



# Nebraska Vadose Zone Monitoring Guide

*Nebraska Water Sciences Laboratory*

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## How to Use This Document

This document provides a high-level overview of the vision, mission, scope and processes of the vadose zone monitoring program. It answers the Five-Ws: who, what, where, when and why. It is intended for people with varying backgrounds, and requires no existing vadose zone expertise. It serves as an introduction to the Nebraska vadose zone monitoring program, and so will be a good document to read early and refer to often.

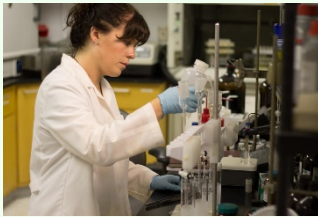
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# The Five Ws of Vadose Zone Monitoring

## WHO

The vadose zone work is led by the **Nebraska Water Sciences Laboratory (WSL)**. The lab supports water and environmental research and public health through technical services, expertise, and training. The vision for this program came from **Dr. Dan Snow**, the Director of the WSL.



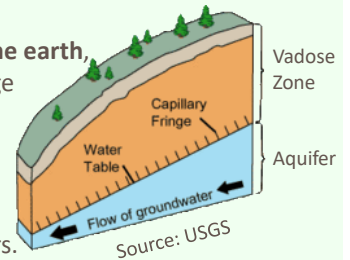
(L) WSL student worker (R) Dan Snow

## WHAT

The vadose zone is the area **below the land surface and above the ground water table**, where a mixture of air, water, and other chemical and biological microorganisms fills the spaces between rock and soil particles.

The zone acts as the **“skin” of the earth**, regulating ground water recharge and *chemical movement*.

Contaminants present in the vadose zone can eventually appear in the underlying aquifers.



## WHERE

Monitoring is occurring across the state of Nebraska (NE), where 85% of the population uses groundwater for drinking water supply.<sup>1</sup> Natural Resources Districts (NRDs) are active in water management in NE. The NE Dept. of Env. Quality (NDEQ) also administers a **Wellhead Protection (WHP)** program, which assists communities in preventing contamination of water supplies.

The NRDs and NDEQ are a few of many partners that contribute to the database.

(R) NRD Map



## WHEN

Vadose Zone monitoring has **occurred for decades**, and is still **on-going**. The Nebraska Vadose database standardizes collection, processing, analysis, and sharing of vadose zone monitoring data, including historic and new information. Currently, our oldest dataset is from the 1980s.

We will digitize paper copies of vadose studies, to make that information available for everyone to use.



## WHY

### PUBLIC HEALTH

The vadose zone connects the land surface with the underlying aquifers. With groundwater as the primary source of drinking water in NE, it is important to understand what is happening in the vadose zone, especially regarding chemicals such as nitrate, which are federally regulated and have enforceable **Maximum Contaminant Levels**.



### PUBLIC POLICY

**NRD managers, city planners, regulators, water treatment plant operators, researchers** and others have an interest in monitoring the vadose zone to anticipate if and when contaminants will reach the groundwater supply, and in what amount. **State and local entities** may use this public database to make decisions and prepare for future changes in water quality.

<sup>1</sup> <http://deq.ne.gov/NDEQProg.nsf/OnWeb/Water>

## Vision

Our vision is a scientifically rigorous, quality controlled, user-friendly database characterizing the vadose zone, including location and movement of contaminants having the potential to reach the water table. This will support planning, management and response, especially for Nebraska residents that rely on groundwater for their drinking water source.

## Mission

Our mission is to have a lasting and significant impact on protecting Nebraska's groundwater quality and public health by conducting scientific and policy research, using the research results to inform policy makers, and sharing knowledge through education and communication.

## Scope

The Nebraska Vadose Zone database includes historic and current monitoring and analysis of the vadose zone **nitrate** data, as well as monitoring data for **other chemicals and soil properties pertinent to groundwater management**.

Vadose zone data is collected by deep soil core sampling, which is then analyzed at the laboratory (Figure 1 and 2).



*Figure 1. Set-up of drill rig (L) and soil cores prepared for transport to Water Sciences Laboratory (R)*

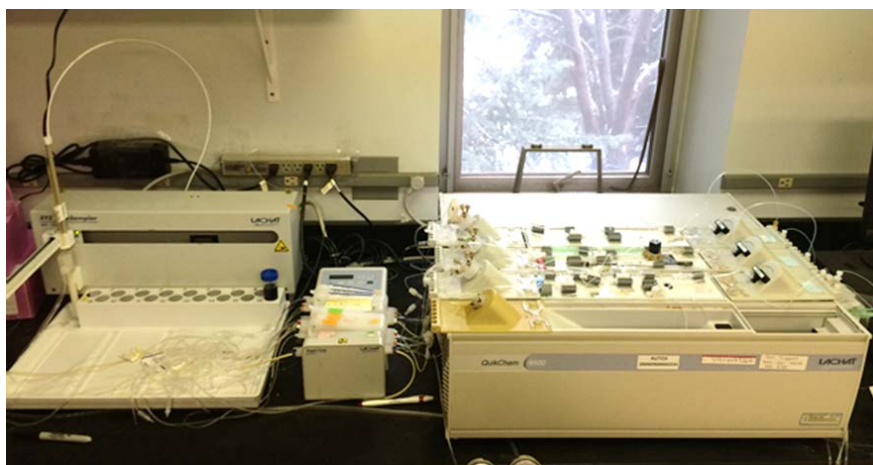


Figure 2. General set-up of laboratory equipment for analysis of vadose zone cores

At a laboratory, a soil core is subdivided into sections, usually not more than 5 feet long (Figure 3). Each section (or interval) is then analyzed for physical and chemical properties. Every soil core in the Nebraska Vadose Zone database has information on nitrate concentrations, in the same units for comparability: microgram  $\text{NO}_3$ /gram soil ( $\mu\text{g/g}$ ). Soil physical characteristics and occurrence of other agrichemicals, such as pesticides, fertilizer and heavy metals, are reported if available. The table below summarizes the main categories of information collected in the database.



