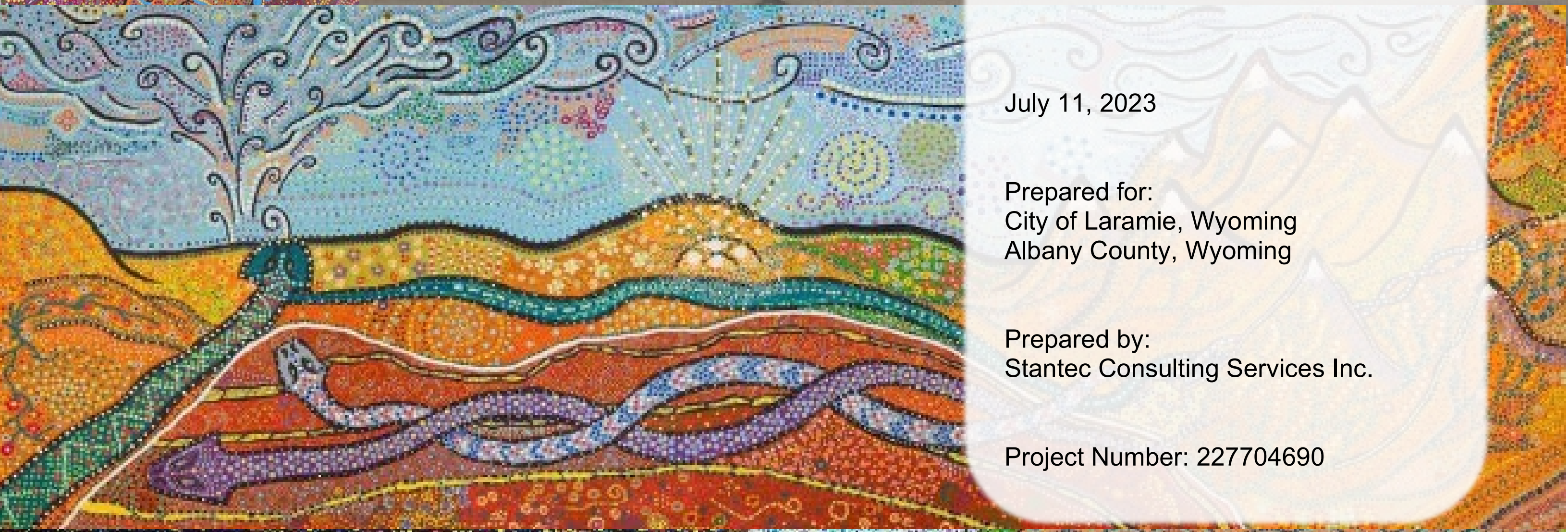
CASPER AQUIFER PROTECTION PLAN UPDATE

July 11, 2023

Prepared for:
City of Laramie, Wyoming
Albany County, Wyoming

Prepared by:
Stantec Consulting Services Inc.

Project Number: 227704690



Acknowledgements

The Casper Aquifer Protection Plan (CAPP) was originally generated through the hard work and dedication from various groups and City and County staff members. The Environmental Advisory Committee and Subcommittee members spent endless volunteer hours devoted to completing the original CAPP. The hard work of previous volunteers, City and County staff, and government officials facilitated this update of the CAPP.

Numerous interested citizens provided their opinions and insights into protecting the Casper Aquifer. Thanks to the following individuals and groups who met with Stantec Consulting Services Inc. (Stantec), the Laramie Planning Division, and Albany County Planning Department to discuss the revision of the CAPP: Albany County Clean Water Advocates, the Casper Aquifer Protection Network, and several geologists and engineers from the local technical community. Comments we received from these groups have been incorporated into this draft document. Those comments along with the relevant document locations are noted in the last appendix included with this document (Appendix K).

Sue Ibarra (Albany County Commissioner); Pat Gabriel, Sharon Cumbie, and Erin O'Doherty (Laramie City Council); David Gertsch (Albany County Planning); Darren Parkin (Laramie Natural Resources); Derek Teini (Laramie Planning); and Mike Lytle (Laramie Public Works) helped Stantec understand the community challenges and perspective. They were invaluable in providing data for revisions, providing access to interested community members, and reviewing the CAPP. Their dedication to the community was apparent throughout this process.

Chris Moody (Wyoming Groundwater), Karl Taboga (Wyoming Geological Survey), and Bern Hinckley (Hinckley Consulting) provided insight to the technical and scientific aspects of the CAPP, specifically Chapter 3, the hydrogeology of the Casper Aquifer.

Disclaimer: This Casper Aquifer Protection Plan Update builds upon the work completed by Wittman Hydro Planning Associates (Wittman) in May 2008 and the Albany County CAPP adopted in January 2011. The GIS data used to create the maps within the CAPP were from existing digital data provided by the City of Laramie, Albany County, and others, and were not field verified by Stantec.

Artwork appearing in the Casper Aquifer Protection Plan was provided by Paul Taylor and Rebecca Watson with the Laramie High School Mural Project.

All pictures appearing in the Casper Aquifer Protection Plan were taken by Wittman, or provided by Chris Moody, Bern Hinckley, the City of Laramie, or Albany County.

Preamble to the Casper Aquifer Protection Plan

This document is a plan to protect our principal drinking water source, the Casper Aquifer, from contamination by current and future land uses. The surface water component of the City of Laramie water supply, the Laramie River, is easily seen and managed. However, the only readily visible manifestations of the extensive groundwater component are the springs where groundwater is discharged from the Casper Aquifer. Herein lies the management challenge in that groundwater is largely hidden from view and may not be fully appreciated as a resource worth protecting.

For over 140 years, the Laramie-area community has depended on the Casper Aquifer for its drinking water. For most of that time the community has gone about its business developing infrastructure, drilling wells, building homes, living lives, turning on the kitchen faucet, and flushing toilets. Fortunately, during the last 30 years the community has gradually become aware of the importance of groundwater to the City and rural water users. Community engagement in aquifer protection began in 1993 when the City conducted a wellhead protection study under the auspices of the Safe Drinking Water Act. Since then, public understanding and concern for aquifer protection has only grown, and county and city authorities have established a series of plans and regulations.

This photo depicts an aggressive artesian flow from a high permeability member of the Casper Aquifer in the Laramie area.

As you read this document, you will find technical information on the hydrogeology of the Casper Aquifer. Terms and concepts such as permeability, fractures, faults, folds, potentiometric surface, recharge, discharge, and vulnerability are discussed. Lots of jargon, but necessary for a comprehensive overview of how the Casper Aquifer is put together and functions as a water supply. But to put it in simple terms: the Casper Aquifer is a world-class aquifer and it's in our backyard. By proximity and choice, we live on top of the aquifer and the aquifer supports us. And to our benefit and with a shared responsibility, we are upstream of others, but not upstream of ourselves.

Process wise, the porous sandstones on the flank of the mountain range east of Laramie (i.e. recharge area) are water-bearing rocks that receive snowmelt and rain, store a tremendous amount of water in 700 feet of rock, and convey the water by gravity through connected pore-space and fractures to springs and wells at the base of the range. Day-in and day-out. Simple, inexpensive, and effective…and vulnerable to contamination by human activities on the recharge area.

Laramie has been fortunate that historic land use on the aquifer has been limited to livestock grazing and rural residences. However, limestone quarry mining and the I-80 transportation corridor raise concerns. Although impacts to water quality have been documented locally, a contamination event requiring groundwater treatment or that has prevented use as a drinking supply has not yet occurred. However, fortunes change, accidents occur, and best management practices sometimes fail. Considering the significant costs associated with remediation, the most cost-effective approach to aquifer protection is to prevent contamination before it occurs.

As climate change in the arid West and Rocky Mountain Region plays out, the surface water portion of Laramie's water supply may become increasingly unreliable. Groundwater from the Casper Aquifer, with its dynamic recharge, large storage capacity, high-yield wells, and supply flexibility will be a keystone to the social, cultural, and economic health of the Laramie-area community.

As a citizen of the City of Laramie and Albany County or as an elected official responsible for public policy, read this document in the spirit of education and becoming an informed participant in the protection of a resource vital to the long-term viability of the community.

The plan provides education and guidance and sets the stage for land-use regulations that the City-County community believes will help to ensure safe and dependable drinking water in the years and for the generations to come.

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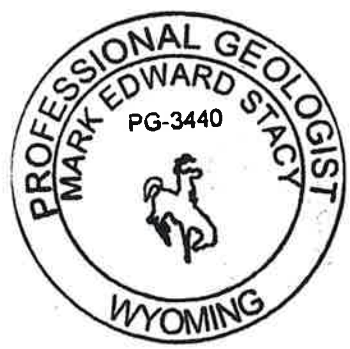
Professional Geologist's Certification

I certify that this aquifer protection plan has been prepared by me or under my direct supervision, and that I am a duly registered professional geologist in the State of Wyoming.



Signature/Date: 7/11/23
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Registration: State of Wyoming Professional Geologist
License No. PG-3440

Professional Engineer's Certification

I certify that the engineering aspects of this aquifer protection plan have been prepared by me or under my direct supervision, and that I am a duly registered professional engineer in the State of Wyoming.

Signature/Date: July 11, 2023
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Executive Summary

Introduction

The Casper Aquifer Protection Plan (CAPP) is an aquifer protection program for the City of Laramie and Albany County, Wyoming. It is a local land use plan developed by the City and County under statutory authority and incorporates elements of a local wellhead protection plan as established by the Wyoming Department of Environmental Quality (WDEQ). Any aquifer protection program must be responsive to the needs of the local community. For a community to remain viable it must have a safe source of drinking water. As such, the primary purpose of the CAPP is to protect and preserve the Casper Aquifer so that both current and future City and County residents within the protection area can enjoy high quality drinking water. The plan seeks to protect both the municipal and domestic wells drawing water from the Casper Aquifer that is recharged within the protection area.

The Casper Aquifer supplies approximately 55% of the drinking water for the 31,317 residents of the City of Laramie and 100% for many of the nearby residents of Albany County. The aquifer is vulnerable to contamination from overlying land uses across the recharge area, and along the western margin in areas where the typically protective Satanka Shale has been compromised because of fracturing. Due to the highly faulted, fractured, cavernous, and folded nature of the Casper Aquifer along with natural drainages, a contaminant introduced at the ground surface might easily enter the aquifer and move rapidly away from the entry point. Once contaminated, aquifers are difficult and expensive to remediate and municipalities or responsible parties may have to pay for site studies, remediation, and property damage. Protecting our precious water supply is critical to maintaining our quality of life.

The original CAPP was completed in 2001. That comprehensive document was a joint County and City effort led by the Environmental Advisory Committee. It included a community planning team comprised of stakeholders, government representatives, utility representatives, and technical advisors. This CAPP update builds upon the significant effort of the Laramie community and the data that have been acquired since the prior updates in 2008 and 2011. Published geologic mapping, water well drilling logs, and aquifer testing data were reviewed and used to inform our understanding of the hydrogeology and extent of the Casper Aquifer. Delineation of the protection area was conducted using aquifer vulnerability mapping techniques that incorporate present knowledge of aquifer use, recharge mechanics, and the dynamics of groundwater movement within the Casper Aquifer and its underlying and overlying geologic strata. This commonly used approach to identify aquifer protection areas has been used with many other public water systems across the country.

For the City of Laramie and Albany County residents along the western flank of the Laramie Range, this plan presents the detailed hydrogeology and water quality of the Casper Aquifer, the aquifer protection area that contributes water to the aquifer, existing and potential sources of contamination within that area, potential management strategies to address these contaminant sources, and a contingency plan. The plan includes numerous recommendations related to these items. This plan does not include regulations to be enforced by City or County officials, but it does provide a basis from which regulations or ordinances could be enacted to enhance aquifer protection.

AQUIFER PROTECTION AREA DELINEATION

The Casper Aquifer Protection Area (CAPA) encompasses approximately 72 square miles that lie east of the City of Laramie and extends to the crest of the Laramie Range. The north and south boundaries are approximately 5 and 6 miles north and south, respectively, of Laramie city limits. The CAPA designation identifies the area from which rain and snowmelt that recharge the Casper Aquifer ultimately make their way to City of Laramie wellfields and local domestic wells to provide drinking water.

Delineation of the CAPA was based on the hydrogeologic setting and vulnerability mapping both of which contribute to defining risks to the drinking water source. Relevant to this plan is the recharge area for the Casper Aquifer that consists of the entire exposed outcrop area of the Casper Formation on the west flank of the Laramie Range. In addition to extensive exposures of porous sandstone that serve as routes for potential contamination, additional locations where permeable pathways intersect the land surface have been documented but not all are known. Also not well known are the flow direction or amount of water being conveyed through these pathways, although studies indicate that the potential for rapid conveyance along at least some of these structures is high. This uncertainty requires a conservative approach that protects all water contributing areas of the aquifer, even those that are not directly upgradient of municipal or domestic wells.

Flowing artesian well completed in the Casper Aquifer near Laramie.

For areas where the Casper Aquifer is covered by overlying strata, the protective capabilities of each geologic layer were carefully considered. In areas where the hydrogeologic confinement of the aquifer is potentially compromised or the potential for hydraulic connection between the surface and the Casper Aquifer has been documented, the Casper Aquifer Protection Area was delineated to provide an additional thickness of overlying protective geologic materials to adequately protect drinking water supplies.

The northern, eastern, and southern boundaries remain as identified by previous aquifer protection planning efforts. However, the current plan amends the western boundary to account for a protective Satanka Shale thickness of at least 75 feet, and aligns the western boundary primarily with property boundaries west of the protective Satanka Shale thickness line. This western boundary revision was done to allow for easier implementation and property administration, and generally moved the boundary somewhat eastward with the respect to that previously established by the City and somewhat westward with respect to that previously established by the County. The plan maintains the previously established thickness of 75 feet of Satanka Shale as a minimum thickness, adds two areas where additional protection was needed at the Turner Wellfield and Simpson Springs, and amends the western boundary in areas where the former interpolated line was identified as inaccurate based on physical observations and drilling data.

CONTAMINANT SOURCE INVENTORY

The contaminant source inventory identifies potential and existing contaminant sources that may threaten the Casper Aquifer and is a necessary component of an aquifer protection plan. Within the CAPA the potential contaminant sources include transportation corridors, residential land use, wells, underground and aboveground storage tanks, stormwater and urban runoff, commercial land use, limestone quarries, agricultural land use, and other miscellaneous uses. Of all the inventoried contaminant sources, residential septic systems at the east end of Grand Avenue are the only documented source that has contaminated the Casper Aquifer, resulting in nitrate as nitrogen concentrations that exceed the EPA primary drinking water standard of 10 mg/L in some domestic wells (City of Laramie, 2009).

CONTAMINANT MANAGEMENT PLAN

The contaminant management plan presents a set of management strategies for the potential contaminant sources identified in the contaminant source inventory. Management strategies may include both regulatory and non-regulatory approaches. The plan also recommends changes to City and County aquifer protection regulations that seek to facilitate a comprehensive protection approach and encourages the collection and management of additional data that could be essential for future updates. The following general approaches are recommended for managing potential contaminant sources in the CAPA.

1. Approve the updated CAPA to replace the Aquifer Protection Overlay and Aquifer Protection Overlay Zone in City and County regulations.

2. Expand the existing groundwater monitoring well network, and design and implement an expanded groundwater monitoring program.

3. Incorporate the revised site-specific investigation requirements into current regulations.

4. Approve the list of additional prohibited activities. This short list includes commercial animal feeding operations serving more than 1,000 animal units per facility and intensely managed turf with high water demand.

5. Require the use of advanced treatment units for new septic systems and for replacement septic systems within any portion of the CAPA where the lot size is less than 35 acres.

6. Conduct annual household hazardous waste disposal days.

CONTINGENCY PLAN

The final chapter in the CAPP lays out a contingency plan in the event of groundwater contamination that impacts the City of Laramie's ability to provide an adequate quantity of safe drinking water to the public. Three scenarios were analyzed to determine impacts to the City's water supply. These scenarios included contamination upstream of the water intake on the Laramie River or short or long term drought that limits or eliminates diversions and treatment of surface water, a hazardous material spill on Interstate 80 affecting the Turner Wellfield, and a hazardous material spill on Interstate 80 affecting the Pope and Soldier Springs Wellfields. Local domestic well owners are encouraged to have their own contingency plans.

Acronyms / Abbreviations

ACCWA	Albany County Clean Water Advocates
AEM	Airborne Electromagnetic Geophysical
AFO	Animal Feeding Operations
APO	Aquifer Protection Overlay
APOZ	Aquifer Protection Overlay Zone
AST	Aboveground Storage Tank
AWWA	American Water Works Association
BMPs	Best Management Practices
Bti	Bacillus Thuringiensis Israelensis
CAFO	Concentrated Animal Feeding Operations
CAPA	Casper Aquifer Protection Area
CAPP	Casper Aquifer Protection Plan
CEC	Contaminants of Emerging Concern
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CERCLIS	CERCLA Information System
CFR	Code of Federal Regulations
CMP	Contaminant Management Plan
CSIS	Contaminant Source Identification Subcommittee
DDE	Dichlorodiphenyldichloroethylene
DDT	Dichlorodiphenyltrichloroethane
DEQ	Department of Environmental Quality
DNAPL	Dense Non-Aqueous Phase Liquid
EAC	Environmental Advisory Committee
EOC	Emergency Operations Center
EPA	Environmental Protection Agency
FEMA	Federal Emergency Management Agency
FRDS	Federal Reporting Data System
GIA	Groundwater Impact Assessment
GIS	Geographic Information System
Gpd/ft	Gallons per day per foot
GPM	Gallons Per Minute
GPS	Global Position Systems
HHWC	Household Hazardous Waste Collection
HWDMS	Hazardous Waste Data Management System
IDEQ	Idaho Department of Environmental Quality
LARC	Laramie Albany Records and Communications
LHS	Laramie High School

LHSMP	Laramie High School Mural Project
LNAPL	Light Non-Aqueous Phase Liquid
LQD	Land Quality Division
LRRC	Laramie Rifle Range Corporation
LRDWPP	Laramie Regional Drinking Water Protection Program
LUST	Leaking Underground Storage Tank
MCL	Maximum Contaminant Level
MDEQ	Montana Department of Environmental Quality
Mgd	Million Gallons per Day
Mg/L	Milligrams per Liter
MLCC	Mountain Land & Cattle Company, LLC
MOA/MOU	Memorandum of Agreement or Understanding
NPDES	National Pollution Discharge Elimination System
PCB	Polychlorinated Biphenyls
PDSI	Palmer Drought Severity Index
PFAS	Perfluoroalkyl and polyfluoroalkyl substances
PFOA	Perfluorooctanoic Acid
PFOS	Perfluorooctane Sulfonic Acid
PIO	Public Information Officer
PPIC	Pollution Prevention Information Clearinghouse
PUD	Cluster/Planned Unit Development
PWS	Public Water System
RCRA	Resource Conservation and Recovery Act
RCRIS	RCRA Information System
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
SEO	State Engineer’s Office
SNOTEL	Snow Telemetry
SPCC	Spill Prevention Control and Countermeasure
SWAP	Source Water Assessment and Protection Program
SWD	Solid Waste Division
TAC	Technical Advisory Committee
TDS	Total Dissolved Solids
TOT	Time of Travel
TRI	Toxic Chemical Release Inventory
UIC	Underground Injection Control
UPRR	Union Pacific Railroad
USGS	United States Geological Survey
USGS NWIS	USGS National Water Information System
UST	Underground Storage Tanks
UW	University of Wyoming

WDEQ	Wyoming Department of Environmental Quality
WDEQ-STP	Wyoming Department of Environmental Quality Storage Tank Program
WEMA	Wyoming Emergency Management Agency
WHP	Wellhead Protection
WHPA	Wellhead Protection Area
WMDP	Wyoming Medication Donation Program
WOC	Water Outreach Coordinator
WQD	Water Quality Division
WRI	Wyoming Research Institute
WSEO	Wyoming State Engineer's Office
WWC	Western Water Consultants, Inc.
WWTP	Wastewater Treatment Plant
WYDOT	Wyoming Department of Transportation

Glossary

Alluvium	A general term for clay, silt, sand, gravel or similar unconsolidated material deposited during comparatively recent geologic time by a stream or other body of running water.
Analytical Model	A model that provides approximate or exact solutions to simplified mathematical forms of the differential equations for water movement and solute transport. Analytical models can generally be solved using calculators or computers.
Anisotropy	The condition of having different properties in different directions. The direction of flow.
Anticline	A fold in rock strata that is convex upward.
Aquiclude	A subsurface rock, soil or sediment unit that does not yield useful quantities of water.
Aquifer Test	A test to determine hydrologic properties of an aquifer, involving the withdrawal of measured quantities of water from, or addition of water to, a well and the measurement of resulting changes in head in the aquifer both during and after the period of discharge or addition. Same as pump test.
Aquifer/Aquifer System	A formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield sufficient quantities of water to wells and springs to constitute a usable supply.
Aquitard	The less-permeable beds in a stratigraphic sequence that tend to restrict or impede groundwater flow relative to the more permeable beds that serve as aquifers.
Area Of Influence	Area surrounding a pumping or recharging well within which the water table or potentiometric surface has been changed due to the well’s pumping or recharge.
Artesian Conditions	In a confined aquifer, when the water level in a well rises above the top of the aquifer.
Attenuation	The process of diminishing contaminant concentrations in groundwater, due to filtration, biodegradation, dilution, sorption, volatilization, and other processes.
Collection Area	The area surrounding a groundwater source which is underlain by collection pipes, tile, tunnels, infiltration boxes, or other groundwater collection devices.
Colluvium	Loose, heterogeneous, incoherent mass of soil material and/or rock fragments deposited chiefly by mass-wasting.
Conduit Flow	Groundwater flow through passages filled or partially filled with water. Passages may include large dissolution features, faults, fractures, folds, joints, bedding planes, cavities, voids, or other openings.
Cone of Depression (COD)	A depression in the groundwater table or potentiometric surface that has the shape of an inverted cone and develops around a well from which water is being withdrawn. Its trace (perimeter) on the land surface defines the zone of influence of a well. Also called pumping cone and cone of drawdown.

