Lead in the Gymnasium Drinking Fountain: Using Water Quality to Practice Hypothesis Testing for AP Statistics

by Dalton Cooper, 2020 CTI Fellow
West Charlotte High School

This curriculum unit is recommended for:
AP Statistics

Keywords: AP Statistics, Unit 7, Inferential Statistics, Water, Environmental Justice

Teaching Standards: See Appendix 1 for teaching standards addressed in this unit.

Synopsis: AP Statistics is a course modelled off an introductory-level college math course. Teachers are not provided with clear standards or guidance for teaching inferential statistics in North Carolina math courses and so for many learners, this class is their first exposure to hypothesis testing: a central and critically important skill in hard sciences, policy, and social sciences. My unit uses water resources as a focal point for examining tests for statistical significance in assessing water quality both in municipal and natural systems. While there are a number of procedures for inferential statistics in AP Stats, this unit was specifically chosen to be Unit 7, which covers the t-distribution, as it would allow for teachers to utilize small data sets for analysis. By doing so, this opens the possibility for interdisciplinary, experiential learning wherein a relatively small class of students can collect and record their own data on water quality for statistical analysis.

I plan to teach this unit during the coming year to 25 students in AP Statistics

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Introduction

Since its partnership with Equal Opportunity Schools (EOS) began, West Charlotte High School has set to address equity issues facing students of lower socioeconomic status with access to rigorous high school coursework, including Advanced Placement (AP) and International Baccalaureate (IB) classes. Historically, schools use standardized test scores and grade point average (GPA) as indicators to track students into advanced coursework; however, according to their research has found that student motivation, perseverance, and effective studying and note-taking skills are the three best predictors of a student's ability to succeed in AP and IB classes[1]. Because of this, West Charlotte High School has two criteria for identifying students to place in advanced classes: a minimum 1.7 GPA and a teacher recommendation. With guidance from EOS in shaping these criteria, West Charlotte has been able to steadily increase enrollment in AP and IB courses since the beginning of the partnership. Among the offerings of advanced coursework at West Charlotte was AP Statistics; an introductory college-level statistics course that covers a variety of topics including univariate and bivariate data, experimental design, and inferential statistics.

Unlike much of the North Carolina integrated math curriculum, as well as offerings in AP Calculus and IB Mathematics, AP Statistics is highly applied and the standards of the course reflect the premium placed on selecting, utilizing, and justifying statistical methods. College Board has indicated three "Big Ideas" which spiral across multiple units in AP Statistics: variation and distribution (VAR), patterns and uncertainty (UNC), and data-based predictions, decisions and conclusions (DAT). Variation and distribution-based standards entail students understanding mathematical probability distributions and understanding that these can be used to determine whether variation is a result or random sampling or a more meaningful distinction. Understanding of distributions can then be applied to patterns and uncertainty, which provides the mathematical tools and methodology to engage with anticipating patterns in data, as well as utilizing probabilistic reasoning. Finally, students' discretion to utilize appropriate statistical methods, as well as interpret and results is encapsulated under decisions and conclusion standards[2].

These "Big Ideas" are then combined with one of four skills, which spiral across units, in order to create standards guiding the statistical thinking for which students are expected to demonstrate mastery on the AP Statistics exam. The first skill category encapsulates selecting statistical methods for collecting and/or analyzing data for statistical inference. The second skill category encapsulates describing patterns and trends in data. The third skill category covers exploring random phenomena. Finally, the fourth skill category entails statistical argumentation, including

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[1] Equal Opportunity Schools, "Equal Opportunity Schools Report: 2018-19 Equity Pathways Report."

[2] College Board, "AP Statistics Course and Exam Description", pp 17-18.

developing and justifying a conclusion based on evidence from data, definitions, and/or statistical inference[3]. With this, students taking AP Statistics are exposed to every component of statistics from the process of collecting data, to understanding mathematical reasoning with the data, before interpreting and justifying evidence. Because of this, AP Statistics provides high school students access to the methodology used by researchers in academia and provides relatively powerful tools for analytics with even just an introductory view of statistics. As such, the unit will utilize water quality testing as a lens for applying statistical methodology.

