DOE-FIU SCIENCE & TECHNOLOGY WORKFORCE DEVELOPMENT PROGRAM

STUDENT SUMMER INTERNSHIP TECHNICAL REPORT

June 6, 2011 to August 12, 2011

PRELIMINARY STUDIES OF NITROGEN CONCENTRATION IN WELLS 0437, 0438, AND 0439

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ABSTRACT

Uranium ore was mined in significant quantities in the United States for more than 40 years. Initially, the ore was mined and milled by private companies for federal government use in national defense programs. After the 1950s, uranium was also needed as fuel for nuclear power plants to produce electricity. These milling operations created process-related wastes and tailings, a radioactive sandlike material. The tailings were slurried to unlined impoundments that accumulated over time, forming piles. Excess water in the piles drained into underlying soils, contaminating the groundwater. Scientists, community leaders, and public officials became more aware of the potential health risks associated with long-term exposure to uranium mill tailings during the 1970s. Public concern about potential human health and environmental effects of uranium mill tailings led the U.S. Congress to pass the Uranium Mill Tailings Radiation Control Act (UMTRCA) in 1978 (Public Law 95–604), which required the cleanup of inactive uranium-ore processing sites. In 1983, the U.S. Environmental Protection Agency (EPA) developed regulations [Title 40 Code of Federal Regulations (CFR) Part 192] to protect the public and the environment from potential radiological and nonradiological hazards at inactive uranium-ore processing sites. The U.S. Department of Energy (DOE) is responsible for cleaning up the millsites and for bringing groundwater contamination at the former processing sites into compliance with EPA standards (Subpart B of 40 CFR 192). The radioactive materials are encapsulated in U.S. Nuclear Regulatory Commission (NRC)-accepted disposal cells. The NRC general license for post-closure requirements of UMTRCA sites is established in 10 CFR 40.27.

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1. INTRODUCTION

In 2003, DOE implemented the first phase of an interim action system at the Moab site to address concerns regarding elevated ammonia levels in groundwater discharging to the Colorado River. This first phase consisted of 10 extraction wells (called Configuration 1). Four additional configurations of wells have been added since then, for a current total of 42 wells that are designed to prevent ammonia from discharging to the river. To date, a total of more than 168 million gallons of groundwater has been extracted through the interim action system, preventing more than 687,000 pounds of ammonia and about 3,150 pounds of uranium from reaching the river.

With installation of the Configuration 5 wells, extraction is now from wells located closer to the tailings pile. Extraction was restarted for 2011 on March 31. Extraction was suspended in May due to the level of the river and was restarted on August 24. Extracted groundwater is pumped via pipeline to a lined evaporation pond or to forced air evaporators. The evaporation pond covers approximately 4 acres and is located on top of the tailings pile. Two forced air evaporators operate when weather conditions are conducive to help evaporate the extracted groundwater.

Wells in Configurations 1 through 4 along the river are used to inject freshwater (diverted river water) as an additional way to minimize the discharge of ammonia to the Colorado River. Freshwater injection through wells in Configuration 4 was suspended in May due to the level of the river and restarted on August 3. About 5,505,000 million gallons of freshwater has been injected during 2011. DOE continues to evaluate the effectiveness of the interim action system, which will likely become part of the final groundwater remedy. The well configurations are shown in Figure 1.

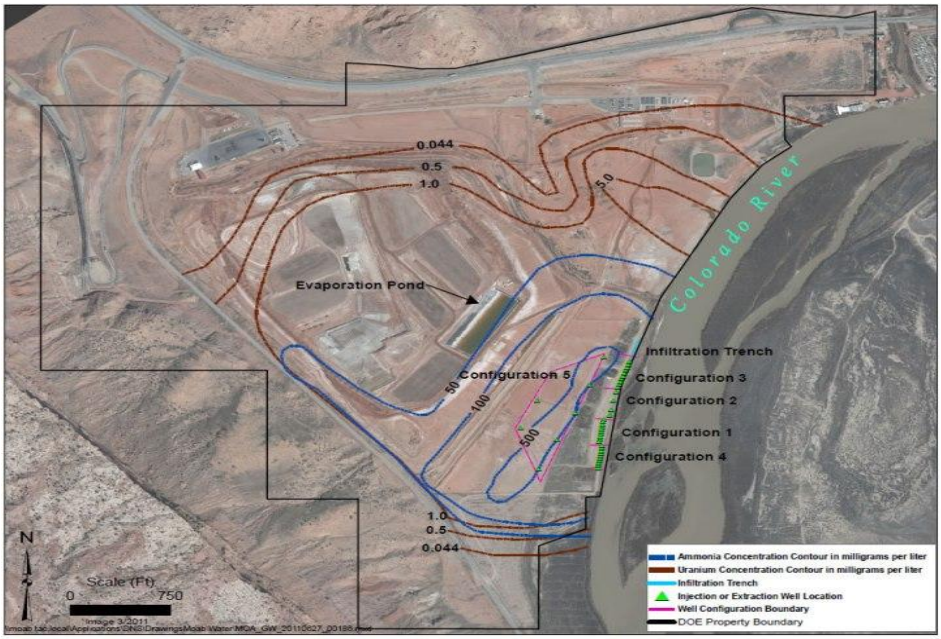

Figure 1. Well configurations.

2. EXECUTIVE SUMMARY

This research work has been supported by the DOE-FIU Science & Technology Workforce Initiative, an innovative program developed by the US Department of Energy's Environmental Management (DOE-EM) and Florida International University's Applied Research Center (FIU-ARC). During the summer of 2011, a DOE Fellow intern (Alexander Henao) spent 10 weeks doing a summer internship at the Moab site under the supervision and guidance of Ken Pill. The intern's project was initiated on June 7, 2011, and continued through August 12, 2011.

