GROUNDWATER PROTECTION STUDY

Prepared for:
Virgin Town
114 Mill Street
P.O. Box 790008
Virgin, UT 84779

May 5, 2026

PREPARED BY:
Sunrise Engineering, LLC

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May 5, 2026

Mayor Jean Krause
Virgin Town
114 Mill Street
P.O. Box 790008
Virgin, UT 84779

Subject: Groundwater Protection Study
Virgin Town
Washington County, Utah

Mayor Krause,

Enclosed herein is the report for the groundwater protection study for Virgin Town in Washington County, Utah.

If you have any questions concerning this report, or if we may be of further assistance, please let us know.

Prepared by:

LICENSED PROFESSIONAL ENGINEER
DAOQIONG YANG
STATE OF UTAH
5/5/2026

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Derek Anderson, P.E.
Principal / Division Manager

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EXECUTIVE SUMMARY

Sunrise Engineering, LLC (Sunrise) completed a groundwater protection study for the Town of Virgin, and other stakeholders, evaluating septic system impacts on local groundwater and surface water quality. Similar evaluations have been performed for the Town previously, though these evaluations relied heavily on general assumptions about the local groundwater conditions. This study provides valuable new data, collected over the course of a year, to refine the evaluations performed previously, as well as to propose possible different approaches to the evaluation.

While the study provides valuable new information, this study concludes that additional data is needed to determine whether the Town's current septic density requirements are appropriately protective or could be reduced.

In this study, Sunrise performed the following tasks:

- Previous readily available study reports for the septic systems in the Town of Virgin were reviewed.
- Four piezometers were installed for groundwater quality monitoring and sampling.
- Water samples were collected monthly from the four piezometers between June 2024 and May 2025. Surface water samples were also collected at three locations: two in the Virgin River (one upstream of the town and one downstream of the town) and one in North Creek. Additionally, two sampling events took place at the Truman Well in April and May 2025.
- Collected water samples were analyzed in two different laboratories. First, the water samples collected between June and December 2024 were analyzed by the Southern Utah University Water Lab. Once Sunrise realized that the nitrate concentration in the water sample collected at the upstream Virgin River location was higher than that in the water sample collected at the downstream Virgin River location, Sunrise delivered the water samples collected between January and May 2025 to the Chemtech-Ford Laboratories for laboratory analysis.
- Inverse modeling was performed, using the results of the laboratory analyses, to estimate the ambient groundwater flow of the alluvial aquifer.
- Based on the inverse modeling results and analysis of the laboratory data, Sunrise realized that the mass balance approach used in previous studies needed to be improved and an alternate approach was provided in this study.
- Sampling for emerging contaminants commonly associated with wastewater resulted in several anthropomorphic compounds being detected in the groundwater monitoring wells. These constituents were only sampled once toward the end of the study period, limiting the ability to establish trends or determine their impact on the river.
- The results of the data collection and evaluations were summarized in a draft of the study.
- The study draft was reviewed by a third-party. Loughlin Water Associates (Loughlin) performed this review.

Based on the work completed, Sunrise concludes the following:

- The alternate approach assumes that nitrate originating from septic systems and irrigation recharge in the Town of Virgin migrates into two distinct aquifer systems: the alluvial aquifer and a shallow bedrock aquifer. Based on these assumptions and the available sample results, it was hypothesized that approximately 12% of the nitrate from septic systems and irrigation recharge migrates to the alluvial aquifer that is connected to the Virgin River, while the remaining nitrate migrates to a shallow bedrock aquifer with apparently limited hydraulic connectivity to the Virgin River.
- During the third-party review, Loughlin introduced another alternative hypothesis to explain the results, which differed from the alternative proposed by Sunrise. This hypothesis included the possibility that algae in the river may be assimilating a substantial portion of the nitrate load.
- Without additional investigation, this study is unable to conclude the accuracy of either alternative explanation.
- These alternative explanations, together with laboratory evidence of emerging contaminants in the aquifer adjacent to the river, highlight the need for additional data collection to reduce uncertainty and more fully evaluate the assumptions used in groundwater flow and nitrate-transport interpretations.

Based on the work completed, Sunrise recommends the following:

- Current 90% nitrate removal requirement should continue, and no additional restriction is recommended for commercial developments.
- It is recommended that Virgin Town seek additional understanding of the area's deeper aquifers, their potential hydraulic connectivity with the Virgin River, and the presence of emerging wastewater contaminants before making significant changes to the allowable septic density.
- Maintaining the current septic density limit while pursuing opportunities for sewer infrastructure represents a prudent and balanced path forward for Virgin Town.
- The Town may consider policies which require septic users to connect to sewer trunk lines when they become available.

The groundwater protection study conducted for the Town of Virgin provides new insight into the potential influence of septic systems on water quality. While the data collected during the study improves the understanding of site-specific conditions, uncertainties remain. Additional monitoring and evaluation of the interaction of the aquifer with the river will be essential to refine models and support future policy decisions. In the meantime, maintaining current septic density limits and nitrate-removal requirements for commercial properties, while pursuing options for future sewer infrastructure, is a measured approach for the Town of Virgin.

1 INTRODUCTION

Sunrise Engineering, LLC (Sunrise) was retained by the Town of Virgin to conduct a groundwater protection study in Virgin, Washington County, Utah.

1.1 Background

Residential developments in rural areas have become a significant land use issue in many parts of the United States. Rural developments often rely on on-site wastewater treatment systems for wastewater disposal. Local county officials are in charge of regulating unsewered residential development, and regulations in some areas are driven by concerns about the impacts of development on groundwater quality. On-site treatment of wastewater can release contaminants such as nitrate, bacteria, viruses and household hazardous chemicals to the subsurface, posing potential threats to groundwater and surface water.

The Town of Virgin is located along the Virgin River in eastern Washington County. The Town provides drinking water to commercial and residential customers through its water system. The Water is provided by a Water Supply Agreement with the Washington County Water Conservancy District (WCWCD). Due to elevated levels of sulfate and total dissolved solids (TDS) in the groundwater in the area of the Town, there are no local public drinking water wells.

The Virgin River supplies more than half of all drinking water in Washington County, making its protection essential to the region. Water is diverted from the river downstream of the Town, stored in Quail Creek and Sand Hollow Reservoirs, treated at the Quail Creek Water Treatment Plant and delivered to multiple municipalities across the county. Maintaining high water quality in the Virgin River is critical whereas so much of the county depends on it as a primary drinking water source.

Pursuant to Article 13 of the Water Supply Agreement with WCWCD, "Until such time as a groundwater protection study is completed which determines the impact of septic tanks on the groundwater in the river system (which may allow a greater density), the Town shall not approve a project density of less than one unit per acre, except for R.V. Parks and Planned Unit Developments may be allowed if engineering studies reveal that there is no significant pollution to groundwater sources as a result of installing a community septic system or other treatment facilities, then the Town may decide to adjust its zoning ordinance to allow greater density". The Town is receiving considerable interest from parcel owners and developers relative to the possibility of increasing the allowable septic density. As a result, the Town also desires to perform a groundwater protection study that will evaluate the impact of septic tanks, including a potential increase in septic density, on the groundwater in the river system.

1.2 Previous Studies

1.2.1 Hansen, Allen & Luce 1997 Study

Hansen, Allen, and Luce (1997) completed a study with the purpose of recommending a range of septic system densities that could be considered by local authorities. It was intended to help ensure long term protection of regional groundwater for use as a public drinking water supply, with primary emphasis on protection of the Navajo aquifer.

This study examined hydrogeology, existing groundwater quality, future land use, septic system usage, septic system related pollution, regulatory considerations, and a determination of septic system densities. The recommendation of septic system densities depended not only upon the risk and mass balance analysis that was performed, but also upon how local regulatory authorities manage the development review process. It was determined the adoption of acceptable average septic system densities for areas having similar physical conditions and risks would be the most appropriate. This was chosen rather than establishing procedures which could be used by developers to determine the site-specific septic system density required for each development.

The prescribed septic system densities were based upon an allowable groundwater degradation standard above the estimated background concentration (taken in this study to be 1 mg/L). Utah Administrative establishes the maximum allowable nitrate concentration in groundwater as 10 mg/L. However, an anti-degradation standard of 2 to 4 mg/L above background was used to develop the recommendations for this study. This is in keeping with the recommendations provided in the *Hansen, Allen & Luce (1997)* study.

Virgin is not mentioned specifically in this study because at the time, Virgin owned and operated their own systems and as such were not participants in the study.

1.2.2 Ensign 2015 Study

Ensign Engineering & Land Surveying (Ensign) (2015) completed a wastewater study update for the Town of Virgin. It used a population growth rate of 3.6% per year to predict future demand. The purpose of the 2015 study was to supplement a study that was completed in 2000 titled "Virgin Town Wastewater Study" to answer the question of the sufficiency of the current approach to treating wastewater with septic systems. The 2015 study update was also intended to explore alternatives for treatment when the load from septic poses an unacceptable risk to groundwater and surface water quality.

The 2015 study analyzed the Town data by dividing the Town into several areas and counting both residential and commercial septic systems. Populations were projected into the future using a 3.6% growth rate. A Risk Analysis was then performed to analyze the effect of the Town's septic systems on nitrate levels in the groundwater. The analysis was done using a mass-balance approach. A level of 5 mg/L was used as a key indicator for excess nitrates in the groundwater. It was determined in the study that if nothing was done, the nitrate levels in groundwater will reach 5 mg/L by 2035, but if 90% nitrogen removal is required on new commercial connections then nitrogen levels will not likely hit 5 mg/L until 2045. Ensign (2015) predicted that the nitrate concentration in groundwater would reach 3.4 mg/L by 2025 if 90% nitrogen is removed from new commercial connections.

Ensign (2015) also analyzed a variety of options to control wastewater in the future. These options included regional treatment by Ash Creek Special Service District (ACSSD), facultative lagoons, and alternative onsite septic systems. The report recommended the use of alternative onsite treatment for new commercial connections to prolong the Town's ability to remain on septic until approximately 2045. Ensign (2015) recommended that the development density set forth in the service agreement with WCWCD remain one unit per acre.

1.2.3 Sunrise 2022 Study

Sunrise (2022) completed a wastewater study update for the Town. Based on the building growth between 2017 and 2021, a growth rate of 3.32% was used in the study. In this study, the concept of Equivalent Residential Units (ERUs) was introduced. One ERU is defined as the amount of wastewater produced by an average residential connection. Based on the ERU concept, commercial or other types of connections may be converted to equivalent residential connections based on the amount of wastewater discharge. It was determined that one ERU would have a wastewater discharge of 237 gallons per day (GPD) in Virgin.

With the help of the Town, Sunrise (2022) estimated that there were a total of 399 residential connections 399 and 18 total commercial connections in 2022. Based on the wastewater discharge from the 18 commercial connections, they were converted to 375 ERUs. Thus, the total ERUs were 774 (399+375).

Based on the current zoning map, Sunrise (2022) estimated that the total buildout residential connections would be 2,004 and total commercial connections 58 (1,184 ERUs). Under the current zoning ordinance, Sunrise (2022) estimated the total buildout ERUs would be about 3,188.

Sunrise (2022) estimated that the nitrate concentration in the groundwater would be 3.18 mg/L in 2022 under the following discharge restrictions for commercial connections. The study assumes that the effluent concentration of the existing 120 commercial ERUs remains unchanged. Through the buildout period, the study assumes the remaining 2555 commercial ERUs will be required to remove 90% nitrate content from effluents through treatment.

In conclusion, Sunrise (2022) recommended that Virgin Town begin pursuing the installation of a sewer collection system and use the regional treatment facility operated by the ACSSD. Compared to other wastewater treatment alternatives (alternative onsite treatment and facultative lagoon treatment), the transmission of wastewater to the regional treatment facility would be less expensive for the Town of Virgin. Installing a sewer collection system also opens the Town to growth opportunities.

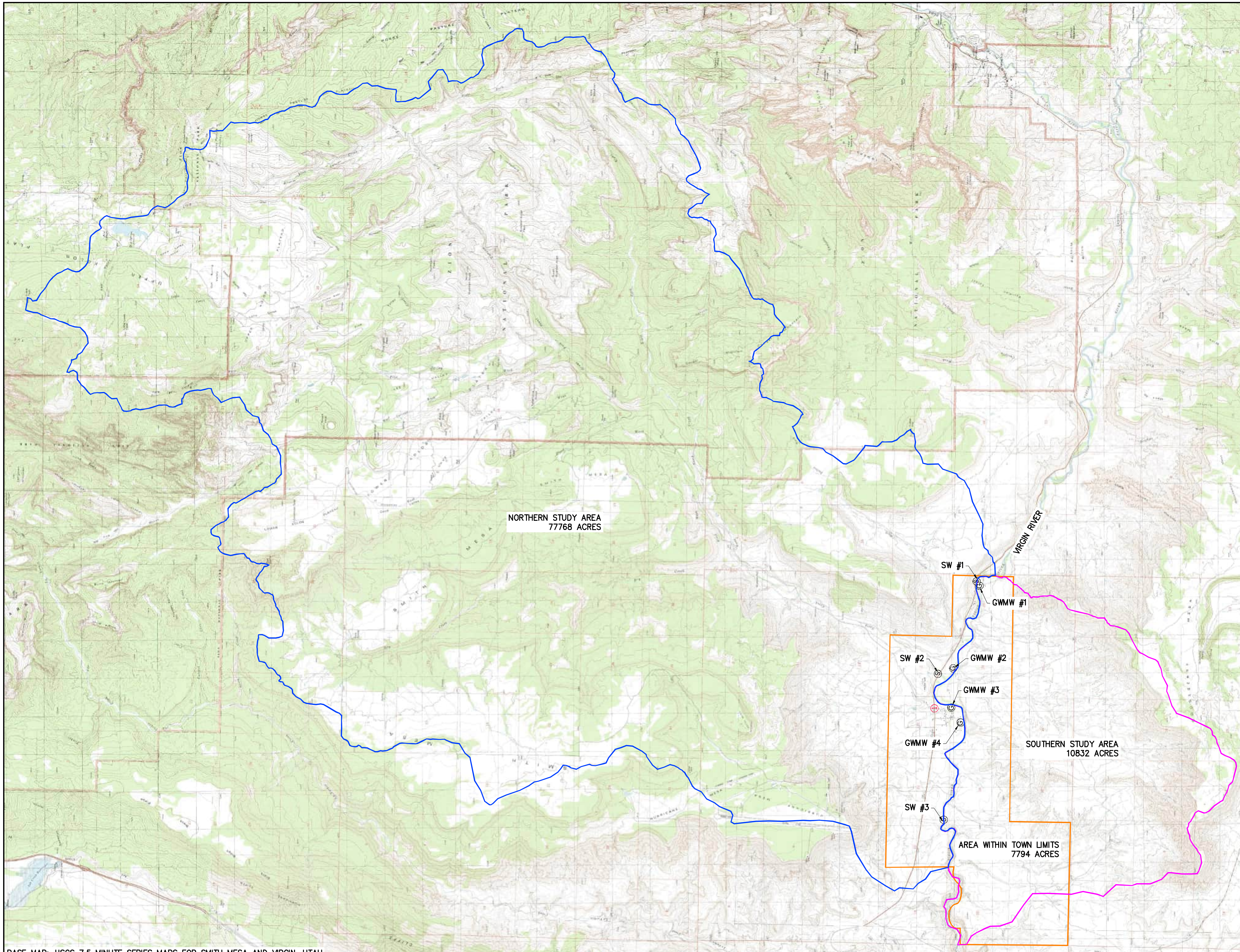
1.3 Purpose and Scope

The purpose of this study is to reevaluate the allowable septic density within the Virgin Town limits by conducting a groundwater protection study. In this study, the following tasks were performed:

1. **Data Collection**: Weather data, especially precipitation data, was collected from weather stations within the study and nearby areas. Available groundwater study reports, topographic and geologic maps, geologic data and well logs were also collected. The most recent (2024) Virgin Town water use data were collected and analyzed. Moreover, the findings of the previous studies were reviewed.
2. **Groundwater Quality Monitoring**: Four piezometers were installed at locations near the Virgin River for groundwater sampling. Three surface water sampling locations were selected based on site accessibility observed during a site inspection. Two surface water sampling sites were located in the Virgin River (one near the downstream limit and the other near the upstream limit of Virgin Town). The other surface water sampling site was located in North Creek where it crosses Highway 9. Twelve

monthly sampling events occurred at the seven sampling locations. The sampling locations are shown in **Figure 1**. Additionally, two sampling events occurred at the only well (Truman Well) located within the Town (at 24 South 170 East). The samples were delivered to chemical laboratories for analysis of total dissolved solids (TDS), nitrate or nitrate + nitrite and pH).

3. **Inverse Modeling**: Inverse modeling was performed using Virgin Town's 2024 water use data and the water quality data collected in Task 2 to estimate the ambient groundwater flow.
4. **Mass Balance Modeling**: With the estimated ambient groundwater flow calculated using inverse modeling, the development density was modeled using an improved mass balance approach.



NORTH

SCALE

0 4000' 8000'

LEGEND

- SOUTHERN STUDY AREA BOUNDARY
- NORTHERN STUDY AREA BOUNDARY
- VIRGIN TOWN BOUNDARY
- EXISTING WATER WELL
- SURFACE WATER SAMPLING LOCATION
- GROUNDWATER SAMPLING LOCATION

AREA MAP

REV NO.	COMMENT	DATE

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DATE

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VIRGIN TOWN

GROUNDWATER PROTECTION STUDY

PROJECT LOCATION MAP

SEI NO.	DESIGNED	DRAWN	CHECKED	SHEET NO.	
09817	DY	DY	DSA	01 of 06	FIG. 1

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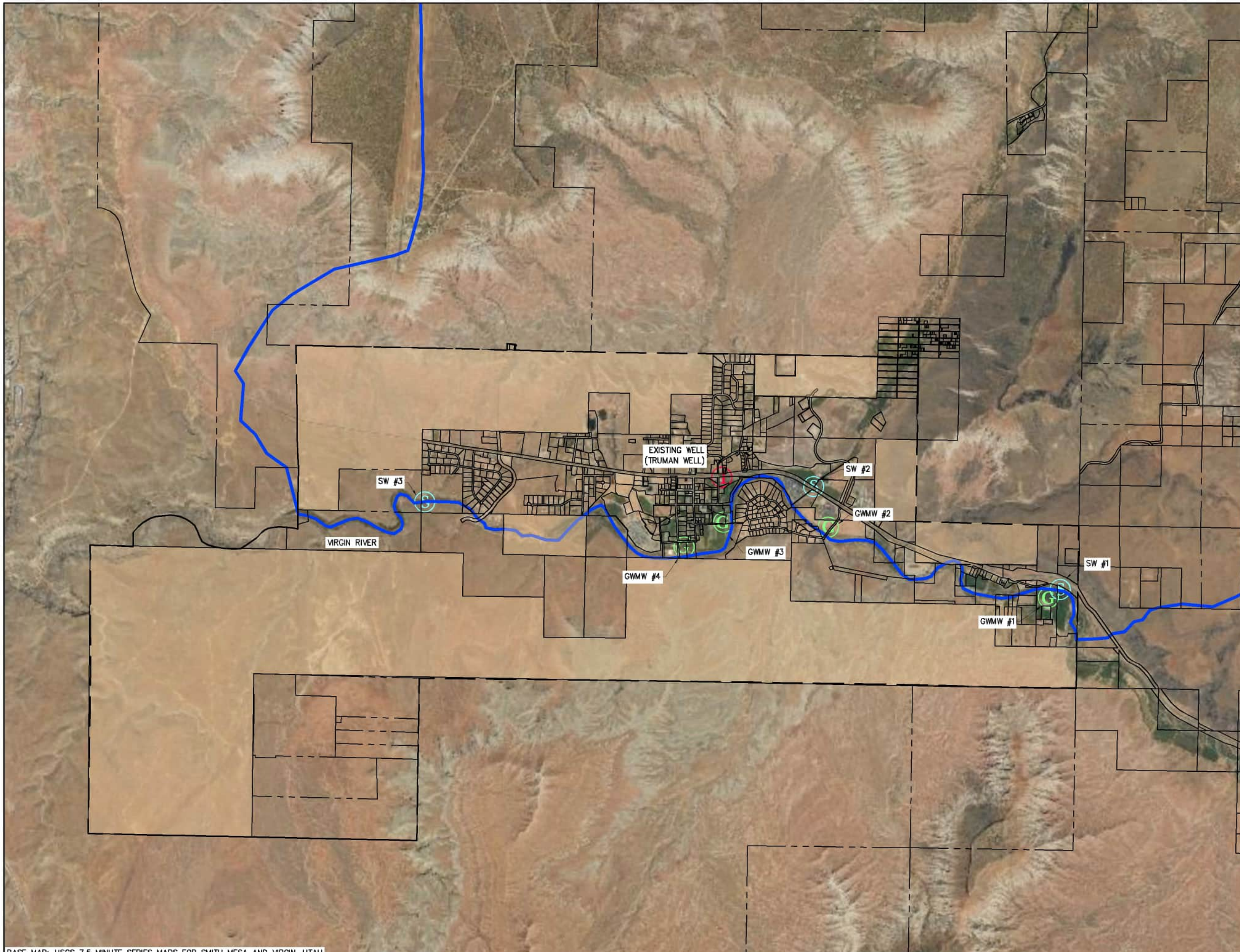

NORTH

SCALE
0 1000 2000

LEGEND

- EXISTING WATER WELL
- SURFACE WATER SAMPLING LOCATION
- GROUNDWATER SAMPLING LOCATION
- PARCEL BOUNDARY
- VIRGIN TOWN MUNICIPAL BOUNDARY
- BLM

AREA MAP

VIRGIN

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VIRGIN TOWN
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SAMPLE LOCATION MAP

SEI NO.	DESIGNED	DRAWN	CHECKED	SHEET NO.	
09817	DY	DY	DSA	01 of 06	FIG. 1a

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5. **Data Digitization and Analysis**: A drainage analysis was performed using GIS tools to more accurately define the study area boundaries. The topographic data was digitized using GIS tools so that data regression analysis could be performed on the precipitation data and recharge distribution. Bryan (2005) has noted that precipitation varies complexly in three dimensions (latitude, longitude and elevation). The precipitation data from relevant weather stations was analyzed using the numeric regression tool and the precipitation distribution in the study area was generated. Contour maps were generated for the estimated precipitation and recharge associated with precipitation.
6. **Study Report**: A groundwater protection study report was prepared to summarize the results and provide recommendations for development options.

1.4 Study Area

The study area shown in **Figure 1** was delineated through a drainage analysis. The total study area is approximately 88,600 acres with about 77,768 acres in the area north of the Virgin River and roughly 10,832 acres in the area south of the Virgin River.

2 GEOLOGIC SETTING

2.1 Geologic Background

The study area is located along the Virgin River in eastern Washington County in southwestern Utah. Southwest Utah straddles the transition zone between the colorful, flat-lying strata of the Colorado Plateau to the east and the highly faulted Basin and Range Province to the west. The transition zone melds parts of each so that southwest Utah contains a remarkable diversity of rocks, structures, and landforms – essentially doubling the geologic diversity in the region (Biek and others, 2010).

Erosion is the dominant geologic process in southwest Utah. Since the inception of modern basin-range extension beginning in late Tertiary time, erosion has stripped away a tremendous thickness of rock, in effect providing a geologic cross section across southwest Utah revealing the effects of more than 1.7 billion years of Earth history. The timing and history of erosional exhumation is recorded by fault relationships, the stratigraphy of associated basin-fill deposits, Pliocene and Quaternary basaltic lava flows and their spectacular examples of inverted topography. Erosion has also revealed a wide variety of compressional and extensional geologic structures (Biek and others, 2010).

Parts of four north-trending, regional-scale features dominate the geology of southwest Utah: (1) the leading edge of the Sevier orogenic belt, (2) the transition zone between the Colorado Plateau and Basin and Range physiographic provinces, (3) the southern part of the Intermountain seismic belt, and (4) the major controlling feature, the north-trending Utah hingeline, which has influenced Utah geology for more than 600 million years. The Utah hingeline originated as a long-lived boundary between a stable continental shelf to the east and a subsiding marine basin to the west and is manifest today as the boundary between the Basin and Range and Colorado Plateau–Rocky Mountains Provinces (Biek and others, 2010).

Collectively, these four regional-scale features overprint Paleoproterozoic metamorphic and igneous rocks exposed in the Grand Canyon—and the vast thickness of overlying sedimentary and volcanic rocks in the remainder of the map area—and help us to understand the distribution and structure of the rocks that make this part of the state so interesting. The Sevier orogeny (part of the larger Cordilleran orogeny, which produced a zone of deformation that stretched from Mexico to Alaska along the western margin of North America) was one of the most important events in Utah's geologic history. The orogeny, or mountain-building event, was a direct result of the subduction of the Farallon tectonic plate (the Farallon plate was part of an earlier Pacific Ocean basin) beneath the North American plate. In Utah, deformation associated with this collision is expressed as long folds and thrust faults that formed during the Cretaceous to Eocene, about 100 to 45 million years ago (Biek and others, 2010).

In southwest Utah, such deformation is dramatically displayed at Square Top Mountain, where a thrust fault by that name places Pennsylvanian and Permian rocks on top of Jurassic and Cretaceous rocks. Late Cretaceous sediments shed from the southern Utah part of the Sevier thrust belt are preserved on the southern edge of the Bull Valley Mountains, in Pine Valley Mountains, and in the Markagunt, but late Tertiary erosion stripped away much of the story in the greater St. George area. Still, two of the most prominent geologic features visible today in southwest Utah mark the leading edge of the Sevier compressional deformation – the Virgin and Kanarra anticlines (Biek and others, 2010).

The area of what are now the Colorado Plateau and Basin and Range physiographic provinces was uplifted several thousand feet during early Tertiary time. But by about 17 million years ago, western Utah began to "collapse" away from eastern Utah due to changing motions of the Earth's tectonic plates, thus dividing the Basin and Range from the Colorado Plateau. Today, the Earth's crust is pulling apart east-to-west across the Basin and Range. Compared to the Colorado Plateau – a wide area underlain by mostly gently warped sedimentary rocks and only locally disrupted by broad uplifts and igneous intrusions – the Basin and Range crust is thinner, is broken into north-trending fault blocks, and has experienced widespread igneous activity (Biek and others, 2010).

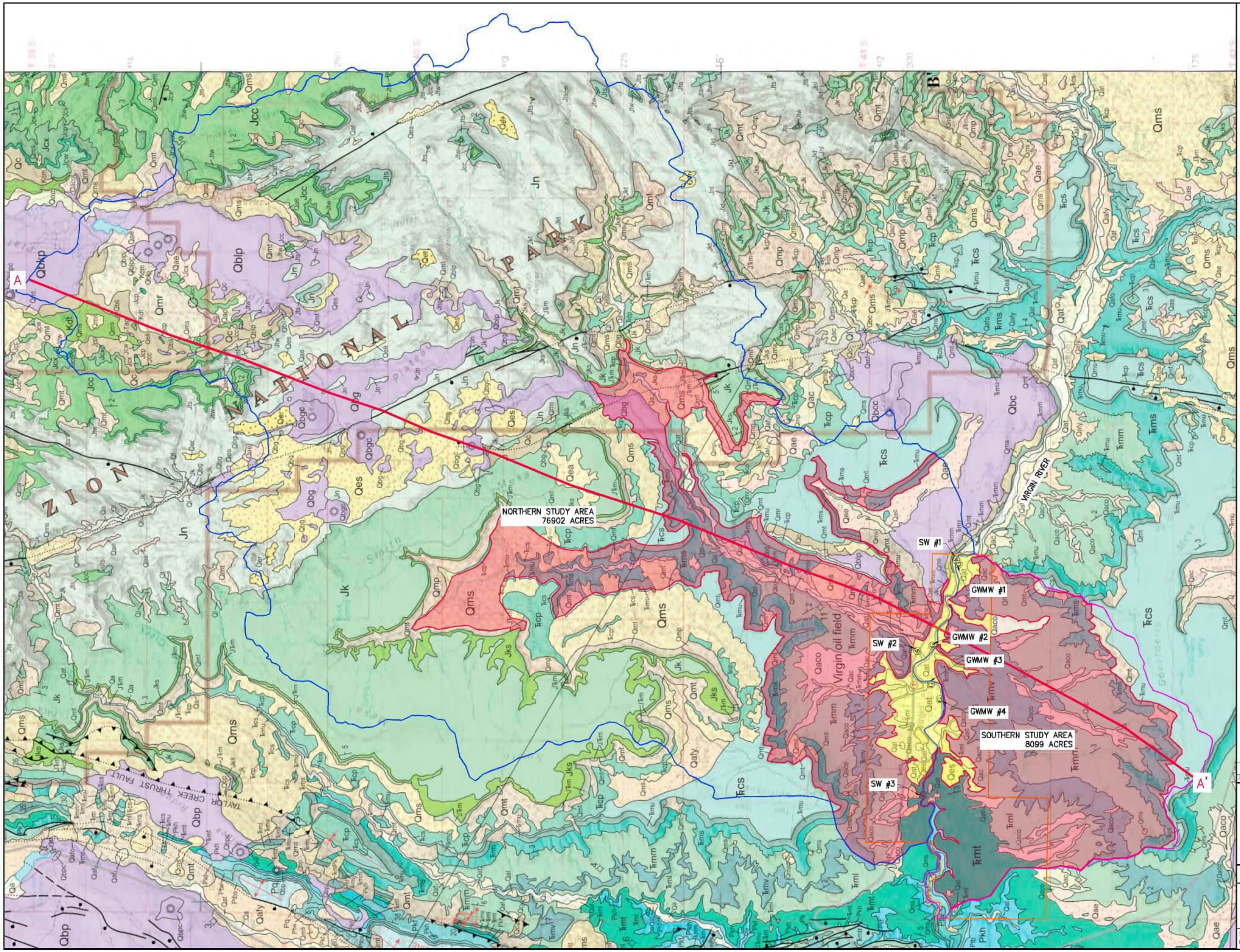
2.2 Stratigraphy

Exposed rock units present in the study area range from upper Permian to Cenozoic. **Figure 2** shows the local geology in the vicinity of the study area (Biek and others, 2010). **Figure 3** provides the general geologic stratigraphy of the region and geologic unit descriptions. **Figure 4** presents one geologic cross section of the study area. Below is a geologic overview of the rock units in the study area:

- Kaibab Formation (Upper Permian, around 270 million years old): This is the oldest exposed rock unit in this area, primarily consisting of marine limestone and some siltstone, often forming the lowest visible cliffs. It was deposited in a shallow, warm tropical sea and coastal flats, indicating a predominantly marine environment with abundant fossilized marine life.

- Moenkopi Formation (Lower Triassic, around 240-250 million years old): Characterized by thin, brick-red to reddish-brown, thinly bedded sandstones and siltstones, often displaying ripple marks, with interbedded mudstone and some gypsum. Limestone layers also occur within the Moenkopi Formation. These sediments were laid down on broad tidal flats, slow-moving rivers, and floodplains of a vast coastal plain, suggesting an arid to semi-arid climate with distinct wet-dry cycles. The Moenkopi Formation consists of the following members:
    1. Upper Red Member (200-280' thick)
    2. Shnabkaib Member (300-500' thick)
    3. Middle Red Member (450-550' thick)
    4. Virgin Limestone Member (0-250' thick)
    5. Lower Red Member (0-300' thick)
    6. Timpoweap Member (50-180' thick)
    7. Rock Canyon Conglomerate Member (0-200' thick)

- Chinle Formation (Upper Triassic, around 210-225 million years old): Known for its distinctive purplish, pink, blue, white, yellow, gray, and red variegated colors, forming slopes. This varied unit is composed of mudstone, siltstone, sandstone, and conglomerate, deposited in the channels and floodplains of a large ancient river system, similar to today's Amazon.



SCALE
0 4000' 8000'

LEGEND

- SOUTHERN STUDY AREA BOUNDARY
- NORTHERN STUDY AREA BOUNDARY
- VIRGIN TOWN BOUNDARY
- ALLUVIAL AQUIFER EXTENT IN TOWN
- SHALLOW BEDROCK AQUIFER RECHARGE AREA
- EXISTING WATER WELL
- SURFACE WATER SAMPLING LOCATION
- GROUNDWATER SAMPLING LOCATION

AREA MAP

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VIRGIN TOWN

GROUNDWATER PROTECTION STUDY

GEOLOGIC MAP

SEI NO.	DESIGNED	DRAWN	CHECKED	SHEET NO.	
09817	DY	DY	DSA	02 of 06	FIG. 2

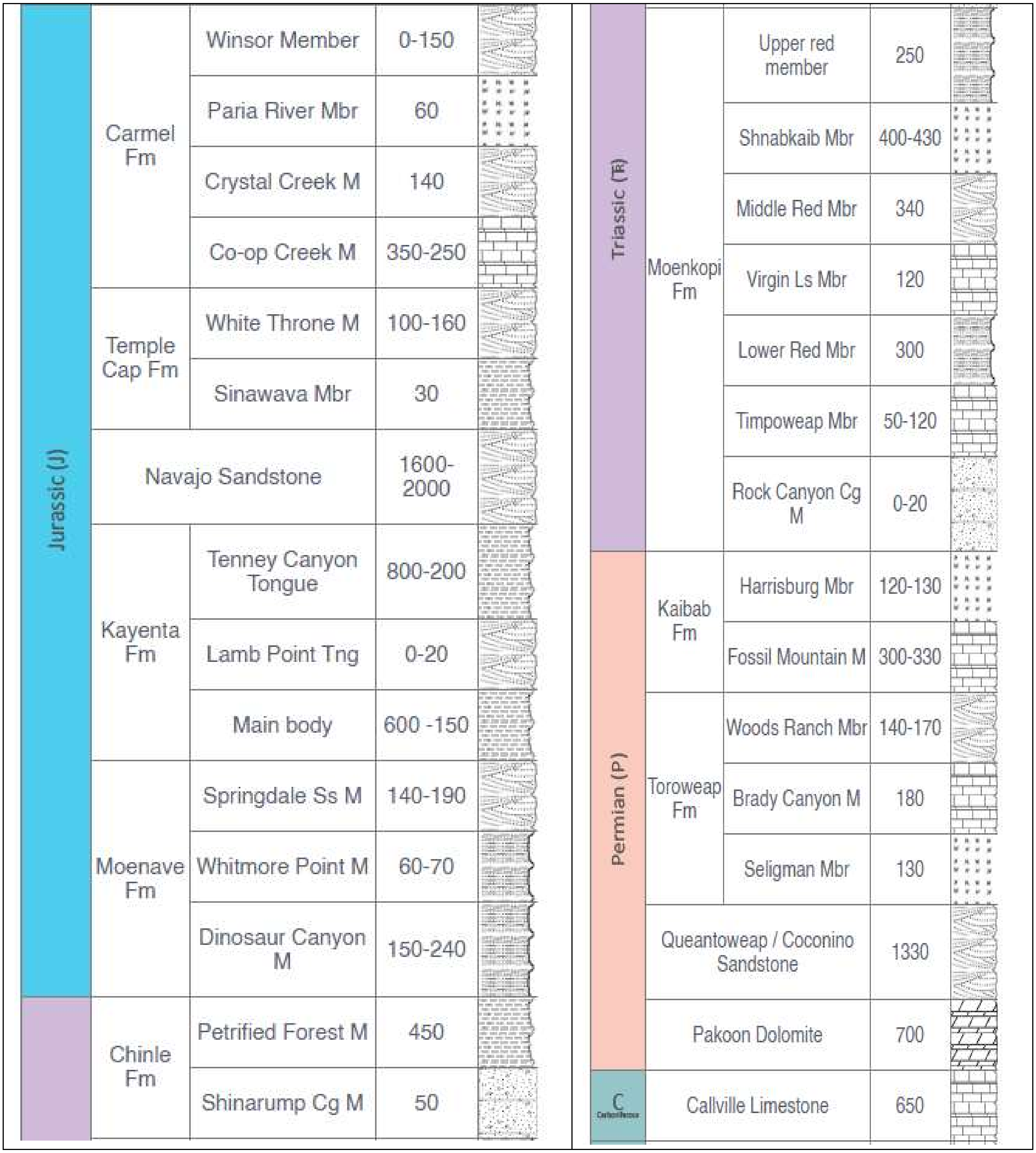
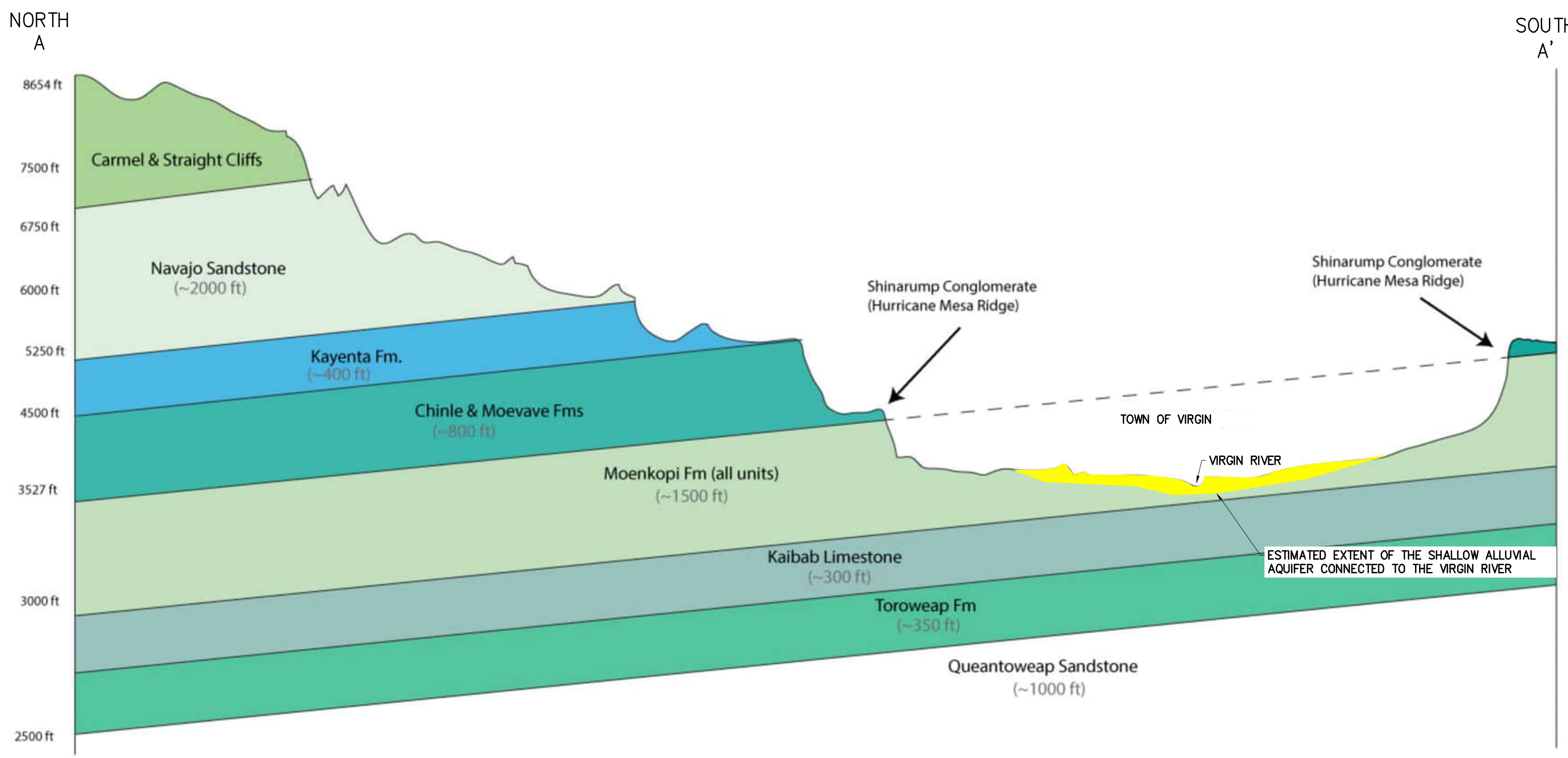


Figure 3. General Geologic Stratigraphy of the Study Area



VERTICAL SCALE

0 600' 1200'

VERTICAL ENLARGEMENT FACTOR = 8

AREA MAP

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GEOLOGIC MAP

SEI NO.	DESIGNED	DRAWN	CHECKED	SHEET NO.	
09817	DY	DY	DSA	04 of 06	FIG. 4

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- Moenave Formation (Lower Jurassic, around 195-210 million years old): Composed of reddish-brown sandstone, siltstone, and varicolored mudstone, forming crumbly rocks and steep slopes. These sediments represent a transition from the river systems of the Chinle to increasingly arid conditions, deposited in streams, floodplains, and lakes.

- Kayenta Formation (Lower Jurassic, around 185-195 million years old): This formation consists of reddish-brown and pink sandstone, along with varicolored mudstone and siltstone, which typically form steep, loose slopes and ledges. It was deposited by streams and rivers within an increasingly arid environment, indicating a vast fluvial plain preceding extensive desert condition.

- Navajo Sandstone (Lower to Middle Jurassic, around 180-190 million years old): The most prominent and iconic rock unit, forming towering white, cream, and reddish cliffs, domes, and monoliths. It is characterized by massive, sweeping crossbedding, representing the fossilized remnants of colossal wind-blown sand dunes from a vast ancient desert that stretched across much of western North America.

- Temple Cap Formation (Middle Jurassic, around 170-175 million years old): A relatively thin, reddish sandstone unit often forming the capstone of many spires and mesas. It consists of flat-bedded sandstones and siltstones, with some limestones and thin clay beds, representing a brief return to coastal and tidal flat environments with iron oxide-rich muds, indicating fluctuating arid and semi-arid conditions.

- Carmel Formation (Middle Jurassic, around 165-170 million years old): Overlying the Temple Cap Formation, this unit is composed of marine limestone, mudstone, sandstone, and gypsum. Its composition reflects deposition in a shallow interior seaway, marking another period of widespread marine transgression over the continent.

- Cedar Mountain Formation (Lower Cretaceous, around 120 million years old): This is the youngest major sedimentary rock layer seen in the region, primarily composed of conglomerate and sandstone. It was deposited by inland-flowing rivers, signifying a return to a more terrestrial environment dominated by significant river systems.

- Volcanic Rocks (Cenozoic, relatively young, various ages up to 1.1 million years old): Younger volcanic rocks, mainly basalt flows and cinder cones, occur in the higher plateaus and some valley areas, often capping the older sedimentary layers. These formed from magma rising through fractures in the Earth's crust during the extensive uplift of the Colorado Plateau, resulting in surface volcanic activity.

3 HYDROGEOLOGY

3.1 Aquifers

To evaluate the aquifers in the study area, well drillers' reports for wells installed in the study area were collected from the database administered by the Utah Division of Water Rights. However, only one water well is present in the study area, as plotted in **Figures 1** and **2**. The well log is presented in **Appendix A**. The well was drilled to a depth of 150 feet below grade and has a diameter of 6 inches. The static water level was 20 feet below grade when the well was completed on November 16, 1994. Steel casing was installed from 18 inches above grade to a depth of 41 feet below grade with an open hole from 41 feet to the bottom of the borehole. The steel casing was perforated between 30 and 35 feet below grade.

There are two shallow aquifers in the study area: unconsolidated alluvial aquifer and shallow bedrock aquifer. The unconsolidated alluvial aquifer is small in extent and is likely a narrow zone consisting of clay, silt, sand, gravel and boulders present in the area close to the Virgin River. At the water well location, alluvial deposits were encountered from the ground surface to a depth of 38 feet underlain by shale, as described by the driller. At this location, the thickness of the alluvial aquifer is only 18 feet (from 20 feet to 38 feet below grade). The aquifer is anticipated to thicken towards the river, and is assumed to be fully connected to the river.

This report hypothesizes that the shallow bedrock aquifer consists of the weathered shale or siltstone, mudstone and fine-grained sandstone of the Moenkopi Formation. It is estimated to be about 200-1,500 feet thick in the Virgin area (see **Figure 4**). The members of the Moenkopi Formation mostly act as confining units, however the Shinarump Conglomerate member of the Chinle, and the upper red and Virgin Limestone members of the Moenkopi are known aquifers (Inkenbrandt et al., 2013). However, the commonly known aquifers in the area such as the Navajo Sandstone, Kayenta and the Shinarump Conglomerate do not exist in Virgin since the formations are exposed on mountain slopes (see **Figure 4**).

Figure 4 also shows that the Moenkopi Formation is underlain by the Permian Kaibab Formation. According to Inkenbrandt et al. (2013) limestone of the Harrisburg and Fossil Mountain Members makes up the Kaibab Formation. These members are described as karstic and fractured rock, that *may* provide some water. In particular, it has been noted that a source of water from the Kaibab Formation may be possible near the fractured zones of the Hurricane Fault (Dutson, 2005). However, due to the presence of gypsiferous beds, the groundwater quality may be considered saline (Inkenbrandt et al., 2013).

The Hurricane Fault is located just west of the study area, and represents a significant groundwater divide in each of the aquifers described in this section. Exposure of the geologic units in the footwall of the Hurricane Fault indicates that the overlying Moenkopi and Navajo units are discontinuous across the fault, meaning that the aquifers are truncated at the fault in this area. Furthermore, the fine-grained nature and gypsum mineralization of the Moenkopi Formation are thought to seal the Hurricane Fault from groundwater flow where these units are present. Flow between the Moenkopi units of the footwall and hanging wall of the Hurricane Fault is likely negligible because they are separated by several thousands of feet of throw along the fault. Fractures in the Kaibab Formation caused by the Hurricane Fault may provide hydrologic connections between the upper and lower aquifers, however there is little groundwater data available to support this hypothesis (Inkenbrandt et al., 2013).

3.2 Aquifer Characteristics

Aquifer properties describe the ability of a groundwater system to transmit and store water. The distribution of the properties of the shallow aquifer within the study area vary by location. Aquifer properties can be estimated with aquifer tests by pumping groundwater from a well and monitoring the water-level changes in the pumped well or in nearby observation wells. Since this method results in localized values that are generally representative of conditions near the pumped well, it may not be representative of the variability and heterogeneity throughout the aquifer.

Aquifer test data is commonly used to estimate the values of transmissivity (T) and hydraulic conductivity (K). Both are measurements that describe the ease with which water can move through the pore spaces or conduits within an aquifer. More specifically, K is the volume of water flowing through a unit cross-sectional area of an aquifer under a unit hydraulic gradient in a given amount of time, and T is the volume of water flowing through a cross-sectional area that is one unit wide multiplied by the aquifer thickness in a given amount of time.

Only one single family well has been installed within the study area. The well penetrates the alluvial aquifer and partially penetrates the shallow bedrock aquifer. No pumping tests have been recorded for the well. In addition, the well production is about 3.5 gallons per minute (gpm). When water is withdrawn with the pump in the well (installed at a depth of 84 feet below grade), the well was pumped dry within a short period of time. Therefore, it is not likely to run a legitimate test at the well.

3.3 Groundwater Movement

Since there is only one well in the study area, there are not enough data points to generate any potentiometric surface data within the alluvial or shallow bedrock aquifers. Thus, the actual groundwater movement direction and gradient within the study area were unknown locally.

According to Inkenbrandt et al (2013), groundwater in the region generally follows the surface topography and flows towards the Virgin River.

3.4 Recharge from Precipitation

3.4.1 Methodology

In this study, an empirical recharge model developed by Maxey and Eakin (1949) was used to estimate the recharge rate to the watershed boundary from precipitation. The Maxey-Eakin method consists of an empirical relationship between precipitation and recharge to a groundwater basin. Specifically, the Maxey-Eakin recharge for a basin is calculated by (1) estimating the mean annual volumes of precipitation within several precipitation zones for the drainage basin, (2) scaling these volumes by a factor representing losses from evapotranspiration and surface-water runoff that does not become groundwater recharge, and (3) summing the resulting recharge to the groundwater basin. This method for estimating recharge to a groundwater basin has been applied to more than 200 basins in Nevada and in other western states since its development by Maxey and Eakin in 1949 (Avon and Durbin, 1994). Maxey and Eakin (1949) used discharge data for 13 basins in east-central Nevada to determine the recharge percentages by the trial-and-error balancing of recharge with estimated groundwater discharges. **Table 1** shows the precipitation zones and the corresponding recharge coefficients that were developed by Maxey and Eakin (1949) and Eakin and others (1951). Accordingly, calculation of the Maxey-Eakin recharge for a given basin can be expressed by:

$$R = \sum_{i=1}^{5} C_i P_i$$

Where R = recharge for a basin;

P_i = volume of precipitation within each of the five precipitation zones; and

C_i = recharge coefficient for each of the five precipitation zones.

Table 1: Precipitation Zones and Corresponding Coefficients for Maxey-Eakin Method

Precipitation Zone (inch)	Maxey-Eakin Coefficient (%)
>20	25
15-20	15
12-15	7
8-12	3
<8	0

3.4.2 Precipitation

Bryan (2005) has noted that precipitation varies complexly in three dimensions (latitude, longitude and elevation). To obtain representative precipitation data for the study area, mean annual precipitation data was collected from 6 weather stations within and surrounding the study area. Weather station information is listed in **Table 2**.

Table 2: Weather Station Locations, Precipitation and Data Availability

Station Name	Latitude (Degrees)	Longitude (Degrees)	Elevation (Feet)	Mean Annual Precipitation (Inches)	Data Availability
La Verkin, UT	37.20000	-113.26667	3220	10.97	4/19/1950-6/9/2016
Zion NP, UT	37.21667	-112.98333	4050	16.19	1/1/1904-6/9/2016
Gunlock PH, UT	37.28333	-113.71667	4110	12.31	1/14/1930-2/29/2016
Colorado City, AZ	37.00000	-112.98333	5010	14.00	1/1/1948-12/31/2005
New Harmony, UT	37.48333	-113.30000	5290	17.12	6/13/1911-6/10/2016
St. George, UT	37.11667	-113.58333	940	8.18	1/1/1993-6/10/2016

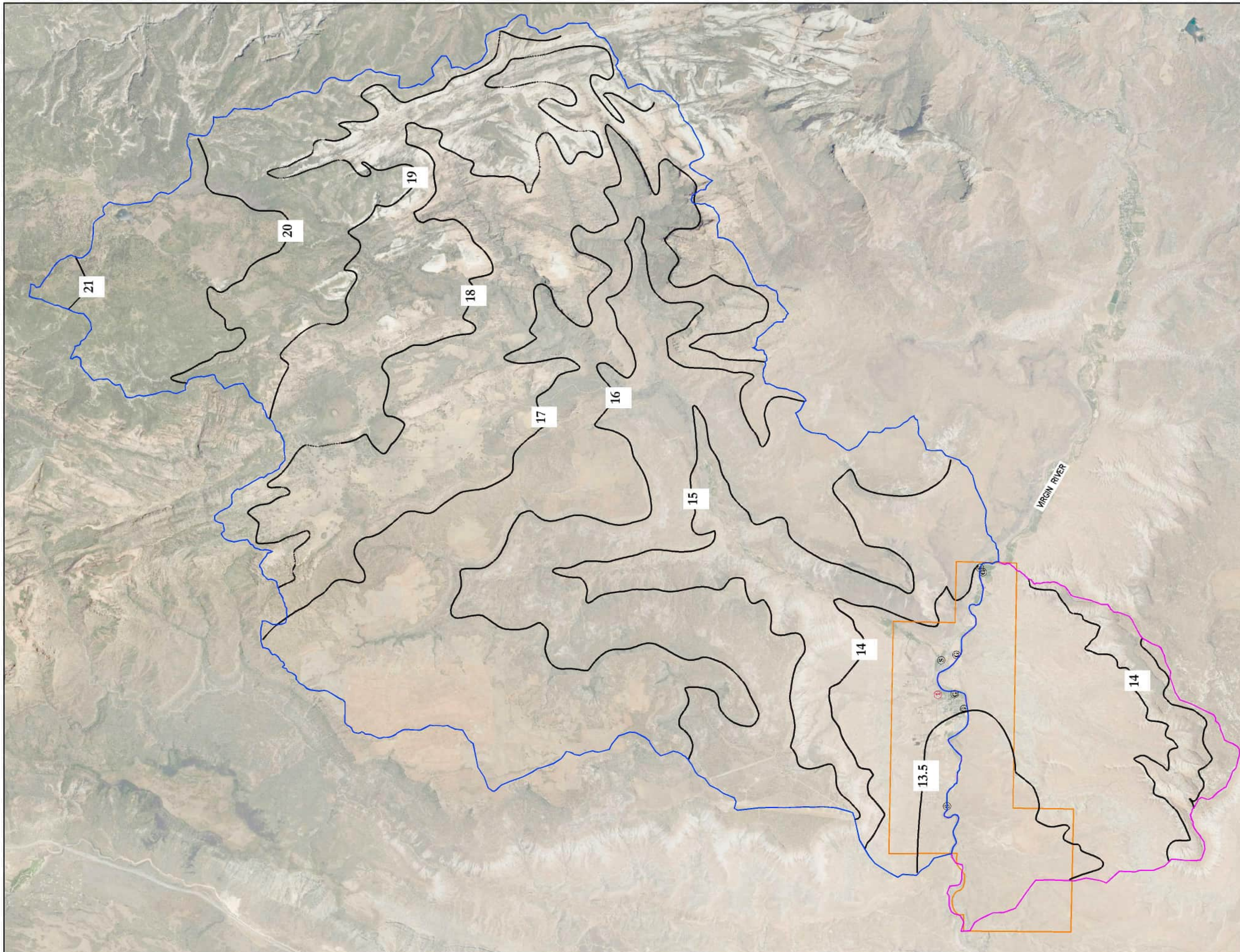
A linear relationship between the mean annual precipitation and the spatial variables (elevation, latitude and longitude) was assumed in this study. The regression equation is presented below:

$$P = 380.5478 + 5.37906 * Lat + 5.046785 * Long + 0.001163 * E \quad (R^2 = 0.906)$$

Where P = precipitation in inches;
E = elevation in feet;
Lat = latitude in degrees; and
Long = longitude in degrees.

The linear regression equation expressed above shows a good correlation, thus the equation was used to calculate the precipitation distribution within the study area.

To estimate the mean annual precipitation distribution, the topographic information within the study area was first digitized. With the digitized data (latitude, longitude and elevation), the mean annual precipitation distribution within the study area estimated using the linear regression equation was plotted in **Figure 5**. The highest estimated average annual precipitation of 21.5 inches occurs in the northern study boundary where the elevation is the highest, while the lowest estimated annual precipitation of 12.79 inches is on the Virgin River at the western study boundary. The average annual precipitation was estimated to be 16.89 and 13.88 inches within the northern and southern study areas, respectively. The resulting average annual precipitation volume was approximately 109,433 and 12,529 acre-feet/year (ac-ft/year) in the northern and southern study areas, respectively, with a total average annual precipitation of roughly 121,990 ac-ft/year within the study area.