Confined Aquifer	The following criteria are met in order to verify and maintain an upward hydraulic gradient in the producing aquifer: an effective confining layer must exist between the ground surface and the producing aquifer, and the potentiometric surface must extend above the contact between the aquifer and confining layer when the aquifer is penetrated by a well.
Contact	The surface where two different kinds of rock come together.
Contaminant	An undesirable substance not normally present, or an unusually high concentration of a naturally occurring substance, in water, soil, or other environmental medium.
Contamination	The degradation of natural water quality as a result of man’s activities.
Controls	The codes, ordinances, rules, and regulations currently in effect to regulate a potential contamination source.
Criteria	The conceptual standards that form the basis for WHPA area delineation to include distance, groundwater time of travel, aquifer boundaries, and groundwater divides.
Criteria Threshold	A value or set of values selected to represent the limits above or below which a given criterion will cease to provide the desired degree of protection.
DEQ	Wyoming Department of Environmental Quality.
Designated Person	The person appointed by a PWS to ensure that the requirements of State-wide wellhead protection program are met.
Development	As defined by W.S. §18-5-203 or Laramie Municipal Code whichever is applicable, the location, erection, construction, reconstruction, enlargement, change, maintenance or use of any building or land. For purposes of aquifer protection, development is generally considered any use or modification of the natural land surface that may increase the vulnerability of the Casper Aquifer to contamination.
Dip	The angle at which a stratum or planar feature is inclined from the horizontal.
Dispersion	The spreading and mixing of chemical constituents in groundwater caused by diffusion and mixing due to microscopic variations in velocities within and between pores.
Drawdown	The vertical distance groundwater elevation is lowered, or the amount head is reduced, due to the removal of groundwater. Also the decline in potentiometric surface caused by the withdrawal of water from a hydrogeologic unit. The distance between the static water level and the surface of the cone of depression. A lowering of the water table of an unconfined aquifer or the potentiometric surface of a confined aquifer caused by pumping of groundwater from wells.
Existing Groundwater Source of Drinking Water	A public supply groundwater source for which plans and specifications are submitted to DEQ.
Expansion	The addition of buildings, structures, facilities, machinery, equipment, property, or uses for the purpose of increasing production capacity, business services, or product sales.
Fissure	A fracture or crack in a rock along which there is a distinct separation.

Flow Line	The general path that a particle of water follows under laminar flow conditions. Line indicating the direction followed by groundwater toward points of discharge. Flow lines generally are considered perpendicular to equipotential lines.
Flow Model	A computer model that calculates a hydraulic head field for the study area using numerical methods to arrive at an approximate solution to the differential equation of groundwater flow.
Flow Path	The path a water molecule or solute follows in the subsurface.
Flow System/Hydraulic Boundary	A hydrologic feature that prevents the flow of groundwater. Examples include groundwater divides or low permeability material that impedes groundwater flow.
Flowing Artesian	When the water level in a well rises above and flows at the ground surface.
Footwall	The lower side of a horizontal or inclined rock body or fault. If the fault has dip-slip translational movement along a normal fault, the footwall block is upthrown; the footwall block is downthrown along a reverse fault.
Fracture	A general term for any break in a rock, which includes cracks, joints, and faults.
Groundwater Barrier	Rock or artificial material with a relatively low permeability that occurs (or is placed) below ground surface, where it impedes the movement of groundwater and thus may cause a pronounced difference in the heads on opposite sides of the barrier.
Groundwater Basin	General term used to define a groundwater flow system that has defined boundaries and may include more than one aquifer. The basin includes both the surface area and the permeable materials beneath it. A rather vague designation pertaining to a groundwater reservoir that is more or less separate from neighboring groundwater reservoirs. A groundwater basin could be separated from adjacent basins by geologic boundaries or by hydrologic boundaries.
Groundwater Divide	Ridge in the water table, or potentiometric surface, from which groundwater moves away at right angles in both directions. Line of highest hydraulic head in the water table or potentiometric surface.
Groundwater Mound	Raised area in a water table or other potentiometric surface, generated by groundwater recharge.
Groundwater Source	Any well, spring, tunnel, adit, or other underground opening from or through which groundwater flows or is pumped from subsurface water bearing formations.
Hanging Wall	The upper side of a horizontal or inclined rock body or fault. The hanging wall is downthrown along a normal fault with dip-slip movement; the hanging wall is upthrown along a reverse-slip fault.
Head, Total	Height of the column of water at a given point in a groundwater system above a datum plane such as mean sea level. The sum of the elevation head (distance of a point above datum), the pressure head (the height of a column of liquid that can be supported by static pressure at the point), and the velocity head (the height to which the liquid can be raised by its kinetic energy).
Heterogeneity	Characteristic of a medium in which material properties vary from point to point.

Homogeneity	Characteristic of a medium in which material properties are identical throughout.
Hydraulic Conductivity (K)	A coefficient of proportionality describing the rate at which water can move through a permeable medium. It is a function of the porous medium and the fluid.
Hydraulic Gradient (I)	Slope of a water table or potentiometric surface. More specifically, change in head per unit of distance in a given direction, generally the direction of the maximum rate of decrease in head. The difference in hydraulic head divided by the distance along the flowpath.
Hydrogeologic Methods	The techniques used to translate selected criteria and criteria thresholds into mappable delineation boundaries. These methods include, but are not limited to, arbitrary fixed radii, analytical calculations and models, hydrogeologic mapping, and numerical flow models.
Hydrogeologic Unit	Any soil or rock unit or zone that because of its hydraulic properties has a distinct influence on the storage or movement of groundwater.
Impermeable	Characteristic of geologic materials that limit their ability to transmit significant quantities of water under the head differences normally found in the subsurface environment.
Interference	The result of two or more pumping wells, the drawdown cones of which intercept. At a given location, the total well interference is the sum of the drawdowns due to each individual well. The condition occurring when the area of influence of a water well comes into contact with or overlaps that of a neighboring well, as when two wells are pumping from the same aquifer or are located near each other.
Isotropy	The condition in which the properties of interest (generally hydraulic properties of the aquifer) are the same in all directions.
Land Management Strategies	Zoning and non-zoning controls which include, but are not limited to, the following: zoning and subdivision ordinances, site plan reviews, design and operating standards, source prohibitions, purchase of property and development rights, public education programs, groundwater monitoring, household hazardous waste collection programs, water conservation programs, memoranda of understanding, written contracts and agreements, and so forth.
Leakage	The vertical flow of groundwater; commonly used in the context of vertical groundwater flow through confining strata.
Limestone	A bedded sedimentary deposit consisting chiefly of calcium carbonate.
Maximum Contaminant Level (MCL)	Maximum permissible level of a contaminant in water that is delivered to the users of a public water system. Maximum containment level is defined more explicitly in Safe Drinking Water Act (SDWA) regulations (40 CFR Section 141.2).
New Groundwater Source of Drinking Water	A public supply groundwater source of drinking water for which plans and specifications are submitted to DEQ.
Nonpoint Source	Any conveyance not meeting the definition of point source.
Normal Fault	A fault, with an angle usually between 45-90 degrees, at which the hanging wall (upper block) has moved downward relative to the footwall (lower block).
Observation Well	A well drilled in a selected location for the purpose of observing parameters such as water levels or water chemistry changes.

Permeability	Capacity of a rock or soil material to transmit a fluid.
Piezometric Surface	See potentiometric surface.
Point Source	Any discernible, confined, and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, animal feeding operation with more than ten animal units, landfill, or vessel or other floating craft, from which pollutants are or may be discharged. This term does not include return flows from irrigated agriculture.
Pollution Source	Point source discharges of contaminants to groundwater or potential discharges of the liquid forms of “extremely hazardous substances” which are stored in containers in excess of “applicable threshold planning quantities” as specified in SARA Title III. Examples of possible pollution sources include, but are not limited to, the following: storage facilities that store the liquid forms of extremely hazardous substances, septic tanks, drain fields, Class V underground injection wells, landfills, open dumps, landfilling of sludge and septage, manure piles, salt piles, pit privies, drain lines, sewer lines, and animal feeding operations.
Porosity	The ratio of the volume of void spaces in a rock or sediment to the total volume of the rock or sediment.
Potable Water	Suitable for human consumption as drinking water.
Potential Contamination Source	Any facility or site which employs an activity or procedure which may potentially contaminate groundwater. A pollution source is also a potential contamination source.
Potentiometric Surface	A surface that represents the level to which water will rise in tightly cased wells. If the head varies significantly with depth in the aquifer, then there may be more than one potentiometric surface. The water table is a particular potentiometric surface for an unconfined aquifer.
Pump Test	A test to determine hydrologic properties of an aquifer, involving the withdrawal of measured quantities of water from, or additional of water to, a well and the measurement of resulting changes in head in the aquifer both during and after the period of discharge or addition.
PWS	Public water system.
Radial Flow	The flow of water in an aquifer toward a well.
Recharge Area	Area in which water reaches the groundwater reservoir by surface infiltration. An area in which there is a downward component of hydraulic head in the aquifer.
Residual Soil	Unconsolidated or partly weathered material, presumed to have developed in place (by weathering) from the consolidated rock on which it lies.
Reverse Fault	Fault with a dip greater than 45 degrees at which the hanging wall (upper block) appears to have moved upward relative to the footwall (lower block).
Sandstone	A cemented or otherwise compacted detrital sediment composed predominantly of quartz sand grains.
Shale	A laminated sediment in which the constituent particles are composed of clay. Same as mudstone, except mudstone may be composed of a percentage of silt and may or may not be laminated.
Stagnation Point	A place in a groundwater flow field at which the groundwater is not moving.

Storage Coefficient	The volume of water an aquifer releases from or takes into storage per unit surface area of the aquifer per unit change in head.
Thrust Fault	Fault with a dip of 45 degrees or less in which the hanging wall (upper block) appears to have moved upward relative to the footwall (lower block).
Time of Travel (TOT)	The time required for a particle of water to move in the saturated zone from a specific point to a groundwater source of drinking water.
Transmissivity	The rate at which water of a prevailing density and viscosity is transmitted through a unit width of an aquifer or confining bed under a unit hydraulic gradient. It is a function of properties of the liquid, the porous media, and the thickness of the porous media.
Unconfined Aquifer	Any aquifer that does not meet the definition of a confined aquifer. An aquifer over which there is no confining strata and the water table forms the upper boundary.
Vulnerability	Aquifer vulnerability means an aquifer's intrinsic susceptibility, as a function of the thickness and permeability of overlying layers and land use practices, to contamination from both human and natural impacts on water quality.
Wellfield	An area containing two or more wells supplying a public water supply system.
Wellhead	The physical structure, facility, or device at the land surface from or through which groundwater flows or is pumped from subsurface, water- bearing formations.
Wellhead Protection Program (WHP)	The program to protect drinking water source protection zones and management areas from contaminants that may have an adverse effect on the health of persons.
Wellhead Protection Area (WHPA)	The surface and subsurface area surrounding a water well or wellfield, supplying a public water system, through which contaminants are reasonably likely to move toward and reach such water well or wellfield.
Zone of Contribution (ZOC)	The area surrounding a pumping well, spring, or tunnel that encompasses all areas and features that supply groundwater recharge to the well spring, or tunnel.
Zone of Influence (ZOI)	The distance from the well where changes in the groundwater surface (water levels) can be measured or inferred as a result of pumping.

1 Introduction

Aquifer:
A formation, group of formations, or part ofa formation that contains sufficient saturated permeable material to yield sufficient quantities of water towells and springs to constitute a useable supply.

1.1 PURPOSE

The primary purpose of the Casper Aquifer Protection Plan (CAPP) is to reduce the opportunity for and prevent contamination of groundwater within the Casper Aquifer which supplies the City of Laramie and Albany County residents with drinking water. The CAPP has been updated in light of new data. As in earlier CAPP versions, this plan seeks to balance aquifer protection and growth, and to synchronize City and County land use planning. The intent is to protect and preserve the Casper Aquifer so that both Laramie and Albany County residents can continue to depend on high quality drinking water from the aquifer for years in the future.

1.2 DRINKING WATER PROTECTION PLANNING OVERVIEW

In 1986, amendments to the Safe Drinking Water Act (SDWA) established the Wellhead Protection (WHP) Program. Under these amendments, each state was called upon to develop and submit to the U.S. Environmental Protection Agency (EPA) for approval a plan to protect groundwater that supplies wells, wellfields, springs, and tunnels that in turn provide drinking water to the general public. The minimum elements that states must address in their WHP plans are also specified in the SDWA.

In 1996, the SDWA was again amended to increase protection of drinking water in the United States (U.S.). The 1996 amendments established the need for consumer confidence reports, source water assessment programs for surface water and groundwater, operator certification, strengthening protection from microbial contaminants and disinfection byproducts, and cost-benefit analysis of each new standard proposed by the EPA (EPA, 2007). Wellhead protection is now included as part of the source water assessment guidelines established in the 1996 Amendments.

On September 18, 1997, Wyoming became the 46th state to have an EPA-approved WHP Program. Wyoming's WHP plan adopts the systematic and logical proactive approach to protecting drinking water supplies that has been established under the SDWA Amendments of 1986 and 1996. The elements of Wyoming's WHP plan are described in Wyoming's Wellhead Protection Program Guidance Document Version 3.1, dated June 1998. This document is intended to serve as a guide to communities, public water systems, and others to develop WHP plans. The criteria include the following five steps.

- Step 1: Formation of a community planning team that includes members of the public to initiate, lead, and oversee the creation and implementation of the local WHP plan.
- Step 2: Delineation of local Wellhead Protection Areas that represent the surface and subsurface area surrounding a well or wellfield through which contaminants are reasonably likely to move toward and reach the well or wellfield.

- Step 3: Completion of a Contaminant Source Inventory that identifies the locations of potential sources of contamination.
- Step 4: Completion and implementation of a Contaminant Source Management Plan.
- Step 5: Completion of a Contingency Plan that identifies alternative public water supply and emergency response if contamination occurs.

During the 1998 legislative session, the Wyoming Legislature authorized DEQ to set aside 10%, or $1.2 million, of the 1997 federal Drinking Water State Revolving Fund monies to develop a Source Water Assessment and Protection Program (SWAP) and complete Source Water Assessments. Similar to the Wellhead Protection Program which preceded it, the United States Congress intended the SWAP to complement the more traditional drinking water quality programs. Unlike the Wellhead Protection Program, however, Source Water Assessment and Protection applies to drinking water supplies using any combination of surface water and groundwater. The Source Water Assessment and Protection Program was intended to encourage the creation and implementation of drinking water protection programs on a local level. DEQ issued its SWAP guidelines in October 2000. The steps involved in the SWAP are very similar to those involved in the WHP.

While the WHP and SWAP programs provide guidance to delineate areas and aquifers that provide drinking water, neither program is required by DEQ for public drinking water systems in Wyoming. The basis for developing protection plans is the authority of the City of Laramie and Albany County to implement land use plans that promote public health. This CAPP includes reference to the five steps in a WHP where appropriate for the purpose of presenting the information needed to define the area and aquifer extent to protect drinking water for the City of Laramie and local Albany County residents from potential threats to drinking water quality that exist within that area.

1.2.1 WELLHEAD PROTECTION VERSUS AQUIFER PROTECTION

1.2.1.1 WELLHEAD PROTECTION AREAS

The delineation of a wellhead protection area is an important means of directly and immediately protecting the public water supply (Witten and Horsley, 1995). As defined in the 1986 Federal SDWA Amendments, a wellhead protection area is "the surface and subsurface area surrounding a water well or wellfield, supplying a public water system, through which contaminants are reasonably likely to move toward and reach such water well or wellfield." Pumping wells within an aquifer will affect the natural movement of groundwater by drawing water to the well. Wellhead protection areas are those land areas that contribute groundwater (and potential contaminants) to the pumping wells. In this sense, wellhead protection areas are subsets of a larger aquifer protection area.

1.2.1.2 AQUIFER PROTECTION AREAS

The 1996 SDWA Amendments promoted source water or "aquifer" protection. Source water protection areas will usually encompass a larger area than wellhead protection areas, and thus provide even greater safety for public water supplies and for individual residential wells that lie within the source water or in this case aquifer protection area (Figure 1-1). By protecting a larger portion of the aquifer that contributes groundwater to municipal water supply wells, it is expected that groundwater available to all users within that delineated area will be protected from contamination over the long-term. In the case of the Casper Aquifer, Albany County residential wells within the source water area are protected along with the municipal wells belonging to the City of Laramie.

The protection of a source water area for groundwater requires an understanding of the extent of the aquifer, its permeability and recharge characteristics, and its overlying and upgradient lands which influence its water quality and quantity. The delineation of a source water protection area is independent of the effects of pumping wells and is more directly related to natural hydrologic flow patterns. Where groundwater flow patterns are primarily dictated by conduits such as fractured bedrock, hydrogeologic and aquifer vulnerability mapping techniques are used to delineate the source water area. Hydrogeologic mapping techniques use surface observations in combination with subsurface geologic data to identify aquifer boundaries and areas that may contribute water to the aquifer. Conduit flow aquifers such as the Casper Aquifer have extremely variable flow patterns and rates, making times of travel difficult to predict. The entire aquifer may be delineated as the source water area if groundwater flow divides are not present (WDEQ, 2000).

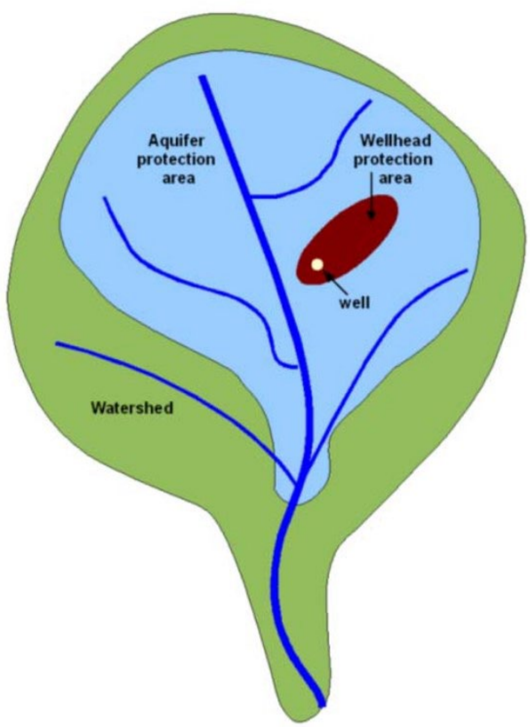


Figure 1-1: The difference between a wellhead protection area and an aquifer protection (source water) area. Adapted from Witten and Horsley (1995).

1.2.2 CASPER AQUIFER PROTECTION PLAN BACKGROUND

1.2.2.1 INTRODUCTION TO THE CASPER AQUIFER AS A WATER SUPPLY

Drinking water supplies have always influenced the location and development of communities by defining and directing growth. Historically, the location of a good source of drinking water was a key factor in determining the location of towns and cities. Safe drinking water is essential to the quality of community life because of the link between public health and the quality of the public water supply (EPA, 1997, Wittman, 2008).

Among Wyoming residents, approximately 54 percent of public water systems and 100 percent of rural residents depend on groundwater for their primary source of drinking water (NGWA, 2020). Groundwater is derived from rain and snow infiltrating through the soil, and from surface water (drainages, streams, rivers, and lakes) that recharge aquifers. An aquifer is a saturated, permeable geologic unit that can transmit useable quantities of groundwater to wells and springs. Aquifers may be localized or underlie several towns or counties. The Casper Aquifer underlies several counties and provides water to both municipalities and individual private residences across its extent. Only a small portion of the Casper Aquifer proximal to the City of Laramie is addressed in this plan.

The Casper Aquifer consists of approximately 700 feet of interbedded sandstone and limestone with minor siltstone and shale interbeds (Western Water Consultants and others, 2006). The uppermost occurrence of groundwater is typically between 0-100 feet below ground surface at the City of Laramie’s wellfields. Due to the highly faulted, fractured, cavernous, and folded nature of the Casper Aquifer and natural drainages, a contaminant introduced at the ground surface might easily enter the aquifer and move rapidly away from the entry point. Once contaminated, aquifers are difficult and expensive to remediate and municipalities or responsible parties may have to pay for site studies, remediation, and property damage. One example is from Cheyenne, Wyoming, where the use of trichloroethene (TCE) by the U.S. Air Force at the Atlas D missile site on Belvoir Ranch has contaminated the High Plains Aquifer. Initiated through missile cleaning activities in the early 1960s, the TCE contaminant plume currently stretches 12 miles and has affected both Cheyenne’s Borie Wellfield and Dyno-Nobel’s Wellfield along with several domestic wells (URS Group, 2021). The U.S. Army Corps of Engineers is currently operating treatment plants to remediate the TCE contamination, which could require tens of millions of dollars and more than 100 years to complete (Brown, 2016). The most cost-effective approach to aquifer protection is to prevent contamination before it occurs, rather than attempting to remedy existing contamination. In the case of individual residences using the Casper Aquifer as a drinking water source, remediation of the individual well would most likely be too expensive for the homeowner to bear.

As shown on Figure 1-2, the Casper Aquifer supplies approximately 55% of the City of Laramie's drinking water based on 1991 through 2014 data to its 31,317 residents. Many residents who live outside the Laramie municipal service area also rely on groundwater from the Casper Aquifer for 100% of their drinking water supplies. The City also uses treated water from the Laramie River to supply approximately 45% of its drinking water to the community (WWC Engineering and others, 2015). The averages shown on Figure 1-2 reflect 2001 through 2006 production data (Wittman, 2008).

