

Developing and Assessing New Curriculum  
for Missouri's Future Soil Evaluators

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BY

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The undersigned, appointed by the dean of the Graduate School,

Have examined the thesis entitled

DEVELOPING AND ASSESSING NEW CURRICULUM FOR  
MISSOURI'S FUTURE SOIL EVALUATORS

Presented by Joseph Meinert, a candidate for the degree of Master of Science,  
and hereby certify that, in their opinion, it is worthy of acceptance.

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Associate Professor John Tummons, Ph. D.

To my wife, Laura, for loving and supporting me over the past 3 years.

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DEVELOPING AND ASSESSING NEW CURRICULUM  
FOR MISSOURI'S FUTURE SOIL EVALUATORS

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ABSTRACT

One-quarter of households in the state of Missouri are connected to an onsite sewage treatment system. These small wastewater treatment systems rely on the properties of the soil to provide the necessary treatment of wastewater before it reenters the water cycle. The functioning of these systems relies on the evaluation of the soil properties by an onsite soil evaluator. There are currently 46 soil evaluators that serve the 114 counties of Missouri. National estimates show that more than one-third of wastewater professionals will retire over the next five years. The Missouri Department of Health and Senior Services, Missouri Small Flows, and The University of Missouri sought the creation of training materials for new future soil evaluators to assist in preparing individuals for this profession. This project worked to develop these materials for in-person and online workshops and assess the efficacy of these materials for providing information on the necessary skills and knowledge for the onsite soil evaluator profession.

An initial survey was developed to discover the parts of the profession that current soil evaluators struggled the most with when they were new to the profession. From this survey, six topics were selected and six courses were developed to provide instruction on these topics. These six courses were prepared for in-person and online workshops. These courses were offered through Missouri Small Flows Continuing

Education Workshops and to students at the University of Missouri. Participants completed voluntary pre- and post-workshop surveys related to their self-assessed knowledge of skills and topics associated with the onsite soil evaluator profession.

Results showed that across all cohorts, participants demonstrated significant change ( $p < .05$ ) in their pre and post self-assessed knowledge for the survey items. The effect of these changes varied greatly depending on the background of the cohort, with university students showing “very large” or “huge” effects based on Cohen’s  $d$  test, while wastewater professionals showed “small” to “medium” effect sizes. Overall, these results suggest that in-person and online workshops can be effective at teaching the skills and knowledge necessary for future soil evaluators.

## **CHAPTER 1: INTRODUCTION**

### **Statement of Purpose**

This research intended to examine the current state of Missouri's soil evaluators and develop and assess the efficacy of introductory in-person and online workshops for the training of future soil evaluators. The research herein took place between the years of 2023 and 2024.

### **Current State**

One of the most overlooked yet necessary parts of any building project, from a home, to a business, to the maintenance of an entire community, is what happens with the sewage produced onsite. This is especially true for rural homeowners/businesses that are not able to connect with a municipality's wastewater treatment services. An estimated 25 percent of Missouri residents rely on an onsite septic system to treat their wastewater according to the Missouri Department of Health and Senior Services (2024). Recent studies indicate that one-third of new single-family homes being built between 2016 and 2018 are served by these individual centralized systems (National Environmental Services Center, 2020). Furthermore, many rural towns lack the funds to produce large scale, high functioning, stand-alone wastewater treatment plants and therefore must rely on some form of soil treatment in their wastewater treatment plans (EPA, 2021a). Collectively across the United States more than four billion gallons of sewage are being treated through these private wastewater systems (EPA, 2021a). These systems are key cogs in the management of our public and environmental health (Center for Disease Control and Prevention, 2023) and require the knowledge and skills of a soil evaluator to

assess the properties and characteristics of the soil to ascertain the sufficient functioning of these onsite wastewater treatment systems (OWTS).

There are 46 registered soil evaluators in Missouri (MODHSS, 2023). These individuals use their knowledge of soil properties, local geology, and hydrology to site onsite septic systems for landowners and describe the capabilities of the soil to treat wastewater. As private professionals, these soil evaluators can choose which counties they would like to serve. This tends to provide some counties such as Boone County with 8 available soil evaluators while a more rural county, like Shannon or Clark County, may only have one or two registered soil evaluators. This presents a problem if studies, like Holodak et al., (2023) in their national assessment of onsite wastewater professionals are representative of Missouri. The current estimate is that nationally 37% of their respondents are looking to retire in the next 5 years. This would mean losing around 16 of our certified soil evaluators, perhaps leaving counties without a registered soil evaluator.

### **Missouri Administrative Rules**

The rules governing the licensing and requirements of a Missouri registered Onsite Soil Evaluator are regulated by the Department of Health and Senior Services (hereinafter, MODHSS) - MO 19 CSR 20-3.080. These rules regulate the construction of onsite septic systems, the necessary acceptable soil properties for specific onsite septic systems, and describe the certification process for new soil evaluators. Individuals who are interested in receiving their onsite soil evaluator license shall have at least 15 college credits in soil with a minimum of 3 credit hours focusing on morphology. Applicants

must pass a written and field test administered by MODHSS, and register with MODHSS upon certification. There are currently only three colleges in the state of Missouri that provide the required number of credits (15) necessary for certification (Southeast Missouri State University, Missouri State University, and University of Missouri – Columbia), while there are 8 other colleges and universities that provide <15 soils credits.

The position of a registered onsite soil scientist emerged from the passing of Missouri Laws Accompanied by Department of Health and Senior Services Rules Governing Onsite Wastewater Treatment Systems in 1996, 19 CSR 20-3.060-3.080. Prior to the release of these rules, some counties had regulations governing the installation and management of onsite soil septic systems, but there were no statewide guidelines. This resulted in many homes being installed that provided no treatment to the human wastewater prior to it flowing into ditches, streams, ponds, and rivers. The rules governing the requirements of an onsite soil evaluation are laid out in the document 19 CSR 20-3.060(7).

An important aspect of this process is understanding that while these individuals are registered in the state of Missouri, they are not state employees, but rather private citizens who run small businesses across the state. There are no assurances to the citizens of Missouri that there will be a registered onsite soil evaluator close to their property of interest. The state is relying on the powers of the market to fill in the needs of locations with few soil scientists in their area.

## **Future of Soil Evaluators**

The pipeline for new soil evaluators is currently small and may not have improved over the past 20 years since the implementation of the position of a registered soil evaluator. There are national trends that show some concern over the past 25 years in the overall supply of soil evaluator candidates. From 1992 to 2004 the number of graduate soil science students declined by approximately 42% (Baveye et al., 2006). Since then, there have been signs that nationally there has been some growth shown in undergraduate studies between 2009 and 2013 (Brevik et al., 2018).

This profession is 1 of 17 designated by the federal government in the wastewater industry as a “Bright Outlook” job, meaning growing at a rate of seven percent or higher and a “Green Job” as it will likely change with the implementation of new environmentally focused practices (EPA, 2021a). Specific training for this profession is rare though, as only 5 universities across the United States offer full, semester-long courses on decentralized/onsite systems (EPA, 2021b), none of which are located in Missouri. This combination of increasing need and lack of specific training or knowledge of the profession poses risks for Missouri’s future. Furthermore, simply having soil science graduates does not ensure that they would be capable or willing to complete the certification and become practicing soil evaluators. Our initial survey found that 73% of current soil scientists learned the necessary skills on the job. There needs to be training that addresses many of the unique challenges that this profession has and that can provide quality standard practices for new soil evaluators.

To inform the development of such a program, a survey in conjunction with MSO (Missouri Small Flows Organization) was conducted of Missouri's current soil evaluators to help inform the development of an introductory course for new soil evaluators. 19 of the 46 registered soil evaluators responded to the survey. The survey sought information on common issues that soil evaluators ran into during their early years in the profession, how soil evaluators learned the skills necessary for the job, and the information that these soil evaluators would have wished to have as new professionals.

This survey along with advice from current professionals and MODHSS guided the development of this training program into 6 distinct lessons; Missouri Geology, Soils across Landforms, Soil Profile Description, Septic Systems for Soil Evaluations, Site Evaluation & Field Layout, and Forms, Maps, and the Final Product. These lessons are offered both in-person through MSO yearly soils workshops and online through the National Onsite Wastewater Recycling Association's Online Learning Academy.

### **Comparison of Training Programs**

Throughout the installation process of an onsite septic system, there are typically 3-4 types of professionals that will most likely engage with the development of a septic system; the soil evaluator, the engineer (if required), the installer, and the county/state regulator. Each of these professionals requires a differing level of certification, training or education, and has a different set of responsibilities. Examining these differences can help explain the need for an introductory course for new soil evaluators.

Missouri's septic installers can attend a 3-day basic and/or a 2-day advanced licensing course provided by the state depending on the type of work they would like to

do. These workshops cost \$300 or \$200 respectively. After passing these courses, installers should have the necessary knowledge and can proceed with installing conventional and advanced treatment septic systems. Most installers receive their license while working for another certified installer.

Engineers must go through a more rigorous licensing process than soil evaluators. They must have a bachelor's in engineering from an accredited school, four years of satisfactory engineering experience and must complete two exams. Very few university courses in engineering specialize in the specifications of advanced septic system design and much of the necessary knowledge must be obtained through continuing education courses specific to the engineering components of septic system design.

As the education requirement increases for these professions, the role the state takes in their training decreases, relying more heavily on the will of the professionals to educate and train themselves in the specifics necessary for their profession. This may mean that the quality of the work being offered by soil evaluators or engineers is dependent on the enthusiasm a professional has for increasing and developing their skills and knowledge and the pride that individual has in their own work. We hope that through developing workshops for new soil evaluators we can create a baseline of quality work from which each soil evaluator can begin their profession.

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## CHAPTER II LITERATURE REVIEW

This literature review explores the theories and concepts that support the present study around the engagement of professionals through adult education offered both in-person and through online courses. The current situation for soil scientists in Missouri is laid out in the introduction, describing the requirements and guidelines for certification. This section will compare the certification process of similar positions in different states and examine the topics of courses offered in different states specifically for instruction in onsite wastewater soil evaluations. The structure of this literature review replicates reviews from other master's and doctoral theses on similar topics: soil evaluator training, educational materials development, and natural resources programs (Haig, 2011; Palmer, 2017; Khadka, 2019; Burnett, 2021; Kronenberg, 2022)

### **Adult Education**

#### Principles of Adult Education

Soil Evaluators must complete a certification process to become licensed in Missouri. This consists of university course work, a written examination, and a field examination. Throughout their career, they are required to complete continuing education credits to maintain their license. The majority of the knowledge and preparation for this profession occurs when the candidates are already adults. The strategies and concepts that guide adult education (andragogy) are different than those that guide the education of children (pedagogy). Ozuah (2005) describes the principles of adult learning. These can be summarized into 4 main points:

1. Applicable

Adults will learn better if they understand the reasons behind their need for this new knowledge. Real-life situations and problems they will be responding to should be provided, to help guide and stimulate their learning. Topics should be directly relevant to the adult learner; these can often be problem-centered or task-centered.

## 2. Active & Accessible

Mature learners prefer to have control over the learning process and require the ability to apply what they are learning immediately.

## 3. Respect is Shown

Environments and lessons that value the previous experience of the individuals should be utilized. These should be non-threatening and meet multiple different learning styles.

## 4. Reflection is Allowed

Adults require ample time for assimilation of new information. Feedback should be provided to help them progress towards their goals. Adults rely much more on their prior experiences in their learning than children and allowing them to reflect on how this new information melds with their experiences provides the richest source of learning.

The centrality of these principles dates back to many of the central tenets laid out in Knowles *The Modern Practice of Adult Education: Andragogy versus Pedagogy* (Knowles et al., 1970), where he stresses the importance of referencing and centralizing

the experiences and interests of the adult learner. He was one of the first adult education theorists to prioritize the learner's interests, rather than focusing on the believed interests held by the instructor. His five original assumptions of andragogy are that adults are self-directed learners, adult learners bring a wealth of experience to the educational setting, adults enter the educational settings ready to learn, adults are problem-centered in their learning, and adults are best motivated by internal factors. He stressed that teachers should be guiding learners through cooperative experiences that lean into the interests and curiosity of the adult learner.

Critics of Knowles have been numerous throughout the ages. Many came out in the 1980s questioning the validity of his claims; highly preoccupied with its empirical basis or lack thereof. While not disagreeing with his core concepts around adult education, many, such as Sandlin (2005) claimed that Knowles' theory of andragogy centered the learning process too highly on the individual rather than the on the wider cultural and social context in which the learning process is occurring. Others have stated that Knowles put too much emphasis on the cultural norms of a widely white, American, middle-class ideology (Loeng, 2018).

While these critiques are of importance, they have largely not dissuaded the central tenets of Knowles from leading much of the development of coursework for adult learners. The professionalization of a large portion of western society in the late 20<sup>th</sup> century increased the need for adult education and training courses (Savićević, 2008). This push has largely been led by the concepts laid out by Knowles (Loeng, 2018), with the focus remaining on self-actualization, self-directed learning, and learning directed towards the lived experience of the individual.

## Effective Adult Training Programs

The current demand for an appropriately skilled workforce in an ever-evolving global economy has drastically increased the prevalence of adult education and training courses (Benavot et al., 2022). These courses have sought in recent years to move from the dispersal of information to the centering of the adult learner as an active participant seeking to apply their learning in practice (McNamara et al., 2010). Alongside this training there has been the implementation of professional development and continuing education requirements for many professions across the United States. While professional development and adult education occur across many different fields in the United States, many of the concepts that guide effective professional development remain consistent.

Salopek and Dixon (2000) lay out in their book, “Common Knowledge: How Companies Thrive by Sharing What they Know”, different strategies for transferring knowledge from experts, who have the experience and background necessary for the tasks, to newcomers who will eventually take over the responsibilities of these experts. To determine the best type of transfer the organization must prioritize the following:

- Who will receive the knowledge? How similar are the task and context?
- The task's nature in terms of how routine and frequent it is?
- The type of knowledge being transferred.

Salopek and Dixon's (2000) suggested knowledge transfer methods are: (a) Strategic transfer: collective knowledge needed to accomplish a strategic task that occurs infrequently and it is critical to the whole organization is made available for future use; (b) Expert transfer: a team experiencing a knowledge gap with respect to a technical question beyond the scope of its own knowledge seeks the expertise of other people in

the organization; (c) Far transfer: tacit knowledge a team gained from doing a nonroutine task is used by other teams doing similar work in another part of the organization; (d) Serial transfer: knowledge a team has gained from doing a task in one setting is transferred to the next time that same team does the task but in a different setting; (e) Near transfer: explicit knowledge a team has gained from doing a task that is both frequent and repeated is reused by other teams doing similar work. For the work that soil evaluators will be attempting, the transfer types that would most align with their work are those of serial transfer, near transfer, and the expert transfer. While the work of soil evaluators is routine in that the steps and tasks are often the same, the ever-changing environment and work conditions of each job site may require expert knowledge beyond that of a beginner soil evaluator.

Beyond what the organization believes the learners should know, many adult learners go into professional development with the questions of “What is in it for me?”, “What do you think I must know?”, “What do I want and need to know and learn?”, and “What is of importance for me to know to keep on learning and growing?”. Effective adult education should be centered around answering and addressing these questions (Mahlangu et al., 2017).

While there are very limited amounts of studies on the training of wastewater professionals, let alone soil evaluators, there has been research into the development of other professional training programs for other career paths, such as trade jobs, teachers, engineers, health care workers, etc. For many of these commercial or technical professions, training programs that focused on (1) conceptual knowledge and (2) professional problem solving were found to be most effective (Norwig et al., 2017).

These two concepts were centralized in the BEST-Training program (Berufsbezogenes Strategietraining or Professional Strategy Training). It calls for professional problem-solving strategies linked directly to the context in which they will be used all while providing the training in the skills necessary to complete the required tasks (Norwig et al., 2013) The strategy of building professional competencies has been effective in the wastewater industry in developing the professional skills necessary for civil engineers working with onsite wastewater systems (Barry et al., 2008). Though Barry et al. used a different method (Problem based learning) the general instructional design principles remained similar:

- To provide an accessible context for the learning (conditions of when and how to use the knowledge);
- To encourage reflection, as well as refine and reapply learned knowledge;
- Continual testing of knowledge (formative assessment) and provide formative feedback;
- To encourage synthesis and integration of ideas in varying and similar contexts

These methods for providing training to adult learners both clearly focused on initially providing the necessary knowledge, giving them problems that reference their learning in a variety of contexts that are specific to the profession, and finally, providing feedback and guidance for the skills that are necessary.

### **Video Learning**

Many of these principles were developed with the in-person classroom in mind. Throughout the past few decades there has been a large push for online and self-directed

adult education courses. While the mode of delivery is very different from that of traditional classrooms, many of the principles that guide these courses remain the same. The core tenet of self-directed learning is one of the leading concepts that drives the development and expansion of online adult education (Blondy, 2007).

For niche professions, like the onsite soil evaluator, self-directed learning offers opportunities and timetables that would not be feasible for in-person learning environments. Currently, about 0-4 people take the annual certification tests for soil evaluators in Missouri. For professions with such a small, interested group, training programs that rely on large in-person classrooms would be unsuitable for providing the necessary skills and knowledge as they would be cost and location restrictive. For this reason, we imagine most use cases for the developed materials will be through online means or through continuing education credits that can be offered to soil evaluators, installers, and engineers in the onsite profession.

Video learning has both benefits and drawbacks when compared to in-person workshops and courses. Video learning can be a highly effective educational tool for teaching (Kay, 2012). Videos have been used in various contexts to support students in self-study at home or school. These can take the form of web lectures, short knowledge clips, or how-to videos (Hoogerheide et al., 2016). Video learning, similarly, to any type of educational lesson or tool, must be balanced. They must promote active learning and listening, they must not overwhelm the cognitive load of the viewer, and they must work to maintain student engagement (Brame, 2015). Brame outlines recommendations for each of these three central concepts;

- Balancing the cognitive load of the viewer can be achieved through signaling (onscreen cues to highlight information), segmenting (chunking information in small pieces), weeding (eliminate unnecessary information), and matching modalities (using auditory and visual cues simultaneously).
- Active learning and listening can be achieved through using guided questions, using interactive features, integrating questions into the videos, and embedding the video as part of a larger educational goal.
- To maintain engagement, videos should be short (less than 10 minutes), use a conversational style, speak relatively quickly and with enthusiasm, ensure its relevance to the topic, and matching the modalities (matching the audio and video for a single purpose).

There has been a long ongoing debate about the viability of teaching hands-on skills through video instruction (H. Karimi-Moneghi et al., 2003). Many of the skills necessary for soil evaluators require hands-on experience and knowledge, such as soil texturing, site evaluation, and horizon identification. Video learning can be effective in teaching these skills, though perhaps not as effective as instruction that is done both in person and through video instruction (van Duijn et al., 2014). Students may even prefer video instruction for some of the more difficult hands-on skills, as it provides students with the opportunity to learn at their own pace, rewind, re-view, and provide equally good viewing opportunities for students (Luginbuehl et al., 2023).

### **Significance of the Study**

#### State Requirements for Soil Evaluators

Onsite wastewater treatments systems (OWTS) and the professionals connected with them are not regulated by the federal government. The professionals, systems, and all necessary site and soil conditions are all regulated by state and/or local officials. This process allows each state to create rules and regulations relevant to the state's unique geographic/soil/water conditions. The rules governing the responsibilities and requirements for becoming a soil evaluator differ by each state, with some states having strict designations on who may perform soil evaluations while others have more relaxed standards. As discussed earlier, the main requirements for receiving a certification as a soil evaluator in Missouri are completing 15 college credit hours in soil science and passing a written and field test. After this process, there is a short probationary term, in which the state looks over the first 10 soil evaluations that are performed (Requirements for Percolation Testers, On-Site Soils Evaluators and Registered On-Site Wastewater Treatment Installers, 2016). This model could be called the open certification model. After certification new soil evaluators are open to perform the profession with few questions asked. After the short probation period, there is little oversight into the work Missouri's soil evaluators are doing. These requirements provide little specific training regarding the responsibilities of a soil evaluator, as the college courses rarely touch on the profession's nuances or requirements. Other states require specific courses/workshops to be taken, mentorships with current professionals, or proof of employment working with soil morphology or soil classification.

Many of the state's original soil evaluators were part of a cohort of soil mappers being trained by NRCS and DNR to map the soils across the state and on public land (Wollenhaupt & Buchholz, 1993). These professionals already had a good deal of

experience with mapping, classifying, and describing soils before they moved into the soil evaluator profession, with the state seeking out these individuals to become the first soil evaluators when the law was passed in 1996. With the completion of the county-based soil surveys in 2002, this prior training for Missouri's newer soil evaluators has more or less been lost (Young et al., 2007). Many younger soil evaluators who are entering the profession have little field experience with the requirements of soil evaluations, relying on nonformal mentorships, continuing education courses, and the few resources that are provided by the state. This lack of training could make it difficult for new soil evaluators to feel comfortable taking the risk of opening a small business that has some liability risk. This project's goal is to provide some initial training as a soil evaluator.

Looking at states in the Midwest and from around the country will shed some light on Missouri's current circumstances on OWTS. The responsibility of soil evaluators falls to soil classifiers in Illinois. Their requirements and responsibilities with OWTS are similar to those in Missouri, with an evaluation of the soil onsite being required for any onsite private sewage disposal system. The requirements for this position are slightly stricter than those of Missouri. A bachelor's degree is required with at least 15 credit hours in soils. An applicant must pass a written and field test. Applicants must have 4 years of experience working with classifying soils or have received an advanced degree, lowering the necessary years of experience (Illinois Soil Classifiers Association, 2021). The required professional experience in working in soil classification is the main difference between Missouri and Illinois. Illinois' model, while similar to the open

certification model of Missouri, has the requirement of proven experience, so this model could be called the experience certification model.

Other states with programs similar to the experience certification model of Illinois are Tennessee, Wisconsin, North Carolina, and Minnesota. Each of these states has slight differences in the requirements or type of tests that are necessary to be taken, such as national tests through the Council of Soil Science Examiners and the Soil Science Society of America versus tests developed by and for the state. Minnesota requires a mentorship of 2 years working with certified soil scientists (Examination of Geoscientist Applicants, 2011), while other states require longer amounts of experience to be recorded, such as the 5 years in Wisconsin (Examining Board of Professional Geologists, Hydrologists and Soil Scientists, 1997). Tennessee has the same requirements of experience and testing, but requires an initial probationary period for the production of the initial 10 maps of a soil evaluator, and then a final certification after 25 maps have been produced (Subsurface Sewage Disposal Systems, 2024). North Carolina has a unique model as the person who performs the soil evaluation is also responsible for the siting, design, and construction, as well as for the development of an appropriate management plan for the OWTS (North Carolina Soil Science Licensing Act, 1995). Most of these states reduce the amount of experience required when advanced degrees have been acquired.

There are states that have similar programs to Missouri, or the open certification model. These states are Indiana and Nebraska. These states require proof of course work like Missouri but may have different tests. Applicants in Nebraska must only pass one examination issued by the state (Onsite Wastewater Treatment Systems, 2022), while

Indiana must pass the CSSE/SSSA fundamentals exam and then an Indiana field test (Professional Soil Scientists, 2001).

Some nearby states have no state certification process. These states would make up the non-certification model. These states are Kansas, Iowa, and to a minor extent Colorado and Arizona. In Iowa, a person “demonstrating training and experience in soil morphology” may perform the soil analysis (Private Sewage Disposal Systems, 2012). Courses that provide this training are offered at the Des Moines Area Community College in Des Moines, Iowa. In Kansas, “a trained and qualified person would include a soil scientist (such as those with NRCS), environmental health specialist, sanitarian, or other person who has received appropriate soil training and through experience” (Minimum Standards for Design and Construction of Onsite Wastewater Systems, 1997). Training is provided by local sanitarians, The Kansas Department of Health and Environment, or through Kansas State University system (Chisam et al., 2004). These programs and training will be discussed in the following sections. Arizona allows for site and soil evaluations to be performed by state-registered engineers, geologists, sanitarians, or by anyone who has received a certificate of training from a recognized course in Arizona (Aquifer Protection Permits – General Permits, 2001). Colorado requires either a degree in soil science or a related field or attendance of a training/workshop for soil evaluation for OWTS that includes class and field work (On-site Wastewater Treatment System Regulation, 2013). Colorado has no state-wide test to certify soil evaluators.

The last model discussed will be that of Kentucky. Kentucky has moved the responsibilities of soil and site evaluations from private companies to the local health departments (Kentucky On-site Sewage Disposal Systems, 2023). Onsite soil evaluations

are performed by local county onsite septic systems inspectors. According to the state, these employees must be certified by the cabinet after receiving training programs and demonstrate skill in evaluating onsite soil conditions. This is the only state in nearby proximity that has moved the responsibility out of the market and into the public sector. While soil scientists and engineers can evaluate and submit soil evaluations, the vast majority are performed by local county onsite septic system inspectors. This position must meet the initial requirements for hiring and then must go through a 1-year training period before being allowed to perform soil evaluations for the county or state. The initial requirements for the position are 28 hours of science credits from a college or university. Upon being hired at the county level, new hires are sent to the University of Kentucky for a weeklong course in basic soils morphology and genesis. This is a 4-day course that focuses on field, lab, and classroom aspects. Following this initial course, soil evaluators must pass a written test to continue with the certification process (Chris Edwards CHFS, personal communication, Aug. 26, 2024).

After this test, soil evaluators begin phase 1. In phase 1, soil evaluators must attend a weeklong course focused on the onsite regulations and rules of Kentucky. Following this, they shadow a state regulator on 5 new septic system inspections. Septic system inspections involve both system layout and design. Once they pass another written test, they may become provisionally certified.

Once a county health professional is certified as a provisional onsite septic system inspector, they enter phase 2. At this point, they can begin performing inspections on their own. They are often moved around the state to perform septic inspections in different counties. Quarterly, throughout this first year of phase 2, the state regulator from

phase 1 returns to check and evaluate the work being done by the provisional septic inspector. During this provisional phase, they often attend 2-day courses offered by the University of Kentucky or Western Kentucky University, where professors go through multiple soil backhoe pits to describe the soil conditions that are common in a specific region of Kentucky. After this initial year of certification, provisional septic system inspectors must pass a written and field test to receive their full certification. At this point they work for a county health department, where onsite septic system inspections are often just one part of their job as registered sanitarians.

Evaluating the efficacy of these different certification programs is beyond this study's scope but does present the possibility of future research.

#### Onsite Soil Evaluator Training Courses

There are training courses that are offered for soil evaluators across the United States. As many of the responsibilities for certifying and registering soil evaluators falls onto the states, and any training programs for these positions are often provided by private organizations such as onsite wastewater associations, as in Missouri or Iowa, associations for professional soil scientists, as Illinois or Minnesota, are offered through technical colleges and universities, as in Minnesota, Kansas, Iowa, Wisconsin, or North Carolina, or are offered through one of the 23 onsite wastewater treatment centers across the USA. It is important to note that many of these organizations only offer introductory soils courses that do not get into the specifics of the soil evaluator position. Many of these courses explore similar themes and learning outcomes. We will look more closely at the continuing education courses offered through the Universities of Minnesota, the University of Arizona, and North Carolina State University, the longer course offered

through Moraine Technical College, courses offered through professional or state organizations, such as those through the Kansas Small Flows Organization or through Onsite Wastewater Training Centers.

Many of the soils courses specific to OWTS that are taught in universities fall under their extension programs. These programs have been part of the land-grant university system for more than 100 years focused on outreach and engagement with the agricultural community (Al-Kaisi et al., 2015). They have since moved into a much wider audience with the inclusion of gardening, horticulture, arts programs, community health, and even onsite wastewater treatment. These extension offices offer continuing education credits for many different professions, with soil evaluators being one of them. The University of Minnesota, The University of Arizona, and the North Carolina State University extension offices offer courses focused on soils.

The two and a half day University of Minnesota course focuses on preparation for the required exam and provides information on “how to identify and understand specific soil properties that affect the treatment of sewage”. These topics touch on soil basics, a preliminary evaluation, soil texturing, structure and color, performance of a percolation test, how to draw a site map, the use of soil survey, and soil interpretation for the treatment of wastewater. Beyond this in-class experience, there is a 0.6 day of hands-on instruction in a soil pit and with known samples for soil color and texturing practice.

The three-day course offered through University of Arizona extension fulfills the requirements of the state of Arizona to perform site and soil evaluations. This course examines the requirements for a site investigation in Arizona. The first day is focused on

identification of soil texture, color, and structure, both in the field and in the classroom. It discusses preliminary site evaluations and perc testing and sizing. The second day examines field site evaluations and mapping, the use of soil survey as a tool and an overview of Arizona soils. This continues with field work on landscape evaluation, perc test performance, the required tools, and soil pit work. Participants receive homework to further reinforce the information from this day. The third day is a review and a course completion exam.

The two-day course of North Carolina State University titled: Soils 101: Soil Profiling for Wastewater Siting, teaches “participants how to use soil profiling to assess site acclimation to various end uses. These end uses include on-site wastewater treatment and dispersal systems.” The informational portion of the workshop focuses on morphology and genesis of soil, and the use of soil colors to identify and describe a water table, soil wetness class, and water movement. They will define and describe redoximorphic features, mottling, relic and lithochromic colors. From here the course moves into describing the physical characteristics of the soil in texturing, structure, and consistence. The last portion of the workshop focuses on a field practicum of identifying soil characteristics. The first part focuses on horizons and soil color, with the second portion examining texture, structure, and consistence. Finally, there is an independent work time in which students, working in small groups, are to describe a soil pit.

The courses offered by Moraine Technical College in Wisconsin are directed towards exam preparation and continuing education classes. According to their website they offer 5 courses that cover many of the requirements for certified soil testers. These are Introduction to Onsite Wastewater Treatment and SPS 383/385, Soil Fundamentals,

Describing and Interpreting Soil Profiles, Site Mapping Techniques and POWTS Design Rules/Principles, and Soil Testers: Field Practicum. The idea of these courses is to cover the entirety of what will be tested for the certification exam and to prepare future soil evaluators for the different responsibilities of the soil classifier.

Courses offered by non-college organizations are structured in a similar manner. These courses are often directed towards continuing education credits rather than specifically training new soil evaluators. They prioritize field experience, a review of general soil knowledge, and discuss the specifics of the position for their local state. A continuing education workshop offered through Onsite Wastewater Professionals, a training center in North Carolina, has a 6-hour course that covers the following topics:

- Soil properties and characteristics
- Soil types and classifications
- Soil testing methods and procedures
- Soil health and management practices
- Soil and septic system interactions

By the end of the course, it is expected that participants will “have a solid understanding of soil basics and their critical role in septic system installation and maintenance”. It should be noted that the profession in North Carolina has further requirements beyond soils evaluation, such as system design, that in other states is the responsibility of other parties.

In Colorado, the experience required to perform soil/site evaluations can be completed through classes/workshops registered with the Division of Water Quality

Control. One of these courses is offered through the Colorado Professionals in Onsite Wastewater. This is a two-day course.

Day one includes:

1. Basic Principles of On-Site Wastewater Treatment (OWTS) siting and design
2. Regulation specific requirements for conducting preliminary and field site investigations with “real world” examples
3. Basic geology and soil formation processes
4. Percolation test methods
5. United States Department of Agriculture (USDA) soils classification system
6. Relationship between soil types and movement & treatment of effluent
7. Basics of how to identify limiting layers and high rock content (Type R soils)
8. Hands-on soil texturing

Day two includes:

1. Preview of field site
2. Site visit and test pit evaluation
3. Re-cap of site visit
4. Review and Q&A
5. Exam

Following this or a similar course offered through other organizations or schools, soil evaluators in Colorado can perform soil evaluations.

The final method of certification is that of Kentucky, in which local government employees perform the soil and site evaluations. The training for this is discussed in the certification section of the literature review but focuses heavily on the regulations and

rules of Kentucky, while providing coursework and practical experience from trained professionals from universities and overseeing government employees.

As stated earlier, comparing the success rate and outcomes of these training programs is beyond this review's scope but provides future research opportunities.

### **Survey Methodology**

The knowledge, attitudes, and practices methodology (KAP) has served for decades as a surveying method in a wide variety of fields, from public health to education to anthropology. Originally developed in 1970 by The Population Council and revised in 2008 by the World Health Organization, KAP serves as a social research method that measures changes in human knowledge, attitudes, and practices in response to a specific intervention, usually education or extension. This method is highly problem-solving oriented and the WHO lays out a 6-step program to help in the use of KAP surveys:

1. Define the survey objectives
2. Develop the survey protocol
3. Design the survey questionnaire
4. Conduct the KAP Survey
5. Analyze the data
6. Use the data

-(World Health Organization, 2008)

KAP surveys were first developed to evaluate public health interventions with the idea to identify knowledge gaps and misconceptions that may hinder the adoption of preventative measures (Zarei et al., 2024). KAP evaluations have since expanded into a wider array of fields, such as nutrition, environmental health, education, and even the

adoption of agricultural practices. While not often used in the field of Natural Resources, it has been used in natural resource projects in the United States (Eckman et al., 2011).

There are difficulties and gaps in the efficacy of KAP evaluations. These can include; data collection, survey design, discrepancies between reported and actual behaviors, and inadequate data analysis (Zarei et al. 2024). These difficulties need to be considered during the development of the surveys, during the survey, and finally within the data analysis to ensure that the conclusions of KAP studies are relevant. KAP surveys should provide easily interpretable results from easily quantifiable data (Launiala, 2009)

KAP surveys are structured as pre- and post-intervention surveys to gather longitudinal data that measures the changes in the participants. This aligns closely with this project's goals to evaluate the effectiveness of the developed workshops for teaching those interested in the soil evaluators profession while teaching about the job's specifics and requirements. Participants fill out the pre-tests assessing their knowledge, attitude, or current practices around a specific topic. They then participate in the workshop or course. Finally, participants fill out a post survey, assessing the change in their knowledge, attitude, or practice for the specific questions asked in the pre-test.

This study uses a model of a pretest and a posttest to measure the improvement gained in both knowledge and practices from participating in the curriculum. This study is focused on self-assessed knowledge and practices gains. Self-assessment has been shown to be effective in testing pretest-posttest knowledge differences in multiple environments; university, extension, business (Guillory & Blankson, 2017; Stufflebeam & Wingate, 2005; Nielsen, 2011). Participants either received the pretest-posttest in the

traditional manner of completing the pretest before the workshop and then the posttest following completion or through the retrospective pretest-posttest, in which participants filled out both the pretest and posttest after completing the workshop. Both retrospective and traditional pretest-posttest evaluations have been shown to provide accurate assessments of program outcomes (Pratt et al., 2000, Little et al., 2020).

Through incorporating the tenets of adult education and online/video education, while using standard social science research tools, this investigation will be able to systematically measure the effects of the workshops/courses developed as a part of this research project. This information will allow for further refinement and improvement of educational materials for new soil evaluators and the development of effective new courses for those interested in the soil evaluator profession.

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## **CHAPTER III: Developing and Assessing New Curriculum for Missouri's Future Soil Evaluators**

### **ABSTRACT**

One-quarter of households in the state of Missouri are connected to an onsite sewage treatment system. These systems are necessary due to the risks human effluent poses to public health and our states aquifers and waterways. For these systems to function correctly, a thorough and accurate evaluation of the soils and landforms onsite must be accomplished. There are currently less than 46 certified onsite wastewater soil evaluators registered in Missouri to perform these evaluations for new and replacement systems in Missouri. This project develops in-person and online introductory courses for new soil evaluators to ensure that the regulations and standards of Missouri's laws and statutes are followed by Missouri's future soil evaluators. Participants completed voluntary pre- and post-workshop surveys related to their knowledge of skills and topics regarding onsite soil evaluations. Participants' knowledge increased significantly across all six areas of study. Overall, participants indicated that these workshops provided quality training that they would recommend.

### **1 INTRODUCTION**

Onsite wastewater treatment systems (OWTS) are a daily part of millions of Missourians lives, with one in four Missourians relying on an OWTS (Missouri Department of Health and Senior Services, (MODHSS), 2024). Recent studies indicate that one-third of new single-family homes being built between 2016 and 2018 are served by these individual centralized systems (EPA, 2020). Collectively across the United States more than four billion gallons of sewage is being treated through these private

wastewater systems (EPA, 2021a). These systems are key cogs in the management of our public and environmental health (Center for Disease Control and Prevention, 2023) and in Missouri the assurance of the viability of these systems relies on the knowledge and skills of a soil evaluator.

A soil evaluator uses their knowledge of soil properties, local geology, and hydrology to assess the onsite soil and land conditions to provide recommendations for the viability and feasibility of an OWTS. There are currently 46 registered soil evaluators in Missouri according to the Missouri Department of Health and Senior Services, the certifying agency for soil evaluators in the state (DHSS, 2023). These 46 soil evaluators provide their services for the new construction and repair of OWTS for the 114 counties in Missouri. National surveys of the wastewater industry report that 37% of wastewater professionals are intending to retire in the next 5 years (Holodak, 2023). At the same time, the number of students choosing training and a career path in soil science has dwindled (Overbay et al., 2023; Baveye et al., 2006; Brevik et al., 2018). This combination of factors poses a large risk to Missouri's future public and environmental health. With this in mind, MODHSS, Missouri Small Flows (MSO), a nonprofit focused on wastewater education in Missouri, and the University of Missouri advocated for the development of workshops and materials targeted at training new individuals interested in the soil evaluator profession.

This profession is 1 of 17 designated by the federal government in the wastewater industry as a "Bright Outlook" job, meaning growing at a rate of seven percent or higher and a "Green Job" as it will likely change with the implementation of new environmentally focused practices (EPA, 2021a). Specific training for this profession is

rare though, as only 5 universities across the United States offer full, semester-long courses on decentralized/onsite systems (EPA, 2021b), none of which are located in Missouri. While two universities in Missouri offer the required coursework for certification, the need remains for the introduction and training in the specifics of the profession. The materials that have been created seek to develop the necessary knowledge and skills that are required to provide an onsite soil evaluation. Herein, I provide a brief overview of the courses and workshops that have been developed and discuss the impact of this curriculum on participant's knowledge as assessed by pre- and post- activity self-assessed surveys conducted across three in-person cohorts and through online participation.

## **CORE IDEAS**

- Onsite wastewater treatment systems are key components in the maintenance and management of our public and environmental health.
- There is a need for specific training for new soil evaluators.
- Survey results indicate significant learning of the necessary skills and knowledge of a soil evaluator.
- Workshops offered online and in-person are needed to reach the widest audience.

## **2 PROGRAM DEVELOPMENT**

### **2.1 Initial Survey**

The creation and evaluation of the curriculum developed as part of this project has been a collaboration of Missouri Small Flows (MSO) and the faculty and staff at the University of Missouri, along with the assistance and participation of state-wide agencies,

such as Missouri Department of Health and Senior Services, as well as soil evaluators across the state. The development and evaluation of this curriculum began with an initial survey of registered soil evaluators in Missouri. This survey was distributed by MSO through their email and mailing lists. 19 responses to the survey (response rate of 41.3%) were received. The survey was developed by MSO, faculty at the University of Missouri, and myself. The goal of the initial survey was to assess areas that current soil evaluators struggled with when they were new in the profession, how soil evaluators go about their job, and what topics they wished they knew more about as new professionals. The survey was a mixture of multiple choice and short answer questions. See the additional materials for the full list of questions and responses.

From the analysis of these results, comparisons with similar programs in other states, and through a series of meetings and discussions, using the concept of backwards design (Wiggins & McTighe, 2005) we decided on the six most important learning outcomes for this curriculum;

- Missouri geology
- How soils change across landforms
- Soil profile description
- Types of septic systems
- How to layout and site a septic field
- Correct procedures for state forms and maps

## 2.2 Courses

Engaging participants in the required practices of a soil evaluator was the primary goal of this curriculum. Therefore, courses were developed to focus on the key areas

necessary for a soil evaluator: knowledge of the characteristics of soils in Missouri, skills for the completion of an onsite soil evaluation, and knowledge of the rules and regulations of Missouri. Through this, the following six courses were developed:

### 2.2.1 Missouri Geology

This course discusses the origins of soils across several regions of Missouri, (the northern till plains, the St. Francois Mountains, the Springfield Plateau, the Osage Plains, the Ozark Plateau, the Mississippi Embayment and Missouri River Floodplains). It reviews the main geologic events that affected the soils of these regions. It introduces participants to the common types of bedrock throughout the state and their distribution. It discusses some of the common soil characteristics of the soils in these regions, such as the types of clay, the average soil depth, or coarse fragment percentage, etc. The lesson's goals are to ensure that students understand the basic differences between the regions of Missouri and to familiarize themselves with common soil characteristics and differences in each of these regions.

### 2.2.2 Soils Across Landforms

This course discusses how soils can change across specific landforms; hills, terraces, and floodplains. It provides examples, both theoretical and real-life, of mapped soils across these landforms, while providing the background information necessary to discuss these landforms using the correct terminology. It goes into typical restrictive horizons that are present across these landforms that can prevent the installation of OWTS. The goal of this lesson is to have students understand that while soils of a region have similar traits,

they can be highly variable simply because of changing conditions, such as hill slope position, aspect, or landform.

### 2.2.3 Soil Profile Description

This course goes through the practice of describing a soil profile through the requirements and responsibilities of an onsite soil evaluator. It discusses the importance of each of the different soil characteristics (designation, structure, texture, color, boundary, pores, roots, consistence, coarse fragments, etc.) and their impact on OWTS. It examines the influences of these characteristics on the application rate for an OWTS. It provides examples of soil profile descriptions and evaluations with the final goal of teaching students about how to assess a soil profile for overall suitability for an OWTS.

### 2.2.4 Septic Systems for Soil Evaluators

This course examines the different types of OWTS that are allowed in the state of Missouri through the lens of a soil evaluator. It discusses how each system functions, describes the soil requirements for each system, and gives general use cases for each type of system. The goal is to give students a better understanding of the final product that will be installed on these properties while giving them the necessary information to be able to discuss and advise on systems based on onsite soil conditions.

### 2.2.5 Field Layout and Site Evaluation

This course examines the responsibilities of a soil evaluator as a professional. It discusses the details of the day-to-day life of a soil evaluator and lays out the requirements that a

soil evaluator will have to perform when onsite. It examines the onsite requirements of the profession and goes through examples of how to accomplish these responsibilities, such as field layout, evaluating natural and manmade features for OWTS risks, assessing setback distances, and more. The goal is to provide participants with an outline they can follow for performing the majority of the responsibilities necessary to fulfill an onsite soil evaluation.

#### 2.2.6 Forms, Maps, and the Final Product

This course examines the forms required by the state of Missouri for a soil evaluation. It reviews the necessary information that should be recorded and gathered. It explains how to create the visual representation required of the property and the OWTS. Finally, it discusses how to make final recommendations as a soil evaluator for an OWTS. The goal of this course is to familiarize participants with the rules and regulations of the state as well as the forms required by the state and to give them an understanding of the required information and its importance for OWTS.

#### 2.3 Distribution

These courses may be acquired by request through the author for education purposes only. They will continue to be offered for specific workshops, conferences and courses through Missouri Small Flows. The online courses may be accessed through The National Onsite Wastewater Recycling Association's Online Learning Academy.

### 3 METHODS

#### 3.1 Implementation

These courses were developed over 2023 and 2024 to be used as part of MSO yearly soils workshops, in university classrooms, and as online video workshops as continuing education credits through the National Onsite Wastewater Recycling Association's Online Learning Academy. There have been four initial trials of this curriculum; three in-person and one online. The in-person workshops have been: the 2023 MSO soils workshop at Shealy Farm in Springfield, MO, the 2024 MSO soils workshop at Bradford Research Center in Columbia, MO, and the University of Missouri Soils Morphology Course in Spring of 2024. The online materials are being assessed by the University of Missouri Soils Genesis course in Fall of 2024.

#### 3.2 Survey

A survey was designed to assess participants' learning regarding various topics related to each course. Learning was measured with a set of questions asking participants to self-assess their knowledge of a skill or concept included in the courses. The level of understanding was reported on a five-point Likert scale of the participants knowledge, representing *Very Low*, *Low*, *Moderate*, *High*, and *Very High*. Some of the specific topics assessed for each course are listed in Table 1. Overall, there were 38 central questions that were surveyed across the six courses, though in some workshops fewer/more questions were asked regarding knowledge gain in the course depending on the requested topics of the workshop.

Table 1. Items assessed in the surveys based on course

<b>Course</b>	<b><i>Skill or Concept</i></b>
Geology	<p>Landform areas and boundaries (i.e. Ozark plateau, glacial till plain)</p> <p>Underlying geology in each region</p> <p>Relationship of MO soils to this geology</p> <p>Effect of glaciers on MO soil and landscapes</p> <p>How each region formed and how that affects the soil in that region</p> <p>The qualities of the different types of bedrock</p> <p>Under what conditions high shrink-swell clays form</p>
Soils Across Landforms	<p>Hillslope position effects on soils</p> <p>The effect of aspect on soils</p> <p>The types of restrictive horizons (fragipans, claypans, gravel)</p> <p>How soils are deposited by rivers and streams</p> <p>How differing landforms can affect siting a septic system</p>
Soil Profile Description	<p>Identification of soil horizons</p> <p>Effect of soil drainage on soil color and onsite systems</p> <p>Water table identification</p> <p>How to estimate coarse fragments in soil</p> <p>Structure effect on soil drainage</p> <p>Texture effect on soil water availability</p> <p>Where to find information on the shrink-swell potential of soil</p> <p>Correct use of soil horizon designations</p>
Septic Systems	<p>Types of septic systems</p> <p>How to size a conventional system</p> <p>How to size a Low Pressure Pipe (LPP) or Drip Irrigation system</p> <p>The suitable soil conditions for each septic system</p> <p>Soil or site conditions that necessitate a specific system</p>
Site Evaluation	<p>Materials needed prior to your arrival onsite</p> <p>What qualifies as a suitable area</p> <p>Natural and manmade conditions that restrict a field location</p> <p>The setback distances necessary for a tank and a field</p> <p>How to calculate or measure slope</p> <p>How to site a septic tank and a septic field</p> <p>The necessary number and locations of soil pits</p>

Forms and Maps	<p>How to draw a site diagram</p> <p>How to choose a proper loading rate</p> <p>How to assess whole site suitability</p> <p>Mitigations of unsuitable conditions</p> <p>What conditions pose high environmental risks</p> <p>Who to contact with questions/concerns</p>
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### 3.3 Analyses

Survey results were compiled, and pre- and post-workshop responses were compared for statistically different mean responses using Wilcoxon Signed Ranks Test. Significance was tested at the 95% level of confidence to reject the null hypothesis of “no difference” in a given test. Additionally, effect sizes were calculated for each workshop that was given to provide a way of contextualizing the level of meaningfulness for the differences. Cohen’s *d* was used as a measure of effect size for the Signed Ranks Test. It is equal to the mean difference (MD) divided by its standard deviation. The labeling of the effect sizes was laid out by Sawilowky (2009) as follows: .2 is small; .5 is medium; .8 is large; 1.20 is very large; and 2.0 is huge. Examining the effect size provided more context into which lessons had larger or smaller effects on different cohorts. All statistical analyses were conducted in IBM SPSS Statistics (Version 26, 2019). Open ended responses were categorized and described.

## 4 RESULTS

### 4.1 Participants & Workshops

Not all courses were able to be offered at every workshop due to time restraints and the wishes of the organizing host.

The initial in-person pilot testing of three of the six lessons (Missouri Geology, Soils Across Landforms, and Soil Profile Description) was given in September of 2023 to a continuing education course offered by MSO of 24 soil evaluators, engineers, and installers. The participants consisted of 11 soil evaluators (45.8%), 7 installers (29.1%) and 6 regulators/engineers (25%).

All six workshops were presented at the University of Missouri Morphology class. This course was a mixture of sophomores, juniors, and seniors. The courses were presented over three weeks with two courses taught each week. The first workshop (Missouri Geology and Soils Across Landforms) had 22 participants. The second workshop (Soil Profile Description and Septic Systems for Soil Evaluators) had 14 participants. The third workshop (Site Evaluation and Forms, Maps, & Final Product) had 16 participants. These students had differing amounts of experience in soils. 37.5% of the participants only had 1 prior course in soils. 37.5% of the participants had 2-3 prior courses in soil science. 12.5% of participants had 3-5 prior courses in soil science and 12.5% had more than 5 prior courses in soil science.

The prepared online videos were presented to the University of Missouri Soil Genesis course in Fall of 2024. This testing was for Geology of Missouri and Soils Across Landforms. There were 34 participants in this course ranging from sophomores, juniors, seniors, and graduate students with a variety of soils experience prior to this course. 8 participants (23.5%) had one or fewer prior soils courses. 15 participants (44.1%) had 2-3 prior courses in soil science. 7 participants (20.6%) had 3-5 prior courses in soil science and 4 participants (11.7%) had more than 5 prior courses on soils.

A fourth workshop was given in October of 2024 to an MSO Soils Workshop, presenting the course Soils Across Landforms. This workshop consisted of 20 participants. The participants were 10 soil evaluators (50%), 4 installers (20%), and 6 regulators or engineers (30%).

#### 4.2 Quantitative Surveys

Participants were surveyed about their knowledge of different skills or topics related to an onsite soil evaluation using items generated by the project team to assess the desired outcomes of the courses. Across the workshops some items were reworded slightly to adjust to the specific requirements of the workshop. Responses from the different workshops to some of the survey questions, along with the mean response values on scale of 1 (very low knowledge) to 5 (very high knowledge), the standard deviation, and the  $p$ -value are summarized in tables 2, 3, and 4. As all of the results for the in-person and online workshops were found to be statistically different from the pre-test to the post-test, not every item has been included in these tables. For a list of all of the assessed questions across all the workshops, their means, SD and  $p$ -value, please see the additional materials.

**TABLE 2** Self-assessed knowledge of skills/concepts related to the topics of the workshop. Surveys were administered to professionals (soil evaluators, installers, engineers) (n=23) in September 15 of 2023. Mean response is described on a 5-point Likert scale from very low (1) to very high (5) knowledge rating. Responses were compared using Wilcoxon Signed Ranks Test.

	Question/Skill	<i>Pre</i>		<i>Post</i>		P-Value
		Mean	SD	Mean	SD	
MO Geology	Landform areas and boundaries (i.e. Ozark plateau, glacial till plain)	3.27	1.077	3.86	0.834	.005
	Underlying geology in each region	2.86	1.037	3.45	0.912	.005
	Relationship of MO soils to this geology	3.00	0.976	3.59	0.908	.006
	Effect of glaciers on MO soil and landscapes	2.91	1.192	3.73	0.883	.004
	How each MLRA region formed and how that affects soil in that region	2.74	1.096	3.57	0.896	.002
	How and where high shrink-swell clays form.	3.09	1.109	3.77	0.922	.002
S.A.L.	Hillslope position effects on soils	3.59	0.908	4.09	0.684	.008
	How knowledge of landform effects on soil can be used to select an onsite location	3.77	0.922	4.18	0.795	.007
Soil Profile Description	Effect of soil drainage on soil color and onsite systems	3.68	1.287	4.23	0.922	.006
	Water table identification	3.50	1.225	4.00	0.976	.016
	Structure effect on soil drainage	3.90	0.995	4.24	0.831	.038
	Texture effect on soil water availability	3.82	1.053	4.09	1.019	.034
	Correct use of soil horizon designations	3.50	1.225	4.05	0.899	.005
	Determining soil horizons	3.67	1.155	4.24	0.831	.010

(S.A.L) = Soil Across Landforms

TABLE 3 Self-assessed knowledge of skills/concepts related to the topics of the Soils Across Landforms Workshop. Surveys were administered to professionals (soil evaluators, installers, regulators, and engineers) (n=20) in October 11 of 2024. Mean response is described on a 5-point Likert scale from very low (1) to very high (5) knowledge rating. Responses were compared using Wilcoxon Signed Ranks Test.