While there is great opportunity to increase access to advanced coursework for historically underrepresented students, there will also be challenges to implementing this content at West Charlotte High School that the curriculum unit will need to address. West Charlotte High School is a Title 1 high school in the Central 1 Learning Community, which includes most schools in the city center surrounding the I-277 beltway. At one point in time, West Charlotte was renowned for being one of the most successful schools to be integrated during the Civil Rights Movement; however, following the Leandro v State of North Carolina lawsuit in 1997 and Charlotte-Mecklenburg Board of Education's "School Choice" plan starting in 2002, West Charlotte saw a decline in socioeconomic diversity, followed with a decline in academic performance; this resulted in severe sanctions imposed by both new standards set by the State of North Carolina for evaluating schools based on standardized test data, as well as President George W. Bush's "No Child Left Behind" policy in 2001[4]. For these reasons, West Charlotte High School presently has the designation of a high-needs Title 1 high school: 98% of students qualify for free or reduced lunch indicating a high proportion of students are from families of low socioeconomic status. Additionally; 80.3% of West Charlotte's 1,456 students in rolled are African-American, 13.0% are Hispanic, 2.7% are Asian, and 1.5% are White, indicating that the school is effectively segregated[5]. The disadvantages for students of low socioeconomic status are reflected in math test data as well: in the 2018-19 school year, only 8.8% of students received "College and Career Ready" (CCR) scores on the Math 3 End-of-Course (EOC) assessment, with only 26.8% receiving scores considered "Grade Level Proficient" (GLP), despite the school seeing considerable growth on the exam; additionally, literacy has also been a persistent issue at West Charlotte--on the English 2 EOC Exam, 20.6% of students receiving scores in the CCR range and 28.4% GLP[6]. As such, any statistics curriculum, instruction, and assessment will have to both take into account the student body's demographics, as well as the considerable amount of academic scaffolding that will be necessary to enable students to succeed in the rigor of an AP course.

In light of this, the AP Statistics unit that I will write has several goals. First, the unit must be instructionally sound to prepare students for the content and rigor of the AP Statistics Exam. To achieve this, all instruction must align to the topics and difficulty posed on the assessment so that students may demonstrate mastery; however, due to existing academic deficiencies in literacy and mathematics, there will need to be sufficient scaffolds in place to quickly spiral in prerequisite knowledge, as well as flexibility for academic remediation built in to reloop and

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[3] College Board, p16.

[4] Grundy, Pamela. *Color and Character: West Charlotte High School and the Struggle for Educational Equity in America.* pp 140-143.

[5] Charlotte-Mecklenburg Schools. "West Charlotte High School Profile Overview"

[6] Ibid.

retest any gaps on new material. Seconds, the unit should take advantage of the opportunities presented by the content and rigor of AP Statistics to bridge the gap between West Charlotte High School Students, many of whom are the first in their families to graduate high school and/or attend college, and academia. To accomplish this, I will plan the unit to integrate elements of water-quality testing with potential for a university host with whom West Charlotte has strong connections, such as Johnson C. Smith University, Central Piedmont Community College's School of Engineering Technology, or UNC-Charlotte. Finally, I plan on viewing water quality testing in two aspects: the health of Charlotte's waterways, as well as municipal water quality. The Flint Water Crisis is arguably the best-known instance of inferential statistics being applied to testing water quality; however, even recently several schools in Charlotte-Mecklenburg Schools had tested positive for traces of lead in their water. Students' conception of potable water can then be shifted from the final, consumed product to its sources and understand the need for monitoring water at every stage of its journey.

Content Research

There are two aspects of water my curriculum unit will use as focal points for statistical reasoning: the quality of municipal potable water and health of local waterways. The goal of using both aspects is to not only give a more holistic view of water as a critical element of human society, but also to provide students with multiple frameworks of environmentalism to examine water health as it connects to human health. My rationale for doing so is to broaden the scope of traditional definitions of environmentalism to a more inclusive definition that encompasses environmental justice. Doing so will make the unit more relevant to the student body of West Charlotte High School.

Historically, environmentalist movements have not been inclusive and early environmentalism had excluded people of lower socioeconomic status, as well as people of color. Given the demographics of West Charlotte High School, I want to ensure that any environmental themes in my unit are more closely aligned to the Environmental Justice paradigms as opposed to earlier environmental movements. Arguably, the first environmentalist was the British economist Thomas Malthus, whose essay 1798 *Essay on the Principal of Population* argued that human population growth exceeded means of agricultural production, which in turn would cause severe environmental degradation and a population crash[7]. Malthus's direct application of laws of nature to human society was common among proponents of eugenics. Even after advances in agriculture during the Industrial Revolution contradicted Malthus's theory, his work continued to influence racist pseudoscience for decades.