NORTH

SCALE

0 4000' 8000'

LEGEND

- SOUTHERN STUDY AREA BOUNDARY
- NORTHERN STUDY AREA BOUNDARY
- VIRGIN TOWN BOUNDARY
- ESTIMATED PRECIPITATION CONTOUR (INCH)
- EXISTING WATER WELL
- SURFACE WATER SAMPLING LOCATION
- GROUNDWATER SAMPLING LOCATION

AREA MAP

REV. NO.	COMMENT	DATE

FOR REVIEW ONLY NOT FOR CONSTRUCTION DATE

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VIRGIN TOWN

GROUNDWATER PROTECTION STUDY

ESTIMATED PRECIPITATION CONTOUR MAP

SEI NO.	DESIGNED	DRAWN	CHECKED	SHEET NO.	
09817	DY	DY	DSA	05 of 06	FIG. 5

P:\Virgin Town\09817 GPS\Design 3D\Virgin GWPS 2025 Aug.dwg Aug 05, 2025 9:29am dyang

3.4.3 Recharge from Precipitation

Using the mean annual precipitation estimates shown in **Figure 5**, the mean annual recharge distribution within the study area was estimated using the Maxey-Eakin model.

The total mean annual recharge was estimated to be approximately 16,212 and 953 acre-feet/year within the northern and southern study areas, respectively. As a result, the estimated ratio between recharge and precipitation was estimated to be 14.8% and 7.6% for the northern and southern study areas, respectively. The total average annual precipitation-related recharge was estimated at approximately 17,165 ac-ft/year in the study area. The mean annual precipitation-related recharge estimated using the Maxey-Eakin model is plotted in **Figure 6** which indicates the average recharge rate within the Virgin Town limits is about 1.0 inch/year.

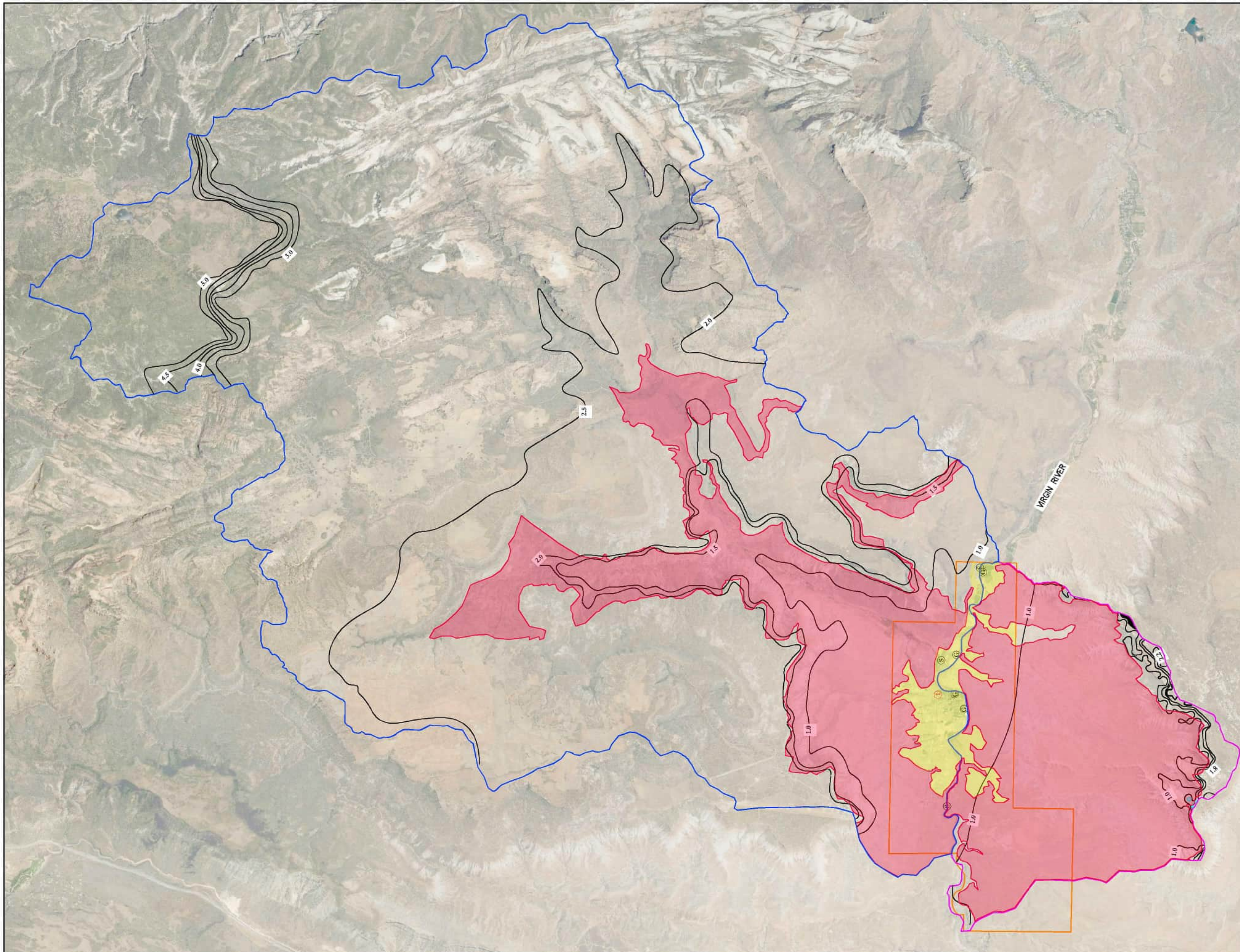
3.5 Surface Water and Groundwater Interaction

As part of this study, groundwater samples were collected and water levels were monitored monthly at four piezometers within the study area over a 12-month period, as described in Section 5. However, because the surface water elevation of the Virgin River was not surveyed, a definitive hydraulic gradient between the shallow alluvial aquifer and the river cannot be established from the available data.

Anecdotal evidence collected during this study, such as the measured static water levels in the piezometers, their proximity to the river and the relatively shallow alluvial aquifer described in Section 3.1, is consistent with groundwater levels that may be near or above the river's water surface elevation. This would match the characterizations of the Virgin River as a gaining stream by the US Geological Survey (Gardner, 2018; Herbert, 1995). These studies were conducted on selected reaches of the Virgin River between Pah Tempe Springs and Harrisburg Dome in Washington County, Utah, and each study concluded that the Virgin River is a gaining stream along most of the stretch examined, and not a losing stream along any of it.

It should be noted that the relationship between the river and the shallow aquifer can vary seasonally. Rivers can gain and lose water along their length, and heavy rainfall can temporarily cause a gaining section of river to transition to losing conditions if the river stage rises above the adjacent groundwater table. During high-flow events on the Virgin River the hydraulic gradient may be temporarily reversed, with river water recharging the alluvial aquifer. Under baseflow conditions, the gradient is expected to return to the gaining configuration described above.

While the evidence at these locations suggests gaining stream conditions, surveying of the ground and surface water elevations relative to established survey datum is recommended as part of any future investigation to confirm this relationship quantitatively.



SCALE

0 4000' 8000'

LEGEND

- SOUTHERN STUDY AREA BOUNDARY
- NORTHERN STUDY AREA BOUNDARY
- VIRGIN TOWN BOUNDARY
- ESTIMATED RECHARGE CONTOUR (INCH)
- ALLUVIAL AQUIFER EXTENT IN TOWN
- SHALLOW BEDROCK AQUIFER RECHARGE AREA
- Ⓘ EXISTING WATER WELL
- Ⓢ SURFACE WATER SAMPLING LOCATION
- Ⓖ GROUNDWATER SAMPLING LOCATION

AREA MAP

VIRGIN

REV NO.	COMMENT	DATE

FOR REVIEW ONLY
NOT
FOR CONSTRUCTION
DATE

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VIRGIN TOWN

GROUNDWATER PROTECTION STUDY

ESTIMATED PRECIPITATION-RELATED RECHARGE CONTOUR MAP

SEI NO.	DESIGNED	DRAWN	CHECKED	SHEET NO.	
09817	DY	DY	DSA	06 of 06	FIG. 6

4 THE VIRGIN RIVER WATER QUALITY ISSUES

As mentioned in the Introduction, the Virgin River is a critical resource as it supplies more than half of all drinking water in Washington County. Maintaining high water quality in the Virgin River is critical whereas so much of the county depends on it as a primary drinking water source. In the Virgin Town area, septic systems represent threat to water quality, and the potential impact of septic systems on the river is evaluated in this study.

According to the Utah Department of Environmental Quality (DEQ) (2025) and National Park Service (2025), the Virgin River watershed has been monitored for harmful algae mats, or algal bloom by the DEQ and Zion National Park. The algal blooms consist of benthic cyanobacteria capable of producing harmful toxins, including anatoxins, which pose risks to human and animal health, and negatively impact ecological health, recreational use, and downstream water supplies.

These toxic algal blooms persist in the Virgin River. For nearly four years, from La Verkin Creek to the North Fork in Zion National Park and south into St. George and Arizona, the lingering presence of harmful algal blooms in the Virgin River that produce toxic cyanobacteria has been the subject of recurring health advisories and warnings from state and federal agencies. The bacteria produced by blooms can be harmful to humans and pets, especially dogs (Utah Public Radio, 2025).

Algal blooms are primarily caused by an overabundance of nutrients, especially nitrogen and phosphorus, in the water, often from nutrient pollution. These excess nutrients, just like fertilizers, promote rapid algae growth, especially when combined with warm water temperatures and still or slow-moving water. Other favorable conditions promote algal blooms. Algae need sunlight to photosynthesize and grow, so areas with ample sunlight are more susceptible to algal blooms. Warmer temperatures favor certain types of algae, particularly cyanobacteria, giving them a competitive advantage over other algae and leading to blooms. Stagnant water allows for thermal stratification, where a layer of warm water sits on top of cooler water, creating ideal conditions for algae growth. In essence, with excess nutrients, warm water, sunlight and still conditions, the algae can proliferate rapidly, forming a visible bloom.

Sources such as agricultural runoff (fertilizers), sewage and urban runoff introduce excess nutrients into waterways. These nutrients stimulate the rapid growth of algae. Activities like agriculture, wastewater treatment, and urban development can all contribute to nutrient pollution and increase the likelihood of algae blooms.

This study does not attempt to analyze algal growth in the Virgin River. Instead, water quality concerns are discussed to provide context for the investigation. The field study will attempt to measure the nitrogen mass migrating to the Virgin River and compare that against the estimated nitrogen mass flux from septic loading from ERUs. If nitrate measurements are observably high, it could create conditions that support algal blooms.

Nitrate was selected as the primary analyte for both groundwater and surface water because it is mobile, commonly associated with septic effluent, and relatively easy to measure. The intent was that, if measurable nitrate loading from groundwater to the river could be identified, the study could evaluate whether septic systems may be contributing to observed algal blooms.

However, as discussed in Sections 5, 6, and 7, elevated nitrate concentrations were not observed in the Virgin River along the study reach. As a result, an excess of nitrate attributable to septic systems could not be demonstrated, and a direct link between septic loading and algal blooms could not be established based on the data collected. It is also possible that biological processes within the river—such as uptake by algae or microbial activity—are reducing nitrate concentrations before they can be measured. These processes were not evaluated as part of this study but may help explain the observed conditions. For this reason, discussion of algal blooms in this report is intended to provide general context only. Additional study focused on nutrient uptake and biological activity would be needed to better understand the causes of algal growth in this reach of the Virgin River.

5 GROUNDWATER AND SURFACE WATER SAMPLING

5.1 Piezometer Installation

In cooperation with Virgin Town, Sunrise installed four piezometers for groundwater sampling (GWMW #1 through GWMW #4) within the Town of Virgin, Utah on June 24, 2024. The locations of the piezometers are shown in **Figure 1**. Each piezometer was constructed using 2-inch-diameter PVC casing with the lower 5 feet of each pipe manually slotted to facilitate groundwater inflow. The slots were cut approximately one-half of the way through the pipe with a hacksaw blade approximately 0.065 in. thick. Slot spacing was approximately 3-inches. The bottom of each pipe was sealed with a cap prior to installation.

Test pits were excavated using a Case 590 backhoe until groundwater was encountered, as shown in the following photographs. The slotted pipes were then inserted and held in place during backfilling. Backfill material was loosely compacted to avoid damaging the PVC casings. Due to field conditions and the nature of backhoe installation, some casings were installed with deviations from vertical alignment.

Figure 7: Field installation of piezometer casings on June 24, 2024.

The subsurface materials observed during excavation generally consisted of silty sand interbedded with thin lenses of silt and clay to the maximum depth of each excavation. However, at the location of piezometer GWMW #3, which was the deepest installation, numerous boulders and cobbles were encountered, resulting in more challenging excavation conditions.

A summary of the piezometer locations, the length of pipe and installation angle, along with a description of the subsurface conditions encountered is given in **Table 3**.

Table 3: Piezometer Data Summary

Well Name	Well Location	Angle From Horizontal (°)	Length of Pipe (ft)	Stickup (in)	Subsurface Conditions
GWMW #1	V-2144-A-3-B	52.8	13.8	35	Silty sand
GWMW #2	V-2136-C	63.3	13.5	30	Silty sand
GWMW #3	Town Property near V-37-B-1	55	20.4	28	Silty sand overlying cobble to boulder sized gravels.
GWMW #4	Town Property near V-9-A	90	10.1	34	Silty sand

Note: GWMW = groundwater monitoring well

5.2 Sampling Methodology

Groundwater samples were collected on a monthly basis from each piezometer over a 12-month monitoring period, beginning in June 2024. Sampling was typically conducted toward the end of each month. Prior to sample collection, the static groundwater elevation was measured at each piezometer using an electronic water level indicator. A disposable bailer was used to purge the piezometers. The volume of standing water in each piezometer casing was estimated, and a volume of water equal to approximately three times the standing water volume was purged from the piezometer prior to obtaining a sample. This procedure is consistent with standard groundwater sampling protocols (e.g., ASTM D4448).

The record of sample dates, the measured depth to groundwater, the estimated stagnant water volume and the volume of water purged from the piezometer are presented in **Table 4** through **7**.

Table 4: Sampling Record from Piezometer GWMW #1 between June 24, 2024, and May 28, 2025

GWMW#1							
Date	Sample No.	Sampled By	Sample Time	Measured Depth to Water (ft)	Measured Total Well Depth (ft)	Stagnant Water Volume (gal)	Volume of Purged Water (gal)
6/24/2024	1	PA/DY	18:25:00	Not Measured	13.8	Not Measured	Not Measured
7/25/2024	2	PA	8:40:00	7.1	13.8	0.28	1.25
8/30/2024	3	PA	10:28:00	6.3	13.8	0.41	1.25
9/27/2024	4	PA	13:35:00	4.8	13.8	0.65	2
10/31/2024	5	PA	10:45:00	6.4	13.8	0.39	1.25
11/27/2024	6	PA	9:50:00	6.85	13.8	0.32	1
12/30/2024	7	PA	11:12:00	6.9	13.8	0.31	0.75
1/27/2025	8	PA/DY	15:00:00	7.1	13.8	0.28	1.5
2/27/2025	9	PA	15:04:00	7.1	13.8	0.28	1.8
3/19/2025	10	PA	16:34:00	6.9	13.8	0.30	1.75
4/30/2025	11	PA	10:26:00	6.0	13.8	0.45	2
5/28/2025	12	PA	12:23:00	3.5	13.8	0.87	2.5

Table 5: Sampling Record from Piezometer GWMW #2 between June 24, 2024, and May 28, 2025

GWMW#2							
Date	Sample No.	Sampled By	Sample Time	Measured Depth to Water (ft)	Measured Total Well Depth (ft)	Stagnant Water Volume (gal)	Volume of Purged Water (gal)
6/24/2024	1	PA/DY	17:55:00	Not Measured	13.8	Not Measured	Not Measured
7/25/2024	2	PA	10:05:00	4.9	13.8	0.64	1.25
8/30/2024	3	PA	10:55:00	4.7	13.8	0.67	1.25
9/27/2024	4	PA	13:05:00	4.7	13.9	0.69	0.75
10/31/2024	5	PA	11:25:00	4.8	13.8	0.65	1.5
11/27/2024	6	PA	10:25:00	4.3	13.8	0.73	1
12/30/2024	7	PA	10:43:00	4.6	13.8	0.69	0.75
1/27/2025	8	PA/DY	15:00:00	4.6	13.5	0.64	1.5
2/27/2025	9	PA	14:15:00	4.5	13.85	0.71	3.2
3/19/2025	10	PA	15:41:00	4.4	13.8	0.72	3
4/30/2025	11	PA	11:03:00	4.6	13.9	0.70	3
5/28/2025	12	PA	13:05:00	4.7	13.85	0.68	3

Table 6: Sampling Record from Piezometer GWMW #3 between June 24, 2024, and May 28, 2025

GWMW#3							
Date	Sample No.	Sampled By	Sample Time	Measured Depth to Water (ft)	Measured Total Well Depth (ft)	Stagnant Water Volume (gal)	Volume of Purged Water (gal)
6/24/2024	1	PA/DY	17:25:00	Not Measured	20.4	Not Measured	Not Measured
7/25/2024	2	PA	11:10:00	9.7	20.4	0.93	2
8/30/2024	3	PA	11:50:00	9.65	20.2	0.91	1
9/27/2024	4	PA	13:05:00	9.8	20.4	0.91	1
10/31/2024	5	PA	12:15:00	9.2	20.4	1.01	1
11/27/2024	6	PA	11:10:00	11.6	20.4	0.62	1
12/30/2024	7	PA	10:00:00	9.6	20.4	0.95	1
1/27/2025	8	PA/DY	7:45:00	9.8	20.4	0.92	3
2/27/2025	9	PA	13:26:00	9.4	20.4	0.98	2.7
3/19/2025	10	PA	15:05:00	8.8	20.4	1.07	3
4/30/2025	11	PA	12:10:00	9.5	20.4	0.97	3
5/28/2025	12	PA	14:30:00	9.4	20.4	0.98	3

Table 7: Sampling Record from Piezometer GWMW #4 between June 24, 2024, and May 28, 2025

GWMW#4							
Date	Sample No.	Sampled By	Sample Time	Measured Depth to Water (ft)	Measured Total Well Depth (ft)	Stagnant Water Volume (gal)	Volume of Purged Water (gal)
6/24/2024	1	PA/DY	16:55:00	Not Measured	10.2	Not Measured	Not Measured
7/25/2024	2	PA	11:35:00	6.5	10.1	0.00	1
8/30/2024	3	PA	12:17:00	5.9	10.2	0.00	3
9/27/2024	4	PA	11:57:00	6.1	10.25	0.00	3
10/31/2024	5	PA	12:35:00	5.8	10.1	0.00	1.5
11/27/2024	6	PA	11:30:00	6.1	10.2	0.00	1.5
12/30/2024	7	PA	9:38:00	6.4	10.2	0.00	1
1/27/2025	8	PA/DY	16:34:00	6.5	10.2	0.00	3
2/27/2025	9	PA	12:29:00	5.8	10.1	0.00	3
3/19/2025	10	PA	14:13:00	6.1	10.1	0.00	2
4/30/2025	11	PA	12:25:00	5.0	10.1	0.01	2.5
5/28/2025	12	PA	14:45:00	5.6	10.1	0.00	3

During the first seven months, between June and December 2024, groundwater samples were analyzed by the Southern Utah University Water Testing Laboratory, while the samples from the remaining five events, January to May, were analyzed by Chemtech-Ford Laboratories in Sandy, Utah. Samples were stored in coolers and transported on ice to preserve sample integrity in accordance with standard chain-of-custody procedures.

5.3 Surface Water Sampling

In parallel with groundwater monitoring, surface water samples were collected monthly from three locations:

- SW#1 - From the Virgin River, upstream of the Town of Virgin (to establish baseline water quality),
- SW#2 - from North Creek, upstream of its confluence with the Virgin River,
- and SW#3 - from the Virgin River, downstream of the Town, near the Sheep's Bridge recreation area.

The distance between the upstream SW#1 location, and the downstream SW#3 location represent a reach of the river of approximately 8 kilometers (km) (4.9 mi.). SW#2 is situated approximately 3.2 km (1.98 mi.) downstream from SW#1.

Surface water samples were collected by directly submerging laboratory-supplied bottles beneath the surface to avoid surface film contamination. All surface water samples were subject to the same handling, preservation, and laboratory testing protocols as the groundwater samples. The surface water sampling locations are also shown in **Figure 1**.

5.4 Analytical Parameters

All samples were analyzed for the following parameters:

- Nitrate (NO_3^-) as nitrogen, reported in mg/L
- Total Dissolved Solids (TDS), reported in mg/L

During the course of the project, it became beneficial to ACSSD, a stakeholder in this study, to evaluate ground and surface water for additional analytes. Sunrise obtained additional samples at the same sampling locations for following additional analytes:

- Microcystins and nodularins for surface water samples (only for April 2025 sampling event)
- PPCP (pharmaceuticals, personal care products) & EDC (endocrine disrupting compounds and their metabolites) for groundwater samples (only for May 2025 sampling event)

Nitrate is the only constituent considered in the mass balance approach performed in this study. Other constituents were selected based on their relevance to groundwater quality in the region and their use as indicators of anthropogenic influence and overall water quality status.

5.5 Laboratory Data Summary and Analysis

5.5.1 Nitrate

The laboratory reports are provided in **Appendix B** and the results for nitrate are summarized in **Table 8**.

The data presented in Table 8 indicate that nitrate concentrations measured in all groundwater samples were below the maximum allowable concentration of 10 mg/L as nitrogen (N) established under the Utah Ground Water Quality Standards (Utah Administrative Code R317-6-2). In addition, all measured groundwater nitrate concentrations were below the antidegradation threshold of 4 mg/L, indicating that groundwater quality remained within background protection limits throughout the sampling period.

Measured nitrate concentrations in the surface-water samples ranged from non-detect (<0.1 mg/L) to a maximum of 1.22 mg/L. Nitrate concentrations measured at SW#2 (North Creek) in June 2024 and December 2024, as well as at SW#3 in July 2024, may exceed the applicable surface-water numeric criterion of 0.40 mg/L as N established under Utah Administrative Code R317-2, depending on stream classification and the applicable assessment methodology. A determination of exceedance would require further evaluation in accordance with Table 2.14.8 of R317-2, including consideration of averaging periods and assessment thresholds. The nitrate concentration measured at SW#2 in July 2024, however, exceeded the 0.40 mg/L criterion under any applicable evaluation method. It should be noted that the samples taken and delivered to the lab on August 30, 2024 were not analyzed until October 1, 2024 and exceeded the maximum 28-day holding period recommended by US EPA 353.3.

Table 8 indicates that the laboratory results of the water samples collected from Truman Well in April and May are relatively high (about 6 and 7 mg/L) and higher than the laboratory results (1.7 and 2.2 mg/L, respectively) of the two water samples collected by Ensign (2015) on July 21 and 22, 2015 from the same well. July is the month that the highest amount of irrigation water is applied. During April and May, not much irrigation water is used, which is likely one of the reasons that the concentrations in the water samples collected from Truman Well in April and May of 2025 are higher than those of the samples collected in July 2015. Another possible contributing factor is that there is a 10-year difference in the sampling events.

Another reason for the high nitrate concentrations in the water samples collected from Truman Well may be due to the fact that the family well is located close to the family septic system (approximately 100 feet apart). The nitrate concentration distribution is an exponential function with a negative exponent or a type of $C = C_0e^{(-d)}$ (or an exponential decay) equation which means the nitrate concentration peaks at the point source and decreases rapidly away from the point source, which is the theoretical explanation as to why the nitrate concentration is higher at the well. The following chart illustrates the behavior of a simplified exponential decay function.

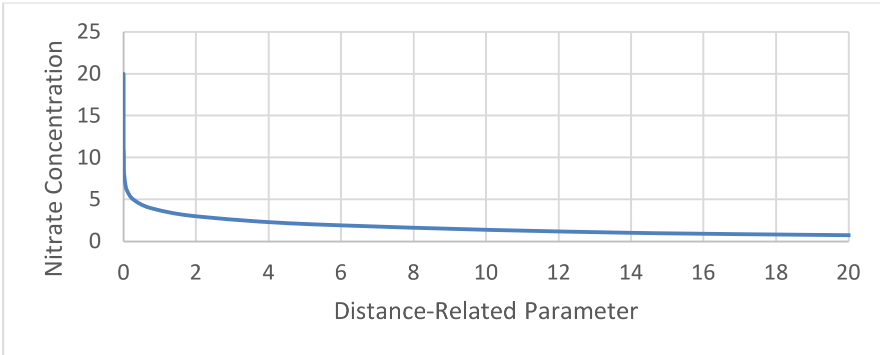

Figure 8: Simplified Attenuation Function Representing Decreased Nitrate Concentration with Increased Distance from Point Contamination Source

Table 8: Summary of Laboratory Results and Statistical Analysis for Nitrate

Sampling Month	GWMW #1	GWMW #2	GWMW #3	GWMW #4	SW #1	SW #2	SW #3	Truman Well	North Creek Flow (cfs)	Virgin River Flow (cfs)
	(mg/L)									
Jun-24	0.144	0.412	0.634	1.87	< 0.100	0.485	0.185		0.8	83.5
Jul-24	0.115	< 0.1	< 0.1	0.187	0.247	1.220	0.422		0.58	63.27
Aug-24	0.133	< 0.1	0.257	0.781	0.397	0.179	0.314		0.58	70.02
Sep-24	< 0.1	< 0.1	< 0.1	0.613	0.283	0.185	0.318		0.65	66.14
Oct-24	1.73	0.3	0.169	0.475	< 0.1	< 0.1	< 0.1		NA	94.91
Nov-24	< 0.1	< 0.1	< 0.1	0.334	0.43	0.267	0.398		NA	238.85
Dec-24	< 0.1	< 0.1	0.284	0.37	0.204	0.767	0.395		NA	105.33
Jan-25	< 0.1	< 0.1	< 0.1	0.41	0.22	0.24	0.23		NA	97.76
Feb-25	< 0.1	< 0.1	< 0.1	1.15	0.16	0.14	0.11		NA	120.45
Mar-25	< 0.1	< 0.1	< 0.1	0.74	0.16	< 0.1	0.14		NA	165.46
Apr-25	< 0.1	< 0.1	< 0.1	^ 3.53	0.28	< 0.1	0.25	6.08	NA	85.25
May-25	< 0.1	< 0.1	< 0.1	0.13	0.19	< 0.1	0.19	7.06	NA	72.6
Statistical Analysis										
Mean	0.244	0.143	0.179	0.883	0.231	0.32	0.25			105.30
Max	1.73	0.412	0.634	3.53	0.43	1.22	0.42			238.85
Min	0.1	0.1	0.1	0.13	0.1	0.1	0.1			63.27
Std. Deviation	0.468	0.102	0.158	0.961	0.104	0.35	0.11			50.76
95% Upper Limit	1.265	0.366	0.523	2.978	0.458	1.08	0.5			215.95
95% Upper Limit Mean	1.283									

Note: < means below the indicated laboratory detection limit but the detection limit was used in the statistical analysis; and ^ means this data point appears to be an outlier in the data set.

5.5.2 *Microcystins and Nodularins*

Microcystins and nodularins are toxins produced by cyanobacteria (also known as blue-green algae) that can contaminate drinking water sources. These toxins, particularly microcystin-LR, can cause liver damage (hepatoxicity) in humans and animals. The U.S. Environmental Protection Agency (EPA) has established health advisories for microcystins in drinking water, recommending levels below 0.3 µg/L for young children and 1.6 µg/L for older children and adults (Shimadzu, 2025).

Near the end of the sampling phase of the project, and at the request of ACSSD, surface water samples collected on April 30, 2025, were delivered to Chemtech-Ford Laboratories for analysis. None of the six analytes of microcystins and nodularins were detected above the instrument detection limit of 0.5 µg/L. This study does not investigate the relationship between harmful algal blooms and the quality of groundwater in Virgin Town. The results of these laboratory analyses are presented in this report only for reference (see Appendix B).

5.5.3 *PPCP & EDC*

The presence of PPCP & EDC in water supplies has been known back to 1980s and before. Much of the original concerns were associated with reports of physiological abnormalities associated with fish and other aquatic organisms in areas near or surrounding discharge sites of wastewater treatment facilities. The occurrence of PPCP and EDCs in both surface water and groundwater sources is global in nature (Water Quality Association, 2014). EPA has established the Maximum Contaminant Level (MCL) for some of the analytes but not for all.

Groundwater samples collected on May 29, 2025, were delivered to Chemtech-Ford Laboratories for the analysis and seven of 37 PPCP & EDC analytes were detected above the instrument detection limits (see **Appendix B**). The detected analytes and their concentrations are summarized in **Table 9**.

Table 9: Summary of PPCP & EDC Detected Analytes and Concentrations (ng/L)

Analyte	GWMW #1	GWMW #2	GWMW #3	GWMW #4	Truman Well	EPA MCL
TDCPP	290	27	ND	31	ND	None
Acetaminophen	10	6	13	ND	ND	None
Bisphenol A	14	13	17	30	ND	None
Caffeine	ND	31	53	21	ND	None
Carbamazepine	ND	ND	ND	43	ND	None
Declofenac	ND	ND	12	ND	ND	None
Erythromycin	ND	ND	ND	17	ND	None

Note: ND = Not detected above laboratory instrument detection limit; red number means the detected level is above the EPA MCL established for drinking water; ng/L = nanogram per liter.

5.6 Slug Tests at Piezometers

Additionally, slug tests were performed at the four piezometers on January 27, 2025.

5.6.1 Test Procedures

An approximately 3'-5" long 1.5-inch diameter bailer was used as a slug for tests at each piezometer. Before starting a slug test, the static water level in the well was measured using an electronic water level indicator. A pressure transducer with a datalogger was tied to a string, pre-programmed to set start time and water level reading intervals, and then lowered to the bottom of the well. A string was tied to the bailer (slug), then the slug was placed just below the static water level. When the water level in the well recovered to the static level, the slug was pulled out (theoretically) instantaneously to start the test. Each test continued until a 95 to 100% water level recovery (one complete test). After each test was complete, the pressure transducer with datalogger was pulled out of the well and recorded data was downloaded to a laptop computer. The pressure transducer/datalogger was then re-set for the next test. The test procedure described is called a slug-out test. Slug-out tests are generally considered more representative of the actual aquifer conditions. At each piezometer, three slug-out tests were performed.

However, since the casings for GWMW #1 through #3 had angles outside of 90°, (ranging from 52.8° to 63.3°), the slug out cannot be described as "(theoretically) instantaneous", which may have impacted the analytical results. Moreover, each of the piezometers did not have factory-manufactured screens, which likely lowered the groundwater recovery or the hydraulic conductivity of the tested strata.

5.6.2 Slug Test Results

The slug test data were analyzed using the Bouwer and Rice (1976) method which is used widely for unconfined and confined conditions, partially penetrating to fully penetrating, screened, perforated or otherwise open wells. The method is based on a modification of the Thiem equation for steady-state flow (Thiem, 1906). The update by Bouwer (1989) indicates that the method is applicable to confined or stratified aquifers if the top of the screen or perforated section is some distance below the upper confining layer. The analytical results of the slug tests are provided in **Appendix C** and summarized in **Table 10**. It should be noted that the piezometers consisted of 2" diameter PVC with slotted openings cut by a hacksaw as the screen at the bottom 5-foot section. The opening ratio of the piezometer is a function of the aggregate area of the openings (slots) divided by the total surface area of the slotted pipe section. The main factors affecting this ratio are the width of the slot (assumed equal to the width of the tines of the hacksaw blade used, or 0.065 in.), the length of the opening (estimated to be 1/2 the pipe circumference per slot), and the spacing between slots (approximately 3-inch spacing, on average). Given these measurements and assumptions, the opening area is calculated to be 0.817 square inches per foot, or an opening ratio of 1.08%. For a factory-made 2-inch PVC screen, the opening area is 6.6 square inches per foot (https://www.shop-esp.com/2-x-5-PVC-Well-Screen-020-Sch40-brMale-x-Female-Threads-2TPI-P262.aspx), resulting in an opening ratio of 8.75%. The ratio between opening ratios of the factory-made screen and the handsaw cut slotted casing is about 8. In other words, the recovery efficiency of the factory-made screen could be 8 times the handsaw cut slotted casing used in the piezometers. Moreover, standard monitoring wells are generally installed with sand around the screen that can further improve the recovery efficiency of standard monitoring wells. The hydraulic conductivity at the piezometer locations may range from the test data to 8 times the test data, as shown in **Table 10**.

Table 10: Summary of Analysis of Slug Tests (in feet/day)

Piezometer Name	Test 1	Test 2	Test 3	Mean	Standard Deviation	High*
GWMW #1	2.9	2.1	1.7	2.23	0.61	17.87
GWMW #2	4.9	4.8	7.6	5.77	1.59	46.13
GWMW #3	5	11	3.7	6.57	3.89	52.53
GWMW #4	12	13	13	12.67	0.58	101.33
Average Hydraulic Conductivity				6.81	1.67	54.47

Note: *The high value is 8 times the average hydraulic conductivity obtained from slug tests at each piezometer.

Table 10 indicates that the test results at piezometers GWMW #1 through #3 vary much more than the results from piezometer GWMW #4. Variations in results may be due to the fact that the casings of the three piezometers were not straight. Furthermore, if factory-manufactured screens were used in the piezometers, the resulting hydraulic conductivities may be much higher (last column of **Table 10**). Based on the observations during test pit excavation, the aquifer material was predominantly silty sand or fine sand. The hydraulic conductivity for fine sand generally ranges from 3 to 20 feet/day. The aquifer can be characterized by silty sand, cobble- and boulder-sized gravels and a hydraulic conductivity of 100 feet/day is reasonable for coarse sand and up to 1,000 feet/day for gravel is not unreasonable. Using a hydraulic conductivity of 30 feet/day (2.5 times the value obtained from GWMS #4) for the alluvial aquifer may be still conservative and acceptable.

6 INVERSE MODELING FOR AMBIENT GROUNDWATER FLOW

Prior studies relied on parametric assumptions to develop the mass balance approach. The aim of this section is to use the additional collected data and analyses from this study to refine those parametric assumptions and then compare the accuracy of the background nitrate concentration predicted by the prior groundwater and wastewater studies mentioned in Section 1.2.

The inverse modeling for ambient groundwater flow was based on the water use data between January 1 and December 31, 2024, provided by Virgin Town and the laboratory testing results of water samples collected by Sunrise. With the water use data and average water use per equivalent residential unit (ERU) of 237 gallons per day (Sunrise, 2022), the number of ERUs for residential and commercial connections were estimated. The water use data and ERU estimates are summarized in **Table 11**.

Table 11: 2024 Water Use Data and ERU Estimates

Culinary Water Use Category	Annual Quantity (Gallons)	ERU Estimates
Residential Use	46,380,327	536
Commercial Use	29,265,207	338*
Institutional Use	2,249,762	26
Total	**77,895,296**	**900**

Note: * The number of standard commercial ERUs is 120 and that of ERUs for commercial connections with 75% nitrate removal 218.

The mass balance approach used in the previous studies may be expressed as follows:

$$Q_sN_s+Q_{sc1}N_{sc1}+Q_{c2}N_{cs}+Q_pN_p+Q_iN_i+Q_bN_b=Q_tN_t$$

Where:

- Q_s discharge from standard residential ERUs
- N_s nitrate concentration in standard ERU effluents
- Q_{sc1} discharge from standard commercial ERUs
- N_{sc1} nitrate concentration in standard commercial ERUs
- Q_{c2} discharge from commercial ERUs with 75% nitrate removed from effluents
- N_{c2} nitrate concentration from commercial ERUs with 75% nitrate removed from effluents
- Q_p precipitation-related recharge
- N_p nitrate concentration in precipitation-related recharge
- Q_i recharge associated from irrigation water
- N_i nitrate concentration in irrigation recharge
- Q_b ambient groundwater flow
- N_b background nitrate concentration in groundwater
- Q_t total flow = $Q_s+Q_{sc1}+Q_{c2}+Q_p+Q_i+Q_b$
- N_t nitrate concentration in groundwater with impact of septic effluents

The analyses in the previous studies were based on the following assumptions as summarized in **Table 12**.

Table 12: Assumptions Used in Analyses of Previous Studies

Parameter	Symbol	Quantity Used		Unit
		Previous Studies	Inverse Modeling	
Aquifer Hydraulic Conductivity	k	3	--	feet/day
Aquifer Mixing Thickness	d	60	--	feet
Aquifer Width	L	12,000	--	feet
Aquifer Hydraulic Gradient	i	0.05	--	feet/foot
Residential Wastewater Nitrate Loading	N_s	40	40	mg/L
Existing (Standard) Commercial Nitrate Loading	N_{sc1}	100	100	mg/L
Existing & Future (90/75% Removal) Commercial Nitrate Load	N_{c2}	10	25	mg/L
Precipitation	P	12.97		inches/year
Recharge from Precipitation	r_p	1.297	1	inches/year
Drainage Area	A_d	6,000	1,632	acres
Nitrate Loading from Precipitation	N_p	0.5	0.5	mg/L
Irrigation Rate	I_r	6	6	feet/year
Recharge from Irrigation	r_i	50% I_r	50% I_r	inches/year
Irrigation Area	A_i	500	500	acres
Nitrate Loading from Irrigation	N_i	1	1	mg/L
Background Nitrate Concentration in Groundwater	N_b	0.5	0	mg/L

The following comments are made on the assumptions in previous studies:

1. The hydraulic conductivity was not determined from any aquifer tests. There are no public wells in the area since the TDS concentration in the groundwater is high. Based on Sunrise's field observations during installation of piezometers, the subsurface material encountered at the piezometer locations consisted predominantly of fine sand with silt and boulders. The hydraulic conductivity for fine sand ranges from 3 to 20 feet/day (Bouwer, 1978). The assumed hydraulic conductivity of 3 feet/day in previous studies is the lowest for the sand with silt. In the inverse modeling, there is no need to use any hydraulic conductivity value. As discussed in Section 5.6.2, the shallow alluvial aquifer consists of silty sand, and cobble- and boulder-sized gravel and a hydraulic conductivity of 30 feet/day for the shallow alluvial aquifer may be reasonable.
2. Prior reports have established a 90% nitrate removal requirement for commercial septic systems. While 90% removal is the design requirement, ACSSD reports that in their experience, 75% nitrogen removal is more realistically attainable. As such, this study uses a conservative commercial nitrogen loading rate of 25 mg/L. Sunrise recommends that the 90% removal standard remain in force for commercial septic systems.
3. The assumed recharge from precipitation is 10% of total precipitation without any analysis to verify the assumption. Based on the recharge analysis in Section 3.4.3 in this study and shown in **Figure 6**, the average recharge within the Town limits is 1.0 inch/year. This value was used in the inverse modeling.

4. The drainage area was assumed to be 6,000 acres in previous studies. However, the area of the town is 7,494 acres based on the town boundary map shown in **Figure 1**. The area of the alluvial aquifer within the Town limits is estimated to be approximately 1,642 acres, which is the value that was used in inverse modeling. This is the area wherein recharge is estimated to contribute to dilution of wastewater.
5. Since a groundwater contour map could not be generated due to the lack of well data in the area, the groundwater gradient was assumed to be 5%. This value appears to be high. Based on the water level measurement at piezometer #4 and the river water surface elevation, the gradient between the two points is estimated to be approximately 1.67% (5 feet elevation difference over a distance of 300 feet). In the inverse modeling, there is no need to use any hydraulic gradient value.
6. Since there is only one family well in the area, the aquifer thickness cannot be determined from the well data. Thus, the thickness of the aquifer was assumed to be 60 feet. It is apparent that the aquifer used in the analysis refers to the alluvial aquifer close to the Virgin River. Prior studies have not examined the extent of the alluvial aquifer or questioned whether the wastewater from all residential and commercial connections can reach this alluvial aquifer. Based on the data collected during this study, Sunrise concludes that it may be possible that most of the wastewater has never migrated to this aquifer, and that it may be possible that most of the wastewater has migrated to a different aquifer.
7. It is apparent that the ambient groundwater flow assumption affects the estimated septic density significantly. Without enough information to determine the ambient groundwater flow, it is best to use the available data and reasonable assumptions to estimate the ambient groundwater flow in inverse modeling.
8. The background nitrate concentration, N_b, was assumed to be 0.5 mg/L in previous studies. Laboratory results of water samples collected from GWMW #1 through #3 indicate the nitrate concentrations are below the laboratory detection limit of 0.1 mg/L most of the time. Therefore, N_b should be set to 0 mg/L.

Based on the laboratory results, as summarized in **Table 8**, the ambient groundwater flow was estimated using the inverse model under the assumption that the other parameter values in the previous studies are correct, as summarized in **Table 13**.

Table 13: Inverse Modeling Results for Ambient Groundwater Flow

Item	Value	Unit	Comments
Q_s	504,287	L/day	=562*237*3.785
N_s	40	mg/L	
Q_{sc1}	107,645	L/day	=120*237*3.785
N_{sc1}	100	mg/L	
Q_{c2}	195,831	L/day	=218*237*3.785
N_{c2}	25	mg/L	
Q_p	462,415	L/day	$1/12*1642*43560/365*3.048^3$
N_p	0.5	mg/L	From previous studies
Q_i	5,069,103	L/day	From previous studies
N_i	1	mg/L	From previous studies
N_b	0	mg/L	Based on sampling data
N_t	2.978	mg/L	Highest 95% confidence upper limit (**Table 8**)
Q_b	**7,472,771**	L/day	Inverse modeling result
Q_t	13,811,993	L/day	

The estimated ambient groundwater flow of 7,472,771 L/day using the inverse model is more than twice (2.44) the value of 3,057,219 L/day (60 feet * 3 feet/day * 12,000 feet * 0.05 * 3.048^3 L/feet^3) used in previous studies. In the inverse model, the ambient groundwater flow estimate (Q_b) increases with decreasing value of N_t. If the average of 95% confidence upper limits of 1.283 mg/L for the four groundwater sampling points is used, the estimated ambient groundwater flow would be approximately more than eight times the value used in previous studies. If the highest average N_t of 0.883 that occurs at GWMW #4 is used, the estimated ambient groundwater flow would be more than 13 times the value used in previous studies. **Table 14** summarizes the inverse modeling results for the three scenarios.

Table 14: Summary of Different Values of N_t versus Ambient Groundwater Flow in Inverse Modeling

Description of N_t	N_t Value (mg/L)	Estimated Ambient Groundwater Flow (L/day)	Q_b Estimate/ Q_b Used in Past Studies	Average Total Nitrate Loading Wastewater Flow (L/day)
Highest 95% Upper Limit	2.978	7,472,711	2.44	6,339,282
Mean of 95% Upper Limits	1.283	25,720,044	8.41	6,339,282
Highest Mean	0.883	40,242,955	13.16	6,339,282

The ambient groundwater flow of 3,057,219 L/day assumed in previous studies is only 48% of the average total nitrate loading flow and is not a good estimate.

If the variation of irrigation water-related recharge is considered, the ambient groundwater flow used in previous studies can be considered as even less accurate. According to the Utah Division of Water Rights (1994), the irrigation season in the area (based on the data collected at the closest weather station in La Verkin) is from March through October for pasture and alfalfa. The net irrigation requirements range from

30.53 to 38.34 with an average of 34.44 inches/year. The percentage for each month is summarized in **Table 15**.

Table 15: Net Irrigation Requirements, Irrigation Use and Irrigation-Related Recharge

Month	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
Alfalfa (Inch)	0.65	4.28	5.83	6.94	7.46	6.58	4.57	2.03	38.34
Pasture (Inch)	0.63	2.75	4.74	6.12	6.42	4.70	3.32	1.85	30.53
Mean (Inch)	0.64	3.52	5.29	6.53	6.94	5.64	3.95	1.94	34.44
Irrigation (inch)	1.34	7.35	11.05	13.65	14.51	11.79	8.25	4.06	72.00
Recharge (inch)	0.67	3.67	5.53	6.83	7.26	5.90	4.12	2.03	36.00

Based on the irrigation-related recharge distribution, the estimated monthly nitrate loading flow is summarized in **Table 16** which indicates the highest total nitrate loading wastewater flow in July 2025 is 13,529,650 L/day which is 4.42 times the ambient groundwater flow assumed in previous studies. Therefore, the assumptions regarding the groundwater flow system in previous studies are not reasonable.

Table 16: Estimated Monthly Nitrate Loading Wastewater Flow (L/day)

Month	Standard Residential Septic Tanks	Standard Commercial Septic Tanks	Commercial Septic Tanks with 75% Nitrate Removal	Precipitation-Related	Irrigation-Related	Total
Jun	504,287	107,645	195,831	462,415	11,535,210	12,805,388
Jul	504,287	107,645	195,831	462,415	12,259,472	13,529,650
Aug	504,287	107,645	195,831	462,415	9,963,030	11,233,208
Sep	504,287	107,645	195,831	462,415	6,968,821	8,238,999
Oct	504,287	107,645	195,831	462,415	3,427,000	4,697,178
Nov	504,287	107,645	195,831	462,415	0	1,270,178
Dec	504,287	107,645	195,831	462,415	0	1,270,178
Jan	504,287	107,645	195,831	462,415	0	1,270,178
Feb	504,287	107,645	195,831	462,415	0	1,270,178
Mar	504,287	107,645	195,831	462,415	1,130,557	2,400,735
Apr	504,287	107,645	195,831	462,415	6,209,228	7,479,406
May	504,287	107,645	195,831	462,415	9,335,924	10,606,102

It is apparent that the lower the value of N_t, the higher the ambient groundwater flow estimate. Applying the same inverse model to the buildout scenario as described by Sunrise Engineering (2022) with the N_t = 4.0 mg/L, the estimated required ambient groundwater flow is 19,567,046 L/day, as summarized in **Table 17**.

Table 17: Inverse Modeling Results for Ambient Groundwater Flow at Buildout Scenario

Item	Value		Unit	Comments
Q_s	1,797,678		L/day	=2,004*237*3.785
N_s	40		mg/L	
Q_{sc1}	107,645		L/day	=120*237*3.785
N_{sc1}	100		mg/L	
Q_{c2}	954,456		L/day	=1,184*237*3.785
N_{c2}	25		mg/L	
Q_p	462,415		L/day	$1/12*1642*43560/365*3.048^3$
N_p	0.5		mg/L	From previous studies
Q_i	5,069,103		L/day	From previous studies
N_i	1		mg/L	From previous studies
N_b	0.0		mg/L	
N_t	4.0		mg/L	Proposed limit
Q_b	**19,567,046**		L/day	Inverse modeling result
Q_t	27,958,344		L/day	

The inverse modeling results, summarized in **Tables 14** and **15,** suggest that the nitrate concentration in the groundwater of the alluvial aquifer will not exceed 4 mg/L at buildout under the current zoning ordinance. If it is assumed that the ambient groundwater flow estimated using the average of 95% confidence upper limits is reasonable, the buildout ERUs could be 1.31 times higher if the ratio between residential ERUs and commercial ERUs remains unchanged (as prescribed in the current zoning ordinance). In other words, the results suggest that the lot size per septic system ERU may be **0.76 acres (or 1/1.31)**.

7 AN ALTERNATE APPROACH TO EVALUATION OF VIRGIN TOWN'S SEPTIC EFFLUENTS

This section is intended to evaluate the mass balance of nitrate flux in the Virgin River. Two surface water sampling points in the Virgin River (upstream and downstream of Virgin Town) were used to monitor nitrate concentrations. The surface water flow of the Virgin River at the USGS gauge station at Virgin Town was obtained from the USGS website for each day surface water samples were collected. If all the nitrate from the nitrate loading wastewater within the Town limits migrates into the Virgin River, we would expect the difference between the estimated nitrate mass fluxes at the two surface monitoring points to be very close to the nitrate mass flux from the nitrate loading wastewater within the Town limits.

Based on historical flow data, the flow from North Creek is about 0.9% (**Table 8**) of the Virgin River. The average nitrate loading wastewater flow is about 2.4% of the average river flow at the gauge station. The ambient groundwater flow between the two surface water sampling points (SW #1 and SW #3), including the nitrate loading wastewater flow, also flows into the river. According to the USGS gauge station map, the USGS gauge station at Virgin Town is located downstream. To calculate the stream flow, this study assumes that all groundwater within the Town boundary enters the Virgin River. In the absence of streamflow data for the North Fork, it is also assumed that the flow of the North Fork entering the Virgin River flow is 5% of the Virgin River flow. In other words, it is assumed that river flow at the upstream monitoring point is 95% of the stream flow recorded at the gauge station, to account for the flows from North Fork. Based on the information described herein and data from Table 8, the estimated and measured nitrate concentration difference between SW #3 and #1 are summarized in **Table 18**.

Table 18: Estimated Nitrate Concentration Difference between SW #3 and SW #1

Sampling Month	SW #1	SW #2	SW #3	Virgin River Flow	Total Nitrate Loading Flow		Nitrate Concentration Difference between SW #3 and SW #1 (mg/L)	
	mg/L			(cfs)	(L/day)	(cfs)	Lab Results	Estimated*
Jun-24	< 0.10	0.485	0.185	83.5	12,805,388	5.234	0.085	0.233
Jul-24	0.247	1.220	0.422	63.27	13,529,651	5.530	0.175	0.312
Aug-24	0.397	0.179	0.314	70.02	11,233,208	4.591	0.000	0.000
Sep-24	0.283	0.185	0.318	66.14	8,239,000	3.368	0.035	0.266
Oct-24	< 0.10	< 0.10	< 0.10	94.91	4,697,178	1.920	0.000	0.000
Nov-24	0.43	0.267	0.398	238.85	1,270,178	0.519	0.000	0.000
Dec-24	0.204	0.767	0.395	105.33	1,270,178	0.519	0.191	0.140
Jan-25	0.22	0.24	0.23	97.76	1,270,178	0.519	0.010	0.151
Feb-25	0.16	0.14	0.11	120.45	1,270,178	0.519	0.000	0.122
Mar-25	0.16	< 0.1	0.14	165.46	2,400,735	0.981	0.000	0.092
Apr-25	0.28	< 0.1	0.25	85.25	7,479,407	3.057	0.000	0.203
May-25	0.19	< 0.1	0.19	72.6	10,606,102	4.335	0.000	0.256
Average	**0.23**	**0.32**	**0.25**	**105.3**	**6,339,282**	**2.59**	**0.04**	**0.15**

Note: *If all wastewater effluents within the Town limits flow into the Virgin River, the nitrate concentration difference between the upstream and downstream sampling points was calculated using the mass balance approach.

Based on the mass balance approach and the assumptions and data presented in Table 18, there is an apparent disagreement between the estimated and measured nitrate concentration differences between surface water sampling points SW#1 and SW#3 on the Virgin River. The magnitude of this disagreement is substantial — as discussed in Section 7.2, the mass balance analysis indicates that only approximately 11.9% of septic effluent nitrate loading would need to migrate to the river to account for the measured downstream concentration increase. This suggests that the majority of nitrate mass originating within the Town limits is not reaching the Virgin River through the alluvial aquifer under typical conditions. To explain this observation, this report hypothesizes that septic effluent from Virgin Town migrates into two different aquifers: the shallow alluvial aquifer adjacent to the Virgin River and the shallow bedrock aquifer of the Moenkopi Formation, as described in Section 3.1.

The shallow aquifer hypothesis provides a plausible explanation to account for the significant difference in nitrogen mass between the estimated and measured values. While plausible, this study acknowledges that other processes may also contribute to nitrogen attenuation between the upstream and downstream monitoring points. In-stream nitrogen cycling processes, including biological assimilation by aquatic vegetation and algae, and microbial denitrification within the streamed, are recognized mechanisms by which nitrogen mass can be attenuated within a river system without migrating to either a surface or subsurface pathway. Seasonal variability in river discharge and uptake by vegetation could also contribute to the observed differences.

Laboratory analyses to characterize in-stream biological processes were not performed as part of this study, and the available data is insufficient to quantify the contribution of these mechanisms to the observed nitrogen attenuation. In the absence of such data, and given the hydrogeologic setting described in Section 3, this report proceeds with the dual-aquifer hypothesis as the primary analytical framework, with the understanding that in-stream processes may account for a portion of the unresolved nitrogen mass and represent an area warranting further investigation.

The alternate approach to evaluating the shallow aquifer hypothesis is explained in this section.

7.1 Noticeable Impacts of Nitrate Loading to the Virgin River

The data summarized in **Tables 8** and **18** indicates that two noticeable impacts of nitrate loading to the Virgin River occurred in July 2024 and December 2024, respectively.

In July 2024, the nitrate concentration difference between SW #1 and SW #3 was 0.175 mg/L, which is 60% of the estimated 0.312 mg/L using the mass balance method, as shown in **Table 18**, and is much higher than most of the other months' data. In December, the nitrate concentration difference between SW #1 and SW #3 was 0.191 mg/L, which is 144% of the estimated 0.140 mg/L and is the highest of all the months' data. These two high nitrate concentration differences are likely associated with more than just average visitors to Virgin and loading from feedlots near SW #1.

According to Kem C. Gardner Policy Institute (2024), Washington County, Utah boasts a blend of outdoor recreation opportunities and retirement communities that contribute to a large number of temporary residents. There were 64,235 temporary residents in Washington County on an average day in addition to the already estimated 198,533 permanent residents in 2023. The overnight visitors were estimated to be 25,600 on an average day. Overnight visitors stay in a variety of commercial, private, and/or free accommodations. Commercial paid accommodation could include hotels, beds & breakfasts (B&B), short-term rentals, resorts, RV parks, and campgrounds. Free or not commercially taxed accommodation could include second homes (e.g., houses, timeshares, and condominiums) and family or friend's private residences. These estimates did not include overnight visitors who stay in short-term rentals (e.g., Airbnb), camp on BLM lands, sleep in cars, or day visitors. The following chart created by Kem C. Gardner Institute (2024) illustrates the monthly peak occupancy and maximum capacity for Washington County hotels and B&B in 2023.

