A Basin Based in Redlands

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I. Abstract

We investigated possible stormwater management options that could be installed on the land behind Hedco Hall. From 6 sample sites, we measured soil compaction, soil moisture, and soil temperature. Working with CASC, we also measured infiltration rates. Additionally, we collected elevation data with the help of Nathan Strout. Through ArcGIS Pro and Excel calculations, we determined drainage area. From our geotechnical analysis of this data, we found that a northeastern region of the site has low infiltration (<44 in/hr), low soil moisture (<29%), high soil temperature (>26°C), and low soil compaction (<132 psi). Comparing this with our elevation data, this region appears to naturally dip. With this insight, we recommend an infiltration basin to be installed in this specific region that can hold up to 1.26 cubic feet. By focusing specifically on this region, we can allow the rest of the site to maintain the good infiltration rates that it already has. This bare land behind Hedco is currently not being used for anything. With the construction of our new solar panels and the roof of Hedco itself, stormwater is directed toward this site. Through landscaping, we can transform this land to not only make it more eye-pleasing but also make it more environmentally sustainable.

II. Why Capture Stormwater?

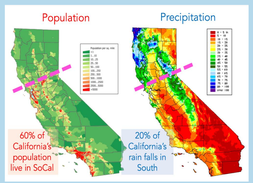

Figure 1: Maps of California that show the spatial inequity and spatial mismatch.

Importance of Stormwater Management in California

- California's growing population is greatest in the region of lowest annual rainfall
- Urban sprawl means less pervious surfaces
- Rainfall is more frequent during winter due to the jet stream, yet water usage is highest during the summer

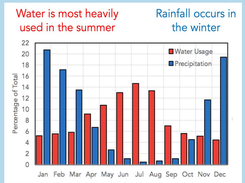

Figure 2: A chart that shows California usage, visualizing temporal inequity and temporal mismatch.

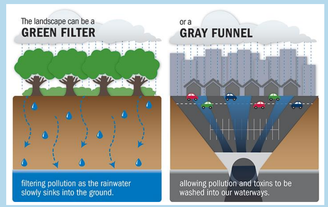

Figure 3: A rural vs. urban landscape and how stormwater flows differently between them

Stormwater Management in Redlands

- Storm drains direct runoff into nearby bodies of water
- Runoff can collect pollution and is often left untreated
- By constructing a basin in Hedco, we can collect more stormwater to infiltrate the ground rather than letting it runoff into the parking lot

III. Proposed Site

Hedco Locality

- Hedco hall is a chemistry/biology building on our campus.
- Directly behind this building is a stretch of bare land.
- Stormwater is funneled toward the area of interest because of Hedco's roof and the parking lot solar panels

Figure 4: Map of where the Hedco site is located on UoR campus

Figure 5: Map of our 6 sample sites.

Sample Sites

- Soil data was collected at 6 sites throughout the area.
- All samples were taken at a depth of 3 inches.
- Data collected includes infiltration rates, soil moisture, soil temperature, and soil compaction.

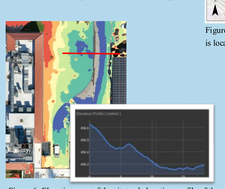

Figure 6: Elevation map of the site and elevation profile of the red cross section.

Site	Soil Moisture (%)	Temperature (C)	Soil Compaction (psi)	Infiltration (inch/hour)
1	44.8	21.4	200	
2	27.1	27.3	100	2362.204724
3	28.3	22.8	150	3543.307087
4	31.3	21.6	250	5905.511811
5	41.9	21	200	
6	50.1	20.3	300	

Figure 7: Table of the data collected at each site. Infiltration data was collected with the help of CASC.

Elevation Profile

- With the help of Nathan Strout, drones were used to collect elevation data.
- The site slopes downward from west to east.
- An existing dip can be seen in the northeastern region

Methods

- Infiltration data collected by a double ring infiltrometer
- Soil moisture and temperature collected by an AS-PH3 soil probe
- Soil compaction collected by an agratronix soil penetrometer

IV. Geotechnical Analysis

Soil Temperature

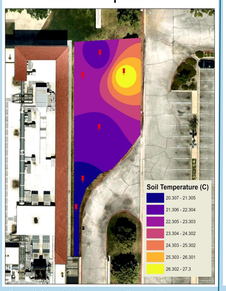

Figure 8: Map of soil temperature. Purples indicates cooler temperatures while oranges/yellows indicate warmer temperatures.