The DOE Moab Uranium Mill Tailings Remedial Action (UMTRA) Project site is located approximately 3 miles northwest of the city of Moab in Grand County, Utah, and includes the former Atlas Minerals Corporation (Atlas) uranium-ore processing facility. The site is situated on the west bank of the Colorado River at the confluence with Moab Wash. The site encompasses 439 acres, of which approximately 130 acres is covered by a uranium mill tailings pile. The Moab mill was constructed in 1956 by the Uranium Reduction Company, which operated the mill until 1962 when the assets were sold to Atlas. Uranium concentrate, the milling product, was sold to the U.S. Atomic Energy Commission through December 1970. During its years of operation, the mill processed an average of approximately 1,400 tons per day. Atlas operated the site until 1984 under a license and regulatory authority provided by NRC. When the processing operations ceased in 1984, an estimated 12 million cubic yards (16 million tons) of mill tailings and tailings-contaminated soil were present in a pile located in the western portion of the property. Atlas placed an interim cover over the tailings pile in 1995 as part of decommissioning activities conducted between 1988 and 1995. Atlas proposed to reclaim the tailings pile for permanent disposal in its current location but declared bankruptcy in 1998 and, in doing so, relinquished its license and forfeited its reclamation bond. Because NRC could not legally possess a site it regulated, NRC appointed Pricewaterhouse Coopers as the Trustee of the Moab Mill Reclamation Trust and the licensee for the site. The Trustee used the forfeited reclamation bond funds to initiate site reclamation, conduct groundwater studies, and perform site maintenance. The Floyd D. Spence National Defense Authorization Act for Fiscal Year 2001, Public Law 106–398, stipulated that the license issued by NRC for the materials at the Moab site be terminated and that the title and responsibility for cleanup be transferred to DOE. Title to the site was transferred to DOE on October 25, 2001. Specifically, the DOE Office of Environmental Management in Grand Junction, Colorado, now has primary responsibility for the Moab site. The act further designated that the Moab site undergo remediation in accordance with Title I of UMTRCA.

3. RESEARCH AND RESULTS

The main purpose of the research in this report is to observe if there are any trends or patterns in the concentration of nitrogen from water sampled at 3 different wells. The three wells that are going to be analyzed include Well 0437 (6665399.33/2183802.67), 0438 (6665241.03/2185009.53) and 0439 (6664189.32/2184731.49), all located near the Colorado River. Nitrogen in its different forms will be the main element investigated. The different forms that will be studied include: ammonia as nitrogen, ammonia as NH_4^+, nitrate and nitrite, and nitrogen as NO_3. When comparing the three wells in the same categories, the distance to the Colorado River, the depth of the wells and the depth of the sampling will be taken into consideration. Well 0437 is located farthest from the Colorado River then Well 0438 and, finally, closest to the river is Well 0439.

On the graphs below, the activity in concentration of ammonia as nitrogen is shown over a particular period time (Figures 2, 3, and 4). As the distance of the wells from the river increases, the concentration of ammonia tends to decrease. The highest concentration of ammonia was recorded for Well 0438 at a level of about 21 parts per million on July 2005. One particular trend that is persistent with the data is that there seems to be peak periods, especially during the summer season. This might occur due to the fact that, in the winter time, the volume of the river decreases and more sediment settles to the bottom of the river. When the snow pack starts to melt in the spring and the flow of the river increases, the sediment mixes with the water and increases the concentration of ammonia. As a whole, the concentration is decreasing as time passes for Wells 0438 and 0439; yet it can be seen that in Well 0437, where the concentration is relatively low, the concentration is increasing as times passes. This particular form of nitrogen is very harmful to marine wildlife and is dependent on water temperature as well as pH level.

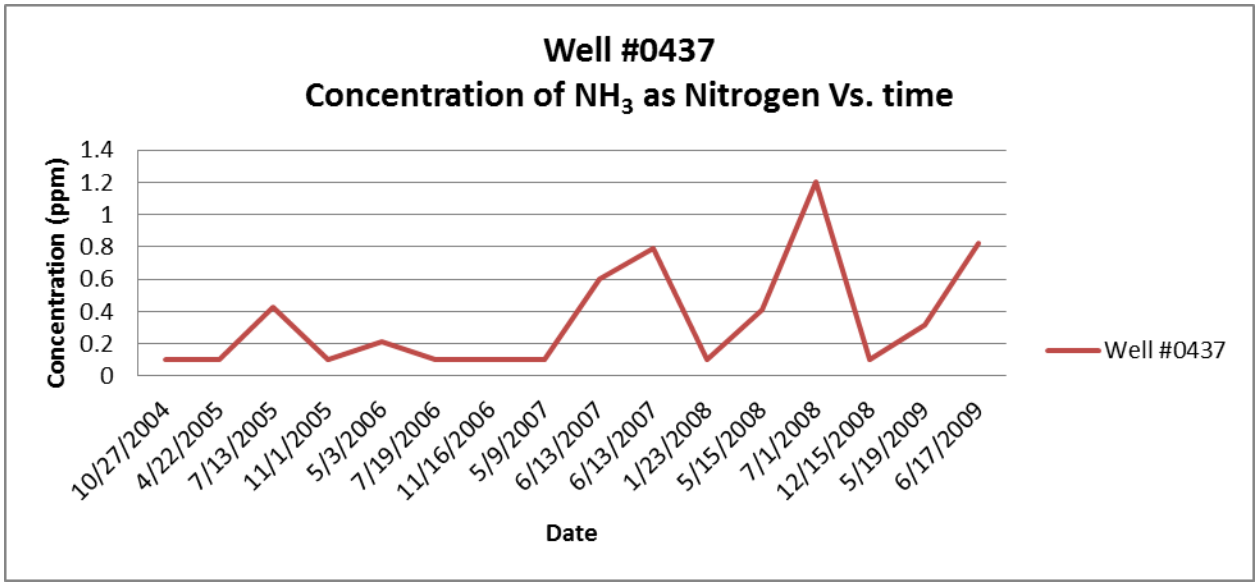

Figure 2. Concentration of nitrogen vs time for Well 0437.

