Wastewater Collection System
A Practice Understanding Task

Purpose: In this activity, students are working for a Civil Engineering firm where they need to consider the amount of wastewater being collected and the size of the pump needed to convey the water to a wastewater treatment plant.

Career Field: Civil Engineering

Company: Highfill

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NC Math 4 Standards:

NC.M4.AF.5 Understand how to model functions with regression.
NC.M4.AF.5.1 Construct regression models of linear, quadratic, exponential, logarithmic, & sinusoidal functions of bivariate data using technology to model data and solve problems.

Unit Alignment:

NC Math 4 - Unit 2: Lesson 7 - Regression Models

Common Core State Standards for Mathematical Practice
>   1. Make sense of problems and persevere in solving them.
>   2. Reason abstractly and quantitatively.
>   4. Model with mathematics.
>   5. Use appropriate tools strategically.

Prerequisite Skills
These skills could be reviewed in a warm-up and are addressed in the Desmos Activity
- Unit Conversions
- Linear, Exponential, and Quadratic Regression

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Time Required
The time required to complete this activity is approximately 90 minutes.

Materials Needed
- Student Activity Sheet
- Excel
- Desmos
- Graphing Calculator

The Teaching Cycle:
Launch: Begin the activity by showing the video about Civil Engineering, Highfill, and WasteWater Collection. Have students complete the [Wastewater Desmos Launch Activity (opens in a new window)](https://teacher.desmos.com/activitybuilder/custom/5f889f002f73012f3ae851c3?collections=5f6cae0049988f0bfcd6f9f8) [plain text link: https://teacher.desmos.com/activitybuilder/custom/5f889f002f73012f3ae851c3?collections=5f6cae0049988f0bfcd6f9f8]. The Desmos Activity contains a link to the video.

Explore:
Before passing out the student activity sheet, ask students what they think a "WasteWater Collection System" consists of. Possible answers include pipes, drains, pumps, sewers, grates, etc.

Pass out the Student Activity Sheet. Spend some time looking at the map. You may ask students to discuss the map with a partner to simply make sense of what they are looking at. You could also discuss the map as a whole class to explain the green sewer lines are being acted on by gravity to move the wastewater to a collection area at the lower left corner of the map. Have them read the handout up to Question 1. Students may work independently or with a partner to calculate Q. While it can be done by hand, we used an Excel spreadsheet to make it a little bit easier, not just to calculate Q, but to answer the questions that follow.

Discuss:
There needs to be a discussion about unit conversions when calculating Q or the answer units will not be correct. This would be a good time to talk through the formula, discussing each variable so that students realize they will need to convert the diameter from inches to feet. If time is a concern, you could share the Excel spreadsheet with your students so that the formulas are already in place. You will also need to discuss the conversion of Q from CFS to GPD based on the info on the Average Daily Flowrates that were provided. As students answer Q1-Q3, you can tie in the fact that as we learned how to develop regression equations, we do it with the purpose of using the equation to make predictions. And although we are using a spreadsheet and/or formula instead of the graph of an equation, we are still making predictions for one value given another. You may have students that have considered if we could do a regression for the data in the table, so that we could predict Q based on pipe diameter. And while there are too many variables, they may still think to try it. Whether you discuss or even attempt it would be up to how much time you were willing to spend on this task. But it would just be another point to reinforce the concept of regression equations. Aside from the mathematics, you could use a question like Q2 to discuss the implications of new construction in areas and how it could cause problems with existing wastewater systems.

 Launch: Task 2. At this point, we need to remind students (assuming it is part of the launch video,) that from an industry standpoint, we can't rely completely on gravity to move the water as we would have to keep digging deeper and deeper and that is not cost efficient. So, at some point we have to move the water uphill,

either over a ridge to a collection or treatment facility, or even to another set of pipes where gravity will take over once again. This is where pumps and pumping (or lift) stations come in.

Explore: Task 2. Have students read through Task 2 up to Q4. They can read through it independently or with a partner. There is a lot of technical jargon and abbreviations so they may need to read through it more than once. Have them answer Q4 and Q5. You can have partner pairs share out their answers for Q5 to elicit as many different answers as possible. As you move into the last portion you may ask if any of your students have experience with the pump that is shown in the picture. For Q6, you could have students think independently about what the question is asking and then discuss with his/her partner.

Discuss: Hopefully students will think to find regression equations for the two graphs shown so that they can intersect them with the TDH equation from Q4. And even if regression is their method of choice, they will have to decide linear vs quadratic. *(Technically the industry uses a cubic equation but we have chosen quadratic because of where this fits in Math 4. If the class has knowledge of higher order regressions then they certainly could try the cubic.)* However, students may try to solve it using tabular data or some kind of "plug and chug" method. Observe students as they work and, if possible, choose students who solved with different methods to share out their solutions.

Exit Ticket: Choose 3 of the following questions to answer.
- What are the benefits of performing a regression analysis?
- How can the slope of a linear regression equation be interpreted?
- How can the correlation coefficient of a data set be interpreted?
- What is the relevance of the correlation coefficient?
- What is the accuracy of a prediction obtained from a regression equation?
- In what ways can mistakes be made using a regression equation to make predictions?

Extension:
Have students research a new development in the US (hotel, restaurant, stadium, neighborhood, office space) and use that to calculate average daily flowrate, peak flowrate, and full pipe capacity needed to serve that area.