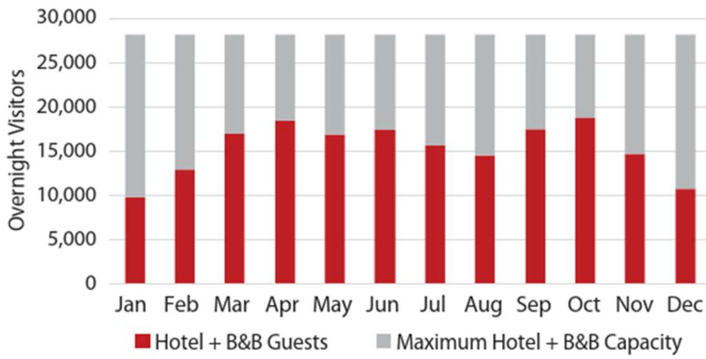

Figure 9: Seasonal Capacity and Occupancy of Washington County Hotels.

The chart indicates that the number of overnight visitors peaked from April through June and September and October of 2023. Virgin Town may experience a similar visitor pattern. This trend coincides with the nitrate concentration in the water sample collected from North Creek. Specifically, the nitrate concentration of the water sample collected from North Creek in July was the highest (1.22 mg/L) of the year (see **Tables 8** and **18**), which indicates that more people visited Virgin in April through June. The nitrate transport in groundwater takes some time (e.g. one or two months or even longer) depending on groundwater conditions. At the present time, groundwater conditions in the Virgin area are not well understood. The second highest concentration of nitrate from the water sample collected from North Creek was 0.767 mg/L (see **Tables 8** and **18**) in December.

The nitrate concentration difference between SW #3 and SW #1 in December 2024 was likely skewed more by nitrate loading from two feedlots near SW #1 where two property owners generally keep their cows during the winter months. Therefore, the data for December 2024 is considered an outlier in the data set and should be eliminated from further analysis in estimating the percentage of septic effluents migrating to the alluvial aquifer.

7.2 Percentage of Septic Effluents Migrating to Alluvial Aquifer

Seven nitrate concentration differences are ≤ 0, which indicates that the impact of the septic effluents and other nitrate sources (irrigation water recharge) on the Virgin River on those dates was imperceptible, or the nitrate from the septic systems and irrigation nitrate sources may not have migrated to the alluvial aquifer.

Using the mass balance approach with the December 2024 data outlier being eliminated, it is estimated that an average of approximately 11.9% of nitrate from septic effluents and irrigation water recharge reached the Virgin River, or the alluvial aquifer. **Table 19** summarizes the analysis.

In evaluating the septic density for future planning, to be conservative, an average of 12% of nitrate loads from septic effluents and irrigation water recharge may be considered to migrate to the alluvial aquifer or the Virgin River. Thus, 88% of nitrate loading from the septic effluents and irrigation water recharge migrate to the shallow bedrock aquifer.

Table 19: Percentage of Septic Effluents to Alluvial Aquifer without December 2024 Outlier

Sampling Month	SW #1	SW #2	SW #3	Virgin River Flow	Total Nitrate Loading Flow		Nitrate Concentration Difference between SW #3 and SW #1 (mg/L)		Nitrate Mass Flux in River	Percentage of Total Mass Flux
	mg/L			(cfs)	(L/day)	(cfs)	Lab Results	Estimated*	(mg/day)	(%)
Jun-24	< 0.10	0.485	0.185	83.5	12,805,388	5.234	0.085	0.233	18,386,015	38.6%
Jul-24	0.247	1.220	0.422	63.27	13,529,651	5.530	0.175	0.312	29,000,812	60.0%
Aug-24	0.397	0.179	0.314	70.02	11,233,208	4.591	-0.083	0.000	0	0.0%
Sep-24	0.283	0.185	0.318	66.14	8,239,000	3.368	0.035	0.266	7,953,281	18.5%
Oct-24	< 0.10	< 0.10	< 0.10	94.91	4,697,178	1.920	0.000	0.000	0	0.0%
Nov-24	0.43	0.267	0.398	238.85	1,270,178	0.519	-0.032	0.000	0	0.0%
Dec-24	0.204	0.767	0.395	105.33	1,270,178	0.519	0.191	0.140		
Jan-25	0.22	0.24	0.23	97.76	1,270,178	0.519	0.010	0.151	5,022,722	13.9%
Feb-25	0.16	0.14	0.11	120.45	1,270,178	0.519	-0.050	0.122	0	0.0%
Mar-25	0.16	< 0.1	0.14	165.46	2,400,735	0.981	-0.020	0.092	0	0.0%
Apr-25	0.28	< 0.1	0.25	85.25	7,479,407	3.057	-0.030	0.203	0	0.0%
May-25	0.19	< 0.1	0.19	72.6	10,606,102	4.335	0.000	0.256	0	0.0%
								Average	**5,487,530**	**11.9%**

Note: Estimated* means that the nitrate concentration difference between upstream and downstream sampling points was calculated using the mass balance approach as if all wastewater effluent from septic systems within Virgin Town limits was to flow into the Virgin River; < means below the indicated laboratory detection limit.

7.3 Development Density Recommendations

As discussed in Section 7.2, it is plausible that a significant percentage of the septic effluents migrate to the shallow bedrock aquifer. Based on the Truman Well log, the bedrock consists of shale (weathered) of the Moenkopi formation. As shown in **Figure 4**, the productive regional drinking water aquifers (Navajo, Kayenta and Shinarump Conglomerate) are above Virgin. The productivity and hydrogeologic connectivity of the potential deeper Kaibab aquifer is described in Section 3.1.

Based on the data collected and analyzed in the above sections, the nitrate concentration at the SW#3 location, as estimated by the mass balance approach, is higher than the actual measured nitrate concentration. Considering this, it appears that not all of the nitrogen mass is entering the river and therefore, the shallow bedrock aquifer does not appear to be well connected with the Virgin River. If the shallow bedrock aquifer is not connected to the river, and if the shallow and deeper bedrock aquifers are of poor drinking water quality, as described in Section 3.1, then the allowable nitrate concentration in the shallow bedrock aquifer could not have any limit. In the following analysis, the target residential and commercial ERUs are twice the buildout estimates by Sunrise (2022), that is to say, the allowable septic density could be 0.5 acres per ERU.

7.3.1 Alluvial Aquifer Modeling

For the alluvial aquifer, the following additional adjustments should be made from the assumptions in previous studies, which were discussed in Section 6:

- The hydraulic conductivity for the shallow aquifer is higher than 3 feet/day based on the slug test results as discussed in Section 5.6. A hydraulic conductivity of 30 feet/day may be used for fine sand with cobble- and boulder-sized gravel, as discussed in Section 6.
- The hydraulic gradient of 0.05 or 5% may be too high. A value of 1.67% or 0.0167 may be more reasonable based on Sunrise's observations of the water level difference between piezometer #4 and the surface water level (about 5 feet in elevation difference over a distance of approximately 300 feet).
- The thickness of 60 feet for the alluvial aquifer is considered appropriate, as discussed in Section 6. While the Truman Well log indicates that the thickness of the alluvial aquifer is 18 feet at the well location, the aquifer likely becomes thicker closer to the river.
- The extent of the alluvial aquifer within the town limits is delineated as approximately 1,642 acres based on the geologic information shown in **Figures 2** and **6**. The total precipitation-related recharge to the alluvial aquifer within the town limits is estimated to be 462,415 L/day which is about 21% of that used in previous studies.

Under the assumption that 12% of the total nitrate loading would migrate to the alluvial aquifer that would have a nitrate background level of 0 mg/L, the mass balance result is presented in **Table 20**. The results indicate the estimated total nitrate concentration will not exceed 4 mg/L (2.13 mg/L) in the alluvial aquifer in the buildout scenario when the density is changed from one acre per ERU to 0.5 acres per ERU.

7.3.2 Shallow Bedrock Aquifer Modeling

Not much information about the shallow bedrock aquifer is available at the present time. According to Biek and others (2010) and as shown in **Figure 4**, the shallow bedrock aquifer consists of mudstone, siltstone, sandstone and limestone of the Moenkopi Formation. It is believed that the recharge from precipitation in the study area (north and south study areas) would become groundwater flow to the Virgin Town limits. The extent of the recharge zone of the shallow bedrock aquifer is approximately 11,925 acres for the north study area and 9,868 acres for the south study area. The average recharge rate is estimated to be 1.3637 inches/year for the north study and 1.0 inch/year for the south study area. Since there are not many developments in the south study area, the recharge from the south study area is not included in the shallow bedrock aquifer modeling. No additional recharge from precipitation is used. The modeling result is presented in **Table 20** which indicates the estimated total nitrate concentration will be 13.3 mg/L in the shallow bedrock aquifer in the buildout scenario when the density is changed from one acre per ERU to 0.5 acres per ERU.

7.4 Sensitivity Analysis

Sensitivity analysis was used to measure the degree of uncertainty in the modeling caused by uncertainties in the estimates of model parameters. During sensitivity analysis for mass balance modeling, the percentage of nitrate loading from septic systems and irrigation water recharge to the alluvial aquifer was changed in the simulation within a predefined plausible range factor. The accompanying change in estimated nitrate concentrations in the alluvial and shallow bedrock aquifers were then analyzed as a measure of the sensitivity of the model to the parameter. Factors of 0.5 and 2.0 were selected as a plausible range for model parameters.

When the percentage of nitrate loading from septic systems and irrigation water recharge was changed to 6%, the estimated nitrate concentration was 1.14 mg/L in the alluvial aquifer and 13.57 mg/L in the shallow bedrock aquifer at buildout with a lot size of 0.5 acres. The modeling results are shown in **Table 21**.

When the percentage of nitrate loading from septic systems and irrigation water recharge was changed to 30%, the estimated nitrate concentration was 3.82 mg/L in the alluvial aquifer and 12.67 mg/L in the shallow bedrock aquifer at buildout with a lot size of 0.5 acres. The modeling results are shown in **Table 22**.

In both cases, the estimated nitrate concentration was still below 4.0 mg/L in the alluvial aquifer and lower than 14.0 mg/L in the shallow bedrock aquifer.

Table 20: Mass Balance Analysis for Alluvial and Shallow Bedrock Aquifers

Parameter	Symbol	Quantity	Unit	Distribution between Aquifers			
				Total	Alluvial Aquifer	Bedrock Aquifer	Unit
					12.0%	88.0%	
Common Nitrate Sources/Recharges							
Irrigation Water Recharge							
Irrigation Acres	A_i	500	acres				
Irrigation Rate	I_r	6	feet/year				
Recharge from Irrigation	r_i	0.5	-				
Nitrate Loading	N_i	1	mg/L	5,069,103	608,292	4,460,811	mg/day
Irrigation Water	Q_i	5,069,103	L/day	5,069,103	608,292	4,460,811	L/day
Wastewater from Residential							
Effluent from Population Equivalent	Q_{pe}	237	GPD/ERU				
Equivalent Residential Unit	ERU	**4,008**	ERU				
Nitrate Loading	N_s	40	mg/L	143,814,254	17,257,711	126,556,544	mg/day
Total Flow from Septic Tanks	Q_s	3,595,356	L/day	3,595,356	431,443	3,163,914	L/day
Wastewater from Existing Commercial (Standard)							
Effluent from Population Equivalent	Q_{pe}	237	GPD/ERU				
Equivalent Residential Unit	ERU	**120**	ERU				
Nitrate Loading	N_{sc1}	100	mg/L	10,764,540	1,291,745	9,472,795	mg/day
Total Flow from Septic Tanks	Q_{sc1}	107,645	L/day	107,645	12,917	94,728	L/day
Wastewater from Commercial (75% Removal)							
Effluent from Population Equivalent	Qpe	237	GPD/ERU				
Equivalent Residential Unit	ERU	**2,248**	ERU				
Nitrate Loading	N_{s2}	25	mg/L	50,413,929	6,049,671	44,364,258	mg/day
Total Flow from Septic Tanks	Q_{s2}	2,016,557	L/day	2,016,557	241,987	1,774,570	L/day
Aquifer-Specific Nitrate Sources/Groundwater Flow/Recharge							
Background Flow of Groundwater							
Hydraulic Conductivity	K				30		feet/day
Mixing Zone Thickness	d				60		feet
Aquifer Width	b				12,000		feet
Hydraulic Gradient	i				0.01667		feet/feet
Nitrate Loading (As Nitrogen)	N_b				0		mg/L
Groundwater Flow	Q_b				10,194,065		L/day
Recharge Associated with Precipitation							
Nitrate Loading	N_p				0.5	0.5	mg/L
Alluvial Aquifer Area in Town	A_{pr}				1,642	11,925	acres
Recharge Rate	R_p				1	1.3637	inch/year
Nitrate Mass Flux					231,207	2,289,862	mg/day
Recharge from Precipitation	Q_p				462,415	4,579,724	L/day
Total Concentration							
Total Flow	Q_t				11,951,119	14,073,747	L/day
Nitrate Concentration Based on ERUs	$N_{t\text{-}est}$				2.13	13.30	mg/L

Table 21: Mass Balance Analysis for Alluvial and Shallow Bedrock Aquifers (Sensitivity Analysis 1)

Parameter	Symbol	Quantity	Unit	Distribution between Aquifers			
				Total	Alluvial Aquifer 6.0%	Bedrock Aquifer 94.0%	Unit
Common Nitrate Sources/Recharges							
Irrigation Water Recharge							
Irrigation Acres	A_i	500	acres				
Irrigation Rate	I_r	6	feet/year				
Recharge from Irrigation	r_i	0.5	-				
Nitrate Loading	N_i	1	mg/L	5,069,103	304,146	4,764,957	mg/day
Irrigation Water	Q_i	5,069,103	L/day	5,069,103	304,146	4,764,957	L/day
Wastewater from Residential							
Effluent from Population Equivalent	Q_{pe}	237	GPD/ERU				
Equivalent Residential Unit	ERU	**4,008**	ERU				
Nitrate Loading	N_s	40	mg/L	143,814,254	8,628,855	135,185,399	mg/day
Total Flow from Septic Tanks	Q_s	3,595,356	L/day	3,595,356	215,721	3,379,635	L/day
Wastewater from Existing Commercial (Standard)							
Effluent from Population Equivalent	Q_{pe}	237	GPD/ERU				
Equivalent Residential Unit	ERU	**120**	ERU				
Nitrate Loading	N_{sc1}	100	mg/L	10,764,540	645,872	10,118,668	mg/day
Total Flow from Septic Tanks	Q_{sc1}	107,645	L/day	107,645	6,459	101,187	L/day
Wastewater from Commercial (75% Removal)							
Effluent from Population Equivalent	Qpe	237	GPD/ERU				
Equivalent Residential Unit	ERU	**2,248**	ERU				
Nitrate Loading	N_{s2}	25	mg/L	50,413,929	3,024,836	47,389,093	mg/day
Total Flow from Septic Tanks	Q_{s2}	2,016,557	L/day	2,016,557	120,993	1,895,564	L/day
Aquifer-Specific Nitrate Sources/Groundwater Flow/Recharge							
Background Flow of Groundwater							
Hydraulic Conductivity	K				30		feet/day
Mixing Zone Thickness	d				60		feet
Aquifer Width	b				12,000		feet
Hydraulic Gradient	i				0.01667		feet/feet
Nitrate Loading (As Nitrogen)	N_b				0		mg/L
Groundwater Flow	Q_b				10,194,065		L/day
Recharge Associated with Precipitation							
Nitrate Loading	N_p				0.5	0.5	mg/L
Alluvial Aquifer Area in Town	A_{pr}				1,642	11,925	acres
Recharge Rate	R_p				1	1.3637	inch/year
Nitrate Mass Flux					231,207	2,289,862	mg/day
Recharge from Precipitation	Q_p				462,415	4,579,724	L/day
Total Concentration							
Total Flow	Q_t				11,303,799	14,721,066	L/day
Nitrate Concentration Based on ERUs	$N_{t\text{-}est}$				1.14	13.57	mg/L

Table 22: Mass Balance Analysis for Alluvial and Shallow Bedrock Aquifers (Sensitivity Analysis 2)

Parameter	Symbol	Quantity	Unit	Distribution between Aquifers			
				Total	Alluvial Aquifer	Bedrock Aquifer	Unit
					24.0%	76.0%	
Common Nitrate Sources/Recharges							
Irrigation Water Recharge							
Irrigation Acres	A_i	500	acres				
Irrigation Rate	I_r	6	feet/year				
Recharge from Irrigation	r_i	0.5	-				
Nitrate Loading	N_i	1	mg/L	5,069,103	1,216,585	3,852,519	mg/day
Irrigation Water	Q_i	5,069,103	L/day	5,069,103	1,216,585	3,852,519	L/day
Wastewater from Residential							
Effluent from Population Equivalent	Q_{pe}	237	GPD/ERU				
Equivalent Residential Unit	ERU	**4,008**	ERU				
Nitrate Loading	N_s	40	mg/L	143,814,254	34,515,421	109,298,833	mg/day
Total Flow from Septic Tanks	Q_s	3,595,356	L/day	3,595,356	862,886	2,732,471	L/day
Wastewater from Existing Commercial (Standard)							
Effluent from Population Equivalent	Q_{pe}	237	GPD/ERU				
Equivalent Residential Unit	ERU	**120**	ERU				
Nitrate Loading	N_{sc1}	100	mg/L	10,764,540	2,583,490	8,181,050	mg/day
Total Flow from Septic Tanks	Q_{sc1}	107,645	L/day	107,645	25,835	81,811	L/day
Wastewater from Commercial (75% Removal)							
Effluent from Population Equivalent	Qpe	237	GPD/ERU				
Equivalent Residential Unit	ERU	**2,248**	ERU				
Nitrate Loading	N_{s2}	25	mg/L	50,413,929	12,099,343	38,314,586	mg/day
Total Flow from Septic Tanks	Q_{s2}	2,016,557	L/day	2,016,557	483,974	1,532,583	L/day
Aquifer-Specific Nitrate Sources/Groundwater Flow/Recharge							
Background Flow of Groundwater							
Hydraulic Conductivity	K				30		feet/day
Mixing Zone Thickness	d				60		feet
Aquifer Width	b				12,000		feet
Hydraulic Gradient	i				0.01667		feet/feet
Nitrate Loading (As Nitrogen)	N_b				0		mg/L
Groundwater Flow	Q_b				10,194,065		L/day
Recharge Associated with Precipitation							
Nitrate Loading	N_p				0.5	0.5	mg/L
Alluvial Aquifer Area in Town	A_{pr}				1,642	11,925	acres
Recharge Rate	R_p				1	1.3637	inch/year
Nitrate Mass Flux					231,207	2,289,862	mg/day
Recharge from Precipitation	Q_p				462,415	4,579,724	L/day
Total Concentration							
Total Flow	Q_t				13,245,759	12,779,107	L/day
Nitrate Concentration Based on ERUs	$N_{t\text{-}est}$				3.82	12.67	mg/L

7.5 Potential Impact on Virgin River Water Quality

As discussed in Sections 6 and 7, septic systems in Virgin Town do not appear to contribute significant nitrogen mass flux into the Virgin River. Instead, it is hypothesized that most of the nitrate from septic systems in Virgin Town migrates to a shallow bedrock aquifer. If this conceptual model is correct, nitrate loading from septic systems within Virgin Town is not anticipated to have a significant direct influence on algal blooms in downstream surface water bodies such as the Virgin River, Quail Creek Reservoir or Sand Hollow Reservoir.

Based on the findings of this study, septic systems within Virgin Town appear to contribute only minor quantities of nitrate to the Virgin River and, therefore, are unlikely to have a measurable direct impact on threatened and endangered species through nutrient enrichment. However, relatively small contributions may become more relevant when considered cumulatively with other nutrient sources throughout the watershed, including upstream communities, agricultural return flows, and livestock operations.

An alternative consideration is that biological uptake processes within the Virgin River may account for a portion of the rapid attenuation in nitrate concentrations observed along the study reach. Algal blooms and microbial denitrification can substantially reduce dissolved inorganic nitrogen concentrations under favorable conditions. These processes are often most active in reaches with sufficient light penetration, warm temperatures, and longer residence times, all of which can occur seasonally within the Virgin River system.

Quantifying the effect of in-stream and near-stream biological processes involves evaluating nutrient uptake rates using approaches such as nutrient spiraling metrics, or tracer studies involving the controlled addition of nitrate and conservative tracers. Published studies of similar river systems indicate that nitrate uptake rates can vary widely but may be on the order of 0.01 to 1.0 mg/L per km under biologically active conditions, with higher rates associated with dense algal growth and favorable environmental conditions. For example, Jones et al. (2018) report that nitrate concentrations declined 0.11 mg/L, or about 1.9%, per km in-stream, and 35% in total across an 18 km reach of a fourth-order stream draining an agricultural watershed in Iowa.

Laboratory analyses of groundwater samples collected from the four monitoring locations indicated that microcystins and nodularins were not detected above analytical detection limits. Of the 37 pharmaceutical and personal care product (PPCP) and endocrine-disrupting compound (EDC) analytes evaluated, seven were detected (see **Table 9**). Surface water samples were not analyzed for PPCPs or EDCs as part of this study; however, concentrations in the Virgin River are expected to be lower than those observed in groundwater due to dilution, dispersion, and potential degradation processes.

The Virgin River watershed is generally in a rural area where agricultural activities, grazing lands, feedlots and septic systems are common. All these are nutrient sources. To resolve the algal bloom issues in the watershed, collaborative efforts will be required from all communities in the rural areas. Feedlots are great sources of nutrients and should be kept far away from the Virgin River and its tributaries. If feasible, all agricultural runoffs should be retained, and septic systems should be replaced with a sewer system.

8 DISCUSSION OF ALTERNATE APPROACH

The findings of this study represent a meaningful step forward in the understanding of groundwater flow dynamics and nitrate transport within the Virgin Town area. Based on the alternate approach and the data presented herein, a substantial portion of the nitrogen mass flux within the Virgin River system appears to be unaccounted for through direct measurement. This report evaluates a plausible conceptual model in which a significant fraction of nitrogen mass migrates into a shallow bedrock aquifer, rather than discharging to the river through the alluvial aquifer. Available geologic and hydrogeologic information supports the presence of both an alluvial aquifer and a shallow bedrock aquifer system within the Virgin area, and it is reasonable to infer that septic effluent may be distributed between these units. This section discusses the alternate approach in further detail.

8.1 Geologic Conditions Supporting the Hypothesis

The alternate analytical approach estimates that approximately 12% of septic effluent migrates to the alluvial aquifer while the remaining 88% infiltrates a shallow bedrock aquifer system. The inferred presence of a shallow bedrock aquifer within the Moenkopi Formation is consistent with the mapped geologic stratigraphy, as well as published descriptions in regional reports of aquifer characteristics and their potential hydrogeologic connectivity (Biek, 2010; Inkenbrandt, 2013). The hypothesis that nitrogen mass is migrating to the shallow bedrock aquifer appears to be supported by the groundwater and surface water quality data collected as part of this study.

While this data appears to support the hypothesis, the actual areal extent, hydraulic properties, and degree of connectivity between the aquifer systems remain uncertain. This study assumes that the shallow bedrock aquifer is hydraulically isolated from the river, and from other aquifers of potable water quality. Also, the vertical and lateral limits, and the hydraulic connectivity, of the Moenkopi and Kaibab aquifers are undefined.

This study further assumes that elevated nitrate concentrations within the shallow bedrock aquifer would not result in significant adverse impacts. This assumption deserves careful consideration. While the Moenkopi and Kaibab aquifers are believed to contain saline water, it is possible that the Kaibab aquifer may represent a potential future source of usable water for the county (Inkenbrandt, 2013).

Furthermore, other mechanisms—such as in-stream uptake by vegetation and algae, and microbial denitrification within the stream channel—likely contribute to the observed reduction in nitrogen concentrations; however, these processes were not quantitatively evaluated as part of this study.

8.2 Uncertainties and Recommendations for Future Work

First, the findings of this study provide a reasonable conceptual understanding of groundwater flow, however, several key uncertainties remain. These uncertainties limit the degree of confidence that can be placed on the quantitative results. Future investigations should attempt to address these uncertainties.

8.2.1 Uncertainty in Aquifer Characterization and Hydrogeologic Framework

There is limited information regarding the lateral and vertical extents of the geologic units underlying the study area, and the hydrogeologic setting remains incompletely defined. A thorough hydrogeologic model would require extensive mapping of the alluvial aquifer, the Moenkopi Formation and deeper Kaibab Formation, along with the potentiometric surfaces of these aquifers to properly estimate groundwater flow directions and gradients.

The nature of the potential groundwater divide at the Hurricane Fault introduces additional uncertainty. The aquifers may be connected via fracture-controlled flow paths, or the large fault offset and fine-grained layers of the Moenkopi may occlude groundwater movement across this feature. The presence and significance of such pathways are not fully understood.

Future work to better characterize the local groundwater conditions might include the following:

- Installation of monitoring wells screened within each of the anticipated aquifers to differentiate hydraulic heads between aquifers.
- Development of a potentiometric surface map based on groundwater level measurements.
- Geophysical investigations such as seismic refraction or electrical resistivity, to better define stratigraphy and structural features.
- Aquifer testing to estimate the hydraulic conductivity of the bedrock aquifers.
- Evaluation of potential aquifer connectivity across the Hurricane Fault.

8.2.2 Limitations in Field Survey Control and Hydraulic Gradient Definition

The study is limited by a lack of precision survey control at the groundwater monitoring wells and at the surface water sampling locations. Reliable survey control monuments at each sampling location would allow for the accurate comparison of relative water surface elevations and an accurate hydraulic gradient definition between the groundwater and the Virgin River along the study reach. Since these are not available, the study is limited in its ability to assess gaining versus losing stream conditions or groundwater flow direction.

It is recommended that future studies consider the following work to more accurately define the hydraulic gradient:

- Establish permanent survey benchmarks that can be tied to a common datum.
- Survey the elevations of well casings and surface water sampling locations.
- Install continuous water level loggers to evaluate temporal variability in water elevations.
- Perform seepage run measurements to quantify gains and losses along the river reach.

8.2.3 Limitations in Water Quality and Nutrient Dataset

This study focused primarily on nitrate as the indicator of wastewater effluent. While this is appropriate for evaluating septic system influence, other constituents were not consistently evaluated, which limits the ability of the study to assess the presence and impacts of these constituents on the river quality.

It was only late in the study that ACSSD requested that samples of cyanotoxins (microcystins and nodularins) and anthropogenic contaminants be evaluated, and each of these constituents was only analyzed once in the laboratory. This limited dataset does not allow for evaluation of seasonal, or potential episodic, variability in these concentrations.

It is recommended that future studies expand the dataset of constituents of concern. This could include the following:

- Expanded water quality sampling program including:
    - Total nitrogen, total phosphorous and dissolved organic nitrogen and carbon.
- Seasonal and event-based sampling to capture variability across seasons, such as during the irrigation season, or monsoon season.
- Repeated sampling for PPCP, EDC and cyanotoxins to evaluate longitudinal trends.
- Inclusion of field parameters such as temperature, pH, dissolved oxygen at each sampling location.

8.2.4 Uncertainty in Biological Nutrient Uptake and Transformation Processes

This study did not evaluate biological uptake or transformation processes that may influence the observed nitrate concentrations in the river. Without direct measurement, the effects of these mechanisms cannot be quantified. It is recommended that future work consider and account for these processes. The following methods may be considered to evaluate these mechanisms:

- Nutrient spiraling studies to estimate uptake length and uptake velocity.
- Controlled tracer studies using nitrate and conservative tracers to quantify in-stream removal rates.
- Measurement of chlorophyll-a to estimate algal biomass.
- Continuous monitoring of dissolved oxygen to assess algal growth and decomposition.
- Stable isotope analysis to evaluate sources and potential denitrification processes.

8.2.5 Temporal Variability and Hydrologic Conditions

Data collection for this study represents a limited time window and may not capture the full range of conditions typically experienced in the study area, including seasonal flow variations, storm events or irrigation return flows. These conditions can significantly influence groundwater-surface water interactions. Furthermore, the flows of North Creek at SW#2 were unreported by the USGS gauge station, making it necessary to estimate these flows.

Future work should attempt to minimize these uncertainties by attempting the following:

- Monitor hydrologic conditions over a long period of time including multiple seasons.
- Perform targeted sampling during significant high-flow and runoff events.
- Establish a reliable stream gage on the North Creek to more reliably estimate nitrate flux at this confluence.

8.2.6 Concluding Remarks on Uncertainties

Despite these limitations, the study provides an important foundation for understanding nutrient dynamics in the Virgin River system and for evaluating the relative influence of septic systems within the Virgin Town area. The findings consistently indicate that septic-derived nitrate is not measurably contributing to the Virgin River via the alluvial aquifer under the conditions evaluated. However, the degree to which nitrate is attenuated through biological processes or potentially transmitted to deeper aquifers remains unresolved.

Given the potential long-term implications for groundwater resource management, surface water quality, and downstream water users, a phased and targeted approach to additional investigation is warranted. Future efforts should prioritize reducing the most consequential uncertainties—particularly those related to aquifer connectivity, nutrient fate and transport, and biological uptake processes—through integrated field monitoring, laboratory analysis, and, where appropriate, numerical modeling.

Addressing these uncertainties through targeted data collection and analysis will improve confidence in the conceptual model and provide a more robust basis for evaluating groundwater protection strategies and nutrient management within the Virgin River watershed.

8.3 Regional Trends Toward Municipal Sewer Systems

Throughout Washington County, the prevailing trend is toward municipal sewer collection and centralized wastewater treatment that enables reuse of treated effluent for irrigation and other non-potable purposes. Reuse water comprises a significant portion of WCWCD's long-term water budget and is a key element of the County's strategy for sustainable water management. Accordingly, the opportunity to incorporate the Town of Virgin into a regional sewer and reuse system is substantial and would align the Town with countywide efforts to enhance water supply reliability and long-term resource stewardship. Notably, Virgin Town's potable water source is WCWCD's Cottam Well system; so, collection of wastewater in Virgin Town would allow the return of WCWCD source water into the reuse system.

Given Virgin Town's current small population and early stage of development, the Town is in a favorable position to plan for and implement sewer infrastructure before higher densities and additional septic systems make such a transition more difficult and expensive in the future. To facilitate this trend, the Town may consider policies which require septic users to connect to sewer trunk lines when they become available.

8.4 Additional Water Quality Considerations

Laboratory analyses of groundwater and surface water samples obtained for this project identified trace levels of other contaminants, including caffeine, PFOA compounds, and pharmaceutical or industrial chemicals. Although nitrate remains the primary constituent of concern for this study, the detection of emerging contaminants is noteworthy.

PFOA, in particular, presents serious long-term concerns because:

- They are highly persistent in the environment and resist natural degradation.
- Their extreme mobility in groundwater allows them to migrate over large distances, forming difficult-to-remediate plumes.
- Health effects at very low concentrations are prompting increasingly strict regulations and treatment requirements.

Utah Administrative Code does not have state-specific numeric water quality criterion for PFOA in waters of the state. However, policy makers should consider the potential impact of PFOA and other PFAS compounds if allowable septic density is changed. Increased septic system density could raise the potential for additional and more complex groundwater impacts over time.

8.5 Long-Term Planning and Community Benefits

Under the current restriction of one septic system per acre, opportunities for growth are limited. Sewer infrastructure would enable future zoning adjustments and more efficient land use, promoting both housing affordability and economic opportunity for current and future residents of Virgin Town.

8.6 Discussion Summary

Due to the uncertainty associated with the extent of and long-term groundwater quality of the shallow bedrock aquifer, a cautious approach to policy change is warranted. It is recommended that Virgin Town seek additional understanding of the shallow bedrock aquifer before making significant changes to the allowable septic density.

The implementation of a municipal sewer collection and treatment system offers a forward-looking solution that not only protects local water resources but also supports the County's broader goals of water reuse and sustainable growth. Maintaining the current septic density limit, while pursuing both additional understanding of the deeper groundwater aquifer and opportunities for sewer infrastructure, represents a prudent and balanced path forward for Virgin Town.

9 SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Sunrise completed a groundwater protection study for the Town of Virgin. In this study, Sunrise performed the following tasks:

In this study, Sunrise performed the following tasks:

- Previous readily available study reports for the septic systems in the Town of Virgin were reviewed.
- Four piezometers were installed for groundwater quality monitoring and sampling.
- Water samples were collected monthly from the four piezometers between June 2024 and May 2025. Surface water samples were also collected at three locations: two in the Virgin River (one upstream of the town and one downstream of the town) and one in North Creek. Additionally, two sampling events took place at the Truman Well in April and May 2025.
- Collected water samples were analyzed in two different laboratories. First, the water samples collected between June and December 2024 were analyzed by the Southern Utah University Water Lab. Once Sunrise realized that the nitrate concentration in the water sample collected at the upstream Virgin River location was higher than that in the water sample collected at the downstream Virgin River location, Sunrise delivered the water samples collected between January and May 2025 to the Chemtech-Ford Laboratories for laboratory analysis.
- Laboratory data were analyzed, and inverse modeling was performed to solve the ambient groundwater flow of the alluvial aquifer. Based on the inverse modeling results, the lot size can be lowered to 0.76 acres/ERU when using the estimated ambient groundwater flow from the average of the 95% confidence upper limits of laboratory results for the four groundwater sampling points.
- Based on the inverse modeling results and analysis of the laboratory data, Sunrise realized that the mass balance approach used in previous studies needed to be improved and an alternate approach was provided in this study.
- Sampling for emerging contaminants commonly associated with wastewater resulted in several anthropomorphic compounds being detected in the groundwater monitoring wells. These constituents were only sampled once toward the end of the study period, limiting the ability to establish trends or determine their impact on the river.
- The results of the data collection and evaluations were summarized in a draft of the study.
- The study draft was reviewed by a third-party. Loughlin Water Associates (Loughlin) performed this review.

Based on the work completed, Sunrise concludes the following:

- The alternate approach assumes that nitrate originating from septic systems and irrigation recharge in the Town of Virgin migrates into two distinct aquifer systems: the alluvial aquifer and a shallow bedrock aquifer. Based on these assumptions and the available sample results, it was hypothesized that approximately 12% of the nitrate from septic systems and irrigation recharge migrates to the alluvial aquifer that is connected to the Virgin River, while the remaining nitrate migrates to a shallow bedrock aquifer with apparently limited hydraulic connectivity to the Virgin River.

- Based on geologic data, the known productive regional drinking water aquifers, Navajo Sandstone, Kayenta, and Shinarump Conglomerate, are not present in Virgin. These formations are exposed in the cliffs above Virgin. Moreover, the groundwater in the Virgin area has a high concentration of TDS (above 3,000 mg/L). Therefore, the bedrock aquifer is not anticipated to be developed for drinking water sources. However, due to the uncertainty of the groundwater behavior and potential contaminant spread in the shallow bedrock aquifer, a cautious approach to policy change is warranted.
- Using the improved mass balance approach, the following results are obtained at buildout:

Lot Size	0.76 acres/lot
Total Residential ERUs	4,008
Total Standard Commercial ERUs	120
Total Commercial ERUs (75% Nitrate Removal)	2,248
Nitrate Concentration in Alluvial Aquifer	2.13 mg/L
Nitrate Concentration in Shallow Bedrock Aquifer	13.3 mg/L

- Sensitivity analysis indicates that the nitrate concentration in groundwater is sensitive to the percentage of nitrate loading from septic systems and irrigation water recharge. However, when the percentage was halved or doubled, the estimated nitrate concentration was still below 4 mg/L in the alluvial aquifer.
- During the third-party review, Loughlin introduced another alternative hypothesis to explain the results, which differed from the alternative proposed by Sunrise. This hypothesis included the possibility that algae in the river may be assimilating a substantial portion of the nitrate load.
- Without additional investigation, this study is unable to conclude the accuracy of either alternative explanation.
- These alternative explanations, together with laboratory evidence of emerging contaminants in the aquifer adjacent to the river, highlight the need for additional data collection to reduce uncertainty and more fully evaluate the assumptions used in groundwater flow and nitrate-transport interpretations.

Based on the work completed, Sunrise recommends the following:

- Current 90% nitrate removal requirement should continue, and no additional restriction is recommended for commercial developments.
- The exact groundwater conditions within Virgin Town remain unknown, as there are lingering uncertainties. Before making significant changes to the allowable septic density, it is recommended that Virgin Town seek additional understanding of the groundwater and surface water interaction between both the alluvial and shallow bedrock aquifers. Furthermore, the amount of nitrogen mass that is taken up from in-stream processes is unknown. Further studies should investigate the in-stream nitrogen regulating dynamics to evaluate whether, and what percent, of the nitrogen mass is accounted for by in-stream processes.
- Maintaining the current septic density limit while pursuing opportunities for sewer infrastructure represents a prudent and balanced path forward for Virgin Town.

- The Town may consider policies which require septic users to connect to sewer trunk lines when they become available.

The groundwater protection study conducted for the Town of Virgin provides new insight into the potential influence of septic systems on water quality. While the data collected during the study improves the understanding of site-specific conditions, uncertainties remain. Additional monitoring and evaluation of the interaction of the aquifer with the river will be essential to refine models and support future policy decisions. In the meantime, maintaining current septic density limits and nitrate-removal requirements for commercial properties, while pursuing options for future sewer infrastructure, is a measured approach for the Town of Virgin.

10 GENERAL COMMENTS

The services provided for this project, as described in this report, include professional opinions and judgments based on the data collected and analyzed. These services were performed in accordance with current generally accepted water resources engineering principles and practices.

This report does not provide a warranty as to variable subsurface conditions (including production) that may exist. This report does not apply to the areas outside of the study area. In addition, evaluation of geologic and hydrogeologic conditions is a difficult task. Engineers and hydrogeologists must occasionally make general judgments leading to conclusions with incomplete knowledge of the geologic history, subsurface conditions, and hydraulic characteristics present. The estimated aquifer parameter values are based on geologic information gathered from geologic maps, published and unpublished reports, and have not been verified by subsurface field investigations. As additional information becomes available, the interpretations and recommendations expressed in this report will be subject to revision.

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Appendix A

Water Well Log

WL1

WELL DRILLER'S REPORT
State of Utah
Division of Water Rights

For additional space, use "Additional Well Data Form" and attach

Well Identification

CHANGE APPLICATION: a22452(81-3864)

RECEIVED
NOV 29 1999
WATER RIGHTS

Owner *Note any changes*

Truman, Grant S.
170 North 100 East, PO Box 155
Virgin, UT 84779

Contact Person/Engineer:

Well Location *Note any changes*

COUNTY: Washington
NORTH 1360 feet WEST 950 feet from the SE Corner of
SECTION 22, TOWNSHIP 41S, RANGE 12W, SLB&M.

Location Description: (address, proximity to buildings, landmarks, ground elevation, local well #)

~~In Virgin Town~~

Drillers Activity Start Date: Nov 4 99 Completion Date: Nov 16 99

Check all that apply:
☐ New ☐ Repair ☐ Deepen ☐ Abandon ☐ Replace ☐ Public Nature of Use:

DEPTH (feet) FROM	TO	BOREHOLE DIAMETER (in)	DRILLING METHOD	DRILLING FLUID
0	18	10	Cable	water
18	150	6"	Cable	

Well Log

DEPTH (feet) FROM	TO	WATER	PERMEABLE high	PERMEABLE low	CLAY	SILT	SAND	GRAVEL	COBBLES	BOULDER	OTHER	ROCK TYPE	COLOR	DESCRIPTIONS AND REMARKS (include comments on *water quality* if known.)
0	6												Brown	Soil
6	30						X	X		X				
30	38				X	X		X						
38	68												red	shale
68	80												red	shale
80	120												"	"
120	150												red	shale

Static Water Level

Date Nov 16 99 Water Level 20 feet Flowing? ☐ Yes ☒ No

Method of Water Level Measurement Tape If Flowing, Capped Pressure ______ PSI

Point to Which Water Level Measurement was Referenced ground

Height of Water Level reference point above ground surface ______ feet Temperature ______ ☐ °C ☐ °F

Well Log

Construction Information

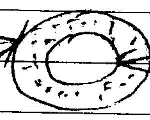
DEPTH (feet) FROM	TO	CASING TYPE AND MATERIAL/GRADE	WALL THICK (in)	NOMINAL DIAM. (in)	DEPTH (feet) FROM	TO	SLOT SIZE OR PERF SIZE (in)	SCREEN DIAM. OR PERF LENGTH (in)	SCREEN TYPE OR NUMBER PERF (per round/interval)
+18"	41	Steel	.250	6"	30	35	1/4 X 2		8 per ft.

CASING — SCREEN ☐ PERFORATIONS ☐

Well Head Configuration: Well seal Access Port Provided? ☐ Yes ☒ No

Casing Joint Type: Weld Perforator Used: Mills

FILTER PACK / GROUT / PACKER / ABANDONMENT MATERIAL

DEPTH (feet) FROM	TO	ANNULAR MATERIAL, ABANDONMENT MATERIAL and/or PACKER DESCRIPTION	Quantity of Material Used (if applicable)	GROUT DENSITY (lbs./gal.,# bag mix, gal./sack etc.)
0	18	Cement	7 cu ft	
		10"  6"	approx 12 cubic ft.	6 sag

Well Development / Pump or Bail Tests

Date	Method	Yield	Units GPM	Units CFS	DRAWDOWN (ft)	TIME PUMPED (hrs & min)
Nov 16-94	pump	3½	X			2 hrs

Pump (Permanent)

Pump Description: Submersible Horsepower: 1/2 Pump Intake Depth: 84 feet

Approximate maximum pumping rate: 3½ Well disinfected upon completion? ☐ Yes ☒ No

Comments

Description of construction activity, additional materials used, problems encountered, extraordinary circumstances, abandonment / procedures. *Use additional well data form for more space.*

Well Driller Statement

This well was drilled or abandoned under my supervision, according to applicable rules and regulations, and this report is complete and correct to the best of my knowledge and belief.

Name Ballard Drilling Co License No. 212

(Person, Firm, or Corporation – Print or Type)

Signature [signature] Date Nov 22 94

(Licensed Well Driller)

Appendix B

Laboratory Reports

Southern Utah University
WATER LAB
"Chemical and Bacteriological Testing"

Report of Analysis

Name:	Sunrise Engineering 11 North 300 W Washington, UT 84780	**Sample ID#:**	K2024 01306
Sample Date:	6/24/2024 4:55:00 PM	**Sample Type:**	Ground Water
Receipt Date:	6/25/2024 9:20:00 AM	**Sampler:**	PAUL ANDERSEN
Report Date:	7/26/2024		
Sample Site:	GWMW #4		

Parameter	Sample Result	Units	MRL	Method	Analysis Date	Analysis Time	Analyst
Receiving pH	7.11	SU	0	4500 H	6/25/2024	10:46:00 AM	BR
Receiving Temperature	18.3	C	0	2550	6/25/2024	10:46:00 AM	BR
Nitrate+Nitrite Total	1.87	mg/L	0.1	353.3	7/10/2024	9:45:00 AM	NB
Total Dissolved Solids	3000	mg/L	20	2540 C	6/28/2024	8:00:00 AM	BR

Report Approved By: ______________________
Kim Weaver, Director

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Southern Utah University Science Center • Room 206
www.suu.edu/waterlab

Southern Utah University
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"Chemical and Bacteriological Testing"

Report of Analysis

Name:	Sunrise Engineering 11 North 300 W Washington, UT 84780	**Sample ID#:**	K2024 01307
Sample Date:	6/24/2024 5:25:00 PM	**Sample Type:**	Ground Water
Receipt Date:	6/25/2024 9:20:00 AM	**Sampler:**	PAUL ANDERSEN
Report Date:	7/26/2024		
Sample Site:	GWMW #3		

Parameter	Sample Result	Units	MRL	Method	Analysis Date	Analysis Time	Analyst
Receiving pH	7.21	SU	0	4500 H	6/25/2024	10:46:00 AM	BR
Receiving Temperature	19.2	C	0	2550	6/25/2024	10:46:00 AM	BR
Nitrate+Nitrite Total	0.634	mg/L	0.1	353.3	7/10/2024	9:45:00 AM	NB
Total Dissolved Solids	3805	mg/L	20	2540 C	6/28/2024	8:00:00 AM	BR

Report Approved By: Kim Weaver, Director

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Report of Analysis

Name:	Sunrise Engineering 11 North 300 W Washington, UT 84780	**Sample ID#:**	K2024 01308
Sample Date:	6/24/2024 5:55:00 PM	**Sample Type:**	Ground Water
Receipt Date:	6/25/2024 9:20:00 AM	**Sampler:**	PAUL ANDERSEN
Report Date:	7/26/2024		
Sample Site:	GWMW #2		

Parameter	Sample Result	Units	MRL	Method	Analysis Date	Analysis Time	Analyst
Receiving pH	7.25	SU	0	4500 H	6/25/2024	10:46:00 AM	BR
Receiving Temperature	16.3	C	0	2550	6/25/2024	10:46:00 AM	BR
Nitrate+Nitrite Total	0.412	mg/L	0.1	353.3	7/10/2024	9:45:00 AM	NB
Total Dissolved Solids	2640	mg/L	20	2540 C	7/1/2024	10:18:00 AM	JW

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Report of Analysis

Name:	Sunrise Engineering 11 North 300 W Washington, UT 84780	**Sample ID#:**	K2024 01309
Sample Date:	6/24/2024 4:25:00 PM	**Sample Type:**	Ground Water
Receipt Date:	6/25/2024 9:20:00 AM	**Sampler:**	PAUL ANDERSEN
Report Date:	7/26/2024		
Sample Site:	GWMW #1		

Parameter	Sample Result	Units	MRL	Method	Analysis Date	Analysis Time	Analyst
Receiving pH	7.32	SU	0	4500 H	6/25/2024	10:46:00 AM	BR
Receiving Temperature	16.1	C	0	2550	6/25/2024	10:46:00 AM	BR
Nitrate+Nitrite Total	0.144	mg/L	0.1	353.3	7/10/2024	9:45:00 AM	NB
Total Dissolved Solids	2780	mg/L	20	2540 C	7/1/2024	10:18:00 AM	JW

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Report of Analysis

Name:	Sunrise Engineering 11 North 300 W Washington, UT 84780	**Sample ID#:**	K2024 01310
Sample Date:	6/24/2024 6:57:00 PM	**Sample Type:**	Surface Water
Receipt Date:	6/25/2024 9:20:00 AM	**Sampler:**	PAUL ANDERSEN
Report Date:	7/26/2024		
Sample Site:	SW #1		

Parameter	Sample Result	Units	MRL	Method	Analysis Date	Analysis Time	Analyst
Receiving pH	8.13	SU	0	4500 H	6/25/2024	10:46:00 AM	BR
Receiving Temperature	10.9	C	0	2550	6/25/2024	10:46:00 AM	BR
Nitrate+Nitrite Total	<0.1	mg/L	0.1	353.3	7/10/2024	9:45:00 AM	NB
Total Dissolved Solids	320	mg/L	20	2540 C	7/1/2024	10:18:00 AM	JW

Report Approved By: ______________________
Kim Weaver, Director

Southern Utah University
WATER LAB
"Chemical and Bacteriological Testing"

Report of Analysis

Name: Sunrise Engineering
11 North 300 W
Washington, UT 84780

Sample Date: 6/24/2024 7:13:00 PM
Receipt Date: 6/25/2024 9:20:00 AM
Report Date: 7/26/2024
Sample Site: SW #2

Sample ID#: K2024 01311
Sample Type: Surface Water
Sampler: PAUL ANDERSEN

Parameter	Sample Result	Units	MRL	Method	Analysis Date	Analysis Time	Analyst
Receiving pH	7.84	SU	0	4500 H	6/25/2024	10:46:00 AM	BR
Receiving Temperature	11.1	C	0	2550	6/25/2024	10:46:00 AM	BR
Nitrate+Nitrite Total	0.485	mg/L	0.1	353.3	7/10/2024	9:45:00 AM	NB
Total Dissolved Solids	1990	mg/L	20	2540 C	7/12/2024	11:00:00 AM	BR

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Report of Analysis

Name:	Sunrise Engineering 11 North 300 W Washington, UT 84780	**Sample ID#:**	K2024 01312
Sample Date:	6/24/2024 7:42:00 PM	**Sample Type:**	Surface Water
Receipt Date:	6/25/2024 9:20:00 AM	**Sampler:**	PAUL ANDERSEN
Report Date:	7/26/2024		
Sample Site:	SW #3		

Parameter	Sample Result	Units	MRL	Method	Analysis Date	Analysis Time	Analyst
Receiving pH	8.18	SU	0	4500 H	6/25/2024	10:46:00 AM	BR
Receiving Temperature	13.6	C	0	2550	6/25/2024	10:46:00 AM	BR
Nitrate+Nitrite Total	0.185	mg/L	0.1	353.3	7/19/2024	3:48:44 PM	NB
Nitrate+Nitrite Total	0.185	mg/L	0.1	353.3	7/19/2024	3:48:44 PM	NB
Total Dissolved Solids	320	mg/L	20	2540 C	7/12/2024	3:00:00 PM	BR

Report Approved By: ______________________
Kim Weaver, Director

Southern Utah University Water Laboratory

Analysis Request Form / Chain of Custody

Company Sunrise Engineering
Address 11 North 300W
City Washington State UT Zip 84780
Phone 435 652 8450 Fax
Contact Paul Andersen Project ID Virgin Town Groundwater
Email Address Paul.andersen@sunrise-eng.com

Billing Address 11 North 300 West
Billing City Washington State UT Zip 84780
SUU Account # T

❒ Digestion Required

For Utah Water Systems Only:
Send results to state (UT)? ❒Yes ☒No ________(initials)
UTAH Water System ID:________

Lab ID#	Sample Location	Sample Date	Sample Time	Number of Containers	Matrix: Drinking Water	Matrix: Ground Water	Matrix: Surface Water	Matrix: Waste Water	Matrix: Other (Specify):	Analysis Requested: Total Nitrate / Nitrite	Nitrite	Nitrate	Sulfate	BOD / COD / TSS	Lead & Copper	Primary Inorganics	Secondary Inorganics	TDS	Receiving Temp			Receiving pH					
K202401306	1. GWMW #4	6/24/24	16:55			X				X								X	18.3			7.1					
K202401307	2. GWMW #3	6/24/24	17:25			X				X								X	19.2			7.21					
K202401308	3. GWMW #2	6/24/24	17:55			X				X								X	16.3			7.25					
K202401309	4. GWMW #1	6/24/24	18:25			X				X								X	16.1			7.32					
K202401310	5. SW #1	6/24/24	18:57				X			X								X	10.9			8.13					
K202401311	6. SW #2	6/24	19:13				X			X								X	11.1			7.84					
K202401312	7. SW #3	6/24	19:42				X			X								X	13.6			8.18					
	8.																										
	9.																										
	10.																										