Question/Skill	Pre		Post		p-Value
	Mean	Std. Dev	Mean	Std. Dev.	
Hillslope positions effects on soils	3.44	1.097	4.11	0.758	.005
The effect of aspect of soils	3.22	1.353	4.17	0.707	.002
The types of restrictive layers (fragipans, claypans, gravels)	3.33	1.138	4.11	0.832	.002
How soils are deposited by rivers and streams	3.61	1.092	4.17	0.707	.004
How differing landforms can affect siting a septic tank	3.72	0.958	4.22	0.732	.003

TABLE 4 Self-assessed knowledge of skills/concepts related to the topics of the workshop. Surveys were administered to university students (n=14) in February 5 of 2024. Mean response is described on a 5-point Likert scale from very low (1) to very high (5) knowledge rating. Responses were compared using Wilcoxon Signed Ranks Test

	Question/Skill	Pre		Post		p-Value
		Mean	SD	Mean	SD	
Site Evaluation	Materials needed prior to your arrival onsite	1.56	0.814	3.68	0.793	<.001
	What qualifies as a suitable area	2.00	0.894	3.62	0.719	.001
	Natural and manmade conditions that restrict a field location	1.68	0.602	3.38	0.806	.001
	The setback distances necessary for a tank and a field	1.62	0.719	3.69	0.873	<.001
	How to calculate or measure slope	2.69	1.621	3.69	1.014	.006
	How to site a septic tank and a septic field	1.50	0.632	3.43	0.814	<.001
	The necessary number and locations of soil pits	1.50	0.632	3.44	0.727	<.001
Forms and Maps	How to draw a site diagram	1.63	0.885	3.38	0.957	<.001
	How to choose a proper loading rate	1.5	0.816	3.31	0.873	<.001
	How to assess whole site suitability	1.56	0.892	3.38	0.885	.001
	Mitigations of unsuitable conditions	1.62	0.719	3.31	0.793	<.001
	What conditions pose high environmental risks	1.81	0.750	3.56	0.892	<.001
	Who to contact with questions/concerns	1.62	0.957	3.81	0.981	.001

**TABLE 5** Self-assessed knowledge of skills/concepts in Geology video workshop. Surveys were administered to university of Missouri Soil Genesis students (n=34) on August 16, 2024. Mean response is on a 5 point Likert scale of 1 (very low) to 5 (very high) knowledge rating. Responses were compared using Wilcoxon Signed Rank

	Question/Skill	<i>Pre</i>		<i>Post</i>		P-Value
		Mean	SD	Mean	SD	
<b>MO Geology</b>	Landform areas and boundaries (i.e. Ozark plateau, glacial till plain)	2.92	0.845	4.00	0.693	<.001
	Underlying geology in each region	2.58	0.809	3.69	0.736	<.001
	Relationship of MO soils to this geology	2.64	0.638	3.72	0.678	<.001
	Effect of glaciers on MO soil and landscapes	3.20	0.913	4.04	0.611	.001
	How each MLRA region formed and how that affects the soil in that region	1.88	0.927	3.24	0.723	<.001
	The qualities of the different types of bedrock	2.32	1.069	3.28	0.792	<.001
	Under what conditions high shrink-swell clays form.	2.68	0.802	3.88	0.781	<.001

The mean responses for these items were aggregated and averaged to provide the mean difference (MD) for each course that was offered. Table 6 provides the MD of the pre- and post-scores for each course as well as their effect sizes (*d*). As these data reveal, each course showed a statistically significant change in the self-assessed knowledge of the participants with the size of the effect ranging from small to huge. The effect sizes for professionals in the wastewater field were either small (.2) or medium (.5), while the effect size of these courses on university students was either in the very large (1.2) or huge (2.0) range (Sawilowsky, 2009) indicating that the effect size is drastically larger for university students than for professionals. This is particularly true for students in the courses that explore the specifics of the soil evaluator profession and the wastewater field, such as the courses: Septic Systems, Site Evaluation, and Final Forms.

Table 6 Mean differences (MD) and aggregated Cohen's d (d) for self-assessed pre/post-test scores for each workshop and cohort that has been offered. Scores are on a 5-point Likert Scale from 1 (very low) to 5 (very high) knowledge rating.

Workshop	Shealy Farm (N = 23)		Bradford Farm (N = 20)		UM Videos (N = 34)		UM In-Person (N = 20(a),14(b),16(c))	
	MD	<i>d</i>	MD	<i>d</i>	MD	<i>d</i>	MD	<i>d</i>
Missouri Geology	.67 (.12)**	.70			1.36 (0.39)***	1.63	1.15 (a) (.14)***	1.24
Soils Across Landform	.42 (.12)*	.53	.76 (.22)**	.77			1.3 (a) (.27)***	1.23
Soil Profile Description	.46 (.10)*	.49					1.22 (b) (.24)**	1.30
Septic Systems							1.79 (b) (.10)**	2.24
Site Evaluation							1.77 (c) (.35)**	2.34
Final Forms							1.84 (c) (2.67)***	2.18

Note: Standard deviations for means are in parenthesis

\* Significant at  $p < 0.05$

\*\* Significant at  $p < .01$

\*\*\* Significant at  $p < .001$

University of Missouri (UM)

These patterns can be more easily interpreted in Figure 1, which illustrates the mean changes in pre- and post-scores for each course. It is easy to see here that the university students had much lower prescores for the courses that are specific to the job requirements of the soil evaluator profession (Very Low - Low). For the courses in which the assessed knowledge may have been covered in previous university soils courses (Geology, Soils Across Landforms, and Profile Description), the students self-assessed pre-course knowledge is higher (Low - Moderate) and the size of the effect is less drastic. Professionals in the wastewater field showed a much higher knowledge baseline (Moderate - High) than the students. I would hypothesize this is due to their years of experience dealing with onsite wastewater treatment systems and the soil evaluator profession.

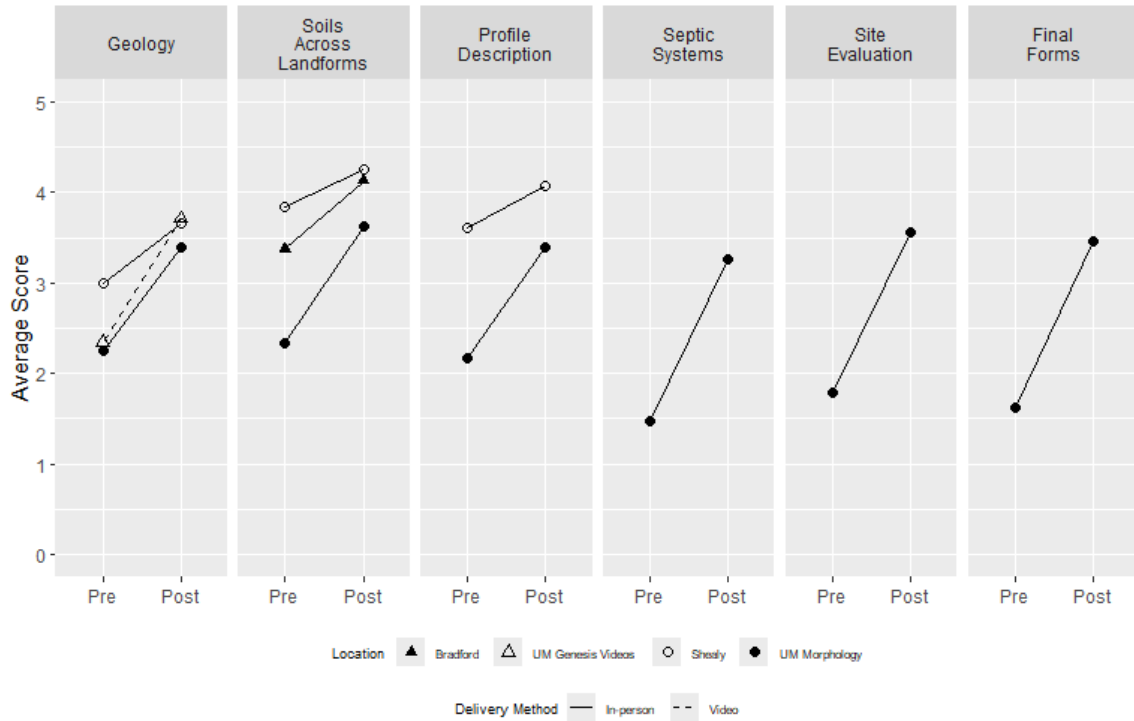


Figure 1 Aggregated changes in pre/post self-assessed survey results for each course and cohort/location. Mean response is described on a 5-point Likert scale from very low (1) to very high (5).

UM = University of Missouri

### 4.3 Qualitative Surveys

#### 4.3.1 Participant Reception of Workshops/Videos

As part of the survey, participants were asked to rank the relevance of the topic to their work, the quality of the workshop, the knowledge of the presenter, and the quality of the presenter. These were measured on a 4-point Likert Scale of 1 (Not Satisfied), 2 (Somewhat Satisfied), 3 (Satisfied), 4 (Very Satisfied). They were also asked ‘Yes’ or ‘No’ whether the presentation/video was easy to understand, whether it met expectations, and whether they would recommend the workshop/video to others. Not all questions were asked at every workshop/presentation. Results can be seen in Tables 7a-d.

Table 7a. Responses - MSO Soils Course (Shealy Farm - September 2023)

<b>Items</b>	<b>M(SD)</b>
How satisfied are you with the relevance of information to your needs?	3.57(0.49)
How satisfied are you with the presentation quality of the instructor?	3.70(0.55)
How satisfied are you with the subject matter knowledge of the instructor?	3.52(0.50)
How satisfied are you with the overall quality of the training workshop?	3.74(0.44)
<b>Items</b>	<b>Result</b>
Was the information easy to understand?	Yes – 100%
Did the training workshop meet your expectations	Yes – 95.6%
Would you recommend this training workshop to others?	Yes - 91.3%

Table 7b. Responses - MSO Soils Course (Bradford Research Center - October 2024)

<b>Items</b>	<b>M(SD)</b>
How satisfied are you with the relevance of information to your needs?	3.45(0.81)
How satisfied are you with the presentation quality of the instructor?	3.40(0.80)
How satisfied are you with the subject matter knowledge of the instructor?	3.55(0.74)
How satisfied are you with the overall quality of the training workshop?	3.39(0.81)
<b>Items</b>	<b>Result</b>
Was the information easy to understand?	Yes – 100%
Did the training workshop meet your expectations	Yes – 100%
Would you recommend this training workshop to others?	Yes - 100%

Table 7c. Responses - Soil Morphology Course (University of Missouri - Spring 2024)

<b>Items</b>	<b>M(SD)</b>
How satisfied are you with the presentation quality of the instructor?	3.38(0.61)
How satisfied are you with the subject matter knowledge of the instructor?	3.62(0.47)
<b>Items</b>	<b>Result</b>
Was the information easy to understand?	Yes – 92%
Did the training workshop meet your expectations	Yes – 93.7%
Would you recommend this training workshop to others?	Yes – 93.7%

Table 7d. Responses from University of Missouri Soil Genesis Course (Online - Fall 2024)

<b>Items</b>	<b>M(SD)</b>
How satisfied are you with the presentation quality of the videos?	3.14(0.60)
How satisfied are you with the subject matter knowledge of the videos?	3.58(0.49)
<b>Items</b>	<b>Result</b>
Was the information easy to understand?	Yes – 100%
Was the information succinct?	Yes – 100%

#### 4.3.2 Qualitative Feedback

Participants at the different workshops were also asked qualitative questions about their experiences with these workshops. The questions that were asked varied from workshop to workshop, but as seen above (Tables 7a-d) the general reception was positive for these courses and workshops. Participants were also asked what they liked most, what they liked least, and what they would change about the workshops/courses. At Shealy Farm, participants responded that they found the hands-on soil pits, the new information on the topics, the quality of the instructor, and the experience with other soil evaluators to be the portions that they enjoyed the most. They thought that this course would be a good starting point for new soil evaluators. Participants thought that specific terms could be better defined or that the topics were too difficult while others thought the topics were too simple and didn't reflect the variability of real-life situations for soil evaluators. Some participants suggested that there needed to be more time for the discussion and profile descriptions and more focus on the rules and regulations of Missouri, while others suggested some content that should be added in future revisions.

Participants in the Morphology class in spring of 2024 found that they most liked the amount of detail and depth in the presentations, learning more about how septic

systems function, and the knowledge of the instructor. They disliked the length of the presentations, thought the lessons moved too quickly, and thought some of the discussions were dense. They suggested more videos and visuals, more examples, and breaking up the lessons into smaller sections.

At Bradford Research Center the participants liked most the discussions that were had amongst the audience, the practicality of the information, the quality of the graphics and visuals, and the field portion. They disliked the environment for making it difficult to hear. They suggested connecting the information more closely with the state forms.

#### 4.4 Change in Interest

The workshops offered in Spring of 2024 to the students of the University of Missouri were the only cohort to receive all 6 courses. The students were asked (no, maybe, yes) if they had any interest in pursuing a career or work as a soil evaluator. Prior to the workshops, one student (6.25%) expressed 'yes' interest in pursuing work as a soil evaluator and one student (6.25%) reported 'maybe'. After participation in the workshop, four students were 'maybe' interested (25%) in the profession and 2 students (12.5%) reported 'yes' they were interested.

## **5 DISCUSSION**

Overall, quantitative findings from this project indicated that there was a strong degree of correspondence between the workshops and the intended learning outcomes. This held true across all the cohorts and workshop types, although the effect size of these outcomes differed greatly depending on the cohort and workshop. Participants reported

significant changes in their knowledge about the topics deemed necessary for beginning a career as a soil evaluator.

While there were some university students (37.5% in Spring of 2024) that expressed interest in the profession of soil evaluator, it is still unanswered if materials like this will increase the number of practicing soil evaluators. This is especially true if these courses are not brought to students in the classroom but must be sought out by the students. Beyond the knowledge requirement, there are further hurdles of receiving enough college credits, passing certification, attaining the materials for the job, opening up a business, gaining more experience, and finding enough clientele to make the business profitable or sustainable. These are complaints that are often expressed among new soil evaluators in Missouri and provide further considerations for developing this profession.

This study shows that providing focused workshops on the topics necessary for soil evaluators can introduce and increase participants knowledge of the profession. Breaking up the knowledge into accessible workshops is important for engaging with those interested in the field and for showing the wide range of topics that are necessary for a soil evaluator to understand. These materials will be provided online, through the National Onsite Wastewater Recycling Association as well as through yearly workshops to help increase the accessibility of this information. Overall, regardless of participating in-person or through online resources, results indicate that this curriculum provides positive growth in participants knowledge about the soil evaluator profession.

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## **CHAPTER IV: SUMMARY CONCLUSIONS**

Over this project, I worked to understand and communicate the basics of the soil evaluator profession to new and experienced participants. While this profession is highly niche, it is central in the protection of our environmental and human health. Maintaining a large enough population of soil evaluators to manage the future construction and growth of homes and businesses in rural areas in Missouri may be a challenge. It is my hope that materials such as these will be used to provide the training for future soil evaluators in Missouri. It is important to understand that materials such as these are often supplementary to experiences that students and those interested in the profession receive from professors and other professionals in the field voluntarily taking on a mentor role for new soil evaluators. These relationships may be fragile or non-existent in some parts of the state, with soil evaluators not wishing to train direct competition for business. Further investigations may be needed to evaluate the future of the soil evaluator position at a state level.

While materials such as those produced here may increase participant interest in this field, it is difficult to say whether this interest will translate into professionals. While there are signs that exposure to a field can increase future engagement in science fields (Wang, 2013; Sithole et al., 2017; Mohd Shahali et al., 2019), the fact that the majority of professionals in this career are small business owners, often of single member LLC, means that there is a significant risk in opening up a business without knowledge of success or the presence of a strong safety net. New soil evaluators in Missouri and other states may struggle with finding clientele and earning enough simply through soil evaluations to make the profession sustainable without secondary sources of income. This lack of stability may leave the position in precarious standings as fewer professionals move into the field.

This study has shown that providing materials and workshops can affect the knowledge of both unexperienced and highly experienced participants. The question still remains as to

whether this knowledge will lead to any long-lasting changes in the practice of the participants. Studies from other fields have shown mixed outcomes as to the effect of knowledge increase on actual practice. (Davis et al., 1999; Grol & Grimshaw, 2003; Parrish & Rubin, 2011). The onsite wastewater industry is unique in many facets as it is a highly private industry with little oversight in Missouri. Soil evaluators, installers, and engineers often work and provide recommendations and installations without second opinions. Further studies could examine the effects of continuing education courses in changing the work practices of these highly independent professions.

Although there was shown to be significant changes among all participants in the workshops the size of the effect change is seen to be closely tied to the type of participant in the workshop and their knowledge base. We saw the highest mean response of knowledge pre- and post- self-assessments among the wastewater professionals in the field that participated in the Shealy Farm and Bradford Farm MSO workshops. The lowest knowledge base was specifically among the students at the University of Missouri who participated in the courses on Septic Systems, Site Evaluation, and Final Forms. This difference in base knowledge and effect size tracks with the idea that professionals who have years of experience with the requirements of a soil evaluation will undergo less of a drastic knowledge change than students who are unfamiliar with the profession or OWTS in general. These three courses also saw the greatest effect size difference, measuring huge in the Cohen's *d* test. These three workshops deal largely with the specifics of the profession and it would not be expected that university students would have a great deal of prior knowledge about OWTS.

This project, the presentations and videos, has undergone revision over the timespan of the surveys. There have been additions and modifications as the authors have received feedback from participants, professors, and government agents. It is likely that there will be future modifications to these materials over time as new feedback comes in and as these workshops are used for different contexts and with different populations. These modifications have not affected

the central learning goals of these workshops, but are often additions to help further explain or clarify topics, such as adding new photos or videos, additional visual aids, such as graphs or diagrams, more context to a specific topic, eg. shrink-swell potential, or additional resources (books, articles, or white papers).

This study shows that providing focused workshops on the topics necessary for soil evaluators can introduce and increase participants knowledge of the profession. Breaking up the knowledge into accessible workshops is important for engaging with those interested in the field and showing the wide range of topics that are necessary for a soil evaluator. Providing resources online for participants is an important step forward, as keeping this information locked behind workshops that may not be geographically accessible to interested parties allows them to access these introductory materials. Taken together, these workshops and courses intend to offer opportunities for new soil evaluators to feel comfortable entering into a field that helps serve the and protect the environmental and human health of Missouri.

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## APPENDIX 1.1: SURVEYS

### 1.1.1 Initial Survey

#### Soil Evaluators Questionnaire

The goal of this questionnaire is to help in the development of an in-person training course for new soil evaluators. Your answers will inform what aspects this course should focus on. Thank you for your time and we appreciate the help. Feel free to reach out to me Joey Meinert (joemeinert@gmail.com) or Tammy Trantham (contact@mosmallflows.org) if you have any questions or would like to be of further assistance.

1. How much time do you typically spend on the job site?

*Check all that apply.*

- less than 1 hour
- 1 to 2 hours
- 2 + hours

2. What are some common issues you run into on the job site?

*Check all that apply.*

- Property lines/corners not marked
- Small lot sizes/little space for the drainage field
- Geological features (caves, spring, sinkhole, floodplain)
- Difficulties with the homeowner
- No plat or site description
- Too much human disturbance
- No homeowner/contractor on site
- Soil or Site is unsuitable to any system
- Utilities not marked or unknown

3. How did you learn the necessary skills for this job?

*Check all that apply.*

- Mentor/on the job
- Self-Taught
- Workshops/courses
- University soils courses
- Other: \_\_\_\_\_

4. What part of the onsite soil evaluation did you struggle with at the beginning of your career?

*Check all that apply.*

- Field Layout (location, spacing)
- Soil Profile Description (horizons, texturing etc.)
- Setbacks and Site Evaluation (Building locations, property lines)
- Suitability (Correct system for the space)
- Finding the correct loading rate
- Identifying restrictive horizons (fragipan, clay pan, bedrock)
- Estimating clay content
- Other: \_\_\_\_\_

5. As a beginner, what did you wish you knew more about?

*Check all that apply.*

- System layout, function and design (trench depths, field size differences)
- Geology of Missouri (Landscape formations, rock types, soil deposition)
- Hydrology and how water moves through the soil
- How to texture and classify soils (4a vs 4b, redox colors)
- How to properly use the tools of the trade (compass, clinometer)
- How to set up/run a small business
- How to use available map and soil data to inform onsite decisions
- Other: \_\_\_\_\_

6. What resources and or experiences have helped you become more certain about your abilities?

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7. What are the steps you take when going through a soil evaluation?

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8. What tools do you find you use the most?

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9. What is a skill you currently would like to have more practice or instruction with?

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10. What is an unexpected skill that you developed as you worked more often in this field?

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11. Have the continuing education credits helped you feel more confident in your abilities?

*Mark only one oval.*

- No  
 Yes  
 Have not taken any

12. How has your business changed since its inception?

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13. Any last comments or questions?

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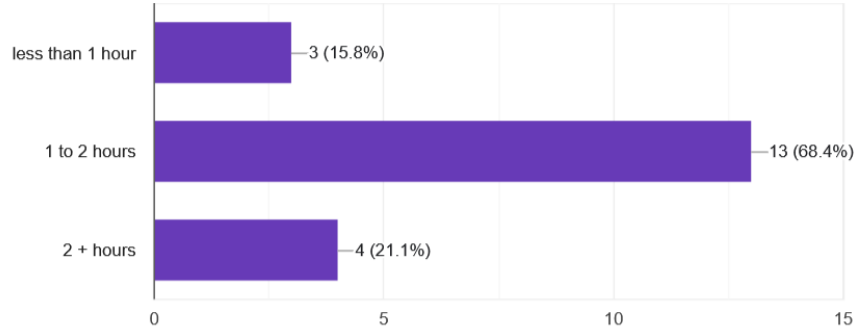
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## 1.1.2 Initial Survey Results

How much time do you typically spend on the job site?

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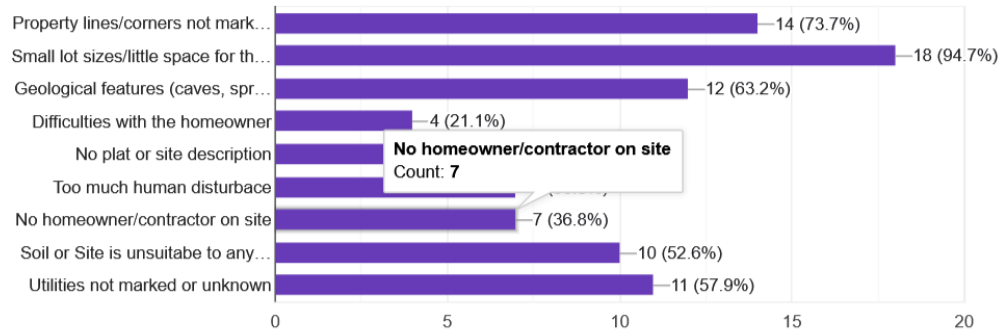
19 responses



What are some common issues you run into on the job site?

 Copy chart

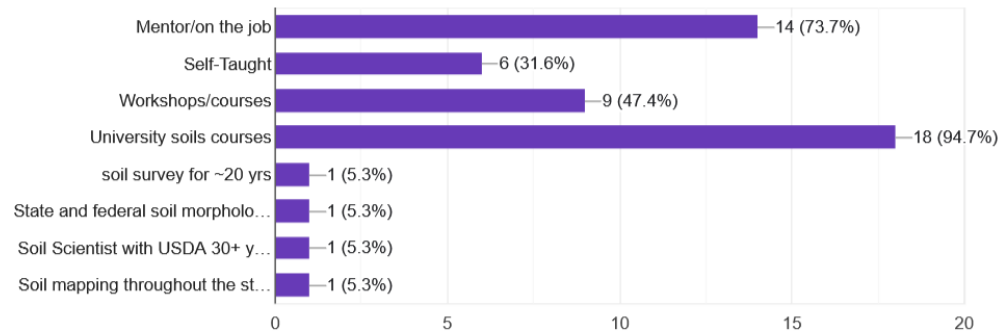
19 responses



How did you learn the necessary skills for this job?

 Copy chart

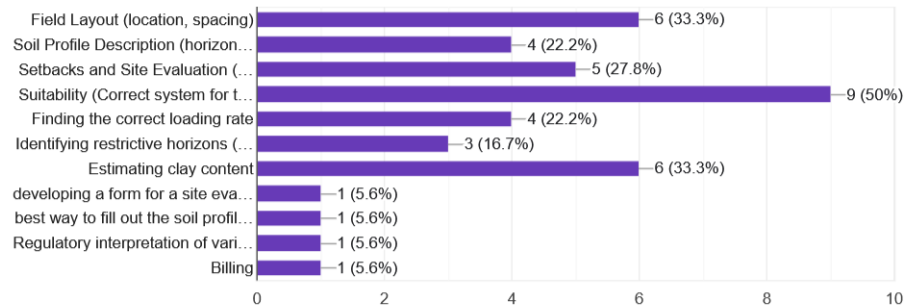
19 responses



What part of the onsite soil evaluation did you struggle with at the beginning of your career?

[Copy chart](#)

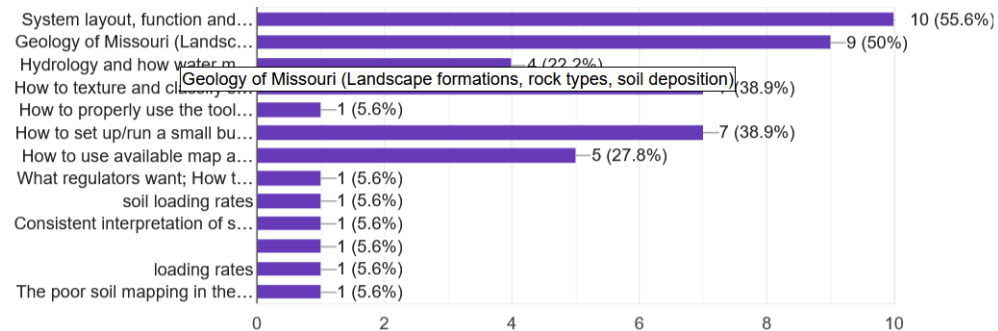
18 responses



As a beginner, what did you wish you knew more about?

[Copy chart](#)

18 responses



What resources and or experiences have helped you become more certain about your abilities?

- On line plat maps and soils.
- Recording data with other evaluators, hands on learning
- geostrat, soil web, soil explorer
- started as an installer
- Working with contractors and regulatory staff.
- Workshops/training opportunities with other soil evaluators. Career experience and continued soil evaluations.
- Installing my own systems
- Working with other experienced soil evaluators
- soil mapping
- Learning the installer side of the business. I took the basic and advanced installer courses until a person had to maintain continuing education credits to do so
- USDA NRSC on-line maps

- I took the basic installers class, took more university courses
- MSO Soil Classes
- Experience across the state.
- Experiences, Web Soil Survey and MSO Classes
- mapping soils with USDA soil scientists
- Networking with other professionals and MSO sponsored classes
- experience and study of likely soils from mapping

What are the steps you take when going through a soil evaluation?

- Ask as to what the owner/contractor expects to have as a system. Locate soil pit. Describe soil. Check UTM coordinates. Measure area evaluated. Locate utilities and existing system if possible. At office: download aerial photo; locate soil pit; locate area evaluated; locate utilities; locate existing system if applicable. Write soil description with suitabilities and limitations. E-mail report with address and notes. Print report. Mail paper copy with signature.
- GIS site research, coordinate excavation, site visit, profile soil pits, prepare soil report
- all of them, I use a check list
- dig holes, lots of them
- Proposed house site location; Property lines; landform/geologic info; setback distances from well, houses, surface waters, drainages; landform slope/shape; soil morphology analysis; evaluation area.
- Confirm property ownership/parcels via county GIS system. Email 'Agreement' to property owner/contractor of expectations, scope of services, and costs along with GIS parcel confirming the property is correct. Call Missouri One Call. Locate the property boundaries while on site, if possible. Locate existing utilities, wells, sewer, etc. Short and long term plans for the property (e.g., outbuildings). Determine proposed home location and property owner's preferred method of wastewater treatment (e.g., subsurface or lagoon). Estimate or measure setback distances to assure they will be met. Advance soil morphology excavation after the completing the above and any supplemental push tube samples, and describe soil profile. Collect GPS of soil profile location and any supplemental push tube samples. Collect photographs of soil profile and its location on the property, and surroundings. Measure final setback distances from soil profile location and estimate soil treatment/evaluation area for OWTS. Backfill soil test pit, mound, and compact. Complete electronic report and email to client.
- Initial gathering of info, scheduling, on-site visit, and finishing eval and mailing to users
- Select appropriate area for test pit, horizon depths, structure, texture, color, slope and site characteristics
- Interenet dig rite ticket, assessor's maps, google maps to get to site, work with homeowner or builder or installer to lay out the system, dig soil pits and describe to fill out a two page data collection form to use to fill out the state form, work with engineer to design pump systems, Make a google earth site map on the

computer. Fill out the form state form electronically, send the reports to the landowner, installer, builder, and county as needed. Send a billing to the customer for payment.

- choosing soil description locations, describing soils, collecting other data, producing reports
- Site layout/review, soil pit descriptions, setback distances, gps all needed points for site diagram
- Get Approval; Get maps; Pit dug by installer or me; record soil profiles; connect samples; at home classify sample, type report with maps.
- go to site- do evaluation- turn in report at site to installer or homeowner.
- Visit site, check soil on-site and in lab.
- Documentation from landowner on his information of the property and home. Layout the field area. Have backhoe pits dug outside of the area of the septic field. Describe each of the backhoe pits to determine the type of system and the size. Collect data on the septic fields environmental properties and all of the required setbacks to insure the field area meets them all. Draw up the site plan accurately to insure it is on the property and meets setbacks.
- Site review and locating all components, Mapping the area, page by page
- Background data collection online about the property, utility marker call, Soil morphology in the pits, mark out the suggested soil treatment area, complete report in office
- often look at the NRCS website to consider "likely" soils, print map of prop limits, try to be thorough on site with the soils probe and/or multiple pits

What tools do you find you use the most?

- Tools I use (all are used "the most"): color book, Abney level, tape measure, rock hammer, GPS receiver, water bottle
- Munsell color book, knife, field book for describing soils, laser transit
- inclinometer, compass, tape measure
- education, backhoe
- Soil probe for variability determination; rock hammer; clinometer; Munsell color charts; Tape measure; pencil and paper.
- Tape Measures, Munsell Color Book, Spade, Pruner, Shovel, Pick Hammer, GPS, Camera
- Knife, munsell, level, clipboard and tape
- Knife, gps, Munsell book
- backhoe, field book for soil descriptions, Munsell color book laser level, flags,
- GPS, clinometer
- GPS, GIS software, parcel data
- USDA NRCS on-line maps, Sampling tools; color book, Excel master report.
- rangefinder, compass
- Soil lab equipment.
- Compass. Clinometer. Color book. Tape measure. A tool for cleaning the face of the backhoe pit.
- Munsell Color Book, pickaxe tool, tape measure tools, flags

- color book, digging tools
- laser for shooting slope, measuring wheel, tools to cut brush for line-of-sight, backhoe for digging pits
- soils probe, Munsell color charts

What is a skill you currently would like to have more practice or instruction with?

- I feel confident in my abilities.
- Geology and soil genesis
- what determines a geologic sensitive area
- soil labs
- Consistent assigning of loading rates based on morphological data.
- Seasonal water table identification: relict/parent material soil colors vs active RMFs.
- Can't think of any
- Use of electronic software on a cell phone to locate assessor tract boundaries in the field for ownership and setbacks.
- determining clay content, also business skills
- Expediting reports and a uniform way to calculate application rates
- Soil layers.
- loading rates, current system types available and when each is appropriate
- Dealing with incompetent County Waste-water personnel...
- Septic system functioning. Soil properties and the effect on vegetation.
- Designs
- clay estimation and types of systems to fit the site
- clay estimation

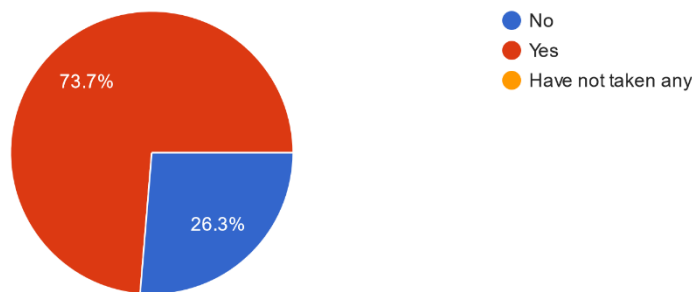
What is an unexpected skill that you developed as you worked more often in this field?

- Knowledge of septic systems.
- ability to problem solve and determine the best location for soil pits
- computers
- N/A
- Identification of discontinuities in glacial depositional environments.
- Learning from each job and trying to be more efficient
- How to incorporate geology, streams, sinkholes, fault lines and other resource information with the CARES site or Ag Site Assessment tool.
- business skills
- not sure, probably more the economics side of system options even though I don't see a lot of the bids
- I am a geotechnical engineer with 42 years of experience and a Navy Seabee equipment operator, being a soil evaluator fill in line with my work.
- Coping with different county officials making up their own rules..... Being physical careful on steep lots.
- Predictions of what will be needed.

- Ability to communicate and explain OWTS with homeowners, builders and realtors
- ability to look at entire landscapes for water movement and vegetation changes in relation to soils
- public relations with the property owner. More often than not, we are the first person on-site and we receive all the questions about treatment options etc. It's good to have a good knowledge of what systems may work to prepare the property owner.
- I am now much better at visually evaluating a site and finding possible areas of better soils, as well as "seeing" existing lateral lines based on the differences in the grass, etc.

Have the continuing education credits helped you feel more confident in your abilities?

Have the continuing education credits helped you feel more confident in your abilities?  
19 responses



How has your business changed since its inception?

- People have come to realize that soil evaluations are necessary whether or not they think the soil evaluation is needed.
- more cost to operate
- Significant reduction in the number of jobs due to increased soil evaluators available and their availability.
- Yes, number/demand of test requests has increased over time.
- Yes
- Added services aside from soil evaluations
- Some, I have been doing a lot more advanced system designs with the engineers.
- increased fees to make the business sustainable
- Definitely more business as relationships develop with installers
- Payment type, I now have a credit card reader.
- I have become more confident and knowledgeable
- Retired--20 years

- A greater amount of work for the public.
- Providing more services
- very little
- Used to work for a land developer/installer. Now I have my own consulting/design business.

Any last comments or questions?

- Those of us who worked in soil survey have learned skills that aid in determining where to dig a soil pit, and how landforms and soil interact. It is important to be able to think in 3 dimensions because soils have a vertical axis as well as horizontal axes. Young soil scientists have less opportunity to work in a way that ties soils and landforms together. The mosaic of soils is important to understand because one soil map unit transitions to another even though the difference is marked as a line. Understanding the soils as mapped in soil survey may have differences in the map unit is necessary to be able to properly evaluate a site and its soils to provide accurate suitability ratings and limitations.
- Hands on education have provided the best learning tools for improving skills in the field
- the education for soil evaluators should be increased and monitoring of soil evaluators soil logs (description)
- N/A
- Thank you for taking the time to help train the next generation of soil scientists. Some of us are getting old and going full speed but slowing down as we age.
- The greatest need for this profession is for county health departments to enforce the state regulations related to septic. There are so many unpermitted systems going in and many installers have given up their license as they cannot compete with the fly by night installers and feel they can also get penalized more by the state for having a license and installing a illegal system.
- I am always worried about getting stuck in the fields or ditches, not having room to turn around the trailer, or getting to the site and the hills are too steep.
- all soil evaluators should use pits and not auger holes
- County Regulators need to take mandatory soil classes to understand this arena.
- Definitions of soil scientist are codified in 701.040,19 CSR 20-3.060 61, and 20-3.080 (H).
- I believe we as a group of soils evaluators/soils scientist should work diligently to become more consistent in our reporting and even our recommendations. While we will always have variance in clay estimation, we should all be making the same or similar recommendations when we have similar profiles. Some assign 0.1 gpd/SF for any drip system recommendation, some more readily assign a 0.05gpd/SF loading rate for high clay content soils. Overall, we should work toward standards that increase consistency between evaluators. I believe there will be a real demand for the "new" soils evaluators in the next ten years and it is important to outline a path now to help properly prepare these individuals to effectively carry out soils descriptions and site evaluations.

## 1.2 Course/Workshop Surveys

### Soil Science for Onsite Soil Evaluators

September 15, 2023

Shealy Farm

#### End of Training Workshop Evaluation

This survey has 4 pages

The University of Missouri is working with Missouri Smallflows Organization to help soil scientists better understand what is expected of them when completing a site evaluation. The lessons presented today are intended for soil scientists to fill any possible knowledge gaps about Missouri geology, soil morphology, or soil landforms. Please take a moment to complete this survey. It will help us know how we can better meet the needs of soil morphologists in the future. It is expected that this material will be used for new soil scientists and as a review for practicing soil scientists. Much of this material is taught in university courses but every soil scientist has a different educational experience, and some may find that their education did not provide them with all of the knowledge and resources needed to work on their own immediately after getting their onsite license.

The information gained from this survey will be used by Joseph Meinert in his MS research in soils education. He can be reached at this email: [jm3zq@missouri.edu](mailto:jm3zq@missouri.edu).

Your participation in this research survey is voluntary. This survey is meant to solicit information on the effectiveness of educational materials prepared for presentation to Missouri licensed onsite soil evaluators and students preparing for licensing. Please kindly provide the information in a frank and truthful manner. The information so provided will be used only for the purposes of the survey and this research. Also, your identity will not be revealed in the output report of this survey without your prior consent. Remember, you may skip any question if you do not feel like answering it and can request to end the survey at any time.

If you want to talk privately about your rights or any issues related to your participation in this study, you may contact University of Missouri Research Participant Advocacy by calling +1 888 280 5002 (a free call) or emailing [MUResearchRPA@missouri.edu](mailto:MUResearchRPA@missouri.edu).

The primary investigator of this research is Kerry Clark, who can be reached at +1 660-351 4696 or at the email address: [clarkk@missouri.edu](mailto:clarkk@missouri.edu).

**Do you consent to participate in this survey? [ ] Yes [ ] No**

**Satisfaction**

Please circle the appropriate number for your level of response.

How satisfied are you with:	Not Satisfied	Somewhat Satisfied	Satisfied	Very Satisfied
The relevance of information to your needs?	1	2	3	4
Presentation quality of instructor(s)?	1	2	3	4
Subject matter knowledge of instructor(s)?	1	2	3	4
Training facilities?	1	2	3	4
The overall quality of the training workshop?	1	2	3	4

Was the information easy to understand?

1. Yes

2. No

What year did you finish your last college degree?

What was your major area of study in college and what level of degree do you have (BS, MS, PhD)?

What year did you get your soil morphologist license?

Have you always worked alone in site evaluation or did you apprentice with anyone?

Do you have other soil science experience? What type of experience and how many years?

**Knowledge Gained from Workshop:**

Please circle the appropriate number to indicate your level of knowledge about the following topics **before** and **after** completing the program. Please use the following key for rating:

- 1. Very Low = Don't know anything about this topic.
- 2. Low = Know very little about this topic
- 3. Moderate = Know about this topic but there are more things to learn
- 4. High = Have good knowledge but there are things to learn
- 5. Very High = Know almost everything about this topic

How do you rate your knowledge about:	BEFORE THIS WORKSHOP					AFTER THIS WORKSHOP				
	Very Low	Low	Mode rate	High	Very High	Very Low	Low	Mode rate	High	Very High
Landform areas and boundaries (i.e. Ozark plateau, glacial till plain)	1	2	3	4	5	1	2	3	4	5
Underlying geology in each region	1	2	3	4	5	1	2	3	4	5
Relationship of MO soils to this geology	1	2	3	4	5	1	2	3	4	5
Affect of glaciers on MO soil and landscapes	1	2	3	4	5	1	2	3	4	5
How each MLRA region formed and how that affects soil in that region	1	2	3	4	5	1	2	3	4	5
How and where high shrink-swell clays form.	1	2	3	4	5	1	2	3	4	5
Hillslope position effects on soils	1	2	3	4	5	1	2	3	4	5
How to calculate or measure slope	1	2	3	4	5	1	2	3	4	5
How knowledge of landform effects on soil can be used to select an onsite location	1	2	3	4	5	1	2	3	4	5
Effect of soil drainage on soil color and onsite systems	1	2	3	4	5	1	2	3	4	5
Water table identification	1	2	3	4	5	1	2	3	4	5

Structure effect on soil drainage	1	2	3	4	5	1	2	3	4	5
Texture effect on soil water availability	1	2	3	4	5	1	2	3	4	5
Correct use of soil horizon designations	1	2	3	4	5	1	2	3	4	5
Proper application rate for soil group	1	2	3	4	5	1	2	3	4	5

Soil Pit Exercise  
Workshop

Before the Workshop

After the

How do you rate your knowledge about:	Very Low	Low	Mode rate	High	Very High	Very Low	Low	Moderate	High	Very High
Determining soil horizons	1	2	3	4	5	1	2	3	4	5
Texturing by feel	1	2	3	4	5	1	2	3	4	5
Determining possible treatment system options	1	2	3	4	5	1	2	3	4	5
Filling out the state site evaluation form	1	2	3	4	5	1	2	3	4	5

Did the training workshop meet your expectation? 1. Yes 2. No

Any comments?

Would you recommend this training workshop to others? 1. Yes 2. No

If not, why:

What did you like the most about this training workshop?

What did you like the least about this training workshop?

How could this training be further improved? Or what material would you add or remove, especially for new soil scientists?

What advice do you have for new soil scientists?

What were your biggest concerns/issues when you first became a licensed site evaluator?

What are your current biggest concerns/issues that you have in your role as a licensed site evaluator?

What was your most impactful continuing education experience/topics?

Optional: Share your name/address/phone number, if you are willing to allow us to contact you for follow-up comments **(Optional)**.

Name: \_\_\_\_\_ Phone Number: \_\_\_\_\_

Address: \_\_\_\_\_

**Thank you for completing this evaluation.**

**We appreciate your input as we make every effort to improve our educational programs.**

## Soil Science for Onsite Soil Evaluators

January 22, 2024

### Course Survey 1 – Missouri Geology and Soils Across Landforms

This survey has 2 pages

The University of Missouri is working with Missouri Smallflows Organization to help soil scientists better understand what is expected of them when completing a site evaluation. The lessons presented today are intended for soil scientists to fill any possible knowledge gaps about Missouri geology, soil morphology, or soil landforms. Please take a moment to complete this survey. It will help us know how we can better meet the needs of soil morphologists in the future. It is expected that this material will be used for new soil scientists and as a review for practicing soil scientists. Much of this material is taught in university courses but every soil scientist has a different educational experience, and some may find that their education did not provide them with all of the knowledge and resources needed to work on their own immediately after getting their onsite license.

The information gained from this survey will be used by Joseph Meinert in his MS research in soils education. He can be reached at this email: [jm3zq@missouri.edu](mailto:jm3zq@missouri.edu).

Your participation in this research survey is voluntary. This survey is meant to solicit information on the effectiveness of educational materials prepared for presentation to Missouri licensed onsite soil evaluators and students preparing for licensing. Please kindly provide the information in a frank and truthful manner. The information so provided will be used only for the purposes of the survey and this research. Also, your identity will not be revealed in the output report of this survey without your prior consent. Remember, you may skip any question if you do not feel like answering it and can request to end the survey at any time.

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The primary investigator of this research is Kerry Clark, who can be reached at +1 660-351 4696 or at the email address: [clarkk@missouri.edu](mailto:clarkk@missouri.edu).

**Do you consent to participate in this survey? [ ] Yes [ ] No**

#### Satisfaction

Please circle the appropriate number for your level of response.

How satisfied are you with:	Not Satisfied	Somewhat Satisfied	Satisfied	Very Satisfied
Presentation quality of instructor(s)?	1	2	3	4
Subject matter knowledge of instructor(s)?	1	2	3	4

Was the information easy to understand?

1. Yes

2. No

**Knowledge Gained from Workshop:**

Please circle the appropriate number to indicate your level of knowledge about the following topics **before** and **after** completing the program. Please use the following key for rating:

- 1. Very Low = Don't know anything about this topic.
- 2. Low = Know very little about this topic
- 3. Moderate = Know about this topic but there are more things to learn
- 4. High = Have good knowledge but there are things to learn
- 5. Very High = Know almost everything about this topic

How do you rate your knowledge about:	BEFORE THIS WORKSHOP					AFTER THIS WORKSHOP				
	Very Low	Low	Moderate	High	Very High	Very Low	Low	Moderate	High	Very High
Landform areas and boundaries (i.e. Ozark plateau, glacial till plain)	1	2	3	4	5	1	2	3	4	5
Underlying geology in each region	1	2	3	4	5	1	2	3	4	5
Relationship of MO soils to this geology	1	2	3	4	5	1	2	3	4	5
Effect of glaciers on MO soil and landscapes	1	2	3	4	5	1	2	3	4	5
How each MLRA region formed and how that affects the soil in that region	1	2	3	4	5	1	2	3	4	5
The qualities of the different types of bedrock	1	2	3	4	5	1	2	3	4	5
Under what conditions high shrink-swell clays form.	1	2	3	4	5	1	2	3	4	5
Hillslope position effects on soils	1	2	3	4	5	1	2	3	4	5

The effect of aspect on soils	1	2	3	4	5	1	2	3	4	5
The types of restrictive horizons (fragipans, claypans, gravel)	1	2	3	4	5	1	2	3	4	5
How soils are deposited by rivers and streams	1	2	3	4	5	1	2	3	4	5
How differing landforms can affect siting a septic system	1	2	3	4	5	1	2	3	4	5

## Soil Science for Onsite Soil Evaluators

February 5, 2024

### Course Survey 2 – Soil Profile Description and Types of Septic Systems

This survey has 2 pages

The University of Missouri is working with Missouri Smallflows Organization to help soil scientists better understand what is expected of them when completing a site evaluation. The lessons presented today are intended for soil scientists to fill any possible knowledge gaps about Missouri geology, soil morphology, or soil landforms. Please take a moment to complete this survey. It will help us know how we can better meet the needs of soil morphologists in the future. It is expected that this material will be used for new soil scientists and as a review for practicing soil scientists. Much of this material is taught in university courses but every soil scientist has a different educational experience, and some may find that their education did not provide them with all of the knowledge and resources needed to work on their own immediately after getting their onsite license.

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The primary investigator of this research is Kerry Clark, who can be reached at +1 660-351 4696 or at the email address: [clarkk@missouri.edu](mailto:clarkk@missouri.edu).

**Do you consent to participate in this survey? [ ] Yes [ ] No**

#### **Satisfaction**

Please circle the appropriate number for your level of response.

How satisfied are you with:	Not Satisfied	Somewhat Satisfied	Satisfied	Very Satisfied
Presentation quality of instructor(s)?	1	2	3	4
Subject matter knowledge of instructor(s)?	1	2	3	4

Was the information easy to understand?

1. Yes

2. No

**Knowledge Gained from Workshop:**

Please circle the appropriate number to indicate your level of knowledge about the following topics **before** and **after** completing the program. Please use the following key for rating:

- 1. Very Low = Don't know anything about this topic.
- 2. Low = Know very little about this topic
- 3. Moderate = Know about this topic but there are more things to learn
- 4. High = Have good knowledge but there are things to learn
- 5. Very High = Know almost everything about this topic

How do you rate your knowledge about:	BEFORE THIS WORKSHOP					AFTER THIS WORKSHOP				
	Very Low	Low	Moderate	High	Very High	Very Low	Low	Moderate	High	Very High
Identification of soil horizons	1	2	3	4	5	1	2	3	4	5
Effect of soil drainage on soil color and onsite systems	1	2	3	4	5	1	2	3	4	5
Water table identification	1	2	3	4	5	1	2	3	4	5
How to estimate coarse fragments in soil	1	2	3	4	5	1	2	3	4	5
Structure effect on soil drainage	1	2	3	4	5	1	2	3	4	5
Texture effect on soil water availability	1	2	3	4	5	1	2	3	4	5
Where to find information on shrink-swell of soil	1	2	3	4	5	1	2	3	4	5
Correct use of soil horizon designations	1	2	3	4	5	1	2	3	4	5
Types of septic systems	1	2	3	4	5	1	2	3	4	5

How to size a standard system	1	2	3	4	5	1	2	3	4	5
How to size an LPP or Drip system	1	2	3	4	5	1	2	3	4	5
The suitable soil conditions for each septic system	1	2	3	4	5	1	2	3	4	5
Soil or site conditions that necessitate a specific system.	1	2	3	4	5	1	2	3	4	5

What is your current soils education experience?

0-1 Courses

2-3 Courses

3-5 Courses

5+ Courses

## Soil Science for Onsite Soil Evaluators

February 12, 2024

### Course Survey 3 – Site Evaluation & the Final Report

This survey has 3 pages

The University of Missouri is working with Missouri Smallflows Organization to help soil scientists better understand what is expected of them when completing a site evaluation. The lessons presented today are intended for soil scientists to fill any possible knowledge gaps about Missouri geology, soil morphology, or soil landforms. Please take a moment to complete this survey. It will help us know how we can better meet the needs of soil morphologists in the future. It is expected that this material will be used for new soil scientists and as a review for practicing soil scientists. Much of this material is taught in university courses but every soil scientist has a different educational experience, and some may find that their education did not provide them with all of the knowledge and resources needed to work on their own immediately after getting their onsite license.

The information gained from this survey will be used by Joseph Meinert in his MS research in soils education. He can be reached at this email: [jm3zq@missouri.edu](mailto:jm3zq@missouri.edu).

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The primary investigator of this research is Kerry Clark, who can be reached at +1 660-351 4696 or at the email address: [clarkk@missouri.edu](mailto:clarkk@missouri.edu).

**Do you consent to participate in this survey? [ ] Yes [ ] No**

#### **Satisfaction**

Please circle the appropriate number for your level of response.

How satisfied are you with:	Not Satisfied	Somewhat Satisfied	Satisfied	Very Satisfied
Presentation quality of instructor(s)?	1	2	3	4
Subject matter knowledge of instructor(s)?	1	2	3	4

Was the information easy to understand?

1. Yes

2. No

**Knowledge Gained from Workshop:**

Please circle the appropriate number to indicate your level of knowledge about the following topics **before** and **after** completing the program. Please use the following key for rating:

- 1. Very Low = Don't know anything about this topic.
- 2. Low = Know very little about this topic
- 3. Moderate = Know about this topic but there are more things to learn
- 4. High = Have good knowledge but there are things to learn
- 5. Very High = Know almost everything about this topic

How do you rate your knowledge about:	BEFORE THIS WORKSHOP					AFTER THIS WORKSHOP				
	Very Low	Low	Moderate	High	Very High	Very Low	Low	Moderate	High	Very High
What is needed prior to your arrival onsite	1	2	3	4	5	1	2	3	4	5
What qualifies as a suitable area	1	2	3	4	5	1	2	3	4	5
Natural and manmade conditions that restrict a field location	1	2	3	4	5	1	2	3	4	5
The setback distances necessary for a tank and a field	1	2	3	4	5	1	2	3	4	5
How to calculate or measure slope	1	2	3	4	5	1	2	3	4	5
How to site a septic tank and a septic field	1	2	3	4	5	1	2	3	4	5
The necessary number and locations of soil pits	1	2	3	4	5	1	2	3	4	5
How to draw a site diagram	1	2	3	4	5	1	2	3	4	5
How to choose a proper loading rate	1	2	3	4	5	1	2	3	4	5
How to assess whole site suitability	1	2	3	4	5	1	2	3	4	5
Mitigations of unsuitable conditions	1	2	3	4	5	1	2	3	4	5

What conditions pose high environmental risks	1	2	3	4	5	1	2	3	4	5
Who to contact with questions/concerns?	1	2	3	4	5	1	2	3	4	5

Did these lessons meet your expectation? 1. Yes 2. No

Any comments?

