. Provide each group with printed land-use layers (urban, agriculture, conservation) on clear transparent sheets*, a gridded base map, a satellite map with the Waikele watershed outline, and a hydrologic map.

   ***NOTE:** Be sure to use transparent sheets suitable for your printer type (inkjet or laser). If transparent sheets are not available, overlay the land-use map to the grid map over a light source (e.g. at a well lit window).
2. Instruct students to overlay their clear land-use sheets onto the gridded map to determine the land area for each specific layer.
3. Have students stack the clear layers on top of one another over the satellite map. Explain that this physical layering process represents how Geographic Information Systems (GIS) analyze spatial data.
4. Ask students to calculate the percentage of each land use type within the entire watershed based on their area findings.
5. Transition to a modified *Exploring Permeability Activity* from Lesson 1 to explore how different land uses absorb rainwater differently. Have students attach materials to a sponge to represent the land uses: sandpaper for agriculture, felt for conservation, and duct tape for urban areas.

   NOTE: Use straight pins to attach materials to sponge.
6. Instruct students to spray water over their patched "watershed" sponge and observe how the water runs off the different materials, explaining that this represents real-world runoff behaviors.
7. Have students place their clear land-use sheets over the hydrologic map. Ask them to trace with marker where the stream runs through the different land uses and identify the final receiving water body (ocean/bay).
8. Lead a reflection discussing the specific types of pollutants that are likely to run off from each of the different land use types.
9. Conclude by having students use their Exploring Runoff worksheet to determine the amount of runoff generated from each land use type, as well as the total runoff for the entire watershed.

NOTE: *The figures calculated in this activity are approximations of the actual land use areas within Waikele watershed. Because grid cells are used to simplify area calculations, the resulting boundary in the map is not an exact match for the actual Waikele watershed boundary and land use polygons.*

Adaptations and Resources

Storm Patrol Project Based Learning Activity:

- Guide students on ArcGIS Online to navigate the Oʻahu Watersheds Map, locate layers/legends, zoom, toggle layers, and view attribute tables (see *ArcGIS Online Student Guide*).
- Have students complete *Storm Patrol Project Workbook* (Section 3, Parts 1–3) to identify their site's watershed and evaluate local runoff/pollution impacts.
- Guide students through a watershed land-use analysis on ArcGIS to calculate runoff volumes (similar to the *Exploring Runoff* activity).
- Lead a discussion on land-use changes to mitigate runoff. Have students research storm water solutions and complete the *Map & Observe* workbook section.

1. *The Oʻahu Watershed Map can be accessed through ArcGIS Online (https://gqr.sh/LgG7).*
2. *The ArcGIS Student Guide (https://gqr.sh/5S4G) is meant to help students get familiar with the ArcGIS Online interface.*
3. *The runoff figures given are hypothetical and for example purposes only. To determine a more accurate runoff figure for a site, in depth analysis on factors such as soil type, vegetation presence, and slope must be conducted.*

Activity-Centric Learning Track:

Conduct Activity I and II.

Tips to Truncate Lesson:

- Have students estimate land-use proportions instead of calculating exact surface areas.
- Divide groups to analyze one land-use type each (e.g., residential or commercial) rather than all categories.

Tips to Extend Lesson:

- Have students compare the 1964 Historic Oʻahu Land Use map (https://gqr.sh/MyeK) with the present-day map to identify changes and analyze their impact on storm water runoff and future watershed health.
- Using their Lesson 2 Site Assessment Map, have students design an updated site map incorporating storm water and pollution solutions. Remind them to account for incoming run-on and potential pollutants from neighboring land uses.

Resources:

- Esri, *What is GIS?*, https://www.esri.com/en-us/what-is-gis/overview
- Environmental Protection Agency (EPA), *Urbanization and storm water Runoff*, https://www.epa.gov/sourcewaterprotection/urbanization-and-stormwater-runoff v
- City & County of Honolulu's past projects, https://www8.honolulu.gov/swq/green-stormwater-infrastructure/
- EPA's How's My Waterway, https://www.epa.gov/waterdata/hows-my-waterway
- Hawaiʻi Sea Grant's community project resources, https://seagrant.soest.hawaii.edu/sbcd-stormwater-links/
- Hawaiʻi Department of Transportation's projects, https://www.stormwaterhawaii.com/swmp-in-the-community/
- Hawaiʻi Department of Transportation's watershed plans, https://www.stormwaterhawaii.com/resources/plans/