Figure 3. Diagram of soil core subdivided into intervals for analysis

Data Category	Description
Data Source	Information on the person or organization providing the data and/or conducting the original field work, analysis and reporting. Includes contact and citation information.
Location	Information on where soil coring occurred. Includes latitude and longitude, legal description, county, Natural Resources District, land use history, soil type, and water table depth, etc.
Core	It is possible to have multiple cores at a single location. Therefore, each core's information is tracked separately, including Core Name and Sample Date.
Physical & Chemical	Nitrate concentrations in each core interval. May also include Bulk Density, Water Content, pH, Ammonium, Pore Water Nitrate, and percentage sand, silt and clay.
Lithology	A description of soil type/texture, subdivided by core interval.

## Quality Control

A quality-assessed database is one in which data has been subject to a systematic and thorough review to ensure it meets certain quality standards. Any deviation from the standards are noted and communicated with the data record. All data added to the Nebraska Vadose database is thoroughly vetted for proper collection protocol, analytical integrity, and presence of other ancillary parameters needed for the database.

The WSL has developed a Quality Assurance Project Plan (QAPP) template, which is available on the Nebraska Vadose website for anyone to use in vadose zone monitoring.

### Quality Control Results Shared with the User

Quality assurance and quality control (QA/QC) results for physical and chemical data are shared with the user. This information is provided because it represents value added to the datasets. The WSL evaluated physical and chemical data against reasonable ranges and calculated values.

Reasonable ranges were set using expert judgment. If a value is within the expected range, the QA/QC cell is labeled “OK.” If a value is outside the expected range, the QA/QC cell is labeled “REVIEW.” All data labeled REVIEW have been investigated by the WSL. This investigation included the following steps:

Step 1: WSL confirmed that the data in the Nebraska Vadose Zone database matched the original dataset provided by the organization submitting the data.

Step 2: WSL referred to the report that came with the original data, to determine if any explanation is provided for the unusually low or high value.

Step 3: If needed, WSL contacted the provider of the original data to obtain more information about the unusual value.

WSL reports data as it is provided to us. We do not exclude questionable data, but rather leave the final decision of data suitability to the user. For more information about a REVIEW cell, please email [nebraskavadose@unl.edu](mailto:nebraskavadose@unl.edu).

The ranges used to perform the QA/QC check on physical and chemical data include:

Parameter	Expected Range	Units
Depth	$-200 < x < 0$	ft
Core Interval	$0 < x < 5$	ft
Nitrate	$0 < x < 100$	microgram/gram ( $\mu\text{g/g}$ )
Bulk Density	$0 < x < 3$	grams/milliliter (g/mL)
Gravimetric Water Content	$0 < x < 1$	dimensionless (g/g)
pH	$0 < x < 10$	-
Ammonium	$0 < x < 20$	microgram/gram ( $\mu\text{g/g}$ )

When possible, WSL also calculated values for Pore Water Nitrate and Calculated Nitrate using the following equations:

$$\text{Pore Water NO}_3\text{-N (mg/L)} = \text{NO}_3\text{-N (}\mu\text{g/g)} / \text{Gravimetric Water Content}$$

$$\text{Calculated Nitrate (lbs-N/acre-ft)} = [\text{NO}_3\text{-N (}\mu\text{g/g)} * 2.2 \times 10^{-9} \text{ (lb/}\mu\text{g)} * \text{Bulk Density (g/mL)}] / 8.11 \times 10^{-10} \text{ (Acre-ft/mL)}$$

These values are provided so that the user may compare the calculated value reported by the original data provider to the calculated value determined by WSL as a QA/QC check.

## Standard Operating Procedures

The WSL has also published Standard Operating Procedures (SOPs) on the Nebraska Vadose website. These guidebooks provide detailed instructions and methods to use from start-to-finish in a vadose zone monitoring program. SOPs available on the Nebraska Vadose website include instructions for collecting and processing soil cores, for physical and chemical analysis of vadose zone cores in laboratory settings and for formatting and organizing historic and present vadose zone monitoring data to include in the Nebraska Vadose database.

SOPs help establish a benchmark for quality of information and services. Vadose zone monitoring occurs in multiple locations and by multiple organizations. In this case, SOP's ensure uniformity of data gathering and analysis across different groups and places. This is essential requirement for sustaining user confidence in the data generated.

## More Information

For more information, refer the Nebraska Vadose website at <http://nebraskavadose.unl.edu/>.

Questions may be sent to [nebraskavadose@unl.edu](mailto:nebraskavadose@unl.edu).