The environmental movement in the US started in the middle of the 18th century with wildlife management; wealthy sportsmen organized and lobbied for the creation of bag limits on both game and fish. This would be succeeded by Conservationists of the late 18th century, who advocated for the proper management of natural resources like timber and viewed physical and biological nature as nothing more than a collection of parts that function like a machine, and the Preservationists of the late 18th century that lobbied for the preservation of wilderness areas on the merit of their own inherent self-worth. These schools of environmentalism, however, also proved to be exclusionary and problematic in their own right. The Sierra Club, established in 1892, would remain a WASP enclave throughout the 1950's, systematically excluding groups

[7] Luiz C. Barbosa, "Theories in Environmental Sociology". p 27.

such as Jews and upholding elitist values[8]. It wasn't until the Civil Rights Movement that environmentalism in the US would shift towards a more inclusive paradigm.

The Environmental Justice movement diverted from previous conceptions of environment as wilderness areas towards one that included cities and communities. The movement's origins are commonly attributed to the high-profile disaster at Love Canal, NY in 1976, as well as the Three Mile Island accident in 1979 and organizing in Warren County, North Carolina in the early 1980's[9]. Environmental Justice activists lobby against situations if *environmental injustice*, in which negative environmental conditions disproportionately affect a specific group due to policies, unequal laws, or regulations[10]. Part of the Environmental Justice movement engaged with a specific environmental injustice called *environmental racism*--the deliberate targeting of minority groups for toxic waste facilities, official sanctioning of polluting minority communities, and deliberate exclusion of minorities from environmental decision-making and leadership--often bringing them directly into conflict with "Not in my backyard" (NIMBY) environmentalists of high socioeconomic status[11]. Environmental Justice organizers of color would often organize using the same networks and methods of the Civil Rights Movement, including utilizing churches as a hub for organizing to fight municipal governments and multinational corporation over pollution and poisoning of communities[12]. Due to the demographics of West Charlotte High School, as well as the problematic elements of previous environmental movements, this curriculum unit will primarily focus on water quality through an environmental justice lens as opposed to one that places the intrinsic values of natural waterways at its center within the old paradigm.

The first of two aspects to this unit will be examining water in its final, consumable form as municipal potable water. By 2015, the City of Flint had made national news for a legionare's disease outbreak caused by lead-contaminated municipal water; upon investigation, the failure of the city and state of Michigan to provide its residents with potable water had revealed that the crisis started as early as 2013. The city of Flint's water pipes were installed in 1883 and made of lead; while lead is a toxic heavy metal over time added phosphates create protective deposits coating the pipe which prevents lead from leaching into water[13]. When the city of Flint switched its water source from Lake Huron to the Flint River as a cost-saving measure and due to an inability to reach a satisfactory short-term contract to buy water from the City of Detroit, several experts warned of issues with the corrosiveness of the Flint River water, and expressed concern that the city would not have sufficient time to pilot test the necessary adjustments to make with anticorrosive additives to the new water source[14]. Rapid changes to the alkalinity of the water caused corrosion of the pipes, as evidenced by the red-colored water residents observed from their taps starting in May 2014, and further testing revealed elevated levels of lead exceeding health-based guidelines, as well as unsafe counts of *cryptosporidium e coli* bacteria in May 2015.

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[8] Checkher, Melissa, "Polluted Promises: Environmental Racism and the Search for Justice in a Southern Town". pp 18-19.
[9] Masarenhas, Michael, "Environmental Inequality and Environmental Justice." p 127.
[10] Masarenhas, p.129.
[11] Ibid.
[12] Checkher, p. 109.
[13] Susan J Masten et al. "Flint Water Crisis; What Happened and Why?"
[14] Ibid.

In fall of 2018, a stories reminiscent of the Flint Water Crisis came to light in Charlotte when multiple CMS schools, including West Charlotte High School, had tested positive for elevated levels of lead in drinking fountains and sinks[15]. Local organizers and the NAACP demanded for more transparency regarding testing for lead in schools--a practice not mandated by North Carolina law. The prominence of Flint, Michigan, as well as the proximity of the lead alarm at West Charlotte High School will provide an introduction to the concept of water quality that students may be familiar with to the extent that they may easily engage with and draw connections between these events and the applications of the content of AP Statistics. From here, students can begin to move upstream, so to speak, and begin to explore sources of water and draw connections between waterway health and human health using inferential statistics as a tool for seeing and justifying patterns.