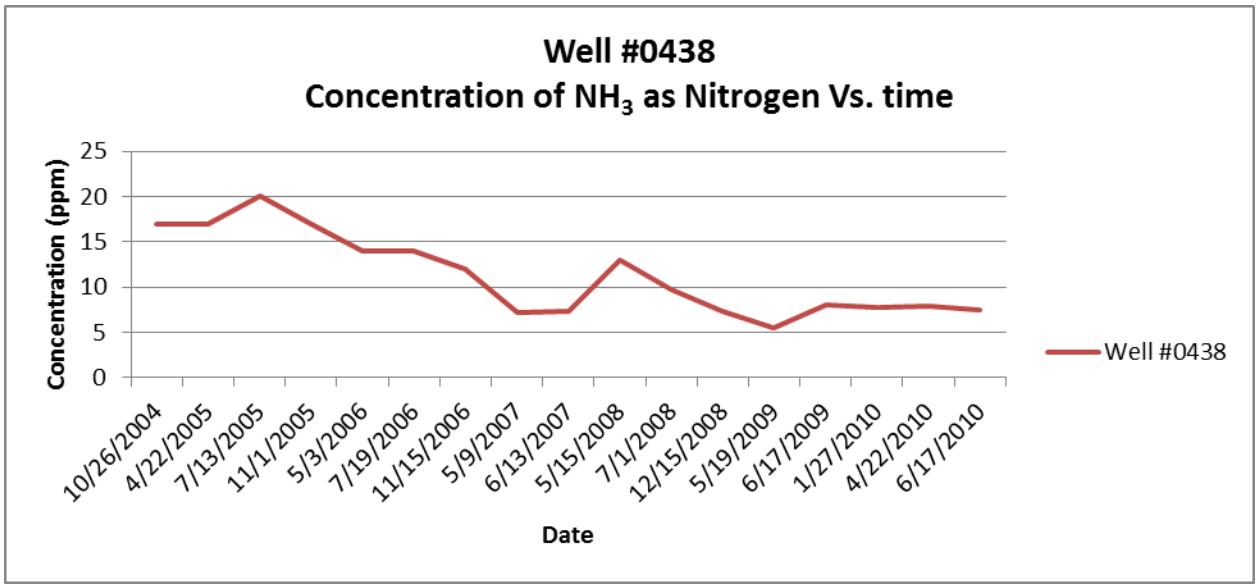

Figure 3. Concentration of nitrogen vs time for Well 0438.

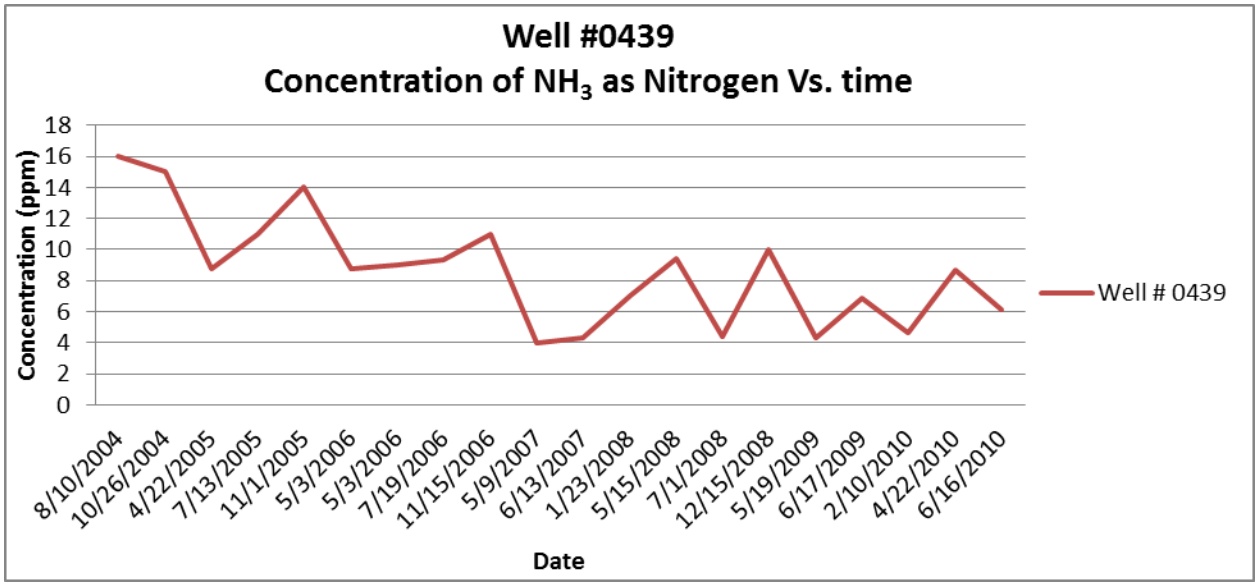

Figure 4. Concentration of nitrogen vs time for Well 0439.

Ammonia in the form of NH_3 is harmful to marine wildlife, while ammonium (NH_4^+) is not; however, it is very important to determine the concentration of NH_4^+ because the composition of nitrogen can rapidly change from one form to another.

The chemical equation that drives the relationship between ammonia and ammonium is:

$$NH_3 + H_2O \leftrightarrow NH_4^+ + OH^- \quad \textbf{(Equation 1)}$$

As the pH increases, the reaction will shift to the right side, making more of the ammonia cation, while if the pH decreases, the reaction will go into the left, producing the ammonia as nitrogen. It can be observe that in all three wells, at the low depth sampling points, the concentration of ammonia as nitrogen is the highest, sometimes as high as 100 times the deeper sampling points. Additionally, the same trend is observed when it comes to distance to the river; the closer the well is to the river, the higher the concentration. Overall, the concentration of ammonia as nitrogen at the other depths seems to be very stable in all three wells. One particular sampling point at 252 ft of Well 0437 showed a significant concentration of ammonia.

