BYU ENGINEERING
Civil & Construction Engineering

CAPSTONE

DRINKING WATER SLUDGE REMOVAL AND DISPOSAL
PROJECT ID: CEEN_CPST_002

by

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A Capstone Project Final Report

Submitted to

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Central Utah Water Conservancy District

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Executive Summary

PROJECT TITLE: DRINKING WATER SLUDGE REMOVAL AND DISPOSAL
PROJECT ID: CEEn_CPST_002
PROJECT SPONSOR: Central Utah Water Conservancy District
TEAM NAME: ByProduct Solutions

This report analyzes alternatives for disposing of sludge from the Don A. Christiansen Regional Water Treatment Plant (DACRWTP), which Central Utah Water Conservancy District (CUWCD) operates in Orem, Utah. Influent water consists only of natural runoff from the Provo River extending from Jordanelle and Deer Creek Reservoirs. DACRWTP produces a high-quality sludge as a byproduct of the treatment process that, due to the levels of heavy metal present, specifically Arsenic (As), is currently being trucked off site and stored at a District facility.

Using CUWCD figures and basic assumptions, we estimate that DACRWTP creates approximately 1,375 cubic yards (cy) of sludge annually. From CUWCD tests as well as test performed by BYU's Environmental Analytics Laboratory, the average As content per sample is 181 parts per million (ppm). These results indicated As levels in the sludge were too high to allow repurposing as a direct fertilizer because it exceeded EPA regulation, despite containing various quality nutrients. (EPA, 2011) Other options, like repurposing as a construction backfill or use in concrete masonry units, were deemed beyond our project's scope and resources as they presented more challenges and complexities than our team had time to work with. We do not, however, suggest these options are inappropriate for CUWCD to explore and potentially initiate in the future.

With the control as the first option (i.e., continue using the current site to store the soil), our team presents two main potential alternatives to store/dispose of the byproduct. CUWCD can either deposit the contaminated soil at North Pointe landfill in Vineyard or attempt to combine their sludge with the sludge from Orem Wastewater (WW) Treatment and repurpose it as a nutrient rich soil available to Orem residents.

We suggest CUWCD dispose of their sludge using North Pointe landfill. According to the matrix presented in the results section, which evaluates public health, social, environmental, and economic factors, we feel this solution has the least negative impact for CUWCD. It is also a long-term solution that we feel can simplify itself as CUWCD becomes a regular depositor over time.

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Introduction

DACRWTP has a capacity of treating 100 million gallons of water per day, which provides clean drinking water to approximately 850,000 people in Utah and Salt Lake Counties (CUWCD, 2018). The water is sourced from the Provo River Watershed and treated with ozone to remove any taste and odor issues and to inhibit the formation of harmful disinfection byproducts. Organic molecules and other contaminants are removed through coagulation (using Ferric Sulfate), flocculation, sedimentation, and filtration processes, after which chlorine disinfects the water. A belt press separates the water from the organic materials, leaving behind the sludge byproduct. This material is rich with various organics and heavy metals, making it a hazardous soil. How this material is dealt with varies throughout the world, from simple landfill disposal to commercial reuse in soil backfill and masonry applications. This report will analyze the sludge production and composition and, considering economic, environmental, and social impacts, suggest three courses of action for disposing of or reusing the sludge produced by DACRWTP. First, we will give an approximate schedule of the project, followed by the assumptions made and limitations imposed on the project. Next, we will present the results of our analysis, detailing the related issues as well. We will give a brief report on the lessons learned by our capstone team, followed by the conclusions of the report. Finally, our recommendations to CUWCD will be given.

Schedule

Beginning in early October, our team began meeting weekly to organize and create tasks for the project. These meetings later consisted of researching, contacting, inquiring into other treatment plants, and compiling ideas and information into this report. Some important events in the timeline of our project are as follows:

October 18th, 2021 – Our team met with the project sponsor (Jon Franklin), faculty mentor (Rob Sowby), and the lab manager from the water treatment plant (Erik Cram).

October 30th, 2021 – We visited the Don A. Christiansen Water Treatment Plant to gain an understanding of the sludge production and removal process. We also visited the sludge storage site.

November 22nd, 2021 -	Our team submitted our Statement of Work outlining our perceived problem, our course of action, and our tentative schedule for discovering a solution.
January 14th, 2022 -	We performed another site visit to the sludge storage site and took various samples that represented surface and subsurface sludge, as well as represented different times of the year.
January 24th, 2022 -	The samples were submitted to the BYU Environmental Analytics Laboratory to get tested for metal contents and concentrations.
February 14th, 2022 -	Our team visited with Jake Nostrom and Thad Monson at the Springville Wastewater Treatment Plant. We reviewed their sludge treatment techniques and received insight on potential routes for our sludge.
February 18th, 2022 -	The lab completed the soil analysis and sent over the results. We began researching effects of certain metal concentrations for different soil applications.
March 11th, 2022 -	We had a meeting with Jon Franklin and Erik Cram of CUWCD to coordinate our progress. We had a great discussion and presented some preliminary ideas and information, as well as received additional information.
April 11th, 2022 -	We delivered the final report, along with the PowerPoint presentation and poster, to CUWCD and Dr. Sowby over dinner.

Assumptions & Limitations

To ensure a concise and attainable goal, several limitations were imposed, and various assumptions were made. Given that the goal of this project was to investigate alternative methods for disposing of the sludge, reductions and/or adjustments to the production of the sludge itself and any other water treatment procedures were not considered. While the sludge contains various types of metals, our early conversations with CUWCD suggested that As, more than other constituents, will limit the sludge disposal options because of its toxicity. We also assumed that As cannot be totally removed from soil particles, which allowed our research to focus on contaminated soil usage rather than methods to decontaminate the soil (though a brief discussion on a method to potentially decontaminate the soil will be presented later in the report). We assumed that the most likely method to reduce the contamination of the soil was to dilute the sludge with a basic type of soil, thus reducing the As concentration. The main limitation with this assumption is that the basic type of soil may not be readily available or even effective, considering the larger assumption that the basic type of soil will have no major contaminants itself.

