

Parking Lot Drainage Challenge Problem

Seventh and Eighth Grade Math



Developed by:

The teachers, students, and mentors in the
Gaming Research Integration for Learning Laboratory® (GRILL®) Summer 2015

TABLE OF CONTENTS

Table of Contents.....	2
1. Parking Lot Drainage Problem	3
1.1. Introduction	3
1.2. Problem	3
1.2.1. First Situation	3
1.2.2. Second Situation	4
1.3. Parameters	6
1.4. Project Write-Up	6
1.5. Rubric	6

1. PARKING LOT DRAINAGE PROBLEM

Primary Resource: Charles E. Emenaker

Adapted by: Adam Timmerman

1.1. INTRODUCTION

Principles and Standards for School Mathematics encourages teachers to move away from giving students just the typical array of drill-and-skill problems and to challenge them with situations that foster the development of problem-solving skills. Ideally, the problem should also relate to the student's everyday life. Therefore we will be looking at the current situation of our school parking lot. The following problem is an example of a situation that requires the efficient use of resources. This problem will require you to work in a group (3-4 students per group).

1.2. PROBLEM

During the current school construction I was driving around the parking lot after a sudden rain that dropped more water than the parking lot could handle. It provoked the following situation and challenge problem.

1.2.1. FIRST SITUATION

Design a drainage system for the parking lot shown in Figure 1. The drainage pipes need to move the water to the main sewer which can be purchased only in twenty-foot lengths. The price and capacity of each size of pipe are listed in Table 1. Because of limited sewer hookups, all the water must drain to the south side of the lot. You will need to install drainage grates so that the water from the lot runs into the pipes. Each drainage grate costs \$250 to install and can drain an area of 7500 square feet. Minimize the total cost for materials while supplying sufficient drainage for the parking lot and meeting the criteria regarding grate placement. Your solution must include the following:

- The number of drainage grates required for this lot.
- A diagram showing the location of
 - Each grate
 - The drainage pipes channel the water to the south side of the lot
 - An explanation of why you positioned the grates in those locations.
- The total cost to implement your plan: Could the lot be drained less expensively? If so, how would it be done?

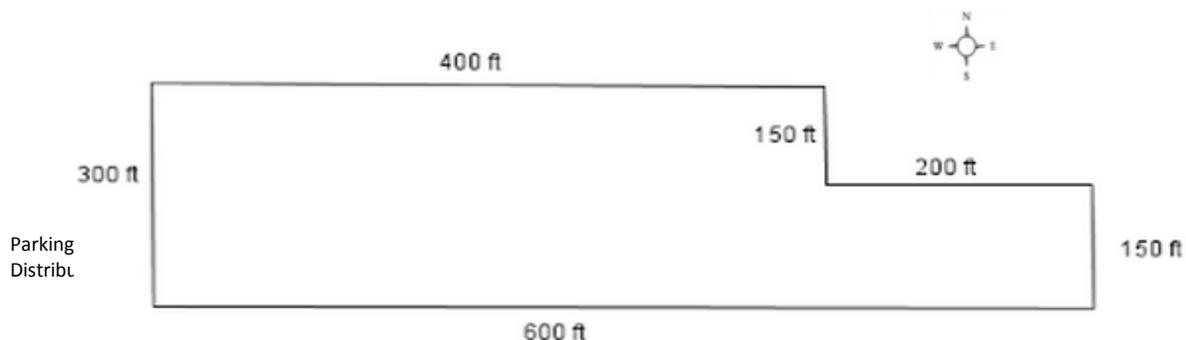


Table 1: Use this table while solving the first situation in the Parking Lot Drainage problem.

Prices and Capacities of Drainage Pipes		
Pipe Diameter (Inches)	Price (20 foot length)	Capacity (Gallons/Hour)
4	\$15.80	2,355
8	\$54.20	9,424
12	\$92.00	21,205
15	\$128.40	33,133

1.2.2. SECOND

You own a company that is bidding on the drainage system for a parking lot at Arcanum-Butler Schools. The city planning commission will allow drainage pipes to connect to sewer pipes only on the south and east sides of the lot. The dimensions of the parking lot are shown in the figure below. To avoid “floods” or complaints from customers and investors, the owners request that your submission minimize the total cost for the project, subject to two conditions. First, the drainage system must handle rainfall of two inches per hour. Second, the drainage grate must be placed to satisfy conditions 1 through 5 below. Your submission must include the following:

SITUATION

contracting

- A diagram indicating the positions of the grates and the routing of the pipes under the parking lot, in addition to showing where the pipes will empty.
- An indication of the maximum flow of water, in gallons per hour, at each point where a pipe empties into the sewer.