Would you recommend these lessons to others? 1. Yes 2. No

If not, why:

What is your current soils education experience?

0-1 Courses

2-3 Courses

3-5 Courses

5+ Courses

What did you like the most about these lessons?

What did you like the least about these lessons?

How could these lessons be further improved? Or what material would you add or remove, especially for new soil scientists?

Do you have any interest in pursuing a Missouri Soil Evaluator License?

Optional: Share your name/address/phone number, if you are willing to allow us to contact you for follow-up comments **(Optional)**.

Name: \_\_\_\_\_ Phone Number: \_\_\_\_\_

Address: \_\_\_\_\_

**Thank you for completing this evaluation.**

**We appreciate your input as we make every effort to improve our educational programs.**

## Soil Science for Onsite Soil Evaluators

August 19, 2024

### Course Survey 1 – Missouri Geology

This survey has 4 pages

The University of Missouri is working with Missouri Smallflows Organization to help soil scientists better understand what is expected of them when completing a site evaluation. The lessons presented today are intended for soil scientists to fill any possible knowledge gaps about Missouri geology, soil morphology, or soil landforms. Please take a moment to complete this survey. It will help us know how we can better meet the needs of soil morphologists in the future. It is expected that this material will be used for new soil scientists and as a review for practicing soil scientists. Much of this material is taught in university courses but every soil scientist has a different educational experience, and some may find that their education did not provide them with all of the knowledge and resources needed to work on their own immediately after getting their onsite license.

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The primary investigator of this research is Kerry Clark, who can be reached at +1 660-351 4696 or at the email address: [clarkk@missouri.edu](mailto:clarkk@missouri.edu).

**Do you consent to participate in this survey? [ ] Yes [ ] No**

**Knowledge Gained from Workshop:**

Please circle the appropriate number to indicate your level of knowledge about the following topics **before** and **after** completing the program. Please use the following key for rating:

- 1. Very Low = Don't know anything about this topic.
- 2. Low = Know very little about this topic
- 3. Moderate = Know about this topic but there are more things to learn
- 4. High = Have good knowledge but there are things to learn
- 5. Very High = Know almost everything about this topic

	How do you rate your knowledge about:	BEFORE THIS VIDEO					AFTER THIS VIDEO				
		Very Low	Low	Mod erate	High	Very High	Very Low	Low	Mode rate	High	Very High
Prior Knowledge	Landform areas and boundaries (i.e. Ozark plateau, glacial till plain)	1	2	3	4	5	1	2	3	4	5
	Underlying geology in each region	1	2	3	4	5	1	2	3	4	5
	Relationship of MO soils to this geology	1	2	3	4	5	1	2	3	4	5
	Effect of glaciers on MO soil and landscapes	1	2	3	4	5	1	2	3	4	5
	How each MLRA region formed and how that affects the soil in that region	1	2	3	4	5	1	2	3	4	5
	The qualities of the different types of bedrock	1	2	3	4	5	1	2	3	4	5
	Under what conditions high shrink-swell clays form.	1	2	3	4	5	1	2	3	4	5
Video 1 - Introduction	The main geologic regions of Missouri	1	2	3	4	5	1	2	3	4	5
	Different soil orders present in Missouri	1	2	3	4	5	1	2	3	4	5

	Conditions that change soil orders	1	2	3	4	5	1	2	3	4	5
	Difference between high shrink swell clays and low shrink swell clays	1	2	3	4	5	1	2	3	4	5
Video 2 - Northern MO	How glaciers have affected the soils of Northern Missouri	1	2	3	4	5	1	2	3	4	5
	The extent of glacial advance in Missouri	1	2	3	4	5	1	2	3	4	5
	Landforms of Northern Missouri	1	2	3	4	5	1	2	3	4	5
	Characteristics of loess	1	2	3	4	5	1	2	3	4	5
	Effects of clay on water movement.	1	2	3	4	5	1	2	3	4	5
Video 3 – Ozark Plateau & St. Francois Mountains	The bedrock characteristics of the St. Francois Mountains	1	2	3	4	5	1	2	3	4	5
	The soil characteristics of the St. Francois Mountains	1	2	3	4	5	1	2	3	4	5
	Soil concerns for St. Francois Mountains	1	2	3	4	5	1	2	3	4	5
	Types & characteristics of the bedrock in the Ozark Plateau	1	2	3	4	5	1	2	3	4	5
	Soil characteristics of the Ozark Plateau	1	2	3	4	5	1	2	3	4	5
	Identification of rocks of Southern Missouri	1	2	3	4	5	1	2	3	4	5
	Characteristics of Karst features	1	2	3	4	5	1	2	3	4	5
	Soil concerns for the Ozark Plateau	1	2	3	4	5	1	2	3	4	5

Video 4 – Osage Plains	Geographic origins of the Osage Plains	1	2	3	4	5	1	2	3	4	5
	Types of landforms of the Osage Plains	1	2	3	4	5	1	2	3	4	5
	Characteristics of shale	1	2	3	4	5	1	2	3	4	5
	Soil characteristics of the Osage Plains	1	2	3	4	5	1	2	3	4	5
	Soil concerns in the Osage Plains	1	2	3	4	5	1	2	3	4	5
Video 5 – Springfield Plateau	Geographic origins of the Springfield Plateau	1	2	3	4	5	1	2	3	4	5
	Types of landforms of the Springfield Plateau	1	2	3	4	5	1	2	3	4	5
	Karst features of the Springfield Plateau	1	2	3	4	5	1	2	3	4	5
	Soil Characteristics of the Springfield Plateau	1	2	3	4	5	1	2	3	4	5
	Soil Concerns for the Springfield Plateau	1	2	3	4	5	1	2	3	4	5
Video 6 - Rivers	Manmade effects on the Missouri River	1	2	3	4	5	1	2	3	4	5
	Geographic origins of Mississippi River	1	2	3	4	5	1	2	3	4	5
	Soil Characteristics of Floodplains	1	2	3	4	5	1	2	3	4	5
	Soil Concerns of Floodplains	1	2	3	4	5	1	2	3	4	5



## **Soil Science for Onsite Soil Evaluators**

**October 11, 2024**

**Bradford Farm**

### **End of Training Workshop Evaluation**

**This survey has 3 pages**

The University of Missouri is working with Missouri Smallflows Organization to help soil scientists better understand what is expected of them when completing a site evaluation. The lessons presented today are intended for soil scientists to fill any possible knowledge gaps about Missouri geology, soil morphology, or soil landforms. Please take a moment to complete this survey. It will help us know how we can better meet the needs of soil morphologists in the future. It is expected that this material will be used for new soil scientists and as a review for practicing soil scientists. Much of this material is taught in university courses but every soil scientist has a different educational experience, and some may find that their education did not provide them with all of the knowledge and resources needed to work on their own immediately after getting their onsite license.

The information gained from this survey will be used by Joseph Meinert in his MS research in soils education. He can be reached at this email: [jm3zq@missouri.edu](mailto:jm3zq@missouri.edu).

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The primary investigator of this research is Kerry Clark, who can be reached at +1 660-351 4696 or at the email address: [clarkk@missouri.edu](mailto:clarkk@missouri.edu).

**Do you consent to participate in this survey? [ ] Yes [ ] No**

**Satisfaction**

Please circle the appropriate number for your level of response.

<b>How satisfied are you with:</b>	<b>Not Satisfied</b>	<b>Somewhat Satisfied</b>	<b>Satisfied</b>	<b>Very Satisfied</b>
The relevance of information to your needs?	1	2	3	4
Presentation quality of instructor(s)?	1	2	3	4
Subject matter knowledge of instructor(s)?	1	2	3	4
Training facilities?	1	2	3	4
The overall quality of the training workshop?	1	2	3	4

Was the information easy to understand?

1. Yes

2. No

What year did you finish your last college degree?

What was your major area of study in college and what level of degree do you have (BS, MS, PhD)?

What year did you get your soil morphologist license?

Have you always worked alone in site evaluation or did you apprentice with anyone?

Do you have other soil science experience? What type of experience and how many years?

**Knowledge Gained from Workshop:**

Please circle the appropriate number to indicate your level of knowledge about the following topics **before** and **after** completing the program. Please use the following key for rating:

- 1. Very Low = Don't know anything about this topic.
- 2. Low = Know very little about this topic
- 3. Moderate = Know about this topic but there are more things to learn
- 4. High = Have good knowledge but there are things to learn
- 5. Very High = Know almost everything about this topic

How do you rate your knowledge about:	BEFORE THIS WORKSHOP					AFTER THIS WORKSHOP				
	Very Low	Low	Moderate	High	Very High	Very Low	Low	Moderate	High	Very High
How to characterize a hillslope position	1	2	3	4	5	1	2	3	4	5
How to classify slope shape	1	2	3	4	5	1	2	3	4	5
Hillslope positions effects on soils	1	2	3	4	5	1	2	3	4	5
Protected vs exposed aspects	1	2	3	4	5	1	2	3	4	5
The effect of aspect on soils	1	2	3	4	5	1	2	3	4	5
The types of restrictive horizons (fragipans, claypans, gravel)	1	2	3	4	5	1	2	3	4	5
How to identify a fragipan	1	2	3	4	5	1	2	3	4	5
How to identify a claypan	1	2	3	4	5	1	2	3	4	5
How soils are deposited by rivers and streams	1	2	3	4	5	1	2	3	4	5
The effect of gravel and sand on wastewater	1	2	3	4	5	1	2	3	4	5

How differing landforms can affect siting a septic system	1	2	3	4	5	1	2	3	4	5
---	---	---	---	---	---	---	---	---	---	---

Did the training workshop meet your expectation?    1. Yes                    2. No

Any comments?

Would you recommend this training workshop to others?    1. Yes                    2. No

If not, why:

What did you like the most about this training workshop?

What did you like the least about this training workshop?

How could this training be further improved? Or what material would you add or remove, especially for new soil scientists?

What advice do you have for new soil scientists?

What were your biggest concerns/issues when you first became a licensed site evaluator?

What are your current biggest concerns/issues that you have in your role as a licensed site evaluator?

What was your most impactful continuing education experience/topics?

Optional: Share your name/address/phone number, if you are willing to allow us to contact you for follow-up comments (**Optional**).

Name: \_\_\_\_\_ Phone Number: \_\_\_\_\_

Address: \_\_\_\_\_

**Thank you for completing this evaluation.**

**We appreciate your input as we make every effort to improve our educational programs.**

## APPENDIX 1.2 Full Evaluation of Responses

TABLE 2 Self-assessed knowledge of skills/concepts related to the topics of the Soils Across Landforms Workshop. Surveys were administered to professionals (soil evaluators, installers, engineers) (n=18) in October 11 of 2024. Mean response is described on a 5-point Likert scale from very low (1) to very high (5) knowledge rating. Responses were compared using Wilcoxon Signed Ranks Test.

Question/Skill	Pre		Post		p-Value
	Mean	Std. Dev	Mean	Std. Dev.	
How to characterize a hillslope position	3.61	1.195	4.22	0.732	.008
How to classify slope shape	3.44	1.199	4.17	0.707	.010
Hillslope positions effects on soils	3.44	1.097	4.11	0.758	.005
What are protected vs exposed aspects	2.89	1.278	4.17	0.618	.002
The effect of aspect of soils	3.22	1.353	4.17	0.707	.002
The types of restrictive layers (fragipans, claypans, gravels)	3.33	1.138	4.11	0.832	.002
How to identify a fragipan	2.89	1.079	3.94	0.873	<.001
How to identify a claypan	3.33	1.188	4.11	0.832	.002
How soils are deposited by rivers and streams	3.61	1.092	4.17	0.707	.004
The effect of gravel and sand on wastewater	3.56	0.984	4.06	0.725	.003
How differing landforms can affect siting a septic tank	3.72	0.958	4.22	0.732	.003

TABLE 2 Self-assessed knowledge of skills/concepts related to the topics of the workshop. Surveys were administered to professionals (soil evaluators, installers, engineers) (n=23) in September 15 of 2023. Mean response is described on a 5-point Likert scale from very low (1) to very high (5) knowledge rating. Responses were compared using Wilcoxon Signed Ranks Test.

	Question/Skill	Pre		Post		p-Value
		Mean	SD	Mean	SD	
Geology	Landform areas and boundaries (i.e. Ozark plateau, glacial till plain)	3.27	1.077	3.86	0.834	.005
	Underlying geology in each region	2.86	1.037	3.45	0.912	.005
	Relationship of MO soils to this geology	3.00	0.976	3.59	0.908	.006
	Effect of glaciers on MO soil and landscapes	2.91	1.192	3.73	0.883	.004

	How each MLRA region formed and how that affects soil in that region	2.74	1.096	3.57	0.896	.002
	How and where high shrink-swell clays form.	3.09	1.109	3.77	0.922	.002
S.A.L.	Hillslope position effects on soils	3.59	0.908	4.09	0.684	.008
	How to calculate or measure slope	4.18	0.907	4.50	0.740	.020
	How knowledge of landform effects on soil can be used to select an onsite location	3.77	0.922	4.18	0.795	.007
Soil Profile Description	Effect of soil drainage on soil color and onsite systems	3.68	1.287	4.23	0.922	.006
	Water table identification	3.50	1.225	4.00	0.976	.016
	Structure effect on soil drainage	3.90	0.995	4.24	0.831	.038
	Texture effect on soil water availability	3.82	1.053	4.09	1.019	.034
	Correct use of soil horizon designations	3.50	1.225	4.05	0.899	.005
	Proper application rate for soil group	3.41	1.054	3.77	1.020	.011
	Determining soil horizons	3.67	1.155	4.24	0.831	.010
	Texturing by feel	3.62	1.071	4.14	0.793	.026
	Determining possible treatment system options	3.67	0.966	4.19	0.873	.005
	Filling out the state site evaluation form	3.35	1.348	3.75	1.118	.023

(S.A.L.) = Soil Across Landforms

TABLE 4a Self-assessed knowledge of skills/concepts related to the topics of the workshop. Surveys were administered to university students (n=21) in January 29 of 2024. Mean response is described on a 5-point Likert scale from very low (1) to very high (5) knowledge rating. Responses were compared using Wilcoxon Signed Ranks Test

	Question/Skill	<i>Pre</i>		<i>Post</i>		p-Value
		Mean	SD	Mean	SD	
Geology	Landform areas and boundaries (i.e. Ozark plateau, glacial till plain)	2.43	1.165	3.48	0.680	<.001
	Underlying geology in each region	2.38	1.161	3.57	0.811	<.001
	Relationship of MO soils to this geology	2.29	1.231	3.43	0.811	<.001
	Effect of glaciers on MO soil and landscapes	2.81	1.167	3.67	0.796	<.001
	How each MLRA region formed and how that affects the soil in that region	1.81	0.814	3.00	0.775	<.001
	The qualities of the different types of bedrock	2.14	1.062	3.38	0.865	<.001
	Under what conditions high shrink-swell clays form.	1.90	1.044	3.24	0.700	<.001
Soils Across Landforms	Hillslope position effects on soils	2.70	1.455	3.85	0.875	.001
	The effect of aspect on soils	2.33	1.354	3.38	1.024	<.001
	The types of restrictive horizons (fragipans, claypans, gravel)	1.86	1.352	3.43	0.978	<.001
	How soils are deposited by rivers and streams	2.76	1.375	3.81	0.814	<.001
	How differing landforms can affect siting a septic system	2.00	1.049	3.67	0.658	<.001

TABLE 4b Self-assessed knowledge of skills/concepts related to the topics of the workshop. Surveys were administered to university students (n=16) in February 14 of 2024. Mean response is described on a 5-point Likert scale from very low (1) to very high (5) knowledge rating. Responses were compared using Wilcoxon Signed Ranks Test.

	Question/Skill	<i>Pre</i>		<i>Post</i>		p-Value
		Mean	SD	Mean	SD	
Soil Profile Description	Identification of soil horizons	3.07	1.072	3.71	0.726	.007
	Effect of soil drainage on soil color and onsite systems	2.00	0.941	3.57	0.938	.002
	Water table identification	1.92	0.760	3.15	1.092	.004
	How to estimate coarse fragments in soil	2.23	1.092	3.38	0.870	.002
	Structure effect on soil drainage	2.23	0.927	3.31	0.630	.002
	Texture effect on soil water availability	2.15	0.987	3.38	0.768	.002
	Where to find information on shrink-swell of soil	1.77	1.013	3.31	0.947	.002
	Correct use of soil horizon designations	2.00	1.155	3.31	0.947	.003
Septic Systems	Types of septic systems	1.50	0.760	3.36	0.842	.001
	How to size a standard system	1.43	0.646	3.07	0.829	.001
	How to size an LPP or Drip system	1.43	0.756	3.14	0.864	.001
	The suitable soil conditions for each septic system	1.50	0.855	3.29	0.914	.001
	Soil or site conditions that necessitate a specific system.	1.50	0.855	3.43	0.938	.001

TABLE 4c Self-assessed knowledge of skills/concepts related to the topics of the workshop. Surveys were administered to university students (n=14) in February 5 of 2024. Mean response is described on a 5-point Likert scale from very low (1) to very high (5) knowledge rating. Responses were compared using Wilcoxon Signed Ranks Test

	Question/Skill	Pre		Post		p-Value
		Mean	SD	Mean	SD	
Site Evaluation	Materials needed prior to your arrival onsite	1.56	0.814	3.68	0.793	<.001
	What qualifies as a suitable area	2.00	0.894	3.62	0.719	.001
	Natural and manmade conditions that restrict a field location	1.68	0.602	3.38	0.806	.001
	The setback distances necessary for a tank and a field	1.62	0.719	3.69	0.873	<.001
	How to calculate or measure slope	2.69	1.621	3.69	1.014	.006
	How to site a septic tank and a septic field	1.50	0.632	3.43	0.814	<.001
	The necessary number and locations of soil pits	1.50	0.632	3.44	0.727	<.001
Forms and Maps	How to draw a site diagram	1.63	0.885	3.38	0.957	<.001
	How to choose a proper loading rate	1.5	0.816	3.31	0.873	<.001
	How to assess whole site suitability	1.56	0.892	3.38	0.885	.001
	Mitigations of unsuitable conditions	1.62	0.719	3.31	0.793	<.001
	What conditions pose high environmental risks	1.81	0.750	3.56	0.892	<.001
	Who to contact with questions/concerns	1.62	0.957	3.81	0.981	.001

TABLE 5a Self-assessed knowledge of skills/concepts in Geology video workshop. Surveys were administered to university students (n=34) on August 16, 2024. Mean response is on a 5 point Likert scale of 1 (very low) to 5 (very high) knowledge rating. Responses were compared using Wilcoxon Signed Rank

	Question/Skill	Pre		Post		p-Value
		Mean	SD	Mean	SD	
Prior Knowledge	Landform areas and boundaries (i.e. Ozark plateau, glacial till plain)	2.92	0.845	4.00	0.693	<.001
	Underlying geology in each region	2.58	0.809	3.69	0.736	<.001
	Relationship of MO soils to this geology	2.64	0.638	3.72	0.678	<.001
	Effect of glaciers on MO soil and landscapes	3.20	0.913	4.04	0.611	.001
	How each MLRA region formed and how that affects the soil in that region	1.88	0.927	3.24	0.723	<.001

	The qualities of the different types of bedrock	2.32	1.069	3.28	0.792	<.001
	Under what conditions high shrink-swell clays form.	2.68	0.802	3.88	0.781	<.001
<b>Introduction</b>	The main geologic regions of Missouri	2.79	1.149	3.94	0.736	<.001
	Different soil orders present in Missouri	3.15	1.077	4.15	0.784	<.001
	Conditions that change soil orders	3.35	0.884	3.94	0.776	.001
	Difference between high shrink swell clays and low shrink swell clays	3.03	0.969	4.06	0.694	<.001
<b>Northern MO</b>	How glaciers have affected the soils of Northern Missouri	3.06	0.919	4.09	0.668	<.001
	The extent of glacial advance in Missouri	3.26	1.310	4.32	0.806	<.001
	Landforms of Northern Missouri	2.42	0.867	3.64	0.699	<.001
	Characteristics of loess	3.06	0.886	4.12	0.729	<.001
	Effects of clay on water movement.	3.35	1.070	4.18	0.716	<.001

*TABLE 5b Self-assessed knowledge of skills/concepts in Geology video workshop. Surveys were administered to university students (n=34) on August 16, 2024. Mean response is on a 5 point Likert scale of 1 (very low) to 5 (very high) knowledge rating. Responses were compared using Wilcoxon Signed Rank*

	<b>Question/Skill</b>	<b>Pre</b>		<b>Post</b>		<b>p-Value</b>
		<b>Mean</b>	<b>SD</b>	<b>Mean</b>	<b>SD</b>	
<b>Ozark Plateau &amp; St. Francois Mountains</b>	The bedrock characteristics of the St. Francois Mountains	1.65	1.098	3.41	0.783	<.001
	The soil characteristics of the St. Francois Mountains	1.68	0.976	3.29	0.676	<.001
	Soil concerns for St. Francois Mountains	1.32	0.684	3.35	0.812	<.001
	Types & characteristics of the bedrock in the Ozark Plateau	1.94	0.983	3.50	0.826	<.001
	Soil characteristics of the Ozark Plateau	1.97	0.937	3.47	0.748	<.001
	Identification of rocks of Southern Missouri	2.06	0.814	3.56	0.860	<.001
	Characteristics of Karst features	2.85	1.202	3.73	0.911	<.001
	Soil concerns for the Ozark Plateau	1.76	0.792	3.48	0.755	<.001

<b>Osage Plains</b>	Geographic origins of the Osage Plains	1.85	0.892	3.56	0.991	<.001
	Types of landforms of the Osage Plains	2.00	1.015	3.59	0.925	<.001
	Characteristics of shale	2.50	0.992	3.76	0.855	<.001
	Soil characteristics of the Osage Plains	1.76	0.890	3.44	0.746	<.001
	Soil concerns in the Osage Plains	1.59	0.821	3.62	0.888	<.001

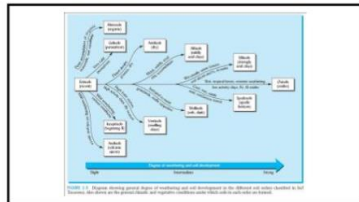
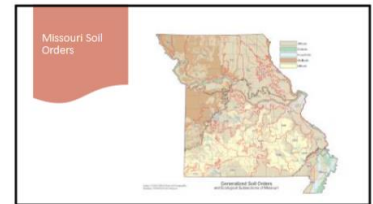
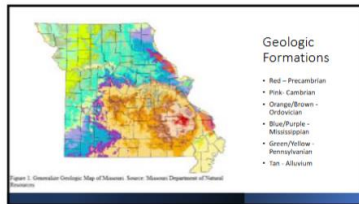
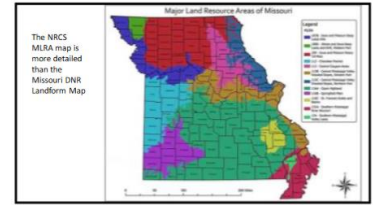
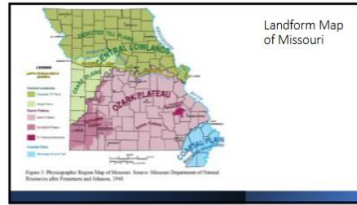
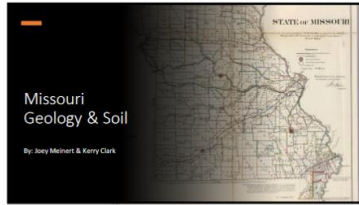
**TABLE 5c** *Self-assessed knowledge of skills/concepts in Geology video workshop. Surveys were administered to university students (n=34) on August 16, 2024. Mean response is on a 5 point Likert scale of 1 (very low) to 5 (very high) knowledge rating. Responses were compared using Wilcoxon Signed Rank*

	<b>Question/Skill</b>	<i>Pre</i>		<i>Post</i>		<b>p-Value</b>
		<b>Mean</b>	<b>Std. Dev</b>	<b>Mean</b>	<b>SD</b>	
<b>Springfield Plateau</b>	Geographic origins of the Springfield Plateau	1.56	0.927	3.21	0.845	<.001
	Types of landforms of the Springfield Plateau	1.56	0.927	3.47	0.992	<.001
	Karst features of the Springfield Plateau	1.71	1.001	3.41	0.957	<.001
	Soil Characteristics of the Springfield Plateau	1.50	0.663	3.38	0.853	<.001
	Soil Concerns for the Springfield Plateau	1.26	0.511	3.38	0.817	<.001
<b>Rivers</b>	Manmade effects on the Missouri River	2.53	1.051	4.00	0.817	<.001
	Geographic origins of Mississippi River	2.74	0.931	3.94	0.851	<.001
	Soil Characteristics of Floodplains	2.94	0.983	4.06	0.851	<.001
	Soil Concerns of Floodplains	2.94	1.071	3.97	0.834	<.001

## APPENDIX 2 – PRESENTATIONS

These materials are available through the author, by request, for academic use one, through MSO courses, conferences, and workshops, or online through The National Onsite Wastewater Recycling Association’s Online Learning Academy.

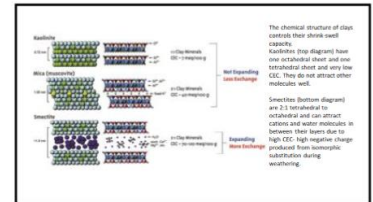
### 2.1 Missouri Geology



**Age and Weathering of Missouri Soils**

- The glaciers exposed and ground up rock, created newer soil which is not as weathered as non-glacial clays.
- Glacial clays tend to be smectites- high shrink swell
- Non glacial clays- especially on the Ozark plateau- are very old and weathered- kaolinite- low shrink swell
- Soils in the Loess hills and MS Valley wooded slopes are from interglacial times and produced from glacial-derived soils. They are usually less weathered (illites). Where clay has developed it is usually high shrink swell (smectites)
- The Cherokee Prairie are is generally mixed mineralogy with high shrink swell clays predominant. Clays here may also be influenced by the breakdown of shale and sandstone.

**Knowing your geology and land formation history will help you know your soils!**



### Brief Timeline

1.8 Billion Years Ago – 1.3 Billion Years Ago – Pre-Cambrian Period – Base rock of Missouri forms as volcanic eruptions occur on the southeastern coast of Laurentia.

542 MYA – 488 MYA – Cambrian Period – First major sea level rise, the Cambrian begins. Oldest known sedimentary rocks deposited in Missouri.

488 MYA – 444 MYA – Ordovician Period – Tepeocan Cycle of sea level rise begins – Large amounts of dolomite deposited. Age of Ozark Dome begins.

393 MYA – 325 MYA – Mississippian Period – Shallow sea covers Missouri but drains by the end of the period.

325 MYA – 299 MYA – Pennsylvanian Period – Pangea formed. Appalachian and Ouachita (Antietan) Mountains created. Frequently faulting. Occasional due to glacial cycle of sea rise creates large swamps and drifts across the state and deposits a mix of shales, limestones, sandstone, and mud.

[Anchor Earth](#)

### Timeline Continued

- 299 – 65 MYA – Mesozoic Era – As Pangea split up, Missouri drifted from the equator up to a more temperate location. Few of the rocks from this time remain due to erosion. Seas covered and receded leaving MO as a coastal area.
- 65 – 23 MYA – Paleogene – Last major sea rise of SE lowlands. Crowley's ridge in SE MO contains rocks from this period.
- 23 – 2.6 MYA – Neogene – Mounds Gravel is the only remnant from this period. A combination of rivers receding, and uplift of the Ozark dome caused large amounts of erosion, alluvial deposits and further erosion thereof, leaving little behind.
- 2.6 MYA – 11,700 – Pleistocene – Most recent ice age. Most rock is eroded or buried from this period. Ice sheets moved from Northern Canada into MO bringing rocks and sediments. Till lies several hundred feet thick across Northern MO. Melting glaciers and wind brings less to much of Missouri.

### Geologic Formations

- Red – Precambrian
- Pink-Cambrian
- Orange/Brown- Ordovician
- Blue/Purple- Mississippian
- Green/Yellow- Pennsylvanian
- Tan - Alluvium

Figure 1. Cross-section Geologic Map of Missouri. Source: Missouri Department of Natural Resources.

### Glacial Features

1. Receding Glacier
2. Ground Moraine
3. Esker
4. Lateral
5. Drumlin
6. Terminal Moraine

### North American Glacial Advances

- Four advances since reorganized:
  - Wisconsin
  - Illinoian
  - Kansan
  - Nebraskan
- Now:
  - Wisconsin
  - Illinoian
  - pre-Illinoian.

### The North - Glaciers

**History**

- Wisconsin
- Illinoian
- Pre-Illinoian
- 5-7 sheets of till across N. Missouri

**Shape & Distribution**

- Irregular
- Fingers
- Moraines

**Coarse Fragments**

- More Rounded
- Disorderly
  - Granite, Rhyolite, Silicified Sandstone.
- Will move up in the soil horizon through freeze/thaw cycles

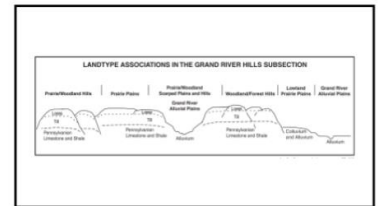
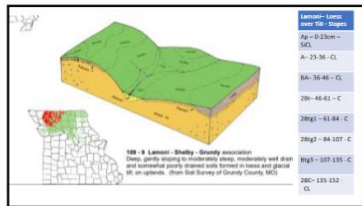
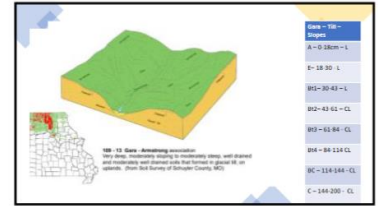
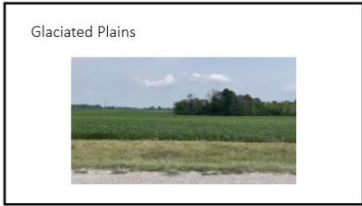
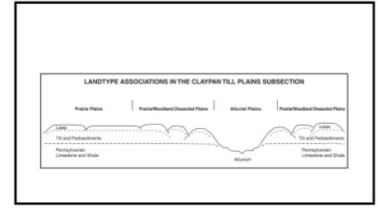
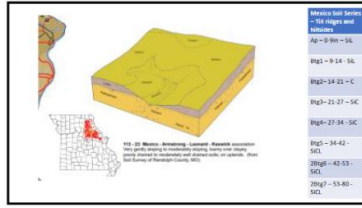
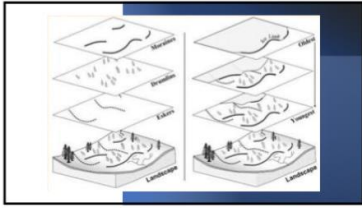
The glacial features in Missouri have evolved away over time.

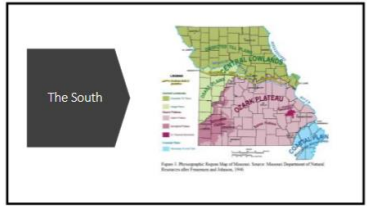
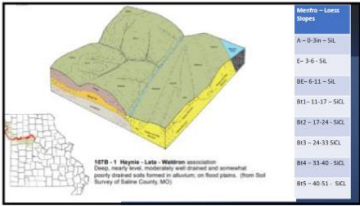
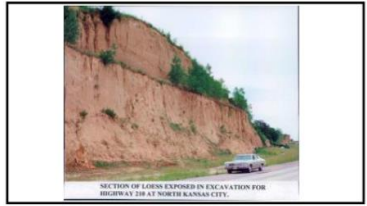
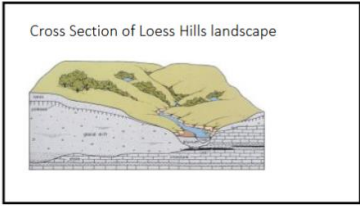
Receding glacier, Drums field, Barren hills, End moraine, Recessional and moraine, Esker, Lateral moraine, Outwash plain, Ground moraine, Barren hills, Barren hills.

### Landscapes of Glacial Till

- Loess Hills
- Erosional formations
- Rolling hills, flat landscapes, and streamways/creeks
- Typically High Drains
- Swell

Figure 1. Cross-section Geologic Map of Missouri. Source: Missouri Department of Natural Resources.





Overview of our Rocks (Sedimentary)

- **Limestone/Dolomite**
  - Common across nearly entire state
  - Weatherable
  - Calcium Carbonate or Magnesium Carbonate
  - Fine Red Grained
  - Moderate - High Permeability
- **Shale**
  - Soft, brittle, easily eroded
  - Clay based
  - Very Fine Grained
- **Clay**
  - In sandstone layers of Missourian and adjacent
  - Fine and medium to coarse
  - Often surrounded by heavy clay
  - Silty sand
  - Very fine grained
  - Low permeability
- **Sandstone**
  - Sand based
  - Visible grains
  - Round Grains
  - High permeability
  - Moderate Weatherability

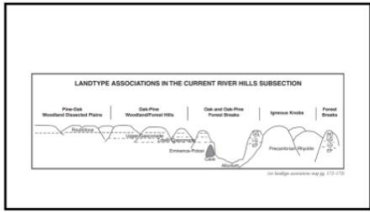
Residuum - Igneous Rocks

- High Amounts of Coarse Fragments
- Mix of Clay and Silt with Sand Approaching the bedrock
- Shallow - Moderately Deep
- Mostly Ultisols
- Low-Moderate Shrink Swell Clays

### St. Francois Mountains & Pre-Cambrian Rocks

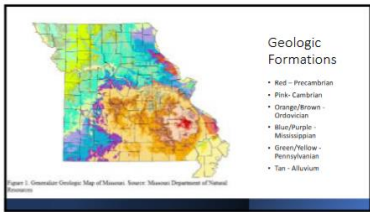
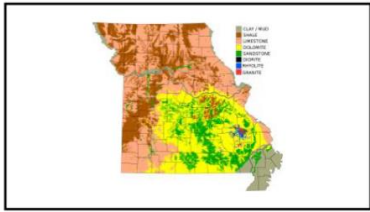
- Signs of this area: Rhyolite, steep slopes, knobs and rock outcrops, densely forested with interspersed glades.
- Lacks over Residuum/Colluvium. High rock content. Shallow soil profiles.
- On Rhyolite/Granite - No residuum only Colluvium/Löss
- Possibility of Fragipan on the hillslopes.
- Heavy Clays in this area = Residuum of Calcium Carbonate Rock

Elevation - Feet	Color
A - 0-30 - 50	Lightest Brown
B - 31 - 50	Light Brown
C - 51 - 75	Yellow
D - 76 - 100	Orange
E - 101 - 125	Dark Orange
F - 126 - 150	Red-Orange
G - 151 - 175	Red
H - 176 - 200	Dark Red
I - 201 - 225	Brown
J - 226 - 250	Dark Brown
K - 251 - 275	Black



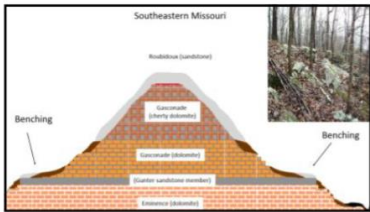
### The Ozark Highlands and the Many Oceans of Missouri

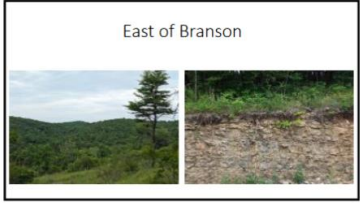
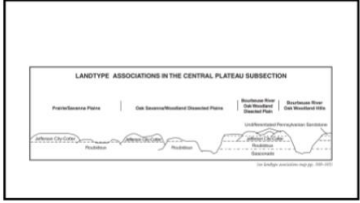
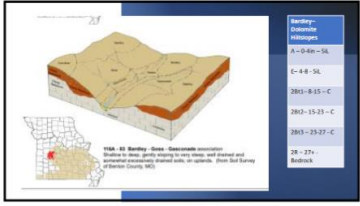
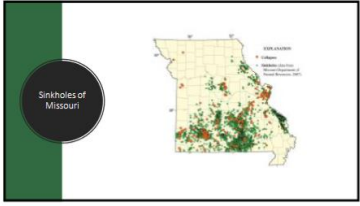
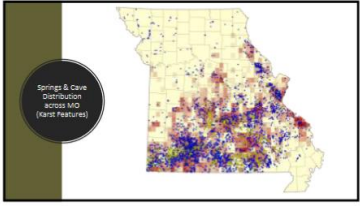
- Since the uplift of the St. Francois Mountains - 6 major cycles of sea rise. 542 MYA - 23MYA
- Led to the development of many different bedrock formations
  - Roubidoux - Pure Sandstone in some locations, but mixes with dolomite and sandy dolomite further south. Up to 190ft thick.
  - Jefferson City - Dolomite bedrock, with interspersed beds of chert and sandstone.
- Large region, Large variation
- Fragipans normally form in the Summit (Majority), shoulder, backslope (Variable) and foot slope (Where colluvium might settle) Slope <15%



### Bedrocks and the Soils of the Ozark Highlands

Dolomite	Roubidoux Sandstone
<ul style="list-style-type: none"> <li>• Heavier Clays that formed in place from weathered dolomite</li> <li>• Lower permeability</li> <li>• High Shrink Swell depending on age (distance from dolomite bed rock)</li> <li>• Chert possible</li> </ul>	<ul style="list-style-type: none"> <li>• Less weatherable</li> <li>• Higher Permeability</li> <li>• Clays present are illuviated clays</li> <li>• Low Base saturation and low shrink swell</li> <li>• Chert possible even Chert Bedrock</li> </ul>



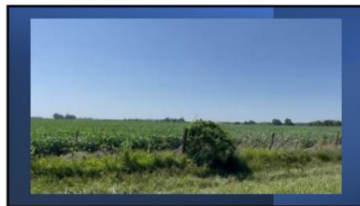
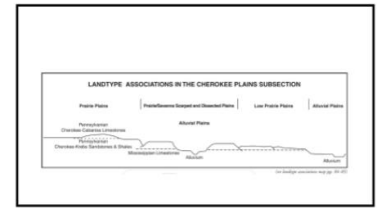


### Cherokee/Osage Plains

- Landscape types (much flatter)
- Pennsylvanian Age bedrock of Shale and Limestone
- Weathered Knoxian, colluvium, loess
- Moderate to high shrink swell

**Barren Series – foot slopes**

A – 0-28cm – SL
BE – 28-46 – SL
ZB1 – 46-58 – SICL
ZB2 – 58-76 – SC
ZB3 – 76-142 – SICL
ZC – 142-200 SICL



### Springfield Plateau

- Well-sorted beds cut off along hills and gullies
- Mississippian Age limestone, rock and sandstone
- Heavy fragments of chert among high clay loam
- Low – Moderate Shrink Swell class
- Regionally, includes, Limestone capped hills

**Barren Series – Back slopes, fringes, footslopes**

A1 – 0-17cm – SL
A2 – 17-33 – SL
B2 – 33-50 – SICL
B2b – 30-37 – SL
ZB2 – 37-45 – SICL
B3 – 45-72 SL



### Shrink Swell Potential of the Springfield Plateau



- Mostly Low-Moderate Shrink Swell (Va clays).
- Some variability in the less weathered soils (Mollisols).
- Va clays are suitable for the installation of septic fields.
- The well distributed red color shows that oxygen is able to move into and out of the soil.



### Soil Profiles

Red Clay Soil (most likely low shrink swell)

Sandstone Bedrock and Fragments

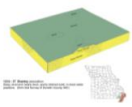



Yellow Clays

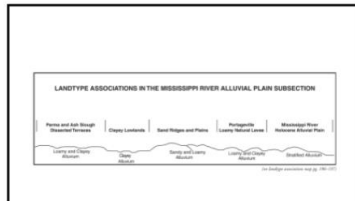
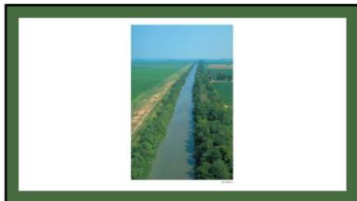


### Mississippi Floodplains

- FLAT Alluvial Soils
- History of the AR used to flooding, very variable soil structure due to frequent flooding, clay sand and silt mix.
- Soil textures sort based on distance from river
- Drained Swamplands



Sharkey Series -	
Ap1	0-6in : C
Ap2	6-10 : C
Bsq1	10-24 : C
Bsq2	24-39 : C
Bsq3	39-58 : C
Bsq4	58-64 : C



## What is a Soil Evaluator

Joey Meinert

## Missouri Onsite Soil Evaluator Overview

A private citizen licensed to perform soil evaluations.

Visiting homes and properties to recommend and advise the homeowner on their septic options.

A professional with a variety of skills and a diverse knowledge base - geology, hydrology, soils, land surveying, etc.

## Septic System Overview



## Why do we need Soil Evaluators?

- Household wastewater contains many biological diseases, contaminants, household chemicals, and toxic levels of nutrients.
- Waterways can become very quickly contaminated and need protection.
- Our drinking water should be safe.
- Our soils are mapped already right?



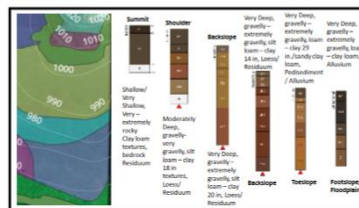
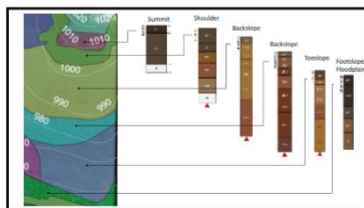
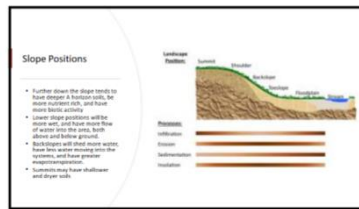
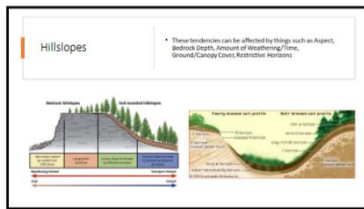
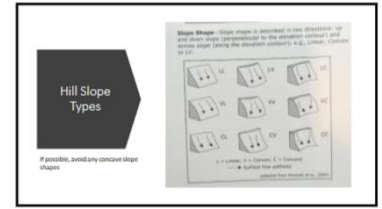
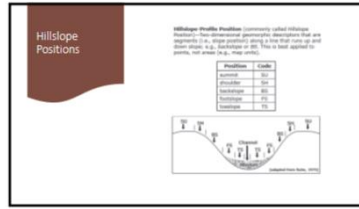
## What do Soil Evaluators do? - Main Responsibilities

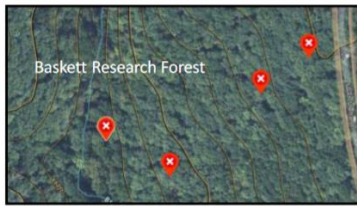
- Locate a suitable site for a septic tank and field.
- Describe the soils of the location from a backhoe pit.
- Recommend a septic system suitable for the site/soils and the homeowner.
- Write up a report for the homeowner and the local government.
- Work with installers and engineers to ensure the correct functioning of the system.

## References

- <https://sites.wustl.edu/monh/geology-of-missouri/>
- <https://mdc.mo.gov/magazines/conservationist/2001-12/missouri-tx-0985>
- [https://geo.libretexts.org/Bookshelves/Geology/Book%3A\\_An\\_Introduction\\_to\\_Geology\\_\(Johnson\\_Affolter\\_Inkenbrandt\\_and\\_Mosher\)/14%3A\\_Glaciers/14.05%3A\\_Glacial\\_Landforms](https://geo.libretexts.org/Bookshelves/Geology/Book%3A_An_Introduction_to_Geology_(Johnson_Affolter_Inkenbrandt_and_Mosher)/14%3A_Glaciers/14.05%3A_Glacial_Landforms)
- <https://oembed-dnr.mo.gov/land-geology/geology/rocks-minerals-fossils/other>
- <https://www.thoughtco.com/what-is-chert-1441025>
- Atlas of Missouri Ecoregions

## 2.2 SOILS ACROSS LANDFORMS





### Baskett Research Forest - Summit

- White Oak/Maple
- <3% slope
- Loess over Pediment
- No Rock Fragments
- Abrupt Textural Change
- No Bedrock
- Stable Landform

### Shoulder

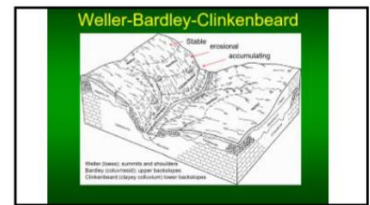
- 10% slope
- Oak/Maple/Eastern Red Cedar
- Colluvium over Residuum
- Very little A horizon
- High amounts of Coarse Fragments
- High Amounts of Erosion
- Bedrock/Saprotite present

### Foot Slope /Bench

- 14% slope
- Oak/Maple
- Loess over Pediment
- No Coarse Fragments
- Depositional
- No bedrock
- Deep Fragic Horizon

### Floodplain/Toeslope

- 0% Slope
- Oak/Hickory/Sycamore
- Multiple Alluvial Deposits
- Few gravels – Extremely Cobbly
- Silt Loam/ Loamy Sand / Loam Textures
- Depositional (Floodplain)



### Summit

- Relatively stable hill slope position (few losses or additions).
- Most likely loess and residuum, glacial till as parent materials.
- May have a significant loess cap of suitable soils above residuum.
- May have shallow depth to bedrock.
- May have high rock fragments mixed with the residuum.
- May not have enough slope (<2%) for a system without provisions to insure adequate surface drainage (eg. adding soil to reach required slope)

### Shoulder Slope

- Stable-erosional hill slope position.
- Loess & Residuum, Glacial Till parent materials, may have hill slope sediment
- Be careful of bedrock shelves in these areas.
- Often a suitable slope percentage >2 and <15 and suitable hill slope type (sheds water).
- May have less of a loess cap than the summit and shallower depths to residuum/high rock content

### Backslope

- Erosional hill slope position – losing surface and organic matter
- Loess, hillslope sediment, & residuum/Glacial Till are common parent materials.
- Often a thin A horizon
- Slopes can be suitable 3%-14%, provisionally suitable (15%-29%) or unsuitable (30%+)
- Care must be taken to avoid drains, gullies, & erosional scars.
- May require interceptor/curtain drains above the field for surface and below ground water
- May have shallow depth to bedrock.
- May have high rock content.
- Soils can vary rapidly across the same backslope.


### Footslope

- Depositional hill slope position – accumulating material from uphill
- Loess, hill slope sediment, alluvium, residuum/Glacial Till – possible parent materials
- Should avoid high concave areas.
- May not have enough slope (<2%) to be suitable unless provisions are made.
- Deeper A horizon.
- May have drainage problems.
- May require interceptor/curtain drains.
- May have high rock fragments that have accumulated over time.

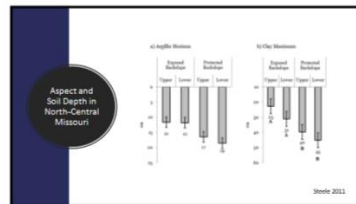
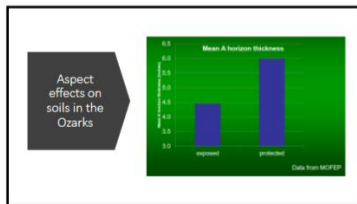
### Toeslope

- Depositional Hillslope Position – Accumulating material from uphill
- Often has deeper A horizon and lower clays
- Hill slope sediment, Colluvium, Alluvium, Residuum/Glacial Till or Outwash, as parent materials.
- May have drainage problems
- May not have enough slope (<2%) to be suitable without provisions being made.
- Curtain drains often necessary to intercept upslope water
- May have high rock content from moving materials/nearby alluvial processes
- Nearby rivers, streams, drains may have had more of an effect on the soil than the hill slope.

### Aspect and Soil



- Northern slopes typically have more soil depth than southern facing slopes
- Larger mesochlor activity on sunny (grassland) slope vs shady (forested) slope.
- Southern slopes have greater evapotranspiration.
- In Missouri Southern slopes less dense tree cover (smaller trees, more dry tolerant species)
- Northern slopes have more dense tree cover and are moister



### Pans (Restrictive Horizons)

#### Fragipans



#### Clay Pans



Source: Lu, Zhou & Wilson, 2006

### Fragipans




- Very dense
- Light colored
- Difficult to dig through
- Often is not permeable
- Slakes (breaks apart in water) quickly
- Tend to have an indurated at the end of the slope (steeper aspect)
- Typically found between B1 and C1e.
- Typically 4-10cm in soil but can be 4-24cm.
- Other Pedons in structure
- Generalized array of wetness and moister
- Regoliths
- Colluvium

### Fragipan Identification

- Highly dense.
  - Backhoe is scratching at soil
  - Hand tools barely making a dent
- Look for channels between the prisms
- Slakes rapidly in water
  - <https://www.youtube.com/watch?v=r0y000qV8o>

### Claypans



- Sharp Boundary
- Very low permeability
- Can have perched water table above
- High clay content, often >40%
- If in till or loess – high shrink swell
- Qualified by an increase of 20% from the horizon above B1, or double if horizon above has less than 20% clay content
- Restrictive horizon
- Anywhere in Missouri



### Hill Slopes & Septic Systems

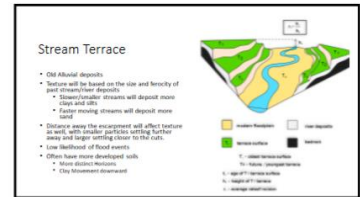
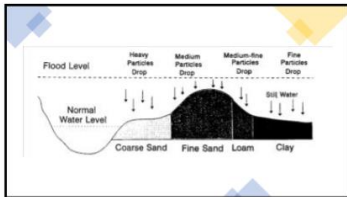
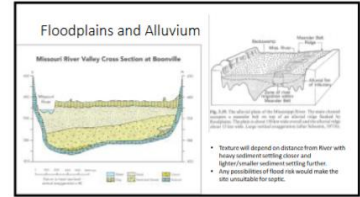
Steep slopes – Modifications above 15% and rarely suitable above 30%

Bedrock Shelves – Depth of bedrock can change rapidly (always dig above and below the field)

Rock Content – Slope positions can accumulate high amounts of rock fragments from colluvium or from weathering (caution at greater than 50%)

Restrictive Horizons – Fragipans & claypans are common

Karst features & surficial bedrock should be avoided at all costs.