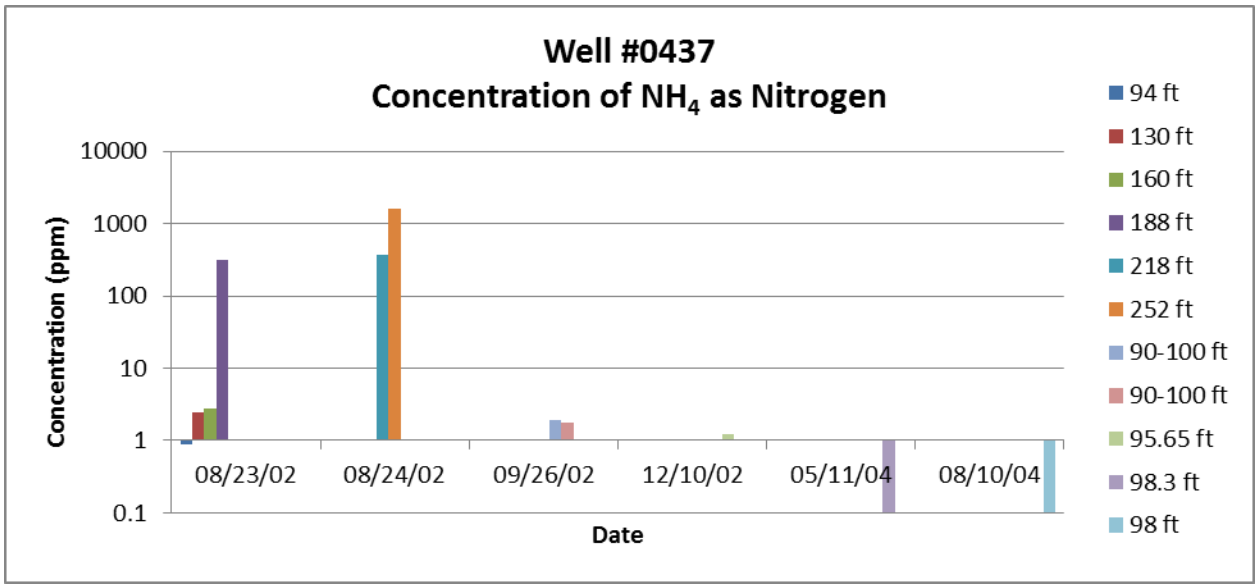

Figure 5. Concentration of NH_4 as nitrogen for Well 0437.

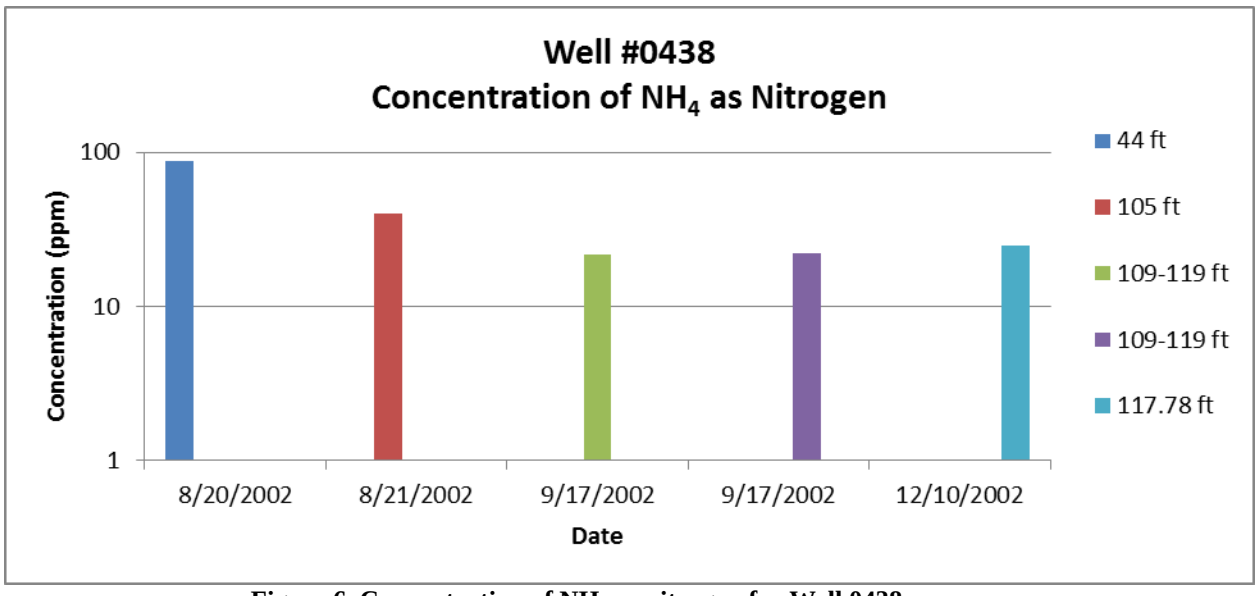

Figure 6. Concentration of NH_4 as nitrogen for Well 0438.

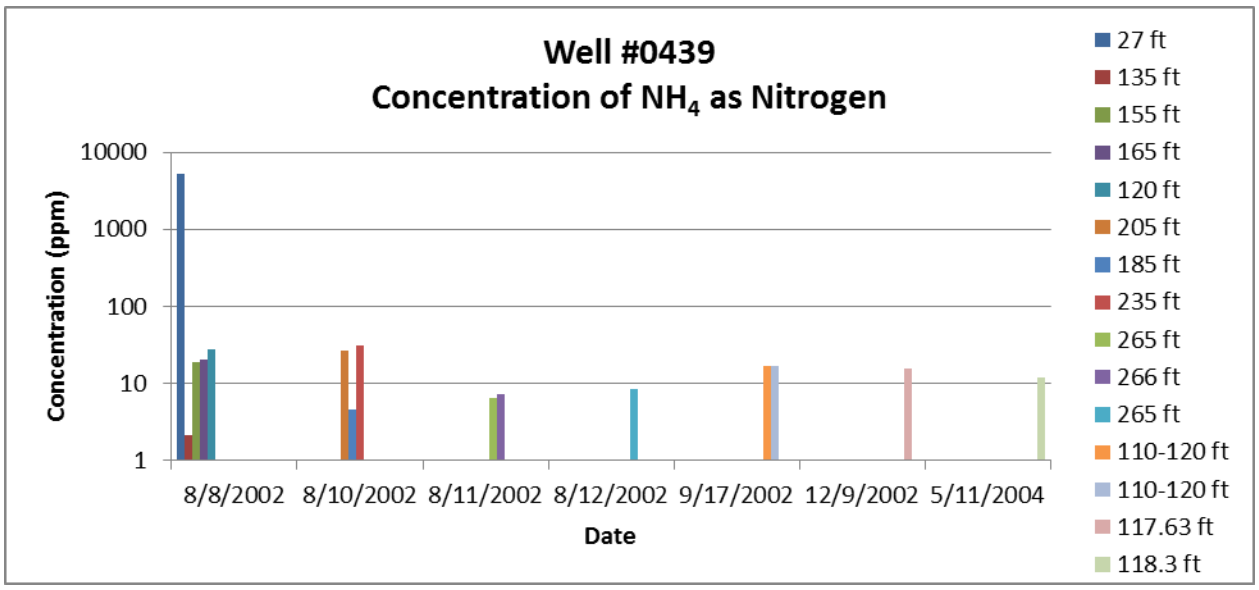

Figure 7. Concentration of NH_4 as nitrogen for Well 0439.