Sampled by: (print) Paul Andersen
Sampled by: (signature)
Receiving Temp. (C):
Receiving PH:
Special Instruction
Sampled Delivered by Courier:

Relinquished by: (signature)	Received by: (signature)	Date/Time 6/25/24 0920	Comments
Relinquished by: (signature)	Received by: (signature)	Date/Time	Comments
Relinquished by: (signature)	Received by: (signature)	Date/Time	Comments

Southern Utah University Water Lab
351 West Center Street
Room 206, Science Bldg.
Cedar City, UT 84720
Phone (435) 586-7914
(435) 865-8395
Fax (435) 865-8051

White: Original Yellow: File Pink: Customer

Southern Utah University
WATER LAB
"Chemical and Bacteriological Testing"

Report of Analysis

Name: Sunrise Engineering
11 N 300 W
Washington, UT 84780
Sample Date: 7/25/2024 9:17:00 AM
Receipt Date: 7/25/2024 1:34:00 PM
Report Date: 8/23/2024
Sample Site: GWMW #1 (Lee)

Sample ID#: K2024 01665
Sample Type: Ground Water
Sampler: PAUL ANDERSEN

Parameter	Sample Result	Units	MRL	Method	Analysis Date	Analysis Time	Analyst
Receiving pH	6.61	SU	0	4500 H	7/25/2024	2:40:00 PM	BR
Receiving Temperature	24.9	C	0	2550	7/25/2024	2:40:00 PM	BR
Nitrate+Nitrite Total	0.115	mg/L	0.1	353.3	7/30/2024	8:50:00 AM	NB
Total Dissolved Solids	3560	mg/L	20	2540 C	7/26/2024	9:30:00 AM	BR

Report Approved By:
Kim Weaver, Director

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Southern Utah University
WATER LAB
"Chemical and Bacteriological Testing"

Report of Analysis

Name: Sunrise Engineering
11 N 300 W
Washington, UT 84780
Sample Date: 7/25/2024 10:05:00 AM
Receipt Date: 7/25/2024 1:34:00 PM
Report Date: 8/23/2024
Sample Site: GWMW #2 (Ferber)

Sample ID#: K2024 01666
Sample Type: Ground Water
Sampler: PAUL ANDERSEN

Parameter	Sample Result	Units	MRL	Method	Analysis Date	Analysis Time	Analyst
Receiving pH	6.85	SU	0	4500 H	7/25/2024	2:40:00 PM	BR
Receiving Temperature	25.4	C	0	2550	7/25/2024	2:40:00 PM	BR
Nitrate+Nitrite Total	<0.1	mg/L	0.1	353.3	7/30/2024	8:50:00 AM	NB
Total Dissolved Solids	3340	mg/L	20	2540 C	7/26/2024	9:30:00 AM	BR

Report Approved By:
Kim Weaver, Director

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Report of Analysis

Name:	Sunrise Engineering 11 N 300 W Washington, UT 84780	**Sample ID#:**	K2024 01667
Sample Date:	7/25/2024 11:10:00 AM	**Sample Type:**	Ground Water
Receipt Date:	7/25/2024 1:34:00 PM	**Sampler:**	PAUL ANDERSEN
Report Date:	8/23/2024		
Sample Site:	GWMW #3		

Parameter	Sample Result	Units	MRL	Method	Analysis Date	Analysis Time	Analyst
Receiving pH	6.79	SU	0	4500 H	7/25/2024	2:40:00 PM	BR
Receiving Temperature	23.4	C	0	2550	7/25/2024	2:40:00 PM	BR
Nitrate+Nitrite Total	<0.1	mg/L	0.1	353.3	7/30/2024	8:50:00 AM	NBB
Total Dissolved Solids	6040	mg/L	20	2540 C	8/1/2024	8:30:00 AM	BR

Report Approved By: [signature]
Kim Weaver, Director

Southern Utah University
WATER LAB
"Chemical and Bacteriological Testing"

Report of Analysis

Name: Sunrise Engineering
11 N 300 W
Washington, UT 84780
Sample Date: 7/25/2024 11:35:00 AM
Receipt Date: 7/25/2024 1:34:00 PM
Report Date: 8/23/2024
Sample Site: GWMW #4 (Town)

Sample ID#: K2024 01668
Sample Type: Ground Water
Sampler: PAUL ANDERSEN

Parameter	Sample Result	Units	MRL	Method	Analysis Date	Analysis Time	Analyst
Receiving pH	6.75	SU	0	4500 H	7/25/2024	2:40:00 PM	BR
Receiving Temperature	23.9	C	0	2550	7/25/2024	2:40:00 PM	BR
Nitrate+Nitrite Total	0.187	mg/L	0.1	353.3	7/30/2024	8:50:00 AM	NB
Total Dissolved Solids	3340	mg/L	20	2540 C	8/1/2024	8:30:00 AM	BR

Report Approved By: Kim Weaver, Director

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Report of Analysis

Name:	Sunrise Engineering 11 N 300 W Washington, UT 84780	**Sample ID#:**	K2024 01669
Sample Date:	7/25/2024 9:08:00 AM	**Sample Type:**	Surface Water
Receipt Date:	7/25/2024 1:34:00 PM	**Sampler:**	PAUL ANDERSEN
Report Date:	8/23/2024		
Sample Site:	SW #1 U/S		

Parameter	Sample Result	Units	MRL	Method	Analysis Date	Analysis Time	Analyst
Receiving pH	7.74	SU	0	4500 H	7/25/2024	2:40:00 PM	BR
Receiving Temperature	23.3	C	0	2550	7/25/2024	2:40:00 PM	BR
Nitrate+Nitrite Total	0.247	mg/L	0.1	353.3	7/30/2024	8:50:00 AM	NB
Total Dissolved Solids	450	mg/L	20	2540 C	8/1/2024	8:30:00 AM	BR

Report Approved By:
Kim Weaver, Director

Southern Utah University
WATER LAB
"Chemical and Bacteriological Testing"

Report of Analysis

Name: Sunrise Engineering
11 N 300 W
Washington, UT 84780
Sample Date: 7/25/2024 10:28:00 AM
Receipt Date: 7/25/2024 1:34:00 PM
Report Date: 8/23/2024
Sample Site: SW #2 (North Crk)

Sample ID#: K2024 01670
Sample Type: Surface Water
Sampler: PAUL ANDERSEN

Parameter	Sample Result	Units	MRL	Method	Analysis Date	Analysis Time	Analyst
Receiving pH	7.23	SU	0	4500 H	7/25/2024	2:40:00 PM	BR
Receiving Temperature	24.7	C	0	2550	7/25/2024	2:40:00 PM	BR
Nitrate+Nitrite Total	1.22	mg/L	0.1	353.3	8/10/2024	9:45:00 AM	NB
Total Dissolved Solids	2120	mg/L	20	2540 C	8/2/2024	2:00:00 PM	BR

Report Approved By: ______________________
Kim Weaver, Director

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"Chemical and Bacteriological Testing"

Report of Analysis

Name:	Sunrise Engineering 11 N 300 W Washington, UT 84780	**Sample ID#:**	K2024 01671
Sample Date:	7/25/2024 12:07:00 PM	**Sample Type:**	Surface Water
Receipt Date:	7/25/2024 1:34:00 PM	**Sampler:**	PAUL ANDERSEN
Report Date:	8/23/2024		
Sample Site:	SW #3 (d/s)		

Parameter	Sample Result	Units	MRL	Method	Analysis Date	Analysis Time	Analyst
Receiving pH	7.81	SU	0	4500 H	7/25/2024	2:40:00 PM	BR
Receiving Temperature	24.6	C	0	2550	7/25/2024	2:20:00 PM	BR
Nitrate+Nitrite Total	0.422	mg/L	0.1	353.3	8/10/2024	9:45:00 AM	NB
Total Dissolved Solids	420	mg/L	20	2540 C	8/2/2024	2:00:00 PM	BR

Report Approved By: Kim Weaver, Director

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Southern Utah Water Laboratory

Analysis Request Form/ Chain of Custody

Company: Sunrise Engineering
Address: 11 N 300 W.
City: Washington State: UT Zip: 84780
Phone: (435) - 652 - 8450 Fax:
Contact: PAUL Andersen
Project ID/Water System ID: Virgin Town GW Protection Study
Email: paul.andersen@sunrise-eng.com

☐ Digestion Required

Billing Address: SAME AS Physical City:
State: Zip: Contact: Carole Ingalls
Email: cingalls@sunrise-eng.com

					Matrix					Analysis Requested																	
Lab ID#	Sample Location	Sample Date	Sample Time	Number of Containers	Drinking Water	Ground Water	Surface Water	Waste Water	Other (specify):	? Total Nitrate/Nitrite	Nitrite	? ~~Nitrate~~	Sulfate	TDS/TSS/COD	Lead & Copper	Primary Inorganics	Secondary Inorganics		Temp Receiving	pH							
K2024 01665	1. GWMW#1 (LEE)	7/25/24	9:17 AM	1		/				X		/		/					24.4	6.1							
K2024 01666	2. GWMW #2 (Ferbd)	7/25/24	10:05 AM	1		/				X		/		/					25.4	6.8							
K2024 01667	3. [illegible]	7/25/24	[illegible]	1		/				X		/		/					23.4	7.7							
K2024 01668	4. GWMW#4 (Town)	7/25/24	11:35 AM	1		/				X		/		/					23.9	6.7							
K2024 01669	5. SW#1 U/S	7/25/24	9:09 AM	1			/			X		/		/					23.3	7.7							
K2024 01670	6. SW#2 (North cee)	7/25/24	10:20 AM	1			/			X		/		/					24.7	7.2							
K2024 01671	7. SW#3 (D/S)	7/25/24	12:07 PM	1			/			X		/		/					24.6	7.8							
	8.																										
	9.																										
	10.																										

GWMW#3 11:10 AM

Sampled by: (print) PAUL Andersen
Sampled by: (Signiture): [signature]
Receiving Temp.:
Receiving pH:

Special Instruction

Sample Delivered by Courier:

Relinquished by: (Signiture) [signature]	Received by (Signiture): [signature]	Date/Time 07/25/24	Comments
Relinquished by: (Signiture)	Received by (Signiture):	Date/Time	Comments
Relinquished by: (Signiture)	Received by (Signiture):	Date/Time	Comments

13:34

Southern Utah University
WATER LAB
"Chemical and Bacteriological Testing"

Report of Analysis

Name: Sunrise Engineering
11 N 300 W
Washington, UT 84780
Sample Date: 8/30/2024 10:28:00 AM
Receipt Date: 8/30/2024 2:29:00 PM
Report Date: 10/22/2024
Sample Site: GWMW #1

Sample ID#: K2024 02049
Sample Type: Ground Water
Sampler: PAUL ANDERSEN

Parameter	Sample Result	Units	MRL	Method	Analysis Date	Analysis Time	Analyst
Receiving pH	7.05	SU	0	4500 H	8/30/2024	2:30:00 PM	BR
Receiving Temperature	5.2	C	0	2550	8/30/2024	2:30:00 PM	BR
Nitrate+Nitrite Total	0.133	mg/L	0.1	353.3	10/6/2024	9:30:00 AM	NB
Total Dissolved Solids	3120	mg/L	20	2540 C	9/5/2024	9:00:00 AM	BR

Report Approved By:
Kim Weaver, Director

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"Chemical and Bacteriological Testing"

Report of Analysis

Name: Sunrise Engineering
11 N 300 W
Washington, UT 84780

Sample Date: 8/30/2024 11:00:00 AM
Receipt Date: 8/30/2024 2:29:00 PM
Report Date: 10/22/2024
Sample Site: GWMW #2

Sample ID#: K2024 02050
Sample Type: Ground Water
Sampler: PAUL ANDERSEN

Parameter	Sample Result	Units	MRL	Method	Analysis Date	Analysis Time	Analyst
Receiving pH	7.08	SU	0	4500 H	8/30/2024	2:30:00 PM	BR
Receiving Temperature	6.5	C	0	2550	8/30/2024	2:30:00 PM	BR
Nitrate+Nitrite Total	<0.1	mg/L	0.1	353.3	10/6/2024	9:30:00 AM	NB
Total Dissolved Solids	3420	mg/L	20	2540 C	9/5/2024	9:00:00 AM	BR

Report Approved By: ______________________
Kim Weaver, Director

Southern Utah University
WATER LAB
"Chemical and Bacteriological Testing"

Report of Analysis

Name:	Sunrise Engineering 11 N 300 W Washington, UT 84780	**Sample ID#:**	K2024 02051
Sample Date:	8/30/2024 11:50:00 AM	**Sample Type:**	Ground Water
Receipt Date:	8/30/2024 2:29:00 PM	**Sampler:**	PAUL ANDERSEN
Report Date:	10/22/2024		
Sample Site:	GWMW #3		

Parameter	Sample Result	Units	MRL	Method	Analysis Date	Analysis Time	Analyst
Receiving pH	7.05	SU	0	4500 H	8/30/2024	2:30:00 PM	BR
Receiving Temperature	5.1	C	0	2550	8/30/2024	2:30:00 PM	BR
Nitrate+Nitrite Total	0.257	mg/L	0.1	353.3	10/1/2024	3:40:00 PM	NB
Total Dissolved Solids	5020	mg/L	20	2540 C	9/5/2024	9:00:00 AM	BR

Report Approved By: ______________________
Kim Weaver, Director

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Southern Utah University
WATER LAB
"Chemical and Bacteriological Testing"

Report of Analysis

Name: Sunrise Engineering
11 N 300 W
Washington, UT 84780
Sample Date: 8/30/2024 12:32:00 PM
Receipt Date: 8/30/2024 2:29:00 PM
Report Date: 10/22/2024
Sample Site: GWMW #4

Sample ID#: K2024 02052
Sample Type: Ground Water
Sampler: PAUL ANDERSEN

Parameter	Sample Result	Units	MRL	Method	Analysis Date	Analysis Time	Analyst
Receiving pH	7.16	SU	0	4500 H	8/30/2024	2:30:00 PM	BR
Receiving Temperature	5.6	C	0	2550	8/30/2024	2:30:00 PM	BR
Nitrate+Nitrite Total	0.781	mg/L	0.1	353.3	10/1/2024	3:40:00 PM	NB
Total Dissolved Solids	3420	mg/L	20	2540 C	9/5/2024	1:00:00 PM	BR

Report Approved By: ______________________
Kim Weaver, Director

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Southern Utah University
WATER LAB
"Chemical and Bacteriological Testing"

Report of Analysis

Name: Sunrise Engineering
11 N 300 W
Washington, UT 84780

Sample Date: 8/30/2024 10:05:00 AM
Receipt Date: 8/30/2024 2:29:00 PM
Report Date: 10/22/2024
Sample Site: SW #1 M/S

Sample ID#: K2024 02053
Sample Type: Surface Water
Sampler: PAUL ANDERSEN

Parameter	Sample Result	Units	MRL	Method	Analysis Date	Analysis Time	Analyst
Receiving pH	8.34	SU	0	4500 H	8/30/2024	2:30:00 PM	BR
Receiving Temperature	4.8	C	0	2550	8/30/2024	2:30:00 PM	BR
Nitrate+Nitrite Total	0.397	mg/L	0.1	353.3	10/1/2024	3:40:00 PM	NB
Total Dissolved Solids	460	mg/L	20	2540 C	9/5/2024	1:00:00 PM	BR

Report Approved By: ______________________
Kim Weaver, Director

Southern Utah University
WATER LAB
"Chemical and Bacteriological Testing"

Report of Analysis

Name: Sunrise Engineering
11 N 300 W
Washington, UT 84780
Sample Date: 8/30/2024 11:18:00 AM
Receipt Date: 8/30/2024 2:29:00 PM
Report Date: 10/22/2024
Sample Site: SW #2

Sample ID#: K2024 02054
Sample Type: Surface Water
Sampler: PAUL ANDERSEN

Parameter	Sample Result	Units	MRL	Method	Analysis Date	Analysis Time	Analyst
Receiving pH	7.99	SU	0	4500 H	8/30/2024	2:30:00 PM	BR
Receiving Temperature	5.3	C	0	2550	8/30/2024	2:30:00 PM	BR
Nitrate	0.179	mg/L	0.1	353.3	10/1/2024	3:40:00 PM	NB
Nitrate+Nitrite Total	0.179	mg/L	0.1	353.3	10/1/2024	3:40:00 PM	NB
Total Dissolved Solids	1650	mg/L	20	2540 C	9/5/2024	1:00:00 PM	BR

Report Approved By: ______________________
Kim Weaver, Director

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"Chemical and Bacteriological Testing"

Report of Analysis

Name: Sunrise Engineering
11 N 300 W
Washington, UT 84780
Sample Date: 8/30/2024 12:50:00 PM
Receipt Date: 8/30/2024 2:29:00 PM
Report Date: 10/22/2024
Sample Site: SW #3 D/S

Sample ID#: K2024 02055
Sample Type: Surface Water
Sampler: PAUL ANDERSEN

Parameter	Sample Result	Units	MRL	Method	Analysis Date	Analysis Time	Analyst
Receiving pH	8.44	SU	0	4500 H	8/30/2024	2:30:00 PM	BR
Receiving Temperature	5.4	C	0	2550	8/30/2024	2:30:00 PM	BR
Nitrate+Nitrite Total	0.314	mg/L	0.1	353.3	10/1/2024	3:40:00 PM	NB
Total Dissolved Solids	520	mg/L	20	2540 C	9/6/2024	1:00:00 PM	BR

Report Approved By:
Kim Weaver, Director

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www.suu.edu/waterlab

Southern Utah University Water Laboratory

Analysis Request Form / Chain of Custody

Company Sunrise Engineering

Address 11 N 300 W, Washington

City Washington State UT Zip 84780

Phone 385 207 9395 Fax

Contact Paul Andersen Project ID

Email Address Paul.Andersen@sunrise-eng.com

❒ Digestion Required

For Utah Water Systems Only:

Send results to state (UT)? ❒Yes ☒No ________(initials)

UTAH Water System ID:________

Billing Address SAME

Billing City________ State________ Zip________

SUU Account # T

Lab ID#	Sample Location	Sample Date	Sample Time	Number of Containers	Matrix: Drinking Water	Ground Water	Surface Water	Waste Water	Other (Specify):	Analysis Requested: Total Nitrate / Nitrite	Nitrite	Nitrate Totals	Sulfate	BOD / COD / TSS	Lead & Copper	Primary Inorganics	Secondary Inorganics	TDS	Nitrate			Receiving Temp			Receiving pH		
K202402049	1. GWMW #1	8/30/24	10:28			X						✓						✓				5.2					7.05
K202402050	2. GWMW #2		11:00			X						✓						✓				6.5					7.08
K202402051	3. " " #3		11:50			X						✓						✓				5.1					7.05
K202402052	4. " " #4		12:32			X						✓						✓				5.6			5.6		7.16
K202402053	5. SW #1 U/S		10:05				X					✓						✓				4.8			4.8		8.34
K202402054	6. SW #2		11:18				X					✓						✓	X			5.3			5.3		7.49
K202402055	7. SW #3 D/S		12:50				X					✓						✓				5.4			8.44		
	8.																										
	9.																										
	10.																										

Sampled by: (print) Paul Andersen

Sampled by: (signature)

Receiving Temp. (C):

Receiving PH:

Special Instruction Keep Receiving Temp < 10° C

Sampled Delivered by Courier:

Relinquished by: (signature)	Received by: (signature)	Date/Time 8-30-24 / 1429	Comments
Relinquished by: (signature)	Received by: (signature)	Date/Time	Comments
Relinquished by: (signature)	Received by: (signature)	Date/Time	Comments

Southern Utah University Water Lab
351 West Center Street
Room 206, Science Bldg.
Cedar City, UT 84720

Phone (435) 586-7914
(435) 865-8395
Fax (435) 865-8051

White: Original Yellow: File Pink: Customer

Southern Utah University
WATER LAB
"Chemical and Bacteriological Testing"

Report of Analysis

Name:	Sunrise Engineering 11 North 300 W Washington, UT 84780	**Sample ID#:**	K2024 02461
Sample Date:	9/27/2024 1:40:00 PM	**Sample Type:**	Ground Water
Receipt Date:	9/27/2024 3:15:00 PM	**Sampler:**	PAUL ANDERSEN
Report Date:	10/30/2024		
Sample Site:	GWMW #1		

Parameter	Sample Result	Units	MRL	Method	Analysis Date	Analysis Time	Analyst
Receiving pH	7.10	SU	0	4500 H	9/27/2024	3:48:00 PM	NB
Receiving Temperature	10.2	C	0	2550	9/27/2024	3:48:00 PM	NB
Nitrate+Nitrite Total	<0.1	mg/L	0.1	353.3	10/14/2024	9:30:00 AM	ZS
Total Dissolved Solids	2770	mg/L	20	2540 C	10/3/2024	9:30:00 AM	EM

Report Approved By: ________________________
Kim Weaver, Director

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"Chemical and Bacteriological Testing"

Report of Analysis

Name:	Sunrise Engineering 11 North 300 W Washington, UT 84780	**Sample ID#:**	K2024 02462
Sample Date:	9/27/2024 1:10:00 PM	**Sample Type:**	Ground Water
Receipt Date:	9/27/2024 3:15:00 PM	**Sampler:**	PAUL ANDERSEN
Report Date:	10/30/2024		
Sample Site:	GWMW #2		

Parameter	Sample Result	Units	MRL	Method	Analysis Date	Analysis Time	Analyst
Receiving pH	7.27	SU	0	4500 H	9/27/2024	3:48:00 PM	NB
Receiving Temperature	12.2	C	0	2550	9/27/2024	3:48:00 PM	NB
Nitrate+Nitrite Total	<0.1	mg/L	0.1	353.3	10/14/2024	9:30:00 AM	ZS
Total Dissolved Solids	3550	mg/L	20	2540 C	10/3/2024	9:30:00 AM	EM

Report Approved By: ______________________
Kim Weaver, Director

Southern Utah University
WATER LAB
"Chemical and Bacteriological Testing"

Report of Analysis

Name:	Sunrise Engineering 11 North 300 W Washington, UT 84780	**Sample ID#:**	K2024 02463
Sample Date:	9/27/2024 12:33:00 PM	**Sample Type:**	Ground Water
Receipt Date:	9/27/2024 3:15:00 PM	**Sampler:**	PAUL ANDERSEN
Report Date:	10/30/2024		
Sample Site:	GWMW #3		

Parameter	Sample Result	Units	MRL	Method	Analysis Date	Analysis Time	Analyst
Receiving pH	7.28	SU	0	4500 H	9/27/2024	3:48:00 PM	NB
Receiving Temperature	10.4	C	0	2550	9/27/2024	3:48:00 PM	NB
Nitrate+Nitrite Total	<0.1	mg/L	0.1	353.3	10/14/2024	9:30:00 AM	ZS
Total Dissolved Solids	4480	mg/L	20	2540 C	10/3/2024	9:30:00 AM	EM

Report Approved By:
Kim Weaver, Director

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Report of Analysis

Name:	Sunrise Engineering 11 North 300 W Washington, UT 84780	**Sample ID#:**	K2024 02464
Sample Date:	9/27/2024 11:57:00 AM	**Sample Type:**	Ground Water
Receipt Date:	9/27/2024 3:15:00 PM	**Sampler:**	PAUL ANDERSEN
Report Date:	10/30/2024		
Sample Site:	GWMW #4		

Parameter	Sample Result	Units	MRL	Method	Analysis Date	Analysis Time	Analyst
Receiving pH	7.13	SU	0	4500 H	9/27/2024	3:48:00 PM	NB
Receiving Temperature	11.8	C	0	2550	9/27/2024	3:48:00 PM	NB
Nitrate+Nitrite Total	0.613	mg/L	0.1	353.3	10/18/2024	9:30:00 AM	ZS
Total Dissolved Solids	3140	mg/L	20	2540 C	10/3/2024	3:20:00 PM	EM

Report Approved By: ______________________
Kim Weaver, Director

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Southern Utah University
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Report of Analysis

Name: Sunrise Engineering
11 North 300 W
Washington, UT 84780
Sample Date: 9/27/2024 1:50:00 PM
Receipt Date: 9/27/2024 3:15:00 PM
Report Date: 10/30/2024
Sample Site: SW #1

Sample ID#: K2024 02465
Sample Type: Surface Water
Sampler: PAUL ANDERSEN

Parameter	Sample Result	Units	MRL	Method	Analysis Date	Analysis Time	Analyst
Receiving pH	8.58	SU	0	4500 H	9/27/2024	4:10:00 PM	NB
Receiving Temperature	15.6	C	0	2550	9/27/2024	4:10:00 PM	NB
Nitrate+Nitrite Total	0.283	mg/L	0.1	353.3	10/14/2024	9:30:00 AM	ZS
Total Dissolved Solids	465	mg/L	20	2540 C	10/3/2024	3:20:00 PM	EM

Report Approved By: ______________________
Kim Weaver, Director

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Report of Analysis

Name: Sunrise Engineering
11 North 300 W
Washington , UT 84780

Sample Date: 9/27/2024 12:50:00 PM
Receipt Date: 9/27/2024 3:15:00 PM
Report Date: 10/30/2024
Sample Site: SW #2

Sample ID#: K2024 02466
Sample Type: Surface Water
Sampler: PAUL ANDERSEN

Parameter	Sample Result	Units	MRL	Method	Analysis Date	Analysis Time	Analyst
Receiving pH	7.94	SU	0	4500 H	9/27/2024	4:10:00 PM	NB
Receiving Temperature	15.2	C	0	2550	9/27/2024	4:10:00 PM	NB
Nitrate+Nitrite Total	0.185	mg/L	0.1	353.3	10/14/2024	9:30:00 AM	ZS
Total Dissolved Solids	1810	mg/L	20	2540 C	10/3/2024	3:20:00 PM	EM

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Report of Analysis

Name:	Sunrise Engineering 11 North 300 W Washington, UT 84780	**Sample ID#:**	K2024 02467
Sample Date:	9/27/2024 11:21:00 AM	**Sample Type:**	Surface Water
Receipt Date:	9/27/2024 3:15:00 PM	**Sampler:**	PAUL ANDERSEN
Report Date:	10/30/2024		
Sample Site:	SW #3		

Parameter	Sample Result	Units	MRL	Method	Analysis Date	Analysis Time	Analyst
Receiving pH	8.38	SU	0	4500 H	9/27/2024	4:10:00 PM	NB
Receiving Temperature	13.6	C	0	2550	9/27/2024	4:10:00 PM	NB
Nitrate+Nitrite Total	0.318	mg/L	0.1	353.3	10/14/2024	9:30:00 AM	ZS
Total Dissolved Solids	510	mg/L	20	2540 C	10/3/2024	3:20:00 PM	EM

Report Approved By: ______________________
Kim Weaver, Director

Southern Utah University Water Laboratory

Analysis Request Form / Chain of Custody

Company Sunrise Engineering

Address 11 N. 300 W

City Washington State UT Zip 84780

Phone 435 652 8450 Fax

Contact Paul Andersen Project ID Vazan BW Protection Study

Email Address Paul.Andersen@sunrise-eng.com

Billing Address 11 N 300 W

Billing City Washington State UT Zip 84780

SUU Account # T

❒ Digestion Required

For Utah Water Systems Only:

Send results to state (UT)? ❒Yes ☑No PA (initials)

UTAH Water System ID:

Lab ID#	Sample Location	Sample Date	Sample Time	Number of Containers	Drinking Water	Ground Water	Surface Water	Waste Water	Other (Specify):	Total Nitrate / Nitrite	Nitrite	Nitrate	Sulfate	BOD / COD / TSS	Lead & Copper	Primary Inorganics	Secondary Inorganics	TDS	temp.	pH							
K2024 02461	1. GWMW #1	9/27/24	[illegible] AM																[illegible]	7.10							
K2024 02462	2. GWMW #2		[illegible]																[illegible]	7.27							
K2024 02463	3. GWMW #3		[illegible]																10.4	7.28							
K2024 02464	4. GWMW #4		11:[illegible] AM																11.5	7.12							
K2024 02465	5. SW #1		1:50PM																15.6	[illegible].52							
K2024 02466	6. SW #2		12:50																15.[illegible]	7.9[illegible]							
K2024 02467	7. SW #3		11:21 AM																13.6	[illegible].38							
	8.																										
	9.																										
	10.																										

Sampled by: (print) PAUL ANDERSEN

Sampled by: (signature)

Receiving Temp. (C):

Receiving PH:

Special Instruction

Sampled Delivered by Courier:

Relinquished by: (signature)	Received by: (signature) 3:15PM	Date/Time 9/27/24	Comments
Relinquished by: (signature)	Received by: (signature)	Date/Time	Comments
Relinquished by: (signature)	Received by: (signature)	Date/Time	Comments

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351 West Center Street
Room 206, Science Bldg.
Cedar City, UT 84720

Phone (435) 586-7914
(435) 865-8395
Fax (435) 865-8051

White: Original Yellow: File Pink: Customer

Southern Utah University
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Report of Analysis

Name:	Sunrise Engineering 11 N 300 W Washington, UT 84780	**Sample ID#:**	K2024 02726
Sample Date:	10/31/2024 10:31:00 AM	**Sample Type:**	Drinking Water
Receipt Date:	10/31/2024 2:33:00 PM	**Sampler:**	PAUL ANDERSON
Report Date:	12/12/2024		
Sample Site:	SW #1		

Parameter	Sample Result	Units	MRL	Method	Analysis Date	Analysis Time	Analyst
Receiving pH	7.23	SU	0	4500 H	10/31/2024	2:40:00 PM	NB
Receiving Temperature	8.6	C	0	2550	10/31/2024	2:40:00 PM	NB
Nitrate+Nitrite Total	<0.1	mg/L	0.1	353.3	12/7/2024	12:00:00 PM	NB
Total Dissolved Solids	2580	mg/L	20	2540 C	11/5/2024	2:35:00 PM	EM

Report Approved By: ______________________
Kim Weaver, Director

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Report of Analysis

Name:	Sunrise Engineering 11 N 300 W Washington, UT 84780	**Sample ID#:**	K2024 02727
		Sample Type:	Drinking Water
		Sampler:	PAUL ANDERSON
Sample Date:	10/31/2024 11:31:00 AM		
Receipt Date:	10/31/2024 2:33:00 PM		
Report Date:	12/12/2024		
Sample Site:	SW #2		

Parameter	Sample Result	Units	MRL	Method	Analysis Date	Analysis Time	Analyst
Receiving pH	7.12	SU	0	4500 H	10/31/2024	2:40:00 PM	NB
Receiving Temperature	8.8	C	0	2550	10/31/2024	2:40:00 PM	NB
Nitrate+Nitrite Total	<0.1	mg/L	0.1	353.3	12/7/2024	12:00:00 PM	NB
Total Dissolved Solids	3600	mg/L	20	2540 C	11/5/2024	2:35:00 PM	EM

Report Approved By: KW

Kim Weaver, Director

Southern Utah University
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Report of Analysis

Name:	Sunrise Engineering 11 N 300 W Washington, UT 84780	**Sample ID#:**	K2024 02728
		Sample Type:	Drinking Water
		Sampler:	PAUL ANDERSON
Sample Date:	10/31/2024 1:05:00 PM		
Receipt Date:	10/31/2024 2:33:00 PM		
Report Date:	12/12/2024		
Sample Site:	SW #3		

Parameter	Sample Result	Units	MRL	Method	Analysis Date	Analysis Time	Analyst
Receiving pH	7.44	SU	0	4500 H	10/31/2024	2:40:00 PM	NB
Receiving Temperature	8.8	C	0	2550	10/31/2024	2:40:00 PM	NB
Nitrate+Nitrite Total	<0.1	mg/L	0.1	353.3	12/7/2024	12:00:00 PM	NB
Total Dissolved Solids	4090	mg/L	20	2540 C	11/5/2024	2:35:00 PM	EM

Report Approved By: ________________
Kim Weaver, Director

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Report of Analysis

Name:	Sunrise Engineering 11 N 300 W Washington , UT 84780	**Sample ID#:**	K2024 02729
		Sample Type:	Drinking Water
		Sampler:	PAUL ANDERSON
Sample Date:	10/31/2024 11:00:00 AM		
Receipt Date:	10/31/2024 2:33:00 PM		
Report Date:	12/12/2024		
Sample Site:	GWMW #1		

Parameter	Sample Result	Units	MRL	Method	Analysis Date	Analysis Time	Analyst
Receiving pH	7.48	SU	0	4500 H	10/31/2024	2:40:00 PM	NB
Receiving Temperature	9.2	C	0	2550	10/31/2024	2:40:00 PM	NB
Nitrate+Nitrite Total	1.73	mg/L	0.1	353.3	12/7/2024	12:00:00 PM	NB
Total Dissolved Solids	2770	mg/L	20	2540 C	11/6/2024	1:30:00 PM	BR

Report Approved By: ______________________
Kim Weaver, Director

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Report of Analysis

Name:	Sunrise Engineering 11 N 300 W Washington , UT 84780	**Sample ID#:**	K2024 02730
Sample Date:	10/31/2024 11:25:00 AM	**Sample Type:**	Drinking Water
Receipt Date:	10/31/2024 2:33:00 PM	**Sampler:**	PAUL ANDERSON
Report Date:	12/12/2024		
Sample Site:	GWMW #2		

Parameter	Sample Result	Units	MRL	Method	Analysis Date	Analysis Time	Analyst
Receiving pH	8.36	SU	0	4500 H	10/31/2024	2:40:00 PM	NB
Receiving Temperature	10.4	C	0	2550	10/31/2024	2:40:00 PM	NB
Nitrate+Nitrite Total	0.30	mg/L	0.1	353.3	12/7/2024	12:00:00 PM	NB
Total Dissolved Solids	475	mg/L	20	2540 C	11/6/2024	1:30:00 PM	BR

Report Approved By: ______________________
Kim Weaver, Director

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Report of Analysis

Name:	Sunrise Engineering 11 N 300 W Washington , UT 84780	**Sample ID#:**	K2024 02731
		Sample Type:	Drinking Water
		Sampler:	PAUL ANDERSON
Sample Date:	10/31/2024 12:10:00 PM		
Receipt Date:	10/31/2024 2:33:00 PM		
Report Date:	12/12/2024		
Sample Site:	GWMW #3		

Parameter	Sample Result	Units	MRL	Method	Analysis Date	Analysis Time	Analyst
Receiving pH	8.09	SU	0	4500 H	10/31/2024	2:40:00 PM	NB
Receiving Temperature	9.8	C	0	2550	10/31/2024	2:40:00 PM	NB
Nitrate+Nitrite Total	0.169	mg/L	0.1	353.3	12/7/2024	12:00:00 PM	NB
Total Dissolved Solids	1080	mg/L	20	2540 C	11/7/2024	11:50:00 AM	EM

Report Approved By: ______________________
Kim Weaver, Director

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Report of Analysis

Name: Sunrise Engineering
11 N 300 W
Washington , UT 84780
Sample Date: 10/31/2024 12:32:00 PM
Receipt Date: 10/31/2024 2:33:00 PM
Report Date: 12/12/2024
Sample Site: GWMW #4

Sample ID#: K2024 02732
Sample Type: Drinking Water
Sampler: PAUL ANDERSON

Parameter	Sample Result	Units	MRL	Method	Analysis Date	Analysis Time	Analyst
Receiving pH	8.41	SU	0	4500 H	10/31/2024	2:40:00 PM	NB
Receiving Temperature	8.8	C	0	2550	10/31/2024	2:40:00 PM	NB
Nitrate+Nitrite Total	0.475	mg/L	0.1	353.3	12/7/2024	12:00:00 PM	NB
Total Dissolved Solids	475	mg/L	20	2540 C	11/7/2024	11:50:00 AM	EM

Report Approved By: ______________________
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Southern Utah University Water Laboratory

Analysis Request Form / Chain of Custody

Company ______________________

Address ______________________

City ______________ State UT Zip ______

Phone ______________ Fax ______________

Contact ______________ Project ID ______________

Email Address ______________

❒ Digestion Required

For Utah Water Systems Only:
Send results to state (UT)? ❒Yes ❒No PA (initials)
UTAH Water System ID:________

Billing Address ______________________

Billing City ______________ State ________ Zip ________

SUU Account # T

Lab ID#		Sample Location	Sample Date	Sample Time	Number of Containers	Drinking Water	Ground Water	Surface Water	Waste Water	Other (Specify):	Total Nitrate / Nitrite	Nitrite	Nitrate	Sulfate	BOD / COD / TSS	Lead & Copper	Primary Inorganics	Secondary Inorganics	~~[illegible]~~ TDS BK 11/4/24	Temp.	pH
K2024 02726	1.	[illegible]	[illegible]	10:51		/					/								/	8.6	7.[illegible]
K2024 02727	2.	[illegible]		11:[illegible]		/					/								/	6.8	7.16
K2024 02728	3.	[illegible]		12:[illegible]		/					/								/	[illegible]	7.94
K2024 02729	4.	[illegible]		[illegible]		/					/								/	1.2	[illegible]
K2024 02730	5.	[illegible]		[illegible]		/					/								/	10.4	[illegible]
K2024 02731	6.	[illegible]		12:10		/					/								/	4.8	[illegible]
K2024 02732	7.	[illegible]		12:32		/					/								/	8.8	[illegible]
	8.																				
	9.																				
	10.																				

Sampled by: (print) [illegible]

Sampled by: (signature) [illegible]

Receiving Temp. (C):

Receiving PH:

Special Instruction

Sampled Delivered by Courier:

Relinquished by: (signature) [illegible]	Received by: (signature) [illegible]	Date/Time 10/31/24 1433	Comments
Relinquished by: (signature)	Received by: (signature)	Date/Time	Comments
Relinquished by: (signature)	Received by: (signature)	Date/Time	Comments

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Fax (435) 865-8051

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Changed to TDS from phone call w/ Paul - BK 11/4/24

Southern Utah University
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Report of Analysis

Name: Sunrise Engineering
11 N 300 W
Washington, UT 84780
Sample Date: 11/27/2024 9:25:00 AM
Receipt Date: 11/27/2024 1:00:00 PM
Report Date: 1/2/2025
Sample Site: SW #1

Sample ID#: K2024 02986
Sample Type: Waste Water
Sampler: PAUL ANDERSEN

Parameter	Sample Result	Units	MRL	Method	Analysis Date	Analysis Time	Analyst
Receiving pH	7.29	SU	0	4500 H	11/27/2024	1:15:00 PM	MA
Receiving Temperature	10.6	C	0	2550	11/27/2024	1:15:00 PM	MA
Nitrate+Nitrite Total	0.43	mg/L	0.1	353.3	12/17/2024	9:00:00 AM	ZS
Total Dissolved Solids	310	mg/L	20	2540 C	12/5/2024	9:00:00 AM	EM

Report Approved By:
Kim Weaver, Director

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Report of Analysis

Name: Sunrise Engineering
11 N 300 W
Washington, UT 84780
Sample Date: 11/27/2024 10:38:00 AM
Receipt Date: 11/27/2024 1:00:00 PM
Report Date: 1/9/2025
Sample Site: SW #2

Sample ID#: K2024 02987
Sample Type: Waste Water
Sampler: PAUL ANDERSEN

Parameter	Sample Result	Units	MRL	Method	Analysis Date	Analysis Time	Analyst
Receiving pH	7.38	SU	0	4500 H	11/27/2024	1:15:00 PM	MA
Receiving Temperature	10.0	C	0	2550	11/27/2024	1:15:00 PM	MA
Nitrate+Nitrite Total	0.267	mg/L	0.1	353.3	12/19/2024	11:00:00 AM	EM
Total Dissolved Solids	198	mg/L	20	2540 C	12/5/2024	9:00:00 AM	EM

Report Approved By: ______________________
Kim Weaver, Director

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Report of Analysis

Name:	Sunrise Engineering 11 N 300 W Washington, UT 84780	**Sample ID#:**	K2024 02988
Sample Date:	11/27/2024 11:52:00 AM	**Sample Type:**	Waste Water
Receipt Date:	11/27/2024 1:00:00 PM	**Sampler:**	PAUL ANDERSEN
Report Date:	1/9/2025		
Sample Site:	SW #3		

Parameter	Sample Result	Units	MRL	Method	Analysis Date	Analysis Time	Analyst
Receiving pH	7.75	SU	0	4500 H	11/27/2024	1:15:00 PM	MA
Receiving Temperature	10.0	C	0	2550	11/27/2024	1:15:00 PM	MA
Nitrate+Nitrite Total	0.398	mg/L	0.1	353.3	12/19/2024	11:00:00 AM	EM
Total Dissolved Solids	315	mg/L	20	2540 C	12/5/2024	9:00:00 AM	EM

Report Approved By:
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Report of Analysis

Name: Sunrise Engineering
11 N 300 W
Washington, UT 84780
Sample Date: 11/27/2024 9:50:00 AM
Receipt Date: 11/27/2024 1:00:00 PM
Report Date: 1/9/2025
Sample Site: GWMW #1

Sample ID#: K2024 02989
Sample Type: Waste Water
Sampler: PAUL ANDERSEN

Parameter	Sample Result	Units	MRL	Method	Analysis Date	Analysis Time	Analyst
Receiving pH	7.21	SU	0	4500 H	11/27/2024	1:15:00 PM	MA
Receiving Temperature	10.2	C	0	2550	11/27/2024	1:15:00 PM	MA
Nitrate+Nitrite Total	<0.1	mg/L	0.1	353.3	12/19/2024	11:00:00 AM	EM
Total Dissolved Solids	2560	mg/L	20	2540 C	12/5/2024	2:20:00 PM	EM

Report Approved By: ______________________
Kim Weaver, Director

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Report of Analysis

Name:	Sunrise Engineering 11 N 300 W Washington, UT 84780	**Sample ID#:**	K2024 02990
Sample Date:	11/27/2024 10:30:00 AM	**Sample Type:**	Waste Water
Receipt Date:	11/27/2024 1:00:00 PM	**Sampler:**	PAUL ANDERSEN
Report Date:	1/9/2025		
Sample Site:	GWMW #2		

Parameter	Sample Result	Units	MRL	Method	Analysis Date	Analysis Time	Analyst
Receiving pH	7.18	SU	0	4500 H	11/27/2024	1:15:00 PM	MA
Receiving Temperature	11.1	C	0	2550	11/27/2024	1:15:00 PM	MA
Nitrate+Nitrite Total	<0.1	mg/L	0.1	353.3	12/19/2024	11:00:00 AM	EM
Total Dissolved Solids	3410	mg/L	20	2540 C	12/5/2024	2:20:00 PM	EM

Report Approved By:
Kim Weaver, Director

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Report of Analysis

Name:	Sunrise Engineering 11 N 300 W Washington, UT 84780	**Sample ID#:**	K2024 02991
Sample Date:	11/27/2024 11:10:00 AM	**Sample Type:**	Waste Water
Receipt Date:	11/27/2024 1:00:00 PM	**Sampler:**	PAUL ANDERSEN
Report Date:	1/9/2025		
Sample Site:	GWMW #3		

Parameter	Sample Result	Units	MRL	Method	Analysis Date	Analysis Time	Analyst
Receiving pH	7.35	SU	0	4500 H	11/27/2024	1:15:00 PM	MA
Receiving Temperature	10.8	C	0	2550	11/27/2024	1:15:00 PM	MA
Nitrate+Nitrite Total	<0.1	mg/L	0.1	353.3	12/19/2024	11:00:00 AM	EM
Total Dissolved Solids	3930	mg/L	20	2540 C	12/5/2024	2:20:00 PM	EM

Report Approved By:
Kim Weaver, Director

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Southern Utah University Science Center • Room 206
www.suu.edu/waterlab

Southern Utah University
WATER LAB
"Chemical and Bacteriological Testing"

Report of Analysis

Name: Sunrise Engineering
11 N 300 W
Washington, UT 84780

Sample Date: 11/27/2024 11:30:00 AM
Receipt Date: 11/27/2024 1:00:00 PM
Report Date: 1/9/2025
Sample Site: GWMW #4

Sample ID#: K2024 02992
Sample Type: Waste Water
Sampler: PAUL ANDERSEN

Parameter	Sample Result	Units	MRL	Method	Analysis Date	Analysis Time	Analyst
Receiving pH	7.10	SU	0	4500 H	11/27/2024	1:15:00 PM	MA
Receiving Temperature	9.8	C	0	2550	11/27/2024	1:15:00 PM	MA
Nitrate+Nitrite Total	0.334	mg/L	0.1	353.3	12/19/2024	11:00:00 AM	EM
Total Dissolved Solids	2760	mg/L	20	2540 C	12/5/2024	2:20:00 PM	EM

Report Approved By: ____________________
Kim Weaver, Director

Southern Utah Water Laboratory

Analysis Request Form/ Chain of Custody

Company: Sunrise Engineering
Address: 11 N 300 W
City: Washington State: UT Zip: 84780
Phone: (435) 652 - 8450 Fax:
Contact: Paul Andersen
Project ID/Water System ID: /
Email: Paul.andersen@sunrise-eng.com

☐ Digestion Required

Billing Address: Same City:
State: Zip: Contact:
Email:

	Lab ID#	Sample Location	Sample Date	Sample Time	Number of Containers	Drinking Water	Ground Water	Surface Water	Waste Water	Other (specify):	Total Nitrate/Nitrite	Nitrite	Nitrate	Sulfate	TDS/TSS/COD	Lead & Copper	Primary Inorganics	Secondary Inorganics		Recieving Temp	Recieving PH					
						Matrix					Analysis Requested															
K202402986	SW #1	1. Virgin - u/s	11/27/24	9:25 AM							/				/					10.6	7.29					
02987	SW #2	2.		10:38AM							/				/					10.0	7.18					
02988	SW #3	3.		11:52 AM							/				/					10.0	7.15					
02989	GWMW #1	4.		9:50 AM							/				/					10.2	7.11					
02990	GWMW #2	5.		10:30AM							/				/					11.1	7.18					
02991	GWMW #3	6.		11:10AM							/				/					10.8	7.35					
02992	GWMW #4	7.		11:30AM							/				/					9.5	7.10					
		8.																								
		9.																								
		10.																								

Sampled by: (print) Paul Andersen	Sampled by: (Signiture) [signature]	Receiving Temp.	Receiving pH:
Special Instruction			
		Sample Delivered by Courier:	
Relinquished by: (Signiture) [signature]	Received by (Signiture): Gemma Maynor	Date/Time 11-27-24 1300	Comments
Relinquished by: (Signiture)	Received by (Signiture	Date/Time	Comments
Relinquished by: (Signiture)	Received by (Signiture):	Date/Time	Comments

Southern Utah University
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"Chemical and Bacteriological Testing"

Report of Analysis

Name: Sunrise Engineering
11 N 300 W
Washington, UT 84780
Sample Date: 12/30/2024 9:07:00 AM
Receipt Date: 12/30/2024 12:22:00 PM
Report Date: 1/28/2025
Sample Site: SW#3

Sample ID#: K2024 03298
Sample Type: Surface Water
Sampler: PAUL ANDERSEN

Parameter	Sample Result	Units	MRL	Method	Analysis Date	Analysis Time	Analyst
Receiving pH	8.10	SU	0	4500 H	12/30/2024	12:28:00 PM	BR
Receiving Temperature	10.4	C	0	2550	12/30/2024	12:28:00 PM	BR
Nitrate+Nitrite Total	0.395	mg/L	0.1	353.3	1/12/2025	2:30:00 PM	NB
Total Dissolved Solids	494	mg/L	20	2540 C	12/31/2024	12:30:00 PM	EM

Report Approved By: ____________________
Kim Weaver, Director

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Report of Analysis

Name:	Sunrise Engineering 11 N 300 W Washington, UT 84780	**Sample ID#:**	K2024 03299
Sample Date:	12/30/2024 9:38:00 AM	**Sample Type:**	Ground Water
Receipt Date:	12/30/2024 12:22:00 PM	**Sampler:**	PAUL ANDERSEN
Report Date:	1/28/2025		
Sample Site:	GWMW#4		

Parameter	Sample Result	Units	MRL	Method	Analysis Date	Analysis Time	Analyst
Receiving pH	7.17	SU	0	4500 H	12/30/2024	12:28:00 PM	BR
Receiving Temperature	10.4	C	0	2550	12/30/2024	12:28:00 PM	BR
Nitrate+Nitrite Total	0.37	mg/L	0.1	353.3	1/12/2025	2:30:00 PM	NB
Total Dissolved Solids	3340	mg/L	20	2540 C	12/31/2024	12:30:00 PM	EM

Report Approved By:

Kim Weaver, Director

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Southern Utah University
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Report of Analysis

Name: Sunrise Engineering
11 N 300 W
Washington, UT 84780
Sample Date: 12/30/2024 10:13:00 AM
Receipt Date: 12/30/2024 12:22:00 PM
Report Date: 1/28/2025
Sample Site: GWMW#3

Sample ID#: K2024 03300
Sample Type: Ground Water
Sampler: PAUL ANDERSEN

Parameter	Sample Result	Units	MRL	Method	Analysis Date	Analysis Time	Analyst
Receiving pH	7.28	SU	0	4500 H	12/30/2024	12:28:00 PM	BR
Receiving Temperature	9.8	C	0	2550	12/30/2024	12:28:00 PM	BR
Nitrate+Nitrite Total	0.284	mg/L	0.1	353.3	1/12/2025	2:30:00 PM	NB
Total Dissolved Solids	3830	mg/L	20	2540 C	12/31/2024	12:30:00 PM	EM

Report Approved By:
Kim Weaver, Director

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Report of Analysis

Name:	Sunrise Engineering 11 N 300 W Washington, UT 84780	**Sample ID#:**	K2024 03301
Sample Date:	12/30/2024 10:26:00 AM	**Sample Type:**	Surface Water
Receipt Date:	12/30/2024 12:22:00 PM	**Sampler:**	PAUL ANDERSEN
Report Date:	1/28/2025		
Sample Site:	SW#2		

Parameter	Sample Result	Units	MRL	Method	Analysis Date	Analysis Time	Analyst
Receiving pH	7.91	SU	0	4500 H	12/30/2024	12:28:00 PM	BR
Receiving Temperature	9.9	C	0	2550	12/30/2024	12:28:00 PM	BR
Nitrate+Nitrite Total	0.767	mg/L	0.1	353.3	1/12/2025	2:30:00 PM	NB
Total Dissolved Solids	868	mg/L	20	2540 C	1/2/2025	3:00:00 PM	EM

Report Approved By: ______________________
Kim Weaver, Director

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"Chemical and Bacteriological Testing"

Report of Analysis

Name: Sunrise Engineering
11 N 300 W
Washington, UT 84780

Sample Date: 12/30/2024 10:43:00 AM
Receipt Date: 12/30/2024 12:22:00 PM
Report Date: 1/28/2025
Sample Site: GWMW#2

Sample ID#: K2024 03302
Sample Type: Ground Water
Sampler: PAUL ANDERSEN

Parameter	Sample Result	Units	MRL	Method	Analysis Date	Analysis Time	Analyst
Receiving pH	7.20	SU	0	4500 H	12/30/2024	12:28:00 PM	BR
Receiving Temperature	11.0	C	0	2550	12/30/2024	12:28:00 PM	BR
Nitrate+Nitrite Total	<0.1	mg/L	0.1	353.3	1/12/2025	2:30:00 PM	NB
Total Dissolved Solids	3290	mg/L	20	2540 C	1/2/2025	3:00:00 PM	EM

Report Approved By

Kim Weaver, Director

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Report of Analysis

Name:	Sunrise Engineering 11 N 300 W Washington, UT 84780	**Sample ID#:**	K2024 03303
Sample Date:	12/30/2024 11:12:00 AM	**Sample Type:**	Ground Water
Receipt Date:	12/30/2024 12:22:00 PM	**Sampler:**	PAUL ANDERSEN
Report Date:	1/28/2025		
Sample Site:	GWMW#1		

Parameter	Sample Result	Units	MRL	Method	Analysis Date	Analysis Time	Analyst
Receiving pH	7.37	SU	0	4500 H	12/30/2024	12:28:00 PM	BR
Receiving Temperature	11.7	C	0	2550	12/30/2024	12:28:00 PM	BR
Nitrate+Nitrite Total	<0.1	mg/L	0.1	353.3	1/18/2025	10:00:00 AM	MW
Total Dissolved Solids	2570	mg/L	20	2540 C	1/2/2025	3:00:00 PM	EM

Report Approved By: _______________
Kim Weaver, Director

Southern Utah University
WATER LAB
"Chemical and Bacteriological Testing"

Report of Analysis

Name: Sunrise Engineering
11 N 300 W
Washington, UT 84780

Sample Date: 12/30/2024 11:21:00 AM
Receipt Date: 12/30/2024 12:22:00 PM
Report Date: 1/28/2025
Sample Site: SW#1

Sample ID#: K2024 03304
Sample Type: Surface Water
Sampler: PAUL ANDERSEN

Parameter	Sample Result	Units	MRL	Method	Analysis Date	Analysis Time	Analyst
Receiving pH	8.27	SU	0	4500 H	12/30/2024	12:28:00 PM	BR
Receiving Temperature	11.6	C	0	2550	12/30/2024	12:28:00 PM	BR
Nitrate+Nitrite Total	0.204	mg/L	0.1	353.3	1/18/2025	10:00:00 AM	MW
Total Dissolved Solids	445	mg/L	20	2540 C	1/2/2025	3:00:00 PM	EM

Report Approved By:
Kim Weaver, Director

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Southern Utah Water Laboratory

Analysis Request Form/ Chain of Custody

Company: Sunrise Engineering
Address: 11 N 300 W.
City: Washington State: UT Zip: 84780
Phone: (435)-652-8450 Fax:
Contact: Paul Andersen
Project ID/Water System ID:
Email: paul.andersen@sunrise-eng.com

☐ Digestion Required

Billing Address: 11 N 300 W City: Washington
State: UT Zip: 84780 Contact: Paul Andersen
Email: paul.andersen@sunrise-eng.com

Lab ID#	Sample Location	Sample Date	Sample Time	Number of Containers	Matrix: Drinking Water	Matrix: Ground Water	Matrix: Surface Water	Matrix: Waste Water	Matrix: Other (specify):	Analysis Requested: Total Nitrate/Nitrite	Nitrite	Nitrate	Sulfate	TDS/TSS/COD	Lead & Copper	Primary Inorganics	Secondary Inorganics		Receiving pH	Temp							
K2024 03298	1. SW#3	12/30/24	9:07				X			X				X					8.0	10.4							
K2024 03299	2. GWMW#4	12/30/24	9:28 AM			X				X				X					7.17	9.8							
K2024 03300	3. GWMW#3	12/30/24	10:13			X				X				X					7.35	9.9							
K2024 03301	4. SW#2	12/30/24	10:26 AM				X			X				X					7.9	11.0							
K2024 03302	5. GWMW#2	12/30/24	10:43 AM			X				X				X					7.70	11.7							
K2024 03303	6. GWMW#1	12/30/24	11:12 AM			X				X				X					8.27	11.6							
K2024 03304	7. SW#1	12/30/24	11:21 AM				X			X				X					8.37	11.6							
	8.																										
	9.																										
	10.																										

Sampled by (print): Paul Andersen
Sampled by (Signature):
Receiving Temp:
Receiving pH:

Special Instruction:

Sample Delivered by Courier:

Relinquished by (Signature)	Received by (Signature)	Date/Time	Comments
	McKenna Anderson	12-30-24 1222	

CHEMTECH-FORD
LABORATORIES

2/10/2025

Work Order: 25A1943
Project: Virgin Town GWPS

Sunrise Engineering Inc. - Midvale
Attn: Dao Yang
6875 South 900 East
Midvale, UT 84047

Client Service Contact: 801.262.7299

The analyses presented on this report were performed in accordance with the National Environmental Laboratory Accreditation Program (NELAP) unless noted in the comments, flags, or case narrative. If the report is to be used for regulatory compliance, it should be presented in its entirety, and not be altered.