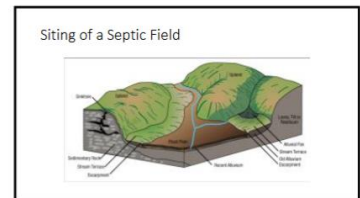


### Gravel & Sand Layer

- Any layer with greater than 50% gravel and a loamy sand or a sand texture is unsuitable.
- Water will move horizontally along this layer and into nearby waterways.
- Water can move through it too quickly without being treated and into the groundwater.
- Commonly found in stream terraces/floodplains/upland drains

### Gravel/Sand Layer

- Multiple Depositions have occurred at this site.
- Some soils are suitable/provisionally suitable
- Gravel/Sand layer is unsuitable



## 2.3 SOIL PROFILE DESCRIPTION



Horizon	Depth (cm)	Color	Texture	Structure	Rooting	Moisture	Other	Notes

The Information we need

Books and Resources

- Munsell Color Book
- Field Book for Describing and Sampling Soils




<https://www.nrcs.usda.gov/topics/field-book/2022/DyFieldBook.pdf>

Horizons & Boundaries

**Horizons**

- Looking for the distinct layers in the soil profile.
  - Signified by change in color, structure, texture
  - Prevalence of roots and rocks can be helpful signs as well.
- Allows for the eventual designation of Horizon

**Boundaries**

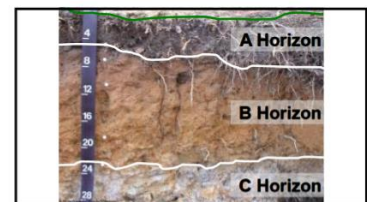
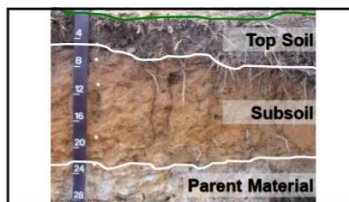
- How the horizons are separated
  - Two distinctions:
    - Clear - Abrupt (1-2cm), Clear (2-5cm), Gradual (5-15cm), Diffuse (15-15cm)
    - Topography: Smooth, Wavy, Irregular, Broken



Depth / Boundary
0-5
AS
5-10
CS
10-22
CS
22-35
3W
35-44
CS
44-52
CS
52-60

Horizon Designations

- O horizon - Organic surface or near surface. Can be a mixture of mineral and organic, but dominated by organic. Rarely found in MO.
- A horizon - Mineral and organic surface horizon. Dominant in MO. Often has Fe, Al, clay with an accumulation of organic matter.
- E horizon - subsurface. Zone of eluviation (lost) losses of clay, silt, or aluminum moves farther down.
- B horizon - Subsoil. Zone of illuviation (gains) of minerals from above, or it is more weathered than parent material.
- C horizon - unconsolidated parent material. Rare unique characteristics of soil development/formation.
- R - Bedrock

Density
rati
A
A
B
B
B
B
C

### Color

- Hue (color) value (Munsell Hue)
- Hue is the color observed (from red/yellow/blue)
- Value is dark to light
- Chroma is the purity of the color
- (Give any information on appearance, water equipment (hydroponic), toxicity, and presence or absence of a root zone)

**Soil Color Affects by:**

- Water
- Nitrate (nitrate and nitrite may be reduced to nitrite)
- Organic matter
- Humidity
- Oxidation (under wet lighter)
- Reduction (grey)

### Soil drainage—rules of thumb

### What is reduction-oxidation and gleying?

- Soil is full of iron. When soil is well drained, oxygen is present, iron oxidizes and is seen as a red color. Black colors are manganese, which usually follow iron wherever it goes.
- In an anaerobic environment, soil microbes reduce iron from the ferric (Fe<sup>3+</sup>) to the ferrous (Fe<sup>2+</sup>) form and manganese from the manganic (Mn<sup>4+</sup>) to the manganous (Mn<sup>2+</sup>) form. When iron becomes reduced it changes to a soluble form. This allows iron and Mn to move around or out of a soil horizon, leaving grey colors behind.
- Grey colors generally indicate that the soil is poorly drained.
- Gley (gle) comes from the Russian word for bluish-grey. Gley colors have a chroma of 2 or less and usually a value of 5 or more. A value of 4 or more is used in high OM soils.
- Some grey colors are from parent material such as shales, sandstone, and sands.

### Discussion: When is redox a water table?

- 2. The vertical separation between the bottom of the drip lines and/or the trench and a limiting layer, including but not limited to bedrock, restrictive horizon, or seasonal high water table, shall be no less than: A. Twenty-four inches (24"); or B. Twelve inches (12") for systems dispensing secondary or higher quality effluent;

Munsell Color (muns)	Redoximorphic Features (R)
10YR 3/2	
10YR 3/3	
10YR 4/4	
10YR 5/4	
7.5YR 4/4	10YR 5/1
5YR 4/6	10YR 5/2
10YR 5/8	10YR 6/1

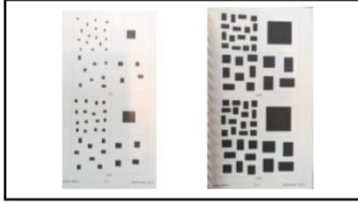
### Roots & Pores

- Quantity and Size (Few Fine, Common Medium)
- Quantity - Few, Common, Many
- Size - Very Fine, Fine, Medium, Coarse, Very Coarse
- Provides information on how well water will move through the horizon.
- Roots - Examine an area (10cm x 10cm area)
- Pores - Examine individual ped

Roots (Pores)
10YR 3/2
10YR 3/3
10YR 4/4
10YR 5/4
7.5YR 4/4
5YR 4/6
10YR 5/8

### Coarse Fragments

- Affects how much water will move through treated/untreated.
- Affects amount of soil available for treatment.
- Affects water holding capacity.
- 10cm x 10cm zone in the horizon
- Provisionally suitable if >50%
- Unsuitable if >70%



% Coarse Fragments by volume	
< 2mm	> 2mm
10	
30	
10	
30	15

### Structure

- Structure is a vital aspect of macropores and water infiltration
- Informs how/ if water will move and be filtered by the soil. Some structures are more permeable than others
- Soil Structure:
  - Number = Grade or how evident structure appears out. 0 = structureless, 1 = Weak, 2 = Moderate, 3 = Strong
  - Soil = Very fine, Fine, Medium, Coarse, Very Coarse
- Structure Type = Granular (GR), Subangular and Angular blocky (SB, AB), Platy (PL), Prismatic (PR), Massive (MA), Single Grain (SG)

### Permeability and Structure

- If moloditic, a great deal depends on the loam/clay percentage in the soils
- High vs Low Shrink Swell Clays

### Granular Structure

- Many sided (ranging towards round) with rounded corners
- Small (1-10mm) and often attached to roots
- Most common in the A horizon of all based soils

### Subangular Blocky

- Rounded Edges
- Often Obuse or right angles
- Comes out with distinct sides

### Angular Blocky

- Sharp or pointed edges
- Corners come to acute points
- Comes out with distinct sides
- Often related to clay percentage or compaction

### Platy Structure

- Layers peel off
- Often in surface horizons due to compaction
- Restrictive to water movement
- Unsuitable unless mitigated

### Prismatic

- Vertical Prisms
- Prisms can be up to 30cm in diameter
- Looking for gaps that are taller than they are wide
- Long vertical cracks
- Often in very High Shrink swell clay soils
- Breaks into angular or subangular blocky structure

### Massive Structure

Caused by clay particles closely bound by cations  
 Can also be parent material which has not developed structure  
 Usually impermeable  
 Unsuitable

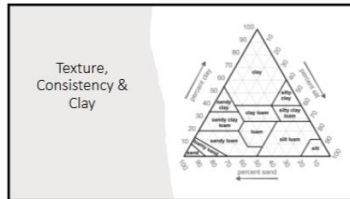


Structure
2MGR
1FSBK
2MSBK
1MABK
1FASK
1MFR
OMA

### Consistence - Moist

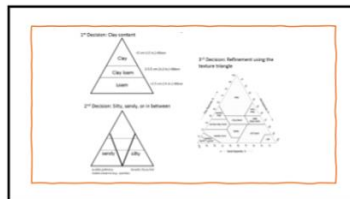
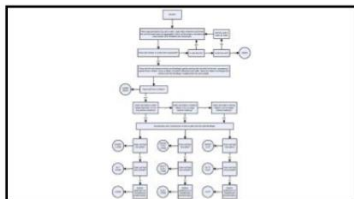
- Soil will break into smaller masses when moist
- Consistence relates to texture, compaction, and the presence of limiting layers
- Friable (FB) – Crushes easily under gentle/moderate pressure between thumb and forefinger
- Firm (FI) – Crushes under moderate pressure – noticeable resistance
- Very Firm (VFI) – Crushes under strong pressure, barely crushable between thumbs and forefinger
- Extremely Firm (EFI) – Crushes only under very strong pressure, can't be broken between thumb and forefinger, must be broken apart bit by bit.

Consistence (Moist)
FR
FR
FR
FI
VFI
VFI
FI



### Texturing

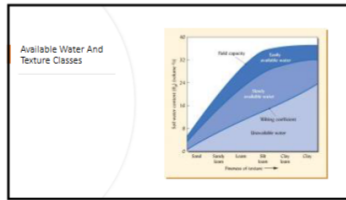
- Ribbon Method**
  - Moisten Soil sample
  - Push up between thumb and side of forefinger
  - Length of ribbon informs clay percentage
- Wire Method**
  - Moisten Soil Sample
  - Roll soil into a wire
  - Firmness of wire informs clay percentage
- Smear**
  - Moisten Soil Sample
  - Smear heavily between thumb and forefinger
  - Amount of shine/size of shine informs clay percentage



### Wire Method - 1/2 in. Wide and 3 in. long

	Clay %	Sand %
Can't make a wire	0-6%	< 20%
Can't make a ball	6-8%	26-41%
Ball breaks when heaved	8-7%	45-86%
Ball doesn't break when heaved	7-9%	86-100%
Wire breaks as it is pushed up	9-12%	
Wire will break if shaken lightly	12-20%	
Wire breaks with shake	20-30%	
Wire breaks	31-44%	
Wire does not break	> 44%	

Texture	
USDA % Clay	% Clay
SIL	12
SIL	14
SKCL	28
CL	33
C	45
C	52
SC	47

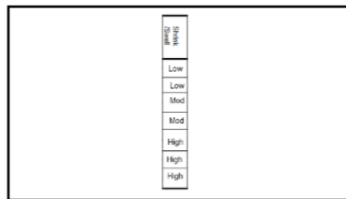


**Clays**

- Kaolinites (low pH) - Low Shrink Swell - Lower CEC - More Weathered - Lower Plasticity
- Smectites (High pH) - High Shrink Swell - Higher CEC - Less Weathered - Higher Plasticity
- Based typically on amount of weathering and mineralogy of soil.
- Understanding the geologic formation, age and weathering of the soil is often necessary in distinguishing shrink/swell potential.

**Finding Shrink-Swell Data (Low, Moderate, High)**

- Gather geologic information about your site.
  - Type of bedrock
  - Type of parent material
  - Age of the landscape
- Look for signs of shrink swell in the pit.
  - Sharp, very apparent clay faces
  - Fractured cracks
  - Slickensides
- Check the mineralogy/lab data your soil series data (smectitic, mixed, kaolinitic etc.)
  - >.06 COLEw expansion is qualified as high shrink swell



**Classifying your soil**

**Horizon Designation**

- Horizons - determined by color, texture, depth in profile, structure, proximity to bedrock, weathering
- O, A, E, R, C, K

**Master Horizons**

- O Horizon - Organic surface layer, very thin in most of MO, decomposed organic matter
- A Horizon - Surface layer if present, darker color, some minerality
- E Horizon - Zone of eluviation, mottled and clay loam soil, lighter in color, often silty
- B Horizon - Subsurface layer, illuvial, high gley, color depends on mineralogy
- C Horizon - Unweathered bedrock or Saprolite
- R Horizon - Bedrock

**Soil Horizon Designations A & E**

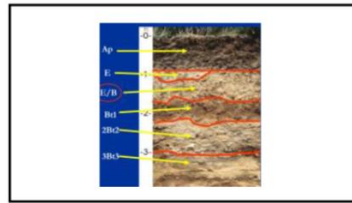
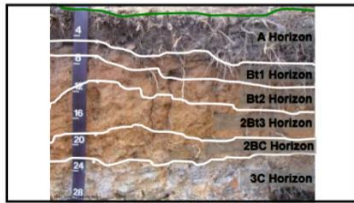
**A**  
p - Anthropomorphic or plow layer (Humans have done something here)  
b - Buried horizon, often found under fill

**E**  
g - rare to find gley colors, but is possible, must have very high water table

**Soil Horizon Designations (B horizon)**

**t** - illuvial clay  
**g** - gleyed-saturated, grey; **Btg**  
**x** - Ozarks- fragipan characteristics, dense, brittle subsoil layers, usually loamy due to dense packing, not a clay  
**b** - buried horizon (can be A, E, B), may have been covered by erosion or catastrophic event. 20 in on top of it. Paleosol-formed under different geological conditions  
**K** - calcic (same but rare)  
**w** - changed from parent material in color or structure

Horizon	Depth (cm)	Moisture (%)	Color	Structure	Texture	USDA Class	CEC (meq/100g)	Shrink (%)	SWP (cm)	SWC (%)
A 21	0-10	10	10YR 5/3	FR	SL	FR	20	10	10	10
A 22	10-20	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 11	20-30	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 12	30-40	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 13	40-50	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 14	50-60	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 15	60-70	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 16	70-80	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 17	80-90	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 18	90-100	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 19	100-110	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 20	110-120	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 21	120-130	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 22	130-140	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 23	140-150	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 24	150-160	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 25	160-170	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 26	170-180	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 27	180-190	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 28	190-200	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 29	200-210	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 30	210-220	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 31	220-230	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 32	230-240	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 33	240-250	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 34	250-260	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 35	260-270	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 36	270-280	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 37	280-290	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 38	290-300	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 39	300-310	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 40	310-320	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 41	320-330	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 42	330-340	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 43	340-350	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 44	350-360	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 45	360-370	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 46	370-380	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 47	380-390	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 48	390-400	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 49	400-410	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 50	410-420	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 51	420-430	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 52	430-440	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 53	440-450	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 54	450-460	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 55	460-470	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 56	470-480	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 57	480-490	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 58	490-500	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 59	500-510	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 60	510-520	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 61	520-530	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 62	530-540	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 63	540-550	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 64	550-560	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 65	560-570	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 66	570-580	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 67	580-590	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 68	590-600	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 69	600-610	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 70	610-620	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 71	620-630	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 72	630-640	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 73	640-650	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 74	650-660	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 75	660-670	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 76	670-680	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 77	680-690	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 78	690-700	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 79	700-710	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 80	710-720	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 81	720-730	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 82	730-740	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 83	740-750	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 84	750-760	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 85	760-770	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 86	770-780	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 87	780-790	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 88	790-800	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 89	800-810	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 90	810-820	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 91	820-830	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 92	830-840	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 93	840-850	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 94	850-860	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 95	860-870	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 96	870-880	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 97	880-890	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 98	890-900	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 99	900-910	10	10YR 5/3	FR	SL	FR	20	10	10	10
B 100	910-920	10	10YR 5/3	FR	SL	FR	20	10	10	10

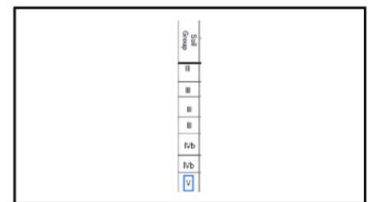


Soil Classes and Application Rates for Standard System			
Soil Class	Soil Textures	Soil Moisture/Color	Application Rate (cm <sup>3</sup> /m <sup>2</sup> )
I	Sand, Loamy sand	And, ustic/Umbric (No plant)	1.2 - 1.8
II	Sandy loam, Loam	Ustic/Umbric, fine and medium subangular blocky Prismatic, coarse subangular and angular blocky	0.7 - 0.7 0.7 - 0.9
III	Silt loam, Clay loam, Sandy clay loam, Silty clay loam, Silty loam, Clay loam, Loam, Silty clay loam	Ustic/Umbric, fine and medium subangular blocky Prismatic, coarse subangular and angular blocky	0.4 - 0.4 0.4 - 0.3

Clay Soils Application Rates			
IVa	Sandy clay, Silty clay, Clay loam to moderate shrink/swell Sandy clay, Clay, Silty clay (low-moderate shrink/swell)	Granular, fine and medium subangular blocky Prismatic, coarse subangular and angular blocky	0.4 - 0.2 0.3 - 0.1
IVb	Sandy clay, Clay, Silty clay loam, Silty clay (high shrink/swell potential)	Subangular, Angular blocky, or Prismatic	Not suitable

Rocky Soils			
V	Skeletal (less than 50% coarse fragments), Silt loam, Silty clay loam, Clay, Silty clay	Anything but platy or massive	0.4 - 0.2

- Must have less than 35% clay content if high shrink swell (Group IVb soils)
- Must have 40% of separation between trench bottom and bedrock if >50% rock fragments



Soil Class and Application Rates for LPP and Drip Systems			
I	Sand, Loamy sand	No structure (Brown colors)	1.2/0.8/0.1
II	Sandy loam, Loam	Granular (fine and medium subangular blocky) Prismatic, coarse subangular and angular blocky	0.4-0.3/0.1 0.3-0.2
III	Silt loam, Clay loam, Sandy clay loam, Silty clay loam, Silty loam, Clay loam, Loam, Silty clay loam	Granular (fine and medium subangular blocky) Prismatic, coarse subangular and angular blocky	0.3-0.2 0.2/0.1/0.1

Clay Soils Application Rates			
IVa	Sandy clay, Silty clay, Clay loam to moderate shrink/swell Sandy clay, Clay, Silty clay	Granular, fine and medium subangular blocky Prismatic, coarse subangular and angular blocky	0.2-0.1 0.1-0.05
IVb	Clay, Sandy clay, Silty clay loam, Clay loam, Silty clay (high shrink/swell potential)	Subangular, Angular blocky, or Prismatic	Not suitable

Rocky Soils			
V	Skeletal (less than 50%), Silt loam, Silty clay loam, Clay, Silty clay	Anything but platy or massive	0.3-0.1/0.1

- Must have less than 35% clay content if high shrink swell (Group IVb soils)
- Must have 40% of separation between trench bottom and bedrock if >50% rock fragments

Site Class	Soil System	Soil Description/Notes
1	Hard Loamy sand	Low plasticity, coarse sand, low clay content
2	Hard Sandy loam	Low plasticity, coarse sand, low clay content
3	Hard Sand loam	Low plasticity, coarse sand, low clay content
4	Hard Sandy clay loam	Low plasticity, coarse sand, low clay content
5	Hard Sandy clay	Low plasticity, coarse sand, low clay content
6	Hard Clay loam	Low plasticity, coarse sand, low clay content
7	Hard Clay	Low plasticity, coarse sand, low clay content
8	Hard Silty clay	Low plasticity, coarse sand, low clay content
9	Hard Silty clay loam	Low plasticity, coarse sand, low clay content
10	Hard Silty loam	Low plasticity, coarse sand, low clay content
11	Hard Silty sand	Low plasticity, coarse sand, low clay content
12	Hard Sand	Low plasticity, coarse sand, low clay content

### Suitability

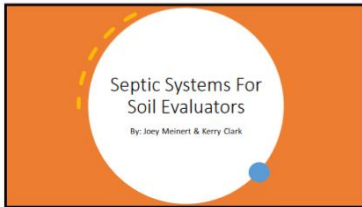
Soil Class	Hydraulic Conductivity (cm/d)	Soil Depth (cm)	Soil Type	Soil Color	Soil Texture	Soil Structure	Soil pH	Soil EC	Soil SOD	Soil SAR	Soil CEC	Soil Cation Exchange Capacity (meq/100g)	Soil Organic Matter (%)	Nutrient Status		
														N (ppm)	P (ppm)	
1	100	0-10	Hard Loamy sand	10YR 6/3	SS	Single	6.5	0.1	0.5	0.5	10	10	0.5	10	10	10
2	100	0-10	Hard Sandy loam	10YR 6/3	SS	Single	6.5	0.1	0.5	0.5	10	10	0.5	10	10	10
3	100	0-10	Hard Sand loam	10YR 6/3	SS	Single	6.5	0.1	0.5	0.5	10	10	0.5	10	10	10
4	100	0-10	Hard Sandy clay loam	10YR 6/3	SS	Single	6.5	0.1	0.5	0.5	10	10	0.5	10	10	10
5	100	0-10	Hard Sandy clay	10YR 6/3	SS	Single	6.5	0.1	0.5	0.5	10	10	0.5	10	10	10
6	100	0-10	Hard Clay loam	10YR 6/3	SS	Single	6.5	0.1	0.5	0.5	10	10	0.5	10	10	10
7	100	0-10	Hard Clay	10YR 6/3	SS	Single	6.5	0.1	0.5	0.5	10	10	0.5	10	10	10
8	100	0-10	Hard Silty clay	10YR 6/3	SS	Single	6.5	0.1	0.5	0.5	10	10	0.5	10	10	10
9	100	0-10	Hard Silty clay loam	10YR 6/3	SS	Single	6.5	0.1	0.5	0.5	10	10	0.5	10	10	10
10	100	0-10	Hard Silty loam	10YR 6/3	SS	Single	6.5	0.1	0.5	0.5	10	10	0.5	10	10	10
11	100	0-10	Hard Silty sand	10YR 6/3	SS	Single	6.5	0.1	0.5	0.5	10	10	0.5	10	10	10
12	100	0-10	Hard Sand	10YR 6/3	SS	Single	6.5	0.1	0.5	0.5	10	10	0.5	10	10	10

### Site Classification Features

Type of System	Depth to limiting condition				
	<42"	42" - 30"	30" - 24"	24" - 18"	<18"
Septic Tank/Conventional	✓	✗	✗	✗	✗
Septic Tank/Conventional With Shallow Placement	✓	✓	✗	✗	✗
Septic Tank/ Low Pressure Pipe (LPP)	✓	✓	✓	✗	✗
Advanced Treatment (AP)	✓	✓	✓	✓	✗
Advanced Treatment/ Subsurface Strip Disposal	✓	✓	✓	✓	✗

- <https://imagegeo.edu.au/view/2720/>
- <https://soils.uga.edu/soils-hydrology/munsell-color-system/>
- <https://imagegeo.edu.au/view/1574/>

## 2.4 SEPTIC SYSTEMS FOR SOIL EVALUATORS



### Treatments

**Primary Treatment – Septic Tank**

- Separates wastewater and solids/floating debris
- Significantly reduces organic matter
- Assimilates breakdown
- Collection of solids

**Secondary Treatment – Field Treatment**

- Processing of contaminants in liquid wastewater (effluent)
- Bacteria and properties of soils filter/breakdown effluent
- Similar treatment levels as a processing plant

### Suitable Soils

The application rate for the system is the most restrictive bottom within the required depth.

Soil Group	Soil Texture	Soil Structure/Depth	Application Rate (gpd/ft <sup>2</sup> )
I	Sand, Loam, Silt	Any structure/depth	1.0-1.5
II	Sand, Silt, Loam	Open, friable, well sorted, permeable, 18" depth	1.0-1.5
III	Sand, Silt, Loam	Open, friable, well sorted, permeable, 18" depth	1.0-1.5
IVa	Sand, Silt, Loam	Open, friable, well sorted, permeable, 18" depth	1.0-1.5
IVb	Sand, Silt, Loam	Open, friable, well sorted, permeable, 18" depth	1.0-1.5
V	Sand, Silt, Loam	Open, friable, well sorted, permeable, 18" depth	1.0-1.5

### Site Classification Features

Type of System	Depth to limiting condition				
	>42"	42" - 36"	36" - 24"	24" - 18"	<18"
Septic Tank/Conventional	✓	✗	✗	✗	✗
With Shallow Placement	✓	✓	✗	✗	✗
Septic Tank/Low Pressure Pipe (LPP)	✓	✓	✓	✗	✗
Advanced Treatment/LPP	✓	✓	✓	✗	✗
Advanced Treatment/Subsurface Drip (Material)	✓	✓	✓	✗	✗

### Common Conditions That Limit Suitable Soil Depth

- Bedrock
- Water Table
- Fragipan
- Claypan
- Rock Content >70%
- IVb Clays

### In-ground Systems

- Allowed on lots smaller than 3 acres.
- Relies on soil and microbes to treat and break down the effluent.
- Must have the required vertical separation between the bottom of the trench and a restrictive layer.

### Conventional System

- Typically, completely gravity fed.
- Typically, cheapest in ground type system.
- Functions through the infiltration of effluent into the ground.

### Cross-Section

- Trench depth at 18"-30"
- 18"-36" trench width.
- 24 inches of vertical separation below trenches of suitable/provisionally soil.
- Gravel filled or gravelless trenches.

### Biomat

- A heterogeneous layer composed of accumulated suspended solids and organic matter contained in the effluent, a large number of microorganisms and their metabolites and by-products (e.g., extracellular polymeric substances).
- Slows drainage but provides treatment to the effluent.

**Size Calculation**

120 Gallons per bedroom or 60 gallons per person, whichever is greater.

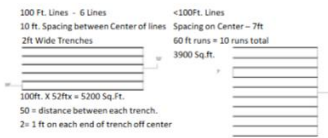
Gallons Per Day + Application Rate of bottom of trench = Total Trench area  
 $360 \text{ Gpd} \div 0.3 \text{ gpd/sq.ft} = 1200 \text{ Sq.Ft.}$

Total Trench Area + Width of Trench = Linear Feet of Trench  
 $1200 \text{ Sq.Ft.} \div 2 \text{ Ft.} = 600 \text{ Ft. Of Trench}$

**Calculation Continued – 600 Linear Ft.**

100 Ft. Lines - 6 Lines <100Ft. Lines  
 10 ft. Spacing between Center of lines Spacing on Center – 7ft  
 2ft Wide Trenches 60 ft runs = 10 runs total  
 3900 Sq. Ft.

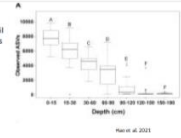
100ft. X 52ft = 5200 Sq. Ft.  
 50 = distance between each trench.  
 2= 1 ft on each end of trench off center



**Trench Depth**

Filtration relies on the inherent properties of the soil and the presence of microbes to break down the effluent.

18" 30" x 45cm 75cm  
 ASV = Richness of species



**Common Reasons for not putting in a Conventional System**

- IVb clays – High shrink swell clays above 35% within 12 inches of bottom of the trench depth.
- Bedrock at unsuitable depth – 12 inches below trench bottom.
- High ground water contamination potential eg. Cherty clays w/o 48" separation between trench bottom and bedrock, or highly permeable sandstone
- Lack of area – low application rate means large field.
- Evidence of high ground water (Chroma 2) before 42" depth
- Restrictive Layer (fragipan, claypan) before 42" depth
- >50% rock content in or below trench depth.

**Restrictions**

- No Lengths longer than 100ft
- Slopes >15% require remediation
  - Slopes >30% are not allowed except when meeting specific requirements and require authoritative approval
- Trench Width Maximum 3ft – recommended 18-24"
- Minimum distance between trenches is 5ft or 3x the width of the trench.
  - Suggested trench separation on center is 10 ft.

**Modifications to the Standard System**


- Sand lined trenches
  - Used when rock content is above 50%
  - When severe geologic limitations are present, meaning high environmental contamination potential.
  - May need county approval
- Shallow Placement
  - Need 2ft separation from bottom of trench to restrictive layer or seasonal high water-table
  - Top end of gravel can be brought to surface and covered with 8-12" of suitable soil (county dependent).
  - Still need minimum separations to restrictive layers.

**Engineered Systems – When a Conventional Doesn't Work**

- Many different types of systems are possible
  - Low Pressure Pipe
  - Drip Irrigation
  - Pressby
  - Sand Mound
  - And more...
- Simply state that an engineered system is necessary, not which type unless a specific system is requested and suitable (in regions)
- Responsibility rests to the engineer and the installer.

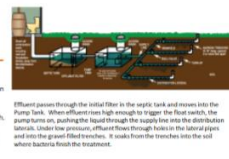
**Engineered Systems Overview (LPP/Drip)**

- In ground systems
- Require design by an engineer
- Water pressure and flow to the field is maintained by a pump
- Electricity is required
- Extra filtration within the tank is required




**Low Pressure Pipe System**

- Can be a smaller footprint than a standard system.
- Requires an effluent filter on the Septic tank.
- Requires a Pump Tank.
- Lines are put in at 22" depth.
- Higher Maintenance.
- May be permitted on sites with cherty clays or geologic restrictions.



### Size Calculations

- Simpler calculation
  - Gallons per day ÷ application rate
- Ex. 360 gpd / .15 = 2400 sq. Ft.
- No line longer than 70ft.



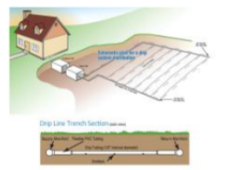
### Requirements/Restrictions

- 12-inch trench depth.
- 12-inch vertical separation from limiting layer.
- 4 ft. Separation between trench bottoms and bedrock in cherty clay soils or soils with geologic restrictions.
- Must be engineered.
- A modified nonstandard septic tank and a pump tank.
- No slopes greater than 10% without modifications.
- Any subsurface ground water (Redox features) shall be diverted to a minimum depth of 24 inches.
- Limit soil disturbance to installation of the field.

### Situations to use the LPP

- Rock Content above 50% or even above 70% (Sand lined trenches) at depths <30inches.
- When there are restrictive layers that occur beyond 12 inches of the trench bottom, or beyond 24 inches of the soil surface that would prevent the installation of a conventional system.
- Areas of lower slope percentage (<10%).
- Smaller sites that require a smaller field area.


### Drip Irrigation System



- Highest maintenance.
- Aeration tank and pump tank.
- Shallowest field (6-8") trench depth.
- Can be located in 10% slopes.
- 6-8 inch trench depth.
- Cleanest output due to aerated tank.

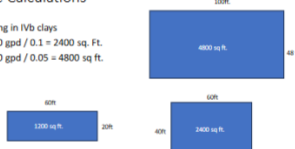
### Size Calculations

- Simpler calculation
  - Gallons per day ÷ application rate
- Ex. 240 gpd / 0.2 = 1200 sq. Ft.
- No line longer than 100ft.



### Size Calculations

- Siting in IVb clays
- 240 gpd / 0.1 = 2400 sq. Ft.
- 240 gpd / 0.05 = 4800 sq. Ft.




### Usage Situations

- Trenches are typically dug at 6 or 8 inch depth. Needs 12 inches of separation between bottom of trench and restrictive horizon.
- Can be placed in IVb clays (.05-.10 gpd/sq.ft. application rate).
- Sites with limited space.
- Sites with shallow bedrock, fragipans, claypans, or horizons with heavy coarse fragments at shallow depths.

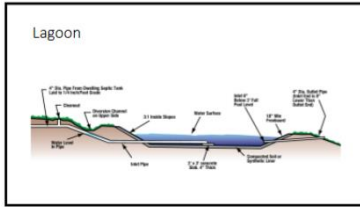
### Requirements/Restrictions

- Requires Electricity to work the aerator and pump tank
- 18" minimum suitable soil depth
  - o 12 inches separation between bottom of trench.
- >70% coarse fragments in top 18"
- Not for sites that are temporary/not receiving consistent water usage.
  - o Loss of aerobic bacteria

### Above Ground Systems



- Lagoon or Constructed Wetland
- Rely on evapotranspiration to treat wastewater
- Highly effective
- Often low in cost



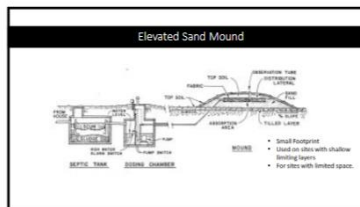
- ### Sizing/location
- 440 sq.ft. per bedroom
  - Possible reduction of 20% if a septic tank precedes the lagoon. (Call local counties to see if this applies)
  - Minimum of 900sq.ft.
  - Keep away from drainage ditches, heavily sloped areas, and heavily wooded areas.

- ### Usage Situations
- Soils with high shrink swell clays.
  - 3 ft separation of soil between pond bottom and bedrock.
  - Not to be sited above fragipans, creviced bedrock, or sites with large quantities of coarse fragments without a liner (clay or synthetic).
  - Typical for larger properties
  - Typically, the cheapest and lowest maintenance system

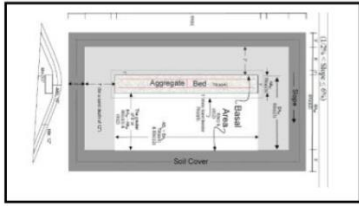
- ### Requirements/Restrictions
- Greater setbacks than in ground systems
  - Not for subdivision lots less than 3 acres
  - 200' from neighboring residence and 100' from homeowner's
  - 12" of high shrink swell clays on site or bentonite clays brought it or a synthetic liner
  - No steep slopes (>15%)
  - Cleared of large trees for 50 feet from the water's edge.
  - No shrubs or deep rooting plants on the embankment
  - Round or rectangular no greater than 3 to 1 dimensions
  - Must have a fence.

- ### Wetland
- Relies on biological and natural processes to treat wastewater.
  - Must have pretreatment (Septic Tank, Aeration Tank)
  - Submerged flow wetlands are the only wetland system allowed in MO
  - Channels are filled with gravel/sand to support root systems of the emergent aquatic vegetation.
  - Setbacks are the same as a lagoon.
  - Single cells are used in soils with slower drainage.
- 
- The diagram shows a cross-section of a wetland system with water flowing through a channel filled with gravel/sand, surrounded by emergent aquatic vegetation. The source is cited as 'Cull.columbia.edu'.

Plant Species	Wet Weight	Dry Weight	Tap Dry	Root Dry	Top/Root	Root Depth
Sediment Bedrock (Scirpus validus)	9.74	4.29	3.20	1.00	3.20	7.0
Horsetail (Equisetum hiemale)	1.80	0.55	0.20	0.35	0.57	11.0
Water Lily (Najas guineensis)	3.28	0.66	0.31	0.35	0.90	8.0
Pickered Rush (Phalaris carolinensis)	6.24	1.30	0.50	0.80	0.63	15.0
Axononema (Sagittaria arifolia)	2.21	0.35	0.17	0.18	0.94	10.0
Cattails	7.89	3.00	1.90	1.10	1.73	8.0
Soft Rush (Lycopus effusus)	3.00	1.05	0.65	0.40	1.62	18.0
Flowering Rush (Lycopus uniflorus)	0.30	0.07	0.01	0.06	0.18	12.0



- ### Sizing
- Basal Area
  - Daily Water usage + Loading Rate of onsite Soil
  - Base Loading rate on 24" depth
  - $360/0.5 = 720$  sq. Ft.
  - Aggregate or Bed area
  - Daily Water Usage + Loading Rate of imported sand
  - $360/1.2 = 300$  sq. Ft.



### Usage Situations

- Flat(fish) areas (0-6% slope) with few ground water contamination possibilities
  - No redox features within 24"
  - No Bedrock within 4", especially in very rocky soils
- Space restricted sites

### Restrictions

- 50 ft. Downslope set-back from the property line.
  - This area is not to be disturbed as it is the part of the effluent dispersal area.
- Bedrock, redox features, or high clay content soils with no pores occurring within 24 inches of the surface.

### Holding Tank

- Last resort system for extremely space limited, setback limited sites.
- Case by case.
- Temporary solution
- Can be used in conjunction with a septic tank.
- Must be approved by the Authority.

### Requirements

- A Contract with a valid septic manager for regular pumping and removal
- An alarm or warning when 75% full
- 400 gallons x number of bedrooms
- Must be readily accessible by a pump tank.

### Sand Filters

- Typically, an additional filtration agent to be used alongside soil absorption systems in slowly permeating soils.
- May discharge onto surface if able to meet setbacks.
- Reduces the size of a conventional field by 1/2 and precludes shallow placement.

Americangeneration.com

### Presby System

- A filtration system with a standard septic tank.
- Processing of BOD happens in the pipes in the trenches.
- Minimum 12" of non 35% I/bv clays
- Small footprint – GPS/Application rate of smaller
- In ground or mounded if less than 24" of suitable soils.

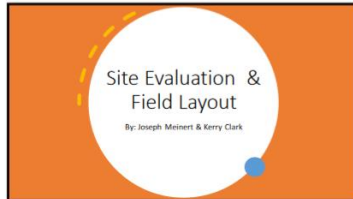
### The right system

- The right system is the system that will
  - Work with the soils onsite
  - Be within the budget of the homeowner
  - Have a manageable maintenance schedule for the homeowner

### Size the following fields

- Standard System 4 bedrooms 0.3gpd/sqft application rate
- LPP system 2 bedrooms .2gpd/sqft application rate
- Lagoon - 6 bedrooms w/ 20% reduction
- Drip Irrigation system - 3 bedrooms .15gpd/sqft application rate

## 2.5 SITE EVALUATION



### Beginning the Process

**Prior to Arrival**

- Homeowner knows all the information they should have
  - Plot, survey, or detailed map of the property
  - Deed number
- Building Plans
  - Homeowner, Sub, or Contractor/Builder
  - Homeowner understands the process and what you will be doing onsite
  - Locate Utilities!

**Upon Arrival**

- Ensure you are at the correct property
- Record the homeowner's information and explain the process and possibilities of outcomes
- Examine and discuss the building plans, survey, property, and possible utility lines
- Begin looking for property lines, and other important features.

### Necessary Information

Property Owner	Billing Address		Date
Site Address			
State	Zip	County	
Latitude, LAT	Longitude, LONG	Legal Location	Lot #
County	Legal Location	Lot #	Sub #
Homeowner's Information	# People	Location	Landmarks
Business Type	Design Fee	golf	System In
		New	Replacement
			Repair

### Materials to bring

**Site Layout**

- Tape Measure (300ft)
- Compass
- Clinometer
- Flags
- GPS recordings
- Pencil
- Report
- Range finder
- App with property lines

**Soil Description**

- Soil Core
  - Hammer/Swinging tool
  - Munsell Color Book
  - Handbook for describing soils
  - Soil Knife/small picking tool
  - Water
  - Tape measurer 12ft
  - Pencil
  - Report

Moisture	Temperature	Color	Texture	Structure	Permeability
100%	60°F	10YR 5/1	CL	Blocky	100%
80%	65°F	10YR 6/1	CL	Blocky	80%
60%	70°F	10YR 7/1	CL	Blocky	60%
40%	75°F	10YR 8/1	CL	Blocky	40%
20%	80°F	10YR 9/1	CL	Blocky	20%
10%	85°F	10YR 10/1	CL	Blocky	10%
5%	90°F	10YR 11/1	CL	Blocky	5%
0%	95°F	10YR 12/1	CL	Blocky	0%

### Variations

**To be considered for a Variance**

- Properties platted prior to 1996
- Higher forms of pretreatment
- Assurances of protection of public health and quality of surface and ground waters.

**Types of Variations**

- Setback Distances
- Depth of restrictive layer/bedrock
- Minimum area

### Checklist – Things to look for in the field

Buildings & Property	Natural Features
<ul style="list-style-type: none"> <li>Home location</li> <li>Property Lines – minimum 10ft distance</li> <li>Powerlines – Utility company easement depends on size</li> <li>Underground Utilities</li> <li>Well (Public 300ft &amp; Private 100ft) distance</li> <li>Old roads - compaction</li> </ul>	<ul style="list-style-type: none"> <li>Floodplains - avoid</li> <li>Drains/dry creeks/beds – 25ft distance</li> <li>Streams, Creeks, Rivers – 50ft distance</li> <li>Rock Outcroppings - avoid</li> <li>Sinkholes - avoid</li> <li>Slope of Landscape</li> <li>Bedrock shelves</li> <li>Seasonal features - avoid</li> </ul>

### Site Evaluation

- Discuss if they have a preferred site or system
- Walk the potential areas – Start downslope from the house with the homeowner.
- Lay out the house, buildings, roads, and any other construction that might influence the septic system.
- Ensure you know where the property lines are. Find a corner, fence row, or other visible marker.
- Look for areas that lay well – Uniform, linear contour, <15% slope, no rock outcrops/surficial bedrock, no drainage ways.
- Often these areas are shoulders or backslopes

### Necessary Site Information

LANDSCAPE POSITION: \_\_\_\_\_ Slope aspect: \_\_\_\_\_

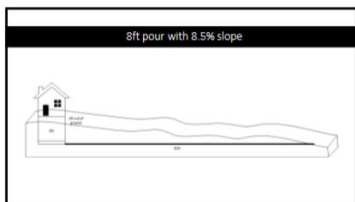
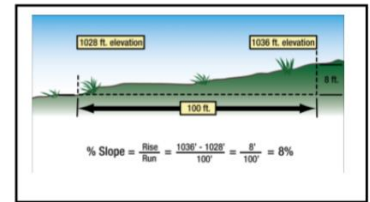
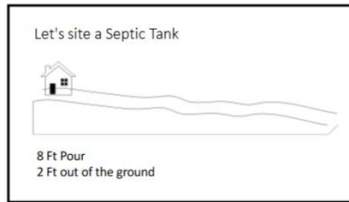
Flooding Frequency: None  Rare  Occasional  Frequent  Surface depression(s) in evaluated area? \_\_\_\_\_

**TOPOGRAPHY** Percent Slope: \_\_\_\_\_ Slope Type: Uniform  Complex

Slope across contour: \_\_\_\_\_ Slope down gradient: \_\_\_\_\_

### Gravity Flow – Drop to the Tank and Field

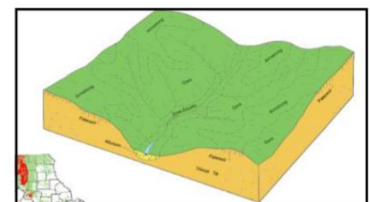
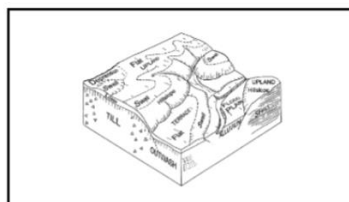
Basement	Foundation
Figure out depth of pour (8, 9, 10ft) and how much they are holding their house out of the ground	Crawlpace or Slab
Drains usually come out 1 ft. underneath the basement floor	Slab – drains 1-2 ft beneath surface
8 ft pour = 2 ft. out of ground + 1 ft for drain = 7 ft of fall necessary.	Crawlpace = 2-3 ft beneath surface

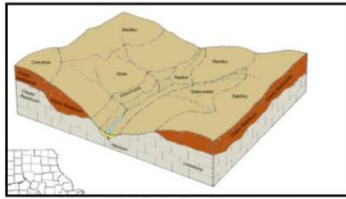


- ### Extras with Tank Siting
- Consider location for ease of pumping.
  - For every 100ft distance you need 1 more foot of fall and a clean out.
  - Keep aware of your Set-Backs
    - Well (50ft.)
    - Stream or lake (50ft.)
    - Driveways (25ft.)
    - Property Lines (15ft.)
  - Be aware of things like having to hammer bedrock for the tank.
  - Avoid crossing ditches, waterways, or gullies
  - Can go under roads

- ### Siting A Field - Good Aboveground Features
- Areas that are uniform - **Must**
    - No complex slopes
    - No drastic changes in slope
  - Downslope from the Home – Good Practice
  - Sheds Water – Good Practice
  - Moderately Sloped >2% and <15% – Good Practice
  - Clear of Trees – Situational

- ### Things to Avoid when Siting a Field
- Flood plains – Avoid almost always
  - Slopes greater than 30% - Avoid almost always
  - Complex Hill Slopes – Always Avoid
  - 1st Order Drains – Always Avoid
  - Rock Outcroppings – Always Avoid
  - Surficial Bedrock – Always Avoid





### Field Layout

- Depends on the discussion with the homeowner as to an inground system or above ground system, but soils are the final decider.
- Calculate field for the maximum size that could be needed eg. A lower application rate (.3 for standard system, .15 for engineered system), more space between runs (10ft recommended).
- After finding setbacks begin laying out most restrictive side (aim for 100ft with the contour).
- Then measure the up or down the slope to find the second side.
- Measure another 100ft line with the contour for the 3rd side.
- Close the rectangle and ensure that there is enough space.

### Siting Techniques – Location Specific

#### Dig First – Site Second

##### PROS

- Gives you soils information first to inform type of system and size
- If you need to relocate haven't laid out field yet

##### CONS

- Soil pit can end up in the field depending on the size.
- Soil pit ends up too far from the field

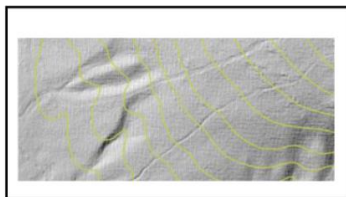
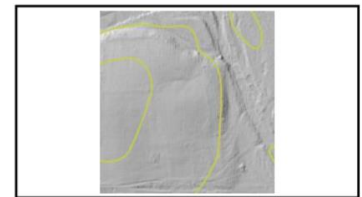
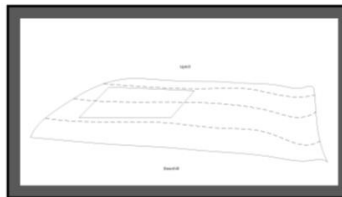
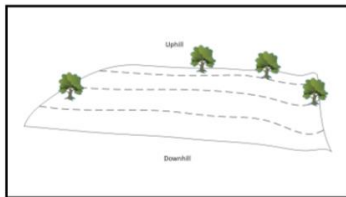
#### Site First – Dig Second

##### PROS

- Siting for maximum size means not having to change sites if soils are not suitable for a standard system.

##### CONS

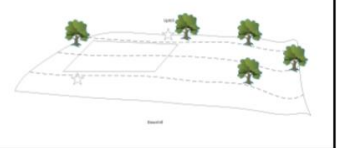
- Can waste time siting if homeowner decides based on the soils they want to try a new location



### Pit Locations

- Recommended 2 pits
  - One above the field
  - One below
  - Try to do opposite corners as well
- Differs depending on county
  - Some more, some less
- Keep the pits out of the field itself
  - Unless it's a lagoon or wetland, then 1 pit in the middle

### Pit Locations - Field



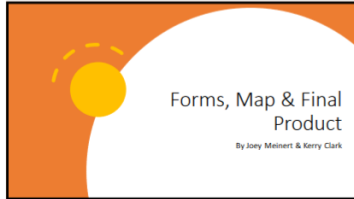
Lagoon

- Ensure the homeowner is ok with having a lagoon
- Need soils with high clay % and high shrink swell if not wanting to use a plastic liner
- There are different setbacks for a lagoon.
- 440sqft x number of bedrooms – minimum 900 sqft.
- Know if your county allows for a reduction in size if it has a septic tank.
- Can not have a greater ratio of 3:1 for the length and width.
  - Must be square, round, or rectangular
- Dig your backhoe pit in the middle of the site
- Avoid Steep Slopes >15%

Closing up the Process – Before you leave

- You have all the homeowner and property information.
- You have agreed to the type and location of the system.
- You have enough soil pits described.
- You have the site completely laid/flagged out and some form of a drawing with measurements on it.
- The homeowner and you agree upon the type of system and its requirements
- You get paid or have an agreement about payment.

## 2.6 FORMS, MAPS, FINAL PRODUCT



**State Form**

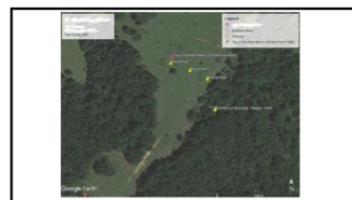
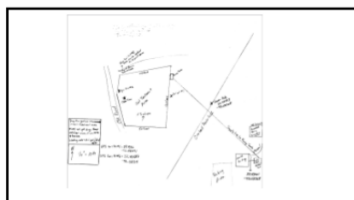
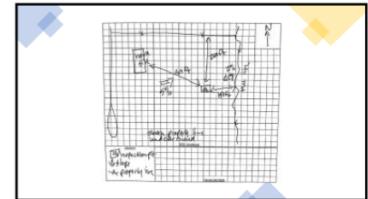
- <https://health.mo.gov/living/environment/0/msha/pdf/StateEval.pdf>
- May need some revision based on county requirements.
  - Number of pits
  - Set-backs
  - Easements
  - Detail of map
- Always contact your local county Health or Building Departments for any questions on county requirements.

**Site Map - Introduction**

Property Owner	Building Address		Date
Site Address	MO	County	
Submission Lot	Dist	Section	
County	Legal Location	1/4	1/4
Number of Bedrooms	# Porch	Latitude	Longitude
Replacement Type	Design Size	System to	Replacement C1
			Replacement C2

**Site Diagram**

- Buildings
- Wells
- Property Lines
- Rock outcroppings, depressions, sinkholes
- Soil WC elevations
- Roads
- Slope & Direction
- Record distances and angles between objects.
- Replacement Area



**Tips and Tricks**

- Familiarize yourself with a drawing software or hand drawing.
- Use GPS points and Google Earth to site yourself.
- Provide some way for an installer to locate the site.
  - Flags
  - GPS points
  - Map (Both Satellite and Drawn)
  - All of the above
- Always try and get a survey from the homeowner.
- Record as much as possible and check you have all necessary information before leaving.



### Environmental Hazards - Ground Water

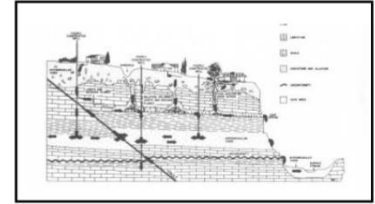
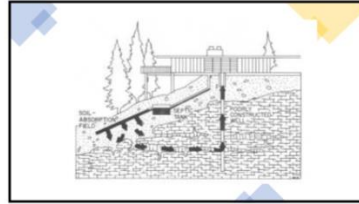
**Ground Water Contamination Potential**

Rapid Permeability – Class V soils with rock content >70%, Very sandy/gravelly soils.  
 Permeable Bedrock – Visual inspection for type of bedrock for specific formation  
 Karst features or fractured bedrock  
 Use **USGS data** to find the formation if you are unfamiliar  
 Shallow Water Tables or close proximity to multiple septic systems.

**Risks**

- Wastewater contaminating aquifers/water sources
- Spreading of pathogens

Bedrock Aspects of Residential Sewer, Liquid Waste Disposal in Missouri – 2005 Reference for best



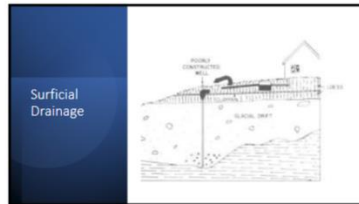
### Surficial Contamination Potential

**Conditions**

- High Slope >15%
- Shallow high permeability bedrock <4ft
- Shallow restrictive horizons
  - Clay, Claypan, Fragipan, Glacial Till
- Shallow high alkalinic swell clays
- Small lot size <1 Acre

**Risks**

- Wastewater surfacing and moving into waterways
- Waste moving into poorly constructed septic
- Spreading of biological effluents/contaminants



### Notes

- Locations of pits
- Type of bedrock – Important for shrink/swell, and geologic risk factors
- Descriptions of restricting horizons (Ex. fragipan vs fragic horizon)
- Removal of soil for lagoons
- Any oddities that be present in the pit, but not representative of the field.
  - High animal pedoturbation
  - Conditions of the pit (holding water, dry, wet)
  - Appearance of Fill Material

### Application Rates/Loading Rates – The Central Part

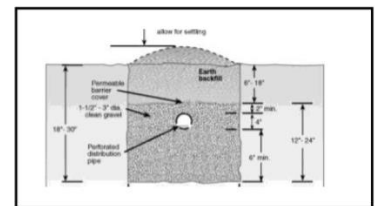
We must think long term!  
 We must give a specific loading rate, not a range.  
 Affects size of the field, amount of trench type, and overall cost of installation.  
 Affected by all the characteristics from the soils.