Unlike Flint, Michigan, the City of Charlotte was not built on a large body of water, such as a lake or river, but rather 3,000 miles of creeks and streams[16]. As the population of Mecklenburg County expanded, the city eventually dammed the Catawba River and would draw its water from the Mountain Island Lake reservoir; to the south, the suburb of Rock Hill, South Carolina would draw its water from the Lake Wylie reservoir. Two of Charlotte's three creeksheds, Irwin Creek and McDowell Creek drain into the Catawba River Watershed, with the latter creek draining into Mountain Island Lake[17]. Both creeks have been polluted with industrial waste, as well runoff from stormwater that can include fertilizer, particulate matter, and fecal matter, rendering them both "impaired waterways." Irwin Creek has fallen victim to environmental racism, as it runs through many historically black communities in Charlotte that had been deliberately targeted for dumping pollution. McDowell Creek's drainage into a critical section of the Catawba River for Charlotte has potential to directly tie human health outcomes to environmental ones for the City of Charlotte and Rock Hill. As such, monitoring water quality of the creeks, Catawba River, and Mountain Island Lake provides a window into the factors that contribute to Charlotte's municipal water--the same factors that were overlooked in Flint, Michigan when the city failed to implement proper pilot testing of its new water source.

The health of creeks and quality of water can be measured in many ways; however, the relevance and viability of the variables will be determined for my second draft. For monitoring creeks, erosion, bacteria, turbidity, and toxicants (specifically heavy metals) are typically monitored when designating "impaired waterways"[18]. Municipal water, such as the contaminated drinking fountains at West Charlotte and tap water of Flint, Michigan, is monitored more for toxicants and bacteria; however, engineers will also monitor other variables that could cause a potential change to the drinking water and pipes, including corrosiveness and concentrations of additives to build protective coating on lead pipes and prevent corrosion[19].

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[15] Glenn, Gwendolyn. "Testing Finds Unsafe Lead Levels in 4 More Sites."

[16] Newsome, Mary. "UP THE CREEKS They Shaped Charlotte's History, but the Creeks Haven't Always Been Treated with Respect."

[17] Ibid.

[18] Halstead, Judith et al. "Urban Stream Syndrome in a Small, Lightly Developed Watershed: a Statistical Analysis of Water Chemistry Parameters, Land Use Patterns, and Natural Sources.

[19] Susan J Masten et al. "Flint Water Crisis; What Happened and Why?"

Instructional Strategies
West Charlotte High School utilizes strategies for instruction, management, and administration that are outlined in the best practices described in Success by Design. For this model, teachers utilize the backwards planning model of designing units by beginning with the final assessment, in this case the AP Statistics exam. The most crucial piece to the curriculum unit, according to this philosophy, is ensuring that all assessments are aligned to the rigor and content of the final exam so that each lesson can be planned accordingly to ensure students are being prepared to succeed. Mathematical instruction typically of direct instruction in the form of a lecture, followed by group practice or a group activity, and independent practice. While each of these components will need to remain, strategies we have been implementing during remote instruction in the covid-19 pandemic can be translated to allow for more time in-class to engage in student talk and class discussion.

Due to the district's guidance that all learning must be able to be performed asynchronously, the West Charlotte math department has moved towards implementing a flipped classroom with fidelity, in which they complete their direct instruction at home (typically in the form of a video with checks for understanding) and class time consisting of addressing misconceptions, discussion, practice, and small-group intervention. While I anticipate challenges with academic deficits from the pandemic due to a 17% cut in total instructional time, I believe that students will have precedent for independent learning to be able to implement these strategies with fidelity.

Presently, my unit will be built around Unit 7 of the AP Statistics course, which covers t-tests, including determining when a z or t-test is appropriate (inferential statistics is introduced through constructing confidence intervals and z-tests in Unit 5), as well as determining independence of samples, and calculating and interpreting a p-value. Since water quality testing relies on relatively small sample sizes with unknown parameters, this would be a fairly close application for the topic. To this point, students should have a some understanding of descriptive statistics (Unit 1), experimental design (Unit 3), and an introduction to inferential statistics using the normal distribution (units 5 and 6); however, spiraling in review with flexibility for data-driven remediation from previous units, as well as continuing to expose students to scaffolds with literacy and prerequisite mathematics will be a priority for my unit based on the needs of the student body at West Charlotte.
Finally, I would like to include a component of experiential, outdoor learning with my curriculum unit, with students performing water testing using both municipal water from Charlotte and/or Rock Hill, as well as water from one of the waterways adjacent to the cities' reservoirs. This would provide students exposure to lab work at the collegiate level and give them opportunity to explore continuing their studies into fields where they can apply statistical methodology and/or research issues of environmental justice.