Our budget of $200.00 and relatively short time frame of 7 months limited our ability to gather long-term data and conduct more specific research according to such data. This time limitation is mostly relevant because the levels of As present in the water varies throughout the year, with the assumption that lower water levels produce higher percentages of As. This assumption can result in potentially inaccurate composition estimations. Similarly, when sampling the sludge deposits, we relied on Jon Franklin's estimates for the month and year during which the sampled piles were produced. From basic preliminary research prior to sampling the sludge for composition testing, we assumed that As concentrations sampled from the surface of the piles would be consistent with As concentrations sampled from the subsurface. This assumption acted as a control for the composition tests to either confirm or deny.

DACRWTP only services runoff water (i.e., no wastewater) and is therefore dissimilar to most nearby treatment facilities of which similar processes could have been adapted. This limited our capacity to compare methods used by other facilities in our region.

Design, Analysis & Results

To find viable solutions for sludge disposal, a specific process was followed to find the necessary criteria for preferable alternatives. To give a brief overview of the procedures, a site visit enabled our team to understand the sludge production process at the DACRWTP in Orem. This facility is pictured in Figure 1. Then we visited the Central Utah Sludge Deposit Site to see the current stockpiles of stored sludge that needed to be disposed of. Samples of this sludge were selected and brought to the BYU Environmental Analytics Laboratory to determine the non-organic composition of the byproduct. Based on the results of this test, research was completed on several solutions that could dispose of our material specific material. Once three possible solutions were found, our team contacted several facilities capable of disposing of the sludge byproduct so we could get more information on the feasibility of our sludge byproduct. Of the three possible solutions, each option was valued based on applicable social, environmental, and economical factors and a final decision was made based off the ranked criteria.

Figure 1: Don A. Christiansen Regional Water Treatment Plant

Procedure

A site visit to the DACRWTP facility was completed on October 30, 2021, and was led by our capstone sponsor, Jon Franklin, and accompanied by Dr. Sowby. This visit allowed our team to get an extensive look at the complete water treatment process and help us see how the sludge was being produced. We discovered that our plant does not deal with wastewater and that the plant cleans water flowing out of the Provo River. Sludge from this facility is generated by gathering the coagulants of the ferric sulfate polymers along an angled filter. By the time water flows through the angled filters from the mixing basins, the polymers have adequately bonded to water impurities found in the Provo River runoff. Periodically, the collected sludge sluffs off of the angled filters once enough coagulant builds up and then collected at the bottom of the filtering bed. A belt press is then used to remove moisture from the sludge to decrease the unit weight and volume of the processed sludge. Depending on the available capacity of the drying beds, the sludge is either directly transported out of the facility or is placed in drying beds for a few weeks until enough byproduct accumulates for removal. The amount of sludge produced increases with the amount of water that is being filtered through the plant. Figure 2 shows the average discharge (cfs) from Deer Creek Reservoir for the 2019-2021 water years, which is the available water for DACRWTP to treat. Typically, the drying beds store sludge between November until April during the slow season of the WTP. More sludge removal trips occur during the high discharge seasons between April and October.

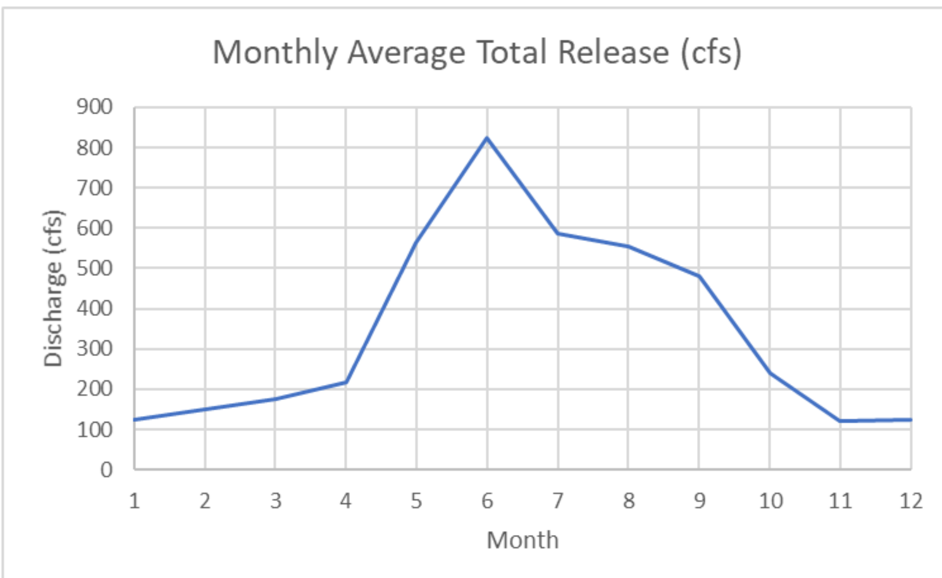

Figure 2: Monthly Average Discharge from Deer Creek Reservoir from 2019-2021

The sludge byproduct is then transported throughout the year to a temporary CUWCD sludge disposal site. This site is 4.8 miles away and has a non-leeching concrete pad where the sludge can be temporarily stored. The sludge disposal site contains byproduct piles from different seasons over the past decade. Figure 3 shows a Google Earth image of the location of the sludge disposal site where the byproduct has been building up. During different water years, and across different seasons, the composition of the sludge byproduct has been theorized to vary according to properties of the watershed. With the composition of the sludge byproduct varying, any solution to relocating or reusing the sludge for a different purpose would have to allow for a range of uncertainty in traceable elements in the sludge pile. We were particularly interested in heavy metals present in the sludge because these elements have several health and safety concerns when used in a public application.