- Texture, structure, pores, roots, coarse fragments, stone sand

Soil Type	Soil Description	Soil Characteristics	LR - BT	LR - BT
II	Heavy Sand, Coarse Sandy Soil, Coarse	Structure: No soil structure. Permeable. Pores: Large, continuous, and regular. Heavy	0.5 - 0.7	0.7 - 0.9
III	1/2" to 2" Clay Scales, Sandy Soil, Coarse	Structure: No soil structure. Permeable. Pores: Large, continuous, and regular. Heavy	0.5 - 0.4	0.4 - 0.5
IIIa	1/2" to 2" Clay Scales, Sandy Soil, Coarse	Structure: No soil structure. Permeable. Pores: Large, continuous, and regular. Heavy	0.4 - 0.3	0.3 - 0.4
IIIb	1/2" to 2" Clay Scales, Sandy Soil, Coarse	Structure: No soil structure. Permeable. Pores: Large, continuous, and regular. Heavy	0.3 - 0.2	0.2 - 0.3
IIIc	1/2" to 2" Clay Scales, Sandy Soil, Coarse	Structure: No soil structure. Permeable. Pores: Large, continuous, and regular. Heavy	0.2 - 0.1	0.1 - 0.2

### Loading Rates – How to decide

- Structure is very important
  - How will water be able to move in and around the structure
- Pores are very important
  - What are the size, shape, and continuity of the pores
- Affected by BOD (Biologic Oxygen Demand)
  - Pretreatment after a septic tank can raise the LR
- Bulk Density (compaction) & clay mineralogy (smectitic vs kaolinitic)
  - Both affect overall water movement or how the soils will react to water



### Adjusting Loading Rates

Site Requirement	Typical LR	Alternative LR	Control LR
Loadage Problem	Highly Restrictive, Nonconform slopes	Lower soil slopes	Shed, Soil or Soil Slopes, or Zoned Slopes
Soil	Clay	Loam	Dark
Soil Structure	Granular or Single Grain	Subangular Blocky	Angular Blocky, Platy
Soil Shrinkage	High or More Than 1.1 day	1.1 day	Moist shrinkage of 2.1 day
Soil Shrinkage	248 inches deep	36-48 inches deep	248 inches
Soil Depth	248 inches deep	36-48 inches deep	>48 inches
Restrictive Horizons	248 inches deep	36-48 inches deep	248 inches deep

### Choosing the right one

- Choosing a Loading Rate above the actual value risks having too small of a field, the lines clogging up, and the system failing.
- Choosing too low of a loading rate means you will have an over-large field and increase the costs for the homeowner.
- It is a range for a reason.

### Loading Rate Practice

Site 1

- Backslope, 18% slope
- >48" Soil depth and no water table or restrictive horizons

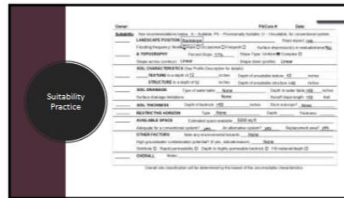
LR	Field	Cost	LR	Field	Cost	LR	Field	Cost
10	1000	1000	20	500	500	30	300	300

### Loading Rate Practice

Site 2

- Footslope 6% slope
- Water Table at 18 inches
- Restrictive Layer at 37 inches

LR	Field	Cost	LR	Field	Cost	LR	Field	Cost
10	1000	1000	20	500	500	30	300	300



### DNR vs SUBDIVISION vs Large Systems

- DNR
  - >3000 gallons per day
  - Contact DNR about the requirements for the application before proceeding.
  - Read through 10 CSR 20-8 to find the specifics needed for this site.
  - Typically involving engineering firms and larger corporations
- Deals with
  - Construction CAD
  - Construction Sewer Extension
  - Construction Wastewater
  - CRF (General Permit Covered Facility)
  - Underground Injection
  - Municipal Wastewater
  - AND MORE!

### Subdivision or Mobile Home Park

- Depends on the county
  - Contact local health department or building code enforcement for information on number of pits, map type, necessary information before the job.
- Feasibilities
  - Map of the soils across the subdivision land, where they change, their characteristics and suitability
  - A pit center for each lot, described with recommended systems.
  - A whole site treatment center.
- Restrictions
  - No lagoons on lots <3 acres.
  - Must record all easements and setbacks.
  - Higher risk of surficial and ground water contamination.

## **APPENDIX 3 – SCRIPTS**

These materials are available through the author, by request, for academic use one, through MSO courses, conferences, and workshops, or online through The National Onsite Wastewater Recycling Association's Online Learning Academy.

### **MISSOURI GEOLOGY**

#### **GEOLOGY INTRO SCRIPT – VIDEO 1**

Hi. My name is Joey Meinert. I am currently a graduate assistant at the University of Missouri Columbia where I study Soil Science. I have also been a registered soil evaluator for the State of Missouri for the past year and have worked in soil evaluations for 3 years. I'll be talking you through our lesson today.

Welcome to our unit on the geology of Missouri. In this unit, we'll be looking at the geologic history of our state and how this history has affected the soils that have developed across our state. It is important to understand the geology of a region as the geologic history plays a big role in shaping the current characteristics of our soil. This can be anything from the color of the soil, to the texture, to the structure. Finally, we'll take a brief look at how the characteristics will affect the work that we soil evaluators are doing when we are on our jobs.

Let's take a look at each of the regions that we'll be studying in Missouri.

In the northern part of Missouri, we have our Central lowlands which have been dominated by the role that glaciers have had upon the region. To understand this region, it is important to know how glaciers deposited their materials as they retreated and the

soils that have formed since then. As we move South, we move out of the glaciated regions into our rockier and more residuum dominated regions. These are the Osage Plains in the west, the Springfield plateau in the southwest, the Ozark plateau in the central and south eastern part of the state that contains the Saint Francois mountains, and finally, we have the coastal plains and alluvial deposits of the Mississippi and Missouri Rivers.

The soils of each of these regions have specific traits and characteristics. These characteristics are dependent on the geologic history of that region. The soils have been shaped by the history of the region and understanding this history can help us make better decisions as soil evaluators. Missouri has a fascinating geologic history. With large scale geologic events having occurred as recently as 11,000 years ago and all the way back 1.5 billion years ago when some of the oldest mountain ranges of the US formed from one of the largest volcanoes in the history of the world. We'll get into more of those as we move into the specific regions, but understand that there is a huge variety of events that have shaped the soils across this state.

We can see that this is true by the different types of soils that are present in our state. As we look at a map of the soil orders of our state. We can see that there are about five common soil orders across the state. In the Western half, we have typically Mollisols. These are our prairie soils with high organic matter content. These formed due to the slightly drier climate of this region. As we move east and south, we have more Alfisols, which are often our forest soils, more highly weathered and with more clay development, and our Ultisols, which are even more, highly weathered soils, often with the accumulation of aluminum or iron. On other end of the spectrum, we have our younger

soils which are our Entisols and our Inceptisols and these are often very common along the many riverways of Missouri.

So we might ask what is often the cause of these different soil orders in Missouri. One of the big things is not only it's geologic history but also how long they've been around.

Here is a common chart that shows the conditions that push a soil to develop into a specific soil order. The amount of moisture present and the temperature are some of the leading forces driving soils into different soil orders. For our Mollisols, they often had semiarid grasslands that have allowed the accumulation of organic matter. Alfisols are more highly weathered in Missouri, often due to higher temperatures and more rainfall of most of Missouri. Clays begin moving downward in the soil profile and accumulate there. Our highly weathered soils, our Ultisols, have lost many of the base cations that were present during their initial formation and these cations have been replaced by iron or aluminum.

Understanding this weathering process is necessary for our job as soil evaluators. This has to do with the central role that clays play in the type of septic system that can be installed. Different types of clays can be restrictive as to whether or not a conventional system, an engineered system or a lagoon, will be required at a site.

Let's go over the specifics of these clay minerals and talk briefly about how they weathered in each region. The two types of clay that we will talk about today are high shrink-swell clays and low shrink-swell clays. Our high-shrink swell clays are our smectitic clays. These are our less weathered clays that have the ability to expand and contract when they are wet or dry. These are common in our glacial regions and for clays

that are closer to their parent material bedrock. Our more weathered clays or our low Shrink swell clays have lost the ability to expand and contract often through high amounts of weathering that have occurred or because of their initial chemical compositions. The rule of thumb here is the less amount of weathering that has occurred at a location, the higher the amount of shrink swell potential these clay minerals have.

We will discuss the specific weathering and clay mineralogy in each region and how that pertains to septic systems in following videos.

Now, let's take a brief look at some of the geologic formations that are present in our state. When I say geologic formations, I mean the bedrock that we would encounter when we're at that location. This could be bedrock that appears at the surface or occurs within a few feet, which is common across much of Southern reaches of our state, especially in the Southeast area. But as you move to the northern parts of our state, the bedrock can often be 50-100 foot down, if not further, because of the depth of our glacial materials that were deposited upon on top of this rock. The geologic formations listed are in order from the oldest on top to the youngest on the bottom. When these bedrocks were first deposited ranges from 1.5 billion years ago with the Precambrian rocks in the St. Francois range in SE Missouri to about 300 million years ago with the sea deposits of the Pennsylvanian age.

As we begin to explore our state, it is important to remember and learn about the geology of this state as the geology and other climatic conditions determine how the soils originally formed and how they have weathered since their formation. These geologic

conditions give us as soil evaluators important information on the siting and suitability of septic systems in each region.

Before we go any further, I wanted to point out some resources that can be used to increase your knowledge of Missouri's geology and help with identification of geological formations in the field.

Missouri Landscapes: A Tour Through Time

Washington Universities Field Guide to the Geology of Missouri

Geologic Aspects of Individual Home Liquid-Waste Disposal in Missouri.

From here, we're going to take a look at some of the individual regions and the soil properties that are common in that region. We'll discuss the geologic history of that region and I'll give you some examples of landscapes and soil profiles that occur there. Finally, we'll discuss some of the challenges and concerns of septic systems we have in each region.

Glaciers & Loess (Northern Missouri) Video 2

If you've spent any time driving around this state, you'll have noticed that the landscapes of Missouri that are South of the Missouri River and those North of the Missouri River are quite different. This has to do with the geologic history of these regions. In this lesson, we will focus on Northern Missouri and look at the ways this landscape was shaped, the different types of parent material that are present across this region and how these characteristics affect wastewater disposal.

For the majority of Northern Missouri, glaciers have been the dominant driver of soil change in the region. So let's take a look at what glaciers are and how they have affected the soils in Northern Missouri.

Glaciers are large sheets of ice that formed during our previous ice ages, from about 1.8 million years ago to about 11,000 years ago. These large thick ice sheets would expand as they moved further and further south, flowing like very slow water across our landscapes. These glaciers had massive amounts of force present in them. As they moved, they ground up rocks and soil, incorporating them into their ice, and mixing them all together. These ground up rocks and soil were then transported with the glacier as it moved.

In Missouri, our most recent severe glacial period, in which large scale glaciers covered the land is around 600,000- 1 million years ago. In the map, we can see the extent that these glaciers reached into Missouri during this time period. That line may appear familiar to many of you. Where the glacier stopped advancing and started retreating set the eventual course of our modern-day Missouri River. As the glaciers melted and began retreating, they deposited much of the ground up materials that had been present in the ice. This material would become the soil of Northern Missouri, and is categorized as either glacial till or glacial outwash. Let's examine each of these more closely.

As glacial till is the deposition of these mixed-up materials, it often has a loamier texture and may have some rocks that are not sorted, meaning they are not found in specific horizons or are not all oriented the same direction. These rocks will also be of varying geologic origin, such as metamorphic or igneous rocks, such as granite, rhyolite, or silicified sandstone, that are not as common in other parts of Missouri. Since the original

deposition of this material, there has been significant amounts of weathering and pedogenic formation. This has led to the downward movement of clays and the formation of a clay bulge in much of this region. This is visible in many of the soils that are present across Northern Missouri. Let's take a look at some of the soils across this region and where they are located. The first is the Mexico soil series, located in the clay pan of eastern Missouri. It has an abrupt textural change at a very shallow depth, moving from a silt loam to a clay. Other series across northern Missouri, such as the Gara in north central Missouri and the Lamoni series in North Western Missouri have similar shallow horizons with high clays percentages present. We'll talk shortly about what this means for septic systems, but first let's look at some of the common characteristics of these landscapes.

As we can see in these block diagrams, much of this region is either relatively flat or has very gentle slopes. It is rare that you will see slopes greater than 20%. In the following videos you'll see some examples of what this region looks like.

The other material that is deposited from glaciers is glacial outwash. These materials were deposited by moving water as the glacier melted, rather than being deposited in place. They moved along with the melting stream of water as the glaciers retreated. For this reason, they often contain coarser materials, meaning more rock and sand, and less clay materials. These soils are much less common than glacial till soils. They should be something that you watch out for particularly around the region where the glaciers ended their advances, as these deposits originate from the melting. Their high rock content can be a concern for septic systems. You may find them in lower parts of the landscape and the clear sign will be high amounts of partially sorted rock fragments.

The last material to discuss that is a product of the glaciers is loess. Loess is a very unique and ubiquitous parent material in Missouri. Nearly the entire state has had some deposition of loess.

What is loess? Loess is typically described as silt and clay particles that have been picked up and then later deposited by wind. For Northern Missouri, we see such large amounts of loess deposits due to the influence that glaciers had upon the land. During the period of glacial retreat, the warmer summers would cause large amounts of ice to melt, causing sediments to be carried off the glacier and deposited in front of the retreating glacier. As the seasons changed and winter came along, the weather was cold enough that the glaciers would no longer be retreating or advancing, but the sediments that were deposited were still present. These exposed sediments would be picked up by the heavy winter winds and moved many miles across the state. These deposits can be as thin as a few feet such as in the clay pan region of North Eastern Missouri, or greater than 20ft deep along the Missouri River.

So how do we recognize these soils. Firstly, as loess is a wind-blown material, it is extremely rare that you will find rock fragments in these soils. If you are moving down the soil profile and encounter a change in rock fragments, you should estimate that you have moved out of the loess and into a different parent material. Second, Loess is typically dominated by silt sized particles. As we can see by some of the loess derived soils of Missouri, such as Menfro, Ida, or Monona, our textures stay relatively consistent as you move down the soil profile. It is extremely rare to find loamy textures in loess parent material. Pedogenic processes still have an influence on these soils and you can

being to see the formation of a clay bulge in loess derived soils. These may be a concern for wastewater disposal.

Loess landforms often occur around our larger rivers of Missouri. The hills of loess landforms are often larger than the hills formed from the erosion of glacial till. They are often rolling hills and can have steeper slopes than glacially formed hills. These landforms and soils are highly erodible, so care should be taken to not expose loess to too many of the elements.

Now let's discuss some of the challenges that Northern Missouri can run into when dealing with wastewater disposal.

The most common and most important concern will be the characteristics of the clays of this region. The clays that have formed in most of our glacial till are high shrink swell clays, or type IVb clays. These clays close up when wet and do not allow for the infiltration and percolation of water. For this reason, it is fairly uncommon to see conventional systems in northern Missouri in our glacial till soils and it is very common to see lagoons or engineered systems that can function with very shallow placement.

In areas where there are deep depositions of loess, it is possible to have the installation of conventional systems if the clay percentages allow for it. Loess often has a moderate-high shrink swell potential meaning it is possible for some of the clays to be qualified as IVb clays, which would restrict the installation of conventional systems.

As we begin to look at other areas of Missouri, it is important to keep this region in mind as well, as there are many transition zones in Northern Missouri between loess, glacial

till, and residuum based soils such as North Eastern Missouri along the Mississippi River and along the boundary between the Missouri River and the lower extent of the glaciers.

#### SOUTHERN MISSOURI – St. Francois Mountains & Ozark Plateau (Video 2)

This video will give an overview of two areas in Southern Missouri, the larger Ozark Plateau and the smaller contained area, the St. Francois Mountains. These areas have a unique geologic history that combines large scale events that have occurred over the past 1.5 billion years, from large volcanoes erupting to shallow oceans blanketing most of the region.

The 3 dominant periods that have had a large influence on the landscape and geography of this region are the Pre-Cambrian Period, the Cambrian Period and the Ordovician Period, a timeline spanning over 1 billion years. So, let's start with looking at our oldest rocks in Missouri.

1.8 billion years ago, long before the first animals stepped foot on land, long before even plants were present on land, even before algae bloomed in the oceans, massive volcanoes erupted due to the collision of islands and the massive continent of Laurentia. These eruptions formed the eventual baserock of the majority of Missouri. The center of these eruptions was around the St. Francois Mountains in SE Missouri and 3 such caldera's are still visible, The Taum Sauk Mtn. (the tallest point in Missouri), The Butler Hill, and the Hawn Peak. Throughout the following ages, these "mountains" remained uncovered by the encroaching oceans and are still visible to visitors today.

This region has remained largely undisturbed by geologic processes other than by weathering and has left some unique bedrock and soils in this region. As these are areas

produced by volcanos, they represent the only location in Missouri to have igneous and a few metamorphic rocks that are native to the region. The two most typical rocks that you will run into in this region are rhyolite and granite. The rhyolite, as seen here, has been called Missouri Red for its reddish hue that it has. Rhyolites and granites are very fine-grained rocks that are very hard to break apart. They weather extremely slowly and are often found on the surface in the form of rock outcrops, knobs, or surficial bedrock.

Much of this land is under state or federal protection but there is still some private land in use in this region. The landscapes of this region are very hilly with numerous intersecting rivers and streams. Most of the region is densely forested, though there are interspersed glades. Slopes can reach up to 60% and there are many rock outcrops or knobs that are present. Bedrock may often be visible in road cuts around the area.

The two main parent materials that you will run into in this region are loess and residuum. While much of the loess did originate from those interglacial periods similar to the loess of Northern Missouri, there have been other deposits of loess throughout our history. One originates from an extremely warm period (the hypsithermal period) around 8000 years ago when there was little vegetation protecting the plains and prairies to the west. Wind was able to pick up silt/clay sized particles and deposit them across much of Missouri. There are many smaller recent deposits that occur as well. From the dust bowl to heavy tillage going on today, large disturbances to soil can throw up particles into the air and get carried miles away. As this soil settles it has and still does add to the depth of top soil that is present across southern Missouri.

The second parent material is the residuum or the weathered igneous bedrock. These soils often contain moderate to high amounts of coarse fragments and are a mix of clay and silt higher up with more sand coming in as we approach the underlying bedrock. Many of these soils are shallow to moderately deep, such as the Taum Sauk or Irondale Series. The majority of these soils are Ultisols, meaning that there is little likelihood that the clays that are present are high shrink swell clays, due to the low base saturation and low CEC potential in these soils.

While the soils do not often have the high shrink swell clay that commonly restricts conventional systems, there are other soil characteristics that are of concern for this area. The starting one is the depth of suitable soil above bedrock. Much of this region may not have the necessary depth of suitable soil above bedrock that would prevent a conventional system from being installed. Steep slopes are also something to watch out for in this region. There is also the possibility of encountering fragipans throughout this region on many of the gentler back slopes and foot slopes of this region. We discuss more about fragipans in the soils across landforms video. The rock content can be a further issue for the installation of septic fields in this area, as it is common for some horizons to have >50% rock fragments. Finally, an abrupt textural change between the loess and the underlying residuum can restrict the movement of water and prevent the installation of a conventional system.

Let's move off the mountains and into the surrounding areas now.

The region surrounding the St. Francois Mts and making up a good portion of Southern Missouri is the Ozark Plateau. This is a very large region with high amounts of variation that are present in both the soil and the geology of the region. From around 540 to 325 million years ago, Missouri almost entirely underwater. A shallow sea covered this region, except the small islands that are currently the St. Francois Mts. 2 distinct time periods happened during this time and each deposited unique materials across this region that eventually shaped the landscape and soils of the Ozark Plateau. The first is the Cambrian Period. The deposits of this time would eventually become mostly calcareous materials of dolomite with some limestone and sandstone deposits. The dominant formations that originated from this period are the Bonne Terre Formation and the Eminence and Potosi Formation. This region is in pink on the map.

The next great sea rise was during the Ordovician period, around 480-440 MYA. At the end of this period the Ozark Dome began to rise up. A great deal of these deposits would end up as sandstone deposits with interspersed limestone and dolomite. The major formations from this time period are the Gasconade formation, The Roubidoux Formation, The St. Peter Sandstone Formation, and The Jefferson City Dolomites. This region is brown/orange on our geologic map. It is important to remember that there is often a layer of loess across the majority of this region.

The two main types of bedrock that you will run into in this region are dolomite and sandstones. As these rocks weather they produce different types of soils. So, let's go over a brief introduction into each.

Dolomite – As dolomite and limestone are calcareous rocks, formed from the calcium rich bodies of marine creatures, the soils they weather into often have high base saturations. Dolomites and limestones often weather directly into very high clay soils, such as the Mano series, The Bardley series, or the Gatewood series. These clays often have a high shrink swell potential, especially as you approach the underlying bedrock. It is very common to find high amounts of chert intermixed with these soils, as chert is very resistant to weathering.

The other dominant bedrock of this region is sandstone, green on this map. Sandstone is often much less weatherable than dolomite/limestone and remains in place. The rocks and the soils produced from such residuum are often more permeable and allow the movement of water through them. The clays that are present are illuviated clays from the loess above and typically have a lower CEC. These soils are often sandier, such as the Lily series, The Coulstone series, or the Topazmill series. It is not uncommon that you will find large amounts of chert intermixed within the soil, or even large chert bedrock layers in these regions.

Being able to recognize the differences between the sandstone and dolomite rocks and bedrocks is important, as these different formations can often be present across the same landform. Looking at this hill slope profile, you can see that the Roubidoux makes a cap on the hill as it is much less weatherable. As you move down the hill you may get into a Gasconade formation, with restrictive clays and shallower bedrock that benches out on top of another sandstone formation. Finally at the bottom of the hill you have another dolomite formation. Being able to assess the type of bedrock you are in is of extreme importance when you are in this region of Missouri.

So let's look at some examples of these types of rocks (dolomites/Limestones, Sandstones, and Chert) and give you some helpful hints as to how to identify them.

Dolomite/limestone is perhaps the easiest if you have the correct materials with you. Both of these rocks are reactive to acid, typically hydrochloric Acid. If you apply some hydrochloric acid to either of these rocks, you should see bubbling/fizzing at the site that you applied the hydrogen peroxide. Limestone should fizz simply from any clean exposure of rock, but for dolomite, you may need to scratch and rough up the rock to get a little bit of powder before it will react strongly. If you are trying to identify this rock visually, it is often of a creamy/grey color with fine flat grains present that should still be slightly visible to the naked eye.

Sandstone is a rock that is often much easier to identify by visual cues or by feel. While it is highly resistant to erosion, it is often broken much easier than limestone/chert. The grains should be rather large and clearly visible to the eye. As you break them off the rock you should see that they feel like sand. Roubidoux sandstone is often very red, while other sandstones will have a more yellowish/brown color.

Finally there is chert. Chert is a highly resistant rock made up of silicon dioxide. When you find it in soils, it is often surrounded by soils that have weathered in place and left the chert in its original location. It is a very fine grained rock, whose grains are difficult to discern with the naked eye. It is a much harder to break rock than either limestone or sandstone and when it does break, it often forms sharp edges and points.

The landforms of this region are often much gentler than the St. Francois Mountains.

While they still have many rolling hills, there are not as many sharp slopes and ravines.

While there is a good deal of land that has been cleared from this region, there remains a good portion of forested area present across the Ozark Plateau. This region is also a region with numerous karst features, such as springs, caves, and fractured bedrocks. Many of these karst features lead to sinkholes, something that soil evaluators should always be on the lookout for. Here is an example of one near Perry Township in SE Missouri.

The variability of this region brings up many concerns for wastewater disposal. Karst features such as sinkholes or fractured bedrock can be of big concern for the safety of our groundwater, as they will not provide enough filtration for the wastewater before it reaches the groundwater and care should be taken when siting septic systems in this region. The high shrink swell (IVb) clays that form close to dolomite/limestone bedrock prevent the installation of conventional systems. It is common to find shallow/moderately deep bedrock in many locations that would prevent the installation of a conventional system. The rock content of many horizons may restrict the type of system that can be installed as well. On many of these gentle slopes it is common to find fragipans at depths between 18 and 30 inches. There are still many sites that have suitable soils across the region, but being able to decipher these differences is a key aspect of our job as a soil evaluator.

#### Springfield Plateau (Video 4)

The Springfield Plateau is the region that makes up the majority of South Western Missouri. The bedrock of this region originated during the Mississippian Period around

360-325 MYA. This is also the final period in which the majority of Missouri was covered in seas. During this period the Ozark Dome was continuing to rise and this rise caused the eventual draining of this shallow sea at the end of the Mississippian Period. During this period there were large amounts of deposits of marine creatures that eventually formed the bedrock of this region. The majority of the bedrock in this region is of the Osagean Series and the Meramecian Series, both of which are limestones, with the Osagean having more chert content and the Meramecian perhaps having interspersed shale deposits. We talk more about the characteristics and formation of shale in the Osage Plains video. As well there are diffuse distributions of sandstone bedrock throughout this region that should be watched out for, but they do not make up the majority of the region and are often not included on the geologic maps of this region. Underlying these more common series are some of the Ordovician age dolomites and limestones. These would only be found lower on the landscape or could be seen in deep cut outs.

This region is a well-aged landscape of rolling hills and gullies. While there are forests throughout this region, much of this land has been converted into pasture or farmland due to the broad summits that are present here. This region is also present to many of the karst features that are common throughout Missouri. They boast some of the highest amounts of springs, caves and sinkholes in Missouri. These karst features originate from the highly weatherable limestone bedrock that is present across this region. During the age following the Mississippian Period, this region was part of the fluctuating swampy coastline of Missouri. This led to areas with stagnant, acidic water that allowed for significant weathering of the Mississippian age bedrock and created many of the karst features of today.

The most dominant parent materials in this region are the residuum from the limestone dolomite and the loess cap that covers most of Missouri. The loess is often shallower in this region ranging from 0-2 feet thick in the southern parts of this region and perhaps up to 5ft thick in the northern parts.

The limestone of this region often weathers into soils with high amounts of clay and low amounts of sand, such as the Hoberg, Viraton, and Creldon series. The residuum of this area can have very red colors. The clays that weathered from the Osagean and Meramecian limestone often have a low - moderate shrink swell potential. This can be beneficial for the siting of conventional systems across this region. Many of these soils have high cherty rock contents, due to weatherability of limestone and the resistance of chert. Due to this high weathering, the majority of these soils are Ultisols, though there are some Alfisols and even some Mollisols interspersed throughout this region. Some care should be taken about assuming that all soils of the Springfield Plateau are of low-moderate shrink swell potential. Soils such as the Bona series, that are less weathered (Mollisol and some of our Alfisols) and have the risk of being high shrink swell soils.

Due to the low-moderate shrink swell potential of the majority of these soils, it is possible that conventional systems can be suitable in the Springfield Plateau. Though, there are many issues that need to be watched out for when in the field and siting a field. Fragipans are very common in these soils and can be located at shallow depths along the gentler slopes of this region. Remember these often originate in the top 18 – 30 inches and heavily restrict the movement of water. The bedrock, as seen in this image, often has highly variable depths and can be too shallow for the placement of a conventional system. This image is a good reminder of why we dig multiple holes and why we use a

backhoe and not a core sampler. It could be easy to overestimate the depth of soil for a system. If there are concerns around bedrock depth, probing for the depth to bedrock using a tile probe is a good strategy. This bedrock can also lead to karst features and sink holes that need to be avoided at all costs in the siting of a septic field as they could lead to contaminated ground water, streams, or wells. Lastly, the change in parent material may lead to an abrupt textural change and restrict the movement of water. This change can also bring in high amounts of chert gravels that may make a conventional system unsuitable. The red clay soils of the Springfield Plateau are of much interest to soil evaluators and are worth taking a trip to go see them.

#### Cherokee Plains/ the Osage Plains (video 5)

The last region that is dominated by the weathering of bedrock is the Cherokee plains/ the Osage Prairie. This region contains some of the youngest remaining bedrock in the state of Missouri, originating from the Pennsylvanian period, around 325-300 MYA. This was the period after the Ozark Dome had finished rising and the seas had mostly drained from Missouri. This led to large swamps and deltas across the western part of the state. These areas were highly unstable, with many fluctuating river and ocean deposits, areas filling with water or draining, and large amounts of vegetation. This variability of landform and deposition led to high variability in the geology of the region as the materials needed for shale, limestone, sandstone, mudstone, and coal to form were all present across this region. The dominant geologic formations of this region are the Cherokee Group, the Marmaton Group and the Kansas City Group. These groups are all dominated by the presence of shale, with differences in the amount of sandstone, limestone, or coal that were deposited with them. The Cherokee group has more sandstone deposited amongst

the shale, while Marmaton has more limestone. The Kansas City group has nearly equal parts limestone and shale deposits. Underlying the Pennsylvanian age bedrocks, it is possible to find Mississippian age limestones and other bedrocks that have weathered into soils along the Alluvial Plains.

As you may have guessed from the name, this area was historically dominated by prairies and is currently one of the few regions in Missouri to still be home to some undisturbed prairies. This landscape is very flat with very gentle slopes, often less than 10%. Much of the landscape has been converted into farmland over the years. There are very few rock outcrops and it is unlikely that you will find surficial bedrock in this region.

Since shale is the dominant bedrock in this region, let's talk more about it. Shale originates from the deposition of clay sized particles that have been compressed through time into a rock. As sandstone is made of sand sized particles, shale is made of clay sized particles. Because of the size of these particles, shale is a very fine-grained rock. The grains are often not visible to the naked eye. Shale can take on many different colors, such as black, grey, brown, purple, white, or blue. These rocks are highly erodible and weather very easily.

As always, it is still very common to find a deposition of loess across this region, with 2-5ft in the south and up to 10 or 20 ft deep as you approach the Missouri River. Remember that loess depositions are highly variable and depend on the slope and aspect of the location you are at.

The soils that weather from shale and the soils of this region are much different than those of the other regions we have looked at. This region is home to a large amount of

Mollisols, that have dark and deep surface horizons. These soils are much less weathered than the soils of much of Southern Missouri. The clays that form through the weathering of shale typically form high shrink swell clays. These can be at shallow depths across this region often at about 12-18 inches, such as in the Kenoma, Hartwell, or Barden series. Because of this shallow depth of clays and the general flat landscapes that are present across this region, many of the soils have water drainage problems, signified by the g next to the B, such as the Haig, Sampsel, or Macksburg soil series. Most of the soils of this region have a lower coarse fragment percentage than the soils of the rest of Southern Missouri.

The shallow clays that often have high shrink swell properties are of the main concern for many waste water disposal sites in the Cherokee Plains Region. These clays will swell up and not allow the downward movement of water. Some other common issues would be the shallow-moderately deep depth to the water table or the underlying bedrock. For sites with shallow high clay soils, it is common to see lagoons or engineered systems. The lack of slope can be of issue as well. Water needs to be shed from the field and it may be necessary to include further drainage possibilities such as curtain drains to ensure that surface water is not entering into the septic field area.

These prairie soils are a relic of a time before large scale farming took over much of Missouri and visiting them is a fascinating chance to see the native landscapes that once filled this unique region in our state.

Mississippi, Missouri & River Floodplains (Video 6)

The last region that makes up a good portion of Missouri are the natural flood plains of our state from the Mississippi, the Missouri, and many of our other rivers both big and small of our state. As many of these floodplains are still currently exposed to flood events, there is little formal “Geology” to these locations. That does not mean though that they have no geologic story to tell about the soils that are located there. For this lesson we will go over the events both human and natural that have shaped the flood plains of Missouri and the soils that have been exposed because of these actions.

Let’s begin by looking at the history of the Missouri River Floodplain, its origins, and how humans have affected the river and therefore the soils that surround the river. The Missouri River has been present in the US for around 30 million years, but the Missouri river’s current course originates from the retreating glaciers that leveled much of Northern Missouri approx. 300,000 years ago and was reshaped around 115,000 years ago as glaciers in the rocky mountains were diverted into the Missouri River. As the ice from the glaciers melted, the water from the melting began carving a channel through the landscape that eventually would become the Missouri River. Historically this river was a very wide, shallow, and meandering river that was prone to minor flood events and changing courses. The course of the river was not consistent over decades and a large floodplain formed between many of the bluffs that channeled and guided the river. It was nicknamed the “Big Muddy” for the large amounts of sediment that it would carry and deposit along its banks. For the eventual development of commerce up the river, in the early 1900s, the Army Corps of Engineers began installing dykes, levees, and dams to better control the flow of water. They were trying to centralize the water into a quicker moving central channel and stabilize the banks of the river. This led to fewer minor flood

events in the flood plains of the river, but when flood events do occur, they are often more extreme and more damaging to the communities and landscapes around them.

The channeling of the river led to the eventual conversion of forested or heavily grassed floodplains/swamps into farmland as farmers drained any areas that would have previously held water. Many floodplains make good farming soil, because of their loamy textures and the deposition of materials that bring in nutrients and organic matter to the land.

The Mississippi River Floodplains of the Bootheel of Missouri share a similar story, but largely different origins. Around 50 million years ago, the continent of North America was looking like it would possibly split in two along the path of the Mississippi River. The river widened and widened until the waters of the ocean eventually touched the South Eastern Part of our state. This widening eventually stopped, but the lowlands that were created remained for the following millennia. The ocean has since retreated but these lowlands became the swamps and floodplains of the Mississippi River. These swamps and floodplains have since mostly been drained and converted into farmland since the early 1900s.

The soils of these drained flood plains often represent their role that they previously served prior to drainage. Many of the swamps and backwater areas of the Mississippi Floodplain near the bootheel of Missouri still have the soil of these swamps, with series like Sharkey or Kobel. These series often have high clay percentages at shallow depths that would have been necessary for maintaining a water level in these swampy areas. The clays of these soils are often high shrink swell clays and may have slickensides present, a

sign of strong movement by the soil peds. Among the soils that originate from the deposits of the Mississippi River, it is common to find soils with high silt amounts and low to moderate sand/clay percentages, such as the Adler or Caruthersville Series.

The soils of the Missouri River Valley are much more dependent on their proximity to the Missouri River during the flood events that led to their deposits. Soils can range from very high sand percentages, such as Treloar or Sarpy, be more loamy such as Lowmo or Haynie, or be high in clay such as Waldron or Sandessin. The interesting aspect of floodplain soils is how quickly they can change and noticing the microtopographies in the landscape that can often signify drastic changes in the soils that are present. There are hills, drainageways, and terraces that can all occur on a landform of 0-2% slopes. So, care needs to be taken when examining landforms that developed in floodplains.

The soils of smaller rivers and floodplains can be highly variable as well. In Southern Missouri, it is more common to find heavy amounts of coarse fragments in the floodplains, as the floodplains are often much narrower, isolated between steeper hills, with some common soil series being Cedargap or Racket. Rivers north of the River may often have fewer coarse fragments and a siltier/more clayey texture. But this is highly dependent on the surrounding source material from the floods and how those materials have been deposited, which we will discuss in the soils across landforms video.

The largest concern that you as a soil evaluator should have when trying to site a wastewater disposal system in a historic floodplain is the flooding frequency. No septic system should be sited in a location of “frequent” flooding, which in the field book for describing and sampling soils defines as >50 times every 100 years. Flooding information

can be found on the FEMA website for any location that you have a concern about. The amount of rock fragments can be of concern as well. It is very possible for some horizons to have upwards of 70% of fine gravel and high amounts of sand. These horizons do not provide filtration to the wastewater and would provide a path along which the wastewater could move laterally, perhaps into the nearby waterways or onto the surface, or vertically into the ground water. Drainage can also be an issue in flood plain soils. As these landscapes are rather flat, providing sufficient drainage is necessary to prevent the ponding of water. Along with this, The clays that are found in floodplains are often high shrink swell clays due to their minerology and lack of weathering that has occurred since their deposition.

The highly variable characteristics of the floodplains of Missouri represent the highly diverse Rivers and streams that we have in our state, from some of the mightiest rivers in the world to small temporary streams in the spring, each of these have led to a variety of different soils.

## **SOIL ACROSS LANDFORMS**

### Soils Across Landforms Script

Welcome to our next course in our Soil Evaluator Preparation Workshop. in this video we'll be talking about how soils change across landforms. The two main landforms that we're going to be focusing on today are hill slopes and floodplains. We will examine how soils change across the different positions on a hill slope and a floodplain, and how these conditions affect the eventual siting of a septic field. We'll look at some things that allow

for the siting of a field and some conditions that prevent the siting of a septic field. We'll begin with looking at hills.

So, the first thing that we'll need to go over is how do we describe a hill slope? When we're looking at hill slope, we need to understand how we can talk about a hill, and therefore talk about how there are changes across the whole slope. A lot of the diagrams that you'll be seeing today are referenced in the handbook to describing and sampling soils from the NRCS. This is a very helpful book and should be one that you have with you when describing and sampling soils out in the field.

So the first thing is hill slope positions. These are basically just the descriptions of the hill slope as you move from the top of the hill to the bottom of the hill. So starting at the top, you have the summit. This is a mostly flat area. It's a very stable area where there's going to be little change. It's not really erosional or depositional. And then moving down from there, you have the shoulder, which is the slightly convex area that leads from the summit to the backslope. In the shoulder, you begin to see the effects of erosion. This area has slightly more slope than the summit but not quite as much as the back slope. Next, you have the back slope which is the linear area connecting the top to the bottom. This is often the longest section of a hill. They lead eventually to the foot slope, which is a slightly concave area. So it's curving back into the flatness of the toeslope. The foot slope is a relatively small area as well. The slopes are becoming gentler here and materials are collecting as they move down the hill slope and settle here. Finally, you have the toe

slope which can be part of an alluvial area. So it might be close to a stream or river, a flood plain, or a drainage way. This area is often a very flat area at the bottom of a slope.

What we just talked about is a look at a hill slope in a two-dimensional way. But we also need to think about hills as a three-dimensional shape and the shape of them as they move downhill. And this is important because the shape of a hill often determines how water will move across that hill. So as we're looking at these hill slope shapes, we have three different shapes that we will see, linear, convex, and concave. These shapes are then combined to describe a slope in two directions: Across the slope and down the slope. The combinations of these shapes going down slope and across slope give us the nine different hill slope shapes seen here.

We need to remember that one of the goals of siting a septic field is to move surficial and rain water away from that field so that the waste water that we're putting into the field can move into the ground. So we want to look for hill slope shapes that shed water. The most effective at this are going to be our convex areas as they disperse water in multiple directions. Linear slopes are also suitable because they are shedding water when there is sufficient slope. But our concave areas are going to be concentrating water into our field area and this is something we want to avoid.

This can be problematic because concave areas would be adding more water to a field area that is already becoming saturated due to the septic waste that's being applied there.

So, as we look across here, these linear-linear and these linear-convex areas are sought out. Most of these four on the top left are suitable due to the fact that they're shedding water away. As we move into these concave shapes, especially on the right side of the chart, those that are concave across the slope, these shapes are the shapes that are concentrating water. They should be avoided at all costs as they would be concentrating water into our field area.

Here's some good examples of those different hill slope positions as well as the hill slope shapes. So here we can see in the side slope. We have a linear linear shape. Across the nose slope. We have a linear shape going down, but a convex shape going across. In this head slope we have a linear shape going down but a concave slope going across. So we're concentrating water. We want to avoid head slopes because they concentrate water but also because they may also be natural drainageways and we have to stay off the drainageways.

On the left, over here we have our concave areas. We can see how the different concave down slope areas look. Here, you'd have that concave across and concave down in the top. Here you'd have that concave down but convex across.

These are some good examples of different hill slopes you'll see out in the field. The two most suitable areas would be this nose slope. And the side slope areas as well as the shoulder which would be this line that runs across the top.

NEW VIDEO

Now that we know how to talk about hills we need to know how soils change across these different hill slopes. Here we have two images that show different aspects of how soils change across hills. First of all, we need to remember that soils are affected by a great number of things such as the bedrock depth, the amount of weathering or time that they've been present, the type of ground cover, or the canopy cover that is present and whether or not, there are restrictive horizons like clay pans or fragipans that are present in our soils. So, looking at this first chart, we can recognize that as we have more humid climates that allow for good plant growth. We move into this more soil, mantled hill slopes, which are the majority of our hill slopes in Missouri.

These soil mantled hill slopes we may have some exposed and very shallow bedrock. You should not be citing septic fields on areas where there is exposed bedrock. We should avoid these areas at all costs. What we see on these more humid hill slopes is that you often have shallower soils at the top. You have that convex slope that is dominated by diffusive processes. Basically, that soil particles are being taken away by wind and rain and moved downhill. As you move downhill, you often have deeper soils, as material is being added through the process of erosion. These are our depositional hill slope locations.

On the right this image that we're looking at shows, two common hill slope profiles. Let's start with the one on the left. The one on the left has surficial bedrock near the shoulder and shallow bedrock across the summit. On the summit, the shallow soils above bedrock may restrict the siting of a system. You should always move up and down the hill slope to see if you can find signs of bedrock outcrops as seen in the image. As you move off the summit and shoulder and onto the backslope, foot slope and toe slope you often do get

deeper soils because of the amount of erosion that is taking place that carries soil particles off the summit and shoulder and deposits them down lower on the slope. It is possible that you can have water problems down along these lower hill slope positions, as the water may have restricted downward movement due to dense bedrock.

On the right here we have our well-drained soil profile. These are hill slopes that have a deep coverage of soil across the whole hill slope. As you can see at the top there is a thin A Horizon up at the summit. With many trees growing. Here, you may have an E Horizon often underneath that A Horizon. And then as you approach the bedrock, you're getting into the weathered residuum and the Bt Horizons that have higher clay content. The properties of which will often depend on the type of bedrock that the clays weathered from. Underneath that Bt, you'll often have a C Horizon of weathered parent material. And then under that, the bedrock itself. On this well-drained soil profile, you have similar characteristics, as you move down the hill slope. So on the back slope itself, you have the formation of more of an A Horizon as you move down, right under that back slope. It's common that on these steeper slopes that you'll lose the E horizon and the soils might go straight from an A to a B Horizon. And then as you move down, you'll have that deeper A Horizon with a B Horizon underneath it.

For this slide we'll be looking at how different hill slope positions have different characteristics and processes that all affect how water moves both in and through the soil. The things we'll be looking at is infiltration or how quickly water moves into the soil, erosion or the speed in which soil materials are carried away from the site, sedimentation or how soils are deposited or where you may see the most deposition at a site, and solar

insolation, meaning how much sun is reaching a location. All of these are important processes when we're thinking about siting a field.

Infiltration allows for the wastewater to move into the soil and be treated. We want to prevent erosion or water moving across our field. We want to have a site that has enough soil to be able to support a septic field. And having high amounts of solar insolation or sunlight shining on the field means we have higher evapotranspiration. Meaning, we're moving more water out of our system.

So let's talk about each. Here on the summit, we have high amounts of infiltration due to it being a pretty stable location. There's not a lot of slope up at the summit meaning the water that hits here can move into the soil. We have little erosion on the summit. We have very little sedimentation here. The only deposition that we'll get on the summit is our loess deposits. The amount of sunlight is often moderate due to the angle of the sun and the amount of cover that may be present. As you move on to the shoulder, you're getting less infiltration, water is being shed off the shoulder and you're beginning to see more erosion on the shoulder with little deposition or sedimentation. As you begin to slope away from the summit you'll pick up the amount of sunlight that will be hitting the hill.

The back slope is the area of highest erosion and least amount of infiltration. You're beginning to see some sedimentation that picks up as you move down the hill, this is the area that we have, the highest amount of sunlight, hitting it, meaning the highest amount of evapotranspiration. Which can be beneficial to our septic systems.

Finally, as we move down to the toe slope and the foot slope this is an area of picks up in infiltration rate due to the lower slope percentage. Remember that infiltration is dependent on the amount of water already present in the soil. These toe may remain saturated longer due to run off and water moving downhill both above and below ground. You have high amounts of sedimentation down here. Erosion is slowing down. It is still going to be moderately high because of all the water that is moving from the entirety of the backslope may continue to move across the foot and toe slope. It still has some amount of insolation present.

#### NEW VIDEO HILL SLOPES

So, let's look at some real examples of how soils change across hillslopes. This is of a hill slope east of Rolla with a gentle 6% slope. Here are the different soil types that we saw across the hill slope and the area that they took up. Here at the summit, we have the Moko series, this is generally a very shallow series. Here we had a combination of rock outcrops and shallow dark soils of the Moko series. This dark color comes from high base saturation of the underlying bedrock that weathered into these soils. These materials developed from the residuum of the area. There were a significant amount of rock fragments present in this soil.

Moving towards the shoulder we had Blueeye, which you can see as a deep A horizon due to being so close to the weathering bedrock of the summit and sediments beginning to settle here as they moved downhill. You begin to see the development of B Horizons, and the formation of clays. Underneath these A Horizons before you hit the bedrock

underneath at <40 inches. This soil had a good deal of rock fragments and originated from loess/loess pedisegment and residuum.

As you move on to the back slope, we saw two main soil series across the back slope.

The main thing to notice is in this back slope, you really lose that A horizon. It loses a lot of its depth. This is also partially due to farming which was present across this hill but also because of the high amounts of erosion across the exposed backslope. We saw high amounts of clay formation in the B Horizons as well. In this backslope, we saw high amounts of rock fragments that were present underneath the top 20 inches. These soils formed in residuum, hill slope sediments and loess/loess pedisegment.

As you move down into the footslope, we see the beginning of a deeper A Horizon. At this location we saw multiple parent materials due to some deposition from the hill slope with those top couple horizons and then the rest of it was formed from old alluvial processes. We could tell this because of the rounded rocks that were present in the lower portion of the soil profile. The amount of sand increased as well as we moved into the alluvial soils.

And then finally, we have the toe slope or the flood plain here at the bottom. You see that once again, the deep dark A Horizons due mostly to the frequent depositions from the stream. There's very little clay development here in the toeslope.

We see another 3D depiction of a hill slope complex. They show another group of soil series, that are common in central Missouri, Weller, Bardley and Klinkenbeard. Up on the summit is the Weller series, you can see it's a residuum based soil with a small loess cap over the residuum. As you move off that summit and move more into the shoulder,

you move into this Bardley soil series. Remember that the shoulder is an erosional position meaning much of the loess has been lost, leaving only a shallow A Horizon over residuum. As you move further down the slope, you start to begin to have the main soil forming process be colluvium, leaving you with little A Horizon and a deep deposition of clayey colluvial soils. These diagrams are to show you what you might expect to see when you are out in the field trying to site a septic field for a soil evaluation.

So let's go over each of the hill slope positions and talk about what some of the benefits and drawbacks of that hill slope position are for siting a septic field.

First the summit. The summit is a relatively stable Hill slope position. There are few losses or additions. Most commonly you're going to have loess as a one of the main parent materials on the summit. And underneath that loess, you'll often have residuum or glacial till as the secondary parent material. One of the benefits can be how deep this loess cap is which often depends on the proximity to the major rivers of our state. If the loess cap is deep enough, it can often be suitable for a conventional system. If you do not have a very deep loess cap, you may have shallow depths to bedrock which can severely restrict the options for septic systems. As you move out of the loess surface and into the residuum, you can have high amounts of rock fragment, which can restrict the type of system that can be installed. Finally, some summits can be very flat. They may not have enough slope or less than two percent, to provide sufficient surface drainage without provisions being made. Such a provision could be adding soil to reach the required slope necessary to shed water away from the field.

The next hill slope position is the shoulder. The shoulder is a partially stable, partially erosional hill slope position. Here, you'll typically see loess as the parent material with the residuum or the glacial till underneath it. At this position you may find some hill slope sediment as a third type of parent material between the loess and the residuum or glacial till. Bedrock shelves and outcrops are more common in the shoulder than the summit and care needs to be taken to avoid siting a field near these features. Shoulders often have a suitable slope ranging often between 2 and 15. And it often has a suitable hill slope type being that slightly convex going downhill. The shoulder may have less of a loess cap than the summit and shallower depths to the residual or glacial till or the high rock content. And this should be considered when you're citing a field.

Next is the back slope. The back slope is hill slope position dominated by erosional forces. While it is gaining materials from above, it's also losing and it's often losing more than it's gaining through the erosional forces. On the backslope, you'll see that there is a much thinner A horizon as much of the organic materials are being carried down hill before they can decay and be incorporated into the soil. This is especially true as you move into your steeper backslopes. The parent materials, on many of the backslopes are loess, hill slope sediment, and residuum or glacial till. The thin A Horizon can be a detriment to the siting of a septic field on backslope because of the possibility of shallow high clay or the high rock content that can be present in the B Horizon. You will often have suitable slopes on back slopes as they are often greater than three percent. But as slopes become steeper, they become provisionally suitable if they're between 15 to 29 percent, or generally unsuitable if you have slopes of greater than 30 percent. While siting a septic field on a backslope you must take care that you're avoiding any drains, gullies, or

erosional scars that are moving water down the hill. Remember you need to stay a minimum of 25 feet from any of those. Septic fields that are cited on backslopes may require Interceptor drains or curtain drains above the field to intercept surface water or subsurface water that would move into the field area. Backslopes can have shallow depth to bedrock or very high rock content as they are an erosional surface. Lastly, soils can vary pretty rapidly across a hill slope so you need to be careful when you're citing a field that you are keeping on generally the same slope and the same landform area. Signs of a change in soil conditions across a backslope may be a rapid change in the percent slope either flatter or steeper, a change in vegetation, or a change in aspect.

Next is our foot slope. This is our first depositional hillslope position. This zone is accumulating a lot of material from uphill, so you'll see a lot of that organic matter or other materials, like your silts, clays, sands, and gravels moving down from your backslope onto your foot slope. It's common to see loess pediments as a parent material on the surface. Alluvial parent materials are possible here if there is close proximity to a body of water. Residuum and glacial till are also possible parent materials underlying the sediments that have been deposited above them. A concern for footslopes is highly concave areas. These areas should be avoided, when citing a field as they would concentrate moving water on to a field that is sited in a highly concave area. These highly concave areas may have drainage problems. Signs of this are redoxomorphic features from redoxomorphic reactions, meaning that water is sitting in these areas for long periods of time and that siting a septic field in this area would not be recommended. Similarly, foot slopes may not have enough slope, meaning less than two percent to be

suitable, unless provisions are made to increase the slope. Footslopes do often have deeper A Horizons because of the amount of deposition that is present. Should there be enough area, this depth may be suitable for conventional systems. If you are able to cite a field in a footslope, they often require interceptor and curtain drains to draw away surface water and intercept the subsurface water from moving into your field area. Finally, footslopes may have high rock fragment content that has accumulated over time from Hill slope sediments moving downhill and this might restrict the type of system that can be installed.

Lastly, we have our toe slope. Remember, the toes level is a depositional hillslope position so it is accumulating material from uphill. These have often deeper A Horizons with lower levels of clay because the majority of the soil has been moved in from either hill slope processes or alluvial process of nearby waterways. The main parent materials are hillslope sediment, colluvium, alluvium, and possible residuum or glacial till/outwash. Once again, there may be drainage problems due to the fact that this is an area that is collecting water from uphill. So you may have signs of gley colors or signs of redox reactions. There may not be enough slope to be suitable without provisions being made to the field. curtain drains and interceptor drains are often necessary to intercept the upslope water or to ensure that no other water is entering your field area. There may also be high rock contents in these toe slope regions due to the amount of materials moving downhill or deposited by nearby alluvial processes. These alluvial processes may have had a larger effect on the soil than the hill slope processes have had, depending on how close the field is to the drainageway, stream, or river at the foot of the slope.

## NEW VIDEO - ASPECT

Another characteristic of hills that we need to think about is the direction that the hill is facing. This is also called the aspect of the hill. We have four main aspects. We have our North facing aspect, our South facing aspect our West and our East facing aspect.

Basically, if you imagine a hill as a cone with a compass at its summit, the cardinal directions will be the different faces or aspects of the hill. The aspect can have a drastic impact on the soil, the moisture level, the types of plants that grow, the amount of rock fragments, the depth of soil horizons, the level of evapotranspiration and many other things. This is because of how our climate and weather have affected this hill over time.

