NYSDOH Environmental Transport Modeling for Dose Reconstruction:

MODFLOW Construction of PFAS Contamination in Hoosick Falls, NY

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**Background**

 In 2014, a citizen concerned with the abnormal rates of cancer and diseases in the village of Hoosick Falls, NY suspected that the village municipal water supply might be contaminated with the chemical family poly- and perfluoroalkyl substances (PFAS) and sought to get it tested (McKinley, 2016). Results indicated that the municipal well system contained 180 to 540 parts per trillion (ppt) of perfluorooctanoic acid (PFOA), a PFAS known for bioaccumulation in the body and linked to thyroid disruptions, neonatal growth disruption, and a variety of cancers, as well as high levels of other PFAS (Post et al., 2012; Sanzone, 2015). Since then, a flurry of studies and research has been conducted within the area to determine a new, safe drinking water source for residents on the municipal well water, as well as those on private water systems. More recently, however, the New York State Department of Health (NYSDOH) has focused on more intricate research such as recreating dosage levels of residents both in the Village of Hoosick Falls, as well as those private citizens just outside the village.

**Introduction**

As a result of the contamination in the Village of Hoosick Falls, NY, NYSDOH has joined the CDC’s 5-year multi-site study to research the link between high PFAS levels in drinking water supplies and increased health impacts. This national study spans across 6 additional states (California, Colorado, Massachusetts, Michigan, New Jersey, and Pennsylvania) and involves dose reconstruction efforts to examine the dose levels and health effects of PFAS ingested by residents in affected areas (The State University of New York at Albany, 2020). Currently, the study is in year 2 of the anticipated 5 years.

NYSDOH’s current approach is to assess the Village of Hoosick Falls, NY and the outlying rural areas through means similar to those presented by the groundbreaking C8 Health Study (Shin et al., 2011a; Shin et al., 2011b). The C8 Health Study, and subsequently NYSDOH’s study, both utilize a pharmacokinetic model for internal dose reconstruction in conjunction with an environmental transport model for external dose reconstruction. The latter was the focus of the author’s internship and research during the summer of 2021.

 The Hoosick Falls’ municipal water supply is a glacially deposited gravel and sand aquifer running along the Hoosic River Valley (Desimone, 2017; Williams & Heisig, 2018). This aquifer is believed to be semi-confined and is thus subject to a degree of surficial contamination (Desimone, 2017; Williams & Heisig, 2018). To assess the contamination in this aquifer, NYSDOH’s chosen program for this environmental transport model is Waterloo Hydrogeologic’s MODFLOW program, with an emphasis on MODPATH due to the environmental fate and transport measures this study focuses on. MODFLOW is a groundwater environmental transport model which can be used to determine the extent, depth, and concentration of a contaminant plume within a designated aquifer (Waterloo Hydrogeologic, 2021). Using these parameters, NYSDOH can then make an educated estimate on the external dose of PFAS an individual may have ingested over the duration of the contamination and use that as a base for the internal dose reconstruction process.

**Work Completed**

 Prior to the author’s internship, NYSDOH researched and assembled a significant portion of data required for the creation of the MODFLOW model. These researched components, outlined in full in Table 1, include municipal wellfields construction specifications and private well depths and were used to assist in the development of the greater layers and functions of the MODFLOW model.

 **Table 1.** MODFLOW components and their functions

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| MODFLOW Components | Function |
| Borehole lithology data | Horizon Creation |
| Aquifer transmissivity | Groundwater flow and rate |
| Aquifer storativity | Groundwater flow and rate |
| Private well depths | Plume depth/extent |
| Municipal well specifications | Plume depth |
| PFAS levels (ppt) | Plume concentration |
| River shapefile | Model boundary |
| Watershed boundary | Model boundary |
| Digital Elevation Map (DEM) | Topography |
| PFAS source location(s) | Plume extent |

However, essential data was missing to develop the rest of the model, such as borehole data to develop horizon layers, as well as additional hydrogeologic data such as aquifer transmissivity, storativity, and hydraulic conductivity to better understand the flow of the plume. The author assisted the team in combing through reports, dossiers, and studies and reaching out necessary government entities (both local and state) to research the necessary final components. While the team was unsuccessful in finding data regarding hydraulic conductivity of the municipal wells, the team was able to determine a general hydraulic conductivity of the semi-confined aquifer and the author was able to find sufficient data regarding the lithology of the municipal well field.

Using 11 borehole logs, the author developed a series of pointfiles in the ArcMap program and interpolated the surface of each major lithologic horizon for the model using the empirical Bayesian kriging method. These horizons included an unconfined aquifer layer, an aquitard layer, and the semi-confined aquifer layer. Once these horizons were completed, the author projected the horizons onto a clipped elevation shapefile to give the model its topographic structure. With these horizons and elevation maps assembled and clipped to the correct area, the author was able to create the first three-dimensional view of the affected aquifer within the study area.

The NYSDOH team determined that the Hoosick town boundary, as well as the Hoosic River, would be used as the basis for the model boundary. The author, upon creating the visual, was then able to start assigning values and boundaries to the study area. This included the creation of a clipped linear shapefile to denote the Hoosic River boundary, which runs directly to the west of the municipal well field, and its subsequent hydrogeologic properties; additional hydrogeologic properties, such as transmissivity and storativity, were assigned to three horizons as well as.

While it would be a pleasure to display an image of the completed preliminary model within this report, due to sensitive nature of the study regarding private citizen rights as well as ongoing litigation in light of the contamination, the author is unable to disclose the model as of this time.

**Future Work**

As this study is still progressing, the internship concluded prior to the final development of the full model; however the creation of the preliminary aquifer visual was used as justification that a fully realized model of the study area could be accomplished despite the data restrictions currently faced by the department.

To develop the final model, additional information is still required. While the author was able to develop a visual model of the aquifer in the vicinity of the municipal well field, this is merely a slice of the full study area and only encompasses those residents on municipal water; additional lithologic data and well head conditions for the rural outlying areas of the study area will be needed to assess those residents on private well water.

Currently, the author is continuing to work with NYSDOH as a volunteer to fully develop the MODFLOW model to its full capacity. As such, it has been a truly enlightening experience for the author; seeing the inner workings of a state-run environmental health project, as well as the intricacies of working in conjunction with other states at a national level has allowed the author to develop a better understanding of data sharing and limitations regarding public health projects at a local, state, and national level. In addition to the valuable experience of working alongside many state-run studies, the author had hands-on experience using the groundwater modeling software, MODFLOW. As this is a relatively niche software system that many government organizations use, it was a unique opportunity for the author to apply her coursework and knowledge and develop her skills using such advanced modeling techniques.

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