As previously stated, the relationship between NH_4^+ and NH_3 is influenced by temperature and pH levels. As shown in the figures below, it can be observed that for Well 0437, the concentration of ammonia as NH_4^+ is higher for mid-range depths compared to low-level depths on the other 2 wells (Figures 8, 9 and 10). Nonetheless, the highest concentration is in Well 439 (closest to the river) at a about 8000 ppm. This result could indicate a low pH in that particular area.

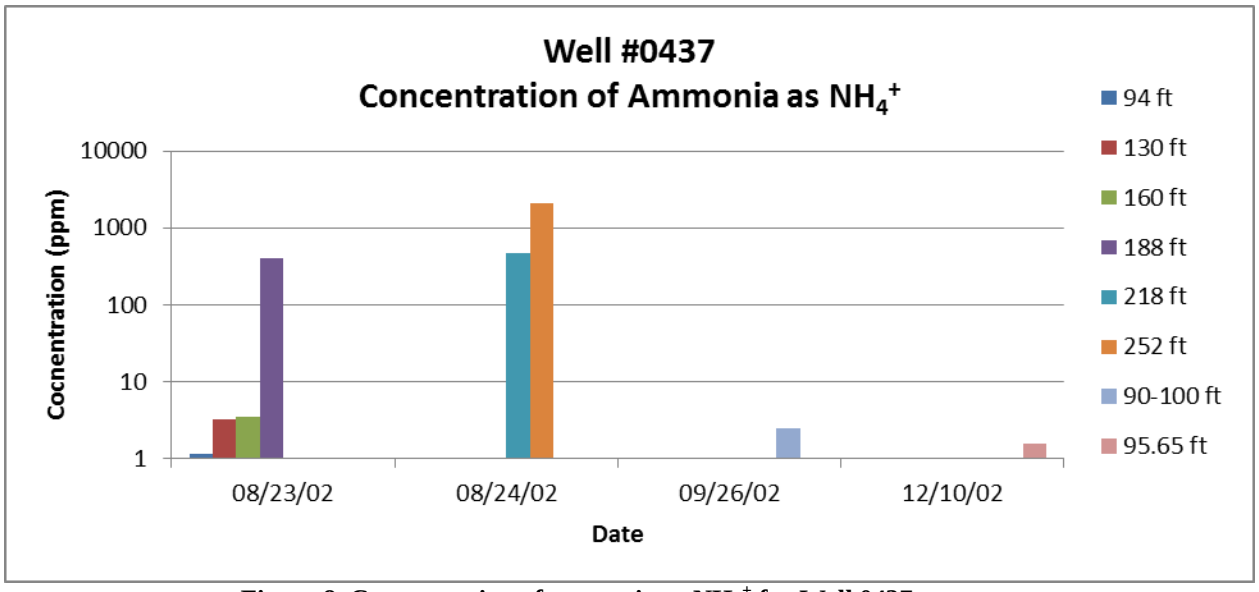

Figure 8. Concentration of ammonia as NH_4^+ for Well 0437.

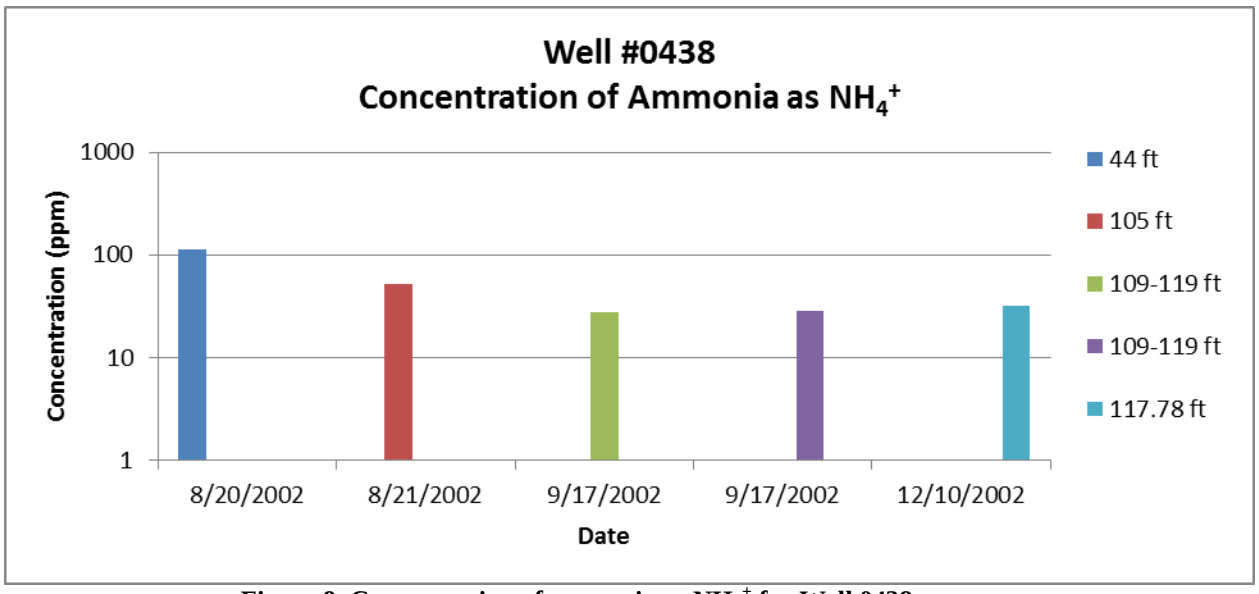

Figure 9. Concentration of ammonia as NH_4^+ for Well 0438.