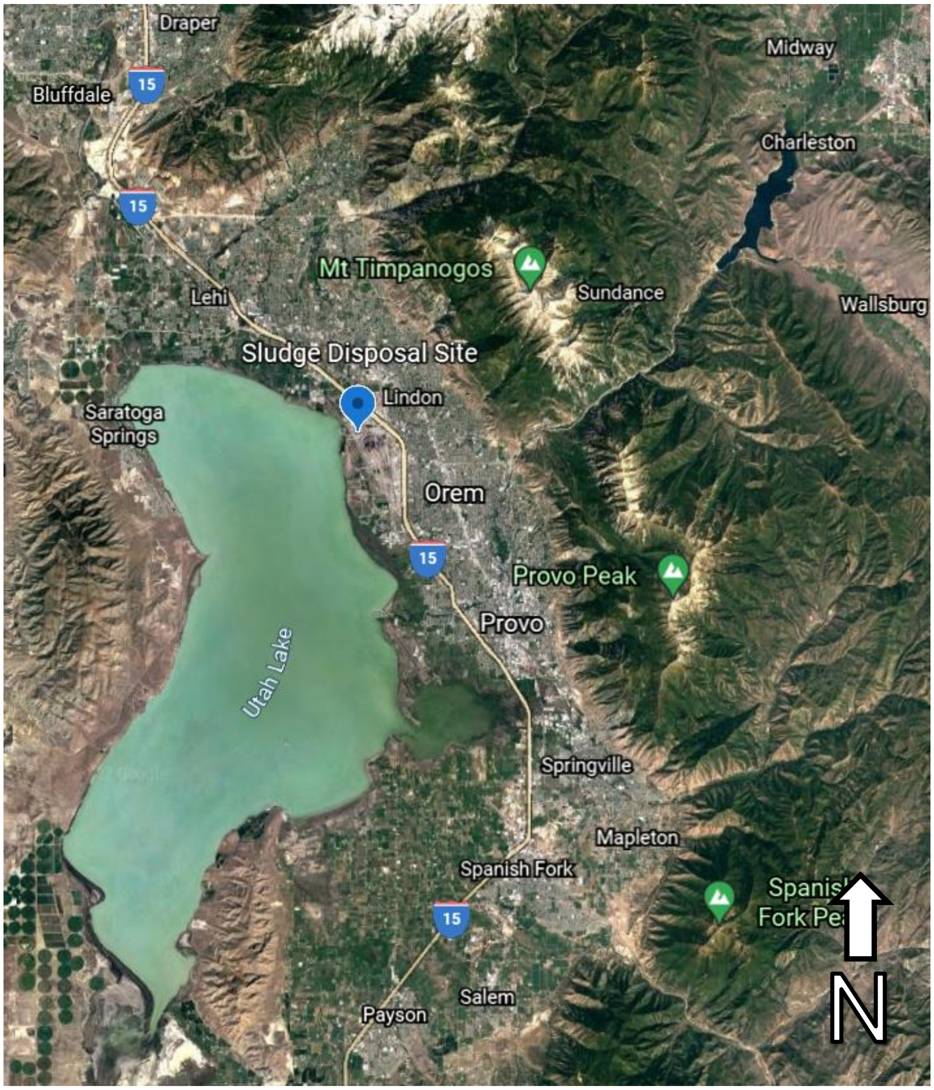

Figure 3: Location of the current CUWCD Sludge Disposal Site

To account for the variety of elements present in the sludge produced at the WTP, specific samples were selected to account for extreme conditions during the water year. We hypothesized that during the slower months (late fall, winter, and early spring), runoff would scour more particles off of the Provo River bottom. Additionally, the slower months would have less discharge and thus have a higher concentration of contaminants for a smaller flowrate. The summer months were hypothesized to have the largest discharge of runoff with the smallest concentration of contaminants. In addition to testing samples for different seasons of the water year, we gathered recently dumped samples and a couple of samples that have been stored at the site for about five years. Surface and subsurface samples were taken for the recently dumped slow season sludge, the recently dumped high volume season sludge, and for the sludge that has been on site since 2017. The subsurface and aged samples were taken because of our researched assumption that UV radiation may affect the concentration of traceable elements in the byproduct (Zafar, 2012). Figure 4 and Table 1 work together to present the location, characteristics, and description of each sample taken.

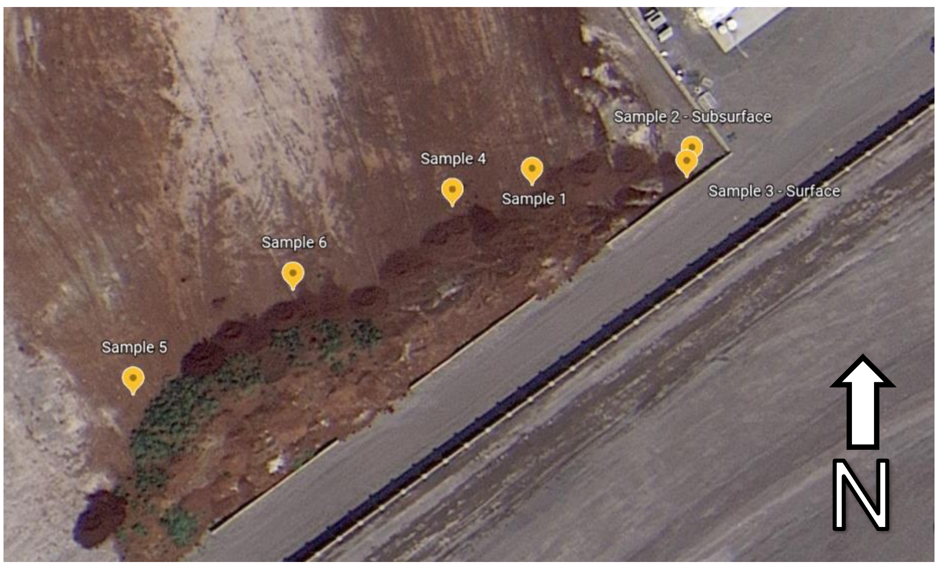

Figure 4: Sample Locations at the Sludge Disposal Site

Table 1: Sample characteristics at the sludge disposal site

	Sample Level	Time of Sludge Deposit
Sample #1	Subsurface	Spring 2021
Sample #2	Subsurface	2017
Sample #3	Surface	2017
Sample #4	Surface	Spring-Summer 2021
Sample #5	Subsurface	Fall-Winter 2021
Sample #6	Surface	Summer 2021

Jon Franklin aided our capstone group in identifying samples at the sludge disposal site that most likely met the extreme values of the composition distribution. Although more samples would have been beneficial to identifying the concentration range of traceable elements, the number of samples were limited by the project budget. Nevertheless, our capstone group was confident that broad enough range of samples were collected for our testing purposes.