- Soil temp ranges from about 20-27°C
- There is a distinct warm region in the northeast region (26-27°C)

Infiltration Rates

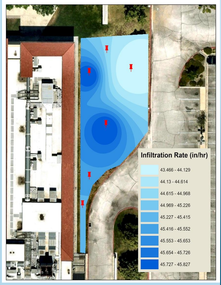

Figure 10: Map of infiltration rates. Darker blues indicate higher infiltration rates, while lighter blues indicate slower rates.

- Infiltration rates range from 43-46 in/hr.
- The northeast region has a low infiltration rate compared to the rest of the site.

Soil Moisture

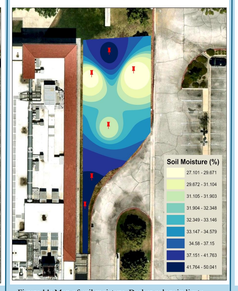

Figure 11: Map of soil moisture. Darker colors indicate higher moisture while lighter colors indicate less moisture.

- Soil moisture ranges from about 27-50.0%
- The middle portion of the site has low moisture compared to the north and south

Soil Compaction

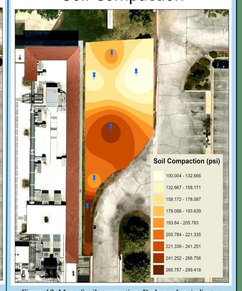

Figure 12: Map of soil compaction. Darker colors indicate more compacted soil, while lighter colors indicate less compaction.

- Soil compaction ranges from about 100-300 psi
- The north region has low compaction compared to the middle and south end of the site

Soil Temp → **Infiltration Rates** → **Soil Moisture** → **Soil Compaction**

- Soil temperature is inversely proportional to all other variables
- As soil temperature rises, infiltration rates, soil moisture, and soil compaction decreases
- This pattern is most noticeable in the northeastern region of these maps

V. Storage Volume Estimates

1. Runoff Coefficient (C)

$$C = 0.1 + 0.9i$$

$$i = \frac{A_{impervious}}{A_{total}} = \frac{2.56\ acres}{2.8\ acres} = 0.9$$

C = 0.1 + 0.9(0.9) = 0.9

2. Runoff Volume (V_r)

$$V_r = P \times C \times A$$

P: precipitation for a given storm event = 4.4 inches (50-year storm event)
C: runoff coefficient = 0.9
A: total drainage area = 2.8 acres

Vr = 4.4 in × 0.9 × 2.8 $acres$ = **41272 $cubic\ feet$**
This is the volume of runoff that occurs during a 50-year storm event.

3. Infiltration Volume (V_{inf})

$$V_{inf} = f \times A_b \times T$$

f: infiltration rate = 3 in/hr (sandy gravel)
Ab: area of base = 0.07 acres
T: drawdown time (48 hours)

Vinf = 3 $\frac{in}{hr}$ × 0.07 $acres$ × 48 $hours$ = **36590 $cubic\ feet$**
If the feature's base is 0.07 acres, then 36590 cubic feet of water is able to infiltrate in 48 hours.

4. Storage Volume Needed(V_S)

$$V_S = V_r - V_{inf}$$

Vs = 41272 − 36590 = **4681 $cubic\ feet$**
This is the minimum volume that the basin should hold.

5. Required Depth

$$V_{trap} = \frac{A_{surface} + A_{base}}{2} \times depth$$

Dimensions to hold 4681 cubic feet of water during a 50-year storm event:
Surface area: 0.1 acres or 4356 square feet
Base area: 0.07 acres of 3049 square feet
Depth: 1.26 feet

VI. Stormwater Feature Recommendation

Figure 13: Hedco Site

Figure 14: Proposed Basin Design at Hedco Site

- The proposed feature would be a basin with a minimum depth of 1.26 feet
- The minimum volume that should be held is 4681 cubic feet with a surface area of 4356 square feet
- Installing away from the Hedco will maintain the building's stability and support
- Relocate trees that were recently planted
- Find and repurpose rocks found around the university

VII. Conclusions

Benefits at Hedco

- Increase ground infiltration of stormwater
- Decrease the amount of runoff → Reduce pollution
- Transform the bare land into a sustainable feature

Where to install?

- Compared to the rest of the site, the northeastern region experiences:
  - Low infiltration rates
  - Less soil compaction
  - Higher soil temperatures
  - Less soil moisture
- This specific area is far enough from the existing building
  - Reduces any impact that installation may have

What to install?

- An infiltration basin with:
  - Surface area of 4356 square feet
  - Base area of 3049 square feet
  - Depth of 1.26 feet
- Can relocate existing trees to surround the basin

VIII. Acknowledgements

We would like to thank Dr. Hillary Jenkins, CASC Engineering , the EVST Department, as well as the University of Redlands