The sun is the first component of aspect. In Missouri the sun is always slightly in the southern sky and as the sun moves from east to west, the intensity of the solar rays increase throughout the day. Both of these conditions result in hotter, more intense sunlight hitting our south and western facing slopes. The second major component is the wind and rain. Most of our wind and rain storms come from the West or Southwest.

Because of this, we have more wind and rain hitting our South and West facing slopes.

Because of these two factors, we call our South and West facing slopes our exposed slopes, as they are exposed to the elements. In contrast, our North and East facing slopes are our protected slopes, these are areas that have less direct wind, rain and sunlight hitting them. All of these conditions have an effect on the soil.

So let's look at some of those impacts. On our protected slopes, there's typically deeper soils than on

our exposed slopes. This is due to the amount of erosion that is present on exposed slopes. When you have wind and rain directly hitting the soil surface, you're going to lose more soil particles. Protected slope allows for more soil, accumulation over time. Due to the drier conditions created by more intense sunlight, exposed slopes often have less dense tree cover and smaller trees that are more drought tolerant. There will often be less ground cover on exposed slopes as well. On protected slopes, due to their higher moisture and deeper soils it is common to have more trees and a dense understory.

Exposed slopes typically have higher levels of evapotranspiration than protected slopes and a higher microbial community, whereas protected slopes typically have a higher fungal population. Both of these can be beneficial in the treatment of wastewater that is applied to a field on an exposed slope.

As we can see here in this chart though, aspect has an effect on soil depth. In the Ozarks, the average thickness of the A horizon is different based on whether it is an exposed or protected slope. An exposed slope averages a 4.5 inch A horizon, while a protected slope averages a 6 inch A horizon. This increased depth could be the difference in the type of system that could be installed for a household. The effects of aspect go beyond A horizon depth, often affecting the underlying horizons. Here we have some charts on the effect of aspect and soil depth In north central Missouri. In these charts we are looking at clay development. In the first chart, we see the depth in centimeters when we reach the start of our argillic horizon. In the exposed slopes the argillic horizon starts at about 12 centimeters. Whereas on protected slopes the argillic begins around 18 centimeters. In the next chart we can really see the differences that both aspect and hill slope position make for the depth to the maximum clay levels. The higher up in the slope, the shallower depth

to the maximum clay level of 23 cm for the exposed upper slope and 40 cm for the protected upper slope. While lower on the slope we have more soil depth, even on the exposed side, with 31 cm. The lower protected backslope has 45 cm of soil before reaching the maximum clay percentage. These minor differences could mean large differences in the type of field and the eventual cost of the system that would need to be installed in these hillslope positions. It's important to remember the clays of this region are typically IVb clays and restrict the installation of an inground septic field. A depth of 45 cm or 18 inches of suitable soils would allow for the installation of some engineered in ground systems, whereas the other hill slope positions and aspects would require additional soil or an above ground system, such as a lagoon.

#### NEW VIDEO – RESTRICTIVE HORIZONS

For the next section, we're going to be moving into different types of restrictive horizons that are common on hillslopes. The two that are most common in Missouri are fragipans and our claypans. Both of these horizons restrict the downward movement of water and prevent the installation of inground septic systems when they are at shallow depths. The fragipan can be seen here on the left. It is the area that has the white chalky color on the surface of the soil horizon. On the right is the claypan. The claypan is this middle section that is light brown and under where the roots stop growing.

Let's talk more about fragipans. Fragipans are a very dense soil horizon. They are typically so dense that they do not allow for the movement of water through them. They form as an initial colluvial deposition of silty and rocky material that has then been

covered by other materials, such as loess. They most commonly form in areas that are currently forested. This original colluvial material forms a dense slurry during wet springs and when it dries out during the summer months it begins to harden. This process repeats over and over and along with the weight of the materials above, this layer is compressed into an extremely hard, dense compacted layer. These are extremely difficult to dig through even for a backhoe and prevent the movement of any water through them. One way about telling a fragipan is if you break off a piece of it and you put it in water, it's going to slake or break apart really quickly. Fragipans tend to form on summits or on very gentler slopes such as shoulders, very gentle back slopes, foot slopes or toe slopes as well.

Fragipans are typically found between 12 and 30 inches in depth. Meaning when there is a fragipan, it is most likely going to prevent the installation of a conventional system. They're often about six to 18 inches thick. But can be much thicker than that. I've observed some being up to 36 inches thick. One of the key identifying characteristics that you can see in this picture are these vertical lines that are running up and down the soil horizon. These are part of the prismatic structure that is common in fragipans. The prisms of fragipans can be up to three to four feet wide. As has been seen on tree throws located above fragipans. You'll be able to look at the tops of the columns underneath the tree to see the large prisms that were present in the fragipan. Another identifying characteristic is that roots typically are not able to penetrate into fragipans, or if they do, it is only along the vertical channels in the prisms. It is very common to see no roots in a fragipan and an abrupt drop off in roots from the horizon above can be a sign of a fragipan. The fact that fragipans and other restrictive layers prevent root growth causes the trees that grow above

these soils to have different growth patterns than trees that grow on unrestricted soils. These trees are often shorter, with more tortured limb patterns and recognizing this characteristic can help with siting a septic field.

Another common characteristic is the formation of high levels of clays above a fragipan. This is because clays typically move down the soil profile with water movement and the fragipan prevents them from moving any deeper, so they end up collecting above the fragipan. These clays, such as in the Union soil series, often have a high shrink swell potential.

The texture of a fragipan is often a silt loam, loam, or maybe a clay loam. They often have lower clay percentages than the horizons above and below them. There is often more coarse fragments that are present in fragipans.

The next restrictive horizon is the claypan. These are areas of an abrupt textural change, specifically related to the clay content. Here you can see the claypan starts at about one foot and goes to about three and a half feet. These claypans are regions with high amounts of clay with low amounts of permeability. This abrupt textural change as we can see, in this video, prevents the movement of water.

The definition of a claypan is any soil horizon that has an increase of 20 percent or more clay from the horizon above it. Or double the clay percentage if the clay content is less than 20 percent in the horizon above it. So let's say this horizon here has 16 percent clay. If the horizon below it has 33 or 40 percent clay, basically double that of 16 because 16 is less than 20, this underlying horizon would qualify as a claypan. Another example, if this

horizon here has 23 percent clay. And this horizon below has 43 percent clay, 44 % clay or higher that would signify the presence of a claypan.

Claypans are restrictive horizons simply because that drastic abrupt change in texture restricts the amount of water movement that can move through them. And this leads to perched water on top of the high clay horizons. This is why above claypans and within claypans, you often see gleyed colors because the claypan holds onto its water very tightly and above the claypan water ends up perched. A good example of a claypan soil is the Mexico soil series. It was a jump from clay percentages in the 20s on the surface, to well over 40 percent right underneath the A horizon.

Lastly the last feature that is restrictive to the siting of a septic field that's common in hilly areas, especially Southern, Missouri are karst features. Karst features are the geologic features that have been produced through highly erodible bedrock, typically Limestone and dolomite bedrock, as it slowly dissolves as the groundwater moves over and through them.

This allows for the formation of caves and voids that may lead to sinkholes, losing streams, and springs. All of these pose a high risk to groundwater contamination and should be avoided at all costs when siting a septic field. There are maps of the known karst features in Missouri. They are available on the Missouri Department of Natural Resources website under their geostrat application. These can be helpful and should be used before you go out to a field to see what characteristics are present at the site that you'll need to make sure to avoid when out in the field, as they can be difficult to discover when in densely forested areas.

Here's a good example of how those form. The highly erodible bedrock has allowed for the formation of vertical cracks and as water moves into the soil, it's beginning to carry soil particles into these cracks in the bedrock. The moving soil particles, eventually form a void in the soil as they fill up the cave system underneath. As the void continues to grow, the soil above it can no longer hold itself together and eventually collapses. This means that you have a direct pathway into the groundwater underneath.

Hillslopes and septic systems, summarized. We want to avoid overly steep slopes as modifications need to be made to a field when it is sited on a slope above 15%. Such as spacing the lines further apart, ensuring that there's enough suitable soil underneath, or providing curtain drains and interceptor drains for moving below ground and above ground water away from the field. Systems are rarely suitable on slopes above 30 percent and there are drastic modifications that need to be made to systems sited in these areas.

Changing bedrock depths can be a challenge to siting a field and you should always have holes dug above and below the area of the field to ensure that no shallow bedrock is present. High rock content is common among many of our hill slopes in Missouri and rock content about 50% can be restrictive to some types of septic systems and rock content above 70% is unsuitable. Many of the common restrictive horizons are present across hill slopes such as fragipans and claypans. Finally, karst features that have developed in our hill slope complexes need to be avoided at all costs. It is extremely common to site a septic system somewhere along a hill slope, and understanding how

soils can change across hill slopes can make the difference in the type of system and the overall cost to the homeowner.

## RIVERS PART 1

For this next section we're going to be talking about how soils develop in floodplains and from alluvial processes. Here we have two cross sections of our largest rivers in Missouri, the Missouri River and the Mississippi River. You can see just how wide the footprints of these rivers are. The Missouri River at this location at Boonville is over 10,000 feet wide. Both of these channels are surrounded by Limestone Bluffs that create the floodplain and the channel of each of these rivers. It is in these floodplains, that we will look at how the depositions of the Missouri and Mississippi Rivers have created the unique soils of their regions.

These can be things like the clayey back swamps along the Mississippi River or they can be loamy sand benches closer to the river, such as along the Missouri River. Much of the variation in soils depends on the distance from the river. And how far the sediment being carried by flood events were able to be moved.

So, here we see a good diagram of how soil particles settle out during a flood event. And kind of the landforms that naturally form from alluvial processes. Here you have a natural water level and during a flood event, you have a much higher water level.

As the moving water begins to slow down soil particles begin to drop out and settle along the ground. The courser particles, such as gravels and sand particles, drop out first closer

to the channel of the river. forming those beach/gravel bar areas. Then you have these natural flood levees that often form from the deposition of particles.

So as you move away from the beach and towards these natural levees, you get your fine sands that begin to settle out

On the back side of this levee, you have your loamier textures, your silt loams your loams, your silty clay loams, your clay loams, and then, finally, the farthest away from the water the finest soil particles drop out. And this is often the areas that allow for very still water. This still water allows for the settling of the clay particles.

So, these would be those areas called the back swamps along the Mississippi River, that form high clay soils. You should be wary of the high clay soils along riverways because they are often high shrink swell clays. so if you do end up in these Backwater Areas or back swamp areas that traditionally held water before they were drained. The clays that we find there are would restrict the type of system that could be installed.

Next, something important to talk about is that many of these waterways of our state, even our smaller streams, have been around for hundreds of thousands, if not millions of years, depositing materials during flood events. And they've been changing their pathways and channels throughout this time. So when we're down in many of these lower valleys, small floodplains, and toe slopes, we need to be careful of where the river used to previously flow.

And one way of doing that is looking at the types and amount of rocks that we find.

When we dig pits and look at their soils in alluvial areas we often find highly rounded rocks. So as we move from the left to the right and higher the rocks become more

rounded. This is showing more signs of weathering from alluvial processes, or of water moving around them eroding them and smoothing them off. As stated previously, our coarser materials were deposited first by flood events, so the more rocks we have and the more heavily eroded they are, the closer we could be to the old river bed.

And so you may find and discover these old deposits when you're digging around or trying to site a field. So if you look in the picture on the left, you can see about two to three feet down, there is a slightly lighter color layer, that is extremely gravelly and has high amounts of sand. There are no real roots growing into that horizon. It is likely that that is either the old creek bed or the Old Creek Bank. Since it's basically only gravel and sand this horizon would be a concern as it does not provide treatment for the wastewater.

These gravelly/sand horizons are the most common restrictive layer along the waterways of our state. This is any layer with greater than 50% gravel and a loamy sand or a sandy texture. These are unsuitable for the application of wastewater. These horizons do not provide the micropores and nutrient holding capacity that is necessary for the microbial life that treats our septic waste. Furthermore, because of their large pore space water often moves very quickly through these horizons, horizontally or vertically. So, if you have a layer like this, in the previous photo, the water can move into that layer and move horizontally into a drainage way or stream without receiving treatment.

It's also common that water will move vertically rapidly through these rocky/sandy horizons. So the waste water could reach this layer and travel quickly into the groundwater or into the bedrock and move into and pollute the groundwater. This quick

movement of water is called rapid permeability and horizons with rapid permeability are unsuitable due to their risk to the groundwater.

Here's an image of a mapped floodplain. and the different soil types that we found in this flood plain. One of the things that we need to recognize is that how variable the soils of floodplains are, and especially in our low slope areas, this might mean that we need to dig three or four pits across an area to make sure that the change in soils is staying consistent across that area rather than simply assuming they are the same. An interesting thing about this area is that the slope of this whole area was less than two percent. It was about zero to one percent slope across this whole region. Except for the drainage way in this purple and red that ran through the middle that perhaps was an old stream bed cut across this field. The important thing to see is that soils change even across relatively uniform landscapes. In this 80 acre field you had things that would be restrictive like high sand and gravel content at very shallow depths of less than 18 inches. There were sites that were highly suitable such as these fine, silty textures, that were very deep. or fine loamy textures of moderate depths. Many of these areas had high sand layers underneath 30-40 inches of silty or loamy textured soils. The higher clay soils were forming towards the back end of the field as you move away. This is what would have deposited the furthest away from that from the original creek.

## NEW VIDEO – RIVERS PART 2

The next landform we have is the stream terraces. So those are those areas in green. They are the old alluvial deposits that have been left behind as the stream cuts deeper into the

landscape. As the stream erodes away the landscape it eventually reaches a point where even the floods, no longer cover the terraces and these become the stream terraces rather than the active floodplain. The soil texture that is present on these old stream terraces really is based on the size and the ferocity of the past stream or river deposits. In general, our slower, smaller streams will deposit, more clays and silts while the faster moving streams will deposit more sands. The distance away from these escarpments, the escarpments are these tan or peach areas, these cuts will affect the texture as well. With smaller particles settling further away and larger particles settling closer to the cuts.

As these areas are no longer in the active floodplain, there's often very low likelihood of flood events and if you can find enough space on one of these old stream terraces for a septic field this may be fine. They could be suitable for some systems to be sited there because of their gentle slopes and loamy textures. These soils have had time since their original deposition to develop as soils. They have much more distinct horizons. They're beginning to see downward movement of clays. Remember that the clays that form from alluvial deposits are often our high shrink small clays. So if you do end up in a soil pit that has 40-50% clay-sized particles, you would estimate that, those are 4B clays and that would restrict the siting of a septic field. On-stream terraces, it is possible to reach the underlying bedrock. Heavy gravel and sand deposits should be avoided when siting the system as they don't provide the necessary treatment.

Looking at siting a system near the waterways. Some of the positives of siting near a toe slope or in our alluvial soils, is the soils are often loamier. They have may have more even portions of sands, silts and clays. And these soil textures are often suitable for our septic systems. They're commonly deep or very deep meaning that if the area is available,

the soils would allow for the installation of a conventional system. These areas are often pretty uniform. They have gentle slopes. This means that you can cite large fields. If you look back at the map of that floodplain, you have large areas, where you could site a septic system if they are outside of the active flood area. A nice thing about working near these drainways or waterways is that you can look in the nearby cuts of the stream to see the type of bedrock that's present or if it's not present at all. Another thing that's beneficial is that you'll often have the necessary fall from the house to the field for the system to be gravity flow as these waterways are commonly at the lowest point in the landscape. There's often a lower risk of hitting bedrock in these areas.

Some concerns for these areas. You have to maintain that 50 foot setback from waterways unless you are able to get a variance from the county or state to be closer. This is really important because we don't want to contaminate the streams, rivers and creeks of our state with human waste. We should always try and make sure that there's a strong vegetative buffer between any field that we site near a waterway and the waterway itself. These buffers should be dense grasses, healthy trees, or large amounts of shrubs.

Something that will slow down water movement if it begins to move that way. The lack of slope can be an issue. Many of these areas have less than two percent slope, meaning that you need some sort of mitigation to assure that you're going to have surface runoff. There can be high amounts of variability in the soil conditions as you move across a field that formed from alluvial processes. You can move from a loamy texture, to a clay texture to high sand or gravel in a relatively short distance. Meaning that you need to make sure that you are correctly assessing the soil conditions across the whole field. There are restrictive horizons that are a possibility. It's rare that you'll find a fragipan in

alluvial soils, but claypans are possible due to the fact that high amounts of clay can be deposited. The most common restrictive horizon will be those high sand and gravel horizons that have rapid permeability, don't provide treatment for wastewater, and would allow wastewater to move into our waterways and groundwater. If you do run into high clay soils, these clays are most likely the high shrink soil clays, meaning our 4B Clays, that restrict the movement of water and therefore, restrict the installation of many of our septic systems. As always, they're never to be cited in areas of frequent flooding, remember you can get flood information from the FEMA website. As well, you should always look at the site conditions to see if there are any signs of flooding, such as knocked over trees or depositions of trash or sediments. Areas with standing or pooling water should be avoided for siting a septic field. Wetland species such as cattail or arrowroot could be a sign that you are in an area that is wet during significant portions of the year and these areas should be avoided as well.

As we look across some of these different Landscapes that we have in Missouri from our hills, to our alluvial formed landscapes, we can often find suitable areas to site a septic system. There will always be conditions that we need to be aware of. Across much of Southern Missouri. Karst features and shallow bedrock are possible and restrict the type of systems that can be sited. Across Northern Missouri, we need to be careful of the lack of suitable soils above claypans. We need to think that fragipans are common on our Uplands as well.

As we move into our alluvial soils, like our stream terraces, floodplains, and toeslopes, we need to consider the amount of gravel that's present, the amount of sand that's present, and whether those will be able to treat wastewater. As well, we need to make sure that

we're not in a flood zone or an area that pools and holds water for long time periods over the year.

Thank you for taking the time to participate in this course. I hope you have learned something about how soils form across different landforms and how those different landforms affect our wastewater treatment in Missouri. Thank you.

## **SEPTIC SYSTEMS FOR SOIL EVALUATORS**

### Septic System Script

Welcome to our series on the different types of septic systems that are common and allowed in the State of Missouri. This video series will give a general overview of the different types of septic systems, their requirements, and some typical use cases for each system. This series focuses on septic systems from the perspective of the soil evaluator, to assist them in recommending systems, evaluating the likelihood of success of a system and assessing a site for system viability. For further specifics and information on these systems and their requirements, it is important to consult Missouri Laws Accompanied by Department of Health and Senior Services Rules Governing Onsite Wastewater Treatment systems or the Green Book. This is linked in the resources tab at the bottom of the lesson overview.

For this first video we will be looking at the basics of an onsite wastewater treatment system, the soil conditions that are necessary and some conditions that limit placement of onsite wastewater treatment systems.

An onsite wastewater treatment system is used to treat all of the water and waste that comes from a house or business on the property of that home or business. This means

anything that goes down the toilets, the sinks, the showers, or almost all the drains in a house goes into this system. The goal of these systems is to treat the water thoroughly enough that is suitable to be returned back into the water cycle. Most commonly an onsite wastewater treatment system contains two main forms of treatment. A primary treatment and a secondary treatment. The primary treatment typically takes the form of some sort of tank, commonly known as a septic tank. The goal of a septic tank is to separate the liquid waste from the solid/floatable waste. Beyond this separation, there are anaerobic processes that are beginning to break down the organic matter and solid waste present inside the tank. These communities of bacteria are very efficient at breaking down the physical waste, but typically the tank is only a long-term holding site for solid waste that will need to be emptied eventually.

The liquid waste that is separated from the solid waste in the tank must undergo further treatment before it can be returned to the water cycle. This is the secondary treatment that is necessary. The liquid waste, or effluent, that is leaving the tank most commonly goes into some sort of field treatment where effluent moves into the soil. Bacteria and microbes in the soil as well as properties of the soil itself help treat the wastewater of contaminants, disease agents, and excess nutrients.

These two treatment steps, the primary tank treatment and the secondary field treatment can be very effective in treating wastewater, with results from these onsite wastewater systems being as effective as wastewater processing plants that filter and treat the wastewater of entire communities.

A large portion of the upcoming videos will discuss suitable soil depth, so let's review the types of soil that are suitable for the majority of septic systems. This is a chart, that if you are unfamiliar with should be learned, as it is central to our jobs as soil evaluators. It describes the amount of wastewater that can be applied per sq. ft. per day or the application rate of the soil. This chart is divided up into soil groups that are defined by soil texture and structure. These soil groups are then further qualified by the soil structure or color to help a soil evaluator decide on a specific application rate for each horizon. It is important to remember that the application rate often changes for each soil horizon and that the final application rate will always be the application rate one foot below the recommended trench depth unless there are specific exceptions noted in the soil evaluator report.

As we can see in the chart, many soil textures are suitable for the application of wastewater. The main soil group that is unsuitable for the application of wastewater are the IVb soils, these are sandy clay, silty clay, silty clay loam and clay soils. These soils shrink when they are dry and swell when they are wet. Should these soils be included in a wastewater treatment field they would remain consistently wet and consistently swollen. When these soils are in their swollen state, they do not allow water to move through them. This would cause wastewater to either move horizontally or vertically and come to the surface untreated. These IVb clay soils are common in many parts of Missouri as they get their shrink swell properties from their parent material. Glacial till clays almost always have high shrink swell potential. Clays that originate from shale typically have high shrink swell potentials, and clays that originate from limestones and dolomite often

have high shrink swell potential. The rest of the soil groups are generally suitable for most onsite wastewater treatment systems.

Let's now look at the depth of suitable soil that is required for some of our more common in ground systems. The three most common in ground systems are the conventional system, the Low Pressure Pipe System, and the Drip Dispersal System. This chart shows the required depth of suitable soil and whether or not that type of system would function well at a specific depth. The check mark means go ahead, the X means not suitable and the Yellow Triangle means that often something must be done to bring the system up to suitability before it can be installed.

There are many things that can limit the depth of a soil profile and therefore restrict the type of system that can be installed at that location. We've already talked about the IVb clays that restrict and prevent the movement of water, but here is a list of other common features that limit the depth of suitable soil.

Bedrock is a major concern for the overall protection of our ground water and drinking water. If wastewater is not sufficiently treated before reaching highly permeable bedrock, it can enter the ground water and drinking water of many people. An impermeable bedrock layer may cause effluent to rise to the surface, polluting nearby waterways.

The water table is the maximum height at which there is either seasonal or permanent water that sits in the soil. This is signified by redoximorphic reactions in the soil and easily noticeable by the grey / gley colors in the Munsell color book. Any soil horizon that has a color 5/2 or lighter in most of Missouri signifies at least a seasonal water table. The application of wastewater into a water table risks allowing contaminants to enter into

the ground water of nearby streams/lakes. In some soils, the water table may be lowered through the installation of curtain and interceptor drains, this requires approval from the county or state department. Curtain drains and interceptor drains are not effective in every situation and should be evaluated based on soil type, slope, landscape positions, and the presence of other restrictive layers.

Fragipans are highly compacted layers of soil that prevent the downward movement of water. They typically form from a layer of colluvium getting covered by another layer of soil, often loess in Missouri. This weight of this soil compacts the underlying horizon and through wet/dry periods that are very common in the forests of Missouri, cements this layer of soil.

Claypans are horizons that have significantly higher percentages of clay than the horizons above them, typically a >20% increase in clay percentage from the horizon directly above it. Water often pools on top of these layers and may not move into this clay pan layer.

Rock content when it is above 70% is unsuitable for the treatment of wastewater.

Wastewater will move through these rocky soils too quickly to be treated. When this much rock is present the soil may lack the microbial capacity to provide treatment.

And lastly, we have the IVb clays that we talked about earlier.

All of these conditions restrict the downward movement of water, allow for the contamination of ground water, or create conditions in which the system may fail and bring wastewater to the surface.

It is necessary to keep the required separation distances between the trench bottoms and these different conditions to assure that a system will function correctly.

## VIDEO 2 – Conventional System

In this video, we are going to be focusing on the conventional system. While this may sound like this should be the typical system that is installed across Missouri. The soil requirements of a conventional system are high and may not be available everywhere in Missouri. The conventional system like other systems is an inground system.

In ground systems rely on the presence of enough soil to treat the effluent through microbial action and other soil processes. These systems must have the necessary vertical separation, or usable soil, from any of the limiting layers mentioned in the previous video.

Now to start looking at the conventional system. It is one of the required parts of the job of the soil evaluator to state whether or not a conventional system is suitable for a given property or not. Let's take a better look at the conventional system, its functions and its requirements.

A conventional system as seen here consists of perforated pipe laid in trenches that leach effluent into the soil below and around the field area. This system is typically gravity fed, meaning that whenever possible these systems should be sited so that waste can flow with gravity from the house to the tank to the field. Lift stations or pumps can help in sites where gravity flow is not possible.

These systems are typically one of the lower costs types of systems to install, and they function through the infiltration of effluent into the ground where it will be treated by the soil and its microbial life.

Here is a cross section of a conventional system. As you can see it is a rather simple system with a pipe surrounded by gravel that distributes effluent into the soil. The trench depths are typically between 18 and 30 inches. It is recommended to place the trenches generally at shallower depths, so as to allow better air movement in and out of the system and greater access for soil microbes, which are most prevalent in the top 6 inches of the soil. As we can see in this diagram, The deeper we go into the soil, the lower the richness of species index for our microbial life. When we get very deep, we lose a good deal of microbial life that helps process and treat the effluent. Deeper placement may be required though due to higher application rates at deeper depths. However, the maximum depth allowed is 30 inches. The widths of the trenches must be between 18 and 36 inches wide. The recommended width of the trenches is 24 inches. 36 inch wide trenches may not be used when the application rate is 0.4 gal/day/sq.ft. or less. The distance between the center of the trenches must be at least 5 ft. as well as be a minimum of three times the width of the trench. For example, a 2ft wide trench must have a 6ft separation on center. The recommended trench width is 10ft separation on center. There are a variety of types of conventional systems that can be installed such as gravelless, or gravel systems, but there is no difference in the size of the field.

Earlier we saw the application rate chart. When deciding the application rate for a conventional system, the application rate comes from the horizon with the lowest application rate between the surface and 1 ft. below the bottom of the trench. This is necessary as we want the effluent to move down into the soil where it will be treated.

An important thing to begin to understand when thinking about septic systems is the biomat that will form within these trenches. This is a layer that forms along the bottom

and perhaps the sides of the trenches that is comprised of accumulated suspended solids and organic matter that is contained within the effluent. There is commonly a large number of microorganisms and their byproducts that live in this biomat. This layer helps treat the effluent that is flowing into the field. This layer is typically very dark in color. If you accidentally dig into an old septic field, this dark color and a slight septic smell will be the first signs that you should stop digging.

Over time this layer can thicken, especially where the application rate is on the higher end of what the soil can handle. As this layer builds up, the drainage slows down. Over time, this can cause the system to fail if too large of a biomat builds up and water will begin to surface. You should always think about the biomat when you are giving a soil an application rate, as over time the amount of effluent that the soil can take in will be reduced. A conservative loading rate may address the issue of biomat production.

One of the important aspects of our job as a soil evaluator is laying out the size of the field for the eventual installation. We will go over more in detail in another video series about the landforms that are suitable for fields, but in this video we will discuss how to get the size of the field that is necessary to treat the effluent. There are 4 things that go into sizing a conventional field. The amount of water used daily, the application rate, the width of the trench, and the spacing between the lines. Let's go over each of these.

The number of gallons per day comes from the number of bedrooms or the number of people, whichever produces a larger number. It is 120 gallons per bedroom or 60 gallons per person. The application rate comes from the soil evaluation and is the lowest

application rate 2ft beneath the trench bottom. The trench width and spacing can be modified depending on the situation to help make the field fit better.

To calculate the size of the field, you begin with the gallons per day. Here we have 360 gallons per day, or a 3 bedroom house. The lowest application rate for this soil in the required depth was a 0.3 gpd/sq.ft. We divide 360 by 0.3 to give us the total trench area. The total trench area is then divided by the width of the trench. Here we are going with the recommended 2 ft. This gives us the total linear feet of trench that will be required for the system.

Once you know the total linear feet of trench that will be required, you can begin thinking about the spacing of those trenches and how long the trenches will be. It is recommended that 100 ft. runs of trench and pipe are used when designing the field layout. Note that 100 ft long trenches is the maximum length limit for convention systems. This would then require 6 runs of 100ft to give us the 600 total linear feet of trench necessary. If we space those runs 10ft apart, we will end up with 50 ft of distance between the runs, plus 1 ft for each trench on the ends as we measured off the centers. Our final field would be 52ft x 100 ft or 5200 sq. ft.

Sometimes it is not always possible to fit in the system with the recommended trench spacing, with 100ft lines or with the recommended trench width and things must be done slightly differently. In this next example we are still using the 600 required linear feet. This time our lines have to be <100 ft due to lot space restrictions. In this field, we could only fit in 60 ft lines. So we will have 10 runs. We chose to space the lines 7 feet apart.

This means we have 9x7 of 63 ft between the centers of the outside runs plus 2 feet for the extra. Our final field is 60 x 65. For a total of 3900 sq. ft.

Whenever possible you should try and stay within the recommended spacing and trench width. Spacing trenches closer together or making wider trenches often means a higher likelihood of system failure. These are options though for sites with high application rates that may not have the necessary space for a full-sized field.

While some counties in Missouri require that the soil scientist show the field layout on their site evaluation, this is not a state requirement and soil scientists should be aware that they are not trained or qualified to design septic systems unless they have had additional engineering training.

There are many soil and site conditions that can restrict the ability to install a conventional system. A conventional system will not be permitted if there is a restrictive layer that is within the required depth of vertical separation beneath the trench. If there is the presence of any of the restrictive conditions, such as IVb clays, bedrock, high ground water, or a restrictive layer such as a fragipan or a claypan that would occur within the necessary 2 feet below the trench bottom, these soils would not be suitable for the installation of a conventional system. Furthermore, any area that shows a high risk of ground water contamination would be unsuitable for a conventional system. The main example is cherty clay soils require a 4ft separation from the bottom of the trench and bedrock.

Some sites lack the area required for a conventional system. Many smaller lots that were created before 1996, when Missouri began requiring soil evaluations, do not have the

space for a conventional system. Some of these lots may be ½ an acre and it is difficult to find the space required for a conventional or any system on these small lots.

Sites that have 50% or higher rock content at or within 2 ft of the trench bottom are also only provisionally suited to a conventional system and may require modifications to the system.

There are other restrictions that we need to be aware of when we are siting a system as well. Trenches may not be over 100ft in length as distribution across the field area becomes uneven. Slopes that are greater than 50% require remediations to the field; such as further spaced lines, interceptor or French drains, or a larger field area and would be unsuitable if these requirements cannot be met. Slopes that are greater than 30% are generally unsuitable unless they can meet specific requirements outlined in the MO DHSS Rules Governing Onsite Wastewater Treatment systems. Trenches have a maximum width of 3 ft. and a minimum separation of 5 ft on center or 3x the width of the trench.

Many times, there will be characteristics present that qualify the site as provisionally suitable. There are modifications that can be made to the field and the site that allow for the installation of conventional systems in these areas that are provisionally suitable. One common issue can be the amount of rock fragments that are present in the soil and would restrict the installation of a conventional system. When the volumetric rock content, or when 50% of the soil horizon's total space is rock fragments, the site is unsuitable unless

the trenches are sand lined. The sand liner helps allow the formation of a biomat and has similar infiltration rates as the rocky soil horizons beneath the trenches. It must be assured though that these areas are not at a high risk of ground water contamination if there are severe geologic limitations that are present within 4 ft. of the trench bottom. A resource to check on severe geologic limitations is the Geologic Aspects of Individual Home Liquid-Waste Disposal in Missouri by James W. Duley.

A second common modification is the shallow placement of the field when perhaps there is less than enough suitable soil for the installation. When systems are placed at shallower depths, a minimum of 2ft of separation is necessary between the trench bottom and a restrictive layer. The top end of the gravel can be at the surface and covered with 8-12 inches of suitable loam soil. Should the trenches be constructed in any filled area. The fill must be of a maximum clay content of 20%.

Another modification is that two alternating fields of 75% size may be used in soils with high clogging potentials or high shrink/swell potential. All of these modifications must be approved by the administrative authority before installation.

While this system is called the conventional system, many of the conditions across the state of Missouri prevent the installation of this type of system and will require engineered systems, or the topic of our next video. Thank you for watching!

### Video 3 – Engineered Systems

For this video and the following videos, we will be talking about options for onsite wastewater disposal when the conventional system is not suitable either due to soil

properties or field size. In this video, we will discuss the Low Pressure Pipe System or LPP and the Drip Irrigation System. These systems require the design of an engineer, who will finalize the drawings for the system and prepare them for the installer. Both of these systems are in ground systems. These systems often require more maintenance when compared to a conventional system. These systems also require a pump tank that controls the amount of water that will be entering into the system at any time to help give the soil time to take in the effluent and perhaps dry out before becoming saturated again. The main benefit of these systems when compared to a conventional system is that these systems require less suitable soil depth to be able to be installed.

The first engineered or alternative system that we will look at is the low pressure pipe system.

Some basics of the design of an LPP system. The main difference between an LPP and a conventional system are the depth at which the lines are set and the primary treatment for the wastewater. The bottom of the LPP lines sit at 12" deep. These lines are 1.5 inch pressurized PVC lines and emit water slowly into the underlying soil. These lines require a foot of separation from any of the restricting layers that we talked about in previous videos. This is possible because of the pretreatment that the LPP has. The filtered tank of the LPP system removes more of the suspended solids that are present in the wastewater before the effluent moves into the pump tank. When the effluent in the pump tank rises high enough, it triggers the float switch and pumps the effluent into the field where it can be treated. Pump tanks may be set up as well to function on time dosing, where they pump effluent at specific intervals.

This system does require electricity to function, so siting for this system should take that into account.

The sizing of this system is much simpler than that of a conventional system. Simply take the gallons per day and divide it by the application rate of the most restrictive soil horizon in the top 24 inches of suitable soil. For a three-bedroom house for example we have 360 gallons per day. This is divided by the 0.15 application rate of a silty clay loam soil. This gives us the size of the field to be 2400 sq. ft. This 2400 sq. ft. can be made up of a variety of lengths and widths provided that the trenches that run with the contour of the landscape are not longer than 70ft.

This calculation is for systems that have the recommended 5ft of spacing between trenches. Systems may require more spacing, but this is the purview of the engineer.

It is possible that these systems can be smaller than a conventional system, as the recommended trench spacing is less than that of a conventional system.

Now some things to keep in mind when you are in the field and describing soils for the possibility of an engineered system. The LPP requires a 12-inch trench depth along with a 12 inch separation from any of the limiting layers, such as fragipans, IVb clays, bedrock etc. Similarly to a conventional system, when there are cherty clay soils with severe geologic restrictions, there needs to be 4 ft of separation between the trench bottoms and the underlying bedrock. These systems must be engineered. It is always important to communicate this information to the homeowner as an engineered system will often cost more than a conventional system to install.

The higher cost also comes from the modified nonstandard septic tank and the pump tank that help this system function correctly.

These systems are not to be placed on slopes greater than 10% unless there have been specific design procedures assuring proper distribution of effluent across the field.

Any signs of ground water that occur within the top 24 inches shall be diverted via interceptor drains or French drains.

Finally, as always there should be limited soil disturbances to the installation of the field area during the construction process.

So in what situations would this type of system be suitable for. The LPP system is more suitable to many of our rocky soils in Missouri. It is suitable when rock content is above 50% but below 70% and is even provisionally suitable for rock content above 70% provided that the trenches are lined with sand.

This system can function on a minimum of 24 inches of suitable soil, or in other words, when there are no restrictive horizons present within 12 inches of the trench bottom. On many smaller lots, the possible smaller field size could be a reason for installing an LPP. Finally, it is fairly common in Missouri to not have the necessary depth of suitable soil for a conventional system and the LPP may be able to meet the requirements to be the correct onsite waste water treatment system.

The next system we will talk about is the Drip irrigation system.

The drip irrigation system is a common system in Missouri that functions on some of our most restrictive sites. A little bit of an overview of the system. The drip irrigation system is a very shallowly placed system. The drip tubing that makes up the majority of the field

is only placed 6-8 inches deep into the ground. This ½ inch tubing emits effluent into the ground through small emitters. As these tubes are very small, they require a high amount of pre-treatment before the effluent enters the field to prevent any clogging of the lines. This pre-treatment can be completed using an aerated treatment tank or a passive media filter. While typical septic tanks break down organic material through anaerobic process, the aerated tanks and media filters bring in oxygen to help create aerobic processes to help break down the organic matter and waste. This along with filters means that the effluent that is leaving the tank is much more highly treated than the effluent leaving a regular septic tank. As the trenches are placed at only 6-8 inches deep, this system only requires that there be 18-20 inches of suitable soil beneath the soil surface for it to be acceptable.

When effluent leaves the aeration compartment, it moves into a pump tank. When the pump tank fills, it will pump water into the field area. The wastewater pressurizes these lines and is emitted into the soil and after the pump finishes its cycle, excess water flows back into the pump tank. This is necessary especially during the winter months, as extreme cold temperatures would freeze the lines if any water remained in them.

This system is one of the highest maintenance systems. It has recommended 6 month maintenance schedule of the filters to ensure that the effluent is clean enough to enter the pump tank and the field. Many counties require that homeowners with drip irrigation systems have a contract with a qualified maintenance company to ensure that the system is kept in good working order.

The drip system provides some unique use cases that allow it in soils that restrict the ability to install a conventional or LPP system. The drip system will often be used in places where there is little suitable soil available due to restrictive layers being present. The lines are usually plowed in at 6-8 inches in depth and there is a required 12 inches of separation between the bottom of these trenches and the restrictive horizon. Overall, you need a minimum of 18 inches of suitable soil for the installation of a drip irrigation system. This means that on sites that have shallow bedrock, fragipans, claypans or other restrictive layers these systems can often be installed.

The drip system is the only system that can be installed in IVb clay soils. If IVb clays occur within 18 inches of the soil surface drip lines can still be plowed into the soil and a system can be installed. The application rate for these soils is very low at 0.05 or 0.1 gallons per square ft per day.

The sizing of a drip irrigation system is very similar to that of the LPP system. It is simply the gallons per day, divided by the application rate for the most restrictive soil horizon within 12 inches of the trench bottom.

For this example, we will be using a two-bedroom house, which requires 240 gallons per day. There is a restrictive horizon at 20 inches. Our application rate will be 0.2 for a skeletal silty clay loam. We then divide 240 by .02 and this gives us 1200 sq ft. This 1200 sq ft can be laid out in a multitude of different ways as long as the longest run is no longer than 100 ft in length.

This application rate when these systems are sited in IVb clays typically increases the field size dramatically. For example, the previous field size of 1200 sq ft from 240

gallons per day and a 0.2 application rate becomes a 2400 sq ft field at a .1 application rate or a 4800 sq ft field at 0.05.

When the soils are suitable though, similarly to an LPP system, drip systems can be used on sites that have little available area.

Some restrictions and requirements that go along with the drip irrigation system. As these systems have an aerated tank or media filter and a pump tank, they require access to electricity and siting for the tank needs to make sure that there is available electricity nearby.

As always, the minimum suitable soil depth of 18 inches is important to remember when out in the field to be able to assess whether an inground system will be able to function. The only restrictive condition that a drip irrigation system can be installed in are the IVb clays.

Drip irrigation systems should not be installed in soils with coarse fragment percentages higher than 70% in the top 18 inches.

One thing about the aerated tanks that can be bothersome for some residents, is that if these tanks are used in locations that are mostly temporary or vacation homes that are not receiving consistent water usage, the aerobic bacteria in the tanks can die off. This may cause a smell to be emitted from the tank. It will take some time of water usage to restore the microbial community to these tanks.

Lastly, there are times when a homeowner wishes for an inground system, but the soils are not suitable even for a drip irrigation system due to shallow restrictive layers, like bedrock or fragipan. It is possible to bring soil onto the site to be able to reach the

required soil depth. The soil brought in should be clean fill, meaning without rock and containing clay percentages lower than 20%. Remember to use the lowest application rate in the soil profile that contains suitable soil. With these shallow placement systems, it is advised to give the system a 0.15.

These engineered systems are fairly common across large portions of the state as there are many soil properties that restrict the installation of a conventional system. There are many other options for wastewater treatment systems beyond the engineered systems though. These will be explored in the next video. Thank you for watching!

Video 4 – Above Ground systems.

For this video, we will be discussing above-ground systems. These systems treat wastewater through different means than the in-ground systems, which rely on the properties of the soil and the microbial communities within the soil. Above ground systems typically rely on forms of evapotranspiration to perform the treatment of the effluent. The two systems that we will talk about today are the lagoon and the wetland. Both systems should have a tank placed before them that will collect the solids while the effluent will enter either of these systems. Some counties restrict the use of above ground systems and you should always contact your local administrative authority to ascertain that these systems are allowed in their jurisdiction.

Let's begin with the lagoon, the more common of the above ground systems. We'll look at the basic structure of the lagoon, its when they are used, and the sizing of the lagoon.

A lagoon, or a wastewater stabilization pond, is a body of water in which the effluent sits and is treated through the force of evapotranspiration. These are very common in parts of

Missouri that have shallow high shrink swell clay soils, such as in northern Missouri with its glaciated landscape. They are used throughout other parts of Missouri also, as high shrink swell clays are common in many parts of Missouri. Effluent enters the lagoon typically from gravity flow from a septic tank. It flows onto a concrete splash pad in the center of the lagoon to prevent erosion and the water will remain there as it evaporates. Lagoons have specific dimensions seen here that must be followed. They must have a berm to shed surface water away from the water of the lagoon, they must have a minimum of 18" of freeboard above the water to allow for to rise during rain events. They must have an outlet pipe to allow for outflow during heavy rain flows without damaging the structure of the lagoon. The water level is typically 36 inches deep and the sides of the lagoon must be sloped in a 3:1 ratio. Most lagoons are constructed in soils that have a high shrink swell potential to hold the water in place and not allow it to percolate into the groundwater, or they are built with a clay or synthetic liner. Any trees within 50ft of the waters edge of the lagoon must be removed, as they pose the risk of their roots entering into the berm and compromising it and the trees can shade the water and impede evapotranspiration. Finally, as seen in the picture, a fence must be placed around the border of the lagoon to prevent humans and wildlife from entering the lagoon. Lagoons are sized at 440 sq. ft. per bedroom. Meaning a 4-bedroom house must have a 1760 sq. ft. lagoon. Many counties will allow for a reduction in the size of the lagoon if there is a septic tank that precedes the lagoon. This reduction is 20%. So the 1760 sq. ft. lagoon would become a 1408 sq. ft. lagoon. Each county is different and contacting the location administrative authority is necessary to know whether the county you are working in allows for the reduction in lagoon size.

Lagoons have stricter setbacks than other systems and being aware of these is important. We will talk more about the specifics of setbacks in the Field Layout Video Series, but for now remember that they should not be sited in drainage ditches, heavily sloped areas, and that heavily forested may require significant tree removal before the lagoon will be suitable.

So why would you install a lagoon. Lagoons are one of the cheapest and most reliable systems that are available for many homeowners. They are very unlikely to fail and last a long time. Maintenance on the system itself is very low, simply needing the tank pumped out periodically, and mowing around the berm to prevent the incursion of trees or shrubs.

These systems are very common on sites that have shallow high shrink swell clays and are often typical on larger properties.

These systems do have many requirements and restrictions placed upon them.

There are greater setbacks for a lagoon than for the inground systems, such as 75 ft from a property line rather than 10'. See the green book for the entirety of the list.

Lagoons are not generally suitable in subdivisions with lots less than 3 acres. They are required to be 100' from the homeowner's house and 200' from any neighboring houses. They must have at least 12" of high shrink swell clays on site or a clay liner or a synthetic liner must be brought in. High shrink swell clays can often be harvested from foundation or basement construction that would be suitable for the construction of the liner.

They are typically not suitable on slopes greater than 15%, as there would have to be significant earth work to assure that the berms are in place and will not fail.

Trees must be cleared 50 feet from the waters edge. This is to both prevent roots from entering into the lagoon and to allow for wind and sunlight to be able to reach the water's surface. Along with this, deep rooted plants or shrubs should not be planted on the embankment.

The shape of the lagoon should be round or rectangular with its dimensions being no greater than 3:1.

Finally, it must have a fence surrounding the water's surface.

Another above ground system is the wetland system. This system is less common than the lagoon as they require some more maintenance from the homeowner/installer than a lagoon. The principles of a wetland system are fairly similar to a lagoon. They rely not only on evapotranspiration to treat the effluent, but also the biological and natural processes of the plants that are present in the wetland system. These systems require some sort of pretreatment for the effluent, either in the form of a septic tank or an aerated tank. When looking at the system itself, Missouri only allows systems in which the effluent flows through channels filled with rocks, so that there is no free standing wastewater. Among these rocks, emergent aquatic plants are growing that help process the effluent. Some percolation may be allowed through the bottom of the wetland, or into a second cell that will allow more percolation of the effluent. The size of the wetland as seen here cannot be calculated without information on the Biological Oxygen Demand from the Influent and effluent of the septic tank. With higher amounts of pretreatment allowing for smaller wetland.

The setbacks for a wetland are the same as a lagoon, and therefore prevent them from being used on smaller lots.

Here is a list of the plants that are acceptable to be planted inside the wetland to help treat the effluent. Many homeowners who have wetland systems enjoy seeing the variety of plants that are growing here and think of this as a garden project that provides food and habitat for local creatures.

These above ground systems while not suitable in all cases fill an important role in the wastewater treatment in Missouri as they are suitable in many sites that would not allow the use of an inground septic system. Some homeowners choose to have lagoons due to the lower installation cost and lower maintenance that a lagoon or wetland may have when compared to a highly engineered inground system. From here we will talk about some other systems and modifications that are possible in Missouri.

Thank you

#### Video 5 - Sand based systems & Other systems

For our final video in this series, we will be going over the sand-based systems and a few of the other systems that are present in the rules and regulations for onsite wastewater disposal. These systems are less common than the other systems mentioned above but are becoming more common in certain areas of Missouri. These systems are often required to be designed by an engineer.

Sand may seem like an odd material to use as a treatment agent. As we learn in our soils classes, sand typically does not provide the pore space necessary for the growth of large amounts of microbial life that are necessary for the treatment of wastewater. Sand has

high percolation rates as well, meaning that the wastewater could move through the sand too quickly and not receive the necessary treatment. These sand based systems rely on the development of a biomat to help in slowing down the percolation rate of the wastewater and to create the environment necessary for the treatment of wastewater. These systems often still rely on the actual soil present at the site for treatment beyond that provided by the sand and there are still required depths of suitable soil that are necessary for these systems.

Often these systems require a specific grade or quality of sand for their construction. This means that the cost of the system can vary greatly depending on your location in the states. Each system has slight differences on the quality of the sand that is necessary.

The first system we will be talking about will be the elevated sand mound. The goal of this system is to provide homeowners with a wastewater disposal system in an area that has shallow restrictive layers and limited site space. The system consists of a mound of sand built above the current soil surface level into which the effluent is dispersed.

Moving through this initial sand system, the effluent receives further treatment before moving into the underlying soil beneath the sand mound. This underlying soil is the basal area for the elevated sand mound system and provides the final treatment to the effluent.

The elevated sand mound has two aspects that need to be calculated, one pertained directly to our job as the soil scientist providing a soil evaluation and one portion dealing with the materials that the installer can provide. These are the Sand Mound and the Basal Area. The Sand Mound is sized based on the material that can be brought in to make the sand mound. These should be of sandy texture and the loading rates are calculated with

the same 120 gallons per day per bedroom. The calculations of the basal area depend on the soil that is currently onsite and that we will describe as soil evaluators. They are based off the basal loading rate and the daily water usage. An example of these calculations can be seen here.

There are some restrictions and requirements for this type of system. There must be 24 inches of suitable natural soil, meaning there can be no evidence of high ground water table, bedrock or other restrictive layers. If the soils are very rocky, there should be at least 4 foot of separation between the soil surface and the underlying bedrock. There is a 50' setback downslope from the system that is required, as this is the effluent dispersal area. Slopes should be no greater than 6% and under no circumstance greater than 12%.

The next system we will discuss is the Presby System, a system that has been newly approved in 2024 and is not present in the DHSS rules governing wastewater disposal handbook. The specifications of the system can be found online through the Presby companies website and through the resources tab in this lesson. The Presby System is an engineered system that functions with a standard septic tank and does not require a pump tank. It is a system that functions as either a mounded or in ground system. It requires a minimum of 12 inches of suitable soil beneath the surface, meaning less than 50% rock fragments and no IVb clays. When there are only 12-24 inches of suitable soil present onsite, the system will be mounded. If there are more than 24" of suitable soil beneath the soil surface, the system can be installed inground. The system functions as an engineered system by allowing oxygen to flow through the inground pipes creating aerobic reactions that occur in the mesh surrounding these pipes to help speed up the treatment process. These pipes are then surrounded by a sand of ASTM C-33 quality. The sources of this

grade of sand can vary greatly depending on the location of the property in the state and may increase the overall cost of this system. This system has the same sizing protocols as the other engineered in ground systems of the gallons per day divided by the application rate of the most restrictive suitable soil horizon. These systems can be smaller than that given size though if the soils are able to meet specific conditions listed in the Presby manual.

Our next topic will be the Sand Filter system. This system is not a stand alone wastewater treatment system, but rather functions as an additional filtration agent to be used alongside other soil absorption systems. These are typically used in areas with very slowly percolating soils. When used in conjunction with an inground septic field, the size of the field may be reduced by one third.

Lastly, it is possible that you will run into holding tanks that are present on older properties. Holding tanks are not a wastewater disposal system that is allowed in the state of Missouri anymore, unless under very strict and specific circumstances that require the approval of multiple state and local agencies. Holding tanks simply hold the solid and liquid waste until it can be pumped out and transported offsite to be treated by another wastewater treatment plant. These systems pose a high risk of failure and contamination and pollution of nearby waterways.

When we are thinking about the wastewater treatment possibilities with a homeowner on a job site, it is incredibly important to remember that the right system is the system that works with the soils onsite. It is our job as soil evaluators to ensure that the humans, animals, ground water, streams, lakes, and environment around this site remain protected

from human waste. It is your responsibility to accurately describe the soil conditions and restrictions that would allow or prevent a specific system. Many times, though, there are options for a homeowner and working with them to know which type of system will work best for them with their budget and maintenance is an important conversation to have with them. While we are rarely providing the final voice in the type of system that will be installed at a home, it is important to inform the homeowner of the options and responsibilities of managing an onsite wastewater treatment system.

Thank you for participating in this series. I hope you are better informed about how the different systems available in Missouri are affected by the soils that we find onsite.

## **SOIL PROFILE DESCRIPTION**

### Soil Profile Description Script

Welcome to our video series on Soil Profile Description. In this video we will go through all the necessary information on the soil profile description sheet for a soil evaluation in the state of Missouri. We will discuss each characteristic that must be described, its importance and influence on wastewater and application rates and go through how to assess and record these.

This is the sheet that you will be filling out for each soil profile description. It is a good reminder that there should be two soil profile descriptions per septic field area, one pit above the field area and one pit below the field area to assess the changes that can occur across this field area. These pits should be dug to a minimum depth of 48 inches and a maximum depth of 60 inches. Soil characteristics should be described down to a depth of 60 inches for suitability of a conventional system.

These pits can either be hand dug or dug by a backhoe. A backhoe will provide wider pits that will allow for more accurate assessment of the soil characteristics and will take much less time than hand dug pits. It is recommended to have pits dug by a back hoe over hand digging.