Lab Results

Promptly after the selected sludge samples were collected, we took the samples to be tested. Through the BYU Environmental Analytics Laboratory, we received results from the Inductively Coupled Plasma (ICP) test performed on our sludge samples. This test was selected for its relatively low cost, and its thoroughness in providing reliable results that can be obtained for about 25 elements with detection limits in the parts per billion range. This test was also recommended by the BYU laboratory technicians because it identifies and measures a range of chemical elements necessary for the analysis of metal samples. Figure 5 shows the applicable metal concentrations of each of our samples on a semi-log plot.

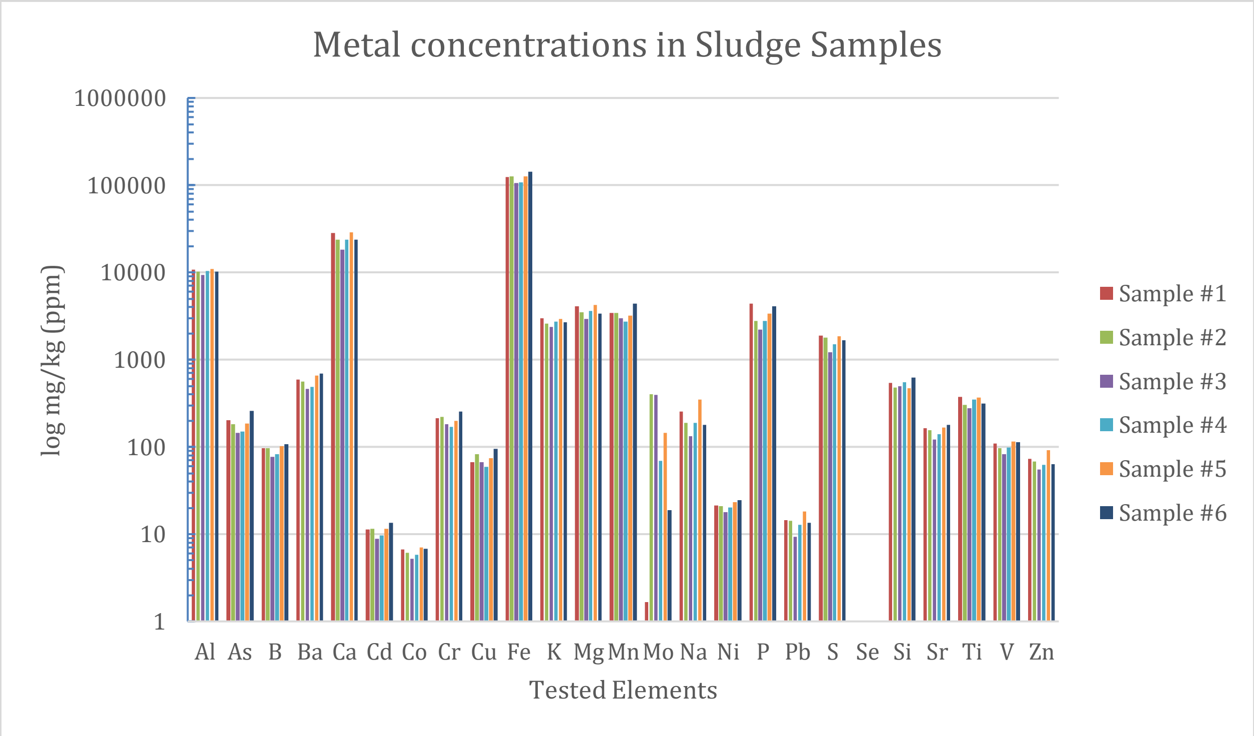

Figure 5: Metal Concentrations for Various Samples using the ICP test

The results from the ICP test gave concentration values fairly homogenous across each sample. Of the 25 different elements tested, nearly all of the elements were within the same degree of magnitude across the 6 samples. Iron (Fe), Calcium (Ca), and Aluminum (Al) were among the elements with the highest concentrations for each of the samples. Since ferric sulfate was used as the mixing coagulant in the sludge production process, Fe unsurprisingly had the highest concentration of around 100,000 mg/kg. The only element with the largest variability was Molybdenum (Mo) which varied from nearly 1 mg/kg to 300 mg/kg. Even though the difference in degree of magnitude was the greatest between Mo in the samples, the relatively small trace of 300 mg/kg was still not significant enough to require special recommendations. The following elements are listed by the World Health Organization as heavy metal contaminants in the soil As, Cd, Cr, Cu, Fe, Hg, Mn, Ni, Pb, Zn (WHO 1996). Each of these elements have an allowable particle per million (ppm) limit that a sample must not reach to be considered uncontaminated. Of the elements that we tested in the BYU environmental analytical lab, our samples exceeded the limit in As, Cd, Cu, Fe, and Mn. Of the four soil violations, Fe was found to have the largest difference in ppm from what is allowable in the soil.

Presentation of Options

Based on the guidelines given from the Environmental Protection Agency (EPA), the contaminated sludge byproduct needs to be disposed of and not released publicly when these particle concentrations are not met (EPA 2011). Due to the contaminated state of the sludge and EPA restrictions, we decided that the do-nothing scenario would be our first option of dealing with the sludge.

Using only the As concentration data from the ICP tests, along with the two sets of composition data given to us by CUWCD, our sludge averaged 181 parts per million As. The data provided by CUWCD, numbers 7 and 8, were sampled on 9/20/18 and 10/1/18, respectively. Figure 6 demonstrates that the sludge has relatively uniform levels of As concentrations throughout various seasons within a given water year and across several years.