The unit plan will outline the standards and their connection to these topics, including data-driven instruction (DDI) remediation opportunities on prerequisite knowledge, review and testing days, and a breakdown of instructional strategies for that particular lesson. At West Charlotte, we typically give two Do Now questions, a preview and a review. The preview of the day's new content, typically reviewing prerequisite material from prior units of courses; this gives the teacher opportunities to address preexisting gaps and misconceptions from previous courses. The review question is more discretionary and either loops content from the day before or serves as an opportunity to remediate previous standards as part of a DDI plan. Additionally, my unit outline will outline exit topics that will serve as data points on that day's material for teachers to collect data on and review. Finally, this school year my professional learning communities (PLCs) have started with delayed testing, a practice wherein teachers wait several days after completing a unit in order to give a summative assessment so that students have additional time to see, learn, and practice material. While I have enjoyed this practice, my unit outline does not provide guidance on this practice.

Two days have potential to be dedicated to field trips; however, depending on feasibility this can be adjusted. The first day is for analyzing water samples: depending on the teacher's flexibility, more sophisticated lab equipment can be utilized for high-precision testing of heavy metals in water; this would require a field trip to UNCC or JCSU. If this is not feasible, inexpensive chemical tests can be easily purchased to test for coliform bacteria, pH, or heavy metals; this field trip would be conducted with the purpose of making concrete a one-sample test of means with a critical value of a health-based standard. The second field trip to Mountain Island Lake and McAlpine Creek is not focused on data collection, as that would require multiple days of testing and, depending on alternative hypotheses and indicator variables, has potential to be highly weather contingent and impractical if examining the role of phenomena such as runoff from stormwater. This could be related to either a one-sample test or testing the difference of means. A third and final field trip to Reedy Creek Nature Preserve has been allotted with the purpose of learning about the stream restoration process conducted by the county; this can coincide with standards on two-sample t-tests to illustrate the progress that has been made as to significantly improving the health of Reedy Creek. The primary objective, as is currently intended, is to give a tangible overview of Charlotte's water source and the larger systems in which it exists.

Unit 7 Outline		
Day	**Standard(s) and Topic(s)**	**Activities**

1	7.1, 7.2	- Do Now (10')
		    - Preview: Conditions for a one-sample z-test of means.
		    - Review: DDI Action plan
		- Direct Instruction (30')
		    - Limitations of z-tests
		        - Small sample size
		        - Unknown population parameters
		    - Introduce t-distribution as an ideal function for a test statistic to construct confidence intervals and/or calculate a p-value for hypothesis tests in some cases.
		        - Small sample size (n<30)

<table>
<tr><td></td><td></td><td>- Unknown population parameters and/or hypothetical population mean.
- Additional assumptions related to sampling and independence.
- I do/you do/we do
- Using a table & TI-84 graphing calculator to calculate t for various probabilities.
- Check for Understanding (25’)
- Whole-class review activity such as Kahoot or quizlet live focusing on the following topics:
- Conditions for choosing a test statistic based on a sample (normal vs t-distribution)
- Calculating z-score, t-value based on information about sample and confidence interval.
- Sampling methods, specifically matched-pair experiments.
- Introduction to Water as a Natural Resource.
- Introduce Flint Water Crisis
- Move from what students have heard and media depictions towards the scientific issues with Flint and the data collected (See Appendix A)
- Water chemistry and corrosiveness of pipes.
- Bacteria and heavy metals concentrations in municipal water.
- Health effects of lead poisoning.
- Indicators of Flint and Charlotte water in data set (See Appendix 2)
- Heavy metals
- Bacteria concentration
- Make comparisons and assessments of Charlotte water using normal distribution hypothesis tests.
- Look at article for CMS lead contamination, specifically West Charlotte High School.
- Unlike previous data sets, this will be a smaller sample size and more appropriate for t-test, which is where things will pick up on Day 2.
- Homework
- Teacher’s choice of practice problems from preferred AP Stats textbook.
- 8-10 questions on t-distribution or conditions for t-test
- 6-10 DDI questions for review.
- Additional readings to preview Day 2.</td></tr>
<tr><td>2</td><td>7.2</td><td>- Do Now (10’):
- Preview: Constructing confidence interval (normal distribution)
- Review: DDI remediation</td></tr>
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		- Activity: Data collection (10’ Instruction, 50’ hands-on)
		    - Students will collect and label water from drinking fountains and sinks around campus in groups. Three samples are to be collected from each source:
		        - One sample immediately after turning on the source.
		        - One sample after letting the source run for 30 seconds.
		        - One sample after letting the source run for 60 seconds.
		    - Students will be examining heavy metals or pH in water to start (depending on availability of lab equipment). Samples may need to have special instructions for storage and treatment with specific containers and/or chemical additives.
		- Guided Practice (30 minutes)
		    - Students will begin multi-day guided practice assignment. Topics covered by the assignment will focus on the study design and population.
		    - Guided practice will finish with students constructing a confidence interval for a one-sample t-test.
		    - Additional time may be allotted to debrief on constructing confidence intervals from t-distribution.
		- Homework:
		    - Teacher’s choice of practice problems from preferred AP Stats textbook.
		        - 8-10 questions on constructing and interpreting confidence intervals for a t-distribution.
		        - 6-10 DDI questions for review.