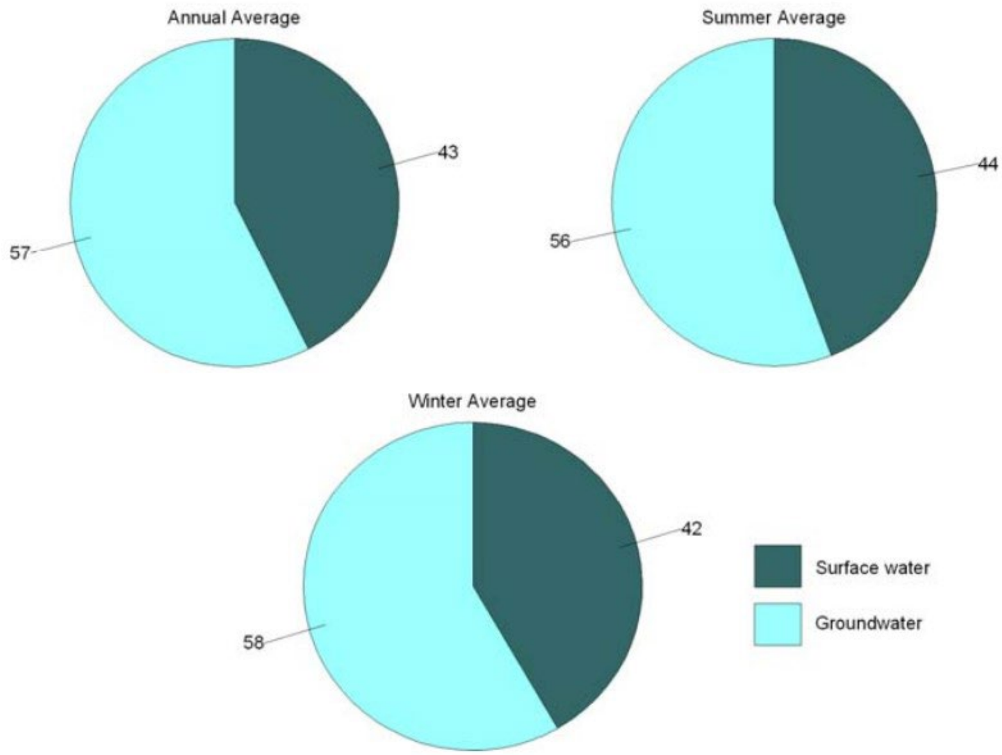


Figure 1-2: The percentage of groundwater and surface water used by the City of Laramie for drinking water. Note: summer months = June, July, and August. Winter months = December, January, and February.

The Casper Aquifer is exposed along the west side of the Laramie Range east of the City of Laramie and is vulnerable to contamination for the following reasons:

1. Municipal and domestic wells and springs that supply drinking water are in close proximity to or within the recharge area of the Casper Aquifer.
2. Most recharge into the Casper Aquifer occurs rapidly as snowmelt runoff in drainages and on the land surface.
3. The Casper Formation is highly permeable in multiple directions where extensive folding, faulting, fracturing, and/or permeability enhancement along bedding surfaces has created a complex groundwater circulation network. In addition, the formation has extensive exposure of porous sandstone. Locations where the permeable pathways in the circulation network occur in the subsurface and intersect with the land surface are not all well known.
4. There are characteristics of the Casper Formation outcrop and Casper Aquifer itself which render the aquifer more susceptible to contamination. These features include: drainages, fractures, faults, folds, dissolution cavities, exposed sandstone, shallow depths to groundwater, springs, and thin soils.

5. There are existing areas of residential and commercial development along the western margin of and within the recharge area. These existing facilities and the pressure to build within the recharge area east of Laramie increase the risk of contamination in two ways:

   - **New potential sources of contamination** – Homes and businesses are new potential sources of contamination to the aquifer depending upon the type of business, how the buildings are connected or disconnected from City services, landscape irrigation practices particularly related to fertilizer or pesticide use, and typical use of many chemicals associated with residential activity.

   - **May alter or enhance pathways for potential contaminants** – New wells and excavations which weaken the integrity of the confining layer may provide or enhance hydraulic communication with the Casper Aquifer or reduce the hydraulic barrier provided by the Satanka Shale that overlies the Casper Aquifer.

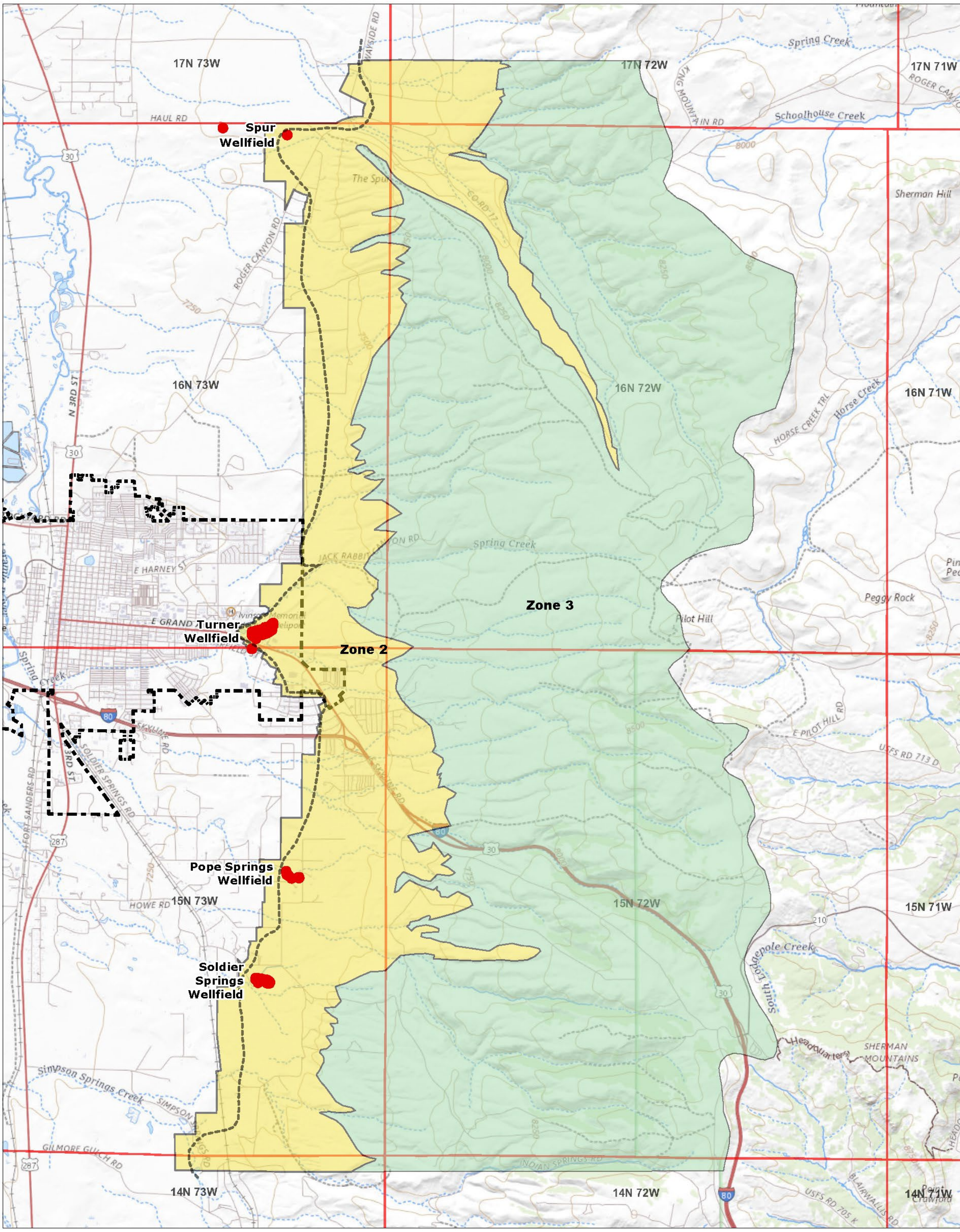
6. Unknown quantities of many hazardous substances are regularly transported and occasionally spilled along Interstate 80 (I-80), which transects the Casper Aquifer recharge area. Spills associated with the Union Pacific Railroad transportation corridor near Simpson Springs present a similar risk to the Casper Aquifer.

7. Stormwater runoff entrains contaminants as it moves down drainages and interacts with other vulnerable features.

Figure 1-3 shows the location of the City wellfields relative to the city limits and to the revised Casper Aquifer Protection Area (CAPA). This figure presents the proposed Aquifer Protection Overlay (APO) for the City and the Aquifer Protection Overlay Zone (APOZ) for the County. The City wellfields from north to south are called: Spur, Turner, Pope Springs, and Soldier Springs. Spur Well No. 1 is on fenced property owned by the City of Laramie surrounded by State of Wyoming property. The Spur Well No. 2 well lies on City property that is surrounded by land owned by the State of Wyoming. Turner Well No. 2 and City Springs lie within fenced property owned by the Union Pacific Railroad. Turner Well No. 1 and the Soldier Springs Well are on fenced property owned and controlled by the City of Laramie. The Pope Springs Wellfield is owned by the City, but not fenced. Technical information for the City's water supply wells is on file at the City Utility Division office and include copies of the well permits and statements of completion on file with the Wyoming State Engineer's Office (WSEO), water-quality data, and other relevant information. This information is summarized throughout the CAPP. The City recently completed a test well on property northeast of the Turner Wellfield. When this well is brought online, the CAPP should be updated to account for this additional water supply well. While not a municipal wellfield, Simpson Springs has been included within the source water protection area because this site has been identified as a source of potential future water supply development and the City already owns the property.

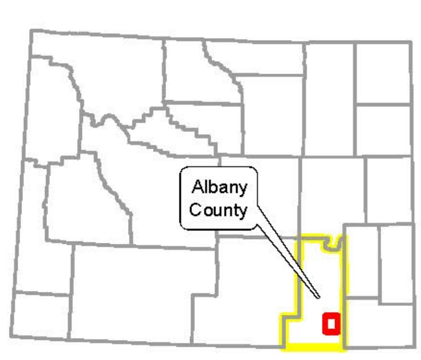
Each domestic well also has an associated protection area around its wellhead because Wyoming DEQ Chapter 25 requires a minimum 100-foot setback from both on-property and neighboring septic absorption fields used for wastewater disposal. These are not depicted on Figure 1-3, but are also relevant to the discussion of aquifer protection.

Any aquifer protection program must be responsive to the needs of the local community. For a community to remain viable and grow it must have a safe source of drinking water. As such, the aquifer protection plan is a dynamic document and should be revisited in the future. As new data on the Casper Aquifer become available, future governing bodies, commissions, and/or staff may recommend or decide to revise the aquifer protection plan.



Legend

- Municipalities
- Protective Satanka Shale Thickness
- CAPA Zone 1
- CAPA Zone 2
- CAPA Zone 3



0 0.6 1.2 Miles

(At original document size of 11x17)
1:76,406

N

Stantec

Notes
1. Coordinate System: NAD 1983 StatePlane Wyoming East FIPS 4901 Feet
2. Data Sources: USGS, City of Laramie, WHPA (2008)
3. Background: USGS 7.5 Minute Quadrangle

Project Location
T16N, R73W
Laramie, Albany Co., WY

Prepared by KAB on 2023-02-15
TR by XXX on 2020-XX-XX
IR by XXX on 2020-XX-XX

227704690

Client/Project
City of Laramie/Albany County
Casper Aquifer Protection Plan Update

Figure No.
1-3

Title
Location of Casper Aquifer Protection Area (CAPA)

V:\2277\active\227704690\03_data\gis_cad\gis\pro\CAPP UPDATE 2022\CAPP UPDATE 2022.aprx Revised: 2023-02-15 By: kberglund

1.2.2.2 HISTORY OF AQUIFER PROTECTION IN ALBANY COUNTY

The City of Laramie was successful in obtaining a grant from the EPA in 1993 to develop a Wellhead Protection Plan. Western Water Consultants, Inc. (WWC) of Laramie developed the initial approach to delineating WHP areas for the City's municipal wellfields at Turner, Pope, and Soldier Springs. The delineations were based on hydrogeologic mapping and time of travel contours defined by major faults and assumed hydraulic behavior of faults and folds (WWC, 1993). The EPA grant required creation of a WHP ordinance, and a draft was completed in late 1996 (City of Laramie, 1996). Citizens voiced numerous concerns at that time, based upon (1) the proscriptive nature of the ordinance, (2) the dependence of the 1993 WHP areas upon the location of identified faults, and (3) the exclusion of limestone quarries from the WHP area.

In 1997, as a result of citizen concerns and challenges to the proposed WHP ordinance, the Laramie City Council and Albany County Commissioners instructed the Environmental Advisory Committee (EAC) to develop an aquifer protection program for the Casper Aquifer, rather than a WHP program. An aquifer protection program provides a higher level of protection for the City of Laramie's public water supply and Albany County residents within the Casper Aquifer recharge area because it includes the entire aquifer resource and groundwater users in the vicinity of the City of Laramie, rather than focusing solely on the municipal wellfields.

In 1998, the first delineation of the CAPA was developed by the EAC Technical Review Subcommittee. The subcommittee included engineers, geologists, hydrogeologists, and one citizen at- large. The subcommittee developed consensus regarding a delineation method, and a delineation report was signed by the Technical Review Subcommittee members on July 25, 1999. The boundary of the CAPA was identified as follows: the eastern boundary was the ridge of the Laramie Mountains, the northern boundary was north of the Spur Anticline, the southern boundary was south of the Simpson Springs Anticline, and the western boundary was calculated from a dip formula where it was estimated that 75 feet of Satanka Shale would be overlying the Casper Aquifer. The delineation report, which was to become Chapter 4 of the CAPP, was presented at a joint work session of the Albany County Commissioners and the Laramie City Council. On January 4, 2000, both governing bodies approved the delineated area through Joint Resolution No. 2000-02 which was needed before work could continue on subsequent chapters of the CAPP. A copy of the resolution is contained in Appendix A and a copy of the delineation report (Version 1.0) is contained in Appendix B to preserve the integrity of the initial delineation effort.

The delineation report (Version 1.0) was submitted to the WDEQ for preliminary approval of the delineation and associated method used. WDEQ staff identified three deficiencies in the delineation that needed to be addressed. These deficiencies were:

- The lack of a Zone 1 protection area for each municipal production well or water supply source;
- Clear identification of Zone 2 and Zone 3 protection areas, and the basis for the northern and southern boundaries of the CAPA which did not comply with criterion stated in the WHP Program Guidance Document; and
- The lack of a higher level of protection for faults and other vulnerable features.

These three deficiencies were addressed in Version 2.0 of the delineation report to address the comments of the WDEQ and to aid in completing a plan that is both protective of the aquifer and readily implementable. A copy of the Version 2.0 delineation report is also contained in Appendix B in its entirety to preserve the integrity of the original delineation reports. In July 2007, the WDEQ reviewed and approved the CAPP. The revised version of the CAPP was adopted by both the City of Laramie and Albany County.

As part of the Wyoming Source Water Assessment and Protection Program in 2002, the City of Laramie volunteered to have a source water assessment prepared through the WDEQ around the time the wellhead protection plan was first submitted. Trihydro (2004) reviewed the Casper Aquifer protection area and plan that had been developed at that time, and prepared a source water assessment of the City's surface water resources based on its intake location on the Laramie River. This project was the first to assess source water protection with respect to the City's surface water source. A susceptibility assessment of the City's water sources was also conducted through this study based on source vulnerability and potential sources of contamination that were identified within the source water protection areas for both its Casper Aquifer wells and surface water source.

Susceptibility is defined as the potential for a public water supply to draw contaminated water at concentrations that would pose a threat or concern to human health. In general, the City of Laramie scored low for land use susceptibility because much of the land surrounding the water sources is undeveloped with the exception of the land surrounding the Turner Wellfield. The point source contaminant susceptibility ratings are high for Zones 2 of the Turner wells and the Spur #2 well due to three underground storage tanks and one solid and hazardous waste site. The Big Laramie River intake also scored high for point source contaminant susceptibility due to two underground storage tanks and one underground injection system located within Zone 2. All of the City of Laramie's water sources scored high for transportation corridor contaminant susceptibility. The wells are in close proximity to highways and interstates.

Soil filled fractures in Casper Formation limestone exposed at land surface.

Residents throughout Albany County recognize the Casper Aquifer as a valuable natural resource. In a phone survey conducted by Fairbank, Maslin, Maullin & Associates (2007), 80% of Albany County residents surveyed in conjunction with the Albany County Comprehensive Plan strongly agreed that "Albany County should guide development to protect natural resources such as groundwater, floodplains, wetlands, and crucial wildlife habitat." In September 2007, Albany County and the City of Laramie hired Wittman Hydro Planning Associates, Inc. (Wittman) to update the CAPP and revise the existing ordinance to ensure protection of the Casper Aquifer. Public workshops and meetings involved local citizens to ensure that voices from diverse perspectives were considered throughout the process.

In 2008, the CAPP was updated by Wittman. The western boundary of the CAPA was modified, straightened and moved to the west. These changes represented Version 3.0 of the CAPA. The western boundary was changed to reflect the fact that there were known places where there is less than 75 feet of Satanka Shale overlying the Casper Aquifer along the previously calculated line. At the Soldier No. 1 well there is 36 feet of Satanka Shale, but the calculated 75 feet line is to the east of Soldier No. 1. At the Turner No. 2 well, there is 74 feet of Satanka Shale so the calculated 75 feet line should roughly coincide with Turner No. 2 yet the calculated line is east of Turner No. 2. At Spur No. 1 well there is 54 feet of Satanka Shale and yet the calculated 75 feet line is very near that well when the actual line should be further to the west of Spur No. 1. Since there were known areas where the previously calculated line was inaccurate, it was decided that the western boundary should be moved so that that at least 75 feet of Satanka Shale was overlying the Casper Aquifer. Additionally, the western boundary was moved to provide continuous protection between Zones 1 and 2. In previous delineations there was a gap of protection between Zones 1 and 2. Finally, the line was straightened and moved primarily to section, quarter section, and quarter-quarter section lines to provide for easier implementation of the CAPP.

The City of Laramie adopted Wittman's updated plan, but Albany County did not. In 2009, the Albany County Planning and Zoning Commission modified the version of the CAPP that the WDEQ had approved in July 2007. This second modified version was adopted by the County in January 2011 leading to two different versions of the CAPP being put into use by the City and County as well as differences in regulation. From 2019 to 2021, revisions to the Albany County Aquifer Protection Overlay Zone Resolution were considered by the Planning and Zoning Commission and the County Commissioners. While regulation changes were approved in November 2021, a subsequent court ruling nullified their adoption. Most of the amendments adopted by the County in 2021 were adopted again in February 2023 after having gone through the county Planning and Zoning Commission. The current (March, 2023) county regulations are attached in Appendix H.

Given the differences between the City and County CAPPs, Stantec was hired in October 2021 to consolidate the City and County CAPPs, and update the existing documents to include information that has been learned since 2008 and 2011. Since 2008, the City and County have completed numerous studies that have expanded our knowledge of Casper Aquifer and potential contaminant sources. These studies included investigations into recharge, nitrate as nitrogen concentrations in the CAPA, septic system effectiveness in nitrogen removal, nitrate loading under existing and future buildout scenarios, wastewater treatment alternatives for the subdivisions east of Laramie, Sherman Hills Fault hydrogeologic conditions, nitrogen sources via isotope analysis, site-specific investigations of proposed development properties along the western boundary, and aerial geophysics along Interstate 80, among others. This CAPP is intended to be approved under the Wyoming statutory provisions for a land use plan and any updated protective regulations must be codified under City ordinance and County regulations.

1.3 CITY OF LARAMIE WELLS AND WELLFIELDS

Since 1992, the City of Laramie has derived approximately 58% of its municipal supply from four wellfields completed in the Casper Aquifer. According to WWC Engineering and others (2015), the capacity of the surface and groundwater resources available to meet the needs of the City is adequate to meet peak water demands at this time and at the 2050 planning horizon. However, it is still necessary for the City to maintain and protect the resources they are currently using and the water resources reserved for long range development. The locations of the City's wellfields are shown on Figure 1-3. Average annual groundwater production from the City's wellfields was 961 million gallons between 2003 and 2014. When the Laramie River was dry at the headgate during the summer of 2002, groundwater production was approximately 1,700 million gallons (WWC Engineering and others, 2015).

While the following sections provide some details on the City of Laramie's wells, more detailed and additional information on these sources is available from the 2015 Laramie Water Master Plan Level I report completed by WWC Engineering and others (2015). These wellfield summaries were derived from that report. Municipal well data are summarized in Table 1-1. The data are derived from City of Laramie Public Works Department files and from the well construction reports. The well data were confirmed with Mike Lytle (2022), Water Treatment Supervisor for the City of Laramie. Pump data for the Laramie municipal wells are provided in Table 1-2. The data were gathered from City of Laramie Public Works

Department Files and well construction reports. The pump data were confirmed with Mike Lytle (2022), Water Treatment Supervisor for the City of Laramie.

1.3.1 SOLDIER WELLFIELD (SOLDIER SPRINGS)

In about 1915 the City began to convey water from Soldier Springs. In 1937, the City dug a 21 foot deep cistern (Forney Shaft) that penetrated the lowermost eight feet of the Satanka Shale and 10 feet of the uppermost sandstone of the Casper Formation, and installed a pump to allow more production. Due to water quality concerns and limited operational flexibility associated with the cistern, the City plugged the cistern in 1998 and replaced it with a production well, Soldier No. 1, which is located 450 feet west of the cistern. Soldier No. 1 went on-line in late 1998 and is designed to provide water by artesian flow or by pumping depending on demand. The importance of the Soldier Spring supply cannot be over emphasized. From 2003 to 2014, the artesian flow from Soldier No. 1 has comprised 69% of the annual groundwater production and 35% of the total annual water supply production by the City.

1.3.2 POPE WELLFIELD (POPE SPRINGS)

The Pope Wellfield consists of four wells located 2.8 miles south of City Springs and a short distance west of the now dry Pope Springs. The wells are clustered within a 6.4 acre parcel. Pope No. 1, No. 2, and No. 3 were installed in 1937-39 after Pope Springs ceased to flow in 1934 due to a prolonged drought and the lowering of the discharge works at Soldier Springs. Pope No. 4 was installed in 1982 as a high capacity well to be used during periods of peak demand. The Pope Wellfield is typically used only along the Spur Wellfield during high demand periods in the summer when combined production from the surface water treatment plant, Soldier No. 1, and the Turner Wellfield cannot keep up with demand. Spur and Pope, however, were critical supply sources during the summer of 2002. Between 2003 and 2014, the Pope Wellfield provided less than 10% of the total annual groundwater production.

1.3.3 TURNER WELLFIELD (CITY SPRINGS)

Prior to 1982, the City obtained groundwater directly from the natural discharge at City Springs. The Turner wells were installed in 1982 to enhance groundwater production capabilities and to intercept groundwater in the subsurface before water discharges to the surface at City Springs. The Turner Wellfield consists of the Turner No. 1 and the Turner No. 2 wells located on the eastern end of Laramie in the vicinity of City Springs. Turner No. 2 is located in the City Springs fenced enclosure a short distance west of the original discharge point of City Springs. Turner No. 1 is located on City property south of the City Springs enclosure. When the Turner wells are operating, City Springs cease to flow; whereas when the Turner wells are off, discharge from City Springs flows into Spring Creek. In general, when annual Turner Wellfield production exceeds 1.6 million gallons per day, there will be little or no discharge from City Springs during that particular year. The Turner wells can be operated separately or concurrently depending on demand. The Turner Wellfield provided approximately 25% of the City’s groundwater supply between 2003 and 2014.