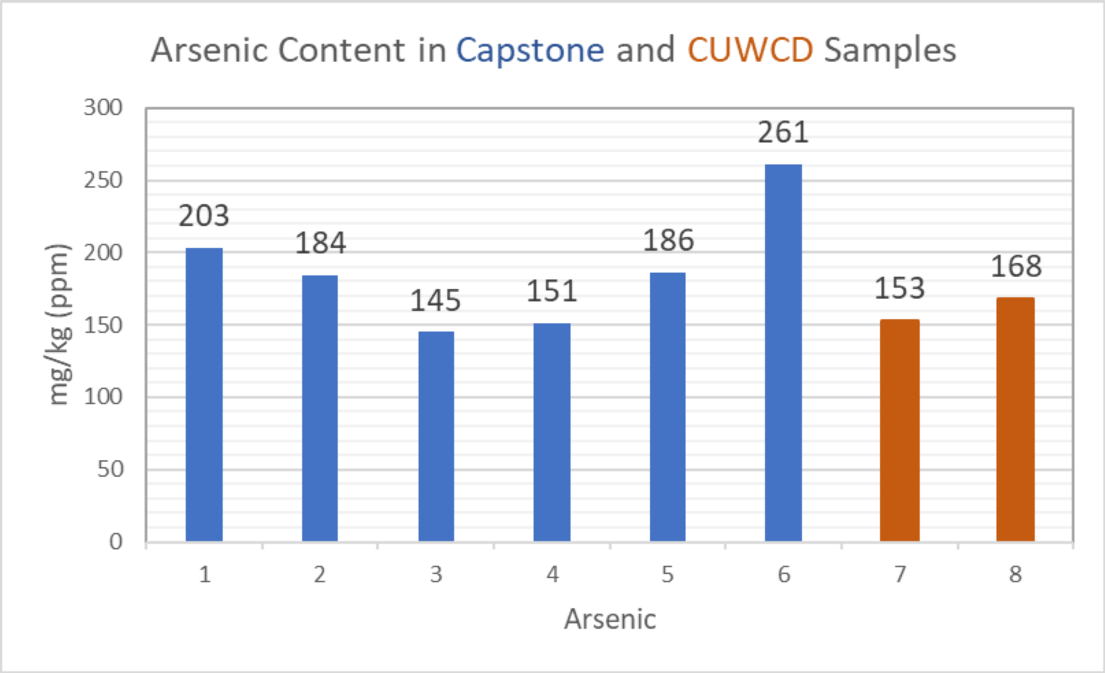

Figure 6: Arsenic Content in samples taken by our capstone team and CUWCD

Once we realized the soil was contaminated to a degree which couldn't easily be remediated, we searched for basic disposal solutions. Simple internet searches returned various business that could treat the material and return it in a different state, but no such companies are in the same region as DACRWTP. With that in mind, we began calling various landfills and transfer stations, including Trans-Jordan Landfill, Bayview Landfill, North Pointe Transfer Station, and Springville Transfer Station. Trans-Jordan was too far to be reasonable when compared to Springville and North Pointe, but Springville did not accept contaminated soils. Bayview is the landfill that North Pointe transfers their material to but because North Pointe is much closer to DACRWTP, it was more cost effective for CUWCD to transport their soils to North Pointe rather than directly to Bayview. Delivering the sludge byproduct to the North Pointe transfer station is our second option of disposing the sludge.

As an alternative to disposing the sludge byproduct, our capstone group explored another option of composting the sludge in a dilution process. Many cities compost their WWTP sludge with green waste to create fertilizer for citizens. For example, Springville citizens unload green waste at the WWTP and the material is then put in a woodchipper and sieved into mulch. Then the compost is made from the useful material that came out of the chipper and the WW sludge. They mix two loads of the quality chipped material with 1 load of sludge (2:1 mixing ratio). After mixing the two ingredients, the newly formed compost is put into piles where it sits for at least 2 months. During this two-month period, the compost piles of E.coli coliform bacteria is killed by UV radiation on the exterior of the pile. Internally, the reaction of oxygen, microorganisms, and water lets off C02 heat and odors. Inside the pile, the heat reaches to about 140 degrees and kills off the remaining bacteria. The pile is mixed occasionally to let oxygen flow through the pile and continue the reaction process. The remaining fertilizer compost is then given off to farmers after the complete chemical reaction has taken place. Figure 6 illustrates the composting reaction at the WWTP.

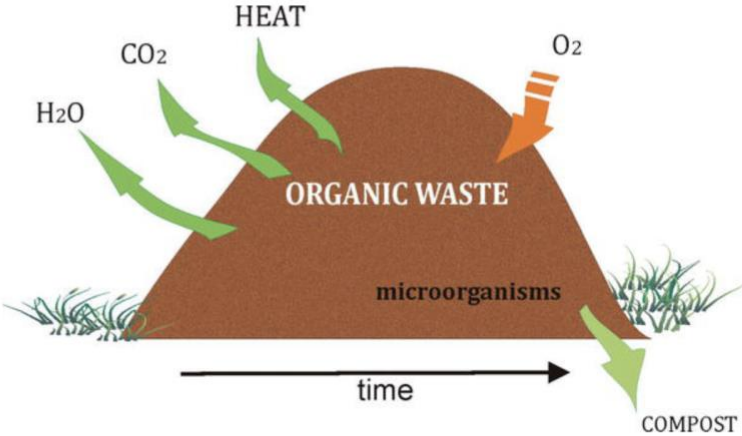

Figure 7 7: Composting reaction for WWTP sludge

The sludge produced from the DACRWTP could potentially be mixed with the sludge from a WWTP in the composting process. The state of Utah gives Springville a permit that gives them permission to use the WWTP sludge to create compost. Figure 8 shows Springville's state approved composting site. The state reports to the EPA and issues out these permits to municipalities. If we wanted to alter the process that a local municipality has in the creation of compost fertilizers, then a permit would be required from the state. Our sludge is very different from the WWTP sludge and so a new permit would require the analysis of the two mixed sludge byproducts into one ingredient for the fertilizer. Additional attention to the amount of sludge mixed into the WWTP would have to be standardized even during the varying seasons of sludge production. This step would be necessary because our sludge may be unlikely to produce effective fertilizer on its own due to the high concentrations of heavy metals that may not be found in the WWTP sludge. Also, closer sites such as the Orem or Pleasant Grove WWTPs could be explored to reduce transportation costs rather than using the Springville WWTP. Composting with another WWTP is the third alternative that we will compare with the previous two options.

Figure 88: Springville City's composting facility

Economic Analysis

With these three options, we evaluated the economic impact of each one. Regardless of the recommended solution, the soil would need to be transported. As such, table 2 shows the transportation cost estimates, which we used as a basis for ranking the economic impact of each option.