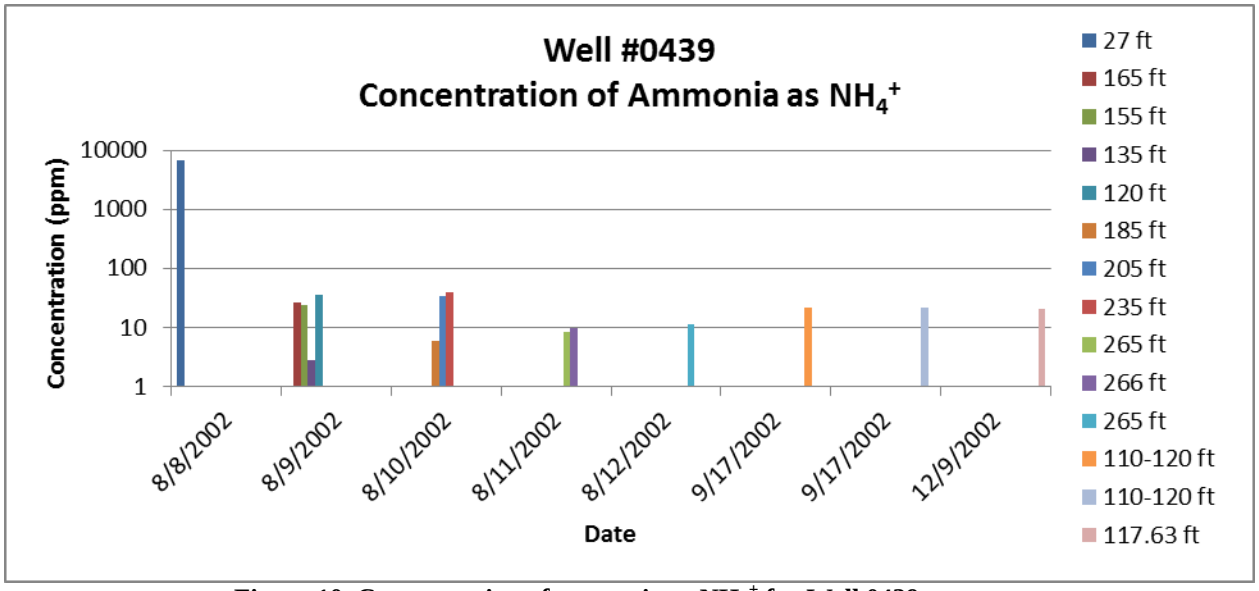

Figure 10. Concentration of ammonia as NH_4^+ for Well 0439.

Nitrate concentration (NO_3^-) in fresh water can cause oxygen depletion. Thus, aquatic organisms depending on the supply of oxygen in the stream will perish or find it very difficult to survive. On the other hand, nitrites (NO_2^-) can produce a serious condition in fish called "brown blood disease." For these reasons, it is very important to know the concentration of these chemicals. For the most parts, when nitrogen concentrations are observed in this particular form, the results are low. Once again, the same pattern is observed. As the distance between the well and the river decreases, the concentration of nitrogen increases. Yet, it is also noted that regardless of the depth of the sampling point, the concentration remains low, but only a little higher in the range of 185 to 252 ft at two different wells, one being the closest to the river and the other farthest from it.

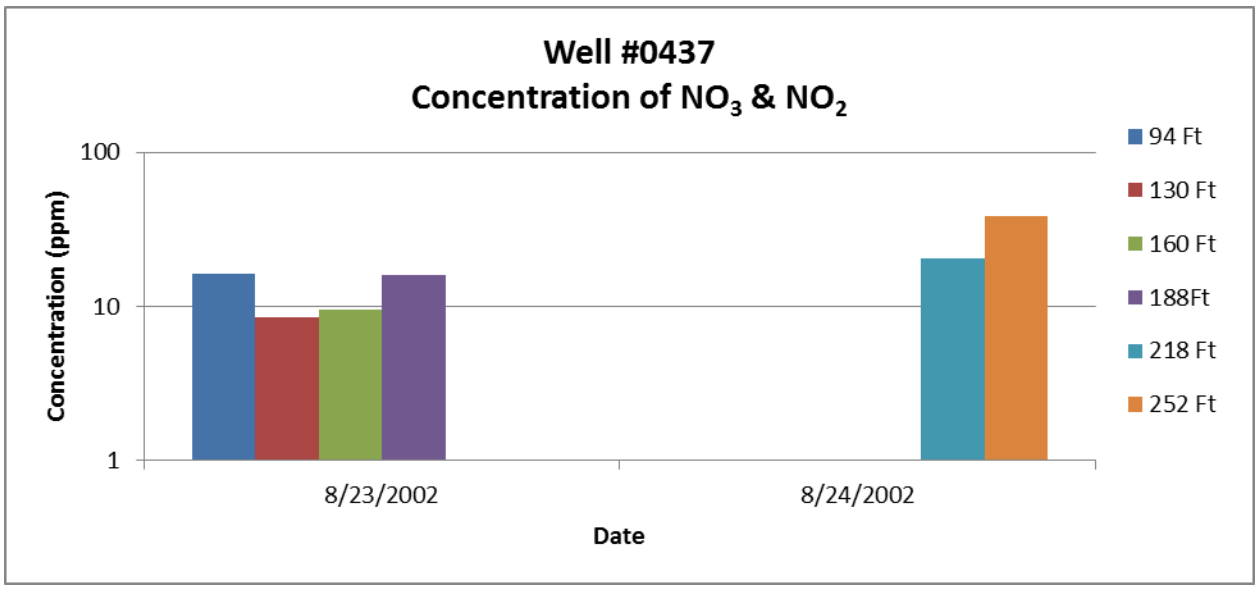

Figure 11. Concentration of NO_3^- and NO_2^- for Well 0437.