1.3.4 SPUR WELLFIELD

The Spur Wellfield is located 5.7 miles north of City Springs and consists of two wells, the Spur No. 1 and Spur No. 2. The Spur wells were installed in 1997 and completed in the Casper Aquifer along the western extension of the Spur Anticline. No springs are present in the vicinity of the Spur Wellfield. Both wells are highly productive as illustrated by less than eight feet of drawdown occurring in each well after being pumped continuously for 30 days at a rate of 1,400 gpm (i.e. 2,800 gpm combined). The Spur wells can be operated separately or concurrently depending on demand. Although the most productive, the Spur wellfield is used sporadically and primarily as a supplemental or emergency supply. Between 2003 and 2014, these wells provided less than 10% of the City's groundwater supply but proved their value in 2002 when the Laramie River ran dry at the headgate during the summer.

Spur No. 2 aquifer test: This well yielded 1,400 gpm for 30 days.

Table 1-1: City of Laramie Municipal Well Data.

Well Name	UW Permit No.	Location	Year Drilled	Elevation (ft)	Lithologic Log Location	Well Diameter (in)	Total Depth (ft)	Cased Interval (ft)	Open Hole Interval (ft)	Casper Members Penetrated (ft)	Approximate Depth to Water (ft)	Test Pumping Rate (gpm)	Well Specific Capacity (gpm/ft)	Pump Setting (ft)	Pumping Rates (gpm)[A]	SEO Adjudicated Pump Rate (gpm)
Soldier Wellfield																
Soldier #1	105576	T15N R73W Sec 23, SE, SW	1997	7322.1	WSEO	16	289	0-79.5	79.5-289	Epsilon, delta, gamma; 248	+2	1,800	191	43	1100/1970[B]	1800
Turner Wellfield																
Turner #1	55507	T15N R73W Sec 2 NE, NW	1982	7272.7	WSEO	16	240	0-100	100-240	Epsilon, delta; 136	0	2,030	66	80	1900	1400[1]
1st ENL Turner #1	61724	T15N R73W Sec 2 NE, NW	1982	7272.7	WSEO	16	240	0-100	100-240	Epsilon, delta; 136	0	2,030	66	80	1900	800[1]
2nd ENL Turner #1	72689	T15N R73W Sec 2 NE, NW	1982	7272.7	WSEO	16	240	0-100	100-240	Epsilon, delta; 136	0	2,030	66	80	1900	300[1]
Turner #2	55508	T16N R73W Sec 35 SE, SW	1982	7259.8	WSEO	16	350	0-100	100-350	Epsilon, delta, gamma, beta; 274	+6	1,730	36	93	1400	1400[2]
1st ENL Turner #2	59131	T16N R73W Sec 35 SE, SW	1982	7259.8	WSEO	16	350	0-100	100-350	Epsilon, delta, gamma, beta; 274	+6	1,730	36	93	1400	200[2]
Pope Springs Wellfield																
Pope #1	153	T15N R73W Sec 14 NE, SE	1937	7335.5	WSEO	8	156	0-64	64-156	Epsilon, delta: 95	11	475	40	55	350	600
Pope #2	154	T15N R73W Sec 14 NE, SE	1938	7338.8	WSEO	8	162	0-64	64-154	Epsilon, delta: 95	NA	NA	NA	60	650	600[3]
1st ENL Pope #2	72690	T15N R73W Sec 14 NE, SE	1938	7338.8	WSEO	8	162	0-64	64-154	Epsilon, delta: 95	NA	NA	NA	60	650	753
Pope #3	155	T15N R73W Sec 14 NE, SE	1939	7338.8	WSEO	15	158	0-66	66-158	Epsilon, delta: 95	15	994	62	62	800	600[4]
1st ENL Pope #3	55505	T15N R73W Sec 14 NE, SE	1939	7338.8	WSEO	15	158	0-66	66-158	Epsilon, delta: 95	15	994	62	62	800	250[4]
2nd ENL Pope #3	72691	T15N R73W Sec 14 NE, SE	1939	7338.8	WSEO	15	158	0-66	66-156	Epsilon, delta: 95	15	994	62	62	800	50[4]
Pope #4	55506	T15N R73W Sec 14 NE, SE	1982	7351	WSEO	16	350	0-100	100-350	Epsilon, delta, gamma, beta; 285	31	1,500	125	80	1500	1750[5]
1st ENL Pope #4	72692	T15N R73W Sec 14 NE, SE	1982	7351	WSEO	16	350	0-100	100-350	Epsilon, delta, gamma, beta; 285	31	1,500	125	80	1500	50[5]
Spur Wellfield																
Spur #1	106547	T16N R73W Sec 2 NE, NE	1997	7290.65	WSEO	16	305	0-91	91-305	Epsilon, delta, gamma; 251	32	2,000	580	76	1400	1400
Spur #2	115181	T16N R73W Sec 3 NE, NE	1997	7269.59	WSEO	16	323	0-255	255-323	Epsilon; 84	12	2,000	440	86	1400	1400

[A]All pumping rates based on data provided by Mike Lytle (2022) and are for each respective well. Aquifer info from WWC Engineering and others (2015).
[B]Approximately 1,100 gpm under flowing artesian conditions, and 1,970 gpm under pumping conditions.
[1]Under UW permit numbers 55507, 61724, and 72689, the City of Laramie is adjudicated a total of 2500 gpm from Turner #1.
[2]Under UW permit numbers 55508 and 59131, the City of Laramie is adjudicated a total of 1600 gpm from Turner #2.
[3]Under UW permit numbers 154 and 72690, the City of Laramie is adjudicated a total of 675 gpm from Pope #2.
[4]Under UW permit numbers 155, 55505, and 72691, the City of Laramie is adjudicated a total of 900 gpm from Pope #3.
[5]Under UW permit numbers 55506 and 72692, the City of Laramie is adjudicated a total of1800 gpm from Pope #4.
Note: UW = underground well, SEO = State Engineers Office; NA = Not available

Table 1-2: City of Laramie Pump Data.

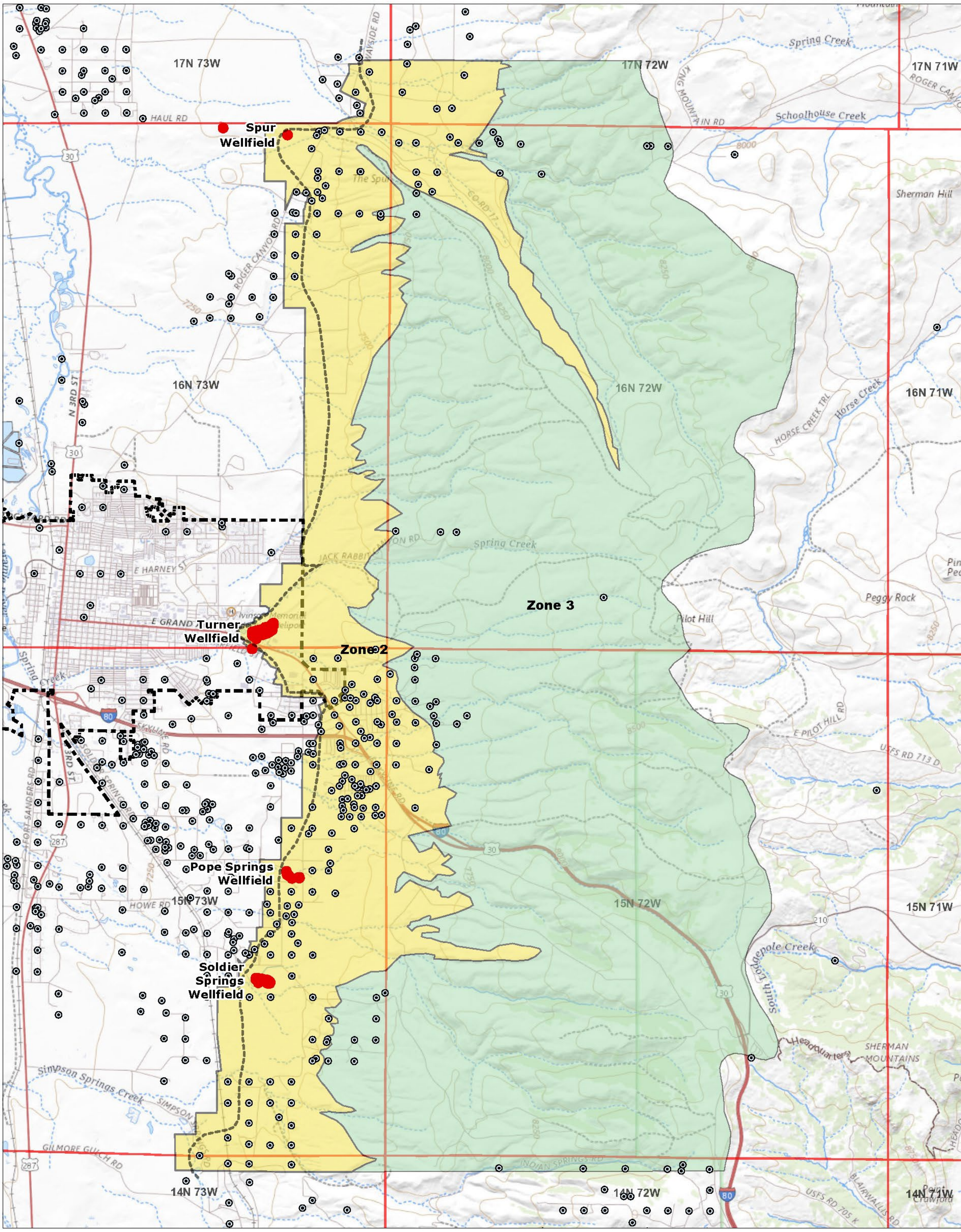
Well Name	Pump Type	Pump Make	Pump Model	Pump Setting (ft)	Pump Capacity (GPM)	Motor Make	Motor Model	Motor Rating (HP)	Year Installed
Soldier #1	Line-Shaft Turbine	Floway	14DKH	43	1970	U.S.	VHS	75	1998
Turner #1	Line-Shaft Turbine	Aurora Verti-Line	V82-70503	80	2100	G.E.	JTJ930342	40	1981
Turner #2	Line-Shaft Turbine	Flowserve	14EMM	93	1600	G.E.	JTJ930341	40	2004
Pope #1	Line-Shaft Turbine	Aurora Verti-Line	V82-70504	55	450	G.E.	BV83131	7.5	1982
Pope #2	Line-Shaft Turbine	Gould	8DHHC	60	1100-1480	Emerson	BF28F	200	2007
Pope #3	Line-Shaft Turbine	Aurora Verti-Line	V82-70500	62	1150	G.E.	AVJ120301	40	1982
Pope #4	Line-Shaft Turbine	Aurora Verti-Line	V82-70501	80	2000	G.E.	GTJ729339	75	1982
Spur #1	Line-Shaft Turbine	Floway	12JKh	76	1700	G.E.	VHS	100	2000
Spur #2	Line-Shaft Turbine	Floway	12JKh	86	1700	G.E.	VHS	100	2000

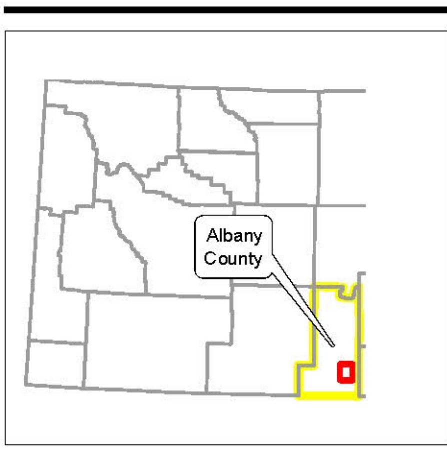
1.4 DOMESTIC WELLS WITHIN THE CAPA

Many households within the CAPA rely on their own private water supply well for both indoor and outdoor uses. Common indoor uses include drinking, washing clothes and dishes, bathing, and flushing toilets. Common outdoor uses are watering lawns and gardens or maintaining pools, ponds, or other landscape features. It has been estimated about 20% of Wyoming households utilize self-supplied water sources. Water for self-supplied domestic use is typically withdrawn from a freshwater groundwater source through the use of a domestic well or captured as rainwater in a cistern. Self-supplied per capita use in Wyoming was estimated to be just below the national average at 75 gal/day (USGS, 2018).

In Wyoming, the SEO has general supervision of the waters of the state and is responsible for permitting appropriations of both surface water and groundwater. According to the Wyoming SEO's Groundwater Rules and Regulations, domestic use includes household use and the watering of lawns and gardens for noncommercial family use. A domestic well is allowed a maximum appropriation of 25 gpm as long as the water is not used for commercial endeavors or the total area of lawns and gardens to be watered does not exceed one acre.

The number of domestic wells within and near the CAPA was estimated using the Wyoming SEO's e-Permit water well database. Water wells having a domestic use within Townships 14N through 17N and Ranges 72 and 73W were included. As shown on Figure 1-4, there are approximately 460 water well permits with some type of domestic use within the CAPA, and approximately 1,500 including the surrounding area. The median permitted yield of these wells is 10 gpm and the average well completion depth is approximately 165 feet. Domestic wells are typically completed with 6-inch casing at land surface, completed into the first water bearing zone of the Casper Aquifer, and equipped with 4-inch pumping equipment to supply the residence. The Wyoming SEO began requiring that permittees provide the coordinates of their well when submitting a Statement of Completion (or UW-6) in 2006. Prior to this requirement, Public Land Survey quarter/quarter sections were required along with subdivision, lot number, and block for some applications prior to that time. Many of the wells permitted before 2006 are not precisely located and are either located in the center of a quarter/quarter section and sometimes in the center of a section. Because of this, many wells on Figure 1-4 are not precisely located.





Legend
- Domestic Well
- Protective Satanka Shale Thickness
- CAPA Zone 1
- CAPA Zone 2
- CAPA Zone 3
- County
- Municipalities
- PLSS Township

0 0.6 1.2 Miles

(At original document size of 11x17)
1:76,406

N

Notes
1. Coordinate System: NAD 1983 StatePlane Wyoming East FIPS 4901 Feet
2. Data Sources: USGS, City of Laramie, Wyoming SEO
3. Background: USGS 7.5 Minute Quadrangle

Notes:
This figure presents approximate domestic well locations based on data provided by the Wyoming State Engineer's Office. Many well locations are centered on the quarter quarter section, and therefore, each symbol may represent more than one well located in that particular quarter quarter section.

Stantec

Project Location
T16N, R73W
Laramie, Albany Co., WY

Prepared by KAB on 2023-02-15
TR by XXX on 2020-XX-XX
IR by XXX on 2020-XX-XX

Client/Project
227704690
City of Laramie/Albany County
Casper Aquifer Protection Plan Update

Figure No.
1-4

Title
Location of Casper Aquifer Protection Area (CAPA) with Domestic Wells

V:\2277\active\227704690\03_data\gis_cad\gis\pro\CAPP UPDATE 2022\CAPP UPDATE 2022.aprx Revised: 2023-02-15 By: kberglund

Although not all well permits are currently active or operational, only domestic wells with complete, incomplete, adjudicated, or unadjudicated permit status designations may legally operate. Permit statuses are listed in Table 1-3 below.

Table 1-3: Permit Statuses of Domestic Wells Within and Near the CAPA

Permit Status Designation	Number of Wells
Complete	1,184
Incomplete	73
Fully Adjudicated	40
Unadjudicated	1
Canceled	196
Abandoned	3
Expired	5

Note – Data pulled from Wyoming SEO e-Permit database on 2/15/2023.

Many domestic wells in the CAPA and surrounding areas serve multiple purposes. In addition to being permitted for domestic uses, wells may also be permitted for industrial, irrigation, stock, monitoring, stock, and miscellaneous uses. Use designations are listed in Table 1-4 below.

Table 1-4: Use Designations for Domestic Wells Within and Near the CAPA

Use Designation	Number of Wells
Domestic	1,093
Domestic and Stock	360
Domestic and Miscellaneous	17
Domestic, Irrigation, and Stock	10
Domestic, Miscellaneous, and Stock	8
Domestic and Irrigation	4
Domestic, Industrial, and Miscellaneous	3
Domestic, Industrial, Irrigation, and Stock	2
Domestic and Industrial	1
Domestic, Irrigation, Miscellaneous	1
Domestic, Irrigation, Miscellaneous, Stock	1
Domestic and Monitoring	1
Domestic, Irrigation, and Stock	1

Note – Data pulled from Wyoming SEO e-Permit database on 2/15/2023.

1.5 CAPP ORGANIZATION

Through the years, the CAPP has been developed and modified to provide the appropriate hydrogeologic data to support the plan and to address the five steps outlined in Wyoming's WHP guidance document. The content and organization of the CAPP is presented as follows:

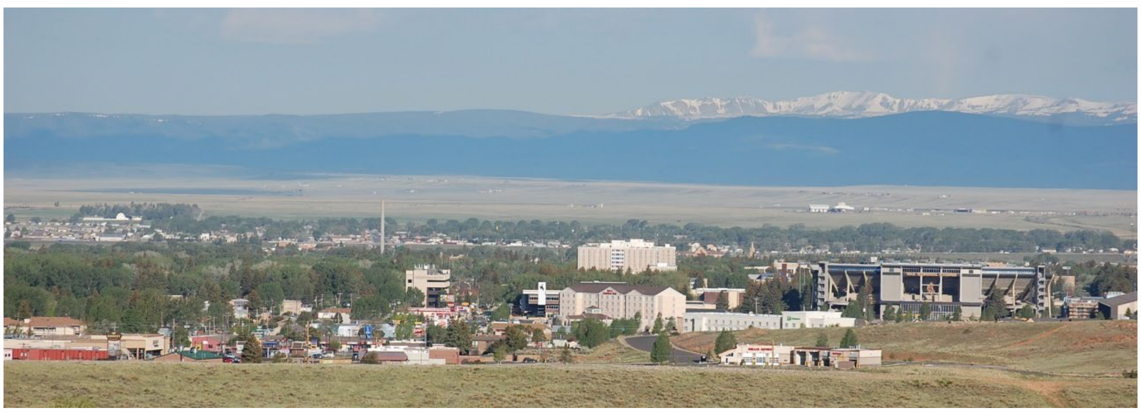
- Chapter 2 describes the formation and function of the volunteer community planning team.
- Chapter 3 presents the hydrogeologic and water quality conditions associated with the Casper Aquifer.
- Chapter 4 describes the delineation of the CAPA.
- Chapter 5 presents the inventory of contaminant sources within the CAPA.
- Chapter 6 presents the Contaminant Management Plan which includes City and County specific recommended actions.
- Chapter 7 presents the Contingency Plan.

2 Community Planning Team

This chapter describes Step 1 of the WHP process as the CAPP has been updated through time: the formation of a community planning team. In addition, this chapter describes past activities performed by the community planning team.

2.1 COMMUNITY PLANNING TEAM OVERVIEW

The main characteristic of a successful local aquifer protection plan is recognition of the importance of public participation in both the creation and implementation of the plan. By forming a community planning team, stakeholders and other interested parties have the opportunity to be involved in the creation, revision, and implementation of their local aquifer protection plan.



A beautiful day in the Laramie valley.

Wyoming's WHP Program guidance document presents a list of entities and individuals who should be considered when developing a community planning team. The list includes:

- City, County, or Tribal Council/Commission representatives;
- Public Water System (PWS) operator(s);
- Private, Commercial, and Industrial interest representatives;
- Residential interest representatives; and
- Technical, legal, and regulatory advisors.

Although several other Wyoming communities have initiated groundwater protection programs, those communities have relied on outside expertise to develop and implement these programs. In contrast, the Laramie Regional Drinking Water Protection Program (LRDWPP) adopted a "do-it-yourself" approach, as advocated in Wyoming's WHP Program Guidance Document (WDEQ/WQD 1998). The LRDWPP utilized the volunteer efforts of over 25 city and county residents divided into five subcommittees under the EAC, each assigned a task from the groundwater protection program described in Chapter 1. The subcommittee which delineated the original aquifer protection area consisted of hydrogeologists, geoscientists, engineers, and others with technical training and background in groundwater protection. This CAPP update builds upon the significant effort of the Laramie community and the data that have been acquired since the Wittman update in 2008.

While a community planning team was not assembled for this current update, Albany County and the City of Laramie made a concerted effort to obtain public comment and to involve the community in the revision of the CAPP. In addition, community involvement continues through citizen appointments to City of Laramie Planning Commission, Environmental Advisory Committee, Albany County Planning and Zoning Commission, and frequent opportunities for public comment before those bodies and the County Commission and City Council. Day to day decisions and community actions either enhance or degrade aquifer protection and the risks posed to the Casper Aquifer. Continued collaboration by the City and County will be a key factor in aquifer protection.

2.2 HISTORY OF THE COMMUNITY PLANNING TEAM

In 1997, the Laramie City Council and Albany County Commissioners charged the EAC with developing the first version of the CAPP. The EAC was a volunteer group of Albany County citizens concerned and interested in environmental issues pertinent to the County.

The EAC created five subcommittees to address the steps included in Wyoming's WHP guidance document. The subcommittees include the Public Education Subcommittee; Technical Review Subcommittee; Contaminant Source Inventory Subcommittee; Contingency Planning Subcommittee, and Aquifer Area Management Subcommittee. The EAC meetings were held once a month at various times and locations in Laramie. Subcommittee meetings were held as needed at the direction of the EAC. Meeting agendas and informational packets were organized by the EAC chairperson. All minutes from EAC and committee meetings are on file at the City Planning Division. A City Council liaison, City Public Works Department staff, and County Commissioner were invited to attend all EAC meetings. All meetings were open to the public.

After the initial CAPP was completed and submitted to the WDEQ in 2002, the City/County Water Outreach Coordinator (WOC), a Public Works Department employee, was responsible for implementing the CAPP. The WDEQ reviewed the original document and requested that some revisions be completed before the plan was accepted by the State. All changes to the original plan were written either by or in cooperation with EAC members and the Water Outreach Coordinator, in response to WDEQ comments. These changes were part of the revised CAPP dated November 2006 that was submitted to the WDEQ for review and approval. The revised CAPP was approved by the WDEQ on July 3, 2007.