Table 2: Transportation cost estimates for each of the three options

	Current	North Pointe	Orem WW
Roundtrip Distance (miles)	9.6	13.4	14.4
Cost per Trip	$ 125.86	$ 175.67	$ 188.78
Annual Transport Cost	**$ 17,305**	**$ 24,155**	**$ 25,958**
Deposit Cost	$ 0	$ 23,203	$ 0
Testing Cost	$ 0	$ 2,160	$ 0
Total Annual Cost	**$ 17,305**	**$ 49,518**	**$ 25,958**
*Additional Equipment Cost**	$ 0	$ 0	$ 500,000

These calculations are based on the approximations of 1375 cubic yards per year and each truck carrying 10 cubic yards, as well as the quoted $12.50 per ton deposit price at North Pointe landfill. A simple 100 lbs./ft^3 was used to estimate the weight of the soil. The annual transport cost is bolded to signify they are constant and not based on any assumptions or rough estimations. The cost per mile (including driver wages) was given to us by CUWCD as the range $12.34 - $13.38 so an average of $13.11 was used. Roundtrip distances were retrieved using Google Maps.

The testing cost projections were made based on the assumption of 12 Toxicity Characteristic Leaching Procedure (TCLP) tests per year (which are required by North Pointe landfill for contaminated soils), using the quoted $180 per test from Chemtech-Ford Laboratories. Given the lack of information currently available for the option to dilute the sludge with Orem Wastewater (WW), we do not have an accurate estimate for the testing cost and have therefore left it at zero.

The additional equipment cost projection was made using information gathered during our visit to the Springville WW treatment facility. They use a large, commercial grade machine that is a combination of a woodchipper and sifter to grind large green waste such as tree limbs delivered to the facility by Springville residents, which is then sifted and combined with their wastewater sludge. If the sludge from DACRWTP could be combined with the wastewater sludge at the Orem WW facility, we are not positive the material would also be combined with green waste materials provided by Orem residents. If CUWCD shows interest in this option, we contacted Rotochopper Inc. for quotes on machines similar to those used by Springville WW. They quoted a shredder/grinder at $325,000 and a screener at $300,000, with model numbers MP2 and MT175, respectively. This information was not gathered with the intent to purchase, but rather for a general estimate at what similar equipment may cost CUWCD. Therefore, we estimated a purchase price of $500,000 (not including any annual operating or maintenance costs) for equipment to enable Orem WW to combine green waste, wastewater sludge, and DACRWTP sludge into a soil fit for reuse by city residents in home (gardening), work (landscaping), or recreational applications. If it were possible to create similar reusable soil without adding green waste, that equipment cost projection would drop dramatically, even potentially to zero, given Orem WW likely already has a front-end loader on site which could mix the two sludges.

Now that we have defined three alternatives with their respective estimated economic impacts, including a summary of the environmental restrictions, we begin evaluating the social and public health factors. Using these four applicable factors (public health, social, environmental, economic), we can define what we believe to be the best alternative for disposing of the sludge.

Related Issues

The disposal of sludge byproduct from the Don A. Christiansen Regional Water Treatment Center with the CUWCD has an array of related issues when analyzing a variety of decisions. Impacts from our project may affect the public health, safety, general welfare, global, cultural, social, environmental, and economic factors. This section will analyze each factor and then provide a table quantifying the impacts of each proposed solution.

The table below quantifies the relative impact of sludge removal for the following solutions. Each category is rated from 1 to 10 with 10 being the largest negative impact. A brief reasoning of the impact of each decision is also given after the table. Since this table is measuring negative impacts of each option, a lower total rating signifies less cumulative impacts, while a higher total value signifies more cumulative impacts.

Table 3: Recommendation Ranking Table

	Option 1 (Null – Do Nothing)	Option 2 (Landfill)	Option 3 (Composting w/ WWTP sludge)
Public Health	4	3	5
Social factors	5	4	2
Environment factors	6	4	2
Economic factors	2	3	10
Total	17	14	19
*Safety, Welfare, Global Factors, and Cultural factors are not included in table due to equal/negligible impacts.			

Every project has some sort of effect on its surrounding factors. This project potentially has direct effects on public health, social factors, environmental factors, and economic factors. The only safety concern has to do with public health and will be covered through that section. The disposal of sludge should not cause any welfare concerns worth considering. Since this project is so local, any global factors would be minimal and not worth exploring. This project will also have no effect on any cultural group or disrupt any area sensitive to any cultural group.

Starting in our early discussions with the client, it became evident that the sludge would contain certain heavy and toxic metals that could potentially pose a risk to any individual that came in contact with it. One factor that has been explored extensively through our research is the As concentration in the sludge and the limitations that these concentrations place on potential uses of the sludge. We learned that As can be extracted from soil by plants and possibly be deposited in fruits or vegetables growing from those plants. This discovery eliminated the possibility of using the raw sludge as a soil for agriculture.

Another risk for public health deals with the potential for the As or other metals to be leached out of the sludge and seep into the groundwater or surface water after heavy rainstorms. This possibility is especially likely for the do-nothing method since it is out in the open and relatively close to the lake. The safest method to avoid potential lake or groundwater contamination would be the landfill method. Landfills are designed to collect this leaching and properly dispose of the hazardous material without contaminating any water sources.

The sludge disposal methods do not necessarily have the potential for negative social effects, but there is potential for positive social impacts to be achieved through the composting methods. The cities of Springville and Provo both have city established composting methods where the citizens can dispose of green waste which the city combines with wastewater sludge to produce fertilizer and mulch that the citizens can purchase. A possible use of drinking water sludge could be to combine it with wastewater sludge and green waste to produce a usable product that benefits the people who use it.

Environmental factors considered in the analysis include the effects of toxic metal leaching and composting. The sludge contains many metals that have the potential of leaching over time and during rainstorms which could potentially leach into groundwater or into streams leading into Utah Lake. This danger applies most to the do-nothing method and its proximity to Utah Lake. The landfill method would be more environmentally mindful since landfills are designed to prevent leaching into ground or surface water. The composting method would provide environmental benefits to local communities by creating methods to increase community agriculture and greenery.