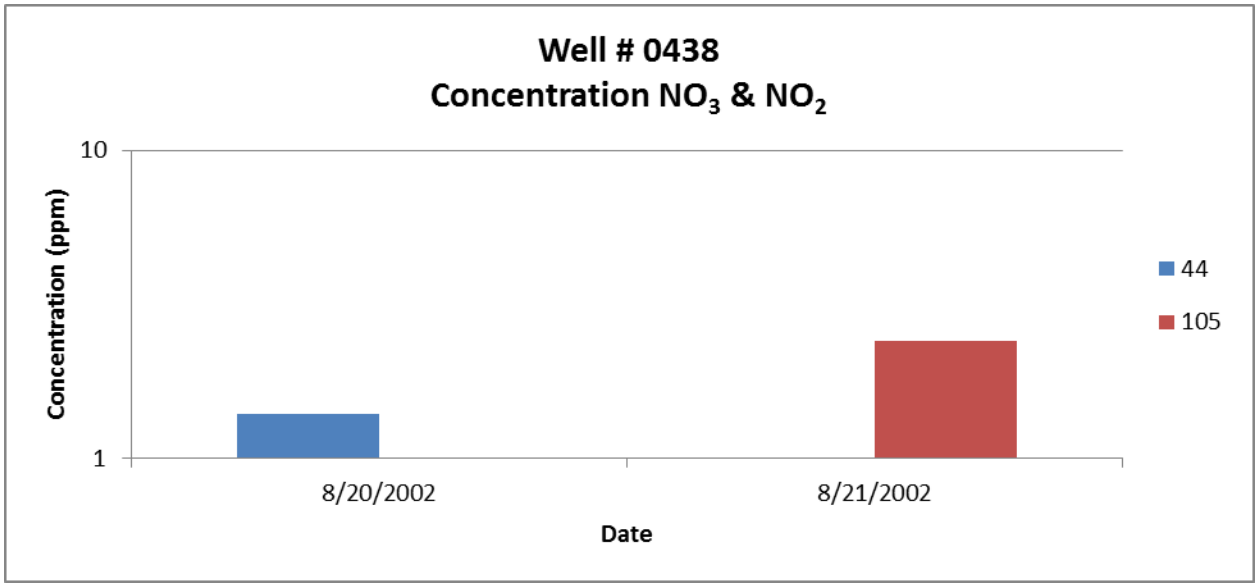

Figure 12. Concentration of NO_3^- and NO_2^- for Well 0438.

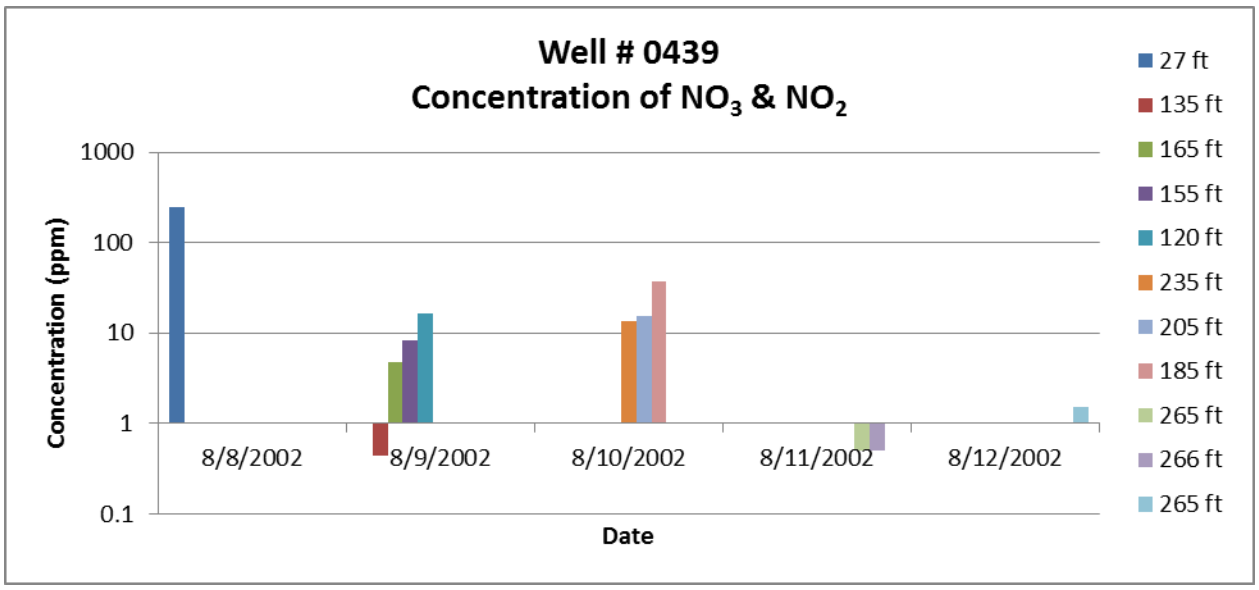

Figure 13. Concentration of NO_3^- and NO_2^- for Well 0439.

In order to have a better understanding of the complexity of nitrogen, different analyses are necessary. In the following figures, the concentration of NO_3^- can be studied (Figures 14, 15, and 16). Once again, it can be seen that the concentration of nitrogen is higher at the well located close to the river (Well 0439). For this particular analysis, Well 0438 showed the lowest concentration of the three wells studied. One particular result appeared on 12/09/2002 – 12/10/2002, where the highest concentration was found over an eight year period on Well 0439 at a depth of 117.63 ft.