Due to continuing community concern regarding the potential impacts of development to the Casper Aquifer in the CAPA, the City of Laramie and Albany County jointly hired Wittman Hydro Planning Associates, Inc. in September 2007 to review and update the CAPP and associated ordinances. This version of the CAPP was completed by Wittman with input provided by City Planning Division and County Planning Department, concerned citizens, and the Technical Advisory Committee (TAC). The TAC was a group of interested individuals including landowners, professionals, and City and County government representatives. The EAC was included as a representative on the TAC but chose to be uninvolved otherwise due to the lack of expertise of the members on the subject at that time. The concerned citizens were incorporated by meeting with several individuals at the beginning of the update so that Wittman could understand the issues surrounding the CAPP and associated regulations.

For the current update, the Intergovernmental Steering Committee between the City of Laramie and Albany County has been the nexus of CAPP planning. The Intergovernmental Steering Committee was created by an August 3, 2021, Memorandum of Understanding between the Albany County Commissioners and the City of Laramie, and consisted of City and County representatives, including Commissioner Sue Ibarra and Council Members Erin O’Doherty, Pat Gabriel, Sharon Cumbie, and Micah Richardson. The committee was established to oversee project consultant selection and to provide oversight to City and County staff who would then facilitate their direction through the public process and then on to the City and County Planning Commissions and the EAC. The committee worked directly with Stantec, and this approach facilitated interaction and discussion between the various entities to benefit the overall CAPP update.

2.2.1 HISTORY OF COMMUNITY OUTREACH AND EDUCATIONAL ACTIVITIES

Historically, the City of Laramie’s Utility Division Manager and the EAC have been involved in outreach and educational activities to promote the importance of protecting and conserving our groundwater resources. Following is a list of these activities.

- Six different brochures relating to the Laramie Regional Drinking Water Protection Program (LRDWPP), water conservation, septic system maintenance and the household hazardous waste collection (HHWC) program were distributed throughout the community.
- A LRDWPP logo was designed and used on all outreach material.
- T-shirts and hats were printed to promote the HHWC program.
- Bookmarks with a list of ten ways to conserve water and to protect groundwater were distributed to school-aged children at the Albany County Public Library.
- A site-specific Laramie-area poster showing the aquifer recharge area and information about the Casper Aquifer was designed and distributed throughout the community and schools.
- A tri-fold poster board describing the LRDWPP and water conservation programs was displayed in City Hall, the Albany County Courthouse, and the Albany County Public Library and at various venues throughout the community.
- The EAC purchased a groundwater model which simulates the Casper Aquifer and shows how the aquifer could be potentially contaminated by wells, septic systems and/or a hazardous material spill on Interstate 80.
- The EAC promoted the LRDWPP during National Drinking Water Week, Earth Day celebrations at the University of Wyoming (UW), the City Summer Safety Fair, the Agriculture Expo Community Night, and through a mini-water festival at the local “Freedom Has A Birthday” Celebration on the 4th of July.

- Several workshops were held to promote water-wise landscaping principles and on water quality and septic system maintenance. A water-wise landscaped garden was planted at the Albany County Public Library in 2001.
- Newsletters about the LRDWPP have been mailed out to the community in the City's utility bills.
- Annual consumer confidence reports are mailed to the community in the City's utility bills. A citizen survey about our drinking water supplies was mailed with the consumer confidence report in 1999.
- Regular press releases or public service announcements are issued when there are hazardous materials spills on Interstate 80.
- Two public-service-announcement videos, shown on the local cable television channel, highlighted the need to protect and conserve our drinking water. The videos were developed in cooperation with the UW Broadcasting Class and the UW Television Department.
- From 1998-2002, 38 press releases were published in local papers relating to groundwater protection and the CAPP.
- Over 30 presentations have been given to local service organizations (i.e. Kiwanis, Lions, Rotary, Soroptimist, the League of Women Voters), to elementary schools, to various University of Wyoming natural resource and geology classes and to the City Council, County Planning and Zoning Commission, City Planning Commission, and to the Albany County Board of Commissioners.
- The EAC participated in the Annual Children's Water Festival in Casper, WY (1999-2001).
- Since 2008, the City has done presentations and speaking engagements to numerous civic groups and other interested organizations, as well as to City Council. There have also been several joint City/County CAPP meetings with elected officials.
- Since 2008, the County has also done presentations concerning septic systems, and has provided educational information about wastewater systems in the aquifer protection area.
- The County wastewater engineer has also held seminars about septic system installations in the area.
- After the County's adoption of the CAPP in 2011 and updates to its regulations, landowners were sent information about the changes, a public meeting was held, and pamphlets were created to distribute to the public.
- Typically, the City and County have done a lot of public outreach when a controversial project is presented to the governing agencies. Since 2017, City and County officials have specifically assisted elected and appointed representatives regarding land use practices potentially impacting aquifer water quality.

The City and County recognize the value of raising awareness as a key factor in aquifer protection. The City of Laramie is a member of both the National Groundwater Association and the Wyoming Groundwater Association. One goal of the National Groundwater Association is to promote confidence in sustainable groundwater resources for domestic, municipal, industrial, ecological, and agricultural uses. Similarly, the Wyoming Groundwater Association is dedicated to the continued use and conservation of groundwater.

2.2.2 COMMUNITY-BASED AQUIFER PROTECTION EFFORTS

In addition to the City and County's community outreach and educational activities, community- based citizen groups have formed to support and advance aquifer protection and education. These groups attest to the high-level of community interest and active involvement in aquifer protection.

Albany County Clean Water Advocates (ACCWA)

Founded in 2008, ACCWA is a non-profit organization dedicated to preserving the high quality and abundance of Laramie-community water supplies through education, advocacy, and the application of science-based decision making. This citizen group participates in and supports governmental efforts regarding land-use regulation and planning and is active in citizen education regarding the Casper Aquifer at public events, field trips, and via a website containing a digital library of published information on the aquifer. Information on ACCWA can be found at the http://albanycountycleanwateradvocates.org/ website. Also found at the website is an ACCWA funded and produced 7-minute educational video on the Casper Aquifer.

Pilot Hill Project

The Pilot Hill Project began in 2017 with the express purpose of providing recreational opportunities, wildlife habitat preservation, and aquifer protection via the acquisition of nine square miles of land on the west flank of the Laramie Range between the east edge of Laramie and the National Forest at the crest of the range. To enhance the experience of hikers and bicyclists using the trails, the project includes educational information on the Casper Aquifer at the trailhead kiosk. Information on the Pilot Hill Project can be found at the https://pilothill.org/ website.

Jacoby Ridge Rural Trail

In 2020, a 2.3-mile rural walking/hiking/running trail was created on University of Wyoming property immediately east of the Red Jacoby Golf Course. Along the trail are interpretive stations that describe the flora/fauna/geology of the area including aspects of the Casper Aquifer and Satanka Shale (confining layer) that can be seen along and east of the trail.

Casper Aquifer Protection Network (CAP Network)

CAP Network is a citizen group founded in 2010 comprised of private well owners located in the Casper Aquifer Protection Zone, primarily in the Sherman Hills Estates Subdivision immediately east of Laramie. CAP Network educates rural property owners regarding aquifer protection via wellhead, pump, and septic tank maintenance, water quality testing, water level monitoring, and use of best management practices. CAP Network provides educational information on the Casper Aquifer at public events. As stated on the CAP Network newsletter header, its general mission is "Preservation of clean, safe groundwater, now and for generations to come, while retaining our property rights." A website is not available for this organization.

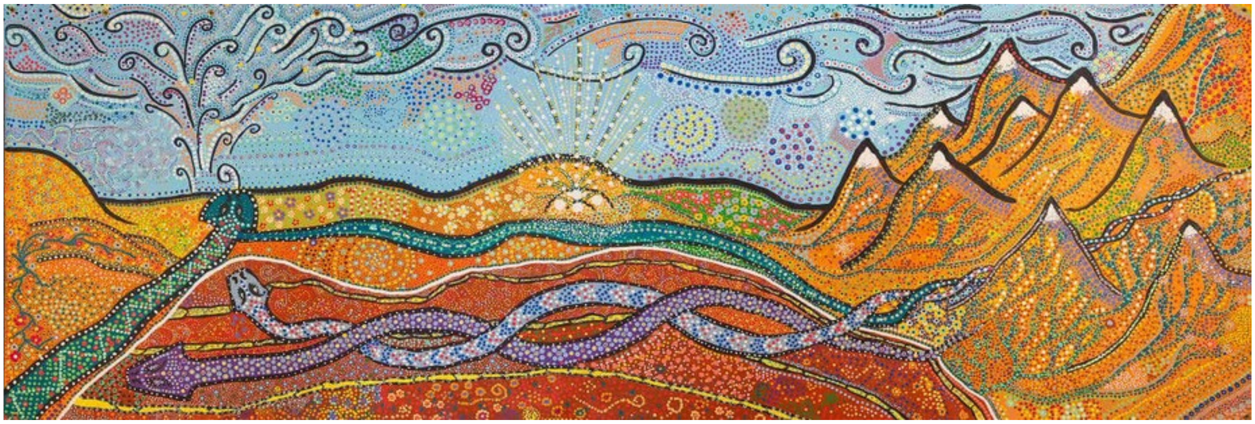
Laramie High School Mural Project (LHSMP)

Beginning in 2018, the LHSMP has created four 12 x 5-foot murals, inspired by indigenous wisdom of "Caring for Country", that illustrate Laramie's "water story" focusing on the Laramie-area community's relationship to the land, Laramie River, and Casper Aquifer. These murals are designed by Laramie High School students in collaboration with scientists, teachers, artists, and students. The murals are painted by LHS students, UW Shepard Symposium participants, and the general public. The mural process supports educational achievement standards in visual, language & performing arts, theater, social studies, science, geography, and STEAM elements. This "art meets science" opportunity for K-12 students is an outstanding example of individuals applying innovative methods and venues for community outreach and aquifer education.

An offshoot of the mural project is the creation of water education curriculum for use by K-12 teachers, and aquifer field tours for students, adults, and educators to facilitate "Caring for Country" and aquifer education.

"Pilot Hill Rainbow Story" - This mural is a symbolic topographical map of our Albany County region telling our unique "water story".

Looking east from Laramie (large central blue circle) towards the Laramie Range (top red section), we celebrate our Pilot Hill Recreation Area, a regional treasure shown in the central dark brown/purple area. These 7,000 acres sit on and protects 13% of our precious Casper Aquifer recharge zone represented in the center gold section. This is the slope of the Laramie Range as you look East. Rain & snowfall (blue dot circles) collects and seeps underground through the blue drainages, flowing downhill in the dark, it emerges in our numerous springs and wells, the smaller blue circles. From T to B we have the 2 Spur wells, 2 Turner wells of the City Springs area, historic Telephone Springs, Pope Springs, and Soldier Springs. These Casper Aquifer fed springs and wells gift our community with 50% of our water. From the Laramie High School Mural Project 2018-2021.



"Gem City Rainbow Story" - When the Railway surveyors looked down from the Laramie Range on our future possible town landscape, they witnessed the sparkling lights of our special natural springs dotting the valley floor. Inspired, they named Laramie, the Gem City of the Plains. This mural features Laramie's world class Casper Aquifer that provides 55% of our water; City Springs in the center; Spring Creek flowing into the Laramie River to the L; and the water evaporation cycle. From the Laramie High School Mural Project 2018-2021

2.3 FUTURE WORK OF THE EAC AND CITY/COUNTY STAFF

It is recommended that the City and County appoint staff persons to new positions to implement the CAPP. Each staff person can oversee the implementation of the CAPP and allow coordination between the City and County governments and ensure that implementation for City and County issues can be addressed. The assigned staff would become the primary contact for all CAPP duties at the City and County such as educational outreach, public/agency inquiries, implementation, periodic plan updates, staff review of site-specific investigations, assisting Planning staff with land development proposal reviews, coordination of consultants hired to review site-specific investigations, and oversee studies related to the CAPP. The EAC will continue to advise and support the work of the assigned staff and implementation of the CAPP.

During the drafting of the original CAPP, the EAC outlined the following goals to implement the CAPP:

- Expand and intensify the public education and outreach efforts;
- Design and implement a groundwater monitoring network; and
- Expand our understanding of how the Casper Aquifer is recharged through more fieldwork and research projects in collaboration with the University of Wyoming, the Wyoming Geological Survey, and the WDEQ.

An extensive campaign of public outreach efforts has been and continues to be successful. While large scale sampling events are unlikely to recur, a groundwater monitoring network has been established and additional funding is being set aside to expand that network. Numerous projects have occurred pertaining to the third goal of more research and collaboration and are part of the reason for the timing of this current update.

Throughout the rest of this document are recommendations that should guide City and County staff through the implementation process. It is imperative that City and County officials and staff continue to work with the stakeholders, local government officials, local experts, and the University of Wyoming to protect the Casper Aquifer. Utilizing all resources, the community has to offer will provide complete implementation and greater assurance that the community will accept and adopt the CAPP.

2.4 REVISING AND UPDATING THE CAPP

Because land use planning is dynamic and evolving, it is understood that the CAPP may be subject to periodic change to make it more useful to the community. The Wyoming WHP Program Guidance Document envisioned that a local Wellhead Protection Plan (i.e. CAPP) be reviewed and, if necessary, updated every two years. The Wyoming Source Water Assessment and Protection Program recommends updates every two years, or whenever significant changes to the public water system occur, i.e. a water source is added or removed; significant development within the source water area occurs; land use changes within the source water area are made; or remediation of contaminant sources is completed (WDEQ, 2000). WDEQ currently has no formal timeframe for revisions, nor authority to require completion of wellhead or aquifer protection plans, and instead encourages water systems to stay engaged with the public over the need for protecting drinking water supplies. Due to differences between the City and County CAPPs, and the large amount of hydrogeologic information acquired since the 2008 and 2011 CAPP updates, Albany County and the City of Laramie decided to hire hydrogeologic consultants to complete the 2023 update. In the future, the County and City will determine the most efficient and effective way to update the CAPP and may use any combination of County and City staff, consultants, and volunteers. Public meetings should always be part of the update process to get all possible relevant input for each update to the CAPP.

The CAPP should be updated and revised whenever new information relating to contaminant sources (existing and potential), contaminant risk and loading rate changes, aquifer characteristics, well construction, source management approaches, or contingency planning becomes available. Significant technical changes to the delineation of the Casper Aquifer Protection Area boundaries should be reviewed by Wyoming licensed professional geologists and approved by the governing bodies of the City and/or County. The CAPP should be revised periodically and when new information related to the following can be included:

- Hydrologic and hydrogeologic characteristics of the Casper Aquifer;
- Changes in water supply or pumping volumes;
- New potential sources of contamination;
- Significant changes in land use within the source water protection area for the Casper Aquifer;
- Planning or development of new water supplies;
- Changes in potential contaminant sources or loading rates, or the threat posed by potential contaminants;
- New aquifer management strategy creation or implementation; and

- Contingency planning and emergency response.

City of Laramie ordinances and Albany County resolutions should be reviewed, amended, and approved as needed to reflect the recommendations provided in the CAPP. Amending the ordinance or resolution does not require the CAPP to be revised.

Following all required public notice requirements, the revised CAPP will be formally presented to the Albany County Planning Department, City of Laramie Planning Division, Albany County Planning and Zoning Commission, City of Laramie Planning Commission, City of Laramie/Albany County Environmental Advisory Committee, the Board of County Commissioners, and the Laramie City Council. The County and City staff will provide recommendations to the Albany County Planning and Zoning Commission and Laramie Planning Commission, respectively. The Albany County Planning and Zoning Commission and Laramie Planning Commission will provide a recommendation to the respective County Commissioners and Laramie City Council. The County Commissioners and City Council will then approve or deny the revised CAPP.

3 Hydrogeologic Setting of the Casper Aquifer

3.1 GEOLOGY, STRUCTURE, AND HYDROSTRATIGRAPHY OF THE LARAMIE AREA

The basic geology of an area is described by the structure and stratigraphy of the rocks. Structure refers to the distribution of rock units on the ground surface and in the subsurface. This distribution is determined by the original processes of rock formation and by later events that move and deform the rock. Stratigraphy refers to the composition and sequence of the rock units. Together, structure and stratigraphy define the framework of earth materials that control the occurrence and movement of groundwater.

Structurally, the City of Laramie including its municipal wells and springs is located within the Laramie Basin. This basin is a broad, north-plunging, asymmetrical syncline that is bounded on the west by the Medicine Bow Mountains, on the north by a series of anticlines, and on the south by the Front Range. To the east the Basin is bounded by the Laramie Range, which lies immediately east of the Laramie city limits. The Range was uplifted by compressional forces during the Laramide Orogeny between 75 and 50 million years ago. In the Laramie area, this uplift resulted in generally uniform stratigraphic dips of between 3 and 5 degrees to the west, with the rocks striking nearly north-south. However, the uplift was not entirely uniform and faults and folds locally interrupt the dip regime (Lundy, 1978).

3.1.1 STRATIGRAPHY

Several geologic formations or units are present in the Laramie area. A formation is a lithologically distinctive rock unit that is sufficiently thick and laterally continuous to be mapped. Formations and units pertinent to the delineation of the CAPA include the geologic units from the Sherman Granite upwards to the Satanka Shale (Figure 3-1). The following provides a summary of these units.

3.1.1.1 PRECAMBRIAN ROCKS

The Precambrian Sherman Granite is a medium to coarse crystalline igneous rock which is predominantly exposed east of the crest of the Laramie Range (Figure 3-2). It was formed by the slow cooling of magma (liquid rock) and is a large mass of interlocking minerals. Other Precambrian rocks in the Laramie area include granite, gneiss, anorthosite and gabbro which are intruded by the Sherman Granite. These rock types are in contrast with the overlying formations that are layered sedimentary rocks derived from chemical precipitation and deposition of detrital material.

3.1.1.2 FOUNTAIN FORMATION

The Pennsylvanian Fountain Formation is an irregularly distributed sedimentary rock unit which is thin (less than 50 feet thick) to absent in the Laramie area but thickens to the south (Lundy, 1978; Ver Ploeg, 2007b). It is comprised of continental, arkosic sandstone with minor amounts of siltstone. Where the Fountain Formation is present, it overlies the Precambrian rocks. Because the unit is not laterally continuous across the protection area, it is grouped with the overlying Casper Formation, where it is present.

3.1.1.3 CASPER FORMATION

The Pennsylvanian-Permian Casper Formation overlies the Fountain Formation, where the Fountain is present, or the Precambrian basement rocks, where the Fountain is absent. The Casper Formation is approximately 700 feet thick and is composed of marine and eolian sandstones interbedded with marine limestone and minor amounts of shale (Figure 3-1). Sandstone comprises approximately 85% of the total thickness with limestone comprising most of the remaining 15% of the lithology. The Casper Formation is informally subdivided, from bottom to the top, into five members, designated alpha, beta, gamma, delta, and epsilon. Each member consists of a primary sandstone layer commonly bounded at the top by a regionally continuous limestone (Lundy, 1978; Ver Ploeg, 2009). The epsilon member does not have a limestone caprock at the top, and the other sandstone members also have limestone interbeds.

The Casper Formation is exposed at the surface on the western slope of the Laramie Range, east of the City of Laramie (Figure 3-2). In the vicinity of Laramie, the outcrop is approximately four to five miles wide and dips 3 to 5 degrees to the west, placing it beneath younger strata across most of the Laramie Basin.