Each method has its economic limitations that might sway the final solution for the sludge disposal. The cheapest option would be to do nothing. The current disposal site is near the treatment plant and requires minimal transport. A sustainable long-term solution would be the landfill method. The North Pointe transfer station would be able to receive the sludge for a per-ton cost and a per-batch testing fee. By far the most expensive option would be the composting option. Transporting would be a similar cost to other methods, but the composting process requires labor and equipment aside from the existing processes. The final product could be sold, but not to the point to be close to breakeven.

Lessons Learned

Our first challenge was ensuring we had accurate, timely, and relevant information regarding our project. Understanding the project's limitations and expectations was something our team continuously sought to improve on. We found this particularly difficult and relevant while doing preliminary research regarding potential uses and disposal methods of water treatment byproducts. Much of our research seemed to push our focus outside the scope of our resources. Once we received more clear and precise data regarding the composition of the sludge, we were able to narrow our research and create more viable, reasonable, and efficient solutions. We suggest Capstone teams make a more diligent and authentic effort to develop a relationship with their sponsors early on in the project timeline. We thoroughly enjoyed working with CUWCD and eventually created such a relationship but had our efforts to do so happened earlier on, we are confident our efficiency and productivity would have been improved.

The second major challenge our team encountered was a lack of response from different water treatment facilities, local city officials, and various professionals within the water treatment industry. Many of them were unresponsive for several days or weeks but eventually got back to us, while others have yet to respond to various forms of contact over the last several months. Unfortunately, there isn't much one can do to counter unresponsive contacts, but we found that using different forms of contact, reaching out at different times of the day, and seeking contact as early-on in the project timeline as reasonably possible were the best ways to improve our chances of getting a response.

Lastly, our team recognizes the importance of establishing a clear control to use in comparing and contrasting the solutions. This may seem like basic knowledge, but we feel it's important to specify as it helps guide the project in the right direction. For our team, visiting the treatment plant and seeing the process first-hand greatly increased our understanding of the control, which helped guide our project in the right direction.

Conclusions

Throughout the course of our research and studies, we found certain conclusions to our prior assumptions and justifications made toward the beginning of our project. One assumption made at the beginning was that Arsenic was the main contaminant of interest. We concluded to maintain this stance after our test results came back with As levels around 200 ppm. Lead was another potential contaminant, but with its much lower concentrations we decided to focus on As.

Another assumption made was that surface and subsurface contaminant levels would be approximately the same. UV radiation was a potential decontaminant for As, but after receiving test results for both surface and subsurface samples, the difference was determined to be negligible.

Our team concluded that the three most feasible options would be to maintain the current method, dispose of the sludge at a landfill, and to organize a composting system with a wastewater treatment plant or a city. Other options were explored but due to lack of information, contact, or research, these options were not explored further. After comparing the weight of different factors, we believe the landfill option is the most reasonable in the aspects described in the results and related issues. The recommendation section outlines the reasons for this conclusion.

Recommendations

Upon analyzing our three options, we suggest using the landfill method with the North Pointe Transfer Station. The factors we used to determine the best method included public health, social factors, environmental factors, and economic factors. Of the three options, the landfill option provided the least concern for public health. The sludge would be kept away from potential contamination methods by being directly disposed of at the landfill and avoiding leaching into water sources.

The landfill option also had relatively smaller impacts for social and environmental factors. There would be little social interaction with this method as the sludge would not interfere with local citizens. Landfills are designed and operated in a way that protects the environment from contaminants and prevents leaching into the groundwater, which cannot be guaranteed with the other options.

Economically, this method would have a slight cost increase compared to what the plant is currently doing. The North Pointe Transfer Station is slightly further than the current dump site and requires testing for contaminants, so travel and testing costs would increase the price slightly. This method would be significantly cheaper than the composting method since all required equipment is already owned by the CUWCD.

Further discussions with Orem or other nearby cities might show the composting option to be desirable for social and environmental reasons. This would provide a source of interaction and service between the city and citizens. The citizens would be able to dispose of their green waste at a facility and the city could dispose of their drinking and wastewater sludge to combine into a sellable compost or mulch. Due to time and budget restraints, this option was not explored to its fullest, but the dialogue can easily be opened to the city.

Another potential lead for the future came from the Southeast Regional Treatment Plant in the Jordan Valley Water Conservancy District. Their current disposal method is with ESP Excavation. They sell their sludge to ESP Excavation for $50 per year and transport it to their facility in American Fork. They perform a test to get approximate contaminant concentrations. The DACRWTP does produce more sludge than the Southeast Regional Treatment Plant and ESP Excavation currently does not have capacity for more sludge, but in the future this option might be more feasible.

Appendix A

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Jordan Lee Christensen

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EDUCATION

Bachelor Degree, Civil Engineering, Brigham Young University, Provo, UT, April 2022
- GPA 3.88/4.00
- Brigham Young Full-Tuition Academic Scholarship
- Utah Regents Exemplary Award Scholarship
- Bingham High School Alumni Scholarship
- Member of the American Society of Civil Engineers Student Chapter

RELATED COURSES

Mathematics
- Multivariable Calculus, Linear Algebra, Differential Equations, Statistics

Civil Engineering
- Statics, Dynamics, Materials, Structural Analysis, Soil Mechanics, Geomatics, AutoCAD/Civil3D, ExcelVBA, Fluids, Hydraulic Engineering, Hydrology, Geometric Design of Highways, Traffic Engineering, Urban Transportation, Metals, Woods, Masonry, Concrete, Asphault

WORK EXPERIENCE

Multimedia Technician Manager, Brigham Young University Office of Information Technology, Provo UT, December 2018 – Present
- Supervise the installation and performance of audio/visual equipment during Brigham Young Univesity's Educational Week (hosts 20,000 people).
- Manage a team of 5 technicians for campus-wide audio/visual troubleshoot.

Hydraulic Technician Manager, Meterworks, Dickinson ND, June 2021 - Aug 2021
- Directed 4 teams of hydraulic technicians in the installation of 3,000 Neptune water meter registers to fulfill a $120,000 contract.

Civil Engineer Intern, Proterra Group, South Jordan UT, July 2020 – August 2021
- Performed on-site land surveying and AutoCAD drafting for residential and commercial developments across five Utah counties.