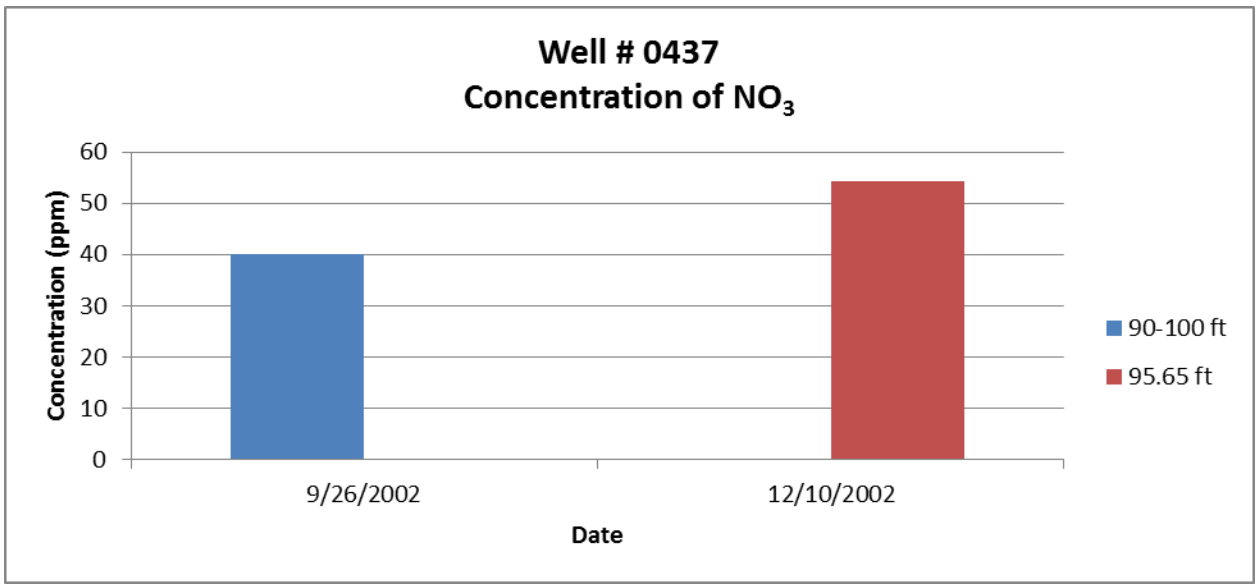

Figure 14. Concentration of NO_3 for Well 0437.

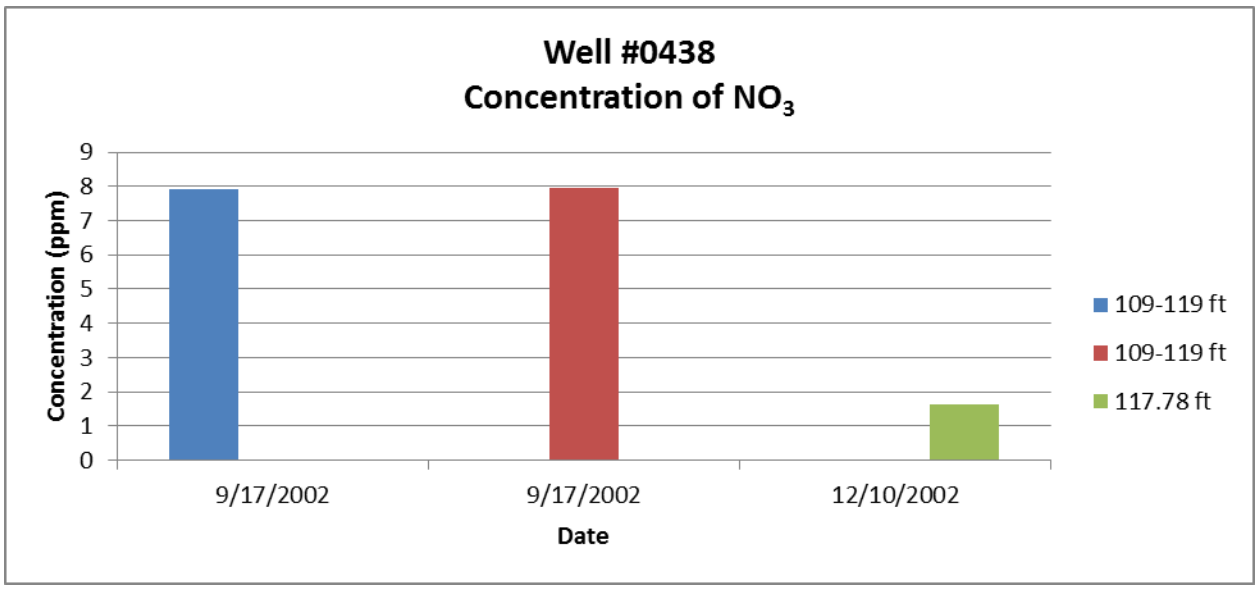

Figure 15. Concentration of NO_3 for Well 0438.

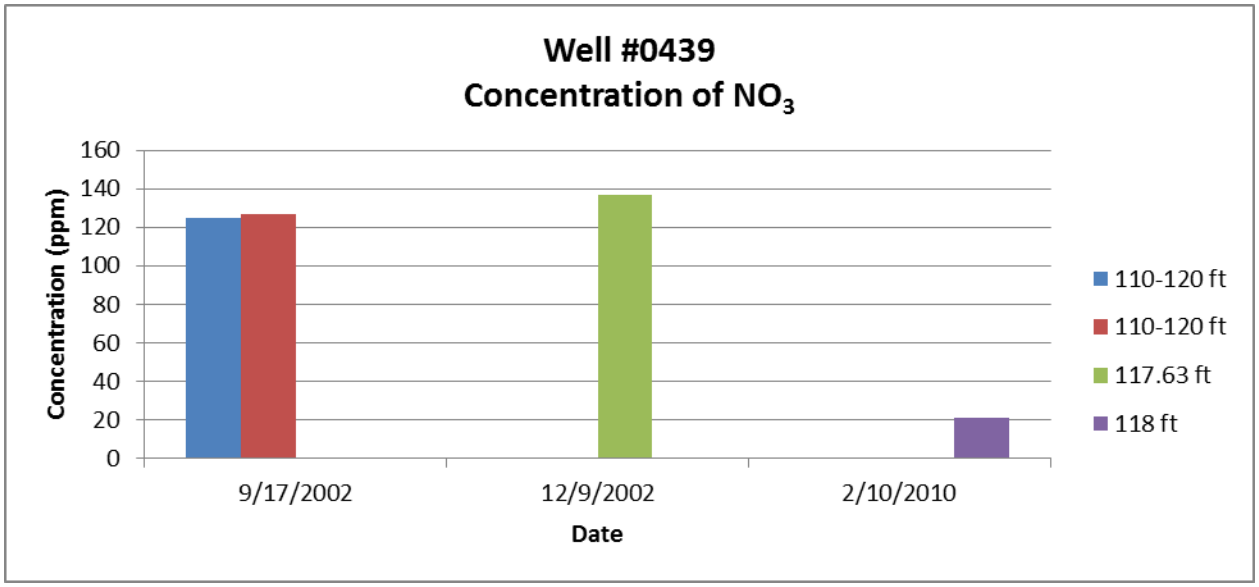

Figure 16. Concentration of NO_3 for Well 0439.

4. CONCLUSION

As the data has shown for the three wells studied for this report, wells located closer to the river contain more nitrogen related species. The depth of the sampling point was not an overall factor, apart from some particular sampling results. In future reports, we will examine a larger number of wells to obtain a better understanding of the movement of nitrogen in this particular zone of the Colorado River.