Let's quickly go over some tools and resources that you'll need for describing a soil profile. For tools, you'll need a hammer or pick to be able to clean a large face, a smaller tool, such as a soil knife to fine clean the face, water, and a measuring tape. You'll also need the Munsell Color book, as well as the Field book for Describing and Sampling Soils. The Munsell Color book must be purchased, but the field book can be acquired free of charge through the NRCS website or in pdf form through their website as well.

### Horizon Designations

One of the first steps when entering a pit after cleaning off the face is to mark the changes in the soil horizons. These changes will be designated by changes in color, texture or structure. You will mark down the depth at which these changes occur. Color is often the most obvious change in horizon, such as is often the case in the change from an A horizon to an E or a B horizon. Texture and structure can be a bit more difficult to notice and may take longer investigation into the soil profile. Care should be taken to compare and contrast soil from different depths to look at how the soil is changing and where the lines marking the changes of the horizons should be drawn.

Once you have these depths marked the next thing will be to look at how these changes occur across the soil profile. You will be noticing the width that it takes for the changes in color, texture, or structure to occur and how this change happens across the soil

horizon. The area of change between two horizons is called the boundary. The width of the separation between the soil horizons is called the class of your boundary. Class is broken up into 4 qualifications, abrupt, clear, gradual, and diffuse. The class tells us how quickly the change between the two horizons occurs. The abrupt boundary means the change occurs in a 1 in or two centimeter area or about the width of your thumb. The clear boundary signifies the change occurs between 1-2 inches or 2-5 centimeter area, or about the width of three fingers. The gradual boundary means a 2-6 inches or 5-15 cm area, or about the width of your hand, and the diffuse boundary is anything greater than 6 inches or 15 cm. Along with the class we will have to record the topography of the boundary, or how the boundary changes across the soil profile. The choices for this section are smooth, wavy, irregular, and broken. Smooth has planar or flat with few or no irregularities. Wavy has undulations or changes in the depth of the soil across the profile and the width of the changes greater than the depth. In irregular topographies, the depth of the change is greater than the width. And Finally broken topographies will have intermingled or isolated pockets of soil that are not continuous across the soil horizon.

Each of these has their own abbreviation as well that gets recorded in the state form. The class precedes the topography of the boundary and each of the different classes or topographies gets shortened to a single letter. For class the abbreviations are A for abrupt C for clear, G for Gradual and D for diffuse. The topographies are abbreviated as S for smooth, W for wavy, I for Irregular and B for broken. Here you can see the boundaries and depths that were recorded for our example soil profile. We've recorded the depths in inches for each horizon and what the lower boundary of that horizon looks like. For example the third horizon goes from a depth of 13 to 23 inches and has a clear smooth

boundary separating it from the fourth horizon. An important note is that the lowest horizon doesn't receive any topography designation and should be left blank. This is because this boundary is not visible, as the horizon continues below the bottom of the pit.

Now that the horizons have been divided and we have recorded the depths of each of them, we can begin looking at the other properties of each of these horizons. The following properties can be examined in almost any order and many soil evaluators do profile descriptions in very different ways. Some like to look at all the properties for a horizon before moving along to the next, others like to perform the same investigation, for example structure, for each horizon before moving to the next property. These properties are the color, the presence of redox features, the textural class and clay percentage, the percentage of coarse fragments by volume at less than and greater than 3 inches. The consistence, the structure, and the roots and pores.

For now, I'll go through these properties in the order than I like to record them, but know you can do these in any order. The first thing that I like to look at is the soil structure. Soil Structure is the way in which the soil particles have been organized by living and non living forces. Structure is created through many ways, such as deposition, living organisms, roots, microbes, worms, the movement of water, freeze thaw cycles, and chemical reactions. As soil evaluators, we record the grade size and structure types, as all three of these will tell us information on how wastewater will move and be treated by this soil. Structure strongly influences how water will infiltrate and permeate through a soil horizon and informs us about whether or not water will move and be treated by the soil. I like to judge soil structure first as we should be looking at how the soil occurs naturally in the profile face as well as how it occurs once it is removed from the soil profile. Other

properties will require breaking or handling the soil, and this can disturb or break up the structure. For this reason, structure is a good property to begin with.

Let's look at the three classifications that are required for the soil structure. A final soil structure entry will have 3 parts. The Grade, the Size, and the Type. For example, an entry may be 2MSBK, the first number is the Grade, the first letter will be the size and the remaining letters will be the type of the structure. The grade or the recorded number is how evident the structure stands out. The different grades are 0 for massive, 1 for weak, 2 for moderate, and 3 for strong. The different grades can affect the application rates of wastewater, with weak structure often receiving a lower application rate than moderate or strong structure, according to the EPA. 3 or strong structure is very evident, it should easily be visible in the soil profile after cleaning a new face off. Often soil evaluators will say for a grade 3 structure, that they could see it from outside of the pit. 2 or moderate structure is a structure that is visible once it has been removed from the soil profile.

Pulling large chunks of soil off the soil profile will often allow for individual peds to begin to be visible. We should be seeing how easy it is to identify individual peds that are emerging from the soil profile. If you can decide the structure only once it has been removed from the soil profile and is in your hand, it would receive a 2 grade. 1 or weak structure, is a structure that is difficult to assess. Even after pulling the soil from the soil profile and examining it closely in your hand, if the individual peds and structure of the soil is still difficult to discern, then it is most likely a weak structure. If there have been signs that soil forming factors have occurred in this horizon, such as root growth, pressure faces, or signs of worms or other living organisms, it most likely has at least weak structure. 0 or massive structure is typically reserved for parent material. This is

material that has not undergone pedogenic forces that would create structure. This may be common in deeper glacial till deposits, or horizons that are newly weather from the underlying bedrock.

The next classification for structure is the size. The sizes of structures are, very fine or vf, fine or f, medium or M, coarse or c, or very coarse or vc. Each soil texture has it's own size classification, so it is often helpful to use the field book for describing and sampling soils from the NRCS to help with the size code for each soil structure. For example, a Medium blocky structure will be from 10mm to 20mm while a medium granular will be from 5 – 10 mm.

The final code that must be recorded in the structural column is the structural type. The most common structure in Missouri are Granular, or Gr, Subangular Blocky or SBK, Angular Blocky or ABK, Platy or Pl, Prismatic or Pr, Single Grain or SG, and Massive or MA. Lenticular, Wedge and Columnar may occur in Missouri, but they are much less likely due to the typical soil forming factors that have acted upon the soils of Missouri.

Structure and permeability are closely aligned and different structures allow for different amounts of water to move through them. In this example, we can see that the single grained soils allow for large amounts of water to move through them. This is true as single grained soils are most commonly of the sand or loamy sand textural class, meaning they have large pores which allows for quick water movement and often they have little organic matter or clay percentages which would hold the water in place and prevent the downward movement of the water.

This is similar to granular structure, as granular structure often has high amounts of pore space and allows for quick movement of water.

Our soil structures with moderate permeability are the blocky and the prismatic soil structures. The permeability of blocky structures strongly depends on the size and grade of the blocky structures. The coarser or larger the size of the blocks, the slower the downward water movement will be. Finer sized soils and soils with stronger structural grades, such as moderate or strong, will allow for more downward water movement. For example, a moderate fine subangular blocky structure will have better water movement than a weak coarse subangular blocky soil structure. This is due to the amount of pores that have most likely developed alongside the finer structures of the soil. Prismatic soil structures often have similar permeabilities to a coarse blocky structure regardless of size, and will often have lower permeability than most blocky structures.

The structures with the slowest permeability are platy and massive structures, both of these structures are unsuitable for septic systems in Missouri. These structures prevent the downward movement of water, as they do not have the pores and cracks that would allow for water to move through the soil.

Let's now look at some examples of soil structure.

Granular structure is one of the most common structures in Missouri and is often found in surface horizons, though it can be found in other horizons. Granular structure is identified by its many sided shape that has very rounded corners and edges. It is a smaller structure on average than the other structures. It is commonly assigned to A horizons that have

strong vegetation and biotic communities that have created numerous pores in the soil. This structure is suitable for septic systems.

The next structure is Subangular Blocky or SBK soils. These soils have rounded edges often with some flat or flat-ish surfaces. Their corners will often come to obtuse or right angles and you should be able to see distinct sides in the peds. This is most likely the most common soil structure in Missouri. It is provisionally suitable for septic systems.

The other blocky structure is Angular Blocky or ABK structure. Where the SBK structure had rounded edges and obtuse angles, this soil structure will have sharp or pointed edges and right or acute angles at its corners. There are often distinct flat sides and smooth faces. ABK structure may be related to clay content or compaction. It is provisionally suitable for septic systems.

Prismatic structure is a structure that is longer than it is wide. These are vertical prisms that often form through the movement of clay or other highly adhesive particles. The prisms can be up to 36 inches in diameter, but most prisms are smaller than this. When looking for prismatic structure, it is a good idea to try and pull out large pieces of soil from the profile face and look at how and where they are cracking. If you can see many vertical cracks but few horizontal cracks, it is likely prismatic structure. Prismatic structure will often break into one of the blocky structures as it begins to fall apart. It is provisionally suitable for septic systems.

The two non-suitable structures are the platy structure and the massive structure.

Platy structure often originates from high amounts of compaction that have occurred on the soil. This causes the natural structure to break apart and the soil to be smashed into

thin or thick plates. These plates have often lost their pores and do not allow for water to permeate or infiltrate. Platy structure is identifiable by horizontal lines that can be separated into smooth, thin layers. Platy structure is unsuitable but may be mitigated through multiple rounds of tilling and the planting of densely rooted grasses.

Massive structure is also an unsuitable structure. It is caused by clay particles that are so closely bound and have not have pedogenic forces acting up them. Soil with this structure is often referred to as parent material, as the forces of soil development have not occurred on these soil horizons. This structure is usually highly impermeable and is overall unsuitable for septic systems.

### **New Video – Roots, Pores, and Coarse Fragments**

In this video we'll be talking about some of the other soil properties that are part of the soil evaluator form. We left off in the last video having pulled some soil off the soil profile and examined the peds. The next property that I like to look at after examining the structure of the soil is the number of roots and pores that are present in this horizon.

While examining the soil structure, I am breaking apart peds and in breaking apart peds, I am looking as well for pores and roots that are present in the soil. I'm comparing what I'm seeing in the individual peds with what is occurring in my cleaned off soil profile.

So what are pores. Pores are the air space that occurs within the soil. This is the network of airways that allow for water and air to move in and out of the soil. They are created through roots moving through the soil, insects and worms moving through the soil, soil

particles being glued together by organic matter and other processes that allow for pores to form. There are two types of pores in the soil. Micropores and Macropores.

Micropores are pores that are not visible to the human eye but do still allow minor amounts of water and air to move through the soil. Almost all soils have micropores, even heavy clay soils. Macropores are pores that are visible to the naked eye. These pores are capable of moving significantly more water and air than micropores. These are the highways of air and water movement. Macropores are very fragile and can be broken due to compaction or tillage. Macropores typically occur where the soil has a coarser texture and where organisms and roots are living in the soil. For the soil profile description sheet, we will only be assessing macropores or those that are visible to the naked eye.

why do we care about roots and pores when we're thinking about wastewater treatment. Let's start with pores. As pores are the negative space to the positive space that is soil, pores allow for the movement of air and water into and out of the soil, two processes that are absolutely necessary for the treatment of wastewater. As wastewater moves through these macro and micro pores, organisms that live in these pores are breaking down some of the harmful compounds and extracting them from the wastewater. Pores also are the exchange sites for the nutrients and chemicals that are present in wastewater. As wastewater moves through the soil, our positively charged nutrients and chemicals latch onto the negatively charged soil where they will be made available for plants and organisms to use.

When pores are not present in a soil, that may mean that water will move much more slowly through the soil profile and may back up and cause wastewater to surface.

Roots are another important aspect that we are looking at. Roots of plants take up large amounts of water through the process of photosynthesis. This drawing in of water helps keep soils dry and ready to accept more wastewater. Furthermore as roots grow and die every year, they are leaving behind new pores for organisms to live in and help treat the wastewater.

How do we assess roots and pores:

The NRCS book gives us a simple guide for estimating and classifying the amount and size of roots and pores that occur in a soil horizon. The classification for both roots and pores follows the same procedure. The first thing to look for is the size of the roots and pores as this affects the assessment area. The size classifications for roots and pores are on the screen, but they range from very fine or less than one mm to very coarse or anything greater than 10mm. you will typically choose the largest size of root or pore that occurs in the soil horizon. Once you've decided on the size of the roots or pores, this will give you the assessment area. If your roots or pores are Medium or larger they will receive a 10cm by 10cm area or 4in by 4 in are in which you will assess the quantity of roots. If the roots or pores are fine or very fine in size, they will get a one centimeter by one centimeter assessment area. You can now begin quantifying the amount of roots and pores using the correct assessment size. This should be done 3 to 5 times across the soil horizon, as it is likely that there will be variability of roots and pores in different sections of the same soil horizon. These quantities are few, common, and many. Few is less than one in the assessment area, common is 1-5 in the assessment area and many is more than 5 in the assessment area. This will leave you with the response to fill into the soil profile

sheet, such as many fine roots, and common fine pores. Let's look at some examples of each of these as they happen on peds or in the soil profile.

When filling out the sheet, roots will be on the top of the row and pores will be on the bottom. It's important to note that while there is often some correlation between root size and quantity and pore size and quantity this is not always true. For example soils that are at depths greater than 36 inches may not have many roots that are present in the soil, but depending on the soil texture and other soil properties, there still may be many or common pores that are present. Another example is in compacted soil. Often in compacted soil on the surface there may be many roots that are present in the horizon, but the compaction has most likely destroyed the majority of the pores. For compacted surface soils, it is common to have common or many roots that are present while only having few or no pores being present.

Roots and pores will affect the overall application rate, with soils that have high amounts of roots and pores being able to take up and treat wastewater better than soils with few roots or pores, even if they are of the same texture and structure.

That wraps up this column of the soil profile description.

Another property that uses the same 10cm x 10cm guide is the estimation of coarse fragments. For the estimate of coarse fragments, you are estimating the percentage of coarse fragments that are present in a soil horizon by volume. Coarse fragments have a large effect on water movement and treatment. Coarse fragments or rocks, do not hold onto water and do not house the microbial life necessary for the treatment of wastewater. Soils with high amounts of coarse fragments can allow for wastewater to move through

these horizons untreated. Soils with greater than 70% coarse fragments are unsuitable for a septic field and soils with greater than 50% coarse fragments by volume require modifications to a standard system or require an engineered system. So how do we estimate coarse fragments.

The NRCS handbook recommends estimating coarse fragments using their designed charts to show the space that the coarse fragments are taking up in that 10cm x 10cm guide area. They provide examples for many of the different percentages. This assessment should be done visibly, but also with a tool, as soil particles can cover coarse fragments and they may not be visible. I like to take my soil knife and tap around in the area to assess whether and how many coarse fragments are present in the soil.

After we have a percentage of coarse fragments by volume for the entire soil horizon, we must break up the coarse fragments into two categories, gravels and cobbles. Gravels are coarse fragments are greater than 2 mm but smaller than 3 inches. This is a very large range. Cobbles are any coarse fragments that are greater than 3 inches along all three dimensions, meaning it must be 3 inches long, wide and tall for it to qualify as a cobble. Even a few cobbles in a soil horizon can make up a large portion of the volume by percentage. These coarse fragments greatly affect how water moves through the soil, and correct and accurate estimates are important for recommending a suitable application rate for the soil.

Thanks for watching this video.

**New Video – Color**

In this video, now that we have assessed the soil for many of its visual physical properties, we can begin looking at other columns on the soil profile description sheet. For this video we will be looking at the soil color and redoximorphic features, which are also assessed through soil color.

Soil color may seem like an odd thing to assess as a soil evaluator, but soil color can tell us a lot about the origins of the soil and the current conditions that the soil is under throughout the year. For assessing color, soil evaluators should use the Munsell Soil Color Book.

When we are evaluating the colors of a soil horizon, we are classifying all the prevalent colors that are present in the soil profile. We examine all the different colors and record them as each of these colors can tell us different things about the soil. Soil colors can tell us about the parent material of a soil. Red sandy soils are most likely originating from Roubidoux Sandstone Residuum, Creamy or tan colors often originate from dolomite residuum. Soils in flood plains often have very dark colors due to the higher organic matter content. Changes in color up and down the soil profile can often signify drastic changes in the soil. An E horizon for example is a zone of eluviation and often has a light color as many of the minerals have been leached out of this horizon by moving water. A sudden change in color may also signify a change in parent material, such as moving from a brown/gray of loess into redder soils of glacial till. Soil color can tell us a great deal about what is happening in our soil.

We record the color of the soil using the code based on the Munsell Color Book. We should be recording three different types of information that will tell us the exact color

that we are referring to. These are the hue, the value, and the chroma. The hue is the general color that we have selected. These are the different pages in the Munsell Color Book. The hue is the first thing we write in the box for the soil profile description color. It is located at the top right of the page in the Munsell Color Book. It is very common when trying to assess the color of a soil to begin with the 10YR page. These numbers and letters are telling us the amount of each color that is making up the page. For example the 10YR page is 10 parts Y or yellow for every one part R of red. Some other common pages may be the 2.5Y page, meaning it is 2.5 parts Y or yellow, or the other YR pages and the R pages, signifying very red soils. The next this we must record is the value of the color. This is the lightness or darkness of the color and is located on the left side of the page in the Munsell Color Book. The lower the value, the darker the color, and the higher the value, up to 8 the more white the color is. The final piece of information is the Chroma or the density, brightness or purity of the color. A low chroma has a more gray or washed out color. A high chroma is a very bright color or has lots of pigment. For example on the 10YR page a chroma of 1 is very gray, but a chroma of 8 is orange. These three pieces of information should be combined into a the code that gets recorded into the Munsell color column. For example this goes 10YR 4/4 meaning hue of 10YR, value of 4/ and chroma of 4.

Color tells us much more than simply information on horizonization or parent material. One of the most important pieces of information that soil color tells us about is the redoximorphic features that are present in a soil. Redoximorphic features are reactions that occur in the soil when it is under saturated conditions. The appearance of redoximorphic features are often a sign of a seasonal or perched water table. Placing

septic systems in soil horizons that show the presence of seasonal or perched water tables is not allowed, as it would allow for the movement of pathogens into the ground water.

Redoximorphic reactions occur because iron and manganese are two of the most common minerals in the soil. Iron often has a red/orange rusty color and manganese has a black color. These minerals are in stable forms when there is enough oxygen moving in and out of the soil. During times of saturation, most commonly in late winter and early spring, the soil is waterlogged and there is no oxygen that is present in the soil. Because of the lack of oxygen, microbes in the soil begin to reduce the iron and manganese from stable to soluble forms. In this soluble form, these minerals are able to move around or out of a soil horizon. When these minerals move, the natural color of the soil becomes apparent, which is a light grey color. This grey or gley color, along with the rusty orange/red and isolated black colors are the colors we are looking when we record information in the Redoximorphic Features Column. The colors that signify the presence of a water table are the gley colors, or colors with a chroma of 2 or less and usually a value of 5 or higher. If there is a high amount of organic matter in the soil, a value of 4 may be used to signify a reduced matrix color.

It's important to note that sometimes you will get these light grey or whitish colors simply from the parent material and not from redoximorphic reactions. These are common in residuum soils that have weathered from shales, sandstones, or limestones.

In the redoximorphic features column you will record the Munsell color of the gley colors, along with the presence of accumulated iron (rusty red colors) or manganese in the soil. It is a good idea to record along with these colors the percent area that is covered

by redoximorphic features, as few or f meaning less than 2% of the area is covered, common or c meaning 2 to 20 percent of the area is covered in redox reactions, or many/m as in more than 20% of the area shows signs of redox reactions.

The recording of these redox reactions is very important as there should be a vertical separation of more than 24 inches between the bottom of the trench for a standard system and a water table, or 12 inches for engineered or alternative systems dispersing more highly treated effluent.

Let's look at our examples:

Thank you for watching this video on color and redoximorphic reactions. I hope you all enjoyed it.

### **New Video - Soil Texture:**

Hi Welcome to our video on soil texture, coarse fragments and consistence. In this video we will be discussing how to perform a field evaluation of soil texture, how to estimate coarse fragments and how to assess soil consistence.

Let's begin with soil texture. As many of you might know, soil is made up of three different textural groups, that are governed by their size. Sand is the largest particle size class, ranging from 2 mm to .05 mm. Soil particles of this size are visible to the naked eye. Sand sized particles mostly consist of particles comprised of quartz. These large particles create large pores in soil but do not hold much water and offer little treatment potential, as they do not have the cation exchange capacity of finer soils or the fine pore space to provide the environment necessary for high amounts of microbial life. The next particle size is silt sized particles. These range from .05 to .002mm. The individual silt

particles are generally not visible to the naked eye. Silt is generally made up of a combination of quartz and other secondary minerals, such as feldspar, mica, or illite. These fine particle sizes provide the pore space necessary for the movement of water while also providing the necessary environment for microbial life. Water does move slower through silty soils than through sandy soils, but there is generally sufficient infiltration in silt heavy soils for the treatment of wastewater. The final particle size class are the very fine sized particles, or the clay particles. These particles are smaller than .002 mm and are generally only visible under high amounts of magnification. Clay particles are generally made up of secondary minerals such as kaolinite, smectite, goethite, and other minerals. These very fine sized particles have very high water holding capacities due to the large surface area that is present in these soils. This high water holding capacity and very small pore size does not allow for large amounts of water movement. Clay particles also can exhibit shrink swell properties that are not as common in the other particles sizes. This is the tendency for some clay particles to expand when they get wet and shrink when they dry. This is due to their chemical composition. We'll go more into this in the next video.

To make an estimate of the textural class, it is necessary to understand the textural triangle and field texturing methods. The textural triangle shows all the possible combinations of the soil particle size classes and the group that these would be assigned to. For example, a soil that is made up of 40 percent sand, 20 percent clay and 40 percent silt is called a loam.

We find these soil textural classes out in the field using a few methods to inform our decisions. We are estimating the soil textural class as well as the specific amount of clay that is present in the soil. The first method is the ribbon method (Filmed Live)

The wire method is the second method for estimating clay percentage. (Video)

The last method is the smear method, this method looks at how smooth the surface is of soil that is pressed and smeared between the forefinger and thumb. Soils with high clay percentages will be form smoother faces and will not rough up or ribbon back.

On the evaluation form, you will fill out the abbreviation for the soil textural class and the specific amount of clay that you found in your field estimates. This is important because the exact amount of clay directly affects the application rate. A silty clay loam with 27% clay will allow for a higher application rate than a silty clay loam with 39 percent clay.

The next thing that we will be measuring is the consistence of the soil. Consistence is how resistant a soil ped is to crushing. The possibilities for this part of the form are friable, firm, very firm and extremely firm. These classification should be done moist. If the soil peds are very dry upon removal from the soil profile, they can be sprayed down with water and allowed to moisten up for a few minutes before attempting the consistence rating. For consistence, you will take a small ped and try and crush the ped between you thumb and forefinger. If the ped breaks apart with gentle to moderate pressure, the consistence would be friable. If moderate pressure is necessary and there is noticeable resistance to crushing, the soil would receive a firm rating. If the ped is barely crushable between the fingers, it would receive a very firm rating. If the soil is not able to be broken

between the fingers, or is only able to be broken apart bit by bit, it would qualify as extremely firm.

#### New Video - Soil Horizonization

Once you have recorded all the soil properties from the soil horizons, it will allow you to give each soil horizon a horizon designation.

You will be recording the different horizon designations on the state form. The main designations for the horizons are the O, A, E, B, C and R horizons. Each of these has their own characteristics that will qualify them as distinct horizons. Horizons can be of any thickness, but it is typical to have the minimum size of a horizon be at least 4 inches thick. The O horizon is a highly organic surface horizon. It is a horizon that may have both organic and mineral soil materials, but is dominated by organic materials. It is very dark in color, but rarely occurs in Missouri.

The next soil horizon is the A horizon. The A horizon is also known as the surface horizon. It often has darker color, more granular structure. It is common that in Missouri the A horizon is composed of loess. This horizon has often lost iron, aluminum and clay through the downward movements, but has a high accumulation of organic matter. A horizons often receive the p as a subordinate distinction. This p after the A signifies that there has been human influence on this horizon. It is often called anthropomorphic influences or the plow layer. This could be due to farming and tillage or due to heavy amounts of compaction.

The E horizon is the sub surface soil. This is a zone of eluviation, or the exiting of clay, iron or aluminum that travels down the soil profile through the movement of water. This horizon should have low clay, often equal to or lower than the A horizon above it.

Because of the loss of many of its minerals, this horizon often has high values in its color, meaning it is often a light brown color. It is rare that the E horizon receives a subordinate distinction, though it is possible if the water table rises into the E horizon and creates gley colors. If this were to occur, the E horizon would receive a small g after it. E horizons do not always occur in Missouri. There are many soil profiles that do not have an E horizon. They are more common in forested areas.

The next horizon is the B horizon, or the sub soil. The sub soil is also called the zone of illuviation or accumulation. This is the soil into which minerals and clay are moving into from above. The B horizons often make up the majority of the soil profile. They can be comprised of the same parent material as the surface and have changed due to the downward movement of materials, or it can be soil material that is more highly weathered than the parent material. The B horizon is the horizon that requires a subordinate distinction, meaning you must write something after the B in the horizon designation. The most common subordinate distinctions are t, meaning that there is the presence of illuvial clays. There should be signs of these silicate clays, such as clay films, lamellae, or clay bridging that are present in the horizon for it to receive a t.

The next most common subordinate distinction is the g distinction. The g signifies that gley colors are the dominant color in the soil horizon.

Another possibility is the x distinction. The x distinction always goes with a t distinction as well in the B horizon, written as Btx. The x signifies that there is the presence of a fragipan or fragic characteristics. These are brittleness, extreme firmness, high bulk density, root restrictive and prismatic structure. Fragipans are very difficult to dig through, even with a back hoe. Fragipans are often a different parent material than the material above, as they are typically colluvium.

The last common secondary distinction in Missouri is the w distinction. This distinction signifies that the horizon in question has had some sort of change in color or structure from the parent material, but has not accumulated material from above. The causes of these changes can often be the growth of roots into the horizon, significant freeze thaw cycles, living organisms moving into the horizon and creating pores and structure.

Something has to have happened to the soil to create structure or color change in the soil that is not present in the parent material.

The next soil horizon is the C horizon. This horizon is the unconsolidated parent material. This mean that there is little to no structural or pedogenic development in this horizon. C horizons can be previous loess deposits, glacial till, weathered bedrock, or alluvial deposits without pedogenic processes. C horizons often have massive structure if they are dominated by clay or silt size particles. Sandy C horizons will most commonly have Single Grain structure.

The C horizon can receive the g distinction, signifying that there are water table issues in this horizon and that gley colors are present. As well the C horizon can receive the r distinction, meaning that this material is weathered or soft bedrock that can be dug and

broken apart by hand with a spade. These can be weathered shale, sandstone, limestone, or dolomite in Missouri.

The final horizon designation is the R horizon. The R horizon qualifies as bedrock. This horizon designation should have the type of bedrock noted with it.

### Live Videos

If the same horizon repeats multiple times, often multiple Bt horizons or Btg horizons as seen in the example. These horizons receive a 1, 2, 3 etc. until there is a different soil horizon that occurs.

If there is a change in parent material, such as moving from loess to colluvium, The horizon designation with the new parent material should have a 2 in front of it. If there is another parent material, such as residuum, underneath the second parent material, this horizon designation would receive a 3 in front of it. The first parent material does not receive a number in front of it ever.

Thank you for watching this video on Soil Horizons.

### New Video – Soil Group, Application Rate, and final suitability

Hi, in this final video we will be going over how to qualify soils by soil group, assign them suitability, and give each horizon a final application rate.

Classifying your soils by soil group is a pretty straightforward task thanks to the charts in the Missouri Laws Governing Onsite Wastewater Treatment Systems. The majority of the classes are directly correlated with the soil textural class. Sand and Loamy Sand are soil

group 1. Sandy Loam and Loam are soil group II. Group III soils are made up of silt loam silty clay loam, sandy clay loam and silty clay loam soils.

Group IV soils are the clay soils. These soils are broken up into two groups. Group IVa and Group IVb. The distinction between these two soils is the shrink-swell capabilities of these clays. Group IVb are the clays that shrink when they are dry and expand when they are wet. Soils of this group are unsuitable for this reason for any in ground wastewater treatment system. Group IVb also includes silty clay loam soils if they have high shrink swell properties. These silty clay loam soils have to have more than 35% clay content. Figuring out the shrink swell capabilities of a soil can be difficult, but some quick guidelines to remember are that high shrink swell capabilities are closely correlated to the minerology of the soil. Soils that have received less weathering are often high shrink swell clay soils. Some examples of these would be the glacial till soils of Northern Missouri. The newly deposited loess soils around the Mississippi and Missouri River often exhibit high shrink swell properties when the clay content rises. Shale residuum has high shrink swell clay properties. Residuum from limestone and dolomite that is near the underlying bedrock (within 2-3 feet) often has high shrink swell properties. Some physical signs in the field of high shrink swell properties will be strong clay films or pressure faces that are occurring on the peds. A lack of pores and roots in a horizon may be a good sign that there is high shrink swell clay present as these clays hold the water too tightly often even for roots to be able to access. If roots are running horizontally above a clay horizon it is likely that this clay is high shrink swell. There are also resources online data lab and web soil survey that you can compare known lab tested samples with your field observations for better information.

IVa soils are clay soils that do not exhibit high shrink swell potentials. These are clays that are highly weathered such as our soils in the oxisol soil order in Southeastern and Southwestern Missouri. Clays near Springfield Missouri often have low shrink swell potentials due to this weathering. Soils with sandstone as a parent material often have low shrink swell potentials.

The last soil group are the rocky soils. These are soils that have 35% or greater coarse fragment content by volume. Any soil texture as long as it has greater than 35% coarse fragment content will be a group V soil. The only way a soil with greater than 35% coarse fragment content can not be a group V soil is if that soil has enough clay and has a high shrink swell potential that would make it a IVb soil group.

Deciding the application rate for each soil horizon begins after you find the soil group. The same chart that gives you the soil groups also defines the range for the application rate for those soil groups. These application rates are given a range as it is up to the soil evaluator to decide upon a final application rate. As you can see in the chart, the application rates are strongly affected by texture, with angular blocky, prismatic and coarse subangular blocky structures receiving lower application rates than granular or fine and medium subangular blocky. From there you will use information from your soil profile description to decide the final application rate. You should look at the clay content for that horizon, is it on the high end or the low end for the soil textural class. You should look at the coarse fragment content. As the coarse fragments increase the capability of the soil to treat wastewater decreases. You should look at the roots and pores that are available to move and treat the wastewater. More pores and more roots means more wastewater can be taken up by roots and enter the pores where microbes will help treat

the wastewater. If there are signs of redoximorphic features, those soil horizons would receive a lower application rate.

Example:

Now that we've assigned an application rate for our horizons, we should see whether these horizons are suitable or not for the application of wastewater. The state of Missouri has some very helpful flow charts for assessing the suitability of each of the properties in the soil profile descriptions. Let's take a look at a couple:

Example:

Now let's go through our soil profile and assign soil suitability ratings for these horizons.

This completes our discussion on soil suitability application rates and soil groups, as well as our examination of the soil profile description sheet. I hope you all learned a lot and please feel free to reach out if you have any questions.

## **SITE EVALUTION**

### Site Evaluation & Field Layout Script

Welcome to this course on Site Evaluation and Field Layout. In this course we will go over the work you should be doing as a soil evaluator before and during your time on a jobsite for an onsite wastewater soil evaluation. This information will help you prepare for each job, know what information is required for your forms, and help you understand your responsibilities in laying out the components necessary for an onsite septic system.

Each soil evaluator may do things slightly differently, but it is important to understand the requirements of this position before jumping into the job.

The responsibilities of a soil evaluator begin before you will even step onto the job site. Typically, a home owner, landowner, or installer will call you asking for your services. While working closely with installers is a very important aspect of our job, it is usually necessary to talk with the homeowner/landowner to get the necessary information you need from them, to explain what you will be doing for them, and how the process will continue after you have left.

Prior to your arrival, there are some necessary steps that should be taken to ensure that your time onsite will go smoothly and keep everyone safe. The homeowner should be aware of all the information that you need to submit with your report. This information is part of the standard state form that you will be providing the homeowner. We will go over this final product in another video. The information necessary includes: site address and mailing address, whether or not this is part of a larger subdivision, Contact information of the homeowner, the county of the site for evaluation, the legal description of the property, the type of business or residence that will be constructed, the number of people that will live there, and the location of the site. The type of business or size of residence is of great importance for the overall size and cost of the system, as it gives us the design flow or the gallons per day, so ensuring that the homeowner has set plans, such as the amount of bedrooms for a house, the number of employees for a business, or the number of seats for a restaurant, is necessary. The most common numbers to remember are a bedroom counts for 120 gallons per day and a person counts as 60 gallons per day. The final total design flow will be whichever comes out to a higher number, either based

on people or bedrooms. For example, a 3 bedroom house with 4 people has a design flow of 360 gallons per day because 3 bedrooms times 120 gallons per day per bedroom is greater than 4 people times 60 gallons per day per person. For businesses, please reference the rules and regulations for onsite wastewater systems in Missouri, as each type of business, such as church, restaurant, laundromat, has different specifications on design flow.

After explaining the information that you require from them, it is always good to explain the process that you will be going through while on their property. Each soil evaluator may perform things slightly differently, but the requirements for each soil evaluator stay the same. It is a good idea to have the land owner on the property with you during the soil evaluation. This ensures that the building plans are laid out correctly, that the field area is in a suitable location, and that they understand what you are doing and the reasons behind your findings. Explain that you will need to know where the property lines are, where the house and other buildings will be located, where the well will be located. After siting these things, you will find a field area that will hopefully work for a septic field. Two holes will be dug to a maximum depth of 60 inches and a minimum depth of 48 inches above and below the field area. These soil profiles will be described and they will give you the suitability of that site for the eventual system that may be installed there. It's important to inform them that the field area can not be drastically moved from the laid out area, as soil properties are highly variable and can change in short distances.

As these holes will need to be dug 60 inches deep, you should always discuss with the homeowner what the plan will be for digging this soil profiles. It is recommended that you have a backhoe present on site to dig the pits where the field area will be. Some

homeowners have a mini excavator already or will rent one, others won't have access to one, and it may be necessary to contact a backhoe operator to dig the soil pits for you on the day that you are onsite. Some soil evaluators choose to dig holes by hand, but do be aware that this can be extremely time consuming and difficult, especially when the soils are very dry, extremely rocky, or contain a restrictive layer, like a fragipan or claypan.

Lastly, before arrival it is necessary to make sure that all utilities have been located and marked. Make sure that either you or the homeowner contact a utility locating service, such as MO-One Call at 811 to locate and mark any underground utilities that may be on their property. Failure to do this can put your health, the landowners, or the backhoe operators health at risk, while also risking destruction of the landowners utilities.

Upon arrival to the property, it is always important to ensure that you are on the correct property. Many of the sites you will be visiting will not be able to be located on digital maps, often due to not having a property address assigned yet . Make sure that you plan ahead for this with the landowner and the backhoe operator if you have one present. If you are unsure that you are on the correct property, contact the landowner first, before beginning to knock on doors.

Once you are in the correct location with the landowner, begin by recording on your form the landowner's and property's information. Once again, explain what you will be doing that day and go through the steps and that your final report will have a conclusion as to whether the site you have selected is suitable to a conventional system or not.

From here there are some differences as to whether or not you will be performing a new construction or a replacement system. A replacement system typically has all the

buildings and utilities already present on the property and the main focus will be laying out a new field area that meets the setbacks laid out in the onsite wastewater regulations book. For a new construction, it is helpful to begin by talking with the property owner about where buildings, driveways, parking areas, the well, and other items will be located on the property before looking for a site for the septic field.

Before beginning to look for a field area, it is good to discuss with the homeowner if they have any preferences on the type of septic system that they would prefer. Some landowners will refuse to have any type of aboveground system, such as a lagoon, while others prefer the system and have an area in their minds that may work for the system. Talking with the land owner about this can save you time and give you direction when on the jobsite. You may have to give some counseling to an unhappy landowner if you discover that their soil is not conducive to their preferred system. This can actually be one of the hardest parts of the job. You must always go with what the soil tells you.

As we begin the job, let's go over some materials and tools that many soil evaluators find helpful for performing their job. For the septic field layout and the site layout, it is often helpful to have a long tape measurer of at least 100 ft, maybe even 300 ft, or a range finder that will give you accurate measurements. Each has their own benefit, but know that many times you may be moving through heavily forested areas with dense cover. A soil evaluator should have a compass for recording the aspect and for recording the direction and layout of the field area. A clinometer or slope measuring device is necessary for recording the slope of the field area and ensuring that there is gravity flow from the house to the tank, and from the tank to the field. Marking flags that are easily visible are a good idea to designate where the field area is located. This is very important

for new construction sites, as all building materials, heavy machinery, and any earthen projects such as moving soil, need to be kept away from the septic field area. Having something to track GPS points, such as a GPS or a phone app can be very helpful in providing the administrative authority with the field layout and the location of the septic area. A pencil and the report are necessary to have. It is a good idea to make duplicates of the report, if you are giving the report to the land owner on the same day as you are completing the soil evaluation. Some soil scientists will type up the report to make sure that everything is legible and accurate. Some soil scientists will use apps that describe the property lines of landowners. These can be very helpful in ensuring that the setbacks are met, but plats and surveys should be used if there is doubt about meeting the setback distance. All of these tools will help you with laying out the field area as well as eventually creating a well-organized, legible, and accurate site plan.

The next group of tools that we go over will be discussed more in the soil profile description course, but it is good to remember that you may need to carry these around with you as well. Some soil evaluators will use a core sampler to help them decide on where might be a good area for the septic field by giving them a very initial idea of what the soil conditions are like beneath the surface. Soil cores should not be used for the final soil evaluation, as they compress the horizons, may miss features only visible in the profile, such as redoximorphic features, roots, pores, and do not allow of the boundary distinction. They can give you an idea of soil depth, if there are few rock fragments, and an idea of the soil texture.

In the pit, a hammer/pick is used to initially clean the soil profile face. The Munsell color book is used to describe the soil colors. The handbook for describing soils helps on

assessments of roots, structure, and pores. A soil knife or small picking tool to get a final clean face with fewer markings. Water for moistening soil for coloring and texturing. And tape measurer to measure depth, a pencil, and typically multiple soil morphology forms.

With all of the preparation finished, your materials ready and the required information, you are ready to begin the process of a site evaluation. Thank you for watching this video.

## Video 2 Setbacks and Features

In this video we will discuss the setbacks from natural and man made features that we need to be aware of when we are laying out a field while on site. The rules and regulations for these setbacks can be found in the Rules and Regulations Governing Onsite Wastewater Treatment Systems or the Green Book. It's important to be aware that counties have the right to be more restrictive than the codes laid out by the state. It is always good to check with a county before being onsite to know if they have any rules and regulations that go beyond the requirements outlined by the state.

Let's start by looking at a list of the features that they mention in the book, from there we will provide you with some examples of what these features look like and provide you with some advice on recognizing these features while out in the field. As well we will go over other features and disturbances that should be avoided that are not mentioned in the Rules and Regulations. These setbacks are very important for ensuring the safety of our ground water and safe living conditions for humans. Many of these are hard restrictions

and receiving a variance to be allowed within the setback distance is possible but can be difficult depending on the administrative authority. Some good conditions to remember is that variances are typically only allowed on properties that were created before 1996, when these rules and regulations were implemented. The soil evaluation needs to show proof that there is no other area available for the siting of the tank or septic tank that follows the rules of the setbacks. To allow for variances, it is often common that higher forms of pretreatment will be required to mitigate the risk of contamination of the ground water or environment.

Let's begin with the man made features that you should be looking out for while out in the field. As always there will be a setback from any manmade construction with a foundation or a basement. This may be barns, sheds, or houses. Tanks need to be 5ft from any foundation and 15 ft from any basement. And a field area needs to be 15 ft from any foundation and 25 ft from any basements. These setbacks are to prevent water damage to the man made structures and as well to prevent the movement of wastewater along these structures that would not treat the wastewater.

It is always good to get a good idea of where the property lines are, especially on smaller lots. Septic tanks and fields need to be a minimum of 10ft away from the property lines, with a recommended 25 ft away from any downslope property lines.

Most properties are going to have some sort of powerline that either runs onto them or runs through them. It is often a good idea to keep the tank and field away from these as most power companies have an easement on power lines. The size of these easements often depends on the size of the powerlines, with easements ranging from 15ft on each

side to 30-40 ft on each side of the powerline. When in doubt it is a good idea to contact the local power company to learn the easement size for the property you are on. Fields or tanks sited within these easements will typically have to receive signed variances from the power company allowing the field or tank to be installed in the area, and should the company have to come out to service the lines and damage the field/tank that is installed within their easement, the responsibility would often fall to the homeowner for repairing any damage.

We should always be looking for underground utilities. The most common of which are gas and water lines. These should be marked by a digging/survey company. Fields and tanks should stay at least 10 ft from any trenched line.

One of the most common ways of ground water contamination is from not maintaining the required setback from both public and private wells. Public wells are wells that provide water to larger communities, rather than to a few individual homes. These wells have larger capacity and are pulling up more ground water than a private well. Public wells can be anything from the wells of the public water district for the county to community wells of private communities in which the residents receive their water from a common well. It is rare to receive a variance for siting a field less than 300 hundred feet from a public well, as contaminating the water of the public at large is not a risk that many administrative authorities wish to take.

Private wells have a setback of 100 ft. These are wells that typically serve one or two households in rural areas. They are often not as deep or as high capacity as community sized wells. Variances for private wells that serve one household are possible given there

are higher levels of pretreatment such as aerated tanks, biofilters or other treatment options installed. While most properties no longer use a cistern as a water source, there are some cisterns still around. These can appear as concrete covered domes or covered holes in the ground. As these simply collect ground water that would flow into them, there needs to be a separation distance of at least 25 ft from them.

Humans have been doing many things to this land for hundreds of years and their past impacts still have effects on the soil today. The most common signs of this are moved earth, old roads, and old structures. Any of these may make a site not suitable for the installation of a septic field. Often during the construction of roads or buildings there will be significant amounts of soil that is moved from one location and deposited on top of another. This deposited soil or fill may not be suitable for a septic field as absorption trenches may not be constructed in unstabilized fill. Construction or heavy vehicles can often lead to high amounts of compaction. This is signified by platy structure. Platy structure does not allow for the downward movement of water and is typically unsuitable for the installation of a septic field. This platy structure is also common on old logging roads or travelling roads that may run across a property, that have since been abandoned. These may have the addition of high amounts of gravel that could restrict siting a field. Even old abandoned roads, often visible by the lack of large trees that are present along a path in the woods, may still have platy structure and be unsuitable for the installation of a septic system. Old foundations and structures are unsuitable for the septic field area. The amount of compaction that has occurred in these areas is too high for the installation of septic lines. Each of these man made conditions may be able to be remediated should no other possibilities for siting a field exist. Platy structure can be tilled over multiple passes

to the necessary depth to eliminate the platy structure. Areas with stabilized Fill may be used if there has been significant time for the reestablishment of roots, the development of soil structure, and the development of pores. Fill may also be required to be removed from a site. Old structures may be required to be removed and the soil underneath mitigated to a specific depth.

All of these man made features are things that are necessary to look out for when you are out in the field.

There are also many natural features that we need to be aware of when trying to site a septic field.

We'll begin with our larger features. Floodplains are very common across Missouri.

When siting a septic field it is important to try and avoid siting a field in areas that frequently flood. Frequently is defined by NRCS as flooding that happens more than 50 times in 100 years, or about once every two years. Siting a field in areas that flood less frequently than this is allowed but will typically need administrative approval and can be rejected. It is good to check the FEMA flood maps prior to arrival to see if there are any risks of flooding on the property you will be working on prior to arrival.

The next large features that we need to avoid are classified streams, creeks, rivers, and lakes that have water in them year round. Septic tanks and systems should remain 50 ft away from any of these. Variances are rarely allowed near waterways whose paths cross multiple properties.

There are some smaller creek beds and drains that are dry for most or part of the year. It is recommended to remain 25 feet away from any creeks or drainage ways. Dry creeks

are typically located at the bottom of hill slope complexes and are often very rocky.

Drainage ways or open ditches can be difficult to explain to homeowners. These often run up and down the hill slopes, often at head slope locations. On a topo map you can see an area where there is a drainage ditch or the head of a drain. These can be difficult to tell in person and you should always look at a possible field area from multiple angles to try and assess whether there may be a drain present in the area or not. Looking at a topo map of the property that you will be at beforehand can be very helpful in guiding the location of a septic field.

Many of our karst features are things that need to be avoided when siting a septic field. No part of a system should be sited in or within the drainage of a sink hole, requiring a setback of 50 ft for a tank and 100 ft from the edge of the sinkhole for a field. Drainage areas for a sinkhole should be avoided and are any area that slopes towards the sink hole. Springs, another karst feature, require a 50 ft setback for a tank and 100ft setback for a field. As the likelihood of running into karst features is very dependent on location, some counties have stricter regulations around the setback distances from karst features. As always, it is good to contact the local authority to ensure that you are following all county regulations.

While out in the field looking for many of these natural features, you should be looking at other characteristics of the site that may help you in the siting of a field. Examining the slope of the landscape is very important to the viability of a field. Remember that fields over 30% slope are rarely allowed for a septic field, and modifications must be made to systems sited on slopes greater than 15%.

Looking around for surficial bedrock is an important task, as it will often mean that there is not going to be a suitable amount of soil in that region. Finally, we want to avoid any erosional features that are present in the landscape. These can be the larger drains that we can see on the topo maps, but also smaller erosional features, like scars that show where water will be moving during times of heavy rain.

Knowing these setbacks is a lot to remember when you are out on the jobsite, so printing out a copy and having it handy is helpful when trying to juggle many of the different distance requirements. With time they will come naturally and you will feel comfortable locating and identifying the natural and manmade features that are important to avoid in siting a septic field. Thank you for watching.

### Video 3 Field Layout

Welcome to the third video in our series on Site Evaluation. In this video we will go over how to lay out a field and give some examples of this in the real world. When laying out a field, there are times when we have the ability to choose the location that would best suit a septic field, other times, often due to lot size or setback distances, the location is more or less forced. We'll go over some things to look for and to avoid when you are siting a field on a property where there are multiple options.

When looking for a field area on a property where there may be multiple suitable locations, it is often helpful to bring a tile probe or a soil sampler to test for things like depth to a restrictive layer or bedrock depth. Taking a few samples will give you an idea of the suitability and depth of the soil in that location. Always remember though, that 2 soil pits must be dug once the site has been selected.

There are some above ground features that you should take into account when you are siting a field. The most important is that the area is a uniform slope. This means there is no drastic change in the hill slope shape across the field. For example if you have a part that is linear linear, but then become linear concave, that would make a complex slope. This is necessary so that the septic lines are all level and stay on the same contour when being installed.

Some other good practices are to site the field downslope from the house. This allows for gravity flow from the house to the tank to the field. This is not a must, but it does save money and future maintenance in not having to have a lift station and a grinder to move waste from the house to the tank.

A hill slope shape that sheds water is preferred. It should be of convex or linear shape across and down to move water away from the field.

Areas that are moderately sloped help move water that might sit on the septic field. These slopes are greater than 2% and less than 15%.

Finally, depending on the system, siting the field in an area with fewer trees can be beneficial to the costs for the homeowner. In highly dense forests, trees may have to be removed for the installation of the trenches or lagoon. During the removal of many trees, the area can become compacted and the soil structure can be damaged. This is a situational recommendation, but something that soil evaluators should be aware of.

As always there are things that need to be avoided when siting a field.

As we've talked about many of these already, we'll just quickly review the features that need to be avoided. Flood plains that frequently flood should never be used as a septic

field. Flood plains that have less frequent flooding should also be avoided unless there are few other options.

Slopes greater than 30% should be avoided almost always, unless the site meets the requirements listed in the rules and regulations regarding onsite wastewater disposal.

Complex hill slopes, where the hill shape changes throughout the field should be avoided. These occurrences often have abnormal water movement both above and below ground.

Drainageways need to be avoided at all costs.

Large rock outcroppings need to be avoided at all costs. Loose surficial rock may be suitable for some systems, but large rocks that are solidly in the ground need to be avoided when siting a field.

Similar to rock outcrops is surficial bedrock. These often emerge on sloped areas. They often have very little or no soil above the bedrock and should be avoided at all costs.

Let's go over some examples of landscapes that would prevent the installation of a septic field area. Looking at this diagram of a glacial till landscape, pick out the landforms that would be suitable and unsuitable for the installation of a septic area. The unsuitable areas would be the depression and the floodplain. The areas that are provisionally suitable would be the flat upland and the flat terrace. These areas may not have enough slope for the siting of a field. The swells may be suitable for the installation of a field provided there is enough space. The hill slopes are typically suitable for a field, given there is enough space between the drainageways.

Here is another example in a glacial landscape. What do you think are some of the limiting features of this type of landscape? The drainage ways are the main natural feature that would prevent the installation of a septic field. In glacial regions, we should always be careful of claypans as well.

In this example, we'd need to be careful of surficial bedrock in the gasconade area and drainage ways that stretch up the hill slope.

### Field Layout Part 2

Now that we have picked out an area, we need to lay out the exact location of the field. Remember that the size of the field layout depends on the daily water usage and the type of system that will be installed, such as an inground or an above ground system. While these discussions with the homeowner are important remember that the soils are the final decider on the system type.

Each soil evaluator may go about this process a little differently, but here are some good practices when laying out the exact field area.

First it is important to calculate the total field area. This can be different for a conventional system or an engineered system. It is often a good idea to layout the field at a larger size, meaning giving the system a lower application rate and more space between the runs. Siting a large field first often means you may be able to shrink the field down if the soil conditions are better than the minimum suitable soil conditions. If we size a field smaller and then have to expand the field, the soil conditions may change outside of the area where we dug the pits, or we may move too close to a required setback.

Once you've found the area that is away from all of your setbacks begin by laying out the most restrictive side that runs across the slope, so the bottom or top or your eventual field area. This could be the side that will be the closest to a setback or nearest to a change in topography. It is good to aim for 100ft when setting this first line. Next you will want to measure up or down the slope to find the second side. If the slope is not perfectly consistent across the field area, pick the side with the steeper slope. So if the slope is 7% on one end of the field area and 9% on the other, start with the end with the steeper slope. This will make sure that there is enough length on the opposite side of the field. You will then measure the distance required up or down slope to get the minimum field size. From here, you will follow the contour across slope 100ft for the third side. Finally, close off the field area and measure to make sure that there is enough space for the required field area. It is a good idea to place marking flags at the corner of the field area. This is important to keep construction materials and heavy vehicles off this area and to provide markers for eventual installation.

From here you would begin with the soil pits.

This technique is just one way of laying out a field area, and different professionals have different techniques that may be better in different locations. What we just did was site the field area first, and then we would dig the soil pits. Some benefits of this strategy is that you are siting the system for the maximum size and regardless of the soil conditions, the field area would not have to change. Some cons of this technique is that time can be wasted if you lay out an entire field, only to discover that the soils are unsuitable for a conventional system. Homeowners then may want to find a different field area that may be suitable for a conventional or other type of system.

Another strategy is to pick a location and dig a pit at that site. You would then describe the soils. This would give you information on the type of system or the size of the system that would be required. If you need to relocate to a different area, you have not spent as much time laying out an entire field. The cons of this type of approach are that the soil pit may end up in the field, which disturbs the natural soil that the system will be sited in and this is difficult to remediate. This strategy can also become a where's waldo of good soil if the homeowner is convinced they want a specific type of system. Lastly, the size and type of field may be completely different based on the other soil pit that is dug after laying out the initial field, and things may need to be resized to accommodate the second pit, if the soils are less suitable than the soils of the first pit.