NELAP ACCREDITED TNI LABORATORY

Approved By:

Mark Broadhead, Project Manager

Chemtech-Ford Laboratories
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Sandy, UT 84070
O:(801) 262-7299 F: (866) 792-0093
www.ChemtechFord.com

Certificate of Analysis

Sunrise Engineering Inc. - Midvale
Dao Yang
6875 South 900 East
Midvale, UT 84047

PO#:
Receipt: **1/28/25 13:23 @ 0.8** °C
Date Reported: 2/10/2025
Project Name: **Virgin Town GWPS**

Sample ID: **SW # 1**

Matrix: **Water**
Lab ID: **25A1943-01**
Date Sampled: **1/27/25 14:52**
Sampled By: **Dao Yang**

	Result	Units	Minimum Reporting Limit	Method	Preparation Date/Time	Analysis Date/Time	Flag(s)
Inorganic							
Nitrate as N	0.22	mg/L	0.10	EPA 300.0	1/28/25 18:09	1/28/25 18:09	
pH	8.4	pH Units	0.1	SM 4500 H-B	1/28/25 16:20	1/28/25 17:41	SPH
Total Dissolved Solids (TDS)	372	mg/L	20	SM 2540 C	1/29/25	1/29/25	

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Dao Yang
6875 South 900 East
Midvale, UT 84047

PO#:
Receipt: **1/28/25 13:23 @ 0.8** °C
Date Reported: 2/10/2025
Project Name: **Virgin Town GWPS**

Sample ID: **SW # 2**

Matrix: **Water**

Lab ID: **25A1943-02**

Date Sampled: **1/27/25 15:33**

Sampled By: **Dao Yang**

	Result	Units	Minimum Reporting Limit	Method	Preparation Date/Time	Analysis Date/Time	Flag(s)
Inorganic							
Nitrate as N	0.24	mg/L	0.10	EPA 300.0	1/28/25 18:24	1/28/25 18:24	
pH	8.2	pH Units	0.1	SM 4500 H-B	1/28/25 16:20	1/28/25 17:40	SPH
Total Dissolved Solids (TDS)	720	mg/L	20	SM 2540 C	1/29/25	1/29/25	

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Dao Yang
6875 South 900 East
Midvale, UT 84047

PO#:
Receipt: **1/28/25 13:23 @ 0.8** °C
Date Reported: 2/10/2025
Project Name: **Virgin Town GWPS**

Sample ID: **GWMW # 2**

Matrix: **Water**

Lab ID: **25A1943-03**

Date Sampled: **1/27/25 16:04**

Sampled By: **Dao Yang**

	Result	Units	Minimum Reporting Limit	Method	Preparation Date/Time	Analysis Date/Time	Flag(s)
Inorganic							
Nitrate as N	ND	mg/L	0.10	EPA 300.0	1/28/25 18:39	1/28/25 18:39	
pH	6.7	pH Units	0.1	SM 4500 H-B	1/28/25 16:20	1/28/25 17:43	SPH
Total Dissolved Solids (TDS)	3150	mg/L	20	SM 2540 C	1/29/25	1/29/25	

Certificate of Analysis

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Dao Yang
6875 South 900 East
Midvale, UT 84047

PO#:
Receipt: **1/28/25 13:23 @ 0.8** °C
Date Reported: 2/10/2025
Project Name: **Virgin Town GWPS**

Sample ID: **GWMW #4**

Matrix: **Water** Lab ID: **25A1943-04**
Date Sampled: **1/27/25 16:24** Sampled By: **Dao Yang**

	Result	Units	Minimum Reporting Limit	Method	Preparation Date/Time	Analysis Date/Time	Flag(s)
Inorganic							
Nitrate as N	0.41	mg/L	0.10	EPA 300.0	1/28/25 19:24	1/28/25 19:24	
pH	7.0	pH Units	0.1	SM 4500 H-B	1/28/25 16:20	1/28/25 17:44	SPH
Total Dissolved Solids (TDS)	3440	mg/L	20	SM 2540 C	1/29/25	1/29/25	

Certificate of Analysis

Sunrise Engineering Inc. - Midvale
Dao Yang
6875 South 900 East
Midvale, UT 84047

PO#:
Receipt: **1/28/25 13:23 @ 0.8** °C
Date Reported: 2/10/2025
Project Name: **Virgin Town GWPS**

Sample ID: **GWMW # 1**

Matrix: **Water**

Lab ID: **25A1943-05**

Date Sampled: **1/27/25 17:10**

Sampled By: **Dao Yang**

	Result	Units	Minimum Reporting Limit	Method	Preparation Date/Time	Analysis Date/Time	Flag(s)
Inorganic							
Nitrate as N	ND	mg/L	0.10	EPA 300.0	1/28/25 19:39	1/28/25 19:39	
pH	7.2	pH Units	0.1	SM 4500 H-B	1/28/25 16:20	1/28/25 17:45	SPH
Total Dissolved Solids (TDS)	2380	mg/L	20	SM 2540 C	1/29/25	1/29/25	

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Dao Yang
6875 South 900 East
Midvale, UT 84047

PO#:
Receipt: **1/28/25 13:23 @ 0.8** °C
Date Reported: 2/10/2025
Project Name: **Virgin Town GWPS**

Sample ID: **SW # 3**

Matrix: **Water**

Lab ID: **25A1943-06**

Date Sampled: **1/27/25 17:52**

Sampled By: **Dao Yang**

	Result	Units	Minimum Reporting Limit	Method	Preparation Date/Time	Analysis Date/Time	Flag(s)
Inorganic							
Nitrate as N	0.23	mg/L	0.10	EPA 300.0	1/28/25 19:54	1/28/25 19:54	
pH	8.2	pH Units	0.1	SM 4500 H-B	1/28/25 16:20	1/28/25 17:47	SPH
Total Dissolved Solids (TDS)	460	mg/L	20	SM 2540 C	1/29/25	1/29/25	

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Dao Yang
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Midvale, UT 84047

PO#:
Receipt: **1/28/25 13:23 @ 0.8** °C
Date Reported: 2/10/2025
Project Name: **Virgin Town GWPS**

Sample ID: **GMWW # 3**

Matrix: **Water**
Lab ID: **25A1943-07**
Date Sampled: **1/27/25 19:40**
Sampled By: **Dao Yang**

	Result	Units	Minimum Reporting Limit	Method	Preparation Date/Time	Analysis Date/Time	Flag(s)
Inorganic							
Nitrate as N	ND	mg/L	0.10	EPA 300.0	1/28/25 20:09	1/28/25 20:09	
pH	7.4	pH Units	0.1	SM 4500 H-B	1/28/25 16:20	1/28/25 17:48	SPH
Total Dissolved Solids (TDS)	3700	mg/L	20	SM 2540 C	1/29/25	1/29/25	

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Sunrise Engineering Inc. - Midvale
Dao Yang
6875 South 900 East
Midvale, UT 84047

PO#:
Receipt: **1/28/25 13:23 @ 0.8** °C
Date Reported: 2/10/2025
Project Name: **Virgin Town GWPS**

Report Footnotes

Abbreviations

ND = Not detected at the corresponding Minimum Reporting Limit (MRL).
1 mg/L = one milligram per liter or 1 mg/kg = one milligram per kilogram = 1 part per million.
1 ug/L = one microgram per liter or 1 ug/kg = one microgram per kilogram = 1 part per billion.
1 ng/L = one nanogram per liter or 1 ng/kg = one nanogram per kilogram = 1 part per trillion.
On calculated parameters, there may be a slight difference between summing the rounded values shown on the report vs the unrounded values used in the calculation.

Flag Descriptions

SPH = Sample submitted past method specified holding time.

CHAIN OF CUSTODY - SAMPLE SUBMITTAL FORM

CHEMTECH-FORD
LABORATORIES

Chemtech-Ford, Inc.
9632 South 500 West
Sandy, UT 84070
Phone: 801-262-7299
www.chemtechford.com

COMPANY: Sunrise Engineering
ADDRESS:
CITY/STATE/ZIP:
PHONE #:
CONTACT: Dao Yang
EMAIL:
PROJECT: Virgin Town GWPS
PO Number:
INVOICE EMAIL ADDRESS:

RUSH Due Date*:	QC Level

* Expedited turnaround subject to additional charge

QC levels definition:
QC1: none (default if blank)
QC2: Batch QC, random sample
QC3: 25% surcharge. Narrative plus Batch QC, your sample selected
QC4: 40% surcharge. Add raw data

Sample condition	
Custody Seal	✓ Correct Containers
✓ Container Intact	✓ Sufficient Sample Volume
✓ COC/Labels Agree	Headspace Present (VOC)
✓ Received on Ice	Temperature Blank
	✓ Received within Holding Time

Delivery Method	
UPS	USPS
FedEx	Chemtech-Ford Courier
✓ Walk-in	Customer Courier

25A1943

Lab Use Only	CLIENT SAMPLE INFORMATION: LOCATION / IDENTIFICATION	DATE	TIME	MATRIX	Nitrate	Total Dissolved Solids (TDS)	pH	[redacted]
01	1. SW #1	1/27/25	2:52 PM		✓	✓	✓	✓
02	2. SW #2	1/27/25	3:33 PM		✓	✓	✓	
03	3. GWMW #2	1/27/25	4:04 PM		✓	✓	✓	
04	4. GWMW #4	1/27/25	4:29 PM		✓	✓	✓	
05	5. GWMW #1	1/27/25	5:10 PM		✓	✓	✓	
06	6. SW #3	1/27/25	5:52 PM		✓	✓	✓	
07	7. GMWW # 3	1/27/25	7:40 PM		✓	✓	✓	
~~A8JF~~	8.							
	9.							
	10.							
				Bottle type			Ap	1372
				Lot #				

Sampled by: [print] Dao Yang
Sampled by: [signature] Dao(time) Yang

ON ICE / NOT ON ICE — Temp (C°): 0.8

Special Instructions:

Samples received outside the EPA recommended temperature range of 0-6 C° may be rejected.

Relinquished by: [signature]	Date/Time	Received by: [signature]	Date/Time
Dao(time) Yang	1/28/25 1323	[signature]	1/28/25 1323

Payment Terms are net 30 days OAC. 1.5% interest charge per month (18% per annum). Client agress to pay collection costs and attorney's fees.

3/11/2025

Work Order: 25B2085
Project: Virgin Town Groundwater Study

Sunrise Engineering Inc. - Midvale
Attn: Dao Yang
6875 South 900 East
Midvale, UT 84047

Client Service Contact: 801.262.7299

The analyses presented on this report were performed in accordance with the National Environmental Laboratory Accreditation Program (NELAP) unless noted in the comments, flags, or case narrative. If the report is to be used for regulatory compliance, it should be presented in its entirety, and not be altered.

Approved By:

Mark Broadhead, Project Manager

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Certificate of Analysis

Sunrise Engineering Inc. - Midvale
Dao Yang
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Midvale, UT 84047

PO#:
Receipt: **2/28/25 11:16 @ -0.4** °C
Date Reported: 3/11/2025
Project Name: **Virgin Town Groundwater Study**

Sample ID: **GWMW #4**

Matrix: **Water**

Lab ID: **25B2085-01**

Date Sampled: **2/27/25 12:29**

Sampled By: **Paul Andersen**

	Result	Units	Minimum Reporting Limit	Method	Preparation Date/Time	Analysis Date/Time	Flag(s)
Inorganic							
Nitrate as N	1.15	mg/L	0.10	EPA 300.0	2/28/25 19:17	2/28/25 19:17	
Total Dissolved Solids (TDS)	3340	mg/L	20	SM 2540 C	3/3/25	3/3/25	

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PO#:
Receipt: **2/28/25 11:16 @ -0.4** °C
Date Reported: 3/11/2025
Project Name: **Virgin Town Groundwater Study**

Sample ID: **GWMW #3**

Matrix: **Water**

Lab ID: **25B2085-02**

Date Sampled: **2/27/25 13:25**

Sampled By: **Paul Andersen**

	Result	Units	Minimum Reporting Limit	Method	Preparation Date/Time	Analysis Date/Time	Flag(s)
Inorganic							
Nitrate as N	ND	mg/L	0.10	EPA 300.0	2/28/25 20:02	2/28/25 20:02	
Total Dissolved Solids (TDS)	3680	mg/L	20	SM 2540 C	3/4/25	3/4/25	

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Midvale, UT 84047

PO#:
Receipt: **2/28/25 11:16 @ -0.4** °C
Date Reported: 3/11/2025
Project Name: **Virgin Town Groundwater Study**

Sample ID: **GWMW #2**

Matrix: **Water**

Lab ID: **25B2085-03**

Date Sampled: **2/27/25 14:15**

Sampled By: **Paul Andersen**

	Result	Units	Minimum Reporting Limit	Method	Preparation Date/Time	Analysis Date/Time	Flag(s)
Inorganic							
Nitrate as N	ND	mg/L	0.10	EPA 300.0	2/28/25 20:48	2/28/25 20:48	
Total Dissolved Solids (TDS)	3090	mg/L	20	SM 2540 C	3/4/25	3/4/25	

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PO#:
Receipt: **2/28/25 11:16 @ -0.4** °C
Date Reported: 3/11/2025
Project Name: **Virgin Town Groundwater Study**

Sample ID: **SW #1**

Matrix: **Water**

Lab ID: **25B2085-04**

Date Sampled: **2/27/25 14:40**

Sampled By: **Paul Andersen**

	Result	Units	Minimum Reporting Limit	Method	Preparation Date/Time	Analysis Date/Time	Flag(s)
Inorganic							
Nitrate as N	0.16	mg/L	0.10	EPA 300.0	2/28/25 21:03	2/28/25 21:03	
Total Dissolved Solids (TDS)	464	mg/L	20	SM 2540 C	3/4/25	3/4/25	

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PO#:
Receipt: **2/28/25 11:16 @ -0.4** °C
Date Reported: 3/11/2025
Project Name: **Virgin Town Groundwater Study**

Sample ID: **GWMW #1**

Matrix: **Water**
Lab ID: **25B2085-05**
Date Sampled: **2/27/25 15:04**
Sampled By: **Paul Andersen**

	Result	Units	Minimum Reporting Limit	Method	Preparation Date/Time	Analysis Date/Time	Flag(s)
Inorganic							
Nitrate as N	ND	mg/L	0.10	EPA 300.0	2/28/25 21:18	2/28/25 21:18	
Total Dissolved Solids (TDS)	2370	mg/L	20	SM 2540 C	3/4/25	3/4/25	

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PO#:
Receipt: **2/28/25 11:16 @ -0.4** °C
Date Reported: 3/11/2025
Project Name: **Virgin Town Groundwater Study**

Sample ID: **SW #2**

Matrix: **Water**

Lab ID: **25B2085-06**

Date Sampled: **2/27/25 15:20**

Sampled By: **Paul Andersen**

	Result	Units	Minimum Reporting Limit	Method	Preparation Date/Time	Analysis Date/Time	Flag(s)
Inorganic							
Nitrate as N	0.14	mg/L	0.10	EPA 300.0	2/28/25 21:33	2/28/25 21:33	
Total Dissolved Solids (TDS)	976	mg/L	20	SM 2540 C	3/4/25	3/4/25	

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PO#:
Receipt: **2/28/25 11:16 @ -0.4** °C
Date Reported: 3/11/2025
Project Name: **Virgin Town Groundwater Study**

Sample ID: **SW #3**

Matrix: **Water**

Lab ID: **25B2085-07**

Date Sampled: **2/27/25 15:39**

Sampled By: **Paul Andersen**

	Result	Units	Minimum Reporting Limit	Method	Preparation Date/Time	Analysis Date/Time	Flag(s)
Inorganic							
Nitrate as N	0.11	mg/L	0.10	EPA 300.0	2/28/25 21:48	2/28/25 21:48	
Total Dissolved Solids (TDS)	472	mg/L	20	SM 2540 C	3/4/25	3/4/25	

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PO#:
Receipt: **2/28/25 11:16 @ -0.4** °C
Date Reported: 3/11/2025
Project Name: **Virgin Town Groundwater Study**

Report Footnotes

Abbreviations

ND = Not detected at the corresponding Minimum Reporting Limit (MRL).
1 mg/L = one milligram per liter or 1 mg/kg = one milligram per kilogram = 1 part per million.
1 ug/L = one microgram per liter or 1 ug/kg = one microgram per kilogram = 1 part per billion.
1 ng/L = one nanogram per liter or 1 ng/kg = one nanogram per kilogram = 1 part per trillion.
On calculated parameters, there may be a slight difference between summing the rounded values shown on the report vs the unrounded values used in the calculation.

CHAIN OF CUSTODY - SAMPLE SUBMITTAL FORM

COMPANY: Sunrise Engineering
ADDRESS: 11 N. 300 W.
CITY/STATE/ZIP: Washington, UT, 84780
PHONE #: 435 652 8450
CONTACT: Paul Andersen
EMAIL: paul.andersen@sunrise-eng.com
PROJECT: Virgin Town Groundwater Study
PO Number:
INVOICE EMAIL ADDRESS: Paul.Andersen@sunrise-eng.com

RUSH Due Date*:	QC Level

* Expedited turnaround subject to additional charge

QC levels definition:
QC1: none (default if blank)
QC2: Batch QC, random sample
QC3: 25% surcharge. Narrative plus Batch QC, your sample selected
QC4: 40% surcharge. Add raw data

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Sample condition		Delivery Method	
Custody Seal	Correct Containers		
✓ Container Intact	✓ Sufficient Sample Volume		
✓ COC/Labels Agree	Headspace Present (VOC)	UPS	USPS
✓ Received on Ice	Temperature Blank	FedEx	Chemtech-Ford Courier
	✓ Received within Holding Time	✓ Walk-in	Customer Courier

25B2085

Lab Use Only	LOCATION / IDENTIFICATION	DATE	TIME	MATRIX	TDS	TOTAL NITRATE
01	1. GWMW #4	2/27/25	12:29 PM		✓	✓
02	2. GWMW #3	2/27/25	13:25		✓	✓
03	3. GWMW #2	2/27/25	14:15		✓	✓
04	4. SW-1	2/27/25	14:40		✓	✓
05	5. GWMW #1	2/27/25	15:04		✓	✓
06	6. SW #2	2/27/25	15:20		✓	✓
07	7. SW #3	2/27/25	15:39		✓	✓
	8.					
	9.					
	10.					
				Bottle type	AP	
				Lot #	1108	

TESTS REQUESTED

Sampled by: [print] Paul Andersen
Sampled by: [signature] Paul

ON ICE NOT ON ICE Temp (C°): -0.4

Special Instructions:

Samples received outside the EPA recommended temperature range of 0-6 C° may be rejected.

Relinquished by: [signature]	Date/Time	Received by: [signature]	Date/Time
Paul Andersen	17: 2/27/25	[signature]	2/27/25 1700
[signature]	1116 2/28/25		2/28/25 1116

Payment Terms are net 30 days OAC. 1.5% interest charge per month (18% per annum). Client agrees to pay collection costs and attorney's fees.

6/30/2025

Work Order: 25C1605
Project: [none]

Sunrise Engineering-Washington
Attn: Paul Andersen
11 N 300 W
Washington, UT 84780

Client Service Contact: 801.262.7299

The analyses presented on this report were performed in accordance with the National Environmental Laboratory Accreditation Program (NELAP) unless noted in the comments, flags, or case narrative. If the report is to be used for regulatory compliance, it should be presented in its entirety, and not be altered.

Approved By:

Reed Hendricks, Lab Director

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PO#:
Receipt: **3/20/25 11:08 @ -0.4** °C
Date Reported: 6/30/2025
Project Name: **[none]**

Sample ID: **SW#1**

Matrix: **Water**

Lab ID: **25C1605-01**

Date Sampled: **3/19/25 14:08**

Sampled By: **Paul Andersen**

	Result	Units	Minimum Reporting Limit	Method	Preparation Date/Time	Analysis Date/Time	Flag(s)
Inorganic							
Nitrate as N	0.16	mg/L	0.10	EPA 300.0	3/20/25 15:17	3/21/25 6:01	
pH	8.4	pH Units	0.1	SM 4500 H-B	3/20/25 17:51	3/20/25 19:24	SPH
Total Dissolved Solids (TDS)	384	mg/L	20	SM 2540 C	3/21/25	3/21/25	

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PO#:
Receipt: **3/20/25 11:08 @ -0.4** °C
Date Reported: 6/30/2025
Project Name: **[none]**

Sample ID: **SW #2**

Matrix: **Water**

Lab ID: **25C1605-02**

Date Sampled: **3/19/25 16:48**

Sampled By: **Paul Andersen**

	Result	Units	Minimum Reporting Limit	Method	Preparation Date/Time	Analysis Date/Time	Flag(s)
Inorganic							
Nitrate as N	ND	mg/L	0.10	EPA 300.0	3/20/25 15:17	3/21/25 6:16	
pH	8.3	pH Units	0.1	SM 4500 H-B	3/20/25 17:51	3/20/25 19:26	SPH
Total Dissolved Solids (TDS)	400	mg/L	20	SM 2540 C	3/21/25	3/21/25	

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Paul Andersen
11 N 300 W
Washington, UT 84780

PO#:
Receipt: **3/20/25 11:08 @ -0.4** °C
Date Reported: 6/30/2025
Project Name: **[none]**

Sample ID: **SW #3**

Matrix: **Water**

Lab ID: **25C1605-03**

Date Sampled: **3/19/25 17:05**

Sampled By: **Paul Andersen**

	Result	Units	Minimum Reporting Limit	Method	Preparation Date/Time	Analysis Date/Time	Flag(s)
Inorganic							
Nitrate as N	0.14	mg/L	0.10	EPA 300.0	3/20/25 15:17	3/21/25 6:31	
pH	8.6	pH Units	0.1	SM 4500 H-B	3/20/25 17:51	3/20/25 19:28	SPH
Total Dissolved Solids (TDS)	360	mg/L	20	SM 2540 C	3/21/25	3/21/25	

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PO#:
Receipt: **3/20/25 11:08 @ -0.4** °C
Date Reported: 6/30/2025
Project Name: **[none]**

Sample ID: **GWMW #1**

Matrix: **Water**

Lab ID: **25C1605-04**

Date Sampled: **3/19/25 16:34**

Sampled By: **Paul Andersen**

	Result	Units	Minimum Reporting Limit	Method	Preparation Date/Time	Analysis Date/Time	Flag(s)
Inorganic							
Nitrate as N	ND	mg/L	0.10	EPA 300.0	3/20/25 15:17	3/21/25 6:46	
pH	7.3	pH Units	0.1	SM 4500 H-B	3/20/25 17:51	3/20/25 19:30	SPH
Total Dissolved Solids (TDS)	2180	mg/L	20	SM 2540 C	3/21/25	3/21/25	

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PO#:
Receipt: **3/20/25 11:08 @ -0.4** °C
Date Reported: 6/30/2025
Project Name: **[none]**

Sample ID: **GWMW #2**

Matrix: **Water**

Lab ID: **25C1605-05**

Date Sampled: **3/19/25 15:41**

Sampled By: **Paul Andersen**

	Result	Units	Minimum Reporting Limit	Method	Preparation Date/Time	Analysis Date/Time	Flag(s)
Inorganic							
Nitrate as N	ND	mg/L	0.10	EPA 300.0	3/20/25 15:17	3/21/25 7:01	
pH	7.2	pH Units	0.1	SM 4500 H-B	3/20/25 17:51	3/20/25 19:30	SPH
Total Dissolved Solids (TDS)	3040	mg/L	20	SM 2540 C	3/21/25	3/21/25	

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Paul Andersen
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Washington, UT 84780

PO#:
Receipt: **3/20/25 11:08 @ -0.4** °C
Date Reported: 6/30/2025
Project Name: **[none]**

Sample ID: **GWMW #3**

Matrix: **Water**

Lab ID: **25C1605-06**

Date Sampled: **3/19/25 15:05**

Sampled By: **Paul Andersen**

	Result	Units	Minimum Reporting Limit	Method	Preparation Date/Time	Analysis Date/Time	Flag(s)
Inorganic							
Nitrate as N	ND	mg/L	0.10	EPA 300.0	3/20/25 15:17	3/21/25 7:16	
pH	7.2	pH Units	0.1	SM 4500 H-B	3/20/25 17:51	3/20/25 19:31	SPH
Total Dissolved Solids (TDS)	3630	mg/L	20	SM 2540 C	3/21/25	3/21/25	

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PO#:
Receipt: **3/20/25 11:08 @ -0.4** °C
Date Reported: 6/30/2025
Project Name: **[none]**

Sample ID: **GWMW #4**

Matrix: **Water**

Lab ID: **25C1605-07**

Date Sampled: **3/19/25 14:13**

Sampled By: **Paul Andersen**

	Result	Units	Minimum Reporting Limit	Method	Preparation Date/Time	Analysis Date/Time	Flag(s)
Inorganic							
Nitrate as N	0.74	mg/L	0.10	EPA 300.0	3/20/25 15:17	3/21/25 7:31	
pH	7.2	pH Units	0.1	SM 4500 H-B	3/20/25 17:51	3/20/25 19:32	SPH
Total Dissolved Solids (TDS)	3410	mg/L	20	SM 2540 C	3/21/25	3/21/25	

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Sunrise Engineering-Washington	PO#:
Paul Andersen	Receipt: **3/20/25 11:08 @ -0.4** °C
11 N 300 W	Date Reported: 6/30/2025
Washington, UT 84780	Project Name: **[none]**

Report Footnotes

Abbreviations

ND = Not detected at the corresponding Minimum Reporting Limit (MRL).
1 mg/L = one milligram per liter or 1 mg/kg = one milligram per kilogram = 1 part per million.
1 ug/L = one microgram per liter or 1 ug/kg = one microgram per kilogram = 1 part per billion.
1 ng/L = one nanogram per liter or 1 ng/kg = one nanogram per kilogram = 1 part per trillion.
On calculated parameters, there may be a slight difference between summing the rounded values shown on the report vs the unrounded values used in the calculation.

Flag Descriptions

SPH = Sample submitted past method specified holding time.

CHAIN OF CUSTODY - SAMPLE SUBMITTAL FORM

COMPANY: Sunrise Engineering, LLC.
ADDRESS: 11 N. 300 W.
CITY/STATE/ZIP: Washington / UTAH / 84780
PHONE #: (435) 652-8450
CONTACT: Paul Andersen
EMAIL: Paul.andersen@sunrise-eng.com
PROJECT: Virgin Town Groundwater protection Study
PO Number: 569817
INVOICE EMAIL ADDRESS: Same AA

RUSH Due Date*:	QC Level

* Expedited turnaround subject to additional charge

QC levels definition:
QC1: none (default if blank)
QC2: Batch QC, random sample
QC3: 25% surcharge. Narrative plus Batch QC, your sample selected
QC4: 40% surcharge. Add raw data

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Sample condition		Delivery Method	
Custody Seal	Correct Containers		
Container Intact	Sufficient Sample Volume		
COC/Labels Agree	Headspace Present (VOC)	UPS	USPS
Received on Ice	Temperature Blank	FedEx	Chemtech-Ford Courier
	Received within Holding Time	Walk-in	Customer Courier

25C1605

Lab Use Only	LOCATION / IDENTIFICATION	DATE	TIME	MATRIX	TDS	Nitrate as N	PH
01	1. SW#1	3/19/25	14:08		/	/	/
02	2. SW#2		16:48				
03	3. SW#3		17:05				
04	4. GWMW#1		16:34				
05	5. GWMW#2		15:41				
06	6. GWMW#3		15:05				
07	7. GWMW#4		14:13				
	8.						
	9.						
	10.						

AP 1407

Bottle type

Lot #

Sampled by: [print] Paul Andersen
Sampled by: [signature]

ON ICE NOT ON ICE Temp (C°): -0.4

Special Instructions:

Samples received outside the EPA recommended temperature range of 0-6 C° may be rejected.

Relinquished by: [signature]	Date/Time	Received by: [signature]	Date/Time
	3/19/25 18:10		3/19/25 18:10
	3/20/25 11:08	Ariane Teer	3/20/25 1108

Payment Terms are net 30 days OAC. 1.5% interest charge per month (18% per annum). Client agrees to pay collection costs and attorney's fees.

6/27/2025

Work Order: 25E0028
Project: [none]

Sunrise Engineering-Washington
Attn: Paul Andersen
11 N 300 W
Washington, UT 84780

Client Service Contact: 801.262.7299

The analyses presented on this report were performed in accordance with the National Environmental Laboratory Accreditation Program (NELAP) unless noted in the comments, flags, or case narrative. If the report is to be used for regulatory compliance, it should be presented in its entirety, and not be altered.

Approved By:

Reed Hendricks, Lab Director

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PO#:
Receipt: **5/1/25 10:58 @ 12.7** °C
Date Reported: 6/27/2025
Project Name: **[none]**

Sample ID: **Truman Well**

Matrix: **Water**
Lab ID: **25E0028-01**
Date Sampled: **4/30/25 9:45**
Sampled By: **Paul Andersen**

	Result	Units	Minimum Reporting Limit	Method	Preparation Date/Time	Analysis Date/Time	Flag(s)
Inorganic							
Nitrate as N	6.08	mg/L	0.10	EPA 300.0	5/1/25 15:04	5/1/25 15:04	
Total Dissolved Solids (TDS)	3220	mg/L	20	SM 2540 C	5/1/25	5/1/25	

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Washington, UT 84780

PO#:
Receipt: **5/1/25 10:58 @ 12.7** °C
Date Reported: 6/27/2025
Project Name: **[none]**

Sample ID: **SW #1**

Matrix: **Water**

Lab ID: **25E0028-02**

Date Sampled: **4/30/25 10:15**

Sampled By: **Paul Andersen**

	Result	Units	Minimum Reporting Limit	Method	Preparation Date/Time	Analysis Date/Time	Flag(s)
Inorganic							
Nitrate as N	0.28	mg/L	0.10	EPA 300.0	5/1/25 15:49	5/1/25 15:49	
Total Dissolved Solids (TDS)	492	mg/L	20	SM 2540 C	5/1/25	5/1/25	
Microcystins/Nodularin by LC/MS/MS							
Anatoxin-a	ND	ug/L	0.50	EPA 544M	5/2/25	5/6/25	
Cylindrospermopsin	ND	ug/L	0.50	EPA 544M	5/2/25	5/6/25	
Microcystin-LR	ND	ug/L	0.50	EPA 544M	5/2/25	5/6/25	
Microcystin-RR	ND	ug/L	0.50	EPA 544M	5/2/25	5/6/25	
Microcystin-YR	ND	ug/L	0.50	EPA 544M	5/2/25	5/6/25	
Nodularin	ND	ug/L	0.50	EPA 544M	5/2/25	5/6/25	

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Certificate of Analysis

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Paul Andersen
11 N 300 W
Washington, UT 84780

PO#:
Receipt: **5/1/25 10:58 @ 12.7** °C
Date Reported: 6/27/2025
Project Name: **[none]**

Sample ID: **GWMW #1**

Matrix: **Water**
Lab ID: **25E0028-03**
Date Sampled: **4/30/25 10:26**
Sampled By: **Paul Andersen**

	Result	Units	Minimum Reporting Limit	Method	Preparation Date/Time	Analysis Date/Time	Flag(s)
Inorganic							
Nitrate as N	ND	mg/L	0.10	EPA 300.0	5/1/25 16:04	5/1/25 16:04	
Total Dissolved Solids (TDS)	2160	mg/L	20	SM 2540 C	5/1/25	5/1/25	

Certificate of Analysis

Sunrise Engineering-Washington
Paul Andersen
11 N 300 W
Washington, UT 84780

PO#:
Receipt: **5/1/25 10:58 @ 12.7** °C
Date Reported: 6/27/2025
Project Name: **[none]**

Sample ID: **GWMW #2**

Matrix: **Water**

Lab ID: **25E0028-04**

Date Sampled: **4/30/25 11:02**

Sampled By: **Paul Andersen**

	Result	Units	Minimum Reporting Limit	Method	Preparation Date/Time	Analysis Date/Time	Flag(s)
Inorganic							
Nitrate as N	ND	mg/L	0.10	EPA 300.0	5/1/25 16:19	5/1/25 16:19	
Total Dissolved Solids (TDS)	3110	mg/L	20	SM 2540 C	5/1/25	5/1/25	

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Date Reported: 6/27/2025
Project Name: **[none]**

Sample ID: **SW #2**

Matrix: **Water**

Lab ID: **25E0028-05**

Date Sampled: **4/30/25 11:13**

Sampled By: **Paul Andersen**

	Result	Units	Minimum Reporting Limit	Method	Preparation Date/Time	Analysis Date/Time	Flag(s)
Inorganic							
Nitrate as N	ND	mg/L	0.10	EPA 300.0	5/1/25 16:34	5/1/25 16:34	
Total Dissolved Solids (TDS)	1060	mg/L	20	SM 2540 C	5/1/25	5/1/25	
Microcystins/Nodularin by LC/MS/MS							
Anatoxin-a	ND	ug/L	0.50	EPA 544M	5/2/25	5/6/25	
Cylindrospermopsin	ND	ug/L	0.50	EPA 544M	5/2/25	5/6/25	
Microcystin-LR	ND	ug/L	0.50	EPA 544M	5/2/25	5/6/25	
Microcystin-RR	ND	ug/L	0.50	EPA 544M	5/2/25	5/6/25	
Microcystin-YR	ND	ug/L	0.50	EPA 544M	5/2/25	5/6/25	
Nodularin	ND	ug/L	0.50	EPA 544M	5/2/25	5/6/25	

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Date Reported: 6/27/2025
Project Name: **[none]**

Sample ID: **GWMW #3**

Matrix: **Water**
Lab ID: **25E0028-06**
Date Sampled: **4/30/25 12:10**
Sampled By: **Paul Andersen**

	Result	Units	Minimum Reporting Limit	Method	Preparation Date/Time	Analysis Date/Time	Flag(s)
Inorganic							
Nitrate as N	ND	mg/L	0.10	EPA 300.0	5/1/25 16:49	5/1/25 16:49	
Total Dissolved Solids (TDS)	3650	mg/L	20	SM 2540 C	5/1/25	5/1/25	

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Date Reported: 6/27/2025
Project Name: **[none]**

Sample ID: **GWMW #4**

Matrix: **Water**
Lab ID: **25E0028-07**
Date Sampled: **4/30/25 12:25**
Sampled By: **Paul Andersen**

	Result	Units	Minimum Reporting Limit	Method	Preparation Date/Time	Analysis Date/Time	Flag(s)
Inorganic							
Nitrate as N	3.53	mg/L	0.10	EPA 300.0	5/1/25 17:34	5/1/25 17:34	
Total Dissolved Solids (TDS)	2210	mg/L	20	SM 2540 C	5/1/25	5/1/25	

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Date Reported: 6/27/2025
Project Name: **[none]**

Sample ID: **SW #3**

Matrix: **Water**

Lab ID: **25E0028-08**

Date Sampled: **4/30/25 14:18**

Sampled By: **Paul Andersen**

	Result	Units	Minimum Reporting Limit	Method	Preparation Date/Time	Analysis Date/Time	Flag(s)
Inorganic							
Nitrate as N	0.25	mg/L	0.10	EPA 300.0	5/1/25 17:49	5/1/25 17:49	
Total Dissolved Solids (TDS)	584	mg/L	20	SM 2540 C	5/1/25	5/1/25	
Microcystins/Nodularin by LC/MS/MS							
Anatoxin-a	ND	ug/L	0.50	EPA 544M	5/2/25	5/6/25	
Cylindrospermopsin	ND	ug/L	0.50	EPA 544M	5/2/25	5/6/25	
Microcystin-LR	ND	ug/L	0.50	EPA 544M	5/2/25	5/6/25	
Microcystin-RR	ND	ug/L	0.50	EPA 544M	5/2/25	5/6/25	
Microcystin-YR	ND	ug/L	0.50	EPA 544M	5/2/25	5/6/25	
Nodularin	ND	ug/L	0.50	EPA 544M	5/2/25	5/6/25	

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PO#:
Receipt: **5/1/25 10:58 @ 12.7** °C
Date Reported: 6/27/2025
Project Name: **[none]**

Report Footnotes

Abbreviations

ND = Not detected at the corresponding Minimum Reporting Limit (MRL).
1 mg/L = one milligram per liter or 1 mg/kg = one milligram per kilogram = 1 part per million.
1 ug/L = one microgram per liter or 1 ug/kg = one microgram per kilogram = 1 part per billion.
1 ng/L = one nanogram per liter or 1 ng/kg = one nanogram per kilogram = 1 part per trillion.
On calculated parameters, there may be a slight difference between summing the rounded values shown on the report vs the unrounded values used in the calculation.

CH[illegible]N OF CUSTODY - SAMPLE SUB[illegible]TAL FORM

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COMPANY: Sunrise Engineering, LLC
ADDRESS: 11 N. 300 W.
CITY/STATE/ZIP: Washington / UT / 84780
PHONE #: 435 - 652 - 8450
CONTACT: Paul Andersen
EMAIL: Paul.andersen@sunrise-eng.com
PROJECT: Virgin Town Groundwater protection Study
PO Number: S09817
INVOICE EMAIL ADDRESS: Same as above

TRK# 8809 3502 3926

RUSH Due Date*:	QC Level

* Expedited turnaround subject to additional charge

QC levels definition:
QC1: none (default if blank)
QC2: Batch QC, random sample
QC3: 25% surcharge. Narrative plus Batch QC, your sample selected
QC4: 40% surcharge. Add raw data

Sample condition		Delivery Method	
Custody Seal	✓ Correct Containers		
✓ Container Intact	✓ Sufficient Sample Volume		
✓ COC/Labels Agree	Headspace Present (VOC)	UPS	USPS
✓ Received on Ice	Temperature Blank	✓ FedEx	Chemtech-Ford Courier
	✓ Received within Holding Time	Walk-in	Customer Courier

25E0028

TESTS REQUESTED: TDS; TN (Total Nitrogen); ~~PPCP~~ incorrect bottles; Microsystems

Lab Use Only	LOCATION / IDENTIFICATION	DATE	TIME	MATRIX	TDS	TN (Total Nitrogen)	~~PPCP~~	Microsystems
01	1. Truman Well	4-30-25	9:45 AM		✓	✓	✓	
02	2. SW #1	4-30-25	10:15 AM		✓	✓		✓
03	3. GWMW #1	4-30-25	10:26 AM		✓	✓	✓	
04	4. GWMW #2	4-30-25	11:02 AM		✓	✓	✓	
05	5. SW #2	4-30-25	11:13 AM		✓	✓		✓
06	6. GWMW #3	4-30-25	12:10 PM		✓	✓	✓	
07	7. GWMW #4	4-30-25	12:25 PM		✓	✓	✓	
08	8. SW#3	4-30-25	14:18 PM		✓	✓		✓
	9.							
	10.							
				Bottle type	A4			
				Lot #	1437			

Sampled by: [print] Paul Andersen
Sampled by: [signature] [signature]

ON ICE   NOT ON ICE   Temp (C°): 12.9

Special Instructions:

Samples received outside the EPA recommended temperature range of 0-6 C° may be rejected.

Relinquished by: [signature]	Date/Time	Received by: [signature]	Date/Time
[signature]	4-30-25 15:29		
		[signature]	5/1/25 1058

Payment Terms are net 30 days OAC. 1.5% interest charge per month (18% per annum). Client agrees to pay collection costs and attorney's fees.

PPCPs on existing Hazmat Angel [illegible] Micro system on surface water

6/27/2025

Work Order: 25E2329
Project: [none]

Sunrise Engineering-Washington
Attn: Paul Andersen
11 N 300 W
Washington, UT 84780

Client Service Contact: 801.262.7299

The analyses presented on this report were performed in accordance with the National Environmental Laboratory Accreditation Program (NELAP) unless noted in the comments, flags, or case narrative. If the report is to be used for regulatory compliance, it should be presented in its entirety, and not be altered.

Approved By:

Reed Hendricks, Lab Director

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PO#:
Receipt: **5/29/25 12:40 @ 16.6** °C
Date Reported: 6/27/2025
Project Name: **[none]**

Sample ID: **GWMW #1**
Matrix: **Water**
Lab ID: **25E2329-01**
Date Sampled: **5/28/25 12:23**
Sampled By: **Paul Andersen**

	Result	Units	Minimum Reporting Limit	Method	Preparation Date/Time	Analysis Date/Time	Flag(s)
Inorganic							
Nitrate as N	ND	mg/L	0.10	EPA 300.0	5/29/25 13:52	5/29/25 23:43	
Total Dissolved Solids (TDS)	2380	mg/L	20	SM 2540 C	5/30/25	5/30/25	
PPCP & EDC - Screen 1							
2, 6-Di-tert-Butylphenol	ND	ng/L	25	EPA 525M/525 Prep	6/2/25	6/3/25	
4-Methylphenol	ND	ng/L	100	EPA 525M/525 Prep	6/2/25	6/3/25	
4-n-Nonylphenol	ND	ng/L	100	EPA 525M/525 Prep	6/2/25	6/3/25	
Carbaryl	ND	ng/L	25	EPA 525M/525 Prep	6/2/25	6/3/25	
cis-Chlordane	ND	ng/L	25	EPA 525M/525 Prep	6/2/25	6/3/25	
Chlorpyrifos	ND	ng/L	25	EPA 525M/525 Prep	6/2/25	6/3/25	
DEET	ND	ng/L	25	EPA 525M/525 Prep	6/2/25	6/3/25	
Diazinon	ND	ng/L	25	EPA 525M/525 Prep	6/2/25	6/3/25	
Dieldrin	ND	ng/L	25	EPA 525M/525 Prep	6/2/25	6/3/25	
Methyl parathion	ND	ng/L	25	EPA 525M/525 Prep	6/2/25	6/3/25	
Phenol	ND	ng/L	100	EPA 525M/525 Prep	6/2/25	6/3/25	
TDCPP	290	ng/L	25	EPA 525M/525 Prep	6/2/25	6/3/25	
Tris (2-chloroethyl) phosphate	ND	ng/L	25	EPA 525M/525 Prep	6/2/25	6/3/25	
Triphenyl phosphate	ND	ng/L	25	EPA 525M/525 Prep	6/2/25	6/3/25	
Tris (2-butoxyethyl) phosphate	ND	ng/L	100	EPA 525M/525 Prep	6/2/25	6/3/25	
PPCP & EDC - Screen 2							
Acetaminophen	10	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/4/25	
Bisphenol A	14	ng/L	10	EPA 1694M/PHARM Prep	6/2/25	6/3/25	
Butalbital	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/3/25	
Caffeine	40	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/3/25	
Carbamazepine	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/4/25	
Cotinine	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/4/25	
Diazepam	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/4/25	
Diclofenac	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/3/25	
Erythromycin	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/4/25	
Estradiol	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/3/25	
Estrone	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/3/25	
Ethinyl estradiol-17	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/3/25	
Fluoxetine	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/4/25	
Gemfibrozil	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/3/25	
Ibuprofen	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/3/25	
Naproxen	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/3/25	
PFOA	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/3/25	
Primidone	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/3/25	

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Receipt: **5/29/25 12:40 @ 16.6** °C
Date Reported: 6/27/2025
Project Name: **[none]**

Sample ID: **GWMW #1 (cont.)**

Matrix: **Water**
Lab ID: **25E2329-01**
Date Sampled: **5/28/25 12:23**
Sampled By: **Paul Andersen**

	Result	Units	Minimum Reporting Limit	Method	Preparation Date/Time	Analysis Date/Time	Flag(s)
PPCP & EDC - Screen 2 (cont.)							
Progesterone	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/4/25	
Sulfamethoxazole	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/4/25	
Testosterone	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/4/25	
Trimethoprim	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/4/25	

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Receipt: **5/29/25 12:40 @ 16.6** °C
Date Reported: 6/27/2025
Project Name: **[none]**

Sample ID: **GWMW #2**

Matrix: **Water**
Lab ID: **25E2329-02**
Date Sampled: **5/28/25 13:05**
Sampled By: **Paul Andersen**

	Result	Units	Minimum Reporting Limit	Method	Preparation Date/Time	Analysis Date/Time	Flag(s)
Inorganic							
Nitrate as N	ND	mg/L	0.10	EPA 300.0	5/29/25 13:52	5/29/25 23:58	
Total Dissolved Solids (TDS)	3140	mg/L	20	SM 2540 C	5/30/25	5/30/25	
PPCP & EDC - Screen 1							
2, 6-Di-tert-Butylphenol	ND	ng/L	25	EPA 525M/525 Prep	6/2/25	6/3/25	
4-Methylphenol	ND	ng/L	100	EPA 525M/525 Prep	6/2/25	6/3/25	
4-n-Nonylphenol	ND	ng/L	100	EPA 525M/525 Prep	6/2/25	6/3/25	
Carbaryl	ND	ng/L	25	EPA 525M/525 Prep	6/2/25	6/3/25	
cis-Chlordane	ND	ng/L	25	EPA 525M/525 Prep	6/2/25	6/3/25	
Chlorpyrifos	ND	ng/L	25	EPA 525M/525 Prep	6/2/25	6/3/25	
DEET	ND	ng/L	25	EPA 525M/525 Prep	6/2/25	6/3/25	
Diazinon	ND	ng/L	25	EPA 525M/525 Prep	6/2/25	6/3/25	
Dieldrin	ND	ng/L	25	EPA 525M/525 Prep	6/2/25	6/3/25	
Methyl parathion	ND	ng/L	25	EPA 525M/525 Prep	6/2/25	6/3/25	
Phenol	ND	ng/L	100	EPA 525M/525 Prep	6/2/25	6/3/25	
TDCPP	27	ng/L	25	EPA 525M/525 Prep	6/2/25	6/3/25	
Tris (2-chloroethyl) phosphate	ND	ng/L	25	EPA 525M/525 Prep	6/2/25	6/3/25	
Triphenyl phosphate	ND	ng/L	25	EPA 525M/525 Prep	6/2/25	6/3/25	
Tris (2-butoxyethyl) phosphate	ND	ng/L	100	EPA 525M/525 Prep	6/2/25	6/3/25	
PPCP & EDC - Screen 2							
Acetaminophen	6	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/4/25	
Bisphenol A	13	ng/L	10	EPA 1694M/PHARM Prep	6/2/25	6/3/25	
Butalbital	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/3/25	
Caffeine	31	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/3/25	
Carbamazepine	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/4/25	
Cotinine	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/4/25	
Diazepam	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/4/25	
Diclofenac	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/3/25	
Erythromycin	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/4/25	
Estradiol	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/3/25	
Estrone	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/3/25	
Ethinyl estradiol-17	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/3/25	
Fluoxetine	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/4/25	
Gemfibrozil	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/3/25	
Ibuprofen	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/3/25	
Naproxen	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/3/25	
PFOA	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/3/25	
Primidone	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/3/25	

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Receipt: **5/29/25 12:40 @ 16.6** °C
Date Reported: 6/27/2025
Project Name: **[none]**

Sample ID: **GWMW #2 (cont.)**
Matrix: **Water**
Lab ID: **25E2329-02**
Date Sampled: **5/28/25 13:05**
Sampled By: **Paul Andersen**

	Result	Units	Minimum Reporting Limit	Method	Preparation Date/Time	Analysis Date/Time	Flag(s)
PPCP & EDC - Screen 2 (cont.)							
Progesterone	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/4/25	
Sulfamethoxazole	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/4/25	
Testosterone	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/4/25	
Trimethoprim	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/4/25	

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Date Reported: 6/27/2025
Project Name: **[none]**

Sample ID: **GWMW #3**
Matrix: **Water**
Lab ID: **25E2329-03**
Date Sampled: **5/28/25 14:30**
Sampled By: **Paul Andersen**

	Result	Units	Minimum Reporting Limit	Method	Preparation Date/Time	Analysis Date/Time	Flag(s)
Inorganic							
Nitrate as N	ND	mg/L	0.10	EPA 300.0	5/29/25 13:52	5/30/25 0:13	
Total Dissolved Solids (TDS)	3700	mg/L	20	SM 2540 C	5/30/25	5/30/25	
PPCP & EDC - Screen 1							
2, 6-Di-tert-Butylphenol	ND	ng/L	25	EPA 525M/525 Prep	6/2/25	6/3/25	
4-Methylphenol	ND	ng/L	100	EPA 525M/525 Prep	6/2/25	6/3/25	
4-n-Nonylphenol	ND	ng/L	100	EPA 525M/525 Prep	6/2/25	6/3/25	
Carbaryl	ND	ng/L	25	EPA 525M/525 Prep	6/2/25	6/3/25	
cis-Chlordane	ND	ng/L	25	EPA 525M/525 Prep	6/2/25	6/3/25	
Chlorpyrifos	ND	ng/L	25	EPA 525M/525 Prep	6/2/25	6/3/25	
DEET	ND	ng/L	25	EPA 525M/525 Prep	6/2/25	6/3/25	
Diazinon	ND	ng/L	25	EPA 525M/525 Prep	6/2/25	6/3/25	
Dieldrin	ND	ng/L	25	EPA 525M/525 Prep	6/2/25	6/3/25	
Methyl parathion	ND	ng/L	25	EPA 525M/525 Prep	6/2/25	6/3/25	
Phenol	ND	ng/L	100	EPA 525M/525 Prep	6/2/25	6/3/25	
TDCPP	ND	ng/L	25	EPA 525M/525 Prep	6/2/25	6/3/25	
Tris (2-chloroethyl) phosphate	ND	ng/L	25	EPA 525M/525 Prep	6/2/25	6/3/25	
Triphenyl phosphate	ND	ng/L	25	EPA 525M/525 Prep	6/2/25	6/3/25	
Tris (2-butoxyethyl) phosphate	ND	ng/L	100	EPA 525M/525 Prep	6/2/25	6/3/25	
PPCP & EDC - Screen 2							
Acetaminophen	13	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/4/25	
Bisphenol A	17	ng/L	10	EPA 1694M/PHARM Prep	6/2/25	6/3/25	
Butalbital	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/3/25	
Caffeine	53	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/3/25	
Carbamazepine	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/4/25	
Cotinine	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/4/25	
Diazepam	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/4/25	
Diclofenac	12	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/3/25	
Erythromycin	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/4/25	
Estradiol	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/3/25	
Estrone	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/3/25	
Ethinyl estradiol-17	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/3/25	
Fluoxetine	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/4/25	
Gemfibrozil	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/3/25	
Ibuprofen	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/3/25	
Naproxen	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/3/25	
PFOA	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/3/25	
Primidone	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/3/25	

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Project Name: **[none]**

Sample ID: **GWMW #3 (cont.)**

Matrix: **Water**
Lab ID: **25E2329-03**
Date Sampled: **5/28/25 14:30**
Sampled By: **Paul Andersen**

	Result	Units	Minimum Reporting Limit	Method	Preparation Date/Time	Analysis Date/Time	Flag(s)
PPCP & EDC - Screen 2 (cont.)							
Progesterone	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/4/25	
Sulfamethoxazole	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/4/25	
Testosterone	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/4/25	
Trimethoprim	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/4/25	

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Date Reported: 6/27/2025
Project Name: **[none]**

Sample ID: **GWMW #4**
Matrix: **Water**
Lab ID: **25E2329-04**
Date Sampled: **5/28/25 14:45**
Sampled By: **Paul Andersen**

	Result	Units	Minimum Reporting Limit	Method	Preparation Date/Time	Analysis Date/Time	Flag(s)
Inorganic							
Nitrate as N	0.13	mg/L	0.10	EPA 300.0	5/29/25 13:56	5/30/25 4:44	
Total Dissolved Solids (TDS)	1570	mg/L	20	SM 2540 C	5/30/25	5/30/25	
PPCP & EDC - Screen 1							
2, 6-Di-tert-Butylphenol	ND	ng/L	25	EPA 525M/525 Prep	6/2/25	6/3/25	
4-Methylphenol	ND	ng/L	100	EPA 525M/525 Prep	6/2/25	6/3/25	
4-n-Nonylphenol	ND	ng/L	100	EPA 525M/525 Prep	6/2/25	6/3/25	
Carbaryl	ND	ng/L	25	EPA 525M/525 Prep	6/2/25	6/3/25	
cis-Chlordane	ND	ng/L	25	EPA 525M/525 Prep	6/2/25	6/3/25	
Chlorpyrifos	ND	ng/L	25	EPA 525M/525 Prep	6/2/25	6/3/25	
DEET	ND	ng/L	25	EPA 525M/525 Prep	6/2/25	6/3/25	
Diazinon	ND	ng/L	25	EPA 525M/525 Prep	6/2/25	6/3/25	
Dieldrin	ND	ng/L	25	EPA 525M/525 Prep	6/2/25	6/3/25	
Methyl parathion	ND	ng/L	25	EPA 525M/525 Prep	6/2/25	6/3/25	
Phenol	ND	ng/L	100	EPA 525M/525 Prep	6/2/25	6/3/25	
TDCPP	31	ng/L	25	EPA 525M/525 Prep	6/2/25	6/3/25	
Tris (2-chloroethyl) phosphate	ND	ng/L	25	EPA 525M/525 Prep	6/2/25	6/3/25	
Triphenyl phosphate	ND	ng/L	25	EPA 525M/525 Prep	6/2/25	6/3/25	
Tris (2-butoxyethyl) phosphate	ND	ng/L	100	EPA 525M/525 Prep	6/2/25	6/3/25	
PPCP & EDC - Screen 2							
Acetaminophen	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/4/25	
Bisphenol A	30	ng/L	10	EPA 1694M/PHARM Prep	6/2/25	6/3/25	
Butalbital	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/3/25	
Caffeine	21	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/3/25	
Carbamazepine	43	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/4/25	
Cotinine	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/4/25	
Diazepam	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/4/25	
Diclofenac	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/3/25	
Erythromycin	17	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/4/25	
Estradiol	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/3/25	
Estrone	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/3/25	
Ethinyl estradiol-17	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/3/25	
Fluoxetine	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/4/25	
Gemfibrozil	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/3/25	
Ibuprofen	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/3/25	
Naproxen	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/3/25	
PFOA	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/3/25	
Primidone	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/3/25	

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Date Reported: 6/27/2025
Project Name: **[none]**

Sample ID: **GWMW #4 (cont.)**

Matrix: **Water**

Lab ID: **25E2329-04**

Date Sampled: **5/28/25 14:45**

Sampled By: **Paul Andersen**

	Result	Units	Minimum Reporting Limit	Method	Preparation Date/Time	Analysis Date/Time	Flag(s)
PPCP & EDC - Screen 2 (cont.)							
Progesterone	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/4/25	
Sulfamethoxazole	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/4/25	
Testosterone	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/4/25	
Trimethoprim	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/4/25	

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Receipt: **5/29/25 12:40 @ 16.6** °C
Date Reported: 6/27/2025
Project Name: **[none]**

Sample ID: **GWMW #5 (Truman Well)**

Matrix: **Water**

Lab ID: **25E2329-05**

Date Sampled: **5/28/25 11:10**

Sampled By: **Paul Andersen**

	Result	Units	Minimum Reporting Limit	Method	Preparation Date/Time	Analysis Date/Time	Flag(s)
Inorganic							
Nitrate as N	7.06	mg/L	0.10	EPA 300.0	5/29/25 13:56	5/30/25 4:59	
Total Dissolved Solids (TDS)	3430	mg/L	20	SM 2540 C	5/30/25	5/30/25	
PPCP & EDC - Screen 1							
2, 6-Di-tert-Butylphenol	ND	ng/L	25	EPA 525M/525 Prep	6/2/25	6/3/25	
4-Methylphenol	ND	ng/L	100	EPA 525M/525 Prep	6/2/25	6/3/25	
4-n-Nonylphenol	ND	ng/L	100	EPA 525M/525 Prep	6/2/25	6/3/25	
Carbaryl	ND	ng/L	25	EPA 525M/525 Prep	6/2/25	6/3/25	
cis-Chlordane	ND	ng/L	25	EPA 525M/525 Prep	6/2/25	6/3/25	
Chlorpyrifos	ND	ng/L	25	EPA 525M/525 Prep	6/2/25	6/3/25	
DEET	ND	ng/L	25	EPA 525M/525 Prep	6/2/25	6/3/25	
Diazinon	ND	ng/L	25	EPA 525M/525 Prep	6/2/25	6/3/25	
Dieldrin	ND	ng/L	25	EPA 525M/525 Prep	6/2/25	6/3/25	
Methyl parathion	ND	ng/L	25	EPA 525M/525 Prep	6/2/25	6/3/25	
Phenol	ND	ng/L	100	EPA 525M/525 Prep	6/2/25	6/3/25	
TDCPP	ND	ng/L	25	EPA 525M/525 Prep	6/2/25	6/3/25	
Tris (2-chloroethyl) phosphate	ND	ng/L	25	EPA 525M/525 Prep	6/2/25	6/3/25	
Triphenyl phosphate	ND	ng/L	25	EPA 525M/525 Prep	6/2/25	6/3/25	
Tris (2-butoxyethyl) phosphate	ND	ng/L	100	EPA 525M/525 Prep	6/2/25	6/3/25	
PPCP & EDC - Screen 2							
Acetaminophen	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/4/25	
Bisphenol A	ND	ng/L	10	EPA 1694M/PHARM Prep	6/2/25	6/3/25	
Butalbital	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/3/25	
Caffeine	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/3/25	
Carbamazepine	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/4/25	
Cotinine	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/4/25	
Diazepam	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/4/25	
Diclofenac	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/3/25	
Erythromycin	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/4/25	
Estradiol	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/3/25	
Estrone	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/3/25	
Ethinyl estradiol-17	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/3/25	
Fluoxetine	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/4/25	
Gemfibrozil	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/3/25	
Ibuprofen	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/3/25	
Naproxen	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/3/25	
PFOA	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/3/25	
Primidone	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/3/25	

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Date Reported: 6/27/2025
Project Name: **[none]**

Sample ID: **GWMW #5 (Truman Well) (cont.)**

Matrix: **Water**

Lab ID: **25E2329-05**

Date Sampled: **5/28/25 11:10**

Sampled By: **Paul Andersen**

	Result	Units	Minimum Reporting Limit	Method	Preparation Date/Time	Analysis Date/Time	Flag(s)
PPCP & EDC - Screen 2 (cont.)							
Progesterone	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/4/25	
Sulfamethoxazole	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/4/25	
Testosterone	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/4/25	
Trimethoprim	ND	ng/L	5	EPA 1694M/PHARM Prep	6/2/25	6/4/25	

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Date Reported: 6/27/2025
Project Name: **[none]**

Sample ID: **SW #1 (U/S)**

Matrix: **Water**

Lab ID: **25E2329-06**

Date Sampled: **5/28/25 11:39**

Sampled By: **Paul Andersen**

	Result	Units	Minimum Reporting Limit	Method	Preparation Date/Time	Analysis Date/Time	Flag(s)
Inorganic							
Nitrate as N	0.19	mg/L	0.10	EPA 300.0	5/29/25 13:52	5/30/25 0:28	
Total Dissolved Solids (TDS)	460	mg/L	20	SM 2540 C	5/30/25	5/30/25	

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Receipt: **5/29/25 12:40 @ 16.6** °C
Date Reported: 6/27/2025
Project Name: **[none]**

Sample ID: **SW #2 (North Creek)**

Matrix: **Water**

Lab ID: **25E2329-07**

Date Sampled: **5/28/25 13:19**

Sampled By: **Paul Andersen**

	Result	Units	Minimum Reporting Limit	Method	Preparation Date/Time	Analysis Date/Time	Flag(s)
Inorganic							
Nitrate as N	ND	mg/L	0.10	EPA 300.0	5/29/25 13:52	5/30/25 0:43	
Total Dissolved Solids (TDS)	1250	mg/L	20	SM 2540 C	5/30/25	5/30/25	

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PO#:
Receipt: **5/29/25 12:40 @ 16.6** °C
Date Reported: 6/27/2025
Project Name: **[none]**

Sample ID: **SW #3 (D/S)**

Matrix: **Water**
Lab ID: **25E2329-08**
Date Sampled: **5/28/25 15:15**
Sampled By: **Paul Andersen**

	Result	Units	Minimum Reporting Limit	Method	Preparation Date/Time	Analysis Date/Time	Flag(s)
Inorganic							
Nitrate as N	0.19	mg/L	0.10	EPA 300.0	5/29/25 13:56	5/30/25 5:44	
Total Dissolved Solids (TDS)	516	mg/L	20	SM 2540 C	5/30/25	5/30/25	

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PO#:
Receipt: **5/29/25 12:40 @ 16.6** °C
Date Reported: 6/27/2025
Project Name: **[none]**

Report Footnotes

Abbreviations

ND = Not detected at the corresponding Minimum Reporting Limit (MRL).
1 mg/L = one milligram per liter or 1 mg/kg = one milligram per kilogram = 1 part per million.
1 ug/L = one microgram per liter or 1 ug/kg = one microgram per kilogram = 1 part per billion.
1 ng/L = one nanogram per liter or 1 ng/kg = one nanogram per kilogram = 1 part per trillion.
On calculated parameters, there may be a slight difference between summing the rounded values shown on the report vs the unrounded values used in the calculation.