To optimize the drainage in each region, it is suggested that the grate be placed in the middle; however to minimize the cost this might not be the most effective way. This decision is up to you. The center is defined as the point where half the area of the drainage region lies south and half the drainage region lies east of the grate.

1. The maximum distance that water can travel to a grate is 150 feet, so that customers do not need to wade through large washes of water.
2. Grates cannot be located in entrance or exit areas of the parking lot.
3. Drainage pipes come in only 20 foot lengths and in the diameters listed in the chart. The cost for a 20 foot section of drainage pipe in different diameters follows.

4. Installing a drainage grate costs about \$250 for material and labor. Each grate can drain 27,500 gallons of water per hour.
5. Assume that all water moves at 1 foot per second.

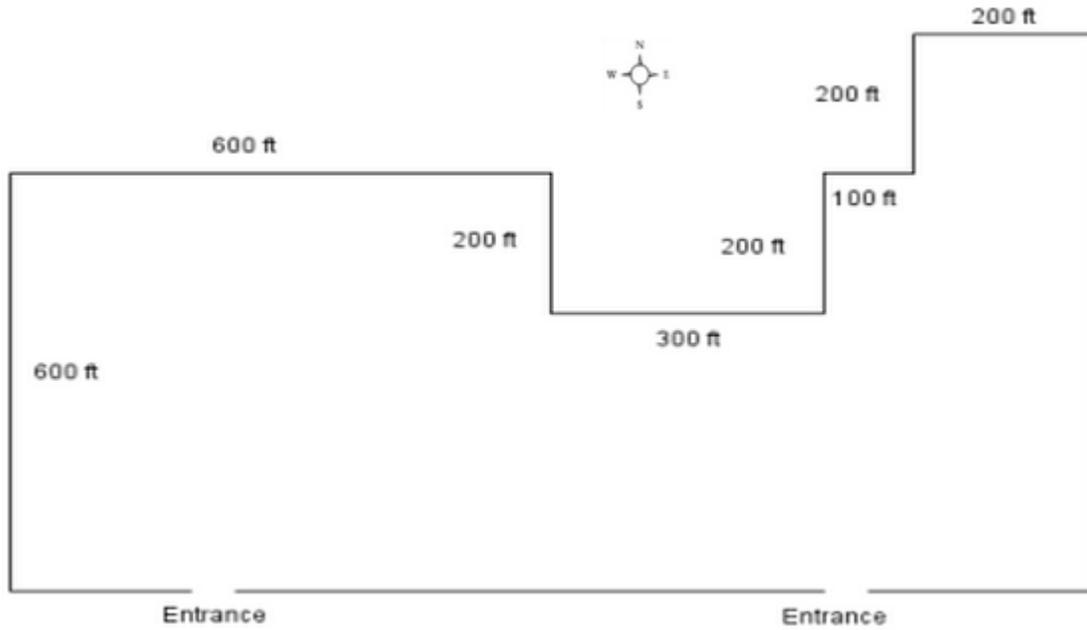


Table 2: Use this table to solve the second situation in the Parking Lot Drainage problem.

Diameter (in Inches)	Cost	Diameter (in Inches)	Cost
4	\$15.80	15	\$128.40
6	\$31.00	18	\$188.60
8	\$54.20	24	\$274.60
10	\$85.80	30	\$420.00
12	\$92.00	36	\$537.60

1.3. PARAMETERS

- Your system should be competitively priced.
- Determine how much water each diameter of pipe can carry each hour, assuming that the water moves at a rate of one foot per second (1 ft³ water = 7.5 gallons).
- There is more than one possible/correct answer, but the “best” solution is the one that solves the problem at the minimum cost. Thus, your challenge for this problem is to follow the stipulations while keeping the cost at a minimum.

1.4. PROJECT WRITE-UP

- A statement of the problem
- A diagram showing how you will run the pipe and where you will place the grate, as well as the diameter of the pipe
- A list indicating the number of each size of pipe that is needed for the project
- The total cost for the project, as well as the amount of material that will be left over
- A clear explanation describing how this system will be able to handle a two-inch-per-hour rain, including all necessary calculations; a section clearly labeled “Explanation of Capacity” must address this issue

1.5. RUBRIC

Category	Components	Points Earned	Comments
<i>Mathematics</i>	There are zero errors in the applied mathematics of this project.	/30	
<i>Rationale</i>	Rationale is provided for all mathematics work and is present throughout the project write-up.	/30	
<i>Research</i>	The group conducted a wide variety of research and the research was properly referenced within the project write-up.	/10	
<i>Layout/Organization</i>	The layout of the group’s work has five or more relevant sections that allow for easy referencing and readability.		

		/15	
<i>Writing Mechanics</i>	The group's write-up has no more than three misspelled words or grammatical errors in the document.	/15	