Here is an example of a gently sloping property. If the house is sitting at the top of the hill, pick out a few locations that may be suitable for the installation of a septic field. This aerial photo can show us some features that we should be avoiding. The two visible drainage ways need to be avoided. The stream on the east side of the property and its floodplain/terrace should be avoided. The extremely steep areas should be avoided where the slope increases drastically. With the home in its current location, a field area may be sited on the north side of the slope, between the two drains or perhaps on the south side of the slope.

This next example is of a more steeply sloped property. The drainageways are much more easily visible on the topography map, signified by the curved lines pointing uphill. This property is more restrictive for the siting of the septic field due to the roads that run

through the property, the steep slopes and the multiple drainageways. See if you can find an area that may be suitable. It looks like there might be an area south of the road in the SE quarter that may be suitable, but much of this property is unsuitable due to complex slopes and drainageways.

The last thing that we will have to do is pick our locations for our soil pits to be dug. It is recommended that there be at least two pits that are dug. One should be above the field, and one should be below the field. They should be placed at opposite corners as well to try and grab all the soil characteristics that are present across the field.

Remember that each county is different. Some counties require 3 pits to be dug, Some require that a pit be dug at a replacement area. Contacting the administrative authority is important prior to reaching the field, as you may not be able to reach someone while you are out in the field.

Do your best to keep the pits out of the field itself. Soil pits disturb a good amount of soil and mix up the soil horizons.

Pit locations for a lagoon or wetland are typically 1 pit in the center of the field area.

After laying out the field it is important to record the necessary site information on your field form. You should record the Landscape position, such as back slope, terrace, summit, etc. You need to record the aspect, typically in degrees or in cardinal directions. You should record the frequency of flooding at the location, whether or not there are surface depressions. While at the field area, you should record the percent slope, the type of slope, and the shape of the slope across and down.

Laying out the field is an important part of our job to make sure that there is enough space for a septic system to function correctly. Maintaining the setbacks and making sure that the area follows the contour of the hillslope is very important for the eventual installation of the system. Thank you for watching this video.

### Video 5 Slope, Fall, Tank Siting, and Final Wrap up

For the final video we will go over the remaining aspects that need to be taken care of when you are out in the field. At this point, you have laid out the buildings on the property and have the field area flagged out.

One of the final responsibilities of the soil evaluator is to set the location of the septic tank. For most locations, soil evaluators should attempt to find a location that allows for gravity flow from the house to the tank. This will save the homeowner money and maintenance. When gravity flow is not possible, a grinder and a pump will need to be installed in the house to lift the waste from the house to the septic tank.

Let's first go over how to calculate slope to help with our eventual placement of the septic tank. Remember that slope is not the same as degrees. Slope is a percentage. It is the calculation of rise over run or the change in height vs the change in horizontal distance. Here in this image we can see that the elevation has changed 8 ft over a 100 ft distance. That means that at this location there is a 8% slope. Another example is a 6 ft change in height over a 50 ft distance. This means that you would have a 12 % slope.

More often the tool that we use in the field, the clinometer will give us the slope and we need to calculate how much rise or run there is. To do this, use the slope percentage side

of the clinometer and shoot to a level location down or upslope from where you currently are. This will give you the slope reading. Let's imagine that we got a 5 % slope reading. This means for a every 100 ft of run or distance along the slope, there is 5 ft of drop. To calculate the drop for less than 100 ft. take the slope percentage and multiply it by the distance or run. So for a distance of 75 ft, you would take .05 multiplied by 75. This would give you a rise of 3.75 ft.

Siting a tank has some unique considerations that need to be taken into account. The first is whether or not the house has or will have a basement, crawlspace or a slab foundation. The septic usually comes out 1 ft below the surface of the basement, crawlspace or slab foundation. This means that to find gravity flow for the tank, we need to take into account the depth of the of the basement, crawlspace or slab and then add 1 ft more to get the total depth that the septic will be coming out of the house. Let's start with the simpler calculations A slab foundation will typically need 1-2 ft of drop from the house to the septic tank. If the site has a slope of 6% and you need a rise of 2 ft. You would divide 2 by .06 and you would need a minimum distance of 33 ft.

For a crawlspace the septic usually comes out of the house 2-3 ft below the surface of the ground.

Basements are more difficult to calculate as they have multiple factors that need to be taken into account. Basements have different depths of pours, 8 ft, 9ft, and 10ft pours. Meaning the walls of the basement to the floor of the basement will be 8, 9 or 10 ft tall. The drain usually comes out 1 ft underneath the basement floor. Finally basements are often held out of the ground a 1-3 ft. This means that the homeowner often needs to know

some of the specifics about the build of their house for you to calculate the location of the tank.

Let's go through an example of siting a septic tank for a house with a basement. This house has an 8ft pour and the house will be held 2 ft out of the ground. This means that you have 6 ft total of basement in the ground plus the one foot that the septic comes out below the floor of the basement. This means that overall you need 7 ft of drop from the surface of the ground at the house to where the tank will be located. If this location has 8.5 % slope let's calculate how much distance we'll need with the 8.5 % slope to get the fall necessary for the tank. With a rise of 7ft and 8.5% slope we'd take 7 divided by .085. This gives us the run or the distance at 8.5% slope to get the 7ft of drop necessary to set a tank with gravity flow. 82 ft.

When siting a tank, there are some work arounds if there is not enough drop from the house to the location where the tank should be sited. Risers can be placed on the tank that allow the tank to be placed deeper into the ground. Setting the tank deeper in the ground may have some drawbacks, as if there is supposed to be gravity flow from the tank to the field, the field may need to be moved to ensure that there is still enough drop from the tank to the field.

Finally, some extra considerations to account for when siting a tank. Tanks typically need to be pumped out every 3-5 years, depending on the amount of waste entering the tank. Finding a location that allows for easy pumping can be helpful for installers and people performing maintenance on the tank. Helpful sites can be close the driveway, road, or in an area that has no buildings between the driveway and the tank.

Second, if the tank is further than 100 ft from the house, there will need to be a cleanout. Cleanouts are necessary every 100ft distance. For any tanks sited beyond 100ft, there will need to be an extra 1ft of drop for every 100 ft of distance from the house to the tank.

The setbacks on the septic tank are different than those of the field area. They are often allowed to be closer to features than the septic field. Make sure to check the book for the specific setbacks on the septic tank.

Restrictive horizons has can provide issues for septic tanks. While it is rare that a restrictive horizon will prevent the installation of a septic tank, installation under certain conditions may require extra work. Shallow bedrock will require the bedrock to be hammered and removed to allow the depth required for the septic tank. High shrink swell clays can damage tanks if there is no gravel or barrier placed around the tank.

When siting the tank, do not have the line between the house and the tank or the tank and the field cross ditches, waterways, or gullies.

Lastly, the lines to and from the tank can be placed underneath roads and driveways.

At this point, after you have finished the soil profile descriptions, here is a quick checklist to make sure that you have all the information necessary before you leave. Go over your soil report and make sure that all necessary information has been recorded, such as the homeowner and property information, landform information etc. It's important to talk with the homeowner and make sure that they understand the type of system that will be required based on their soils and the location of this system. Make sure that you have enough soil pits described. The number is based on the county that you are located in as

well as the type of system that is being installed. Finally, make sure that before you leave you have agreed on how you will be paid.

This wraps up our videos on the site evaluation and field layout. Thank you for watching!

## **FORMS, MAPS, AND FINAL PRODUCT**

### Forms and Maps

Hello and welcome to our course on the forms and maps that are required for soil evaluators. We will review the necessary information that needs to be gathered, how it should be drawn up and filled out, and how all of this information comes together into a final suitability rating for the type of onsite wastewater system that may be installed at a site. We'll go through where this information comes from while on site, how to draw up accurate and legible maps, and provide some examples of how to make interpretations for providing a final suitability rating and recommendation.

The form that we will be discussing today is the state form provided by the department of health and senior services. This form will be accepted by all counties in the state of Missouri for the purposes of soil evaluations. It is important to note that different counties may require or advise providing further information or descriptions beyond this report. These may be things like the number of pits required for describing the soils, the distance of setbacks, and it is always good to contact the local authority to make sure that you are providing the required information prior to submitting a report for county/state approval.

Use of this state report is not required, but the information included in any other reports must meet the minimum standards laid out in this report. The state report can be found on the DHSS website or in the resources tab at the end of this course.

Let's begin by looking at the first page of the state form. Much of this information is discussed in the site layout and evaluation video series. It is good to inform the homeowner that you will need this information prior to arrival to make sure that you are having to track down this information after the fact. Much of this information should be present on a survey or plat of the property. These are helpful in the eventual siting and drawing of the property and septic field.

Make sure that you have the correct information on the property owner, site address and mailing address. Businesses and properties may be owned by companies, trusts, or multiple people and you should make sure that you have the correct entity that is in control of the property. The site address and property address are not always the same. Many times the site address may not have been given a formal address. Under these circumstances, you should record the road that has access to the property along with the town and postal code for the property.

The subdivision and lot are important to record, as some subdivisions and private communities have specific regulations around the type and location of septic fields that are approved for the subdivision. There often is a regulating body for the subdivision or private community that you can contact to make sure that you are meeting any of their specific recommendations.

County and legal location are required for specific locating. The legal location is a description that is often provided in the deed, survey, or plat of the property. The state of Missouri is broken up into sections/townships and ranges as seen here. You are providing the governing authority with the location of the property regarding these three markers. Here is an example of how to find and record the section township and range.

Bedrooms and people should be gathered from the homeowner. If they are unsure of the final number of bedrooms or people, it is advised to plan the system for their larger estimated bedrooms. Homeowners and installers can always size down when their plans are settled.

Latitude and Longitude can be grabbed from any phone or GPS device. These coordinates should be taken at the site of the septic field.

The type and size of the design flow is based off the specific business and should be discussed beforehand. This design flow amounts come from the DHSS rules and regulations regarding onsite wastewater systems. Should the business type not be listed, it is a good idea to contact the local or state authority to get a good idea of what the design flow should be.

Finally, whether the system is new, replacement, or repair should be discussed beforehand. New systems are often connected with a completely new house or business being built on a property. Replacement systems are often replacing a failing system in a new location on the property. Repairs for systems are evaluating the soil to see whether or not the current system can be repaired and brought back into a functioning state.

On the lower half of the state form is the site diagram that is required. The site diagram shows the local or state authority the general layout of the property, buildings, natural features and the siting of the tank and field to make sure that the system is going to meet the setbacks and easements on the property. This site diagram should be legible and to scale. This site diagram includes a good amount of information and many soil evaluators use different methods to record and draw up this site diagram than by performing hand drawings. Let's go over the information that is required to be noted in the site diagram.

Any buildings that are located on the site or that will be built should be drawn to scale. These include houses, sheds, barns, or foundations. The well must be located and drawn on the site plan, along with noting the distance from the well to the field or to other referenced locations, such as buildings.

On smaller properties, or when you are close to the property lines on larger properties (>15 acres), the property lines and the easements of these property lines must be noted. The lengths and angles of the property lines can be found on the survey, plat, or deed. There are some apps that will locate property lines for you with a satellite image. While these apps are helpful, you should always try and find the actual corner markers of the property lines. These are often iron rods that have been beat into the ground. Some surveying companies will place colored rods and flags at the property lines and corners.

Any utilities that are near the house or field area need to be noted. These include both above and below ground power lines, water lines, and gas lines.

Any rock outcrops, depressions or sinkholes need to be noted on the site diagram. Rock outcrops are the visible exposure of bedrock on the surface of the ground. These often

can not be moved by humans or even by some machinery. Depressions are areas in which in every direction the slope runs uphill. These may be collapsed features or karst features that are often signs of high ground water contamination potential. Finally sink holes must be marked on the site diagram.

The locations of the soil pits must be marked on the map. Remember that a minimum of 2 pits are required by the state.

Any roads or driveways, old construction roads, logging roads or cleared areas must be located on the site.

The direction and percentage of the slope must be marked at the site of the septic field.

The distances and angles should be recorded between these natural and manmade features. Using a long tape measurer (200-300ft) or a range finder is necessary for recording these features. Having a compass with you that gives you exact degrees will allow for accurate drawings.

Finally you need to record the location of the replacement area. The replacement area is another site on the property in which the septic field can be located. Some counties require that there be a 3<sup>rd</sup> soil pit dug at the replacement area, so contacting the local authority is important to make sure you are recording the necessary information. On some smaller properties, there may not be a location for a replacement area. This should be noted in the comment section.

Let's look at some examples of site diagrams done by soil evaluators from around the state. The first is a site diagram that was drawn with a computer program. The beneficial part of using a computer program that they give you accurate to scale lengths and angles

of distances, buildings, and property lines. This can be important on many smaller properties for showing the exact location of the field area in regards to property lines, buildings, and all the necessary setbacks. For computer drawn diagrams, it is important to record all of the information in the field accurately, so that they can be converted into the programs you are using back on the computer. Note that the field area, the tank and the house are labeled and their sizes referenced. The drainage ditch and other feature that would affect the location of the field, such as ponds, property lines, or trees for a lagoon, are noted.

The next drawing is a combination of a drawing of the field and using GPS and satellite images to show the layout of the field in drawing form while giving the specific locations of the field and specific features. Note the specific lengths of the field area that are laid out, GPS coordinates of the power pole, the soil pits, and the buildings, while noting that there are surface drainage issues such as the parking area. They also provide the satellite image with these features on it.

It is also possible to hand draw the site plan on the form itself. Some things to note about this, is that it should be legible and to scale. This takes practice to accurately show all the features that need to be laid out on the site plan.

You should also be providing a cross section of the septic field, tank and house. This is to show the slope and the distance between these features. This is to make sure that there is enough fall to make it from the house to the tank and then finally to the field.

Regardless of the style of site plan that you decide on, practicing the technique and making it accurate, legible, and to scale is a good idea. Each person will have different

preferences, but you should always remember the features that need to be noted on the site diagram.

Figuring out a program that allows for capturing and labeling GPS points accurately can be very helpful for many of the responsibilities of soil evaluators. There are many different apps that can work with a smart phone that allow for capturing GPS points.

You should always provide a way for visually laying out the field area on the property. This is often done by marking flags or wooden posts. Having a visual marker on the property itself can be helpful, as during construction, you need to ensure that there is no heavy equipment or earthworks that are placed or performed upon the field area. Heavy disturbance would void the soil evaluation and the soil evaluation would need to be performed again.

Soil evaluators also mark the field area with GPS points or on satellite and drawn images.

All of the above are good options as it will cover you and provide multiple back ups of the field area, should flags get moved or disturbed.

Having a survey from the homeowner is very helpful in drawing up this map and making sure that you can find a property corner and that you are within the property boundaries. Homeowners will often say they know where the property line is, but they are not always accurate. Finding the marked property corners and measuring their specific locations is necessary on many smaller properties.

Finally, it is always good to create back ups of the maps and any information that you record while on site. You want to make sure that you have all the necessary information and that everything is laid out in the correct place before leaving. Many jobs will not be

close to you home/business address and having to drive 1-2 hours for a measurement or 2 is not something that soil evaluators want to be using their time for.

This wraps up the requirements for the front of the state form. If you have any questions about this form or its requirements, it is always appropriate to reach out to the state department of health and senior services. Thank you for watching!

### State Form - Rear

Hi welcome to our next video on the requirements of the state form. In this video we will be going over suitability and the back side of the state form. We will look at the different categories that require suitability for the entire site to be judged as suitable. It is important to note that many of these categories and features have provisions that can be performed to bring the site up to suitable if they are constructed or performed. We will go over when something can be done to mitigate a site feature that would otherwise make the whole site unsuitable.

Looking at the back side of the state form we can see that there is a good amount of information that is required to be gathered from a variety of sources.

For the top section on landscape position and topography, this information is gathered from the field layout and the site evaluation.

The next four sections, Soil characteristics, soil drainage, soil thickness and restrictive horizons all must come from the soil profile descriptions that are performed both above and below the field area. It is important to note that these sections will always have their

suitability based on the soil profile that has the lowest or most restrictive horizons, structure, texture, or water table. For example, if the lower pit has a water table at 24 inches, but the upper soil pit has a water table at 36 inches, the overall depth of the water table is at 24 inches when you are filling out the back of the state form.

The available space will be laid out during the site evaluation part of the job. It is often good to lay out a large field area that can be shrunk down, if the soil characteristics are better than expected.

The other factors are based mostly off of the soil profile descriptions. We will talk later about the specifics of these factors.

The final overall rating is based on the most restrictive result from the above sections. If any of the above sections are unsuitable, the site itself is unsuitable, unless deemed able to be mitigated by the soil evaluator in the comment section. If any of the above suitability ratings are provisionally suitable, the site itself is provisionally suitable and the mitigation strategy should be explained in the comment section.

Now let's go over the specifics that we should be looking for in the form.

The first will be landscape position and Topography. These characteristics affect greatly how/if water will move above and below these landforms.

The first thing that must be recorded is the landscape position. The most common positions are the summit, shoulder, backslope, footslope, and toe slope. The summit is suitable unless it lacks the necessary >2% slope. The should and backslope are typically suitable. The footslope and toe slope are generally only provisionally suitable due to the movement of water from upslope into the field area, should it be located in these hill

slope positions. As you move down the hill it is common that the lower hill slope positions may require mitigation of upslope water movement, both above and below ground. Some other common landscape positions are the stream terrace, the structural bench, or the floodplain.

While examining the hill slope position, you should also record the slope aspect. This can be done with a compass. You should record either the specific angle that the hillslope is facing or the cardinal direction that the hill slope is facing. This angle should always be recorded when looking down the hill. All aspects are suitable for septic systems, but you should note that aspect conditions, such as amount of evapotranspiration, depth to clay, or overall moisture level can affect your loading rate.

In this section you should note the flooding frequency as well. Frequent flooding, or flooding that occurs 50 times every 100 years is unsuitable. Rare or occasional flooding would be provisionally suitable and may require higher amounts of pretreatment to mitigate the risk of contamination of nearby waterways.

Let's look at the topography section. The topography is describing the exact shape and slope of the area you are siting the field at. Slope plays an important role in telling us whether water will remain on the site or will shed away from the site. Slopes less than 2 percent are provisionally suitable and sites in these slopes must be built up to shed water off the septic field area. Slopes between 2 and 15 % are suitable. Sites with a slope between 15 and 30% are provisionally suitable, requiring 3 ft of soil depth under the trench bottom, upslope interceptor drains and a larger than minimum area. Slopes >30% are unsuitable unless they are able to meet the requirements listed here.

We also must record the type of slope that is present across the area. Uniform slopes are slopes that have the same shape across the entirety of the field area. There should be no changes in the direction of the slope. Slopes that do change their shape across the field area would be complex slopes. Complex slopes are unsuitable for the installation of a septic field. The first three shapes show a uniform field area, if the field area is the dotted line. The last two shapes show complex hill slope patterns. If the field, the dotted line were to be placed in this area, this complex slope would make the site unsuitable. It is important to note that complex slopes can occur both across and down the hill.

Finally for the topography you must record the exact shape of the hill across and down the slope. Here are the 9 options for uniform slopes. Note the suitability next to the hill slope positions. The concave areas are generally unsuitable as they concentrate water into the field from multiple directions. The provisionally suitable hill slope positions, Concave Linear, and Concave Convex would require extra mitigation of ground and surface water away from the field area, in the forms of berms or French drains.

The remaining 4 hill slope positions are all suitable for the installation of a septic field.

For the next 4 sections, the information will all come from the description of the soil profile. These include the soil characteristics, the soil drainage, the soil thickness and any restrictive horizons.

For these 4 sections, the department of health and senior services has developed a flow chart to help you decide on the soil group and whether or not the soil characteristics are suitable, provisionally suitable, or unsuitable to a conventional system. For texture there

are two key considerations when thinking about suitability. The first is the percent and type of clay that is present in the horizon. If you have >35% percent clay and it exhibits high shrink swell tendencies, the soil would be a group IVb soil and be unsuitable, this is regardless of rock content. IVb clays even with rock contents greater than 35 % are still qualified as IVb soils and are unsuitable for a conventional system. The second key consideration is the percent of coarse fragments. Soils with greater than 50% rock fragments are provisionally suitable, requiring the trenches to be lined with sand. Soils with greater than 70% rock fragments are unsuitable to a conventional system. Other soil groups and textures are suitable or provisionally suitable. Soil groups 1, 2 and 5 are suitable to a conventional system. Soil groups 3 and 4a are provisionally suitable to a conventional system.

For this section you would mark down the most restrictive but suitable or provisionally suitable soil down to its lowest depth EXAMPLE! Next you would mark the depth at which an unsuitable soil texture occurs, either IVb clays or soils with high rock content.

The suitability of the structure is similar. You will mark down the most restrictive suitable or provisionally suitable structure and the lowest depth that this structure occurs. You would then mark down the depth that unsuitable structure occurs at. Our unsuitable structures are platy structure and massive structure. These do not allow for the easy flow of water and air into and out of the soil and prevent the treatment of wastewater. Blocky, prismatic and columnar structures are provisionally suitable, with the requirement being that the trenches should be dug when dry to prevent smearing of the trench walls.

Granular structure is suitable.

The next section is looking at the soil drainage. This information is gathered from the soil profiles and from the area around the field area. The first step is to recognize when a water table is occurring. A water table is noted when the presence of gleyed colors occur in the soils. These colors signify that water is sitting in this horizon in a saturated state for at least 5 continuous weeks during the year. This is often during the winter when soils can be highly saturated and little water is being taken up by plants. Many of these horizons will dry up completely during the summer and fall months, but the risk of ground water contamination during the weeks/months of saturation mean that these horizons are unsuitable for the treatment of wastewater.

There are a few types of water tables that can be recorded. The first is the apparent water table. This is the water table at which there is continuous groundwater. This type of water table should have permanent water moving in it. If water is actively moving into the backhoe pit that was dug, it is likely that you have reached the apparent water table. The water should stabilize after a period and show where the apparent water table is located.

The next type is the seasonal water table. The seasonal water table is the rise in the water table that occurs during the winter months. In the summer, backhoe pits that reach into a seasonal water table will have gleyed colors but no active movement of water into the backhoe pit, as the water table has receded to its summer level. Seasonal water tables should have signs of redoximorphic reactions from the a starting horizon somewhere below the surface clear to the bottom of the pit, with increasing amounts of redoximorphic features as you increase in depth.

The last water table is the perched water table. The perched water table occurs because of some impermeable layer that is preventing the downward movement of water. Perched water tables often occur higher up on our landscapes in upland regions. The most common impermeable layer is impermeable or moderately impermeable bedrock. The water is not able to move through this bedrock fast enough and perches above this layer during wetter times of the year. Other impermeable layers can be horizons with high amounts of clay and fragipans. Water may perch above these horizons for enough time to allow for redoximorphic reactions. Signs of a perched water table are a higher density of redoximorphic features in a horizon that is above horizons with fewer redoximorphic features.

If you are able to recognize the redoximorphic features that signify a water table, you should record the depth at which these features occur.

In the soil drainage section you record any surface drainage limitations that are present in the field area. These would be features that would prevent the movement of surface water away from the field. These might be lack of slope, depressions in the field area, areas that change slope, surficial bedrock or rock outcrops. These features would make a site unsuitable for the installation of a conventional system.

Finally you must record the runoff slope length. This is the distance from the top of the field area to the top of the hill slope complex that this field area is a part of. We care about this because it gives us an idea of how much water will be moving down the slope and into our field area. Field areas that have long runoff slope lengths require a berm to redirect surface water around the field area. For smaller hills, it is possible to measure

this distance in the field but many of our hill slope complexes are large and require the use of topographic maps to measure the runoff slope length.

For soil thickness, you need to be recording the depth that you reach bedrock. Remember that soil pits should be dug to a minimum of 48 inches. For some soils, like our cherty clay soils, this 48 inch depth is not sufficient to maintain the 48 inches of separation between the bottom of the trench and the bedrock. Use of a tile probe and hammering it into the bottom of the pit to test the depth of bedrock to allow for systems to be installed in these cherty clay soils is advised as pits over 60 inches in depth require shoring up of the sides for the safety of anyone inside the pit.

In this section you should also record any rock outcrops that occur in the field area or nearby. These should be marked on the map as well.

Finally, you must record the type, depth, and thickness of a restrictive horizon if it occurs in your soil profile. Remember that the most common restrictive horizons in Missouri are the fragipan and the claypan, but it can be any horizon that would perch wastewater and prevent the downward movement of water.

In the next section available space, this section should be filled out when completing the field layout section. Here you need to estimate the space available between your two soil profile pits. The estimated field space should be listed in sq ft and have the dimensions of the field area given. For example 100 x 52 for a conventional system at a .3 application rate and the recommended 10 ft trench spacing and 2 ft trench width. The dimensions of the system must be drawn out on the field map as well. You must decide whether or not the area is suitable for a conventional system. This often means making sure that there are

the correct amount of runs and that they have the necessary required spacing. Many times, the area will not be available for a conventional system, but will be available for an alternative system. You should always make sure that the field area you have laid out at least has enough space for either an alternative or a conventional system before leaving. Finally, a replacement area needs to be decided upon. This region needs to have an estimated size and be laid out on the field layout map.

The last section Other factors, comes from the soil profile as well. These are other conditions in the soil that may affect the overall suitability of a conventional field. The two things that we need to consider are the likelihood of ground water contamination potential and surface water contamination potential. Ground water contamination is of great concern for septic systems. When untreated wastewater enters into the ground water, it can contaminate drinking water of entire communities. This can spread pathogens and disease spreading agents to people beyond just the homeowner. Let's go over the conditions that could risk contaminating ground water. The first is rapid permeability. Rapid permeability is defined as anything above 6.0 inches per hour of permeability. These are soil horizons that allow the passage of more than 6 inches of water in one hours. These are soils that have rock content over 70 percent, or soils that are in group 1 that also have high amounts of gravel. A reference point may be that a typical silt loam surface with ~20% clay often has a permeability of 0.6-2.0 inches per hour, which is considered moderate permeability. Another risk factor is highly permeable bedrock. The type of bedrock should always be assessed onsite in the soil profile pits. Highly permeable bedrock is common across Missouri, represented by the high frequency of karst features that are present in Missouri. If you are unfamiliar with the types of

bedrock in Missouri, it is good to reference USGS databases that have mapped out the different formations across Missouri. While this data is helpful, it should not override field observations. To discover whether the bedrock that is mapped across a site is of risk for high ground water contamination potential, it is good to check the charts and information in *Geologic Aspects of Individual Home Liquid Waste Disposal in Missouri*. Here for example we can see that The Meramecian Series as part of the Mississippian age bedrock has low to moderate permeability, but high when there are karst features nearby. You can see in these examples that ground water contamination comes from bedrock that is fractured and has many cracks or fractures. When wastewater reaches these fractures, it travels along the rock and no longer through the soil. This means that no treatment will be accomplished, and untreated wastewater can move into nearby aquifers that supply water to many people.

The common reasons for ground water contamination potential are listed here, but other reasons can be given, such as proximity to old wells that haven't been plugged, springs, or losing streams.

The other common environmental hazard are soil conditions that would cause contamination of local waterways. Surface contamination occurs when wastewater can not move downward through the soil at a rate equal to or greater than the amount of wastewater being applied in an area. This causes the soils to saturate and the wastewater to come back to the surface, where it will move with the slope to drainageways, creeks, streams, and rivers. Once it is on the surface, wastewater can move into the linings of wells, springs, or cisterns. Surficial water contamination is one of the most common types of pollution in Missouri and is the cause of high e. coli in many of the lakes and

rivers in our state. It can spread biological diseases and other contaminants into local waterways.

The common soil and site features that allow for high surficial contamination are areas with high slope, or those over 15%, as it is likely that wastewater will begin moving horizontally on these steep slopes and come to the surface.

Shallow low permeability bedrock will also cause surface contamination, as the wastewater will perch on top of these bedrocks and then move horizontally until it comes to the surface. Shallow restrictive horizons and horizons with high amounts of clay can cause surface contamination. Extremely small lots are at a much higher risk of surface contamination, as the likelihood of compaction, traffic, or additional water from roof and road runoff onto the soil of the septic field area can cause the field to fail.

In this example you can see that the wastewater hits a shallow claypan and then resurfaces. As it moves along, it finds its path into a well that allows for contamination of the drinking water of the area.

The final part on the back page is the overall suitability. If any of the sections on the back page are deemed unsuitable, the site itself is unsuitable unless there are actions that can be performed to the site that would mitigate the risks that are described on the back of the page. These mitigations should be described in the notes/comments section. Other information that should go in the notes section would be the location of the pits. These should also be mapped out on the field map layout. You should note here the type of bedrock as this is important for the shrink swell data and for referencing other geologic

risk factors. You should describe any restrictive horizons that are present, such as fragipans or claypans.

For lagoons, you should comment on how much soil needs to be removed until you reach the soil horizons that meet the requirements for preventing downward leeching of wastewater.

Any other oddities that are present in the pit or the site should be noted as well. These could be high amounts of animal pedoturbation in the soil pit. Whether or not the pit was holding water or water was moving into the pit and finally any fill horizons or buried horizons that have been created through human interference.

This back page is of great importance to the overall success of a septic system and the soil evaluators ability to assess and gather this information is one of the key aspects of the job of a soil evaluator.

### **Application Rates/Loading Rates**

Welcome to the video on loading rates or application rates. In this video we will discuss what application rates are, soil and site conditions that affect application rates and how to decide upon the application rates for each horizon and the final application rate of for the entire septic system.

The application rate in simplest terms is the amount of effluent that can be applied in the trenches to the soil. The rate is calculated in gallons per day per sq ft. For example, a .3 gpd/sqft. Application rate is 38 ounces or slightly more liquid than a large mason jar.

This amount of water is applied over a 1ft/1ft square of soil. The application rate is one of the central parts of our job. It decides the required size of the field, the amount of trench

and pipe to be used, and the type of system that will be installed, the overall cost of the system, and whether or not the system is successful in the long term, so taking the time to think carefully about what application rate to select is of great importance.

The key thing to know is that soil evaluators have to select a specific application rate. As you can see in the application rates chart, there is a range that is given for each soil group that is broken up by the type of structure that the soil has. It is our job as soil evaluators to pick the application rate that most aligns with the properties of the soil. The application rate of a soil is affected by many different properties, such as the soil texture, structure, pores, roots, coarse fragments and the shrink swell of the soil.

Soil texture gives us the overall soil class. Soil texture is important for application rates as it tells us a good deal about how water will move through the soil profile and how tightly water will bond with the soil particles. Sandy soils allow for high amounts of water movement but do not have a high water holding capacity, while clay soils have a high water holding capacity and only allow for slow movement of water.

The structure that these soil particles take greatly affects the application rates. Soils of the same textural class can vary from 0.3-0.6 gallons per day based on structure, as well as other characteristics. Soil structure affects how the water will move in and around the soil peds. Soil structure can create or prevent channels and pores that facilitate or inhibit water and air movement. Soil structure is a highly variable feature that is affected greatly by human interference. Structure can be smeared and have its pores closed off. Structure can be compacted through the application or heavy machinery or high amounts of activity

upon a soil, this greatly decreases the water and air movement of the soil. Structure can be broken through the use of tillage.

We should also be considering the amount, size, shape and continuity of pores in the soil. These affect water and air movement and allow for treatment of effluent.

The BOD or biological oxygen demand is something to think about when thinking about the application rate. This refers to the amount of oxygen that microbes require to break down the organic matter under aerobic conditions. Wastewater that has a higher BOD has more organic matter and suspended solids in it and it will require more time and treatment in the soil to be processed and treated to become clean water again. Providing some form of pretreatment such as aeration or filtration can allow for increasing the application rate, as it lowers the BOD of the effluent. Typical BOD levels of a basic septic tank are between 140-220 mg/l. Wastewater that comes from aerated tanks or receives some form of secondary treatment before entering the field area, are often around 30mg/l. This is a drastic lowering of the demand that will be put on our soils and can affect the application rate.

Finally, the bulk density and minerology of the soil greatly affect the application rate. As soils become more compacted, their bulk density increases, meaning that there are fewer pores and air space within the soil ped. This affects how well water can move through these soils. Signs of high bulk density will be soil structures that have the size of coarse and have few pores or roots that are moving through them. When water reaches soils with high bulk densities, it will take more time for the soil to absorb the water and begin to treat any effluent. The minerology of the clay has a large affect on how the soils will

react to saturated conditions. Soils with smectitic mineralogy are clays that have expand when wet and shrink when they are dry. This has to do with their molecular structure that allows for the influx of water between clay layers. Other clay mineralogies, such as kaolinitic clays, do not allow for as much water influx between clay layers and therefore do not expand when wet and shrink when dry. Clays that do not expand and shrink allow for the movement of air and water through their horizons and can perform the treatment of effluent.

As always, it is important to think about the long term success of the septic system. The soil and trenches that are installed on day one must function for hopefully the next 20 years. Over this time we need to remember that a biomat will often form along the bottom and even the sides of the trenches. While this biomat is helpful for the treatment of wastewater, it slows down the movements of water through the gravel and into the soil. This biomat can begin to develop up the sides of the trench as well if there is often high amounts of effluent sitting in these trenches. This can further slow down the treatment of effluent and perhaps even cause the system to fail when wastewater rises to the surface.

It is important to note the loading rates of all the horizons that will be affected by the septic system. Looking at this trench here, it is easy to assume that only the horizons at or below the trench bottom would be affected by the effluent, but we need to consider all the horizons that are present in the soil profile. Soils with compaction at or near the surface would slow down the movement of air and water into and out of the soil. This would drastically slow down the amount of treatment possible for the effluent that is being emitted. Soil horizons with high amounts of gravel at shallow or moderate depths may

cause effluent to move along these horizons before moving into the soil below, causing effluent to move laterally. Finally the build up of the biomat may cause effluent to move more through the sides of the trenches rather than the bottom of the trenches. These are some reasons as to why it is important to give application rates to all of the soil horizons that are present in a soil profile.

Now lets look at some factors that we can use to help us adjust our loading rates. There are both site and soil features that can affect our loading rates. Let's begin by looking at the site features. The overall landscape position affects how water will move both above and below ground and whether or not there will be water that will be moving onto that landscape position from positions above it. This movement of water affects how much effluent we can add to the soil. Higher loading rates or application rates can be give to landscape positions that shed water and are not gaining water from higher slope positions. These are ridges, shoulders, nose slopes and convex slopes. Our side slopes that are linear will receive an average application rate, as while they are shedding water, they are still gaining water from upslope. Finally landscape positions that are gaining or concentrating water into a field area would receive a lower application rate. These would be our head slopes, foot or toe slopes, or concave slope shapes.

Next the amount of slope affects how quickly water will be shed from the slope. Higher slopes means that surface water will drain off the field area more quickly. Higher loading rates can be given to fields that are located on sites with slopes above 10%. Slopes between 5-9% will receive an average loading rate and slopes between 0-4% should receive a lower loading rate, as surface water will not move as quickly off of these slopes and allow for greater saturation of the field area from water from the environment.

The aspect of a hill affects the amount of sunlight and overall evapotranspiration that will occur on that slope. Our exposed aspects, or downward slopes that face south and west can have a higher application rate. Those hill slopes that have a neutral aspect, or NW and SE can receive an average loading rate, and our protected aspects, or north and east should have their application rate reduced slightly.

All of these site features should be taken into account when giving a soil a loading rate. A steep, shoulder on an exposed aspect could receive a higher loading rate than a low sloped, foot slope, on a protected aspect even if the soil conditions are highly similar.

Let's now look at some of the soil conditions that can affect loading rates.

The first is structure. Granular or single grain structure allows for greater movement of water and therefore allows for a higher application rate. Our subangular blocky structures do slow down the movement of water, but they still allow for moderate treatment and air and water exchange. This structure would receive an average application rate. Finally, our angular blocky and prismatic structures, and our coarse subangular blocky structures limit water movement and would receive a lower application rate.

As discussed earlier, clay mineralogy affects water movements soils with no clay or little (<27%) of 1to1 clays, or kaolinitic clays receive a higher application rate. Soils with significant amounts of 1:1 clays would receive an average loading rate. and soils that have mixed mineralogy or 2:1 clays, or the smectitic clays, would receive a lower loading rate. A quick way to find the mineralogy would be to find a soil series that matches closely with the soil onsite and look at the taxonomic class to get an idea of the

minerology, whether it is mixed as in the union series, smectitic as in the Keswick series, or siliceous as in the viraton series.

Finally the depths to notable features will affect the overall loading rate. If the soil wetness, depth of total soil and depth to restrictive horizons are greater than 48 inches, this would allow a higher application rate. If these features fall in the 36-48 inch depth, this would provide an average application rate. And if these features occur at depths less than 36 inches, that would signify a lower application rate.

It is important to note that these are guidelines and that these adjustments should all be taken into consideration when assigning application rates. Simple because the slope is over 10% does not mean you should give a high application rate, if for example, you also have 2:1 clays and angular blocky structure. These are guidelines to help inform your decisions.

So how do we choose the right application rate.

Over evaluating the application rate risks have too small of a field, the lines clogging, and the system failing over all. It would allow a smaller field area and a slightly lower cost to the homeowner, but in the long run may end up with bigger problems if the system fails and has to be replaced elsewhere on the property.

Choosing too low of a loading rate means you will have an over-large field. This could increase the costs of the field and the installation. As well, it may prevent the field from being located in an area due to setback distances or easements.

The range is allowed for a reason. It is for taking into consideration all of the characteristics of the soil and the landscape and trying to balance these with the water

usage of the property. For new soil evaluators, leaning towards a lower, more conservative loading rate is advisable until you have more experience evaluating soils and seeing more systems in action.

### **Examples/Practice**

Welcome to our video that will be practicing assigning loading rates and overall site suitability. For this video we will be referencing many of the materials from the previous videos for guiding us through our decisions. The first thing that we are going to practice is assigning loading rates for different soils. Remember that there are many factors that affect our loading rates, such as landscape position, slope, soil structure, soil wetness, clay mineralogy, and of course, soil texture. It's important to keep these features in mind when you are assigning a final loading rate for a site. As always, we are basing our loading rates off of the charts in the rules and regulations governing onsite wastewater systems, tables 13 for conventional systems, and table 14 for LPP, Drip, or other engineered systems. You should always be assigning both a conventional and a LPP/Drip loading rate for every horizon.

For our first example, let's look at a site that is located on a Backslope, with 18% slope. We have >48" on soil depth and there are no water table issues or restrictive horizons in this soil profile. Our textural class is a Silty Clay Loam and there are fewer than 35% coarse fragments present in this horizon and the soil is exhibiting low shrink swell properties. For this reason, we end up classifying this soil as a Class III soil. For Table 13 for a conventional system, we can see that the range for a class III soil is 0.6-0.3 gallons

per day. This range is further broken up by structural type, with Granular, and fine and medium Subangular Blocky Structures receiving 0.6-0.4 gallons per day. Prismatic structures, coarse Subangular blocky structure and any angular blocky structures will receive a 0.4-0.3 gallons per day application rate. The soil that we are looking at has a weak fine subangular blocky structure, so our range of choices will be between 0.6 and 0.4 gallons per day. Our clay percentage for this horizon is 29, slightly higher than the middle for a class III soil. Going through our chart, we can see that the hill slope position gives us an average loading rate, The high slope gives us a higher loading rate. The exposed aspect gives us a higher loading rate. The soil structure gives us an average loading rate. The clay minerology gives us a lower loading rate. The Soil wetness, depth, and restrictive horizons are all allowing for a higher loading rate. While there are many things that are telling us that this soil can have a high loading rate, we should probably not go with the maximum 0.6 gallons per day, due to the moderately high clay percentage, the weak structure, and the clay minerology. What loading rate would you suggest for this horizon?

For me, I would assign this soil horizon a conventional loading rate of 0.5 gallons per day. For our LPP or Drip loading rate, we would go through the same process, this time looking at table 14. We end up in the range of 0.3 to 0.2 gallons per day. Because of all the factors we had discussed earlier, I would not go with the highest loading rate for this soil, but also not the lowest loading rate for this soil. I would assign this soil and 0.25 gallons per day loading rate.

Our next site is located on a footslope and has a slope of 6%. There is a water table at 18 inches, directly below this soil horizon. There is a restrictive layer at 37 inches. We are on a protected aspect, and the mineralogy of the region is 1:1 clays. Our textural class is a Silty Clay Loam, there are 35% coarse fragments, and our soil is exhibiting signs of low shrink swell. While the soil textural class is signifying a class III soil, the coarse fragments are at or above 35%, meaning this soil would become a class V soil. The recommended ranges for a class V soil are between 0.4 and 0.2 gallons per day. Let's go through our chart again. Our landscape position is giving us a lower Loading rate. The slope gives us an average loading rate. The aspect gives us a lower loading rate. The soil structure gives us an average loading rate. The clay mineralogy gives us an average loading rate. The soil wetness gives us a lower loading rate. The soil restrictive horizons gives us a lower loading rate.

It is important to remember in class V soils that they can have a wide variety of soil textural classes that can affect the loading rates, as long as the soil has less than 50% coarse fragments, meaning this class can have a clay soil with 60% clay, or a silt loam with 15% clay. The loading rates should reflect these textures as well. So what loading rate would we assign to this soil horizon. While the soil texture, structure and coarse fragment percentages would allow us to have an average or above average loading rate, the external features, such as hill slope position or aspect, and the water table and restrictive horizons, are telling us to lower the application rate. What would you all recommend for this soil horizon.

For me I would assign this soil horizon a conventional loading rate of 0.25. For our LPP/Drip loading rates, I would go through the same process and end up giving this soil a

slightly lower than average loading rate, most likely a 0.20 gallons per day Application Rate.

Let's now look at a couple examples of assigning suitability to a whole site. For the suitability for individual horizons, please see the soil profile description video series.

Let's take a look at an example site and go through how we would assign suitability for each section. Remember that each section can either be suitable, provisionally suitable, or unsuitable. At the end we base our final suitability off the lowest of the uncorrectable characteristics. The uncorrectable characteristics are landscape position and topography, Restrictive horizons, Available Space, and Other factors. Soil characteristics is partially correctable. The depth of suitable or provisionally suitable soil can be modified through the addition of suitable soil on top of the field area. There are limits to the amount of soil that can be added to a field area though. For a conventional system, even with additional soil, there needs to be a minimum of 30 inches of provisionally suitable or suitable, naturally occurring soil in the ground for a conventional system. Platy structure can be mitigated through repeated tillage and the planting of grasses and forbs. Soil thickness can be corrected through the addition of suitable soil on top given that there is 2ft of separation from the bottom of the trench to water table or bedrock.

Soil drainage can be corrected through the use of curtain drains or French drains given that the soil and site conditions are suitable to the water table being lowered. Upslope interceptor drains can also correct large runoff slope lengths.

Let's go through each of these sections:

Landscape position.

Backslope is suitable

Slope aspect is exposed, which is suitable

There is no flooding, suitable.

There are no surface depressions, suitable.

For the first section on Landscape position, this site receives a suitable rating

Topography.

Percent slope 17%, provisionally suitable as it is above 15%.

Slope type: Uniform, suitable

Shape across and down: Linear Linear. Suitable

Topography would receive a provisionally suitable label.

Next section Soil characteristics

We have to talk about texture and structure. In the first section under texture, you are classifying the depth of suitable or provisionally suitable soil for a conventional system.

This soil profile for example only has 12 inches of Provisionally suitable soil. So it would receive a PS next to texture to a depth of 12 inches. The next depth the total depth of soil that is unsuitable. For this soil profile, the soil texture was unsuitable from the 12 inch depth to a depth of 60 inches.

Next is soil structure. This soil had a suitable or provisionally suitable soil structure (Blocky) down to a depth of 60 inches. For this, next to structure, there would be PS.

Overall, Soil characteristics would receive a U or unsuitable due to it not having the required depth of suitable soil texture.

Next is Soil Drainage

Water Table None: Suitable

Depth to water Table >60 inches: suitable

Surface drainage limitations: none: suitable

Runoff slope length 150 feet: suitable

Overall soil drainage gets a suitable rating

Soil Thickness

Depth of bedrock is greater than 60 inches, this is suitable.

There are no rock outcrops: this is suitable

This section gets a S or suitable rating

Restrictive horizons: There are no restrictive horizons

This section gets an S or suitable rating

Available space.

We've laid out 5200 sq ft of space for the system.

This is adequate space for a conventional or alternative system. There is also space on the property for a replacement area.

This section would be suitable

Other factors:

There are no other factors that would show signs of environmental hazards or ground water contamination potential. This section would receive a S or suitable rating.

Overall.

When we look at the overall rating, we have to take the rating from the above section that is the lowest. As there is even one unsuitable rating in an uncorrectable characteristic, this site receives the unsuitable rating overall. For this site, the overall rating would be Unsuitable for a conventional system as there is no way to correct the soil textural depth of only 12 inches being suitable.

Going through each of these sections carefully is very important, as each section has something important that can cause a system to be unsuitable for a conventional system.

### Final Comments and Wrap Up

Welcome to the final video of our forms, maps, and final product. In this video we will talk about any final comments that can be made about the site or the system, go through some recommendations that can be made and review some final responsibilities of soil evaluators beyond homes and small businesses.

Let's first look at the common recommendations that are associated with provisionally suitable or unsuitable classifications and the situations where these are used. These are recommendations that would allow a system to be installed if the site has specific provisionally suitable or unsuitable ratings on the site classification page.

The first and most common recommendation is that trenches must not be dug when wet to prevent damaging soil/trench surfaces. This is connected with a provisionally suitable rating for the soil structure. Soil with a structure of subangular blocky, angular blocky or prismatic all receive a provisionally suitable rating. This recommendation is required for these structures, as these structures have the tendency to smear when they are dug with a backhoe when they are wet and close off the natural pores in the soil from accepting water. This is also common on soils that qualify as IVa soils. For trenches that will be dug in soils that are high in clay and have a provisionally suitable structure, it may be a good extra recommendation to say that the sides of the trenches need to be raked. This ensures that the walls of the trenches aren't smeared and that the pores are open to wastewater.

The second recommendation is that surface water diversion is needed. This is connected with provisionally suitable slope percentages and slope runoff length. For slopes greater than 15% and for slopes with large runoff slope lengths, diverting upslope surface water keeps the septic field area drier and able to take up more wastewater.

The next recommendation is for an interceptor drain to be installed upslope at a depth of x inches. This is in reference to a provisionally suitable or unsuitable soil drainage class.

These interceptor drains are installed to lower the water table in the septic field area.

They are generally only capable of lowering the water table when there is sufficient slope beneath the field area that the interceptor drain can come to daylight. Interceptor drains may not be effective in soils that have high shrink swell potentials, IVb clays, and may have diminished effects in IVa soils. The depth of the interceptor drain should be at a minimum of one foot below the trench depth, though as the slope of the field area

increases greater depths may be necessary. There is a minimum of a two foot depth beneath the trench bottom if the trenches are being placed at depths less than 18 inches or have shallow placement.

The next recommendation is for shallow or modified shallow placed trenches. This is in reference to a provisionally suitable or unsuitable textural class, structural class, soil thickness, or restrictive horizon that occurs within the required soil depth for a conventional system. In this recommendation you are providing the depth in inches for the bottom of the trench. This can be anywhere between 6 inches and 17 inches. Trenches may be placed between 18 and 30 inches without issue. Any shallow placed trench must have two feet of separation between the bottom of the trench and any restrictive horizon, bedrock, or water table. With this recommendation it is good practice to leave a comment on how much soil must be added to the field area. For example, if you state that the trenches should be placed at 12 inches, you would write in that a minimum of 6 inches of soil must be added across the entire field area. This soil must be tilled into the previous surface in layers no more than 4 inches thick and planted with a fast growing grass seed.

The final recommendation is for an alternative or engineered system. This recommendation is for when the site or soil characteristics are unable to be remediated and would remain unsuitable to a conventional system. If there is a specific system that the homeowner is seeking, such as a lagoon, it is a good idea to write this comment next to this recommendation. Remember though, that it is not our responsibility to provide final recommendations on system type or design of a system, but rather only to say that an engineered or alternative system is needed.

It should be said though that after the selection of a site and an examination of the soil characteristics, soil evaluators should try and assess whether some sort of engineered or alternative system would be suitable in that location. If an installer or engineer is not able to design/install a system in a site whose characteristics are completely unsuitable to any system, the soil evaluator would need to come back to the property and find a new location that would be suitable for a system.

These are the most common recommendations to help bring a site from provisionally suitable or unsuitable to suitable for a conventional system. There are other recommendations that can be made to overcome specific other provisionally suitable or unsuitable site and soil conditions, such as sand lining trenches due to high rock content in the soil (between 50 and 70%).

This brings us to the final page with a section for other comments. This area can be used for a multitude of reasons to pass along further information for engineers or installers. Some common things that might be noted in this section would be whether the site needs a pump or lift station to move the wastewater to the field area, whether surficial compaction and platy structure needs to be remediated through tilling, the spacing of trenches or the width of the trenches if the system was not laid out with the recommended spacing of 10 ft or width of 2ft.

Any variances that will be required for the system will need to be noted in this section. If the homeowner will need to apply for a variance to have the system closer to a well, drain, foundation or any of the other setbacks, that should be noted in this comment section with the specific distance to the limiting setback feature.

Further comments may include the need to remove fill from a site or the depth of additional soil that needs to be added to a site.

For field areas in forested sites or for lagoons, a comment might be left about the removal of trees from the area.

These are just some examples of comments and recommendations that can be left in this section. For jobs that have conditions that go beyond the normal conditions, it is always fine to write out the details of possible issues and conditions that are out of the ordinary. Further discussion may need to occur about these characteristics with the administrative authority, the engineer or the installer.

The final section of the report is your name, signature, ID number and the date of the evaluation. After this the report is ready to be submitted to the landowner. From here the landowner will submit the soils report along with any other required documents, such as building plans and a survey to the county or state for final approval.

That wraps up the state evaluation form and the requirements of the soil evaluator regarding this form. For specific questions about the form or the required information, it is good to contact the local administrative authority.

The final thing we will talk about are some responsibilities of soil evaluators that go beyond the soil evaluations for homes and small businesses. The first is for jobs in which the landowner, business, or home will produce more than 3000 gallons of wastewater daily. For jobs of this size, the regulating authority is no longer a county health or building department or the department of health and senior services. For jobs with greater

than 3000 gallons of daily flow, the department of Natural Resources becomes the regulating body regardless of the location in the state. The requirements for a DNR job are different than those required by a DHSS job and are discussed in a separate video series, but know that their forms, requirements and expectations are different. The rules and regulations around DNR jobs can be found in 10 CSR 20-8 or Chapter 8 of DNR's Clean Water Commission. It is always a good job to contact DNR before proceeding with a job to know the exact requirements that will be expected of you as a soil evaluator.

The next type of job is also through DNR and is the approval of subdivisions in which each lot will have its own septic system, rather than being connected to a wastewater treatment plant. It is good to contact the local health department or building code enforcement for these types of jobs, as they may require specific numbers of pits, types of maps or other information. It is common that these are mapping jobs in which the soil evaluator must map out the different soil series that are present across the land, dig and describe an appropriate number of soil pits and describe these pits. They will then be required to design maps of these different soil series as well as design suitability maps for septic systems across these soil series. For more information on soil mapping, please see the soil mapping video series.

These are two other common types of jobs that soil evaluators may perform in the state of Missouri. It is up to the individual soil evaluator and business owner to decide the services that they will offer to the public, but do know that you may be approached for these services.

Thank you for watching this video series on maps, forms and the final product.