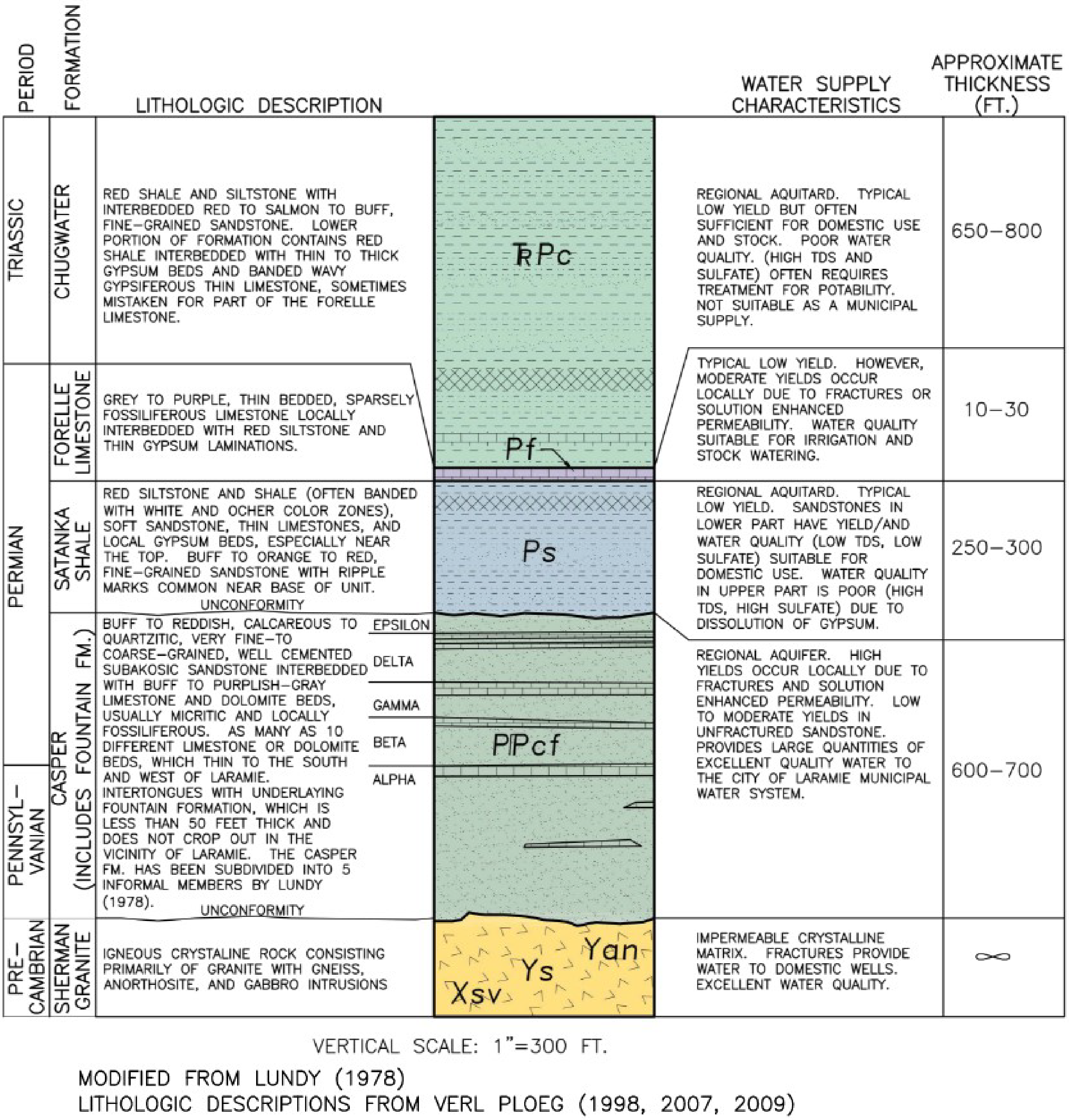
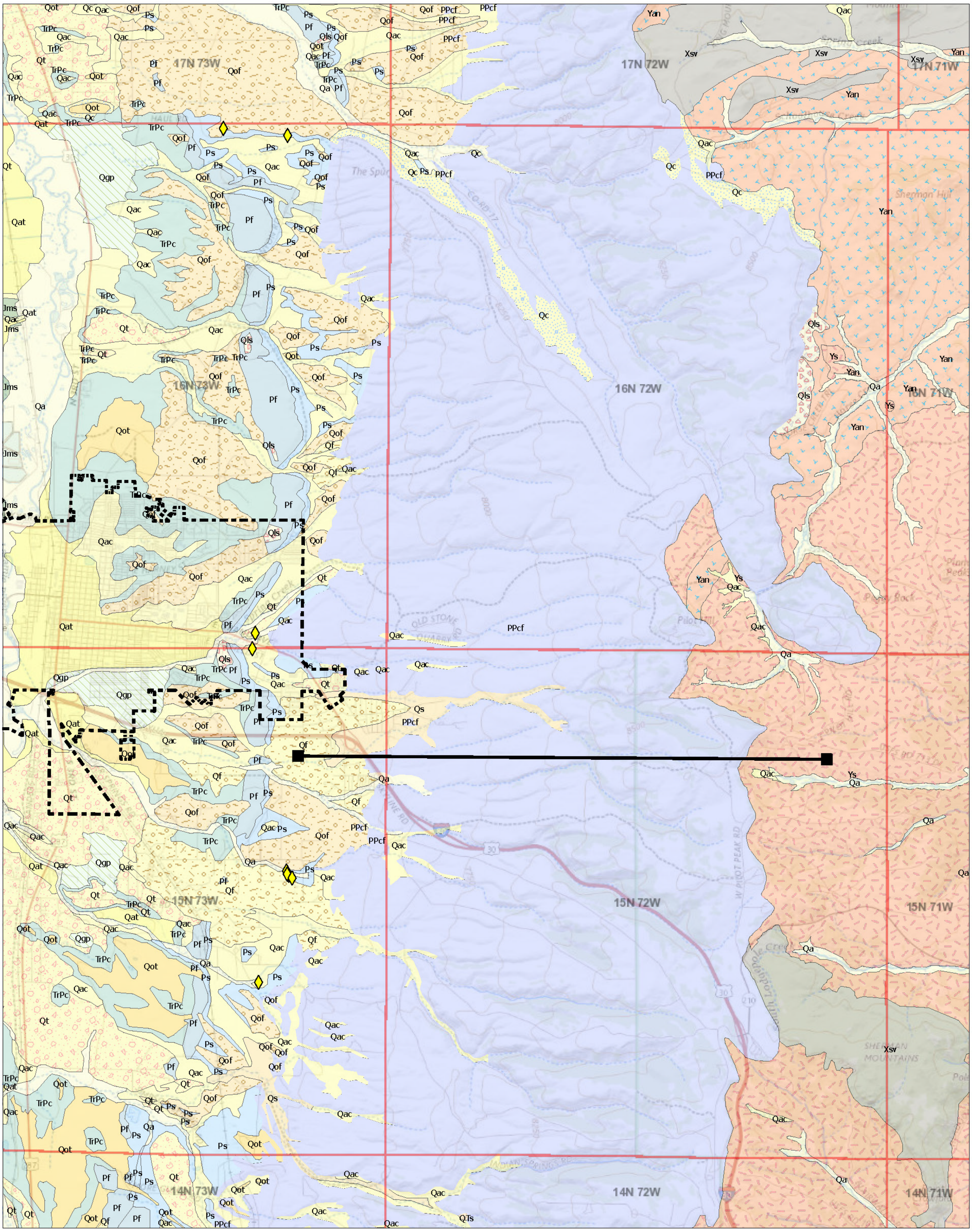


Figure 3-1: Stratigraphic Column of Units Relevant to the Casper Aquifer Protection Area Delineation.



Legend

City of Laramie Municipal Wells
Cross Section
Municipalities

Geology Units

- Qa - Alluvial deposits
- Qat - Mixed alluvium and terrace deposits
- Qs - Wind-blown deposits
- Qc - Colluvium
- Qac - Mixed alluvium and colluvium
- Qf - Alluvial fan deposits
- Qt - Terrace deposits
- Qls - Landslide deposits
- Qgp - Gypsite deposits
- Qof - Older alluvial fan deposits
- Qot - Older terrace deposits
- QTs - Wind-blown deposits
- Jms - Morrison and Sundance formations undivided
- TrPc - Chugwater Formation
- Pf - Forelle Limestone
- Ps - Satanka Shale
- PPcf - Casper and Fountain formations, undivided
- Ys - Sherman Granite
- Yan - Laramie Mountains anorthosite and norite
- Xsv - Metasedimentary and metavolcanic rocks

0 0.6 1.2 Miles
(At original document size of 11x17)
1:76,483

N

Wyoming
Albany County

Notes
1. Coordinate System: NAD 1983 StatePlane Wyoming East FIPS 4901 Feet
2. Data Sources: USGS, Ver Ploeg and Boyd (2007)
3. Background: USGS 7.5 Minute Quadrangle

Stantec

Project Location
T16N, R73W
Laramie, Albany Co., WY

Prepared by KAB on 2022-05-12
TR by XXX on 2020-XX-XX
IR by XXX on 2020-XX-XX
227704690

Client/Project
City of Laramie/Albany County
Casper Aquifer Protection Plan Update

Figure No.
3-2

Title
General Outcrop Area of the Casper Aquifer

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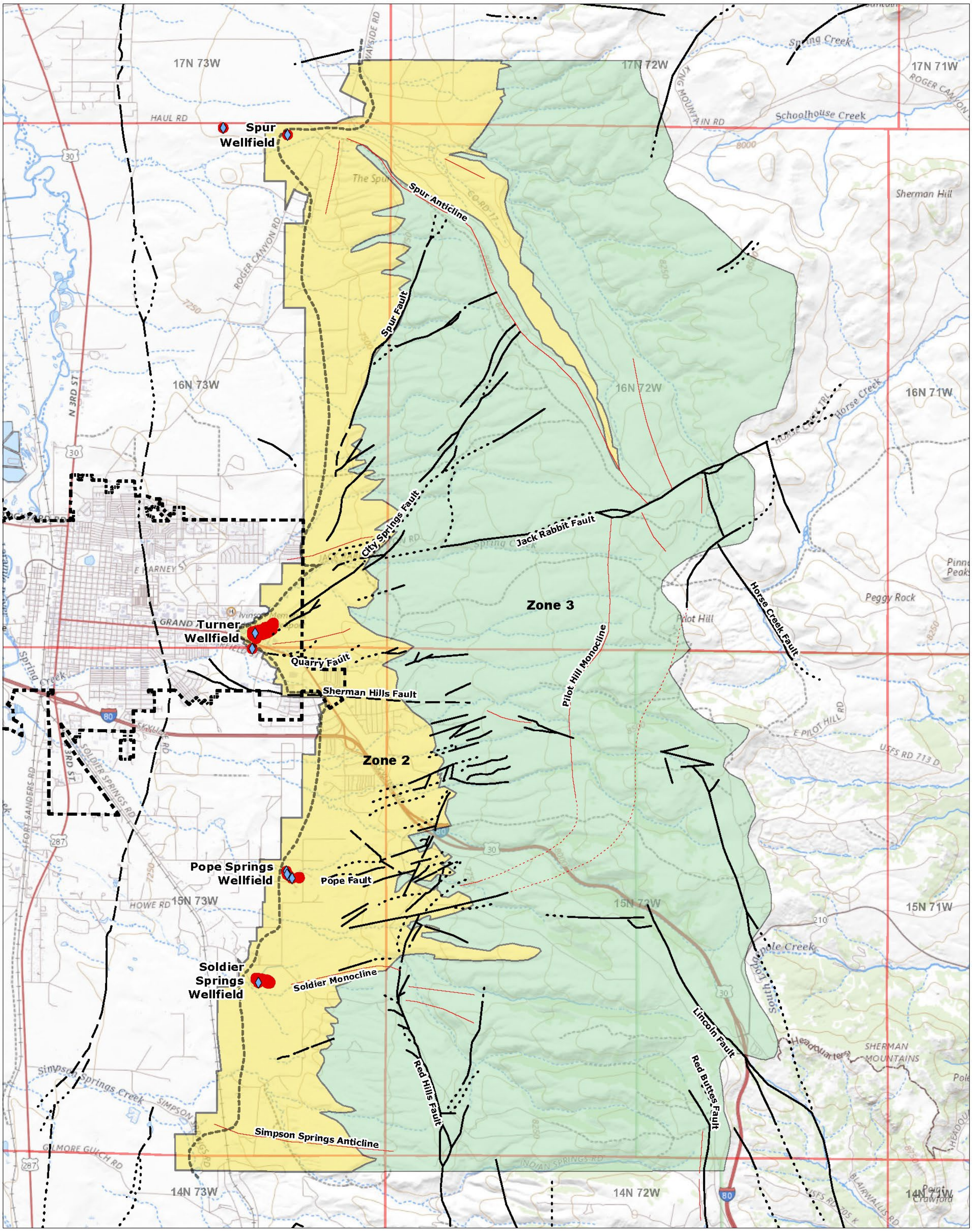
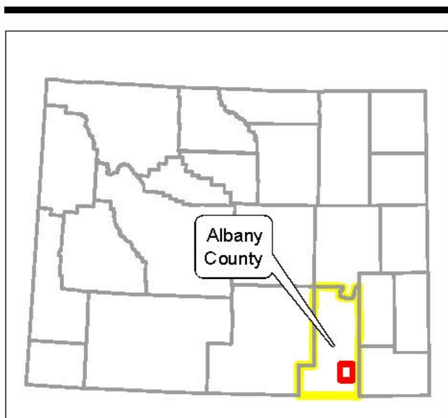
3.1.1.4 SATANKA SHALE

The Permian Satanka Shale overlies the Casper Formation and is predominantly red siltstone and shale with interbedded thin limestone, gypsum, and sandstone layers (Ver Ploeg, 2009). The Satanka Shale is not present directly along the west flank of the Laramie Range but begins to overlie the Casper Formation near the eastern corporate limits of the City and increases in thickness moving west, reaching up to approximately 250 to 300 feet thick beneath most of Laramie. The Satanka Shale thins to a thickness of 140 to 200 feet to the north and south (Ver Ploeg, 2007a, 2007b). The lower 20 to 30 feet of the Satanka Shale has several red and white sandstone beds, which are lithologically similar to the sandstones of the underlying Casper Formation (Wittman, 2008).

3.1.2 STRUCTURAL FEATURES

Mapped structural features and municipal wellfields in the vicinity of the City of Laramie are shown on Figure 3-3.





Legend

- City of Laramie Municipal Wells
- Municipalities
- PLSS Township
- Protective Satanka Shale Thickness
- CAPA Zone 1
- CAPA Zone 2
- CAPA Zone 3
- Fold
- Fault

0 0.6 1.2 Miles

(At original document size of 11x17)
1:76,406

N

Notes
1. Coordinate System: NAD 1983 StatePlane Wyoming East FIPS 4901 Feet
2. Data Sources: USGS, Ver Ploeg and Boyd (2007), Ver Poeg (2007a, 2007b, 2009)
3. Background: USGS 7.5 Minute Quadrangle

Stantec

Project Location
T16N, R73W
Laramie, Albany Co., WY

Prepared by KAB on 2023-02-15
TR by XXX on 2020-XX-XX
IR by XXX on 2020-XX-XX

Client/Project
227704690
City of Laramie/Albany County
Casper Aquifer Protection Plan Update

Figure No.
3-3

Title
Mapped Folds, Faults and Drainage within the Casper Aquifer Protection Area

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3.1.2.1 FAULTS

There are two primary fault types in the Laramie area. The apparent oldest set of faults is the reverse faults and monoclines, which were associated with the compression and uplift of the Laramie Range. There are also normal faults, with associated folds, which were formed by extensional stress. Lundy (1978), Ver Ploeg (2007a, 2007b, and 2009), Ver Ploeg and Boyd (2007), and McLaughlin and Ver Ploeg (2009) have mapped the locations of faults in the Laramie area. Mapping of local faults continues through the efforts of the Wyoming State Geological Survey.

In most cases, the structural features observed in the Casper Formation originate from high angle faults in the Sherman Granite which propagate vertically through the Casper and, sometimes, into overlying formations such as the Satanka Shale (WWC Engineering and others, 2015). These faults and folds do not typically extend through the entire thickness of the overlying Satanka Shale. However, the Sherman Hill and Laramie Faults are exceptions, as offset lithologies indicate shearing through the entire thickness of the Satanka Shale and into the Chugwater Formation.

3.1.2.1.1 Reverse Faults

The Horse Creek, Red Hills, and Laramie Faults are all reverse faults. Lundy (1978) also indicates that the Spur and Pilot Hill monoclines are cored by reverse faults. These reverse faults were the result of northeasterly compressional stresses (Ver Ploeg, 1998, 2009). The reverse faults tend to have north to northwest trends and are steeply dipping. Reverse faults are usually offset and terminated by major normal faults.

Ver Ploeg (2009) has documented right-lateral strike-slip motion on the Red Hills Fault and has suggested that strike-slip motion on many of the Laramie area faults may be more prominent than previously thought. The offset along the fault planes range up to 250 feet and most of the faults have upward offset on the west side of the structure (Lundy, 1978). Folding of the sedimentary rocks extends away from the fault plane on the Horse Creek reverse fault to a distance of less than 50 feet (Lundy, 1978). The width of the deformation associated with the fault reportedly increases in some areas, but no widths are provided.

Recent evaluation of the Sherman Hills Fault at Imperial Heights Park indicated it is also a high angle reverse fault that is more accurately characterized as a fault zone. Upthrown to the north and downthrown to the south, the fault zone reportedly dips northward at an approximately 77º angle. At Imperial Heights Park, the north side of the fault has moved approximately 39 feet up relative to the south side of the fault. While the bedrock appears to be a coherent block north of the fault, the bedrock to the south appeared to be a zone of faulted strata based on geophysical and drilling data (Hinckley Consulting and Wyoming Groundwater, 2015). The width of the fault zone in this area has been reported to be approximately 200 to 300 feet across (Carr, 2014; Hinckley and Moody, 2015a; Wyoming Groundwater, 2017b).

3.1.2.1.2 Normal Faults

Several major normal faults are mapped in the Laramie area. These faults include the Lincoln, Soldier, Pope, Quarry, Jackrabbit, City Springs and Spur Faults. These major normal faults trend northeast to east-west. The faults were probably the result of the relaxation of the compressional stresses that formed the reverse faults (Ver Ploeg, 1998).

The displacement across the normal faults ranges from a few inches to as much as 200 feet (Lundy, 1978), with most of the faults having downward displacement on the south block (Ver Ploeg, 2009). The dips on the fault plane of the normal faults are steep, ranging from 60 to 80 degrees (Lundy, 1978). Lundy (1978) reports that rocks adjacent to the faults are folded in zones tens of feet wide and the offsets on the folds are approximately the same as the offset on the faults.

Numerous minor faults with small displacements and no apparent trends in orientation occur in the Laramie area and can easily be seen from aerial photos (i.e. limestone surfaces east of Pope Springs). Many of these are mapped; however, others may exist that are covered by Quaternary alluvial and colluvial deposits.

3.1.2.2 FOLDS

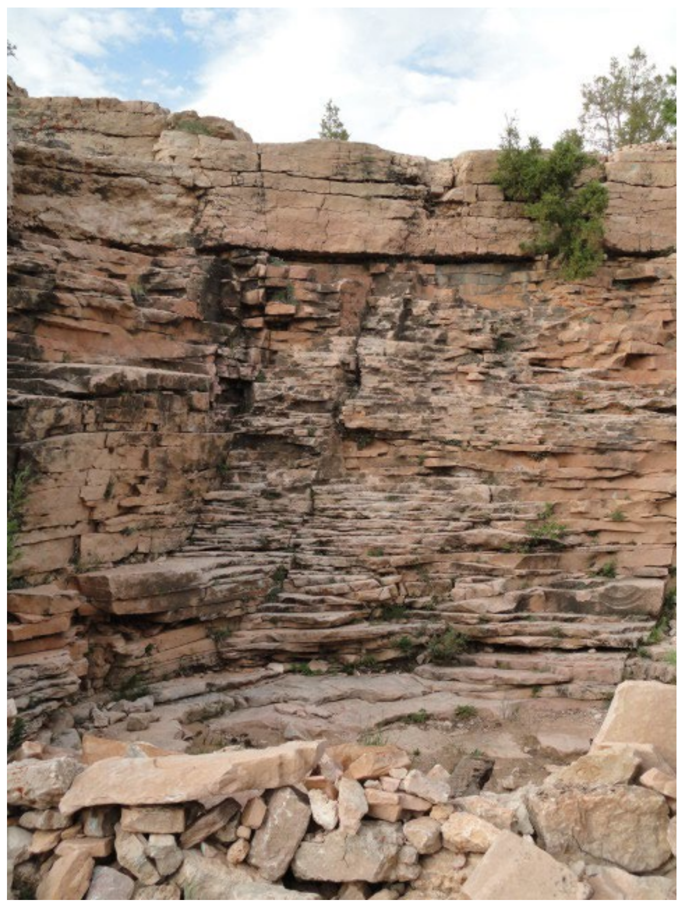
Folding in the Laramie area predominantly occurs as east-west trending, west-plunging anticlines and monoclines. The Simpson Springs Anticline and the Spur Anticline are examples of east-west trending folds in the Laramie area. There are also numerous folds mapped by Lundy (1978) and Ver Ploeg (1998, 2007a, 2007b, and 2009) that are associated with faults. These structural features include the Horse Creek, Jackrabbit, Soldier, and Quarry monoclines. Monoclines associated with the coring reverse faults are as wide as one mile and have structural reliefs that range from 300 to 700 feet. In addition, normal faults often grade laterally or vertically into synthetic folds that are tens of feet wide and have stratigraphic offsets equal to the displacements along the associated faults (Lundy, 1978).

Notice the faults and fractures in Casper Formation limestone exposed along the Quarry Anticline.

Folding of the Casper Formation has resulted in huge variations in aquifer permeability. The process of folding the rock typically results in fractures and fracture networks that preferentially enhance groundwater flow along the axis of the structure. Lundy (1978) noted that fracture permeability associated with faults extends the full length of any associated fold. The width of the fractured zone and associated enhanced permeability along the crest of each fold varies as a function of dip, tightness, and plunge. WWC (1993) reported that the width of the fracture zone can be quite variable, indicated associated fracture zones ranging from 100 to 300 feet wide, and suggested that adjacent rock can be relatively unfractured and undisturbed. Tight folds with steeper dips are likely to have a wider fracture zone along the crest than open folds with shallow dips. The distribution and lateral extent of fracturing associated with folds likely varies between or along structures and is not well understood on all structures in the Laramie area.

3.1.2.3 FRACTURES

Fracturing of the sandstone or limestone beds of the Casper Formation can have a significant impact on the overall permeability and groundwater flow through the aquifer. Fractures are cracks, joints, or other breaks in the limestone, sandstone, or other rock types that may or may not have visible, limited displacement. The permeability of these features depends upon whether the fracture is open or sealed, its opening width, its length, and its connection to other permeable features. Lundy (1978) noted that the density of fractures increased significantly near faults and folds which are prominent features within the recharge area of the Casper Aquifer. While fractures are typically associated with mapped faults and folds, they can be found virtually anywhere across the recharge area. Along with the faults or folds, the fractures resulted from the compressional or extensional forces associated with the Laramie Orogeny and uplift of the Laramie Range.



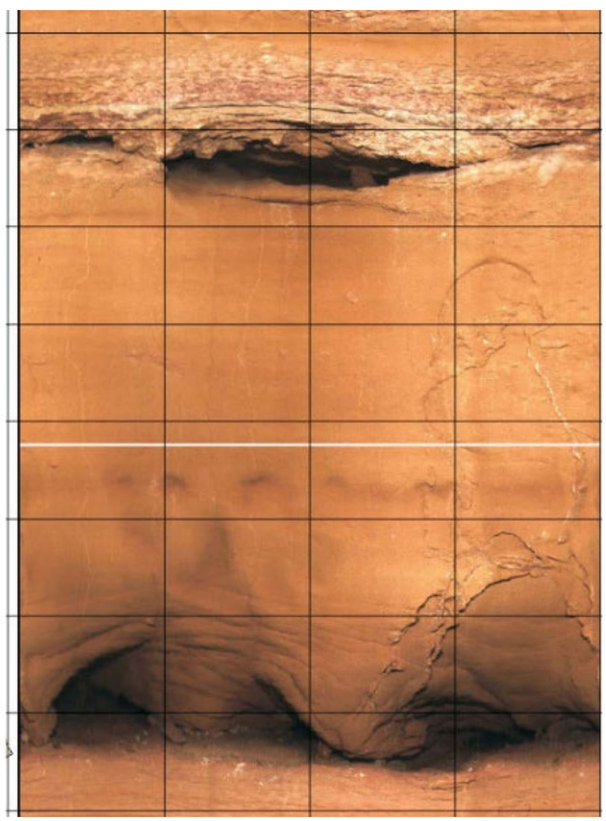
Horizontal and vertical fractures in Casper Formation sandstone below a limestone caprock.

While groundwater flows through the sandstones via intergranular permeability pathways, significantly greater volumes of groundwater can flow through the sandstone and limestone of the Casper Aquifer where interconnected fractures within the rock provide conduit flow. Fractures can transmit tremendous quantities of water, as demonstrated by municipal well production in fracture zones on the order of 1,000 to 2,000 gpm with 4 to 40 feet of drawdown. In many places, most notably at the Spur and the Turner wellfields, vertical fractures associated with faults and folds have disrupted the limestones and have hydraulically integrated the sandstones of all members. However, large contrasts in well productivity have also been observed over short distances where wells were not drilled and completed in the more productive fracture networks of the Casper (Hinckley and Moody, 2015a).