Transportation Engineer Intern, Federal Railroad Administration, Office of Data Analysis and Program Support. Washington DC, April 2020 – July 2020
- Reviewed the public FRA safety data website, identified deficiencies in how information was presented, and provided a finalized report and recommendations for improvement to the Director of Safety.
- Created VBA scripts to automate Paperwork Reduction Act processes and produced a white paper to explain the processes for future users.
- Learned, from shadowing subject matter experts, about cost-benefit analysis, railroad inspections, and the processing of government grants.

Landscape Installation Crew Lead, One Grounds Management, Orem UT, May 2016 – October 2016
- Directed the operations and maintenance of the properties of over 60 Banks spread across Utah.
- Performed customer service for Bank Managers and Landscaping Crews.

SKILLS

Computer:
- Proficiency in ExcelVBA, AutoCAD, Civil 3D, Revit, ARCGIS, R, Synchro, CUBE

Foreign Language:
- Proficiency in reading, writing, and speaking in the Spanish Language

OTHER EXPERIENCE

Full-Time Volunteer Representative, The Church of Jesus Christ of Latter-day Saints, Mexico City, Mexico, October 2016 – September 2018
- Provided leadership, development, and training for 24 volunteer representatives
- Engaged in reconstruction of houses for the post-earthquake relief effort in Mexico City after size 7.2 earthquake destroyed infrastructure.

Miscellaneous:
- Eagle Scout Award, Boy Scouts of America

Mitchell Dial

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EDUCATION

Brigham Young University — Apr 2022
Bachelor of Science, Civil Engineering — Provo, UT

- GPA - 3.61
- Received BYU Half-Tuition Scholarship for 2019-2020
- Member of BYU ASCE Student Chapter
- Member of BYU AREMA and ITE clubs
- Relevant Coursework: AutoCAD, Revit, Fluid Dynamics, GIS Applications, Traffic Engineering

ENGINEERING-RELATED EXPERIENCE

AECOM — April 2020-Present
Inspector and Lab Technician — Sandy, UT

- Earned SRDTT and CTT certifications through UDOT's WAQTC program
- Performed inspection duties on 4 different UDOT-contracted projects
- Provided materials testing of concretes, asphalts, and various types of soils according to AASHTO and ASTM procedures for 20+ projects

Erstad Architects — Sept 2015-Dec 2015
Intern — Boise, ID

- Observed and participated in site planning and organizing documentation for 2 projects
- Developed familiarity with SketchUp and Revit

City of Caldwell Engineering Dept. — Sept 2015-Dec 2015
Intern — Caldwell, ID

- Evaluated system compatibility with city regulations in preparation for potential site acquirement
- Assisted in ensuring sidewalks complied to ADA standards for 2 subdivisions

ADDITIONAL EXPERIENCE

Brigham Young University — Jan 2020-April 2021
Teaching Assistant — Provo, UT

- Lead 102 students under direction from Dr. Grant Schultz (Ph.D. CE) in developing leadership attributes such as communication, humility, group work and self-awareness

Simpson Farms — May 2015-August 2019
Seasonal Farmhand — Caldwell, ID

- Irrigated and harvested Alfalfa hay, requiring proficient use of heavy machinery
- Managed irrigation and harvesting efforts for 400+ acres of land
- Created irrigation maps to support effective training for future employees

VOLUNTEER EXPERIENCE

The Church of Jesus Christ of Latter-Day Saints — April 2016-April 2018
Representative — Oslo, Norway

- Built relationships with local citizens by communicating 10-12 hours per day in Norwegian
- Organized 2 leadership trainings for 30+ volunteer representatives
- Provided leadership, development, and general counseling for 30 representatives

SKILLS/INTERESTS/ACHIEVEMENTS

- Advanced fluency in Norwegian (Bokmål)
- Earned AA in Liberal Arts from College of Western Idaho with a 4.0 GPA as a high school student
- Awarded Utah APWA $2,500 scholarship in September 2021
- Dual-Citizen of the USA and Belgium

Zachary T. Gallini

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817-907-3435 | zgallini98@gmail.com | linkedin.com/in/zach-gallini

EDUCATION

Brigham Young University — **Apr. 2022**
Bachelors of Science: Civil and Environmental Engineering — *Provo, UT*

- GPA: 3.92
- Academic Scholarship recipient
- Member of BYU student chapter of ASCE

WORK EXPERIENCE

LEI Consulting Engineers and Surveyors EIT — **Mar. 2020 - Present**
Spanish Fork, UT

- Assisted in the entitlement process of large residential housing projects for the sizing of backbone infrastructure
- Determined stormwater basin and pipe sizes for storm drain systems on large residential developments with 2400+ units
- Prepared lot grading and mass grading plans for hillside developments containing 2400-13000 units
- Computed cost estimations for phases and developments up to $40 million
- Performed quality check reviews of preliminary and final plans for residential and commercial projects
- Observed construction for municipal culinary waterline

Brigham Young University Teaching Assistant — **Jan. 2020 - Apr. 2020**
Provo, UT

- Aided students in learning and mastering advanced computer skills and Excel VBA

Gallini Landscaping and Christmas Light Installation (Owner) — **Jun. 2010 - Jan. 2020**
Mansfield, TX

- Oversaw job quotes, lawn maintenance, equipment, installation, customer service, and problem resolution

SKILLS

- Technical/Coursework: Accounting, Writing, Information Systems, Business Economics, Statistics, Calculus, Engineering Drafting, Geomatics, Statics, Materials, Dynamics, Structural Analysis, Surveying, Fluids and Hydraulics, Transportation
- Proficient in Office Programs, Word, Power Point, Excel, and other useful programs AutoCAD, Civil 3D, Revit, ArcGIS, Excel VBA, Python, SAP2000, Bluebeam Revu

VOLUNTEER EXPERIENCE

The Church of Jesus Christ of Latter-day Saints (Missionary) — **Jul. 2016 - Jul. 2018**
Bangalore, India

- Provided leadership, development, and training for 16 representatives, establishing and improving upon long and short-term goals

AWARDS AND ACHIEVEMENTS

Magna Cum Laude Graduate- Mansfield High School — **Jun. 2016**
Eagle Scout — **Nov. 2015**
Best Bass Award-Bass Drum Section Leader — **Oct. 2015**

- Led Bass Drum Section to win Best Basses at an international convention