3	7.2	- Do Now (10’):
		    - Preview: Constructing and interpreting one-sample confidence interval
		    - Review: DDI remediation
		- Activity: Testing and Compiling Data (120’)
		    - Groups will test their water samples for the indicator variable.
		        - This day may be a field trip to either JCSU or UNCC, depending on teacher’s connections and/or time and budget constraints.
		    - Data will be compiled and published to common Google Sheets document for all students to access.
		- Homework:
		    - Teacher’s choice of practice problems from preferred AP Stats textbook.
		        - 8-10 questions on t-distribution or conditions for t-test
		        - 6-10 DDI questions for review.
		        - Additional readings to preview Day 4

4	7.2, 7.3, 7.5	- Do Now (10’) - Preview: Difference of means (two-sample z-test)

		- Review: DDI Remediation
		- Guided Practice (45')
		  - Students will access data sets from school water on Day 3 to perform one-sample t-tests on indicator(s).
		  - Guided practice will include calculating and interpreting a p-value for hypothesis testing using a TI-84 graphing calculator in addition to constructing confidence intervals.
		- Direct Instruction (30')
		  - Intro to two-sample t-tests.
		  - Discuss the matched pairs experiment as a requisite for a two-sample t-test in addition to considerations as one-sample t-test.
		  - Practice of pooling variance of samples.
		  - I do/we do/you do for constructing confidence intervals by hand
		  - I do/we do/you do for calculating and interpreting p-value using TI-84 graphing calculator
		- Homework:
		  - Teacher's choice of practice problems from preferred AP Stats textbook.
		    - 6-8 questions in inferential statistics using one-sample t-test and two-sample t-tests.
		    - 6-10 DDI questions for review.
		    - Additional readings to preview Day 5

5	7.5, 7.6	- Do Now (10')
		  - Preview: Two-sample t-test (matched pairs)
		  - Review: DDI remediation plan
		- Introduction to Mountain Island Lake and adjacent systems
		  - Field Trip to Historic Latta Plantation or Charlotte Water Source (the latter requires an appointment)
		    - This will physically show students where Charlotte's water is sourced.
		    - Topics that can be discussed here include possible factors that can cause water quality to fluctuate, both in the short-run and on a long-term basis.
		    - This is a good place to discuss the role of corrosivity and pilot testing, which students should be familiar with from their discussion of the Flint Water Crisis.
		  - Field trip to McAlpine Creek
		    - Indicators of stream health can be discussed at McAlpine Creek, including turbidity, erosion, bacteria, biota, heavy metals, and pH.
		    - This creekshed drains into Mountain Island Lake and students can make connections between the health of tributaries and the health of Charlotte's reservoir.
		  - Field Trip to Martin-Marietta Sodeye Co. Superfund Site
		    - Tangentially related to surface water as this is primarily a

		groundwater pollutant.
		- The role of groundwater can also be discussed, especially as residents of this area previously drank well water.
		- Homework:
		  - Teacher’s choice of practice problems from preferred AP Stats textbook.
		    - 6-8 questions in inferential statistics using one-sample t-test and two-sample t-tests.
		    - 6-10 DDI questions for review.
		    - Additional readings to preview Day 6