Vertical fractures play an important role in the hydraulic integration of the Casper Aquifer sandstone members and create local zones of high permeability, but may not be the primary reason for the high yields observed at the City's wells. Observations during drilling and/or downhole camera surveys at the Spur No. 1 and No. 2 wells, the Turner No. 1 and No. 2 wells, Soldier No. 1, and recently installed Casper Aquifer monitor wells indicate the presence of horizontal bedding plane fractures/openings within the sandstone and immediately above/below the sandstone/limestone contacts in the epsilon, delta, and gamma members. These horizontal fractures/openings in sandstone obviously play a major role in the high yields at municipal wells (Hinckley and Moody, 2015a).

3.1.2.4 BEDDING PLANES

Surface geologic mapping is largely blind to near-horizonal fractures (i.e. bedding plane fractures) which downhole videos have shown may provide important conduits for groundwater flow (Hinckley and Moody, 2015a). These bedding plane fractures can be enlarged through dissolution and piping of the lithology and through tectonic deformation of the clastic sandstones. Observations made during the drilling and downhole camera surveys at local wells indicate the presence of openings along these horizonal bedding planes, immediately above and/or below the sandstone-limestone contacts in the epsilon, delta, and gamma members of the Casper (Hinckley Consulting and Wyoming Groundwater, 2015).



This picture reveals how bedding planes appeared in the Imperial Heights South well (horizontal lines illustrate the depth interval in 0.5-foot intervals between 77.5 at the top of the image and 81.5 feet at the base).

3.1.2.5 SPECIFIC STRUCTURAL FEATURES

As early as 1947 the potential role of faults and folds in supplying groundwater to historic springs and municipal wellfields in the Laramie area was recognized (Morgan, 1947; Huntoon, 1976). The occurrence of springs and the large water production characteristics at each of the municipal wellfields are believed to be related to a particular fault, fold or fault/fold system. The discussion that follows provides a cursory overview of the faults and folds associated with the historic springs (City Springs, Pope Springs, and Soldier Springs) and municipal wellfields in the Laramie area.

The Spur Anticline is a northwest to southeast trending ridge located approximately 6 miles north and northeast of Laramie and has a northwest plunge. Dips on the north side of the anticline range from 30 to 50°, while the dips on the south side vary from 4 to 10° (WWC, 1997b; Ver Ploeg, 2007a). The anticline is cored by a high-angle reverse fault and has a stratigraphic displacement of Sherman Granite and the Casper Formation of up to 250 feet (Lundy, 1978). This structural feature was targeted by the City during development of the Spur Wellfield.

The City Springs Fault is a normal fault with downward relative displacement on the northwest side of the fault. The fault trends northeast-southwest and has measured stratigraphic displacements of between 20 and 150 feet (Lundy, 1978). The Spur Fault is a northeast- southwest trending normal fault. Displacement along the Spur Fault ranges from 50 to 200 feet, with the downward relative displacement being on the northwest side of the fault (Lundy, 1978). The Spur Fault intercepts the City Springs Fault approximately one mile northeast of the City Springs. Jackrabbit Fault is an east-west trending fault that grades eastward into a monocline. Downward displacement on the fault is to the south and ranges from 30 to 80 feet (Lundy, 1978). Jackrabbit and City Springs Faults intersect approximately two miles northeast of the City Springs. The Quarry Fault is also an east-west trending normal fault that is mapped as occurring in conjunction with a monocline (Lundy, 1978). The displacement of the fault is downward to the south and has a maximum displacement of 60 feet (Lundy, 1978). The western terminus of the Quarry and City Springs faults converge in the vicinity of City Springs and the Turner Wellfield.

The Pope Wellfield is located near the western end of the Pope Fault. Abundant small-scale fracturing associated with the fault is present in the Casper formation in this area. A small anticline parallel and to the north of the fault shows slight deformation in the range of 2 to 5 degrees (Ver Ploeg, 2009). The total displacement of the Pope Fault has not been measured.

The Soldier Fault is an east-west trending normal fault that grades into a monocline on its eastern end. The fault has a measured displacement of 40 feet downward on the northern side of the structure (Lundy, 1978) with dips of up to 51 degrees. The Soldier Spring and Soldier No. 1 well are located just west and to the north of this faulting and folding.

The existence of an unmapped north-south fault between the Pope Wellfield and Soldier Springs has been postulated (WWC, 1995) to explain the excellent hydraulic connection between these two locations. The postulated fault would be consistent with the orientation of the Red Hills Fault and Laramie Fault, which are north-south trending faults located to the east and west, respectively. A high-permeability feature in the Satanka Shale or an extensive horizontal fracture system in the Casper are also possibilities (Hinckley and Moody, 2015a).

All of these structural features combined result in a complete three-dimensional fracture network that affects groundwater flow through the Casper Aquifer. The complex fold and fault geometry associated with vertical or near vertical fracture zones is over printed upon horizontal bedding plane fracture surfaces. Combined with local topographic lows, all of these features result in springs along the western margin of the recharge area. The following sections expand upon the hydrogeologic implications of these features.

3.1.3 HYDROSTRATIGRAPHY

The stratigraphy of an area can be further defined in relation to the ability of formations to store and transmit groundwater. The term "formation" is used in this report to describe the lithologic materials that comprise a geologic unit. Additional terms such as aquifer, aquitard, aquiclude, and confining layer can also be used to describe and define the hydrostratigraphy of an area.

The term "aquifer" is used to describe a formation, group or formations, or part of a formation that contains saturated permeable material able to yield sufficient quantities of water to wells and springs to constitute a useable supply. Although this definition can be interpreted to include only the saturated portion of a formation, aquifer characteristics, as used in this report, include the water bearing or transmission properties of the entire hydrostratigraphic formation, even where it is only partially saturated.

Aquitard:
The less-permeable beds in a stratigraphic sequence that tend to restrict or impede groundwater flow relative to the more permeable beds that serve as aquifers.

Figure 3-1 provides a general description of the hydrogeologic role of the Sherman Granite, Casper Aquifer, Satanka Shale, and Chugwater Formation present near and within the Casper Aquifer Protection Area. Figure 3-4 presents the lithologic relationships of the Casper Formation sandstone and limestone interbeds to the overlying Satanka Shale and underlying Fountain Formation and Sherman Granite. The following sections provide a detailed description of the hydraulic role of the primary geologic units used in the delineation of the CAPA.

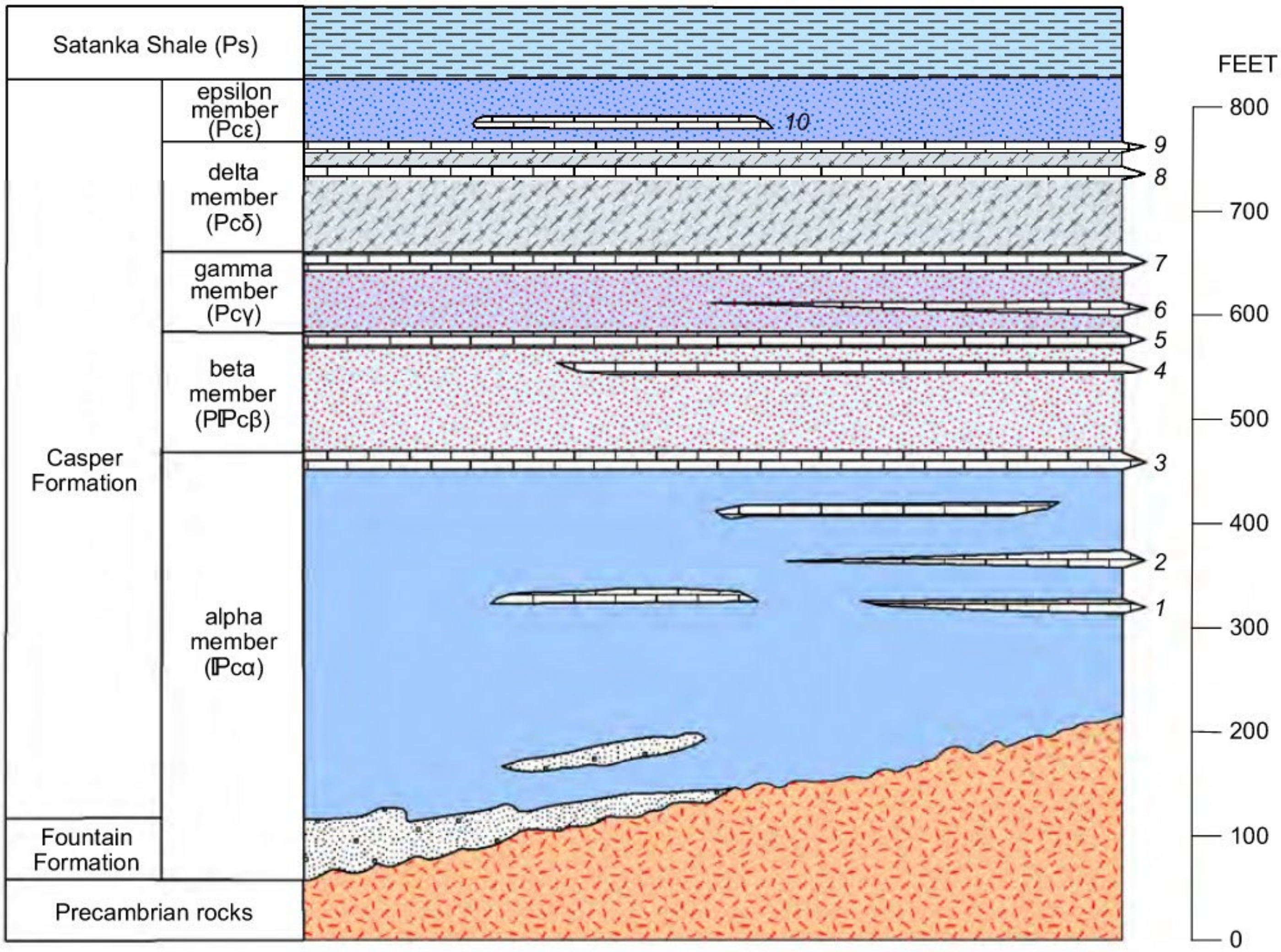


Figure 3-4: General lithology of the Casper Formation members and adjacent units present near and within the Casper Aquifer Protection Area. From Ver Ploeg (2009).

3.1.3.1 SHERMAN GRANITE

Unaltered Sherman Granite has practically no intergranular or intercrystalline permeability. Like most crystalline rocks, permeability within the Sherman Granite is limited to areas where the granite is extensively weathered and/or fractured by faults and joints (Richter, 1981). Groundwater movement within the Sherman Granite is typified by conduit flow (i.e. fractures). Many domestic wells obtain drinking water from the granite, but well yields are typically small and depend on the permeability of fractures. Short-term pump tests of wells completed in the Sherman Granite indicate that the minimum yield is zero, where the rocks are not fractured, and the maximum anticipated yield is approximately 20 gallons per minute (gpm) in weathered or fractured granite (Wyoming State Engineer Office records, various).

To date, there has not been a systematic study of the hydrogeology of the Sherman Granite and its hydraulic relationship to the overlying Casper Aquifer. Because of the much lower permeability and limited storage capacity of fractures in the Sherman Granite compared to the sandstones of the Casper Formation, the Sherman Granite is treated here as the lower confining unit of the Casper Aquifer.

If faults in the Casper Formation are continuous between the two units, there may be some hydraulic connection between them. Preliminary chemical analyses of strontium concentrations and isotopic ratios from groundwater within the Casper Aquifer suggest there may be some mixing of groundwaters of the Sherman Granite and the Casper Aquifer (Frost and Toner, 1996). It is believed that any hydraulic contribution from the Sherman Granite to the Casper Aquifer is minor due to the impermeable nature of the unfractured crystalline rock and the limited storage capacity of fractures where they occur in the granite. Therefore, the Sherman Granite is characterized as an aquitard or aquiclude.

3.1.3.2 SATANKA SHALE

The hydraulic relationship between the Satanka Shale and the underlying Casper Aquifer is a critical element in the delineation of a protection area for the Casper Aquifer. The hydrogeology of the Satanka Shale has not been studied in detail, but observations made during studies of the Casper Aquifer provide some data regarding the hydraulic relationship between the Satanka Shale and the underlying Casper Aquifer (Lundy, 1978; Huntoon and Lundy, 1979; WWC, 1993, 1994, 1997a, b; and Weston, 1995).

Taken in its entirety, the Satanka Shale is a regional confining layer overlying the Casper Aquifer particularly where it has not been disturbed by faults or folds. Approximately 140 to 300 feet of interbedded shale, siltstone, and sandstone of the Satanka Shale hydraulically separate the Casper Aquifer from overlying aquifers, including permeable beds within the Satanka Shale (Ver Ploeg, 2007a, 2007b; Ver Ploeg, 2009). The hydraulic head in the Casper Aquifer is typically 20 to 40 feet greater than the head in the permeable layers within the Satanka Shale (Wittman, 2008). The Casper Aquifer is effectively confined where overlain by a sufficient thickness of the Satanka Shale (JMM, 1989; WWC 1993, 1994, 1997a, b; and Weston, 1995). Hydraulic separation between the Casper Aquifer and permeable layers in the Satanka Shale has been documented during pumping tests conducted at the Spur Wellfield, LaPrele Park Prospect, and the Turner Wellfield, where no observable head declines occurred in the monitored intervals in the Satanka Shale as the Casper Aquifer was pumped (WWC, 1993, 1996, 1997a,b).

The Satanka Shale can be a source of water where it has not been disturbed. Permeable sandstones in the Satanka Shale provide water to many domestic and stock wells in the Laramie area. In addition, water quality in the lower-most sandstones of the Satanka Shale is very similar to water quality of the Casper Aquifer (WWC, 1994). Vertical flow from the Casper Aquifer into the overlying Satanka Shale occurs to some extent in all locations simply because the Satanka has some vertical permeability, and the hydraulic head of the Casper Aquifer is greater (Hinckley and Moody, 2015a). This lower section of the Satanka Shale is assumed to provide little to no protection to the Casper Aquifer.

Contact between the overlying Satanka Shale and Epsilon member of the Casper Formation.

Significant for the delineation of the CAPA is that interconnected fractures associated with faults and folds at some localities allow groundwater from the Casper Aquifer to flow upward through the lower Satanka Shale to land surface. These locations include City Springs, Pope Springs, Soldier Springs, and Simpson Springs. These discharge points are located where faults or folds and associated fractures provide conduits for groundwater flow through the Satanka Shale. The confining ability of the Satanka Shale at these locations has been compromised. The thickness of Satanka Shale that has been disturbed at each of these springs varies. At City Springs, groundwater flows upward from the Casper Aquifer through at least 74 feet of Satanka Shale when the Turner wells are not pumping. When the Turner wells are operating, the wells are capable of capturing all the natural discharge of the springs (Hinckley and Moody, 2015a). While they stopped flowing in 1934, Pope Springs used to flow from the Casper Aquifer through approximately 65 feet of Satanka Shale. At Soldier Springs, only 36 feet of Satanka Shale covers the Casper Aquifer at the Soldier No. 1 well. At Simpson Springs, groundwater from the Casper Aquifer appears to flow to the ground surface through approximately 115 to 125 feet of Satanka Shale based on test wells drilled into the Casper Aquifer (Weston Engineering, 2013).

Consequently, the thickness of Satanka Shale needed to protect the Casper Aquifer depends upon whether the shale has been disturbed by faults or folds. Because of the permeable sandstones and similar water quality in the lower Satanka Shale, it is assumed that the lower 50 feet of the Satanka Shale is in hydraulic communication with the Casper Aquifer where it is undisturbed. Because the protective benefits of the Satanka Shale start at 50 feet, at least 75 vertical feet of undisturbed Satanka Shale is needed to protect the Casper Aquifer from contaminants. However, in locations where the confining ability of the Satanka Shale has been disturbed or compromised through faulting and/or folding, the thickness of Satanka Shale needed to protect the aquifer must be increased based on local hydrogeologic conditions. The degree of confinement and protection both increase with greater thickness of the Satanka Shale.

3.1.3.3 CASPER AQUIFER

The Casper Aquifer is the hydrogeologic unit that supplies water to the drinking water wells and springs used by the City of Laramie and the domestic wells east of Laramie. Sandstones in the Casper Aquifer have large permeabilities compared to the overlying and underlying geologic units. The Sherman Granite provides an effective lower confining layer for the Casper Aquifer and the low permeability shales of the Satanka Shale provide an effective upper confining layer, where there is a sufficient thickness and no fracture conduit to land surface.

The Casper Aquifer is comprised of the saturated or partially saturated portions of the Casper Formation and does not include any portion of the overlying Satanka Shale, underlying Sherman Granite. The Casper Aquifer includes the five sandstone subaquifers termed the epsilon, delta, gamma, beta, and alpha members from the top down, and the interbedded limestones. Water is stored and transmitted primarily in the sandstones whereas the relatively impermeable limestones can function as aquitards between the sandstones (Hinckley and Moody, 2015a). The Casper Aquifer includes saturated or partially saturated portions of the Fountain Formation where it is present below the Casper Formation. Detailed stratigraphic relationships between the sandstone and limestones of this aquifer are presented on Figure 3-4.

3.2 HYDROGEOLOGIC CHARACTERISTICS OF THE CASPER AQUIFER

An expanded discussion of the hydrogeology of the Casper Aquifer is provided in the following sections.

3.2.1 EXTENT

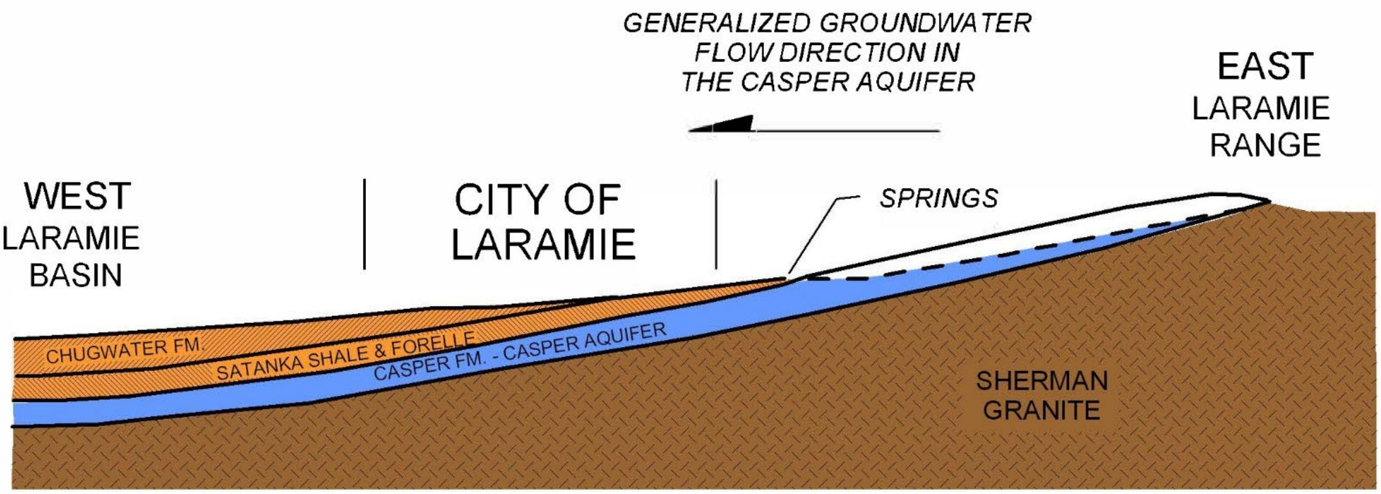
The Casper Aquifer exists where the Casper Formation is partially or fully saturated with groundwater. As shown in Figure 3-5, the upper part of the Casper Formation is unsaturated on the western slope of the Laramie Range. The saturated thickness of the Casper Aquifer generally increases from east to west. While the entire thickness of the Casper is not saturated except where it is confined by the Satanka Shale, there is some thickness of the Casper Formation that is saturated throughout the outcrop area. The Casper Aquifer therefore extends from near the crest of the Laramie Range towards the west into the

Laramie Basin. The aquifer reaches approximately 50 miles north-northwest of Laramie before it is interrupted by a thrust fault and, to the south of Laramie, extends past the Wyoming-Colorado border for a distance of at least 21 miles. For aquifer protection purposes, only the area thought to contribute groundwater to the wells and springs east of Laramie is relevant.

The Casper Aquifer is more deeply buried by the Satanka Shale, and overlying lithology, as one proceeds west from the Satanka and Casper contact. Assuming an average dip of 4°, the estimated depth to the top of the Casper Aquifer near the western city limits of Laramie is approximately 1,500 feet (Figure 3-5). While the Casper Aquifer is present throughout the Laramie Basin, the useful limit of the aquifer to the west can be defined using water quality cutoffs, above which the water is generally unsuitable for drinking water purposes and not suitable for municipal use. This boundary is considered coincident with the 1,000 milligrams per liter (mg/L) total dissolved solids (TDS) contour mapped by Richter (1981) which, in the vicinity of Laramie, lies approximately nine miles west of city limits. TDS refers to the sum of any minerals, salts, metals, cations or anions dissolved in water, and elevated TDS has negative implications for the drinkability of water.

3.2.2 SATURATED THICKNESS

The saturated thickness of the Casper Aquifer varies significantly across the aquifer. As shown in Figure 3-5, the minimum saturated thickness is nearly zero at the crest of the Laramie Range and gradually increases westward towards the contact of the Casper Aquifer and Satanka Shale. West of this contact the aquifer becomes fully saturated and the saturated thickness is 600 feet at some distance west of the Casper-Satanka contact, according to Thompson (1979), and 700 feet near the Spur Wellfield, according to WWC (1997). Deep canyons and elevated regions along the west flank of the Laramie Range result in local variations in saturated thickness.