Flag Descriptions

S-04 = The surrogate recovery for this sample is outside of established control limits due to a sample matrix effect.

S-GC = Surrogate recovery outside of control limits. The data was accepted based on valid recovery of the remaining surrogate.

CHAIN OF CUSTODY - SAMPLE SUBMITTAL FORM

COMPANY: Sunrise Engineering
ADDRESS: 11 N 300 W
CITY/STATE/ZIP: Washington/UT/84780
PHONE #: 435-215-1933
CONTACT: Paul Andersen
EMAIL: paul.andersen@sunrise-eng.com
PROJECT: Virgin Town Groundwater Protection Study
PO Number: S09817
INVOICE EMAIL ADDRESS: paul.andersen@sunrise-eng.com

RUSH Due Date*:	QC Level

* Expedited turnaround subject to additional charge

QC levels definition:
QC1: none (default if blank)
QC2: Batch QC, random sample
QC3: 25% surcharge. Narrative plus Batch QC, your sample selected
QC4: 40% surcharge. Add raw data

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8816 0699 1477

Sample condition	
Custody Seal	Correct Containers
Container Intact	Sufficient Sample Volume
COC/Labels Agree	Headspace Present (VOC)
Received on Ice	Temperature Blank
	Received within Holding Time

Delivery Method	
UPS	USPS
FedEx	Chemtech-Ford Courier
Walk-in	Customer Courier

25E2329

Lab Use Only	LOCATION / IDENTIFICATION	DATE	TIME	MATRIX	Nitrate	TDS	PPCP + EDC List														
01	1. GWMW #1 (x2)	5/28/2025	12:23		X	X	X														
02	2. GWMW #2 (x2)	5/28/2025	13:05		X	X	X					1-8	AQ	1464							
03	3. GWMW #3 (x2)	5/28/2025	14:30		X	X	X														
04	4. GWMW #4 (x2)	5/28/2025	14:45		X	X	X					1-5	AGL	1447							
05	5. GWMW #5 (Truman Well) (x2)	5/28/2025	11:10		X	X	X														
06	6. SW #1 (U/S)	5/28/2025	11:39		X	X															
07	7. SW #2 (North Creek)	5/28/2025	13:19		X	X															
08	8. SW #3 (D/S)	5/28/2025	15:15		X	X															
	9.																				
	10.																				
				Bottle type																	
				Lot #																	

Sampled by: [print] Paul Andersen
Sampled by: [signature]

ON ICE NOT ON ICE Temp (C°): 16.6

Special Instructions:

Samples received outside the EPA recommended temperature range of 0-6 C° may be rejected.

Relinquished by: [signature]	Date/Time	Received by: [signature]	Date/Time
Fed Ex		Aubane Fees	5/29/25 1240

Payment Terms are net 30 days OAC. 1.5% interest charge per month (18% per annum). Client agress to pay collection costs and attorney's fees.

Appendix C

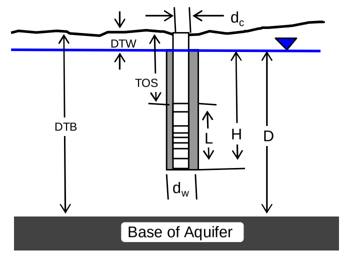
Slug Test Results

WELL ID: GWMW#1

Local ID: GWMW#1 Test 1
Date: 1/27/2025
Time: 14:44

INPUT

Construction:		
Casing dia. (d_c)	2	Inch
Annulus dia. (d_w)	2	Inch
Screen Length (L)	4	Feet
Depths to:		
water level (DTW)	10	Feet
top of screen (TOS)	8.8	Feet
Base of Aquifer (DTB)	12.8	Feet
Annular Fill:		
across screen -- Fine Sand		
above screen -- Backfill		
Aquifer Material -- Fine Sand		



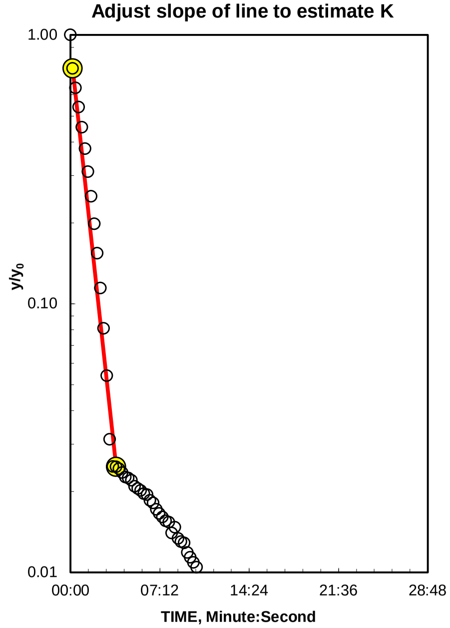
COMPUTED

L_{wetted}	2.8	Feet
D =	2.8	Feet
H =	2.8	Feet
L/r_w =	9.60	
$y_{0\text{-DISPLACEMENT}}$ =	1.85	Feet
$y_{0\text{-SLUG}}$ =	1.92	Feet
From look-up table using L/r_w		
Fully penetrate C =	1.185	
ln(Re/rw) =	1.640	
Re =	1.50	Feet
Slope =	0.007060482	$\log_{10}$/sec
$t_{90\%}$ recovery =	142	sec

Input is consistent.

K =	2.9	Feet/Day

Adjust slope of line to estimate K



K= 2.9 is less than likely minimum of 3 for Fine Sand

REMARKS:

Bouwer and Rice analysis of slug test, WRR 1976

Slug test was conducted in surficial aquifer, Virgin, Utah.

Reduced Data

Entry	Time, Hr:Min:Sec	Water Level
1	14:44:35.0	11.90
2	14:45:00.0	11.22
3	14:45:30.0	10.89
4	14:46:00.0	10.62
5	14:46:30.0	10.42
6	14:47:00.0	10.26
7	14:47:30.0	10.15
8	14:48:00.0	10.10
9	14:48:30.0	10.09
10	14:49:00.0	10.09
11	14:49:30.0	10.09
12	14:50:00.0	10.09
13	14:50:30.0	10.09
14	14:51:00.0	10.08
15	15:04:30.0	10.04
16	15:05:00.0	10.04
17	15:05:30.0	10.04
18	15:06:00.0	10.04
19	15:06:30.0	10.04
20	15:07:00.0	10.04
21	15:07:30.0	10.03
22	15:08:00.0	10.03
23	15:08:30.0	10.03
24	15:09:00.0	10.03
25	#N/A	#N/A
26	#N/A	#N/A
27	#N/A	#N/A
28	#N/A	#N/A
29	#N/A	#N/A
30	#N/A	#N/A
31	#N/A	#N/A
32	#N/A	#N/A
33	#N/A	#N/A
34	#N/A	#N/A
35	#N/A	#N/A
36	#N/A	#N/A
37	#N/A	#N/A
38	#N/A	#N/A
39	#N/A	#N/A
40	#N/A	#N/A
41	#N/A	#N/A
42	#N/A	#N/A
43	#N/A	#N/A
44	#N/A	#N/A
45	#N/A	#N/A

WELL ID: GWMW#1

Local ID: GWMW#1 Test 2
Date: 1/27/2025
Time: 15:21

INPUT

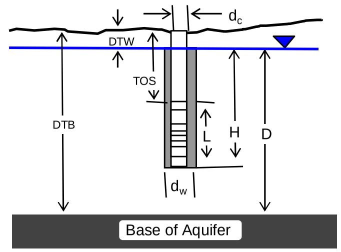
Construction:		
Casing dia. (d_c)	2	Inch
Annulus dia. (d_w)	2	Inch
Screen Length (L)	4	Feet
Depths to:		
water level (DTW)	10	Feet
top of screen (TOS)	8.8	Feet
Base of Aquifer (DTB)	12.8	Feet
Annular Fill:		
across screen -- Fine Sand		
above screen -- Backfill		
Aquifer Material -- Fine Sand		

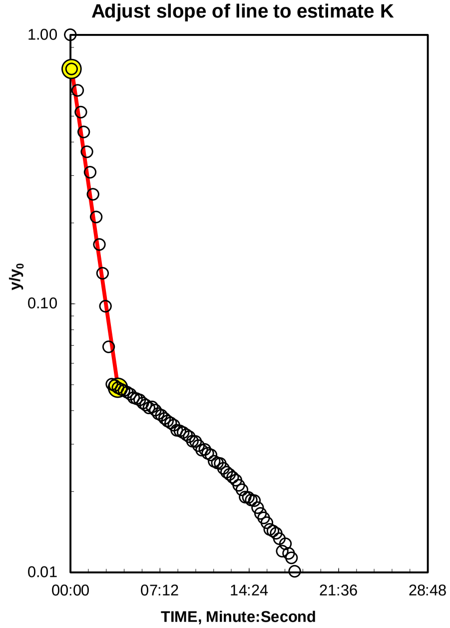
COMPUTED

L_{wetted}	2.8	Feet
D =	2.8	Feet
H =	2.8	Feet
L/r_w =	9.60	
$y_{0\text{-DISPLACEMENT}}$ =	1.72	Feet
$y_{0\text{-SLUG}}$ =	1.92	Feet
From look-up table using L/r_w		
Fully penetrate C =	1.185	
ln(Re/rw) =	1.640	
Re =	1.50	Feet
Slope =	0.00527202	$\log_{10}$/sec
$t_{90\%}$ recovery =	190	sec

Input is consistent.

K = 2.1 Feet/Day





K= 2.1 is less than likely minimum of 3 for Fine Sand

REMARKS:

Bouwer and Rice analysis of slug test, WRR 1976

Slug test was conducted in surficial aquifer, Virgin, Utah.

Reduced Data

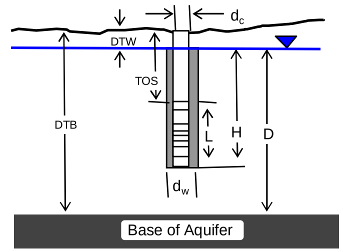
Entry	Time, Hr:Min:Sec	Water Level
1	15:21:25.0	11.82
2	15:22:00.0	11.17
3	15:22:30.0	10.85
4	15:23:00.0	10.63
5	15:23:30.0	10.46
6	15:24:00.0	10.32
7	15:24:30.0	10.22
8	15:25:00.0	10.19
9	15:25:30.0	10.18
10	15:26:00.0	10.18
11	15:26:30.0	10.18
12	15:27:00.0	10.18
13	15:27:30.0	10.17
14	15:28:00.0	10.17
15	15:41:30.0	10.11
16	15:42:00.0	10.11
17	15:42:30.0	10.11
18	15:43:00.0	10.10
19	15:43:30.0	10.10
20	15:44:00.0	10.10
21	15:44:30.0	10.00
22	15:45:00.0	10.00
23	15:45:30.0	10.00
24	15:46:00.0	10.00
25	#N/A	#N/A
26	#N/A	#N/A
27	#N/A	#N/A
28	#N/A	#N/A
29	#N/A	#N/A
30	#N/A	#N/A
31	#N/A	#N/A
32	#N/A	#N/A
33	#N/A	#N/A
34	#N/A	#N/A
35	#N/A	#N/A
36	#N/A	#N/A
37	#N/A	#N/A
38	#N/A	#N/A
39	#N/A	#N/A
40	#N/A	#N/A
41	#N/A	#N/A
42	#N/A	#N/A
43	#N/A	#N/A
44	#N/A	#N/A
45	#N/A	#N/A

WELL ID: GWMW#1

Local ID: GWMW#1 Test 3
Date: 1/27/2025
Time: 15:58

INPUT

Construction:		
Casing dia. (d_c)	2	Inch
Annulus dia. (d_w)	2	Inch
Screen Length (L)	4	Feet
Depths to:		
water level (DTW)	10	Feet
top of screen (TOS)	8.8	Feet
Base of Aquifer (DTB)	12.8	Feet
Annular Fill:		
across screen -- Fine Sand		
above screen -- Backfill		
Aquifer Material -- Fine Sand		



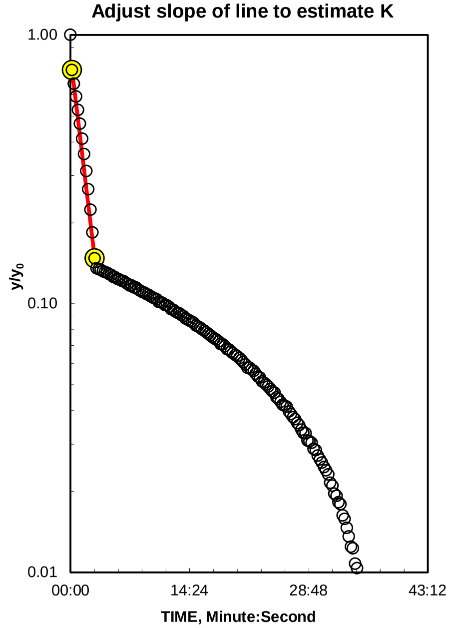
COMPUTED

L_{wetted}	2.8	Feet
D =	2.8	Feet
H =	2.8	Feet
L/r_w =	9.60	
$y_{0\text{-DISPLACEMENT}}$ =	1.71	Feet
$y_{0\text{-SLUG}}$ =	1.92	Feet
From look-up table using L/r_w		
Fully penetrate C =	1.185	
ln(Re/rw) =	1.640	
Re =	1.50	Feet
Slope =	0.004245906	$\log_{10}$/sec
$t_{90\%}$ recovery =	236	sec

Input is consistent.

K = 1.7 Feet/Day

Adjust slope of line to estimate K



K= 1.7 is less than likely minimum of 3 for Fine Sand

REMARKS:

Bouwer and Rice analysis of slug test, WRR 1976

Slug test was conducted in surficial aquifer, Virgin, Utah.

Reduced Data

Entry	Time, Hr:Min:Sec	Water Level
1	15:58:20.0	12.06
2	15:59:00.0	11.36
3	15:59:45.0	11.05
4	16:00:30.0	10.80
5	16:01:15.0	10.60
6	16:02:00.0	10.58
7	16:02:45.0	10.57
8	16:03:30.0	10.57
9	16:04:15.0	10.56
10	16:05:00.0	10.55
11	16:18:45.0	10.46
12	16:19:30.0	10.45
13	16:20:15.0	10.45
14	16:21:00.0	10.44
15	16:21:45.0	10.44
16	16:22:30.0	10.43
17	#N/A	#N/A
18	#N/A	#N/A
19	#N/A	#N/A
20	#N/A	#N/A
21	#N/A	#N/A
22	#N/A	#N/A
23	#N/A	#N/A
24	#N/A	#N/A
25	#N/A	#N/A
26	#N/A	#N/A
27	#N/A	#N/A
28	#N/A	#N/A
29	#N/A	#N/A
30	#N/A	#N/A
31	#N/A	#N/A
32	#N/A	#N/A
33	#N/A	#N/A
34	#N/A	#N/A
35	#N/A	#N/A
36	#N/A	#N/A
37	#N/A	#N/A
38	#N/A	#N/A
39	#N/A	#N/A
40	#N/A	#N/A
41	#N/A	#N/A
42	#N/A	#N/A
43	#N/A	#N/A
44	#N/A	#N/A
45	#N/A	#N/A

WELL ID: GWMW#2

Local ID: GWMW#2 Test 1
Date: 1/27/2025
Time: 12:10

INPUT

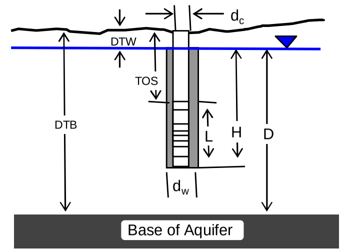
Construction:		
Casing dia. (d_c)	2	Inch
Annulus dia. (d_w)	2	Inch
Screen Length (L)	4.5	Feet
Depths to:		
water level (DTW)	7.08	Feet
top of screen (TOS)	8.5	Feet
Base of Aquifer (DTB)	13	Feet
Annular Fill:		
across screen --	Fine Sand	
above screen --	Backfill	
Aquifer Material --	Fine Sand	

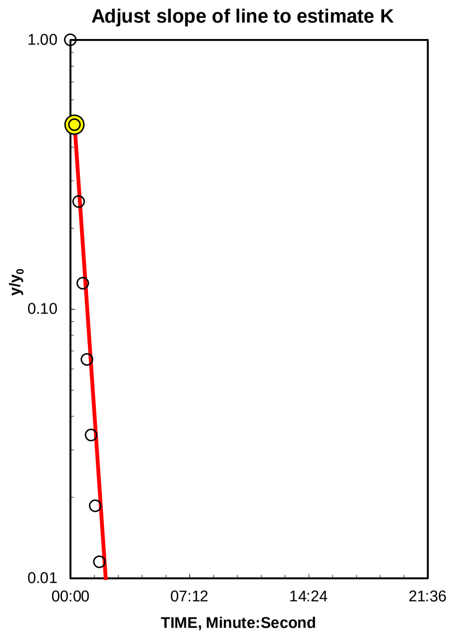
COMPUTED

L_{wetted}	4.5	Feet
D =	5.92	Feet
H =	5.92	Feet
L/r_w =	15.43	
$y_{0\text{-DISPLACEMENT}}$ =	2.17	Feet
$y_{0\text{-SLUG}}$ =	1.92	Feet
From look-up table using L/r_w		
Fully penetrate C =	1.531	
ln(Re/rw) =	2.152	
Re =	2.51	Feet
Slope =	0.01491652	log_{10}/sec
$t_{90\%}$ recovery =	67	sec

Input is consistent.

K =	4.9	Feet/Day





Bouwer and Rice analysis of slug test, WRR 1976

REMARKS:

Slug test was conducted in surficial aquifer, Virgin, Utah.

Reduced Data

Entry	Time, Hr:Min:Sec	Water Level
1	12:10:00.0	9.25
2	12:10:15.0	8.13
3	12:10:30.0	7.62
4	12:10:45.0	7.35
5	12:11:00.0	7.22
6	12:11:15.0	7.15
7	12:11:30.0	7.12
8	12:11:45.0	7.11
9	12:12:00.0	7.09
10	12:12:15.0	7.09
11	12:12:30.0	7.09
12	12:12:45.0	7.09
13	12:13:00.0	7.08
14	12:13:15.0	7.08
15	12:13:30.0	7.08
16	12:13:45.0	7.08
17	12:14:00.0	7.08
18	12:14:15.0	7.08
19	12:14:30.0	7.08
20	12:14:45.0	7.08
21	12:15:00.0	7.08
22	12:15:15.0	7.08
23	12:15:30.0	7.08
24	12:15:45.0	7.08
25	12:16:00.0	7.08
26	12:16:15.0	7.08
27	12:16:30.0	7.08
28	12:16:45.0	7.08
29	12:30:00.0	7.08
30	12:30:15.0	7.08
31	#N/A	#N/A
32	#N/A	#N/A
33	#N/A	#N/A
34	#N/A	#N/A
35	#N/A	#N/A
36	#N/A	#N/A
37	#N/A	#N/A
38	#N/A	#N/A
39	#N/A	#N/A
40	#N/A	#N/A
41	#N/A	#N/A
42	#N/A	#N/A
43	#N/A	#N/A
44	#N/A	#N/A
45	#N/A	#N/A

WELL ID: GWMW#2

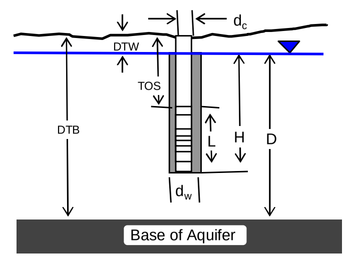
Local ID: GWMW#2 Test 2
Date: 1/27/2025
Time: 12:36

INPUT

Construction:		
Casing dia. (d_c)	2	Inch
Annulus dia. (d_w)	2	Inch
Screen Length (L)	4.5	Feet
Depths to:		
water level (DTW)	7.08	Feet
top of screen (TOS)	8.5	Feet
Base of Aquifer (DTB)	13	Feet

Annular Fill:
across screen -- Fine Sand
above screen -- Backfill

Aquifer Material -- Fine Sand



COMPUTED

L_{wetted}	4.5	Feet
D =	5.92	Feet
H =	5.92	Feet
L/r_w =	15.43	
$y_{0\text{-DISPLACEMENT}}$ =	1.98	Feet
$y_{0\text{-SLUG}}$ =	1.92	Feet

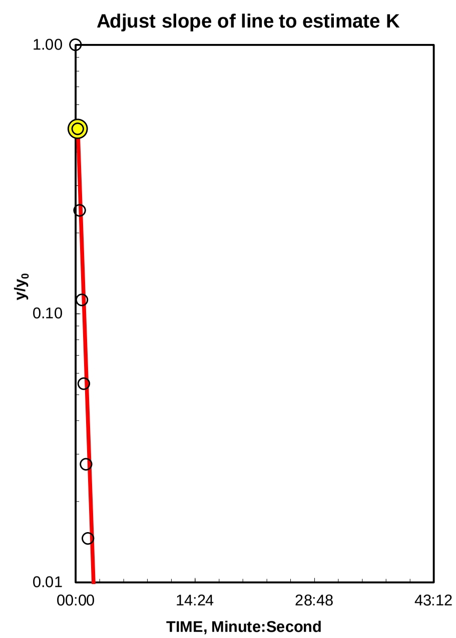
From look-up table using L/r_w

Fully penetrate C =	1.531	
ln(Re/rw) =	2.152	
Re =	2.51	Feet
Slope =	0.014650085	log_{10}/sec
$t_{90\%}$ recovery =	68	sec

Input is consistent.

K =	4.8	Feet/Day

Adjust slope of line to estimate K



Bouwer and Rice analysis of slug test, WRR 1976

REMARKS:

Slug test was conducted in surficial aquifer, Virgin, Utah.

Reduced Data

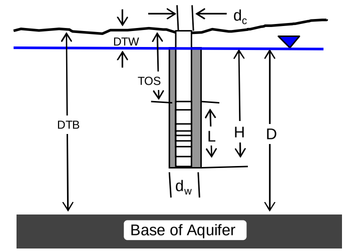
Entry	Time, Hr:Min:Sec	Water Level
1	12:36:30.0	9.06
2	12:37:15.0	7.30
3	12:38:00.0	7.11
4	12:38:45.0	7.10
5	12:39:30.0	7.10
6	12:40:15.0	7.09
7	12:41:00.0	7.09
8	12:41:45.0	7.09
9	12:42:30.0	7.09
10	12:43:15.0	7.09
11	#N/A	#N/A
12	#N/A	#N/A
13	#N/A	#N/A
14	#N/A	#N/A
15	#N/A	#N/A
16	#N/A	#N/A
17	#N/A	#N/A
18	#N/A	#N/A
19	#N/A	#N/A
20	#N/A	#N/A
21	#N/A	#N/A
22	#N/A	#N/A
23	#N/A	#N/A
24	#N/A	#N/A
25	#N/A	#N/A
26	#N/A	#N/A
27	#N/A	#N/A
28	#N/A	#N/A
29	#N/A	#N/A
30	#N/A	#N/A
31	#N/A	#N/A
32	#N/A	#N/A
33	#N/A	#N/A
34	#N/A	#N/A
35	#N/A	#N/A
36	#N/A	#N/A
37	#N/A	#N/A
38	#N/A	#N/A
39	#N/A	#N/A
40	#N/A	#N/A
41	#N/A	#N/A
42	#N/A	#N/A
43	#N/A	#N/A
44	#N/A	#N/A
45	#N/A	#N/A

WELL ID: GWMW#2

Local ID: GWMW#2 Test 3
Date: 1/27/2025
Time: 14:02

INPUT

Construction:		
Casing dia. (d_c)	2	Inch
Annulus dia. (d_w)	2	Inch
Screen Length (L)	4.5	Feet
Depths to:		
water level (DTW)	7.08	Feet
top of screen (TOS)	8.5	Feet
Base of Aquifer (DTB)	13	Feet
Annular Fill:		
across screen --	Fine Sand	
above screen --	Backfill	
Aquifer Material --	Fine Sand	



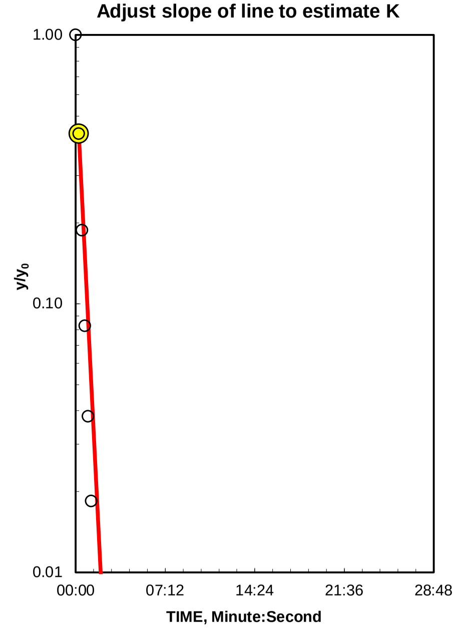
COMPUTED

L_{wetted}	4.5	Feet
D =	5.92	Feet
H =	5.92	Feet
L/r_w =	54.00	
$y_{0\text{-DISPLACEMENT}}$ =	1.95	Feet
$y_{0\text{-SLUG}}$ =	1.92	Feet
From look-up table using L/r_w		
Fully penetrate C =	2.891	
ln(Re/rw) =	3.210	
Re =	2.06	Feet
Slope =	0.015525534	$\log_{10}$/sec
$t_{90\%}$ recovery =	64	sec

Input is consistent.

K = 7.6 Feet/Day

Adjust slope of line to estimate K



Bouwer and Rice analysis of slug test, WRR 1976

REMARKS:

Slug test was conducted in surficial aquifer, Virgin, Utah.

Reduced Data

Entry	Time, Hr:Min:Sec	Water Level
1	14:02:45.0	9.03
2	14:03:15.0	7.45
3	14:03:45.0	7.15
4	14:04:15.0	7.10
5	14:04:45.0	7.09
6	14:05:15.0	7.08
7	14:05:45.0	7.08
8	14:06:15.0	7.08
9	14:06:45.0	7.08
10	14:07:15.0	7.08
11	14:07:45.0	7.08
12	14:08:15.0	7.08
13	14:08:45.0	7.08
14	14:09:15.0	7.08
15	14:22:45.0	7.08
16	#N/A	#N/A
17	#N/A	#N/A
18	#N/A	#N/A
19	#N/A	#N/A
20	#N/A	#N/A
21	#N/A	#N/A
22	#N/A	#N/A
23	#N/A	#N/A
24	#N/A	#N/A
25	#N/A	#N/A
26	#N/A	#N/A
27	#N/A	#N/A
28	#N/A	#N/A
29	#N/A	#N/A
30	#N/A	#N/A
31	#N/A	#N/A
32	#N/A	#N/A
33	#N/A	#N/A
34	#N/A	#N/A
35	#N/A	#N/A
36	#N/A	#N/A
37	#N/A	#N/A
38	#N/A	#N/A
39	#N/A	#N/A
40	#N/A	#N/A
41	#N/A	#N/A
42	#N/A	#N/A
43	#N/A	#N/A
44	#N/A	#N/A
45	#N/A	#N/A

WELL ID: GWMW#3

Local ID: GWMW#3 Test 1
Date: 1/27/2025
Time: 10:59

INPUT

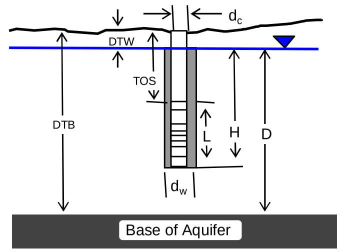
Construction:		
Casing dia. (d_c)	2	Inch
Annulus dia. (d_w)	2	Inch
Screen Length (L)	4	Feet
Depths to:		
water level (DTW)	12.1	Feet
top of screen (TOS)	15.1	Feet
Base of Aquifer (DTB)	19.1	Feet
Annular Fill:		
across screen --	Fine Sand	
above screen --	Backfill	
Aquifer Material --	Fine Sand	

COMPUTED

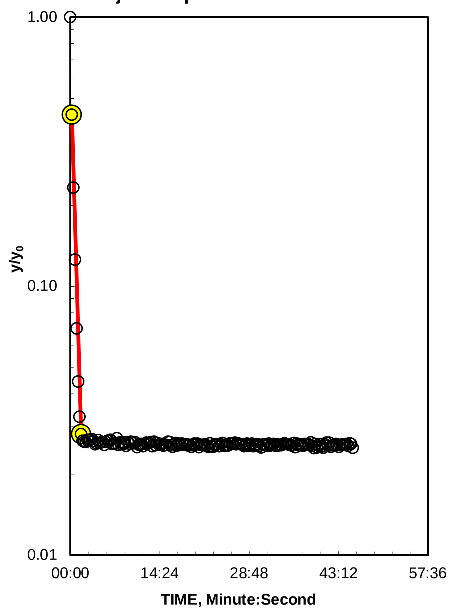
L_{wetted}	4	Feet
D =	7	Feet
H =	7	Feet
L/r_w =	13.71	
$y_{0\text{-DISPLACEMENT}}$ =	2.00	Feet
$y_{0\text{-SLUG}}$ =	1.92	Feet
From look-up table using L/r_w		
Fully penetrate C =	1.444	
ln(Re/rw) =	2.215	
Re =	2.67	Feet
Slope =	0.013191028	log_{10}/sec
$t_{90\%}$ recovery =	76	sec

Input is consistent.

K =	5	Feet/Day



Adjust slope of line to estimate K



Bouwer and Rice analysis of slug test, WRR 1976

REMARKS:

Slug test was conducted in surficial aquifer, Virgin, Utah.

Reduced Data

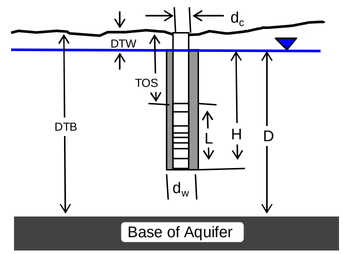
Entry	Time, Hr:Min:Sec	Water Level
1	10:59:30.0	14.05
2	11:00:30.0	12.19
3	11:01:30.0	12.10
4	11:02:30.0	12.10
5	11:03:30.0	12.10
6	11:04:30.0	12.10
7	11:05:30.0	12.10
8	11:19:30.0	12.10
9	#N/A	#N/A
10	#N/A	#N/A
11	#N/A	#N/A
12	#N/A	#N/A
13	#N/A	#N/A
14	#N/A	#N/A
15	#N/A	#N/A
16	#N/A	#N/A
17	#N/A	#N/A
18	#N/A	#N/A
19	#N/A	#N/A
20	#N/A	#N/A
21	#N/A	#N/A
22	#N/A	#N/A
23	#N/A	#N/A
24	#N/A	#N/A
25	#N/A	#N/A
26	#N/A	#N/A
27	#N/A	#N/A
28	#N/A	#N/A
29	#N/A	#N/A
30	#N/A	#N/A
31	#N/A	#N/A
32	#N/A	#N/A
33	#N/A	#N/A
34	#N/A	#N/A
35	#N/A	#N/A
36	#N/A	#N/A
37	#N/A	#N/A
38	#N/A	#N/A
39	#N/A	#N/A
40	#N/A	#N/A
41	#N/A	#N/A
42	#N/A	#N/A
43	#N/A	#N/A
44	#N/A	#N/A
45	#N/A	#N/A

WELL ID: GWMW#3

Local ID: GWMW#3 Test 2
Date: 1/27/2025
Time: 17:34

INPUT

Construction:		
Casing dia. (d_c)	2	Inch
Annulus dia. (d_w)	2	Inch
Screen Length (L)	4	Feet
Depths to:		
water level (DTW)	12.1	Feet
top of screen (TOS)	15.1	Feet
Base of Aquifer (DTB)	19.1	Feet
Annular Fill:		
across screen --	Fine Sand	
above screen --	Backfill	
Aquifer Material --	Fine Sand	



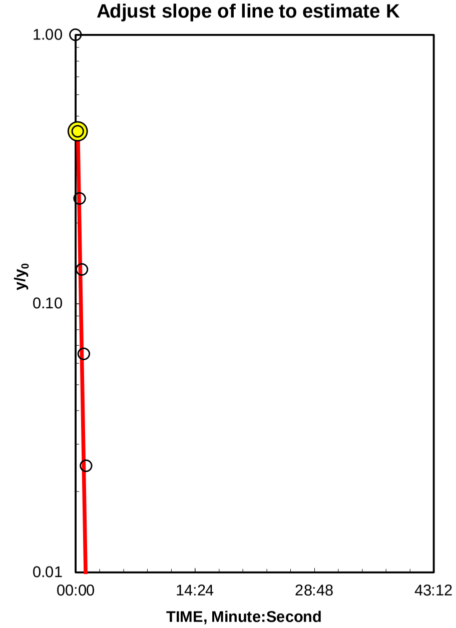
COMPUTED

L_{wetted}	4	Feet
D =	7	Feet
H =	7	Feet
L/r_w =	13.71	
$y_{0\text{-DISPLACEMENT}}$ =	2.00	Feet
$y_{0\text{-SLUG}}$ =	1.92	Feet
From look-up table using L/r_w		
Fully penetrate C =	1.444	
ln(Re/rw) =	2.215	
Re =	2.67	Feet
Slope =	0.02934975	log_{10}/sec
$t_{90\%}$ recovery =	34	sec

Input is consistent.

K =	11	Feet/Day

Adjust slope of line to estimate K



REMARKS:

Bouwer and Rice analysis of slug test, WRR 1976

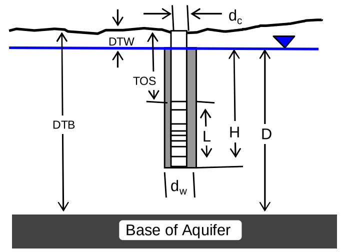
Slug test was conducted in surficial aquifer, Virgin, Utah.

Reduced Data

Entry	Time, Hr:Min:Sec	Water Level
1	17:34:00.0	14.16
2	17:34:45.0	12.42
3	17:35:30.0	12.16
4	17:36:15.0	12.11
5	17:37:00.0	12.10
6	17:37:45.0	12.10
7	17:38:30.0	12.10
8	17:39:15.0	12.10
9	17:40:00.0	12.10
10	17:40:45.0	12.10
11	#N/A	#N/A
12	#N/A	#N/A
13	#N/A	#N/A
14	#N/A	#N/A
15	#N/A	#N/A
16	#N/A	#N/A
17	#N/A	#N/A
18	#N/A	#N/A
19	#N/A	#N/A
20	#N/A	#N/A
21	#N/A	#N/A
22	#N/A	#N/A
23	#N/A	#N/A
24	#N/A	#N/A
25	#N/A	#N/A
26	#N/A	#N/A
27	#N/A	#N/A
28	#N/A	#N/A
29	#N/A	#N/A
30	#N/A	#N/A
31	#N/A	#N/A
32	#N/A	#N/A
33	#N/A	#N/A
34	#N/A	#N/A
35	#N/A	#N/A
36	#N/A	#N/A
37	#N/A	#N/A
38	#N/A	#N/A
39	#N/A	#N/A
40	#N/A	#N/A
41	#N/A	#N/A
42	#N/A	#N/A
43	#N/A	#N/A
44	#N/A	#N/A
45	#N/A	#N/A

WELL ID: GWMW#3

Local ID: GWMW#3 Test 3
Date: 1/27/2025
Time: 18:23



INPUT

Construction:		
Casing dia. (d_c)	2	Inch
Annulus dia. (d_w)	2	Inch
Screen Length (L)	4	Feet
Depths to:		
water level (DTW)	12.1	Feet
top of screen (TOS)	15.1	Feet
Base of Aquifer (DTB)	19.1	Feet
Annular Fill:		
across screen --	Fine Sand	
above screen --	Backfill	
Aquifer Material --	Fine Sand	

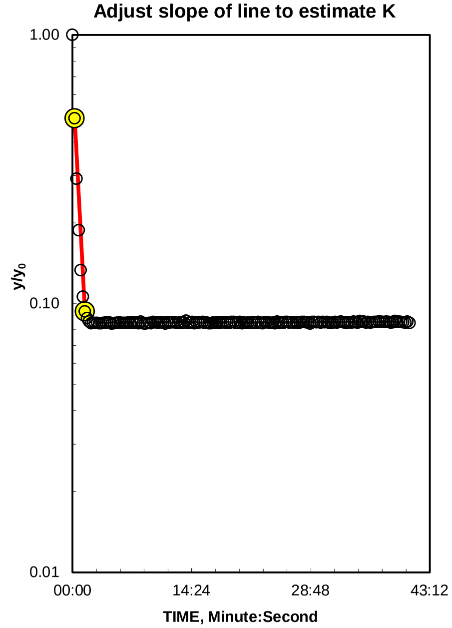
COMPUTED

L_{wetted}	4	Feet
D =	7	Feet
H =	7	Feet
L/r_w =	13.71	
$y_{0\text{-DISPLACEMENT}}$ =	2.00	Feet
$y_{0\text{-SLUG}}$ =	1.92	Feet
From look-up table using L/r_w		
Fully penetrate C =	1.444	
ln(Re/rw) =	2.215	
Re =	2.67	Feet
Slope =	0.009571411	log_{10}/sec
$t_{90\%}$ recovery =	104	sec

Input is consistent.

K =	3.7	Feet/Day

Adjust slope of line to estimate K



REMARKS:

Bouwer and Rice analysis of slug test, WRR 1976

Slug test was conducted in surficial aquifer, Virgin, Utah.

Reduced Data

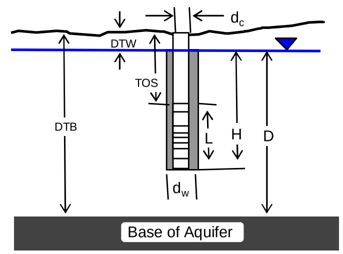
Entry	Time, Hr:Min:Sec	Water Level
1	18:23:00.0	13.93
2	18:23:45.0	12.31
3	18:24:30.0	12.12
4	18:25:15.0	12.10
5	18:26:00.0	12.10
6	18:26:45.0	12.10
7	18:27:30.0	12.10
8	18:28:15.0	12.10
9	18:29:00.0	12.10
10	18:29:45.0	12.10
11	#N/A	#N/A
12	#N/A	#N/A
13	#N/A	#N/A
14	#N/A	#N/A
15	#N/A	#N/A
16	#N/A	#N/A
17	#N/A	#N/A
18	#N/A	#N/A
19	#N/A	#N/A
20	#N/A	#N/A
21	#N/A	#N/A
22	#N/A	#N/A
23	#N/A	#N/A
24	#N/A	#N/A
25	#N/A	#N/A
26	#N/A	#N/A
27	#N/A	#N/A
28	#N/A	#N/A
29	#N/A	#N/A
30	#N/A	#N/A
31	#N/A	#N/A
32	#N/A	#N/A
33	#N/A	#N/A
34	#N/A	#N/A
35	#N/A	#N/A
36	#N/A	#N/A
37	#N/A	#N/A
38	#N/A	#N/A
39	#N/A	#N/A
40	#N/A	#N/A
41	#N/A	#N/A
42	#N/A	#N/A
43	#N/A	#N/A
44	#N/A	#N/A
45	#N/A	#N/A

WELL ID: GWMW#4

Local ID: GWMW#4 Test 1
Date: 1/27/2025
Time: 9:43

INPUT

Construction:		
Casing dia. (d_c)	2	Inch
Annulus dia. (d_w)	2	Inch
Screen Length (L)	5	Feet
Depths to:		
water level (DTW)	6.46	Feet
top of screen (TOS)	5.2	Feet
Base of Aquifer (DTB)	10.2	Feet
Annular Fill:		
across screen --	Silt	
above screen --	Backfill	
Aquifer Material --	Clay	



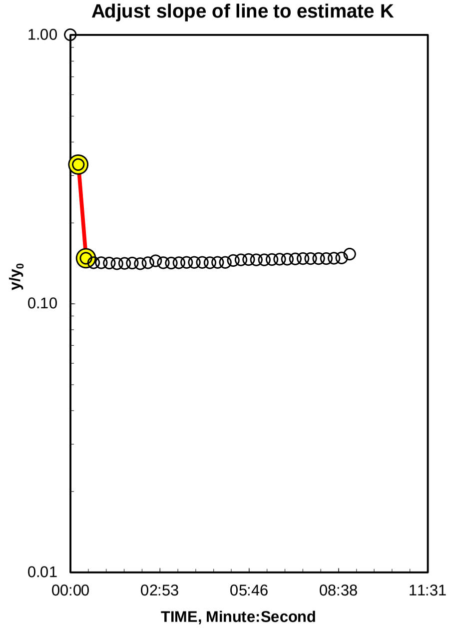
COMPUTED

L_{wetted}	3.74	Feet
D =	3.74	Feet
H =	3.74	Feet
L/r_w =	44.88	
$y_{0\text{-DISPLACEMENT}}$ =	1.90	Feet
$y_{0\text{-SLUG}}$ =	1.92	Feet
From look-up table using L/r_w		
Fully penetrate C =	2.599	
ln(Re/rw) =	2.881	
Re =	1.49	Feet
Slope =	0.023272615	log_{10}/sec
$t_{90\%}$ recovery =	43	sec

Input is consistent.

K =	12	Feet/Day

Adjust slope of line to estimate K



Reduced Data

Entry	Time, Hr:Min:Sec	Water Level
1	9:43:15.0	8.07
2	9:43:30.0	6.80
3	9:43:45.0	6.45
4	9:44:00.0	6.44
5	9:44:15.0	6.44
6	9:44:30.0	6.44
7	9:44:45.0	6.44
8	9:45:00.0	6.44
9	9:45:15.0	6.44
10	9:45:30.0	6.44
11	9:45:45.0	6.44
12	9:46:00.0	6.44
13	9:46:15.0	6.44
14	9:46:30.0	6.44
15	9:46:45.0	6.44
16	9:47:00.0	6.44
17	9:47:15.0	6.44
18	9:47:30.0	6.44
19	9:47:45.0	6.44
20	9:48:00.0	6.44
21	9:48:15.0	6.44
22	9:48:30.0	6.44
23	9:48:45.0	6.45
24	9:49:00.0	6.45
25	9:49:15.0	6.45
26	9:49:30.0	6.45
27	9:49:45.0	6.45
28	9:50:00.0	6.45
29	#N/A	#N/A
30	#N/A	#N/A
31	#N/A	#N/A
32	#N/A	#N/A
33	#N/A	#N/A
34	#N/A	#N/A
35	#N/A	#N/A
36	#N/A	#N/A
37	#N/A	#N/A

REMARKS:

Bouwer and Rice analysis of slug test, WRR 1976

Slug test was conducted in surficial aquifer, Virgin, Utah.

WELL ID: GWMW#4

Local ID: GWMW#4 Test 2
Date: 1/27/2025
Time: 10:07

INPUT

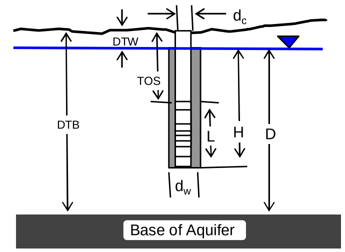
Construction:		
Casing dia. (d_c)	2	Inch
Annulus dia. (d_w)	2	Inch
Screen Length (L)	5	Feet
Depths to:		
water level (DTW)	6.46	Feet
top of screen (TOS)	5.2	Feet
Base of Aquifer (DTB)	10.2	Feet
Annular Fill:		
across screen --	Silt	
above screen --	Backfill	
Aquifer Material --	Clay	

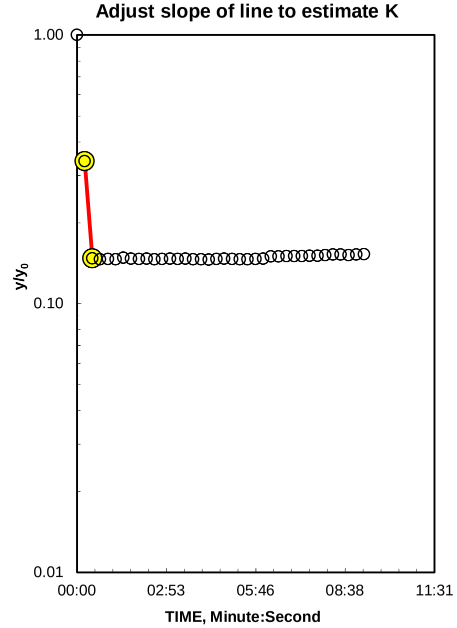
COMPUTED

L_{wetted}	3.74	Feet
D =	3.74	Feet
H =	3.74	Feet
L/r_w =	44.88	
$y_{0\text{-DISPLACEMENT}}$ =	1.90	Feet
$y_{0\text{-SLUG}}$ =	1.92	Feet
From look-up table using L/r_w		
Fully penetrate C =	2.599	
ln(Re/rw) =	2.881	
Re =	1.49	Feet
Slope =	0.024073778	$\log_{10}$/sec
$t_{90\%}$ recovery =	42	sec

Input is consistent.

K =	13	Feet/Day





Reduced Data

Entry	Time, Hr:Min:Sec	Water Level
1	10:07:00.0	8.07
2	10:07:15.0	6.81
3	10:07:30.0	6.45
4	10:07:45.0	6.45
5	10:08:00.0	6.45
6	10:08:15.0	6.45
7	10:08:30.0	6.45
8	10:08:45.0	6.45
9	10:09:00.0	6.45
10	10:09:15.0	6.45
11	10:09:30.0	6.45
12	10:09:45.0	6.45
13	10:10:00.0	6.45
14	10:10:15.0	6.45
15	10:10:30.0	6.45
16	10:10:45.0	6.45
17	10:11:00.0	6.45
18	10:11:15.0	6.45
19	10:11:30.0	6.45
20	10:11:45.0	6.45
21	10:12:00.0	6.45
22	10:12:15.0	6.45
23	10:12:30.0	6.45
24	10:12:45.0	6.45
25	10:13:00.0	6.45
26	10:13:15.0	6.45
27	10:13:30.0	6.45
28	10:13:45.0	6.46
29	#N/A	#N/A
30	#N/A	#N/A
31	#N/A	#N/A
32	#N/A	#N/A
33	#N/A	#N/A
34	#N/A	#N/A
35	#N/A	#N/A
36	#N/A	#N/A
37	#N/A	#N/A
38	#N/A	#N/A

REMARKS:

Bouwer and Rice analysis of slug test, WRR 1976

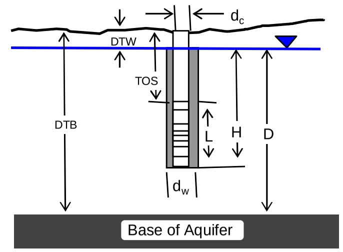
Slug test was conducted in surficial aquifer, Virgin, Utah.

WELL ID: GWMW#4

Local ID: GWMW#4 Test 3
Date: 1/27/2025
Time: 10:20

INPUT

Construction:		
Casing dia. (d_c)	2	Inch
Annulus dia. (d_w)	2	Inch
Screen Length (L)	5	Feet
Depths to:		
water level (DTW)	6.46	Feet
top of screen (TOS)	5.2	Feet
Base of Aquifer (DTB)	10.2	Feet
Annular Fill:		
across screen --	Silt	
above screen --	Backfill	
Aquifer Material --	Clay	

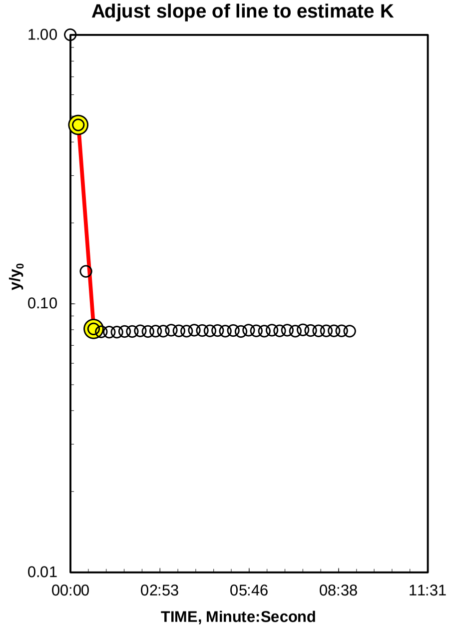


COMPUTED

L_{wetted}	3.74	Feet
D =	3.74	Feet
H =	3.74	Feet
L/r_w =	44.88	
$y_{0\text{-DISPLACEMENT}}$ =	1.90	Feet
$y_{0\text{-SLUG}}$ =	1.92	Feet
From look-up table using L/r_w		
Fully penetrate C =	2.599	
ln(Re/rw) =	2.881	
Re =	1.49	Feet
Slope =	0.025296697	$\log_{10}$/sec
$t_{90\%}$ recovery =	40	sec

Input is consistent.

K =	13	Feet/Day



Reduced Data

Entry	Time, Hr:Min:Sec	Water Level
1	10:20:00.0	8.21
2	10:20:15.0	7.19
3	10:20:30.0	6.56
4	10:20:45.0	6.46
5	10:21:00.0	6.46
6	10:21:15.0	6.46
7	10:21:30.0	6.46
8	10:21:45.0	6.46
9	10:22:00.0	6.46
10	10:22:15.0	6.46
11	10:22:30.0	6.46
12	10:22:45.0	6.46
13	10:23:00.0	6.46
14	10:23:15.0	6.46
15	10:23:30.0	6.46
16	10:23:45.0	6.46
17	10:24:00.0	6.46
18	10:24:15.0	6.46
19	10:24:30.0	6.46
20	10:24:45.0	6.46
21	10:25:00.0	6.46
22	10:25:15.0	6.46
23	10:25:30.0	6.46
24	10:25:45.0	6.46
25	10:26:00.0	6.46
26	10:26:15.0	6.46
27	10:26:30.0	6.46
28	10:26:45.0	6.46
29	#N/A	#N/A
30	#N/A	#N/A
31	#N/A	#N/A
32	#N/A	#N/A
33	#N/A	#N/A
34	#N/A	#N/A
35	#N/A	#N/A
36	#N/A	#N/A
37	#N/A	#N/A

Bouwer and Rice analysis of slug test, WRR 1976

REMARKS:

Slug test was conducted in surficial aquifer, Virgin, Utah.

Appendix D

Third Party Comment & Review Letter Correspondence

January 23, 2026

Loughlin Water Associates
Attn: Bill Loughlin, P.E.
3100 Pinebrook Rd #1100
Park City, UT 84098
Delivery via email

RE: Virgin Town Groundwater Protection Study - Peer Review Response

Dear Mr. Loughlin,

I would like to thank you and your staff for your time and efforts to review the Groundwater Protection Study for the Town of Virgin.

We have completed our review of your comments and have incorporated them into the report where appropriate. We appreciate the thoughtful and constructive comments which added value and improved clarity to the document. We are preparing to submit the revised study to the Utah Department of Environmental Quality later this month.

Some of your team's comments appropriately highlight additional factors that warrant further consideration, such as in-stream denitrification processes and the connectivity between the shallow and deep aquifers. We acknowledge these uncertainties as potential areas of further study to further refine the understanding of hydraulic connectivity between the shallow alluvial system and the deeper aquifer, as well as the role of in-stream processes in influencing the ground and surface water quality.