6	7.6, 7.7, 7.8	- Do Now
		  - Difference of means (z-test)
		    - Opportunity to review null hypotheses notation for difference of means.
		  - DDI Remediation
		- Direct Instruction (30’)
		  - Introduce two-sample t-test to determine if two samples come from the same population.
		  - Conditions for sampling includes independence.
		  - We do/you do: Two-sample t-test.
		- Guided Practice (60’)
		  - Two-sample t-test can be utilized as a tool to detect changes in the quality of water.
		  - The work will make use of measurements (either from an actual data set, or a simulated one) consisting of two samples of water; one before and one after a change.
		  - Examples in the guided practice would include:
		    - Corrosiveness index, coliform bacteria concentration, and lead concentration in samples of water from Lake Huron and the Detroit River; this can be used to show how pilot tests could have averted the Flint Water Crisis.
		    - Indicators of stream health. This can include:
		      - Turbidity for a creek next to a construction site.
		      - Biota at Reedy Creek prior to Charlotte-Mecklenburg Stormwater Services’ restoration.
		- Homework:
		  - Teacher’s choice of practice problems from preferred AP Stats textbook.
		    - 6-8 questions in inferential statistics using one-sample and two-sample t-tests.
		    - 6-10 DDI questions for review.

7A		- Optional field trip day to Reedy Creek and Nature Preserve to learn about the stream restoration project there.

7B	PK	- Do Now
		  - DDI Remediation
		  - DDI Remediation
		- Review for Unit 7 Test
		  - Kahoot or Quizizz Live aligned to skills and content of Unit 7 test
		  - More emphasis can be given to weaker topics.
		- Homework
		  - Study guide for Unit 7 Test

8	PK	- Unit 7 Test

Appendix 1: Teaching Standards:

7.1 - Introducing Statistics
-VAR-1.I: SWBAT identify questions suggested by probabilities of errors in statistical inference.

7.2 - Constructing a Confidence Interval for a Population Mean
-VAR-7.A: SWBAT describe t-distributions.

-UNC-4.O: SWBAT identify an appropriate confidence interval procedure for a population mean, including the mean difference between values in matched pairs.

-UNC-4.P: SWBAT verify the conditions for calculating confidence intervals for a population mean, including the mean difference between values in matched pairs.

-UNC-4.Q: SWBAT determine the margin of error for a given sample size for a one-sample t-interval.

-UNC-4.R: SWBAT calculate an appropriate confidence interval for a population mean, including the mean difference between values in matched pairs.

7.3 - Justifying a Claim About a Population Mean Based on a Confidence Interval
-UNC-4.S: SWBAT interpret a confidence interval for a population mean, including the mean difference between values in matched pairs.

-UNC-4.T: SWBAT justify a claim based on a confidence interval for a population mean, including the mean difference between values in matched pairs.

-UNC-4.U: SWBT identify the relationships between sample size, width of a confidence interval, confidence level, and margin of error for a population mean.

7.4 - Setting Up a Test for a Population Mean
-VAR-7.B: SWBAT identify an appropriate testing method for a population mean with unknown σ, including the mean difference between values in matched pairs.

-VAR-7.C: SWBAT identify the null and alternative hypotheses for a population mean with unknown σ, including the mean difference between values in matched pairs.

VAR-7.D: SWBAT verify the conditions for the test for a population mean, including the mean difference between values in matched pairs.

7.5 - Carrying Out a Test for a Population Mean
-VAR-7.E: SWBAT calculate an appropriate test statistic for a population mean, including the mean difference between values in matched pairs.

-DAT-3.E: SWBAT interpret the p-value of a significance test for a population mean, including the mean difference between values in matched pairs.

-DAT-3.F: SWBAT justify a claim about the population based on the results of a significance test for a population mean.

7.6 - Confidence Intervals for the Difference of Two Means
-UNC-4.V: SWBAT Identify an appropriate confidence interval procedure for a difference of two population means.

-UNC-4.W: SWBAT verify the conditions to calculate confidence intervals for the difference of two population means.

-UNC-4.X: SWBAT determine the margin of error for the difference of two population means.

-UNC-4.Y: SWBAT calculate an appropriate confidence interval for a difference of two population means.

7.7 - Justifying a Claim About the Difference of Two Means Based on a Confidence Interval
-UNC-4.Z: SWBAT interpret a confidence interval for a difference of population means.

-UNC-4.AA: SWBAT justify a claim based on a confidence interval for a difference of population means.

-UNC-4.AB: SWBAT identify the effects of sample size on the width of a confidence interval for the difference of two means.

7.8 - Setting Up a Test for the Difference of Two Population Means
-VAR-7.F: SWBAT identify an appropriate selection of a testing method for a difference of two population means.