We value the opportunity to work with you and hope that we will have the chance to collaborate again on similar groundwater and water resource studies in the future.

Best regards,

Paul Andersen, P.E.
Project Manager

Cc: Dao Yang, P.E., Joseph Phillips, P.E., Derek Anderson, P.E.

GENERAL COMMENTS

In general, we agree with the final conclusions on page 45 (the last two bullet points) that maintaining the current septic density while pursuing opportunities for sewer infrastructure represents a balanced path forward for Virgin Town. However, due to several limitations noted below, we believe there is significant uncertainty in the analyses presented; therefore, they should not be used to justify increasing septic density. For example, this analysis appears to ignore nitrate uptake by algae and other in-stream processes that can reduce nitrate concentrations between Virgin River sample locations SW-1 and SW-3; therefore, these results should not be used as a basis to increase septic density or support the conclusion that 88% of nitrate loading is to the bedrock aquifer.

One primary concern is that the draft study does not adequately evaluate the potential impact of nitrate discharge from septic systems on nitrate levels in the Virgin River and the associated risk of toxic algal blooms. Although toxic algal blooms are acknowledged in Section 9, this discussion occurs after the "*Summary, Conclusions, and Recommendations*" in Section 8. We recommend that the report address algal blooms in the Virgin River and the potential contribution of septic discharges to nitrate loading earlier in the document. Until a more comprehensive understanding and nutrient mass balance of the Virgin River is developed, the potential impact of septic loading on algal blooms should continue to be considered a limiting factor for increasing septic density.

Response: It should be noted that the nitrate contribution from the septic systems in the Town of Virgin is minimal based on monitoring data, as discussed in the report. It is proper to discuss this issue after the "Summary, Conclusion and Recommendations" after we found the contribution of nitrate to the river from the systems in Virgin. Also, the background of this study was not because of the Virgin River water quality, but it is required by compliance.

SPECIFIC COMMENTS

EXECUTIVE SUMMARY

1. What is the basis for the statement that the bedrock aquifer is not connected to the Virgin River? Typically, groundwater elevations are compared to river elevations to assess hydraulic connection (p. 1).

   Response: As stated in the report, it is based on mass balance analysis and field observations. However, further study may be required to investigate the connectivity between the river and the bedrock aquifer.

   Response: An assessment of the groundwater elevation relative to the surface water elevation of the river is outside the scope of this report. However, based on field observations, the elevation of the groundwater table in the shallow aquifer was estimated to be slightly above the surface water elevation of the river during sampling activities.

   While sampling of the deeper groundwater well (Truman Well) was limited to only 2 months of data, the measured nitrate concentrations were far higher in this deeper well than the shallow monitoring wells, and the surface water data. This observation drove the hypothesis that the shallow alluvial aquifer could be connected to the river and to the bedrock aquifer, and that the bedrock aquifer was disconnected from the river.

The authors agree that additional assessment of hydraulic connectivity between the observed aquifers would be beneficial to further understanding.

2. Although comparison to groundwater nitrate standards are presented, there is no consideration of surface-water standards. At least within "*headwater streams*," Utah has a criteria of 0.4 milligrams per liter (mg/L) for total nitrogen (Utah Department of Environmental Quality, 2019). Although it is not clear if this criterion applies to the Virgin River within Virgin Town, it is a point of reference and the authors should present the applicable surface water standard. Notably, in at least one occasion the 0.4 mg/L total nitrogen value was exceeded at SW-3 (p. 2).

   Response: Additional context was added to pg 4 of our report to further explain the groundwater anti-degradation standard used to develop the recommendations of this study. Based on the report by Hansen, Allen & Luce (1997), an anti-degradation standard of 2 to 4 mg/L above the background concentration was selected, rather than the 10 mg/L concentration allowed by Utah Administrative Code.

   Additional comment was also provided in section 4.5 wherein the results of the groundwater sampling data are reviewed. These comments address the surface water concentration limit given in Table 2.14.8 of R317-2.

3. Along with a better understanding of the "*deeper aquifer*," I would add a better understanding of the hydraulic connection between the alluvial and bedrock aquifers and the Virgin River (p. 2).

   Response: This statement has been added.

SECTION 1 – INTRODUCTION

Section 1.3 (p. 5)

1. Groundwater monitoring piezometers appear to be located on either side of the river. Was there any reasoning for placing each on one side of the river or the other?

   Response: The placement of piezometers was not included in the original scope of the project. Originally, Sunrise was to take periodic groundwater samples from existing wells throughout the Town. However, discussion with the town indicates that there is only one well (Truman Well). The other wells identified from the Utah Division of Water Rights database do not exist. Then, at the request of the town, Sunrise proposed sampling from shallow groundwater using piezometers at several locations throughout the Town. The locations for these piezometers were selected such that they were close to the river, and in relatively close proximity to higher concentrations of development throughout the Town. This was done with the intent to measure the increased nitrate concentration in the surface water upstream and downstream of the developed areas of the Town.

2. Paired piezometers on either side of the river would provide the opportunity to compare water levels, water quality, and aquifer properties for the northern vs. southern study area.

   Response: The investigation of groundwater monitoring wells, or the installation of shallow monitoring wells, was not part of the scope of the project. The authors agree that this additional investigation could yield valuable information.

Figure 1 (p. 6)

1. Consider addition of focus map showing more detail on sampling locations. It is difficult to make out surface water vs. groundwater symbols.

   Response: An additional Figure 1a has been provided on a 1”=1,000’ scale so that the sampling locations can be more easily determined.

SECTION 2 – GEOLOGIC SETTING

Figure 2 (p. 10)

1. Define geologic abbreviations on the map. Areas of alluvium outside the town boundary are colored red as “bedrock aquifer,” which appears to be incorrect.

   Response: The reader is directed to the St. George Quad (Biek, 2010) for an exhaustive description of the listed geologic units. The area in red has been labeled as the shallow bedrock aquifer recharge area.

Figure 4 (p. 12)

1. Show the alluvial aquifer unit on the cross section. It is unclear why the exposed units are different on the cross section compared to the geologic map.

   Response: Figure 4 has been revised to show the approximate extents of the alluvial aquifer that may be connected to the Virgin River.

   The cross section shown in Figure 4 is of the Virgin Quadrangle, provided by the UGS. The geologic map shown in Figure 2 is from the St. George Quadrangle, also provided by the UGS.

SECTION 3 – HYDROGEOLOGY

Section 3.1 (p. 14)

1. Present a cross-section conceptual model that illustrates the relationship between the alluvial aquifer, river, and bedrock aquifer.

   Response: Figure 4 has been revised to show the approximate extents of the alluvial aquifer that may be connected to the Virgin River.

Section 3.4.1 (p. 15)

1. What does “the principal aquifer” refer to? Be consistent in terminology regarding the aquifer units.

   Response: The term “principal aquifer” has been changed to the “watershed boundary”.

Figure 6 (p. 19)

1. What is the reason for the feature with many contour lines near the northern extent of the figure, values 3.0 to 5.0?

   Response: This area is just below Goose Springs reservoir and south of Kolob Terrace Rd. The tight spacing of the recharge contours within this area are tighter since this is a grass covered valley, and much of the water from the plateau receiving higher precipitation, contributes to recharge.

2. Consider addition of focus map showing more detail on sampling locations. It is difficult to make out surface water vs. groundwater symbols.

   Response: Figure 1a has been added to more clearly indicate the sampling locations.

SECTION 4 – GROUNDWATER AND SURFACE WATER SAMPLING

Section 4.1 (p. 20)

1. Incorporate field photographs as some sort of figure/attachment/ appendix.

   Response: photographs of the field piezometer installation and sampling activities have been included with the appendix to this report.

2. Consider use of a geo-probe/direct push rig for better vertical alignment on piezometers.

   Response: The authors agree that better quality data would have been obtained from a drill rig installing manufactured well screens. This was, however, not in the scope of the project. The town provided and operated a backhoe for the installation of the piezometers to save costs.

3. Were piezometer locations/stick-ups surveyed?

   Response: No.

4. Groundwater piezometer installation with a backhoe is not a standard approach cited in the U.S. Environmental Protection Agency (USEPA) guidance (e.g., USEPA, 2018).

   Response: The authors agree that better quality data would have been obtained from a drill rig installing manufactured well screens. This was, however, not in the scope of the project.

Section 4.2 (p. 21)

1. Were non-vertical orientations of piezometers considered for water volume estimations?

   Response: Yes, volumetric calculations considered the non-vertical orientation of the piezometers.

2. Bailer sampling with a 3x borehole volume purge is not equivalent to low-flow sampling. The purging procedure described cannot reasonably be characterized as consistent with the EPA low-flow sampling guidance.

   Response: The alluvial aquifer consists of sand, gravel, cobbles and boulders and therefore, the groundwater flow may not be low. According to section 6.1 of ASTM D4448, purging a shallow groundwater well volume of 3 to 5 times the volume of the well casing is generally sufficient practice. In Utah, purging three times the volume of stagnant water is a standard practice.

3. Were the top-of-casing from the piezometers surveyed, such that groundwater elevation can be determined from the depth-to-water measurements? Given the angle of the borings could groundwater elevation even be calculated? Without groundwater elevation data, how was the hydraulic gradient calculated (p. 31)?

Response: We could calculate the groundwater elevation, though the tops of the casing were not surveyed. Based on field observations the water surface elevation of the groundwater was higher than that of the river.

4. Groundwater elevations should be compared to river elevation in order to understand hydraulic connection and gaining/losing status of the river.

   Response: Neither was surveyed and these elevations were approximated.

Tables 3 to 7 (p. 20 to 22)

1. Is the "Depth to Water" accounting for the borehole angle?

   Response: Yes.

Section 4.5.1 (p. 23 to 25)

1. Ensure that the nitrate units are comparable in the first paragraph (and not nitrate-as-nitrate versus nitrate-as-nitrogen).

   Response: Samples were evaluated for the presence of nitrate as nitrogen, as stated in Section 4.5.1.

2. The entire discussion of the advection-dispersion equation on p. 23–25 is superfluous and should be removed. No groundwater fate and transport modeling appears to have been conducted with this approach, with the possible exception of the graph on p. 25 that is presented as a "simplified decay function" only.

   Response: This section has been modified in accordance with the recommendations.

Table 8 (p. 24)

1. Here and throughout the draft study, removal of data as "outliers" is not justified given the limited data collected. No statistical analysis is presented to support data exclusion.

   Response: The comment is acknowledged. The dataset consists of monthly sampling over a 12-month period at four locations, which limits the applicability and statistical power of formal outlier tests. For datasets of this size, conventional statistical methods for identifying outliers are of limited reliability and were therefore not applied as the sole basis for data screening.

   Given the limited sample size, statistical evaluation was supplemented with professional judgment to determine whether to include or exclude individual data points.

   In this study, data points identified as potential outliers were not excluded solely because they deviated from an apparent trend, but because they coincided with site-specific or sampling-specific conditions (e.g., the presence of feed lot animals near SW #1) that may provide a reasonable explanation for the observed deviation.

   Importantly, identified outliers were evaluated separately rather than disregarded and their inclusion or exclusion does not materially alter the overall conclusions of the study. The intent was to prevent anomalous, non-representative measurements from disproportionately influencing interpretation, while still acknowledging the inherent uncertainty associated with a limited dataset. It is possible that the "outlier" points could indicate trends which could be further evaluated in future studies.

Table 9 (p. 26)

1. What is the source of the "EPA MCL" for Bisphenol A? There does not appear to be a primary drinking water standard for this compound (USEPA, 2025a).

Response: The authors acknowledge that this is correct. According to the Bisphenol A Action Plan (EPA, 2010), there are recommended maximum daily intake limits for BPA (0.05 mg/kg/day for BPA). The EPA has not established an MCL for BPA in groundwater or surface water. Table 9 and Section 9 of the report has been revised to remove any statement of an EPA MCL for BPA.

Section 4.5.2 (p. 26)

1. This is the first mention of harmful algal blooms related to nitrogen. We agree that it is relevant but consider discussing this earlier in report.

   Response: Near the end of the sampling phase of the project, and at the request of Ash Creek Special Services District (ACSSD), surface water samples collected on April 30, 2025, were delivered to Chemtech-Ford Laboratories for analysis. This study does not investigate the relationship between harmful algal blooms and the quality of groundwater in Virgin Town. The results of these laboratory analyses are presented in this report only for reference (see Appendix B).

2. Establish connection between microcystins/nodularins/algal blooms and nitrogen levels.

   Response: See response above.

3. Explain reasoning for microcystins/nodularins/PPCP/EDC only being sampled for once while all other sampling was monthly. Budget and scope

   Response: See response above.

4. What is the specific potential source for PPCP and EDC in Virgin? Why is this added to the analyte list?

   Response: Near the end of the sampling phase of the project, and at the request of Ash Creek Special Services District (ACSSD), ground water samples were delivered to Chemtech-Ford Laboratories for analysis of PPCP and EDC. These contaminants are good indicators of human waste that may be introduced to groundwater through residential and commercial septic systems.

   This study does not investigate the relationship between PPCP, EDC or other contaminants, and the quality of groundwater in Virgin Town. The results of these laboratory analyses are presented in this report only for reference (see Appendix B).

   Section 4.4 is revised to explain that nitrate is the constituent considered in the mass balance approach to contaminant transport. The impact of other constituents was evaluated only theoretically, and not analytically.

5. Without sampling data to support, remove the statement that surface water concentrations are lower than groundwater concentrations.

   Response: This comment is acknowledged. PPCP and EDC are not constituents of concern, as it pertains to the mass balance approach. There is, therefore, no need to include this statement and it has been removed.

Section 4.6.1 (p. 27)

1. Non-vertical piezometers will impact slug test results; their use introduces components of vertical flow rather than just horizontal into the piezometer screen.

   Response: The authors acknowledge this impact on the slug test results. The slug test results were used to support the use of the aquifer hydraulic conductivity selected based on professional judgment.

2. Were the physical conditions of the hacksaw modified screens documented before installation? Hand-modified screens introduce potential for inconsistent

inflow from piezometer to piezometer.

Response: The measurements reported in the study are approximate. The piezometers were prepared as consistently as possible in the field.

3. Broader and more even distribution of factory screen could also impact inflow to piezometer vs. hand-modified screens.

   Response: The authors acknowledge that a factory screen would provide more consistent and reliable data.

Section 4.6.2 (p. 28)

1. Why were factory-made screens not used in the piezometer construction? Budget? Availability?

   Response: factory-made screens were not used as piezometer installation was not part of the original scope of the project.

2. What is the reasoning behind multiplying the K of GWMS4 by 2.5 to yield a K of 30 feet per day (ft/d)?

   Response: The hydraulic conductivities of the alluvial materials observed in the test pits have a large range, from 3 to 20 feet/day in fine sand to over 100 feet/day in gravel and cobbles. The measured hydraulic conductivity was multiplied by 2.5 in attempts to account for the hand sawn piezometers, inclination angles, and other uncertainties associated with the slug tests.

Table 10 (p. 28)

1. Remove the "*high*" column if it is not based on actual slug data analysis. It is not clear, but it appears to be an arbitrary multiplier of 8x the slug-test result. Otherwise, we have not reviewed the slug test analysis in detail, but in general slug tests are better suited to low-permeability sediments.

   Response: The "High" column is to indicate that a factory well screen may be 8 times more efficient than the hand sawn piezometers.

SECTION 5 – INVERSE MODELING FOR AMBIENT GROUNDWATER FLOW

Page 29

1. The purpose of this section and the first paragraph is unclear. Clearly state the objective of the analysis. Cite sources for all values assumed (e.g., 237 gallons per day).

   Response: The purpose of Section 5 was added in an introductory paragraph. A citation is made to the study performed by Sunrise (2022) wherein 237 gpd/ERU is determined.

2. The mass balance equation appears to be missing all groundwater discharge components including groundwater discharge to the river and groundwater underflow. It does not appear to account for impacts of evapotranspiration.

   Response: It included everything necessary for the mass balance analysis. This comment should not appear herein.

3. Again, what makes the hydraulic conductivity (K) estimate of 30 feet per day (ft/d) for alluvial aquifer reasonable?

   Response: See the response to Item #2 in Section 4.6.2.

4. Figure 6 is hard to interpret, particularly within Virgin Town itself. Adding a focus map/figure with a closer view of town limits would be helpful.

Response: The estimated recharge map should show the extents of the watershed boundary, which is observable at the current scale.

Page 31

1. Are water level measurements discussed here based on survey data? What is the reference point for piezometer water levels vs. ground elevation vs. surface water elevation?

   Response: The ground and surface water elevations were not surveyed and the gradient is herein approximated.

2. It is not clear why hydraulic gradient is not needed; groundwater flow is calculated based on hydraulic gradient per Darcy's Law.

   Response: The ambient groundwater flow is back calculated using the inverse mass balance approach, updating the parameters assumed in prior studies, such as recharge volume and background nitrate concentration (as measured from field piezometers). This approach was used to evaluate the accuracy of the assumptions used to develop the mass balance approaches used in prior studies.

   The results of the inverse mass balance model indicate that, based on the updated parameters, the ambient groundwater flow is too low to transmit the nitrate loading observed in the piezometers.

   This comment should not appear herein.

3. If gradient is not relevant to inverse modeling, does the correction from 5 to 1.67% need to be discussed? It is currently somewhat confusing to read.

   Response: Because groundwater and surface water elevations were neither surveyed nor recorded, discussion of a potential change in hydraulic gradient is not warranted. However, the authors believe it is appropriate to document relevant field observations as they pertain to both hydraulic conductivity and hydraulic gradient to demonstrate the approximate levels of uncertainty associated with the previously assumed parametric values.

   This comment should not appear herein.

4. The discussion of previous modeling may merit its own section that comes before any details on the newer inverse modeling. Consider separating issues/comments regarding the old modeling in a separate section, then state how they are addressed by newer inverse modeling in its own section.

   Response: This study presents a limited discussion of the assumed parameters used in prior studies. The intent of this section is to demonstrate that the former mass balance approach does not accurately describe the current groundwater conditions as measured in the shallow groundwater monitoring points and surface water sampling.

5. Where does the assumption of 60 feet of aquifer come from? The one family well log? Is this the alluvial aquifer?

   Response: 60 feet was the aquifer thickness assumed from the 2015 study performed by Ensign Engineering. This value was compared against the well log of the Truman well, which was sampled as part of this study. The lithologic log of the Truman well reports 38 feet of alluvium overlying red shale at approximately 38 feet below ground surface. This is less than the assumed thickness of 60 feet, but without sufficient other data points, the assumed thickness of 60 feet was left to simplify the comparisons between this and the prior studies.

6. Questions in Section 5 are confusing and out of place. We believe this section is supposed to contain comments on the previous studies. Consider rephrasing these questions as statements.

   Response: Questions have been rephrased as statements for improved clarity.

7. “as even less accurate” – typo (p. 32)

   Response: Revised.

Table 13 (p. 31)

1. The groundwater flow calculated should be compared against calculations using Darcy’s Law as a check.

   Response: If we had enough data to do a better calculation using Darcy’s Law, this section would not be required. This comment should not appear herein.

Table 16 (p. 33)

1. Constant monthly septic system discharge is inconsistent with Figure on bottom of Page 35 (all figures should be numbered).

   Response: Figure captions have been added for all figures throughout the study. The data shown by the reference figure pose one possible explanation for the observed seasonal fluctuation of nitrate concentration throughout the year. Regional visitation data and septic loading data were not analyzed as part of this study and average values were assumed for daily wastewater generation.

2. Table is titled monthly nitrate loading wastewater flow, but “precipitation related recharge” is listed.

   Response: Table headings have been changed so that “Precipitation Related Recharge” now reads “Precipitation Related” and “Irrigation Related Recharge” now reads “Irrigation Related”.

Page 33

1. The statement that groundwater will not exceed 4 mg/L appears to be based on the assumption of a completely mixed system, which is not reasonable. Standard methods including those listed by Hantzsche and Finnemore (1992) could be used to estimate nitrate in groundwater from septic loadings. Note the typo “4 ml/L.” The draft study also does not account for denitrification.

   Response: The typographical error has been fixed.

   The authors appreciate the citation of and have considered the reference study. The following observations are made of the simplified approach provided by Hantzche and Finnemore (1992).

   “The predictive equations are intended to be used to evaluate average, area-wide ground-water conditions. They do not yield results that can be applied to a single point.” The general predictive equations were applied to the Chico and Baywood/Los Osos land areas within the reference study. The density of wells sampled per acre in Chico (0.0286 wells/acre) and in Baywood-Los Osos (0.0068 wells/acre) is less than the density of wells per acre in this study (0.059 wells/acre), albeit the density is in the same order of magnitude. The simplified expression provided in the reference report (Eq. 1) seems to be suitable for a Town the size of Virgin when comparing Virgin to the Case Study examples provided.

   The simplified approach for land use planning (Eq. 2) may be an evaluation tool worth considering as it pertains to land use planning for future septic systems in Virgin. Based on the estimated wastewater generation per ERU (237 gpd/ERU), and a range of effluent concentrations the following table is generated. This table indicates the recommended allowable septic density based on the estimated denitrification coefficient and effluent strength. For reference residential use is estimated to be 40 mg/L effluent strength and to have a denitrification coefficient of approximately 50%. For this study, commercial effluent was assumed to have an effluent strength of 100 mg/L, though a 75% or 90% nitrogen removal target is in effect.

Nw, effluent strength (mg/L)	d, denitrification coefficient (%)	Allowable Septic Density (gross acres/dwelling unit)				
		0.1	0.25	0.5	0.75	0.9
	40	6.073	4.672	2.336	0.000	-1.401
	60	10.745	9.343	7.007	4.672	3.270
	80	15.416	14.015	11.679	9.343	7.942
	100	20.088	18.686	16.350	14.015	12.613

SECTION 6 – ALTERNATE APPROACH

Page 34

1. The statement that "ambient groundwater flow between the two surface water sampling points, including the nitrate loading wastewater flow, also flows to the river" appears to be unsupported. What data were used to map groundwater flow and discharge to the river? For example, was groundwater evapotranspiration (e.g., by cottonwood trees) considered? Typically, a groundwater-surface water balance study is conducted based on measured data and accounting for all potential groundwater processes.

   Response: A groundwater-surface water balance study was not performed as part of this evaluation. As such, nitrogen uptake by vegetation was not considered.

   The sentence beginning "When calculating" is unclear, and the basis for all assumptions is not stated.

   Response: This paragraph has been revised for improved clarity. The basis for assumptions has been more clearly stated.

Table 18 (p. 34)

1. Note that during lower flow periods (e.g., July 2024, September 2024) when algal blooms are likely, there does appear to be a measurable increase in nitrate within Virgin Town.

   Response: Noted. However, no algal blooms occurred in the Virgin area.

Section 6.1 (p. 36)

1. Due to the time delay between groundwater recharge from septic systems and discharge to the river, the first paragraph may not be particularly meaningful.

   Response: It would be interesting to conduct additional study of the groundwater conditions in and around Virgin Town to better understand the mechanisms of contaminant transport. Based on the current understanding of these conditions, it seems plausible that increased visitation to the area could cause the observed increases to nitrate concentration.

2. The basis to remove the December 2024 data appears to be speculative.

   Response: This is based on the data and the information provided by the town. If the town did not tell us the information regarding the feedlots and cattle issue at the kick-off meeting, we would not know the nitrate concentration spike in the river was related to the feedlots.

Table 19 (p. 36)

1. Asterisk not defined on “Estimated*”.

   Response: This definition has been added.

2. This analysis appears to ignore nitrate uptake by algae and other in-stream processes that can reduce nitrate concentrations between Virgin River surface water sample locations SW-1 and SW-3; therefore, these results should not be used as a basis to increase septic density or support the conclusion that 88% of nitrate loading is to the bedrock aquifer. In-stream uptake can remove the majority of nitrate in streams in the southwestern U.S. (Handler and others, 2024).

   Response: That was just one study, and we cannot assume this process can occur in any other streams the same way. It may occur in the Virgin River, but we don’t believe the Virgin River has that capacity unless such studies prove it. If the river had this capacity, algal blooms would not occur. The communities are generally small with minimal contribution of nitrate to the river.

   Response: The authors acknowledge that nitrogen can be rapidly diluted by in-stream processes, including uptake by the recurrent cyanobacteria notorious on the Virgin River. The results demonstrated in the Oak Creek study show that 81% of nitrogen removal occurred from in-stream processes (Handler et. al., 2024). Due to the problematic recurrence of cyanobacteria, it may be of interest to many parties to understand the relationship between lateral nitrogen loading and the persistence of cyanobacteria. Across the majority of samples, the nitrate concentration decreased between SW#1 and SW#3, which behavior was not supposed. In some months, the nitrate concentration increased between SW#1 and SW#3, as anticipated. It remains unknown to what extent in-stream nitrogen uptake is the reason for the decrease in concentration between upstream and downstream locations, or whether the observed difference between these sampling locations could have been larger.

   It is also true that the nitrate concentration measured from samples at the Truman well was higher than the nitrate concentrations measured from samples drawn from the shallow groundwater monitoring wells. The measured concentration of these samples is also increased substantially from those measured during the previous study in 2015. Additional scrutiny of the in-stream nitrogen uptake would better inform whether nitrogen mass is migrating to the shallow bedrock aquifer.

Section 6.3 (p. 37)

1. Is there some sort of confining bed between the alluvial and bedrock aquifer? “Data collected and analyzed in above sections” does not have any mention of a confining bed that would separate the two.

   Response: The hydraulic conductivity of the shale bedrock is less than the hydraulic conductivity of the alluvial aquifer. In effect, the shale bedrock may act as a confining layer for the shallow alluvial aquifer. However, as stated in the report, we don’t have a good understanding of the shallow bedrock aquifer.

2. Specifically what data support the statement that the “bedrock aquifer does not appear to be well connected to the Virgin River”?

   Response: This paragraph has been revised to more clearly explain the data points which lead to the conclusion that the bedrock aquifer does not appear to be well connected to the river.

3. The idea of connectivity between the aquifers should be introduced much earlier, as it is a key question that needs to be answered to determine if increased septic density is feasible.

Response: The extent and connectivity of either aquifer remain unknown. The concept of nitrogen mass migrating to the bedrock aquifer was drawn out after observing marginal differences between upstream and downstream concentrations, and combining these observations with the limited sampling available at the Truman well.

Section 6.4 (p. 38)

1. What is the predefined "plausible range factor" discussed here?

   Response: The question should not be asked. This is a common term used in uncertainty analysis.

2. There is an opportunity for additional sensitivity analyses for high and low precipitation/recharge years in addition to changes in nitrogen loading from point sources and associated water discharge.

   Response: This recharge was estimated using a widely used model. The precipitation data is a long-term average with a high degree of certainty. The nitrate loading may change. However, this is a compliance study, these values are defined in the county standard.

Table 20 (p. 39)

1. Under Wastewater from Commercial (90% Removal), the nitrate loading is 25% (not 10%) of the Existing Commercial (Standard) category. Note typo in this table: “Assoiated.”

   Response: This should be 75% removal. (90% removal was a typo).

SECTION 7 – DISCUSSION OF ALTERNATE APPROACH

Section 7.1 (p. 42)

1. Connectivity between the two aquifers seems like a significant part of the question that should be answered, yet this is the first mention of it in the draft study.

   Response: This section is revised to acknowledge that in stream nitrogen uptake and groundwater distribution between alluvial shallow and bedrock aquifers are likely explanations for the observation that the predicted nitrate concentrations for the mass balance equation do not match the surface water sample data.

Section 7.3 (p. 43)

1. What is the basis for noting that PFAS compounds were detected? Is this data presented in the appendix? We see reference to PFOA, but all results are non-detect. Note the statement that PFAS compounds are not regulated is not correct; there are federal MCLs in place for PFAS (USEPA, 2025b).

   Response: This is typographical error. PFOA was the specific contaminant that was analyzed. Utah Administrative Code (R317-2) does not specify numeric criterion for PFAS compounds in streams or other waters of the state. The federal MCLs for PFAS are for drinking water standards.

SECTION 8 – SUMMARY, CONCLUSIONS, AND RECOMMENCATIONS

1. Are the results from the SUU laboratory invalid? They are reported and used in the report; address the reasoning for the laboratory change in the methods section (p. 44).

   Response: The basis for switching laboratories was to validate the results of the first. Notably, in multiple data sets we observed that the downstream nitrate concentration was less than the upstream concentration. We expected the downstream concentration to be higher. After observing this in multiple instances, we determined to validate the prior lab data with a second lab.

2. We would rephrase the second-to-last bullet to include gaining a better understanding of groundwater/surface water interaction for both the alluvial and bedrock aquifer, and an improved nutrient mass balance for the Virgin River accounting for in-stream processes. The statements that most of the nitrate migrates to the bedrock aquifer should be based on measured vertical gradients between the alluvial and bedrock aquifers, and studies of potential surface water discharge from the bedrock aquifer to the Virgin River (p. 45).

   Response: This point has been revised to acknowledge the need for a better understanding of in-stream processes.

SECTION 9 – THE VIRGIN RIVER WATER QUALITY ISSUES

1. Section 9 seems like it was added as a bit of an afterthought. A lot of this is good background information that should be discussed in the beginning of the report as background/introduction. It is relevant to reasoning for inclusion of monitoring for algae bloom indicators.

   Response: As stated, this is a compliance study. The Virgin River water quality is not the reason for this study. As required by the District, we added this section to discuss the Virgin River water quality.

2. Recommend moving content from this section into Introduction or Background sections earlier in the report.

   Response: as stated above, the water quality issue in the Virgin River is not the background for this study.

SECTION 10 – GENERAL COMMENTS

1. This content might be included with Section 8.

   Response: We don't agree with this comment.

APPENDIX B

1. Note that the 48-hour holding time for nitrate appears to have been missed for Sample ID#K2024 02054; this should be disclosed in the report (p. 81).

   Response: Noted. Follow up with the SUU water lab confirms that Sample #K2024-02054 was collected and acidified on 8/30/24 and analyzed on 10/1/24, exceeding the maximum 28-day holding time per laboratory testing standard US EPA 353.3. This has been noted in Section 4.5.1 of the report.

GENERAL

1. Be consistent in terminology between "*bedrock aquifer*," "*deeper aquifer*," and "consolidated rock aquifer."
   Response: Good comments and actions taken.

2. The report would benefit from a map of septic systems in the town and surrounding area.

   Response: Figure 1a shows the existing development and each development has a septic system.

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April 30, 2026

Brie Thompson
Associate General Manager, WCWCD
533 East Waterworks Drive
St. George, UT 84770
Delivery via email

RE: Virgin Town Groundwater Protection Study – Comment Response

Dear Ms. Thompson,

I would like to thank you for your time to meet and discuss, and address via comment, the remaining concerns regarding the Virgin Town Groundwater Protection Study. We have incorporated your comments into the revised report. If the revised report meets with the approval of Virgin Town, WCWCD, and ACSSD we will prepare to submit the revised study to the Utah Department of Environmental Quality.

The report has been revised to appropriately address the uncertainties associated with this study that warrant further investigation, such as in-stream denitrification processes and the connectivity between the shallow and deep aquifers. Our revised report presents the information that we discovered as part of this study, and makes recommendations for future work that should be performed to understand these processes prior to making changes to the allowable septic density.

We appreciate the opportunity to collaborate with the WCWCD and ACSSD on this study and hope we can be of assistance in similar water resource studies in the future.

Best regards,

Paul Andersen, P.E.
Project Manager

Cc: Dao Yang, P.E., Joseph Phillips, P.E., Derek Anderson, P.E.

GENERAL COMMENTS

In general, we agree with the final conclusions on page 45 (the last two bullet points) that maintaining the current septic density while pursuing opportunities for sewer infrastructure represents a balanced path forward for Virgin Town. However, due to several limitations noted below, we believe there is significant uncertainty in the analyses presented; therefore, they should not be used to justify increasing septic density. For example, this analysis appears to ignore nitrate uptake by algae and other in-stream processes that can reduce nitrate concentrations between Virgin River sample locations SW-1 and SW-3; therefore, these results should not be used as a basis to increase septic density or support the conclusion that 88% of nitrate loading is to the bedrock aquifer.

One primary concern is that the draft study does not adequately evaluate the potential impact of nitrate discharge from septic systems on nitrate levels in the Virgin River and the associated risk of toxic algal blooms. Although toxic algal blooms are acknowledged in Section 9, this discussion occurs after the "*Summary, Conclusions, and Recommendations*" in Section 8. We recommend that the report address algal blooms in the Virgin River and the potential contribution of septic discharges to nitrate loading earlier in the document. Until a more comprehensive understanding and nutrient mass balance of the Virgin River is developed, the potential impact of septic loading on algal blooms should continue to be considered a limiting factor for increasing septic density.

Response: It should be noted that the nitrate contribution from the septic systems in the Town of Virgin is minimal based on monitoring data, as discussed in the report. It is proper to discuss this issue after the "Summary, Conclusion and Recommendations" after we found the contribution of nitrate to the river from the systems in Virgin. Also, the background of this study was not because of the Virgin River water quality, but it is required by compliance.

WCWCD Comment:
WCWCD shares Loughlin Water Associate's (LWA) concern that because nitrate uptake by algae and other in-stream processes were not considered, the stream nitrate concentrations cannot be used to conclude the majority of nitrate ends up in the bedrock aquifer, and consequently, septic density can be increased. As noted in previously submitted comments, we are also concerned about the uncertainty in river flow measurements used in the inverse modeling approach. It is not clear that the nitrate contribution from the septic systems is minimal based on the uncertainties present. We recommend adding language throughout the report identifying data gaps and revising the conclusion of the study to reflect the unknowns that would need to be addressed to change the septic density.

"Summary, Conclusion and Recommendation" makes sense as the final section of the report. The impact of septic systems on the river was part of the scope of work and river nitrate concentrations were included in the report, so discussing Virgin River water quality issues fits before the conclusion.

Response 4/22/26: The report has been revised to address and raise these uncertainties. Commentary on the Virgin River quality has been rewritten and moved to introductory section 4.

SPECIFIC COMMENTS

EXECUTIVE SUMMARY

1. What is the basis for the statement that the bedrock aquifer is not connected to the Virgin River? Typically, groundwater elevations are compared to river elevations to assess hydraulic connection (p. 1).

   Response: As stated in the report, it is based on mass balance analysis and field observations. However, further study may be required to investigate the connectivity between the river and the bedrock aquifer.

   Response: An assessment of the groundwater elevation relative to the surface water elevation of the river is outside the scope of this report. However, based on field observations, the elevation of the groundwater table in the shallow aquifer was estimated to be slightly above the surface water elevation of the river during sampling activities.

   While sampling of the deeper groundwater well (Truman Well) was limited to only 2 months of data, the measured nitrate concentrations were far higher in this deeper well than the shallow monitoring wells, and the surface water data. This observation drove the hypothesis that the shallow alluvial aquifer could be connected to the river and to the bedrock aquifer, and that the bedrock aquifer was disconnected from the river.

   The authors agree that additional assessment of hydraulic connectivity between the observed aquifers would be beneficial to further understanding.

   WCWCD Comment:
   We agree additional assessment is needed to understand the connection between aquifers and the river. It would be helpful if the report identified information that should be collected in the future. The Executive Summary and subsequent sections of this report should be updated to better describe the uncertainty, unknowns, and proposed next steps.

   Response 4.22.26: The report has been rewritten to better describe the uncertainties and next steps that could be taken in subsequent reports.

2. Although comparison to groundwater nitrate standards are presented, there is no consideration of surface-water standards. At least within "*headwater streams*," Utah has a criteria of 0.4 milligrams per liter (mg/L) for total nitrogen (Utah Department of Environmental Quality, 2019). Although it is not clear if this criterion applies to the Virgin River within Virgin Town, it is a point of reference and the authors should present the applicable surface water standard. Notably, in at least one occasion the 0.4 mg/L total nitrogen value was exceeded at SW-3 (p. 2).

   Response: Additional context was added to pg 4 of our report to further explain the groundwater anti-degradation standard used to develop the recommendations of this study. Based on the report by Hansen, Allen & Luce (1997), an anti-degradation standard of 2 to 4 mg/L above the background concentration was selected, rather than the 10 mg/L concentration allowed by Utah Administrative Code.

   Additional comment was also provided in section 4.5 wherein the results of the groundwater sampling data are reviewed. These comments address the surface water concentration limit given in Table 2.14.8 of R317-2.

3. Along with a better understanding of the "*deeper aquifer,*" I would add a better understanding of the hydraulic connection between the alluvial and bedrock aquifers and the Virgin River (p. 2).

   Response: This statement has been added.

SECTION 1 – INTRODUCTION

Section 1.1 (p. 3)

WCWCD Comment:

Please add a paragraph between the second and third paragraphs in the Background introducing the importance of the Virgin River.

Potential added paragraph:

The Virgin River supplies more than half of all drinking water in Washington County, making its protection essential to the region. Water is diverted from the river downstream of the Town, stored in Quail Creek and Sand Hollow Reservoirs, treated at the Quail Creek Water Treatment Plant and delivered to multiple municipalities across the county. Because so much of the county depends on it as a drinking water source, maintaining high water quality in the Virgin River is critical.

Response 4.22.26: This paragraph has been added.

Section 1.2.1 (p. 4)

WCWCD Comment:

Please remove this sentence: "This study is the basis for the density restriction set forth by WCWCD that set a limit of one unit per acre for the development of Virgin." Virgin was not included in the Hansen, Allen & Luce study published in July 1997, and to our knowledge the HAL study was not the basis for the density restriction. If there is another HAL study that is being referenced here, please reference and share that study with us.

Response 4.22.26: This language was incorrect and has been removed from the text.

Section 1.3 (p. 5)

1. Groundwater monitoring piezometers appear to be located on either side of the river. Was there any reasoning for placing each on one side of the river or the other?

   Response: The placement of piezometers was not included in the original scope of the project. Originally, Sunrise was to take periodic groundwater samples from existing wells throughout the Town. However, discussion with the town indicates that there is only one well (Truman Well). The other wells identified from the Utah Division of Water Rights database do not exist. Then, at the request of the town, Sunrise proposed sampling from shallow groundwater using piezometers at several locations throughout the Town. The locations for these piezometers were selected such that they were close to the river, and in relatively close proximity to higher concentrations of development throughout the Town. This was done with the intent to measure the increased nitrate concentration in the surface water upstream and downstream of the developed areas of the Town.

2. Paired piezometers on either side of the river would provide the opportunity to compare water levels, water quality, and aquifer properties for the northern vs. southern study area.

   Response: The investigation of groundwater monitoring wells, or the installation of shallow monitoring wells, was not part of the scope of the project. The authors agree that this additional investigation could yield valuable information.

   WCWCD Comment:

   These recommendations and other recommendations below and discussed in the follow-up meeting should be summarized somewhere in the report. Perhaps a section could be added for future work.

   Response 4.22.26: Recommendations for future work have been included in section 8 of the text.

Figure 1 (p. 6)

1. Consider addition of focus map showing more detail on sampling locations. It is difficult to make out surface water vs. groundwater symbols.

   Response: An additional Figure 1a has been provided on a 1"=1,000' scale so that the sampling locations can be more easily determined.

SECTION 2 – GEOLOGIC SETTING

Figure 2 (p. 10)

1. Define geologic abbreviations on the map. Areas of alluvium outside the town boundary are colored red as "bedrock aquifer," which appears to be incorrect.

   Response: The reader is directed to the St. George Quad (Biek, 2010) for an exhaustive description of the listed geologic units. The area in red has been labeled as the shallow bedrock aquifer recharge area.

Figure 4 (p. 12)

1. Show the alluvial aquifer unit on the cross section. It is unclear why the exposed units are different on the cross section compared to the geologic map.

   Response: Figure 4 has been revised to show the approximate extents of the alluvial aquifer that may be connected to the Virgin River.

   The cross section shown in Figure 4 is of the Virgin Quadrangle, provided by the UGS. The geologic map shown in Figure 2 is from the St. George Quadrangle, also provided by the UGS.

SECTION 3 – HYDROGEOLOGY

Section 3.1 (p. 14)

1. Present a cross-section conceptual model that illustrates the relationship between the alluvial aquifer, river, and bedrock aquifer.

   Response: Figure 4 has been revised to show the approximate extents of the alluvial aquifer that may be connected to the Virgin River.

Section 3.4.1 (p. 15)

1. What does “the principal aquifer” refer to? Be consistent in terminology regarding the aquifer units.

   Response: The term “principal aquifer” has been changed to the “watershed boundary”.

Figure 6 (p. 19)

1. What is the reason for the feature with many contour lines near the northern extent of the figure, values 3.0 to 5.0?

   Response: This area is just below Goose Springs reservoir and south of Kolob Terrace Rd. The tight spacing of the recharge contours within this area are tighter since this is a grass covered valley, and much of the water from the plateau receiving higher precipitation, contributes to recharge.

2. Consider addition of focus map showing more detail on sampling locations. It is difficult to make out surface water vs. groundwater symbols.

   Response: Figure 1a has been added to more clearly indicate the sampling locations.

SECTION 4 – GROUNDWATER AND SURFACE WATER SAMPLING

Section 4.1 (p. 20)

1. Incorporate field photographs as some sort of figure/attachment/ appendix.

   Response: photographs of the field piezometer installation and sampling activities have been included with the appendix to this report.

2. Consider use of a geo-probe/direct push rig for better vertical alignment on piezometers.

   Response: The authors agree that better quality data would have been obtained from a drill rig installing manufactured well screens. This was, however, not in the scope of the project. The town provided and operated a backhoe for the installation of the piezometers to save costs.

3. Were piezometer locations/stick-ups surveyed?

   Response: No.

4. Groundwater piezometer installation with a backhoe is not a standard approach cited in the U.S. Environmental Protection Agency (USEPA) guidance (e.g., USEPA, 2018).

   Response: The authors agree that better quality data would have been obtained from a drill rig installing manufactured well screens. This was, however, not in the scope of the project.

Section 4.2 (p. 21)

1. Were non-vertical orientations of piezometers considered for water volume estimations?

   Response: Yes, volumetric calculations considered the non-vertical orientation of the piezometers.

2. Bailer sampling with a 3x borehole volume purge is not equivalent to low-flow sampling. The purging procedure described cannot reasonably be characterized as consistent with the EPA low-flow sampling guidance.

   Response: The alluvial aquifer consists of sand, gravel, cobbles and boulders and therefore, the groundwater flow may not be low. According to section 6.1 of ASTM D4448, purging a shallow groundwater well volume of 3 to 5 times the volume of the well casing is generally sufficient practice. In Utah, purging three times the volume of stagnant water is a standard practice.

3. Were the top-of-casing from the piezometers surveyed, such that groundwater elevation can be determined from the depth-to-water measurements? Given the angle of the borings could groundwater elevation even be calculated? Without groundwater elevation data, how was the hydraulic gradient calculated (p. 31)?

   Response: We could calculate the groundwater elevation, though the tops of the casing were not surveyed. Based on field observations the water surface elevation of the groundwater was higher than that of the river.

4. Groundwater elevations should be compared to river elevation in order to understand hydraulic connection and gaining/losing status of the river.

   Response: Neither was surveyed and these elevations were approximated.

Tables 3 to 7 (p. 20 to 22)

1. Is the "Depth to Water" accounting for the borehole angle?

   Response: Yes.

Section 4.5.1 (p. 23 to 25)

1. Ensure that the nitrate units are comparable in the first paragraph (and not nitrate-as-nitrate versus nitrate-as-nitrogen).

   Response: Samples were evaluated for the presence of nitrate as nitrogen, as stated in Section 4.5.1.

2. The entire discussion of the advection-dispersion equation on p. 23–25 is superfluous and should be removed. No groundwater fate and transport modeling appears to have been conducted with this approach, with the possible exception of the graph on p. 25 that is presented as a "simplified decay function" only.

   Response: This section has been modified in accordance with the recommendations.

Table 8 (p. 24)

1. Here and throughout the draft study, removal of data as "outliers" is not justified given the limited data collected. No statistical analysis is presented to support data exclusion.

   Response: The comment is acknowledged. The dataset consists of monthly sampling over a 12-month period at four locations, which limits the applicability and statistical power of formal outlier tests. For datasets of this size, conventional statistical methods for identifying outliers are of limited reliability and were therefore not applied as the sole basis for data screening.

   Given the limited sample size, statistical evaluation was supplemented with professional judgment to determine whether to include or exclude individual data points.

   In this study, data points identified as potential outliers were not excluded solely because they deviated from an apparent trend, but because they coincided with site-specific or sampling-specific conditions (e.g., the presence of feed lot animals near SW #1) that may provide a reasonable explanation for the observed deviation.

Importantly, identified outliers were evaluated separately rather than disregarded and their inclusion or exclusion does not materially alter the overall conclusions of the study. The intent was to prevent anomalous, non-representative measurements from disproportionately influencing interpretation, while still acknowledging the inherent uncertainty associated with a limited dataset. It is possible that the “outlier” points could indicate trends which could be further evaluated in future studies.

WCWCD Comment:

Please review and evaluate outliers that were removed. How would the analysis be impacted if these values were left in. If the values are not true outliers, and the conclusion of the analysis would be different if they were left in, this should be stated and adds to the uncertainty of the analysis. The report should be revised to reflect this.

Response 4.22.26: If a Grubbs test is performed, the July 2024 and December 2024 data are both outliers with a 95% confidence. The July 2024 data is likely the result of more irrigation water was used. However, the data for December 2024 is known to be related to the feedlot. That's why the December 2024 data point was removed from analysis while the July 2024 date was not. If this data point were kept, then the river would have received about 150% of the total nitrate load from all septic system in Virgin.

Table 9 (p. 26)

1. What is the source of the “EPA MCL” for Bisphenol A? There does not appear to be a primary drinking water standard for this compound (USEPA, 2025a).

   Response: The authors acknowledge that this is correct. According to the Bisphenol A Action Plan (EPA, 2010), there are recommended maximum daily intake limits for BPA (0.05 mg/kg/day for BPA). The EPA has not established an MCL for BPA in groundwater or surface water. Table 9 and Section 9 of the report has been revised to remove any statement of an EPA MCL for BPA.

Section 4.5.2 (p. 26)

1. This is the first mention of harmful algal blooms related to nitrogen. We agree that it is relevant but consider discussing this earlier in report.

   Response: Near the end of the sampling phase of the project, and at the request of Ash Creek Special Services District (ACSSD), surface water samples collected on April 30, 2025, were delivered to Chemtech-Ford Laboratories for analysis. This study does not investigate the relationship between harmful algal blooms and the quality of groundwater in Virgin Town. The results of these laboratory analyses are presented in this report only for reference (see Appendix B).

   WCWCD Comment

   Sampling of cyanotoxins, with the addition of anatoxin should be included in recommended future work. Anatoxin has frequently been detected in the Virgin River.

   Response 4.22.26: This has been included.

2. Establish connection between microcystins/nodularins/algal blooms and nitrogen levels.

   Response: See response above.

3. Explain reasoning for microcystins/nodularins/PPCP/EDC only being sampled for once while all other sampling was monthly.

   Response: See response above.

4. What is the specific potential source for PPCP and EDC in Virgin? Why is this added to the analyte list?

   Response: Near the end of the sampling phase of the project, and at the request of Ash Creek Special Services District (ACSSD), ground water samples were delivered to Chemtech-Ford Laboratories for analysis of PPCP and EDC. These contaminants are good indicators of human waste that may be introduced to groundwater through residential and commercial septic systems.

   This study does not investigate the relationship between PPCP, EDC or other contaminants, and the quality of groundwater in Virgin Town. The results of these laboratory analyses are presented in this report only for reference (see Appendix B).

   Section 4.4 is revised to explain that nitrate is the constituent considered in the mass balance approach to contaminant transport. The impact of other constituents was evaluated only theoretically, and not analytically.

5. Without sampling data to support, remove the statement that surface water concentrations are lower than groundwater concentrations.

   Response: This comment is acknowledged. PPCP and EDC are not constituents of concern, as it pertains to the mass balance approach. There is, therefore, no need to include this statement and it has been removed.

   WCWCD Comment:

   Microcystin is misspelled in the heading of 4.5.2.

   Response 4.22.26: This has been corrected.

Section 4.5.3 PPCP & EDC – Table 9

WCWCD Comment:

The word "Surface" does not look like it belongs is in the first sentence of the second paragraph under this heading. Is GWMW#5 the same location as the Truman Well? If so, label consistently throughout the report.

Response 4.22.26: GWMW #5 has been renamed "Truman Well" for consistency throughout the report.

Section 4.6.1 (p. 27)

1. Non-vertical piezometers will impact slug test results; their use introduces components of vertical flow rather than just horizontal into the piezometer screen.

   Response: The authors acknowledge this impact on the slug test results. The slug test results were used to support the use of the aquifer hydraulic conductivity selected based on professional judgment.

2. Were the physical conditions of the hacksaw modified screens documented before installation? Hand-modified screens introduce potential for inconsistent inflow from piezometer to piezometer.

   Response: The measurements reported in the study are approximate. The piezometers were prepared as consistently as possible in the field.

3. Broader and more even distribution of factory screen could also impact inflow to piezometer vs. hand-modified screens.

   Response: The authors acknowledge that a factory screen would provide more consistent and reliable data.

Section 4.6.2 (p. 28)

1. Why were factory-made screens not used in the piezometer construction? Budget? Availability?

   Response: factory-made screens were not used as piezometer installation was not part of the original scope of the project.

2. What is the reasoning behind multiplying the K of GWMS4 by 2.5 to yield a K of 30 feet per day (ft/d)?

   Response: The hydraulic conductivities of the alluvial materials observed in the test pits have a large range, from 3 to 20 feet/day in fine sand to over 100 feet/day in gravel and cobbles. The measured hydraulic conductivity was multiplied by 2.5 in attempts to account for the hand sawn piezometers, inclination angles, and other uncertainties associated with the slug tests.

Table 10 (p. 28)

1. Remove the "*high*" column if it is not based on actual slug data analysis. It is not clear, but it appears to be an arbitrary multiplier of 8x the slug-test result. Otherwise, we have not reviewed the slug test analysis in detail, but in general slug tests are better suited to low-permeability sediments.

   Response: The "High" column is to indicate that a factory well screen may be 8 times more efficient than the hand sawn piezometers.

   WCWCD Comment:

   We would like to better understand the support for multiplying the hydraulic conductivity of GWMW#4 by 2.5 to yield 30 feet per day and the support for the high value being 8 times the average conductivity. The information in the report and response above do not completely explain this.

   Response 4.22.26: The reasoning was not necessarily to multiply the measured value by 2.5 to obtain 30 feet per day, rather 30 feet per day was selected using the reasoning explained in this section. That is, that during test pit excavation the subsurface profiles were logged as sands and, in some cases, gravels and cobbles. A hydraulic conductivity of 30 feet per day would be on the high side for fine sand, but on the low side for coarse sand or gravel. Thus, 30 feet per day was selected based on the observed subsurface conditions. The ratio of 2.5 was mentioned to show that this is less than the ratio of the recovery efficiency between the hand slotted PVC screens and a factory well screen.

SECTION 5 – INVERSE MODELING FOR AMBIENT GROUNDWATER FLOW

Page 29

1. The purpose of this section and the first paragraph is unclear. Clearly state the objective of the analysis. Cite sources for all values assumed (e.g., 237 gallons per day).

   Response: The purpose of Section 5 was added in an introductory paragraph. A citation is made to the study performed by Sunrise (2022) wherein 237 gpd/ERU is determined.

2. The mass balance equation appears to be missing all groundwater discharge components including groundwater discharge to the river and groundwater underflow. It does not appear to account for impacts of evapotranspiration.

   Response: It included everything necessary for the mass balance analysis. This comment should not appear herein.

3. Again, what makes the hydraulic conductivity (K) estimate of 30 feet per day (ft/d)

for alluvial aquifer reasonable?

Response: See the response to Item #2 in Section 4.6.2.

4. Figure 6 is hard to interpret, particularly within Virgin Town itself. Adding a focus map/figure with a closer view of town limits would be helpful.

   Response: The estimated recharge map should show the extents of the watershed boundary, which is observable at the current scale.

Page 31

1. Are water level measurements discussed here based on survey data? What is the reference point for piezometer water levels vs. ground elevation vs. surface water elevation?

   Response: The ground and surface water elevations were not surveyed and the gradient is herein approximated.

2. It is not clear why hydraulic gradient is not needed; groundwater flow is calculated based on hydraulic gradient per Darcy's Law.

   Response: The ambient groundwater flow is back calculated using the inverse mass balance approach, updating the parameters assumed in prior studies, such as recharge volume and background nitrate concentration (as measured from field piezometers). This approach was used to evaluate the accuracy of the assumptions used to develop the mass balance approaches used in prior studies.

   The results of the inverse mass balance model indicate that, based on the updated parameters, the ambient groundwater flow is too low to transmit the nitrate loading observed in the piezometers.

   This comment should not appear herein.

3. If gradient is not relevant to inverse modeling, does the correction from 5 to 1.67% need to be discussed? It is currently somewhat confusing to read.

   Response: Because groundwater and surface water elevations were neither surveyed nor recorded, discussion of a potential change in hydraulic gradient is not warranted. However, the authors believe it is appropriate to document relevant field observations as they pertain to both hydraulic conductivity and hydraulic gradient to demonstrate the approximate levels of uncertainty associated with the previously assumed parametric values.

   This comment should not appear herein.

4. The discussion of previous modeling may merit its own section that comes before any details on the newer inverse modeling. Consider separating issues/comments regarding the old modeling in a separate section, then state how they are addressed by newer inverse modeling in its own section.

   Response: This study presents a limited discussion of the assumed parameters used in prior studies. The intent of this section is to demonstrate that the former mass balance approach does not accurately describe the current groundwater conditions as measured in the shallow groundwater monitoring points and surface water sampling.

5. Where does the assumption of 60 feet of aquifer come from? The one family well log? Is this the alluvial aquifer?

   Response: 60 feet was the aquifer thickness assumed from the 2015 study performed by Ensign Engineering. This value was compared against the well log of the Truman well, which was sampled as part of this study. The lithologic log of the Truman well reports 38 feet of alluvium overlying red shale at approximately 38 feet below ground surface. This is less than the assumed thickness of 60 feet, but without sufficient other data points, the assumed thickness of 60 feet was left to simplify the comparisons between this and the prior studies.

6. Questions in Section 5 are confusing and out of place. We believe this section is supposed to contain comments on the previous studies. Consider rephrasing these questions as statements.

   Response: Questions have been rephrased as statements for improved clarity.

7. “as even less accurate” – typo (p. 32)

   Response: Revised.

Table 13 (p. 31)

1. The groundwater flow calculated should be compared against calculations using Darcy’s Law as a check.

   Response: If we had enough data to do a better calculation using Darcy’s Law, this section would not be required. This comment should not appear herein.

Table 16 (p. 33)

1. Constant monthly septic system discharge is inconsistent with Figure on bottom of Page 35 (all figures should be numbered).

   Response: Figure captions have been added for all figures throughout the study. The data shown by the reference figure pose one possible explanation for the observed seasonal fluctuation of nitrate concentration throughout the year. Regional visitation data and septic loading data were not analyzed as part of this study and average values were assumed for daily wastewater generation.

2. Table is titled monthly nitrate loading wastewater flow, but “precipitation related recharge” is listed.

   Response: Table headings have been changed so that “Precipitation Related Recharge” now reads “Precipitation Related” and “Irrigation Related Recharge” now reads “Irrigation Related”.

Page 33

1. The statement that groundwater will not exceed 4 mg/L appears to be based on the assumption of a completely mixed system, which is not reasonable. Standard methods including those listed by Hantzsche and Finnemore (1992) could be used to estimate nitrate in groundwater from septic loadings. Note the typo “4 ml/L.” The draft study also does not account for denitrification.

   Response: The typographical error has been fixed.

   The authors appreciate the citation of and have considered the reference study. The following observations are made of the simplified approach provided by Hantzche and Finnemore (1992).

   “The predictive equations are intended to be used to evaluate average, area-wide ground-water conditions. They do not yield results that can be applied to a single point.” The general predictive equations were applied to the Chico and Baywood/Los Osos land areas within the reference study. The density of wells sampled per acre in Chico (0.0286 wells/acre) and in Baywood-Los Osos (0.0068 wells/acre) is less than the density of wells per acre in this study (0.059 wells/acre), albeit the density is in the same order of magnitude. The simplified expression provided in the reference report (Eq. 1) seems to be suitable for a Town the size of Virgin when comparing Virgin to the Case Study examples provided.

   The simplified approach for land use planning (Eq. 2) may be an evaluation tool worth considering as it pertains to land use planning for future septic systems in Virgin. Based on the estimated wastewater generation per ERU (237 gpd/ERU), and a range of effluent concentrations the following table is generated. This table indicates the recommended allowable septic density based on the estimated denitrification coefficient and effluent strength. For reference residential use is estimated to be 40 mg/L effluent strength and to have a denitrification coefficient of approximately 50%. For this study, commercial effluent was assumed to have an effluent strength of 100 mg/L, though a 75% or 90% nitrogen removal target is in effect.

		Allowable Septic Density (gross acres/dwelling unit)				
	d, denitrification coefficient (%)	0.1	0.25	0.5	0.75	0.9
Nw, effluent strength (mg/L)	40	6.073	4.672	2.336	0.000	-1.401
	60	10.745	9.343	7.007	4.672	3.270
	80	15.416	14.015	11.679	9.343	7.942
	100	20.088	18.686	16.350	14.015	12.613

SECTION 6 – ALTERNATE APPROACH

Page 34

1. The statement that "ambient groundwater flow between the two surface water sampling points, including the nitrate loading wastewater flow, also flows to the river" appears to be unsupported. What data were used to map groundwater flow and discharge to the river? For example, was groundwater evapotranspiration (e.g., by cottonwood trees) considered? Typically, a groundwater-surface water balance study is conducted based on measured data and accounting for all potential groundwater processes.

   Response: A groundwater-surface water balance study was not performed as part of this evaluation. As such, nitrogen uptake by vegetation was not considered.

   The sentence beginning "When calculating" is unclear, and the basis for all assumptions is not stated.

   Response: This paragraph has been revised for improved clarity. The basis for assumptions has been more clearly stated.

Table 18 (p. 34)

1. Note that during lower flow periods (e.g., July 2024, September 2024) when algal blooms are likely, there does appear to be a measurable increase in nitrate within Virgin Town.

   Response: Noted. However, no algal blooms occurred in the Virgin area.

   WCWCD Comment:

   To our knowledge the presence of algal blooms is unknown during the study period. While some monitoring is performed on the Virgin River, led by the Utah Department of Environmental Quality, it is limited and primarily focused on harmful algal blooms.

   Response 4.22.26: Our comment that no algal blooms occurred in the area has been removed.

Section 6.1 (p. 36)

1. Due to the time delay between groundwater recharge from septic systems and discharge to the river, the first paragraph may not be particularly meaningful.

   Response: It would be interesting to conduct additional study of the groundwater conditions in and around Virgin Town to better understand the mechanisms of contaminant transport. Based on the current understanding of these conditions, it seems plausible that increased visitation to the area could cause the observed increases to nitrate concentration.

2. The basis to remove the December 2024 data appears to be speculative.

   Response: This is based on the data and the information provided by the town. If the town did not tell us the information regarding the feedlots and cattle issue at the kick-off meeting, we would not know the nitrate concentration spike in the river was related to the feedlots.

   WCWCD Comment:

   The first paragraph and third paragraphs under what is now Section 6.2 should be revised to reflect the uncertainty associated with unknown algal up-take or nitrate and what the impact of including the December 2024 data would have on the analysis.

   Response 4.22.26: The report language has been revised throughout to include the uncertainty associated with nutrient uptake. The potential in-stream uptake rates are presented in section 7.5 of the report. Inclusion of the December outlier would have caused the river to receive 150% of the nitrate load from all septic systems in Virgin.

Table 19 (p. 36)

1. Asterisk not defined on “Estimated*”.

   Response: This definition has been added.

2. This analysis appears to ignore nitrate uptake by algae and other in-stream processes that can reduce nitrate concentrations between Virgin River surface water sample locations SW-1 and SW-3; therefore, these results should not be used as a basis to increase septic density or support the conclusion that 88% of nitrate loading is to the bedrock aquifer. In-stream uptake can remove the majority of nitrate in streams in the southwestern U.S. (Handler and others, 2024).

   Response: That was just one study, and we cannot assume this process can occur in any other streams the same way. It may occur in the Virgin River, but we don’t believe the Virgin River has that capacity unless such studies prove it. If the river had this capacity, algal blooms would not occur. The communities are generally small with minimal contribution of nitrate to the river.

   Response: The authors acknowledge that nitrogen can be rapidly diluted by in-stream processes, including uptake by the recurrent cyanobacteria notorious on the Virgin River. The results demonstrated in the Oak Creek study show that 81% of nitrogen removal occurred from in-stream processes (Handler et. al., 2024). Due to the problematic recurrence of cyanobacteria, it may be of interest to many parties to understand the relationship between lateral nitrogen loading and the persistence of cyanobacteria. Across the majority of samples, the nitrate concentration decreased between SW#1 and SW#3, which behavior was not supposed. In some months, the nitrate concentration increased between SW#1 and SW#3, as anticipated. It remains unknown to what extent in-stream nitrogen uptake is the reason for the decrease in concentration between upstream and downstream locations, or whether the observed difference between these sampling locations could have been larger.

   It is also true that the nitrate concentration measured from samples at the

Truman well was higher than the nitrate concentrations measured from samples drawn from the shallow groundwater monitoring wells. The measured concentration of these samples is also increased substantially from those measured during the previous study in 2015. Additional scrutiny of the in-stream nitrogen uptake would better inform whether nitrogen mass is migrating to the shallow bedrock aquifer.

Section 6.3 (p. 37)

1. Is there some sort of confining bed between the alluvial and bedrock aquifer? “Data collected and analyzed in above sections” does not have any mention of a confining bed that would separate the two.

   Response: The hydraulic conductivity of the shale bedrock is less than the hydraulic conductivity of the alluvial aquifer. In effect, the shale bedrock may act as a confining layer for the shallow alluvial aquifer. However, as stated in the report, we don’t have a good understanding of the shallow bedrock aquifer.

2. Specifically what data support the statement that the “bedrock aquifer does not appear to be well connected to the Virgin River”?

   Response: This paragraph has been revised to more clearly explain the data points which lead to the conclusion that the bedrock aquifer does not appear to be well connected to the river.

3. The idea of connectivity between the aquifers should be introduced much earlier, as it is a key question that needs to be answered to determine if increased septic density is feasible.

   Response: The extent and connectivity of either aquifer remain unknown. The concept of nitrogen mass migrating to the bedrock aquifer was drawn out after observing marginal differences between upstream and downstream concentrations, and combining these observations with the limited sampling available at the Truman well.

Section 6.4 (p. 38)

1. What is the predefined "plausible range factor" discussed here?

   Response: The question should not be asked. This is a common term used in uncertainty analysis.

2. There is an opportunity for additional sensitivity analyses for high and low precipitation/recharge years in addition to changes in nitrogen loading from point sources and associated water discharge.

   Response: This recharge was estimated using a widely used model. The precipitation data is a long-term average with a high degree of certainty. The nitrate loading may change. However, this is a compliance study, these values are defined in the county standard.

Table 20 (p. 39)

1. Under Wastewater from Commercial (90% Removal), the nitrate loading is 25% (not 10%) of the Existing Commercial (Standard) category. Note typo in this table: “Assoiated.”

   Response: This should be 75% removal. (90% removal was a typo).

   WCWCD Comment:

   Did the last study recommend 90% or 75%?

   Response 4.22.26: The last study recommended 90% removal. In our meetings with ACSSD it was determined that the 90% standard was optimistically high and that 75% is more realistically attainable.

SECTION 7 – DISCUSSION OF ALTERNATE APPROACH

Section 7.1 (p. 42)

1. Connectivity between the two aquifers seems like a significant part of the question that should be answered, yet this is the first mention of it in the draft study.

   Response: This section is revised to acknowledge that in stream nitrogen uptake and groundwater distribution between alluvial shallow and bedrock aquifers are likely explanations for the observation that the predicted nitrate concentrations for the mass balance equation do not match the surface water sample data.

Section 7.3 (p. 43)

1. What is the basis for noting that PFAS compounds were detected? Is this data presented in the appendix? We see reference to PFOA, but all results are non-detect. Note the statement that PFAS compounds are not regulated is not correct; there are federal MCLs in place for PFAS (USEPA, 2025b).

   Response: This is typographical error. PFOA was the specific contaminant that was analyzed. Utah Administrative Code (R317-2) does not specify numeric criterion for PFAS compounds in streams or other waters of the state. The federal MCLs for PFAS are for drinking water standards.

SECTION 8 – SUMMARY, CONCLUSIONS, AND RECOMMENCATIONS

1. Are the results from the SUU laboratory invalid? They are reported and used in the report; address the reasoning for the laboratory change in the methods section (p. 44).

   Response: The basis for switching laboratories was to validate the results of the first. Notably, in multiple data sets we observed that the downstream nitrate concentration was less than the upstream concentration. We expected the downstream concentration to be higher. After observing this in multiple instances, we determined to validate the prior lab data with a second lab.

2. We would rephrase the second-to-last bullet to include gaining a better understanding of groundwater/surface water interaction for both the alluvial and bedrock aquifer, and an improved nutrient mass balance for the Virgin River accounting for in-stream processes. The statements that most of the nitrate migrates to the bedrock aquifer should be based on measured vertical gradients between the alluvial and bedrock aquifers, and studies of potential surface water discharge from the bedrock aquifer to the Virgin River (p. 45).

   Response: This point has been revised to acknowledge the need for a better understanding of in-stream processes.

SECTION 9 – THE VIRGIN RIVER WATER QUALITY ISSUES

1. Section 9 seems like it was added as a bit of an afterthought. A lot of this is good background information that should be discussed in the beginning of the report as background/introduction. It is relevant to reasoning for inclusion of monitoring for algae bloom indicators.

   Response: As stated, this is a compliance study. The Virgin River water quality is not the reason for this study. As required by the District, we added this section to discuss the Virgin River water quality.

2. Recommend moving content from this section into Introduction or Background sections earlier in the report.

   Response: as stated above, the water quality issue in the Virgin River is not the background for this study.

SECTION 10 – GENERAL COMMENTS

1. This content might be included with Section 8.

   Response: We don’t agree with this comment.

APPENDIX B

1. Note that the 48-hour holding time for nitrate appears to have been missed for Sample ID#K2024 02054; this should be disclosed in the report (p. 81).

   Response: Noted. Follow up with the SUU water lab confirms that Sample #K2024-02054 was collected and acidified on 8/30/24 and analyzed on 10/1/24, exceeding the maximum 28-day holding time per laboratory testing standard US EPA 353.3. This has been noted in Section 4.5.1 of the report.

GENERAL

1. Be consistent in terminology between “*bedrock aquifer*,” “*deeper aquifer*,” and “consolidated rock aquifer.”

   Response: Good comments and actions taken.

2. The report would benefit from a map of septic systems in the town and surrounding area.

   Response: Figure 1a shows the existing development and each development has a septic system.

Appendix E

Field Photographs


Date & Time: Mon. Jun 24, 2024 at 09:24:43 MDT
Position: +037.199842° / -113.182902°
Altitude: 3504ft (±15.5ft)
Datum: WGS-84
Azimuth/Bearing: 216° S36W 3840mils True (±12°)
Elevation Angle: -07.1°
Horizon Angle: +00.2°
Zoom: 0.5X


Position: ±16.5ft
Datum: WGS-84


Position: +037.197610°
Altitude: 3494ft (±21.5ft)
Datum: WGS-84
Azimuth/Bearing: 266° S86W 4729mils True (±12°)
Zoom: 0.5X


Date & Time: Mon. Jun 24, 2024 at 09:25:05 MDT
Position: +037.199552° / -113.184562° (±17.2ft)
Datum: WGS-84
Azimuth/Bearing: 170° S10E 3022mils True (±12°)
Wallace Property MW


Date & Time: Mon. Jun-24, 2024 at 10:39:44 MDT
Position: +037.197129° / -113.191969° (±151.8ft)
Altitude: 3517ft (±74.0ft)
Datum: WGS-84
Azimuth/Bearing: 268° S88W 4764mils True (±12°)
Elevation Angle: -09.7°
Horizon Angle: +00.0°
Zoom: 0.5X


Date & Time: Mon. Jun 24, 2024 at 10:50:11 MDT
Position: +037.197593° / -113.192118° (±19.9ft)
Altitude: 3494ft (±23.6ft)
Datum: WGS-84
Azimuth/Bearing: 309° N51W 5493mils True (±12°)
Zoom: 2.0X


Position: +037.199607°
Datum: WGS-84
Zoom: 0.5X


Date & Time: Mon. Jun 24, 2024 at 10:49:46 MDT
Datum: WGS-84
Azimuth/Bearing: 185° S05W 3289mils True
Elevation Angle: -07.1°
Horizon Angle: +00.6°
Zoom: 0.5X
MW 1


Position: +037.197332° / -113.192284° (±168.9ft)
Altitude: 3526ft
Datum: WGS-84
Azimuth/Bearing: 197° S17W 3502mils True
Elevation Angle: -08.4°


Datum: WGS 84
Elevation Angle: -76.2
Zoom: 0.5X
MW 3

Datum: WGS 84
Zoom: 0.5X

Horizon Angle: +00.9
Zoom: 0.5X

MW#3
SE

Date & Time: Thu, Jul 25, 2024
Datum: WGS 84

Datum: WGS 84
Zoom: 0.5X
SW 3 d/s

Datum: WGS 84

Datum: WGS 84
Zoom: 0.5X


Date & Time: Fri, Aug 30, 2024 at 10:59:00 MDT
Datum: WGS-84
Zoom: 0.5X

Date & Time: Fri, Aug 30, 2024 at 11:05:02 MDT
Datum: WGS-84
GW#2 Ferber - more exposed - please dont break

Datum: WGS-84

Datum: WGS-84
Elevation Angle: -11.0
Zoom: 0.5X

Zoom: 0.5X

Zoom: 0.5X


Horizon Angle: +01.4°
Zoom: 0.5X


Position: +037.202746° / -113.175205°


Position: +037.20262
Datum: WGS-84
Zoom: 0.5X


Date & Time: Fri, Aug 30, 2024 at 11:21:20 MDT
Position: +037.202640° / -113.175369° (±17.6ft)
Datum: WGS-84
Azimuth/Bearing: 200° S20W 3556mils True (±12°)
Horizon Angle: -73.5°
Zoom: 0.5X
SW#2 creek too low to sample from bailer


Elevation Angle: -10.6°
Horizon Angle: +00.2°
Zoom: 0.5X
SW#2 creek too low to sample from bailer

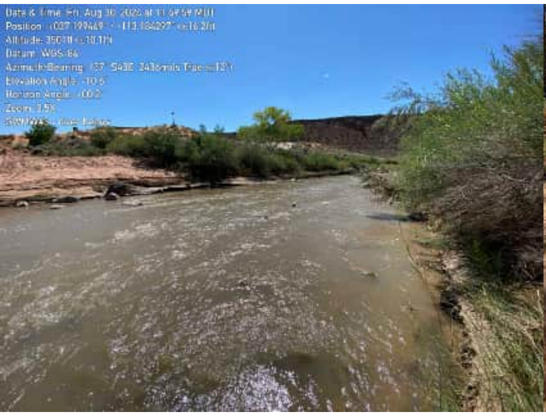

Date & Time: Fri, Aug 30, 2024 at 11:48:58 MDT
Position: +037.199485° / -113.184504° (±25.2ft)
Zoom: 0.5X


Date & Time: Fri, Aug 30, 2024 at 11:23:53 MDT
Position: +037.202619° / -113.175323° (±26.6ft)
Datum: WGS-84
Azimuth/Bearing: 257° S77W 4569mils True (±12°)


MAY


Date & Time: Fri, Aug 30, 2024 at 11:49:46 MDT
Azimuth/Bearing: 027° N27E 0480mils True (±12°)
Zoom: 0.5X

Date & Time: Fri, Aug 30, 2024 at 12:23:52 MDT
Datum: WGS-84
Zoom: 0.5X
GWMW4 test well

Date & Time: Fri, Aug 30, 2024 at 12:55:53 MDT
Datum: WGS-84

Date & Time: Fri, Aug 30, 2024 at 11:49:59 MDT
Datum: WGS-84
Elevation Angle: -10.5°

Date & Time: Fri, Aug 30, 2024 at 12:21:11 MDT
Position: +037.197017° / -113.191951° (±29.4ft)
Altitude: 3489ft (±26.9ft)
Datum: WGS-84
Azimuth/Bearing: 108° S72E 1920mils True (±12°)
Elevation Angle: +86.0°
Horizon Angle: +06.7°
Zoom: 0.5X

Datum: WGS-84
Azimuth/Bearing: 073° N73E 1298mils True (±12°)
Elevation Angle: -10.8°
Zoom: 0.5X
SW43 D/S much lower

Date & Time: Fri, Aug 30, 2024 at 11:50:05 MDT
Position: +037.199483° / -113.184295° (±16.2ft)
Altitude: 3503ft (±10.2ft)
Datum: WGS-84
Horizon Angle: -01.7°
Zoom: 0.5X
GWMW43 - river below

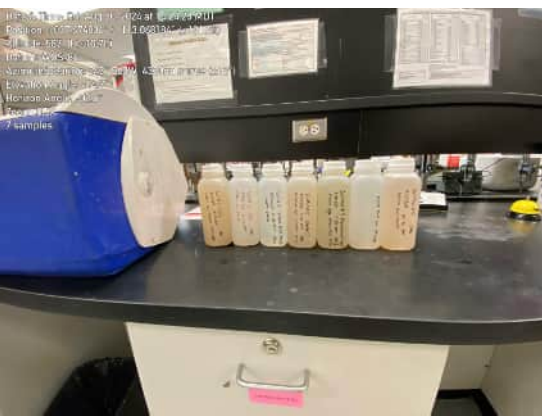
Altitude: 3475ft (±62.4ft)
Datum: WGS-84
Azimuth/Bearing: 310° N50W 5511mils True (±12°)
Elevation Angle: -11.6°
Zoom: 0.5X
SW43 D/S much lower

Date & Time: Fri, Aug 30, 2024 at 13:05:48 MDT
Altitude: 3433ft (±32.4ft)
Datum: WGS-84
Azimuth/Bearing: 266° S86W 4729mils True (±12°)
Zoom: 0.5X
SW43 D/S much lower


Position: +037.208812° / -113.225006° (±70.0ft)
Datum: WGS-84
Elevation Angle: +08.2°
Horizon Angle: +00.2
Zoom: 0.5X
switched 401817 for 481808


Zoom: 0.5X


Azimuth/Bearing: 166° S14E 2951mils True (±13°)
Elevation Angle: -83.4°


7 samples


Date & Time: Fri, Sep 27, 2024 at 12:01:58 MDT
Datum: WGS-84
Azimuth/Bearing: 194° S14W 3449mils
Elevation Angle: -65.3°
Horizon Angle: 19.1°
Zoom: 0.5X


Date & Time: Fri, Sep 27, 2024 at 12:43:34 MDT
Position: +037.199744° / -113.186574° (±114.8ft)
Altitude: 3509ft (±43.6ft)
Datum: WGS-84
Azimuth/Bearing: 322° N38W 5724mils True (±29°)
Elevation Angle: -07.3°
Horizon Angle: 03.8°
Zoom: 0.5X


Azimuth/Bearing: 235° S55W 4178mils True (±12°)
7 samples


Elevation Angle: -22.5°
Zoom: 0.5X


Date & Time: Fri, Sep 27, 2024 at 13:08:20 MDT
Position: +037.199345° / -113.174102° (±54.2ft)
Altitude: 3534ft (±29.1ft)
Datum: WGS-84
Azimuth/Bearing: 329° N31W 5849mils True (±13°)
Elevation Angle: -09.7°
Horizon Angle: 01.2°
Zoom: 0.5X


Date & Time: Fri, Sep 27, 2024 at 13:08:35 MDT
Position: +037.199250° / -113.174130° (±19.2ft)
Altitude: 3533ft (±24.8ft)
Datum: WGS-84
Azimuth/Bearing: 340° N20W 6044mils True (±13°)
Elevation Angle: -06.1°
Horizon Angle: -00.4°
Zoom: 0.5X
GWMW42

Zoom: 0.5X
GWMW42

Zoom: 0.5X

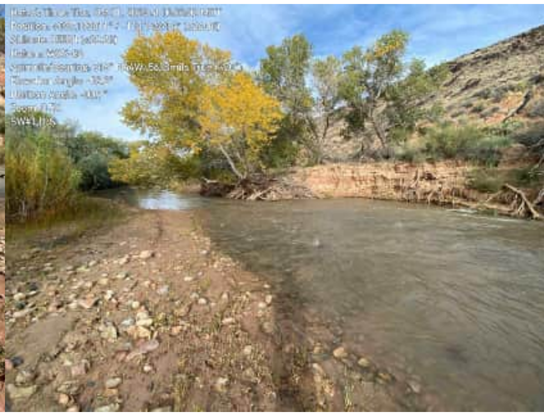
Date & Time: Fri, Sep 27, 2024 at 13:08:38 MDT
Position: +037.199225° / -113.174129° (±17.5ft)
Altitude: 3533ft (±24.9ft)
Datum: WGS-84
Azimuth/Bearing: 049° N49E 0871mils True (±13°)
Elevation Angle: -03.8°
Horizon Angle: -00.1°
Zoom: 0.5X
GWMW42

Date & Time: Fri, Sep 27, 2024 at 13:33:36 MDT
Datum: WGS-84
Zoom: 0.5X

Date & Time: Fri, Sep 27, 2024 at 13:52

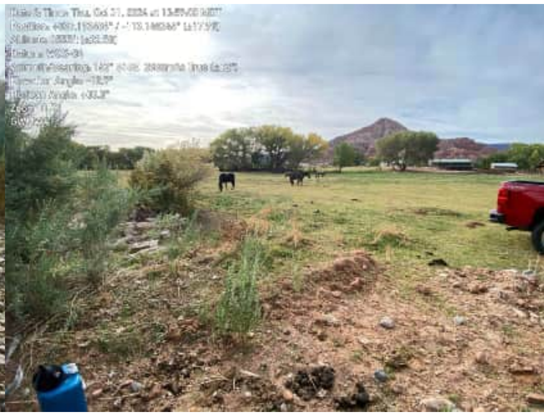


Datum: WGS-84
Zoom: 0.5X









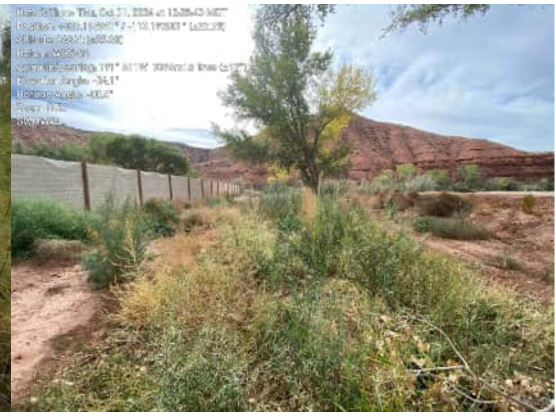
Elevation Angle: -12.9°
Horizon Angle: -01.4°
Zoom: 0.5X
SW#2


Horizon Angle: +00.0°
Zoom: 0.5X
SWMW#2


Datum: WGS-84
Zoom: 0.5X


Datum: WGS-84


Datum: WGS-84
Zoom: 0.5X
GWMW#3




Zoom: 0.5X
GWMW#3


Zoom: 0.5X
GWMW#6


Datum: WGS-84
Zoom: 0.5X
SW#3


Zoom: 0.5X
GWMW#6


Datum: WGS-84
Zoom: 0.5X


Date & Time: Wed. Nov 27, 2024 at 10:20:02 MST
Zoom: 0.5X
GWMW #2

Date & Time: Wed. Nov 27, 2024 at 10:20:44 MST
Altitude: 3528ft (±10.3ft)
Datum: WGS-84
Zoom: 0.5X
GWMW #2


Datum: WGS-84

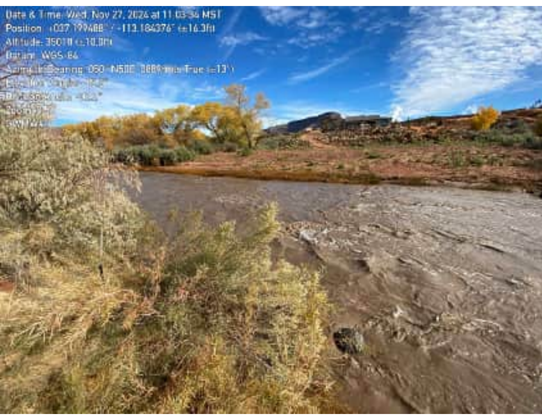
Zoom: 0.5X
GWMW #2


Date & Time: Wed. Nov 27, 2024 at 10:20:25 MST
Altitude: 3528ft (±23.4ft)
Datum: WGS-84

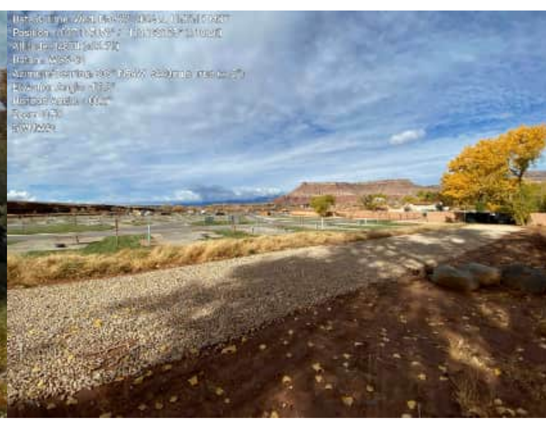
Altitude: 3523ft (±29.6ft)
Datum: WGS-84
SW #2 north creek

Date & Time: Wed. Nov 27, 2024
Altitude: 3521ft (±75.6ft)
Datum: WGS-84
SW #2 north creek





Date & Time: Wed, Nov 27, 2024 at 11:03:34 MST
Position: +037.199488° / -113.184376° (±16.3ft)
Altitude: 3501ft (±10.0ft)
Datum: WGS-84





Position: +037.201368° / -113.219018° (±656.2ft)
Datum: WGS-84
Zoom: 0.5X

Date & Time: Mon, Dec 30, 2024 at 09:04:03 MST
Datum: WGS-84
Azimuth/Bearing: 016° N16E 0284mils True (±12°)
Zoom: 0.5X

Date & Time: Mon, Dec 30, 2024 at 09:25:51 MST
Position: +037.197279° / -113.191961° (±120.9ft)
Azimuth/Bearing: 198° S18W 3520mils True (±15°)

Datum: WGS-84
Azimuth/Bearing: 310° N50W 5511mils True (±12°)

Datum: WGS-84
Azimuth/Bearing: 243° S63W 4320mils True (±14°)
Elevation Angle: -12.6°
Horizon Angle: -01.5°
Zoom: 0.5X
samples delivered

Date & Time: Mon, Dec 30, 2024 at 09:05:29 MST
Datum: WGS-84


Date & Time: Mon. Dec 30, 2024 at 10:02:21 MST
Position: +037.199715° / -113.186512° (±123.4ft)
Datum: WGS-84
Azimuth/Bearing: 142° S38E 2524mils True (±12°)
Elevation Angle: -88.6°
Horizon Angle: -68.5°
Zoom: 0.5X
GW#3


Date & Time: Mon. Dec 30, 2024 at 10:03:41 MST
Position: +037.199475° / -113.184349° (±45.9ft)
Azimuth/Bearing: 088° N88E 1564mils True (±12°)


Date & Time: Mon. Dec 30, 2024 at 10:03:32 MST
Position: +037.199434° / -113.184396° (±121.0ft)
Azimuth/Bearing: 029° N29E 0516mils True (±12°)


Date & Time: Mon. Dec 30, 2024 at 10:04:11 MST
Position: +037.199529° / -113.184492° (±17.0ft)
Azimuth/Bearing: 218° S38W 3876mils True (±12°)
GW#3


Date & Time: Mon. Dec 30, 2024 at 10:47:05 MST
Position: +037.199417° / -113.174071° (±76.4ft)
Altitude: 3533ft (±26.1ft)
Datum: WGS-84
Azimuth/Bearing: 052° N52E 0924mils True (±12°)
Elevation Angle: -03.4°
Horizon Angle: -00.6°
Zoom: 0.5X
GW#3


Date & Time: Mon. Dec 30, 2024 at 10:03:38 MST
Position: +037.199468° / -113.184343° (±45.9ft)
Altitude: 3502ft (±19.0ft)
Datum: WGS-84
Azimuth/Bearing: 144° S36E 2560mils True (±12°)
Elevation Angle: -09.0°
Zoom: 0.5X
GW#3


Datum: WGS-84
Azimuth/Bearing: 166° S14E 2951mils True (±12°)
Zoom: 0.5X
GW#3


Date & Time: Mon. Dec 30, 2024 at 10:47:09 MST
Position: +037.199230° / -113.174079° (±45.9ft)
Altitude: 3533ft (±24.5ft)
Datum: WGS-84
Azimuth/Bearing: 353° N07W 6276mils True (±12°)
Elevation Angle: +01.2°
Horizon Angle: -00.6°
Zoom: 0.5X
GW#3


Date & Time: Mon. Dec 30, 2024 at 10:47:15 MST
Position: +037.199230° / -113.174118° (±45.9ft)
Altitude: 3532ft (±24.1ft)
Datum: WGS-84
Azimuth/Bearing: 290° N70W 5156mils True (±12°)
Elevation Angle: -06.1°
Horizon Angle: -00.7°
Zoom: 0.5X
GW#3

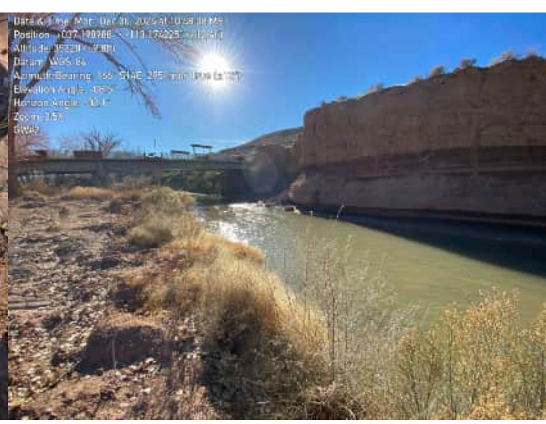
Date & Time: Mon. Dec 30, 2024 at 10:47:48 MST
Position: +037.199039° / -113.174298° (±11.5ft)
Altitude: 3531ft (±9.8ft)
Datum: WGS-84
Azimuth/Bearing: 257° S77W 4569mils True (±12°)
Horizon Angle: -00.9°
Zoom: 0.5X
GW#3

Date & Time: Mon. Dec 30, 2024 at 10:48:12 MST
Position: +037.198992° / -113.174228° (±12.3ft)
Altitude: 3530ft (±9.8ft)
Datum: WGS-84
Azimuth/Bearing: 009° N09E 0160mils True (±12°)
Elevation Angle: -00.3°
Horizon Angle: -00.2°
Zoom: 0.5X
GW#2

Position: +037.199228° / -113.174124° (±17.2ft)
Datum: WGS-84

Date & Time: Mon. Dec 30, 2024 at 10:47:53 MST
Position: +037.199044° / -113.174302° (±11.3ft)
Altitude: 3530ft (±9.8ft)
Datum: WGS-84
Azimuth/Bearing: 260° S80W 4622mils True (±12°)
Elevation Angle: -12.2°
Horizon Angle: -01.1°
Zoom: 0.5X
GW#2

Date & Time: Mon. Dec 30, 2024 at 10:48:27 MST
Position: +037.199165° / -113.174173° (±12.8ft)
Altitude: 3532ft (±9.8ft)
Datum: WGS-84
Azimuth/Bearing: 054° N54E 0960mils True (±12°)
Elevation Angle: +01.2°
Horizon Angle: -01.5°
Zoom: 0.5X
GW#2


Datum: WGS-84
GW#2

Date & Time: Mon. Dec 30, 2024 at 10:48:31 MST
Position: +037.199175° / -113.174173° (±13.3ft)
Altitude: 3533ft (±9.8ft)
Datum: WGS-84
Azimuth/Bearing: 327° N33W 5813mils True (±12°)
Elevation Angle: -02.9°
Horizon Angle: -01.5°
Zoom: 0.5X
GW#2


GW#1

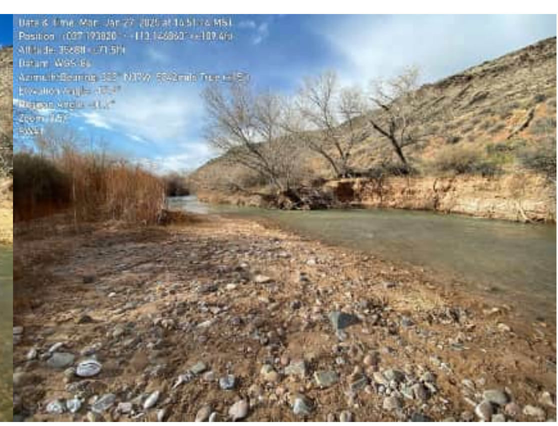

Date & Time: Mon, Dec 30, 2024 at 11:05:25 MST
Position: +037.193626° / -113.148297° (±16.9ft)
Altitude: 3555ft (±20.1ft)
Datum: WGS-84
Azimuth/Bearing: 243° S63W 4320mils True (±13°)
Elevation Angle: -03.1°
Horizon Angle: -03.7°
Zoom: 0.5X

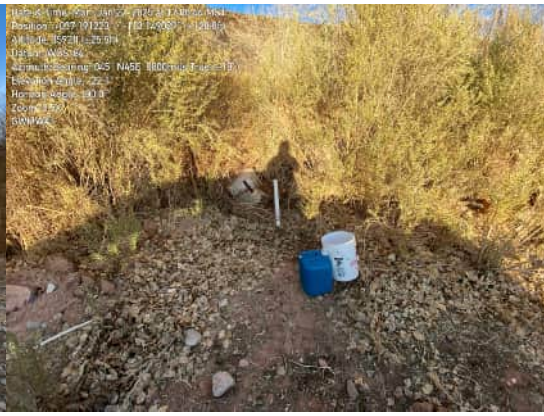

Zoom: 0.5X
slug test on #4


Position: +037.193651° / -113.148267° (±44.4ft)
Altitude: 3555ft (±21.3ft)
Datum: WGS-84
Horizon Angle: +03.0°
GW#1


Altitude: 3555ft (±20.6ft)
Datum: WGS-84
Zoom: 0.5X


Date & Time: Mon, Dec 30, 2024 at 11:21:15 MST
Position: +037.193798° / -113.146733° (±45.9ft)
Altitude: 3561ft (±22.4ft)
Datum: WGS-84
Azimuth/Bearing: 312° N48W 5547mils True (±13°)
Elevation Angle: -04.0°
Horizon Angle: -01.3°
Zoom: 0.5X
SW#1






Datum: WGS-84
Elevation Angle: -06.0°
Horizon Angle: -00.6°
Zoom: 0.5X
GWMW 4


Datum: WGS-84
GWMW #4 grnd damp


Date & Time: Thu, Feb 27, 2025 at 12:35:09 MST
Position: +037.197061° / -113.192113° (±20.7ft)
Altitude: 3492ft (±16.3ft)
Datum: WGS-84
Azimuth/Bearing: 301° N59W 5351mils True (±13°)
Elevation Angle: -02.3°
Horizon Angle: -00.8°
Zoom: 0.5X
GWMW #4 grnd damp


Date & Time: Thu, Feb 27, 2025 at 13:32:10 MST
Position: +037.199445° / -113.184563° (±65.3ft)
Altitude: 3502ft (±23.2ft)
Azimuth/Bearing: 028° N28E 0498mils True (±12°)


Date & Time: Thu. Feb 27, 2025 at 13:32:26 MST
Zoom: 0.5X


Date & Time: Thu. Feb 27, 2025 at 14:20:09 MST
Position: +037.199278° / -113.174165° (±16.5ft)
Altitude: 3532ft (±20.2ft)
Datum: WGS-84
Azimuth/Bearing: 316° N44W 5618mils True (±12°)
Elevation Angle: -06.1°
Horizon Angle: +00.1°
Zoom: 0.5X


Zoom: 0.5X
GWMW#2


Zoom: 0.5X
GWMW#2


Date & Time: Thu. Feb 27, 2025 at 14:20:12 MST
Position: +037.199292° / -113.174158° (±16.4ft)
Altitude: 3533ft (±20.3ft)
Datum: WGS-84
Azimuth/Bearing: 012° N12E 0213mils True (±12°)
Elevation Angle: -01.0°
Horizon Angle: -00.8°
Zoom: 0.5X
GWMW#2


Date & Time: Thu. Feb 27, 2025 at 14:40:30 MST


Date & Time: Thu. Feb 27, 2025 at 14:20:03 MST
Zoom: 0.5X


Date & Time: Thu. Feb 27, 2025 at 14:20:14 MST
Position: +037.199294° / -113.174158° (±22.2ft)
Altitude: 3532ft (±27.7ft)
Datum: WGS-84
Azimuth/Bearing: 082° N82E 1458mils True (±12°)
Elevation Angle: -02.7°
Horizon Angle: -01.3°
Zoom: 0.5X
GWMW#2


Date & Time: Thu. Feb 27, 2025 at 14:40:47 MST
Datum: WGS-84
Azimuth/Bearing: 306° N54W 5440mils True (±12°)
Zoom: 0.5X

Datum: WGS-84
Zoom: 0.5X
SWMWA

SW#2

Zoom: 0.5X

Date & Time: Thu. Feb 27, 2025 at 15:09:58 MST
Position: +037.193629° / -113.148280° (±17.4ft)
Altitude: 3555ft (±20.2ft)
Datum: WGS-84
Azimuth/Bearing: 122° S58E 2169mils True (±12°)
Elevation Angle: -07.5°
Horizon Angle: -02.2°
Zoom: 1.0X
SWMWA

Datum: WGS-84
Azimuth/Bearing: 309° N51W 5493mils True (±12°)

Date & Time: Thu. Feb 27, 2025 at 15:09:42 MST
Azimuth/Bearing: S54E 2240mils True (±12°)

Date & Time: Thu. Feb 27, 2025 at 15:19:00 MST
Position: +037.202612° / -113.175485° (±53.8ft)
Altitude: 3524ft (±46.9ft)
Datum: WGS-84
Azimuth/Bearing: 055° N55E 0978mils True (±12°)
Elevation Angle: -06.3°
Horizon Angle: -01.1°
Zoom: 0.5X
SW#2

Date & Time: Thu. Feb 27, 2025 at 15:37:53 MST
Position: +037.200688° / -113.219536° (±44.7ft)
Altitude: 3449ft (±37.2ft)
Datum: WGS-84
Azimuth/Bearing: 017° N17E 0302mils True (±12°)
Elevation Angle: -10.7°


Date & Time: Thu. Feb 27, 2025 at 15:37:56 MST
Position: +037.203716° / -113.219535° (±29.4ft)
Altitude: 3449ft (±28.7ft)
Datum: WGS-84
Azimuth/Bearing: 337° N23W 5991mils True (±12°)
Elevation Angle: -12.0°
Zoom: 0.5X
SW43


Datum: WGS-84
Azimuth/Bearing: 172° S08E 3058mils True (±19°)
Elevation Angle: -04.4°
Zoom: 0.5X


Date & Time: Wed. Mar 19, 2025 at 14:15:45 MDT
Position: +037.196994° / -113.192115° (±18.5ft)
Altitude: 3487ft (±20.7ft)
Datum: WGS-84
Azimuth/Bearing: 332° N28W 5902mils True (±19°)
Elevation Angle: -04.4°
Horizon Angle: -00.5°
Zoom: 0.5X
SW46


Azimuth/Bearing: 222° S42W
Zoom: 0.5X


Date & Time: Wed. Mar 19, 2025 at 14:15:18 MDT
Position: +037.198228° / -113.192744° (±138.5ft)
Altitude: 3472ft (±81.7ft)
Datum: WGS-84
Elevation Angle: -07.6°
Horizon Angle: -00.2°
Zoom: 0.5X
SW46


Date & Time: Wed. Mar 19, 2025 at 14:15:37 MDT
Position: +037.198201° / -113.192734° (±153.4ft)
Altitude: 3463ft (±98.4ft)
Datum: WGS-84
Azimuth/Bearing: 302° N58W 5369mils True (±19°)
Elevation Angle: -04.2°
Horizon Angle: -00.6°
Zoom: 0.5X
SW46


Date & Time: Wed. Mar 19, 2025 at 15:12:07 MDT
Position: +037.199772° / -113.183408° (±141.8ft)
Azimuth/Bearing: 036° N36E 0640mils True (±16°)


Position
Datum
Azimuth/Bearing


Date & Time: Wed. Mar 19, 2025 at 15:27:25 MDT
Position: +037.199216° / -113.174187° (±13.3ft)
Altitude: 3532ft (±20.3ft)
Datum: WGS-84
Azimuth/Bearing: 351° N09W 6240mils True (±15°)
Elevation Angle: -04.8°
Horizon Angle: -00.1°
Zoom: 0.5X
GW#2


Date & Time: Wed. Mar 19, 2025 at 15:27:38 MDT
Position
Horizon Angle
Zoom: 0.5X
GW#2


Date & Time: Wed. Mar 19, 2025 at 15:27:14 MDT
Position: +037.199341° / -113.174143° (±56.1ft)
Altitude: 3533ft (±22.4ft)
Datum: WGS-84
Azimuth/Bearing: 316° N44W 5618mils True (±15°)
Elevation Angle: -07.6°
Horizon Angle: -00.2°
Zoom: 0.5X
GW#2


Date & Time: Wed. Mar 19, 2025 at 15:27:31 MDT
Position: +037.199207° / -113.174184° (±14.6ft)
Altitude: 3532ft (±21.0ft)
Datum: WGS-84
Azimuth/Bearing: 307° N53W 5458mils True (±15°)
Elevation Angle: -07.5°
Horizon Angle: -00.8°
Zoom: 0.5X
GW#2


Position
Zoom: 0.5X
GW#2


Date & Time: Wed. Mar 19, 2025 at 15:27:21 MDT
Position: +037.199236° / -113.174191° (±44.3ft)
Altitude: 3531ft (±21.0ft)
Datum: WGS-84
Azimuth/Bearing: 062° N62E 1102mils True (±15°)
Elevation Angle: -02.5°
Horizon Angle: +00.1°
Zoom: 0.5X
GW#2


Position
Datum
Horizon Angle
GW#2


Azimuth/Bearing: 305° N55W 5422mils True (±13°)


Wed, Mar 19, 2025 at 16:07:30 MDT
Position: +037.193516° / -113.147966° (±21.9ft)
Datum: WGS-84
S76E 1849mils True (±13°)
Horizon Angle: +00.2°
Zoom: 0.5X


Altitude: 3559ft (±23.4ft)
Datum: WGS-84
Elevation Angle: -04.6°
Zoom: 0.5X
GW#1


Date & Time: Wed, Mar 19, 2025 at 16:10:46 MDT
Datum: WGS-84


Date & Time: Wed, Mar 19, 2025 at 16:11:02 MDT
Position: +037.193861° / -113.146855° (±23.7ft)
Datum: WGS-84
Zoom: 0.5X


Date & Time: Wed, Mar 19, 2025 at 16:07:27 MDT
Position: +037.193506° / -113.148003° (±45.9ft)
Altitude: 3560ft (±22.9ft)
Datum: WGS-84
Azimuth/Bearing: 168° S12E 2987mils True (±13°)
Elevation Angle: -02.4°
Horizon Angle: -00.6°
Zoom: 0.5X
GW#1


Date & Time: Wed, Mar 19, 2025 at 16:10:54 MDT
Datum: WGS-84


Datum: WGS-84
Zoom: 0.5X


Zoom: 0.5X
GW1

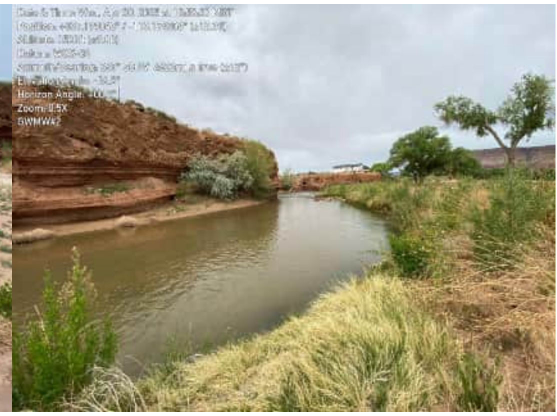

Position: +037.203447° / -113.185495°
Altitude: 3552ft (±22.7ft)
Datum: WGS-84
Azimuth/Bearing: 050° N50E 0889mils True (±12°)
Elevation Angle: -32.5°


Date & Time: Wed, Mar 19, 2025 at 16:47:39 MDT
Position: +037.202610° / -113.175385° (±223.0ft)
Altitude: 3520ft (±128.7ft)
Datum: WGS-84
Horizon Angle: +01.9°
Zoom: 0.5X
SW2


Zoom: 0.5X

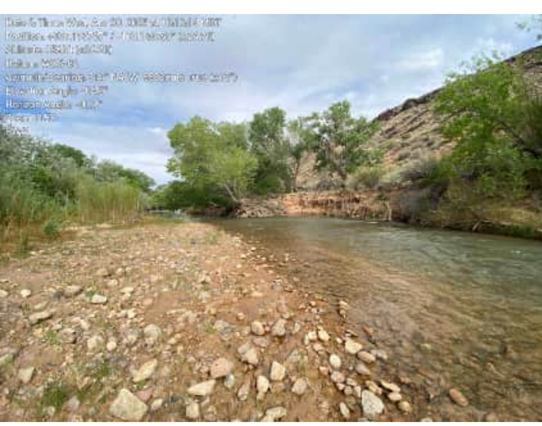

GWMW1


Zoom: 0.5X
GWMW#2


Zoom: 0.5X
GWMW#2


Elevation Angle: -05.5°
Zoom: 0.5X
SW#1

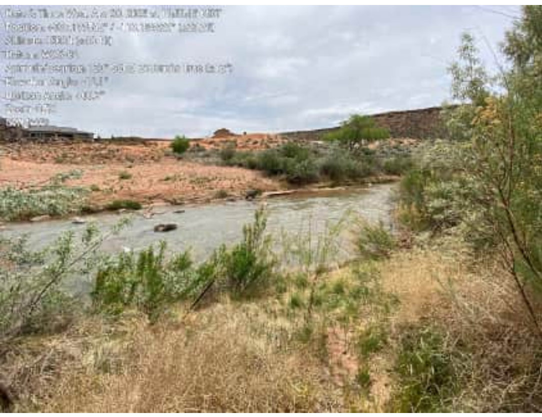

Date & Time: Wed, Apr 30, 2025 at 11:12:34 MDT
Position: +037.202605° / -113.175412° (±167.7ft)
Altitude: 3519ft (±27.6ft)
Datum: WGS-84
Azimuth/Bearing: 043° N43E 0764mils True (±12°)
Elevation Angle: -07.5°
Horizon Angle: -00.0°
Zoom: 0.5X
SW#2




Zoom: 0.5X
SW#2


Zoom: 0.5X
GWMW#2


Date & Time: Wed. May 28, 2025 at 12:25:32 MDT
Position: +037.193716° / -113.148222° (±16.5ft)
Altitude: 3555ft (±20.5ft)
Datum: WGS-84
Azimuth/Bearing: 099° S81E 1760mils True (±12°)
Elevation Angle: -61.7°
Zoom: 0.5X
GWMW#1




Datum: WGS-84
GWMW#2


Date & Time: Wed. May 28, 2025 at 12:30:00 MDT
Datum: WGS-84


Date & Time: Wed. Apr 30, 2025 at 12:21:01 MDT
Position: +037.197005° / -113.191984° (±49.2ft)
Altitude: 3478ft (±98.4ft)
Datum: WGS-84
GWMW#2

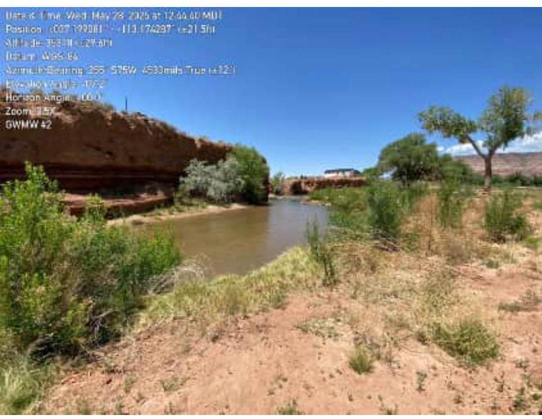

Zoom: 0.5X
GWMW#1


Date & Time: Wed. May 28, 2025 at 12:30:09 MDT
Datum: WGS-84


Date & Time: Wed, May 28, 2025 at 12:44:19 MDT
Position: +037.199305° / -113.174105° (±56.4ft)
Altitude: 3533ft (±21.4ft)
Datum: WGS-84
Azimuth/Bearing: 331° N29W 5884mils True (±12°)
Zoom: 0.5X


Date & Time: Wed, May 28, 2025 at 12:44:50 MDT
Position: +037.199103° / -113.174278° (±14.4ft)
Altitude: 3531ft (±9.8ft)
Datum: WGS-84
Azimuth/Bearing: 341° N19W 6062mils True (±12°)
Elevation Angle: -00.7°
Horizon Angle: +00.3°
Zoom: 0.5X


Date & Time: Wed, May 28, 2025 at 13:20:35 MDT
Position: +037.202663° / -113.175447° (±24.9ft)
Altitude: 3524ft (±25.4ft)
Datum: WGS-84
Azimuth/Bearing: 021° N21E 0373mils True (±12°)
Elevation Angle: -12.3°
Horizon Angle: +01.0°
Zoom: 0.5X
SW#2 North Creek


Position: +037.199081° / -113.174287° (±21.5ft)
Datum: WGS-84
Azimuth/Bearing: 255° S75W 4533mils True (±12°)
GWMW #2


Date & Time: Wed, May 28, 2025 at 12:58:47 MDT


Date & Time: Wed, May 28, 2025 at 14:08:05 MDT
Position: +037.199458° / -113.184540° (±55.0ft)
Horizon Angle: -01.5°
Zoom: 0.5X

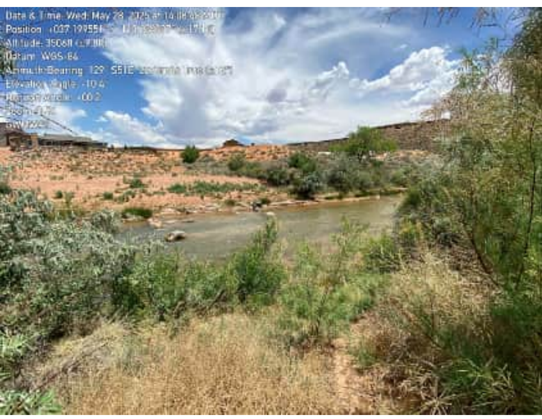

Date & Time: Wed, May 28, 2025 at 12:44:48 MDT
Position: +037.199088° / -113.174258° (±15.6ft)
Altitude: 3531ft (±23.2ft)
Datum: WGS-84
Azimuth/Bearing: 059° N59E 1049mils True (±12°)
Elevation Angle: -04.3°
Horizon Angle: +00.4°


Azimuth/Bearing: 213° S33W 3787mils True (±12°)
Elevation Angle: -08.8°
North Creek


MAY


Date & Time: Wed, May 28, 2025 at 14:08:28 MDT
Datum: WGS-84
Azimuth/Bearing: 336° N24W 5973mils True
Zoom: 0.5X
SWMW43
KEEP OUT

Datum: WGS-84

Date & Time: Wed, May 28, 2025 at 14:45:22 MDT
Position: +037.197008° / -113.192057° (±16.7ft)
Datum: WGS-84
Azimuth/Bearing: 326° N34W 5796mils True
Elevation Angle: -04.6°
Zoom: 0.5X

Datum: WGS-84

Date & Time: Wed, May 28, 2025 at 14:45:11 MDT
Position: +037.196980° / -113.192057° (±16.9ft)
Altitude: 3487ft (±22.9ft)
Zoom: 0.5X
SWMW44

Date & Time: Wed, May 28, 2025 at 15:15:44 MDT
Position: +037.200759° / -113.219612°
Altitude: 3429ft (±63.3ft)
Datum: WGS-84
Azimuth/Bearing: 312° N48W 5547mils True
Elevation Angle: -07.5°
Horizon Angle: -02.0°
Zoom: 0.5X
SW43

Zoom: 0.5X

Date & Time: Wed, May 28, 2025 at 14:45:20 MDT

Altitude: 3446ft (±26.4ft)