-VAR-7.G: SWBAT identify the null and alternative hypotheses for a difference of two population means.

-VAR-7.H: SWBAT verify the conditions for the significance test for the difference of two population means.

7.9 - Carrying Out a Test for the Difference of Two Population Means
-VAR-7.I: SWBAT calculate an appropriate test statistic for a difference of two means.

-DAT-3.G: SWBAT interpret the p-value of a significance test for a difference of population means.

-DAT-3.H: SWBAT justify a claim about the population based on the results of a significance test for a difference of two population means in context.

Appendix 2:

Several data sets on municipal and stream water can be used for the guided practice. There are the following ones that I have found as potentially relevant:

http://flintwaterstudy.org/2015/12/complete-dataset-lead-results-in-tap-water-for-271-flint-samples/

This study provides 2015 data on lead concentration during the 2015 Flint Water Crisis. This would be a set to use for teachers wanting heavy metals to be a key indicator of water quality. The data was collected as part of a citizen science initiative with help from researchers at Virginia Tech University.

https://cltwater.maps.arcgis.com/apps/webappviewer/index.html?id=6155082fd41f4c3faebd69d12a4b7e05

Charlotte Water has published a clearinghouse of water-quality data including major indicators such as heavy metals, bacteria, and other toxicants that has been georeferenced. This is especially useful as it provides teachers not only with multiple indicators to pull for data sets, but also can be tailored to specific locales in which their school is zoned to increase the locality to students. Any additional requests can be made to Charlotte Water, courtesy of the NC Freedom of Information Act.

https://charlottenc.gov/StormWater/SurfaceWaterQuality/Pages/MonitoringData.aspx

Charlotte-Mecklenburg Stormwater Services is obligated to disclose datasets for water quality under the NC Freedom of Information Act. Teachers may request historic information on water quality indicators through the following page, depending on the focus of their instruction and the testing available to them.

https://charlottenc.gov/Water/WaterQuality/Documents/CCR_2018_May232019.pdf

The City of Charlotte publishes its own drinking water report and this provides more detailed statistics on indicators. Datasets are only available through Freedom of Information Act requests; however, for conducting inferential tests with statistics instead of data, the information in this report can immediately be used, especially in contrast to the report with Flint that students will have previously examined.

Works Cited

Equal Opportunity Schools, "Equal Opportunity Schools Report: 2018-19 Equity Pathways Report". EOSchools. 2019. Accessed 25 September, 2020. https://eoschools.org/wp-content/uploads/2018/12/2018-19-Sample-Equity-Pathways-Report.pdf

College Board, "AP Statistics Course and Exam Description." College Board. Fall 2020.

Grundy, Pamela. *Color and Character: West Charlotte High School and the Struggle for Educational Equity in America*. Chapel Hill: UNC Press, 2018.

Charlotte-Mecklenburg Schools, "West Charlotte High School Profile Overview"". Charlotte-Mecklenburg Schools. 2019.

Barbosa, Luiz C.. "Theories of Environmental Sociology." In Twenty Lessons of Environmental Sociology, edited by Kenneth A. Gould, pp 25-44. Oxford: Oxford University Press

Bruelle, Robert J.. "U.S. Environmental Movements." In Twenty Lessons of Environmental Sociology, edited by Kenneth A. Gould, pp 211-227. Oxford: Oxford University Press

Checkher, Melissa. "Polluted Promises: Environmental Racism and the Search for Justice in a Southern Town." New York: NYU Press. 2005.

Masarenhas, Michael. "Environmental Inequality and Environmental Justice." In Twenty Lessons of Environmental Sociology, edited by Kenneth A. Gould, pp 127-141. Oxford: Oxford University Press

Glenn, Gwendolyn. "Testing Finds Unsafe Lead Levels in 4 More Sites." November 13, 2008. WFAE Charlotte.

Newsome, Mary. "UP THE CREEKS They Shaped Charlotte's History, but the Creeks Haven't Always Been Treated with Respect." Keeping Watch, February 10, 2017.

https://keepingwatch.org/programming/creeks/up-the-creeks.

Halstead, Judith, Sabrina Kliman, Catherine Berheide, Alexander Chaucer, and Alicea Cock-Esteb.
"Urban Stream Syndrome in a Small, Lightly Developed Watershed: a Statistical Analysis of
Water Chemistry Parameters, Land Use Patterns, and Natural Sources." *Environmental Monitoring and Assessment* 186, no. 6 (June 2014): 3391–3414.