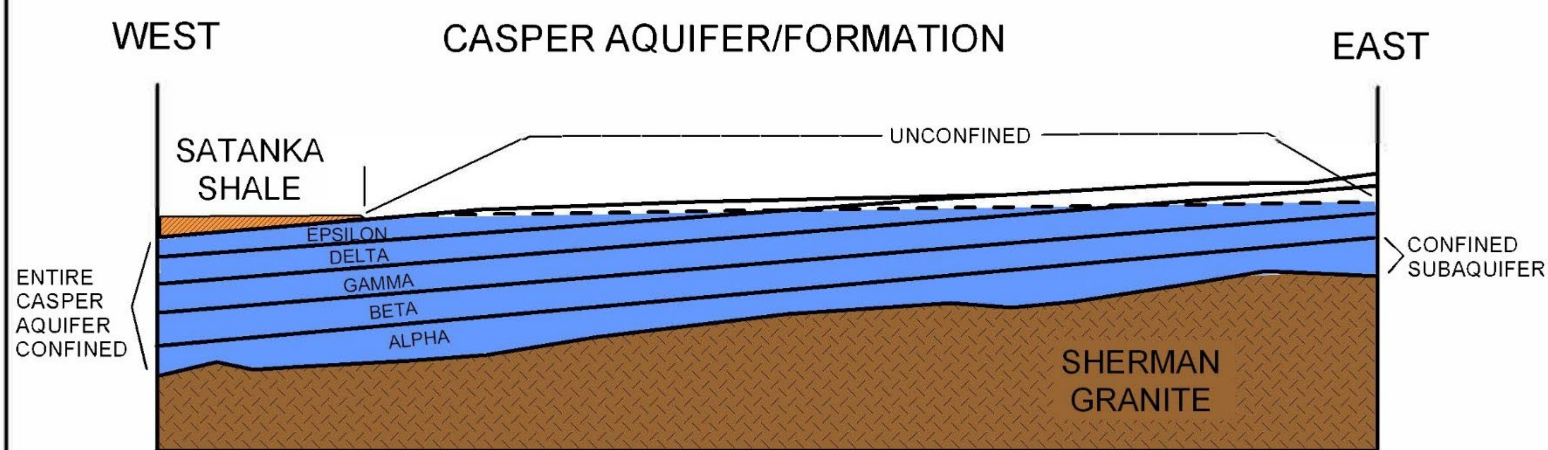
EXPLANATION

NOT TO SCALE

SATURATED CASPER FORMATION

UNSATURATED CASPER FORMATION

GENERALIZED CROSS-SECTION THROUGH THE VICINITY OF LARAMIE, WYOMING.
(SEE FIGURE 3-2 FOR CROSS-SECTON ORIENTATION)



EXPLANATION

NOT TO SCALE

WATER TABLE SURFACE (UNCONFINED AT THAT LOCATION)

SATURATED SANDSTONE IN CASPER FM.

LIMESTONE AQUITARD

UNSATURATED SANDSTONE IN CASPER FM.

GENERALIZED CROSS-SECTION SHOWING CONFINED AND UNCONFINED CONDITIONS IN THE CASPER AQUIFER.

Figure 3-5 General Schematic Cross-Sections

Casper Aquifer Protection Program
Adapted from: WWC (1993)

3.2.3 MEDIA TYPE AND GROUNDWATER FLOW CHARACTERISTICS

The Casper Aquifer is comprised of two media types: porous sandstone, and fractured sandstone and limestone. Groundwater flow within these materials includes both porous and conduit flow. Porous flow occurs within the permeable unfractured sandstone of the Casper Aquifer. Conduit flow occurs within the sandstones and limestones where the permeabilities have been enhanced by fractures and openings caused by folding, faulting, bedding plane partings and/or dissolution.

Porous flow refers to the flow of water through the pore space between individual sand grains and interstitial cement of a sandstone. The intergranular permeability of the sandstones that comprise the five members of the Casper Aquifer is variable, with the greatest permeability occurring in the epsilon and delta members and the lowest permeability in the alpha member. The variation is due to the well sorted and less cemented nature of the epsilon and delta members compared to the greater abundance of very fine sand, silt, and the calcite cement that fills the pore spaces in the lower sandstone members (i.e. beta and alpha). Intergranular permeability is responsible for providing water to wells on the order of 1 to 100 gpm.

Conduit flow refers to the flow of water through cavities, openings, or fractures associated with dissolution, faults, folds, joints, and partings along bedding planes. The permeability of cavities and fractures is orders of magnitude greater than intergranular permeability and is capable of yielding large quantities of water to wells, as demonstrated by the Laramie municipal water supply wells and associated springs. Production from the municipal wells that penetrate fractured Casper Aquifer is on the order of 1,500 to 2,500 gpm. These high-yield wells intersect fractures associated with faults, folds, and bedding planes that have deformed the Casper Aquifer. At the Spur and Turner wellfields, where the rocks have been extensively fractured, all members of the Casper Aquifer are hydraulically connected with each other through a vertical fracture network (Hinckley and Moody, 2015a).

"Rainbow Pathways" - A schematic cross-section through the Casper Aquifer that illustrates recharge, discharge, and groundwater flow paths. In our painting the "eye-ball of Rainbow" is our City Springs and the origin of Spring Creek. The black base layer is the Sherman Granite that contains our Aquifer water from going deeper. The salmon pink represents the "rock sponge" sandstone; the cream thin layers represent the cracked limestone; the earth red layer close to the surface represents the protective Satanka Shale that acts as a barrier to contamination for much of our City area. East of town this protective layer soon disappears, allowing for wonderful water absorption, but also major vulnerability to any possible contaminants.

We set our painting under the night sky to emphasize our Aquifer working for us 24 hours every day.

The stars represent the campfires of all our grandparents passed away, who are looking down, keeping watch, reminding us to care for our land and water. From the Laramie High School Mural Project 2018-2021.

Direct evidence exists of the presence and highly permeable nature of fractures in the Casper Aquifer at Laramie's wellfields. In the course of numerous water supply investigations, downhole camera surveys have been performed in wells at the Spur, Turner, and Pope Wellfields. Videos of open hole completions and observations during drilling in the Casper Aquifer at wells 1941 Turner No. 1, 1941 Turner No. 2, Turner No. 1, Turner No. 2, TW-1, Spur No. 1 and Spur No. 2 (WWC, 1995; WWC, 1996; Wyoming Groundwater, 2004, Hinckley Consulting and Wyoming Groundwater, 2015) demonstrate the presence of fractures in the subsurface of the Casper Aquifer, particularly large horizontal openings and fractures in the epsilon, delta, and gamma member sandstones. A salt tracer test and associated breakthrough curve conducted at the Turner No. 1 well demonstrated how rapidly groundwater can travel through fractures (WWC, 1993). The peak concentration of a dissolved saltwater plume traveled a distance of 147 feet in 12 minutes before arriving at the pumping well (Turner No. 1).

In 2004, the temporary removal of the turbine pump from the City's Turner No. 2 well provided an opportunity to perform a downhole camera survey of the well casing and open hole. The camera survey allowed a visual inspection of approximately 250 feet of lithology within the epsilon, delta, and gamma members of the Casper Aquifer. Large horizontal openings and bedding plane fractures were observed in the sandstones immediately above or below a limestone layer, and vertical fractures were observed in limestone (Wyoming Groundwater, 2004).

In 2010, the temporary removal of the turbine pump from the City's Turner No. 1 well provided an opportunity to perform a downhole camera survey of the well casing and open hole. The camera survey allowed a visual inspection of 135 feet of lithology within the epsilon and delta members. Fracture zones were observed primarily in the epsilon sandstone. Hydrogeologic features (i.e. horizontal openings and fractures) in the Turner No. 1 and No. 2 wells are similar.

It is reasonable to believe that production from the Turner No. 1 and No. 2 wells (i.e. 1,400 gpm) is primarily from the observed cracks, fractures, and openings in the sandstones, and that the horizontal fractures may extend some distance beyond the wellbore to hydraulically connect the well with other fractures networks and porous sandstones within the Casper Aquifer. The prevalence of horizontal fractures and openings in these two municipal wells suggest that the fracture system in the Casper Aquifer is more complicated than just the vertical fracture zones defined by individual or intersecting vertical features associated with mapped faults and folds.

3.2.3.1 POROSITY

The intergranular porosity of the rocks comprising the Casper Aquifer varies significantly. Lundy (1978) reports that the porosity of the well-cemented sandstones is approximately 22 percent, while the porosity of the epsilon sandstone ranges from 15 to 30 percent. The average porosity of the sandstones is 19 percent according to Lundy (1978). No porosity values are available for the limestones within the Casper Aquifer. The porosity is extremely low where the limestones are not fractured but secondary porosity does exist where they are fractured. WWC (1993) estimated that the average effective porosity of the fractures within the Casper Aquifer is 0.02 percent. Although fracture networks represent a very small percentage of whole rock porosity, interconnected fracture networks are capable of transmitting large quantities of water (see Table 3-1).

3.2.3.2 HYDRAULIC CONDUCTIVITY, TRANSMISSIVITY, AND STORATIVITY

Pump testing of wells completed in the Casper Aquifer in the Laramie area demonstrates that there are significant variations in the permeabilities of the sandstones comprising the Casper Aquifer. Table 3-1 shows the hydraulic conductivity and transmissivities reported in Lundy (1978). The most striking variation in the presented permeabilities are observed when comparing unfractured versus fractured aquifer media.

Table 3-1: Hydraulic Conductivity and Transmissivity of the Casper Aquifer. Data Source: Lundy, 1978.

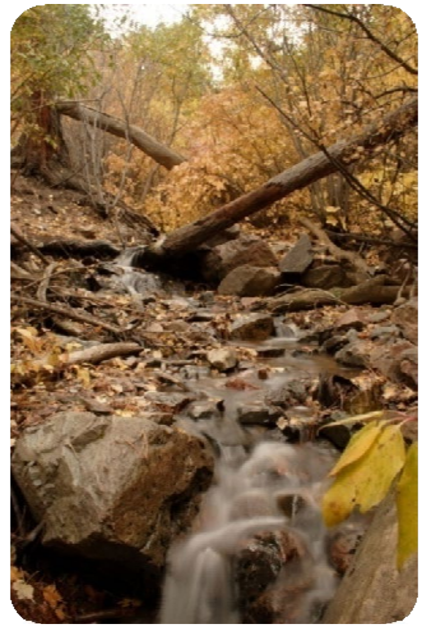
	Hydraulic Conductivity (Feet Per Day)	Transmissivity (Gallons Per Day Per Foot)
Epsilon member	1.3 to 2.6	600 to 970
Gamma member	1.5	435
Aggregate members (alpha through epsilon)	0.21 to 0.32	900 to 1,390
Aggregate members (gamma through epsilon)	0.11 to 0.13	315 to 375
Unfractured areas	0.10 to 2.6	135 to 970
Fractured areas	17 to 40	82,300 to 195,000

Testing of the Spur and Turner wells has indicated that aquifer properties tend to vary with direction. Testing of the Spur Wells by WWC (1997b) indicated that the transmissivity of the Casper Aquifer varied significantly over relatively short distances. Reported transmissivity values, calculated from drawdowns in monitoring wells located close to the Spur Anticline, varied from 1.4×10^5 to 6.4×10^5 gpd/ft. The testing indicates that the aquifer is highly anisotropic with the direction of greatest permeability oriented parallel to the crest of the Spur Anticline and with significant decreases in permeability short distances from the structure. Similarly, a pump test conducted at the Turner No. 1 well yielded a late-time hydraulic conductivity of 14 feet per day (transmissivity = 68,100 gpd/ft) from the observation well (WWC, 1993). Drawdowns in the surrounding monitoring wells during the test varied between 3 feet at a well located 3,200 feet south of the pumping well and 8 feet at a well located 2,500 feet southwest. The asymmetrical drawdown pattern likely reflects directional high-permeability (i.e. anisotropic conditions) present in the Casper aquifer (Hinckley Consulting and Wyoming Groundwater, 2015).

Storage coefficients for the Casper Aquifer are highly variable and are important for estimating how much water the aquifer may contain within the recharge area or confined region west of the Satanka Shale contact. Those reported by Lundy (1978) range from 0.001 to 0.006, which indicate confining conditions in the aquifer range from confined to slightly leaky. Pump test data at the Spur Wellfield indicate that the storage coefficient varies from 0.01 to 0.0091 (WWC, 1997b). However, the storage coefficient for the wells changed significantly with time during pumping, which may be the result of the effects of partial penetration or from varying degrees of interconnection via fracture systems. A storage coefficient was calculated by WWC from barometric efficiency data collected from the Spur Wellfield. The resulting storage coefficient was 5×10^{-4}, which indicates that the aquifer is confined at that location (WWC, 1997b). The fact that the static water level in the Spur wells is significantly above the top of the Casper Aquifer also provides evidence that the aquifer is confined at that location.

It has been clearly shown that aquifer permeability is enhanced in the area of municipal wellfields, all of which are associated with one or more structural features that impart a complex interconnected fracture network. Over a wider area of the CAPA, the precise character of permeability enhancement from fractures associated with faults, folds, and horizontal openings cannot be determined with certainty and may vary along a particular feature. Pumping tests conducted near specific faults, as well as more general hydrogeologic investigations conducted over wider areas with several faults, have indicated the presence of enhanced aquifer permeability. Recent groundwater modeling conducted for an area between the I-80 corridor and the Pope and Soldier wells (Smith and Carr, 2021) interpreted the faults present within the modeled area as areas of low horizontal water movement that may act as barriers to groundwater flow. Further empirical testing of a faults' hydraulic characteristics is required to prove whether a fault acts as a conduit or barrier to groundwater flow. For example, the evaluation of water quality and aquifer testing data across the Sherman Hills Fault at Imperial Heights Park proved that the fault does not provide a barrier to flow and will not prevent the migration of contaminants across the fault (Hinckley Consulting and Wyoming Groundwater, 2015).

3.2.4 RECHARGE



Streamflow in a drainage within the Casper Aquifer recharge area.

Recharge refers to the replenishment of the Casper Aquifer by the infiltration of water derived from rainfall and snowmelt through the unsaturated zone. This process occurs to varying degrees wherever the Casper Formation is exposed at the surface. Consequently, the entire surface exposure of the Casper Formation is assumed to be the recharge area for the Casper Aquifer.

The average annual recharge to the Casper Aquifer is estimated to be 1.4 inches per year or approximately 10% (Lundy, 1978). Recharge estimates typically have high levels of uncertainty and the proportion of precipitation that infiltrates into an aquifer is highly susceptible to variations in climate, vegetation, weather, timing, topography, and seasonal trends among other factors. Precipitation measurements in the vicinity of the Casper Formation outcrop vary with both elevation and length of the measurement record. The longest period of record is available from the Laramie Airport, where average precipitation between 1949 and 2014 was 10.59 inches per year (Hinckley and Moody, 2015a). The precipitation rate over a shorter period from 2004 to 2014 was 10.7 inches per year at the Laramie Airport, and 24.1 inches per year at a higher elevation along the crest of the Laramie Range. Averaging between the high and low elevation precipitation values, and using the 10% estimate, Hinckley and Moody (2015a) estimated an annual recharge volume for the aquifer of 2.3 billion gallons. Wittman (2008b) estimated recharge to the Casper aquifer using the United States Geological Survey (USGS) Soil-Water Balance computer code, corrected for fracture recharge and differences in temperature with elevation. This study found that an average of 10% of precipitation is recharged to the aquifer with total recharge between 1981 and 2007 averaging 1.09 inches per year.

Recharge occurs the most rapidly where porous sandstones are exposed to the surface on the west flank of the Laramie Range. Lundy (1978), Beckwith (1937), and Taboga (2007) have all documented surface water infiltrating rapidly into the exposed gamma sandstone, which has relatively large intergranular permeability. In contrast, surface water tends to shed off exposed limestones, which generally have low permeability. In addition to the infiltration into the porous sandstones, infiltration into the subsurface is also enhanced by fractures, joints, bedding planes, and faults exposed at the surface. The USGS Soil-Water Balance code was used to predict that somewhere between 2 to 25% of recharge occurs through fractures, with a higher percentage of recharge occurring through these features in years with low precipitation (Wittman, 2008b). It is assumed that the vast majority of recharge to the Casper Aquifer occurs in the drainages that dissect the west flank of the Laramie Range. The ability of exposed sandstones or surficial structural features to absorb surface water in the drainage channels is illustrated by the fact that surface water rarely flows out of these drainages.

Rapid recharge into the exposed outcrop has also been observed by documenting rising water levels in groundwater wells during periods of surface discharge. In October-November 2005, a 30-day pump test was conducted at the Brow #2 well located 0.6 miles southeast of Simpson Springs (CBMA, 2006). The test provided a unique opportunity to observe the rapid infiltration of surface water through the unsaturated zone and into saturated sandstone at this location within the Casper Aquifer. The Brow #2 well is spudded on the delta member and has a depth to water of 68 feet. Water from Brow #2 was discharged to the ground surface approximately 600 feet west of the well which corresponds to the west edge of the delta member exposure. Approximately 1,200 minutes (0.83 days) into the pump test, the rate of drawdown in Brow #2 declined and was followed by a brief rise in water level. Apparently, in less than a day, pump test water discharged to the ground surface had infiltrated through approximately 50 feet of unsaturated material and was recycling through the aquifer to the Brow #2 well.

Snowfall is the most important form of precipitation for recharging the Casper Aquifer. Most recharge to the Casper Aquifer occurs in March and April when precipitation is typically above average and the ground has thawed. Recharge rates are negligible in the fall and winter due to frozen ground conditions and rainfall in the summer does not infiltrate due to evapotranspiration by vegetation being at maximum (Huntoon and Lundy,1979). The USGS Soil-Water Balance code estimates that an average of 38% of annual recharge occurs as snowfall (Wittman, 2008b), which is slightly lower than other estimates and observations in the area. Careful examination of water level data by WWC (1997) during a violent summer storm showed temporary increases in water levels in most of the observed monitoring wells. However, the change in water levels was rapidly dissipated and the drawdown in the wells quickly returned to pre-storm levels. The transient event had no long-term effects on water levels in the aquifer, which may serve as evidence that summer storm events do not contribute significantly to recharge of the Casper Aquifer. Instead, precipitation stored and applied to the ground surface as a slowly melting snowpack during the diurnal freeze-thaw period of March-April appears to be the most effective mechanism for recharging the aquifer.

Water levels in the Casper Aquifer and the aquifer's response to recharge can be measured in groundwater wells throughout the Laramie area. The Huntoon No 1 and 2 monitoring wells have the longest available record of water levels in the Casper Aquifer. These wells have been used exclusively for water level monitoring since 1977-78 and are part of a statewide groundwater monitoring well network administered by the State Engineers Office and the USGS. The hydrographs for these wells are considered representative of the Casper Aquifer throughout the Laramie area, as evidenced by their similarity to each other and other key monitoring points throughout the area (Hinckley and Moody, 2015a). Additionally, Karl Taboga performed detailed monthly monitoring of approximately 50 water wells on the west flank of the Laramie Range from September 2003 through 2006.

The most direct evidence of the Casper Aquifer's response to highly variable annual precipitation rates is the rise and fall of water levels in these monitoring wells. Taboga (2007) and others have been able to link measurable rises in well water levels to specific precipitation and snowmelt events. For example, recharge to the Casper Aquifer during the winter of 1983-1984, which was a documented El Nino year, was the greatest magnitude on record. The spring snowfall in 1984 was significantly greater than average and melted slowly, which maximized infiltration of the snowmelt. The recharge event caused noticeable head increases throughout the Casper Aquifer including a water level increase in the Huntoon #1 monitoring well of 21 feet and above-average discharge at City Springs and Soldier Springs (WWC, 1996a and 2006). Water levels in the Huntoon monitoring wells peaked in late 1984 before declining gradually, from 1984 to 1994, to pre-1983 levels.

While a general correlation between above average precipitation and rising aquifer water levels has been observed, the timing and exact response of recharge to climate has proven to be complex. Hinckley and

Moody (2015a) compared water levels at the Huntoon No.1 and No. 2 monitoring wells to a wide array of climate variables including precipitation, the Palmer Drought Severity Index (PDSI), and Snow Telemetry (SNOTEL) Network snow survey data and found no long-term correlation between water levels and any single variable. Instead, the relationship between precipitation and recharge appears to depend on a combination of factors- such as intensity and duration of the precipitation event, the geographic pattern of precipitation and snowmelt, temperature, and the abundance of vegetation- which makes predictions of annual aquifer recharge difficult particularly on a local scale.


Fractures in Casper Formation limestone along a drainage in the recharge area.

In an effort to provide relative ages of groundwater contained within the Casper Aquifer, Dr. Carol Frost and Rachel Toner collected samples from the Casper Aquifer from a number of wells and springs in the Laramie area for tritium analysis (Toner, 2000). Tritium is a hydrogen isotope that was created in large quantities in the 1950s and 1960s as a result of above-ground testing of nuclear weapons. Tritium has a short half-life and has not been produced in large quantities since above-ground nuclear weapons testing was discontinued in the 1960s, so it is often used to obtain the relative age of groundwater. While this analysis does not provide the means of determining the exact age of a water sample, it can provide a maximum potential age of the water, if tritium is detected. In general, the presence of tritium in groundwater samples indicates that the groundwater was exposed at the surface subsequent to the 1950's. The analyses of Casper Aquifer samples detected the presence of tritium in groundwater collected from sites east of Third Street. This indicates that the groundwater in the Casper Aquifer east of Third Street has been recharged within the past several decades and that the average residence time of water in the eastern portion of the aquifer is less than 43 years. Water collected from the Wyoming Research Institute (WRI) Casper well, located west of Third Street, had no detectable tritium, which indicates that the water withdrawn from the WRI well was recharged prior to the 1950s.

Studies of future recharge to the Casper Aquifer (Wittman, 2008b) predict that decreased precipitation or increased temperatures could cause a decrease in aquifer recharge of 17 to 38%. In contrast, increased urbanization within the Casper Aquifer recharge area could increase recharge by up to 3%. This increase is thought to be due to soil recharge which results when water that exceeds the soil moisture capacity infiltrates. In this study, the level of urbanization was only increased along the eastern margin of Laramie, and land use was not changed at the higher elevations toward the crest of the Laramie Range.

To summarize, the Casper Aquifer is a responsive hydrogeologic system due to the mountain flank exposure of porous sandstones with superimposed fracture permeability from bedding planes, faults, and folds. In the upland recharge area, water infiltrates through the unsaturated zone days to weeks after the occurrence of snow melt in March and April. Above-average snowfall in March and April can cause rapid and long-term head increases in water levels in the aquifer, as demonstrated in the Huntoon monitoring wells after the 1983 recharge event. Annual recharge to the aquifer is difficult to predict and relies on a combination of climate variables and factors that affect individual precipitation/snowmelt events. Thus, protecting the recharge area from contamination is necessary to maintain safe drinking water.

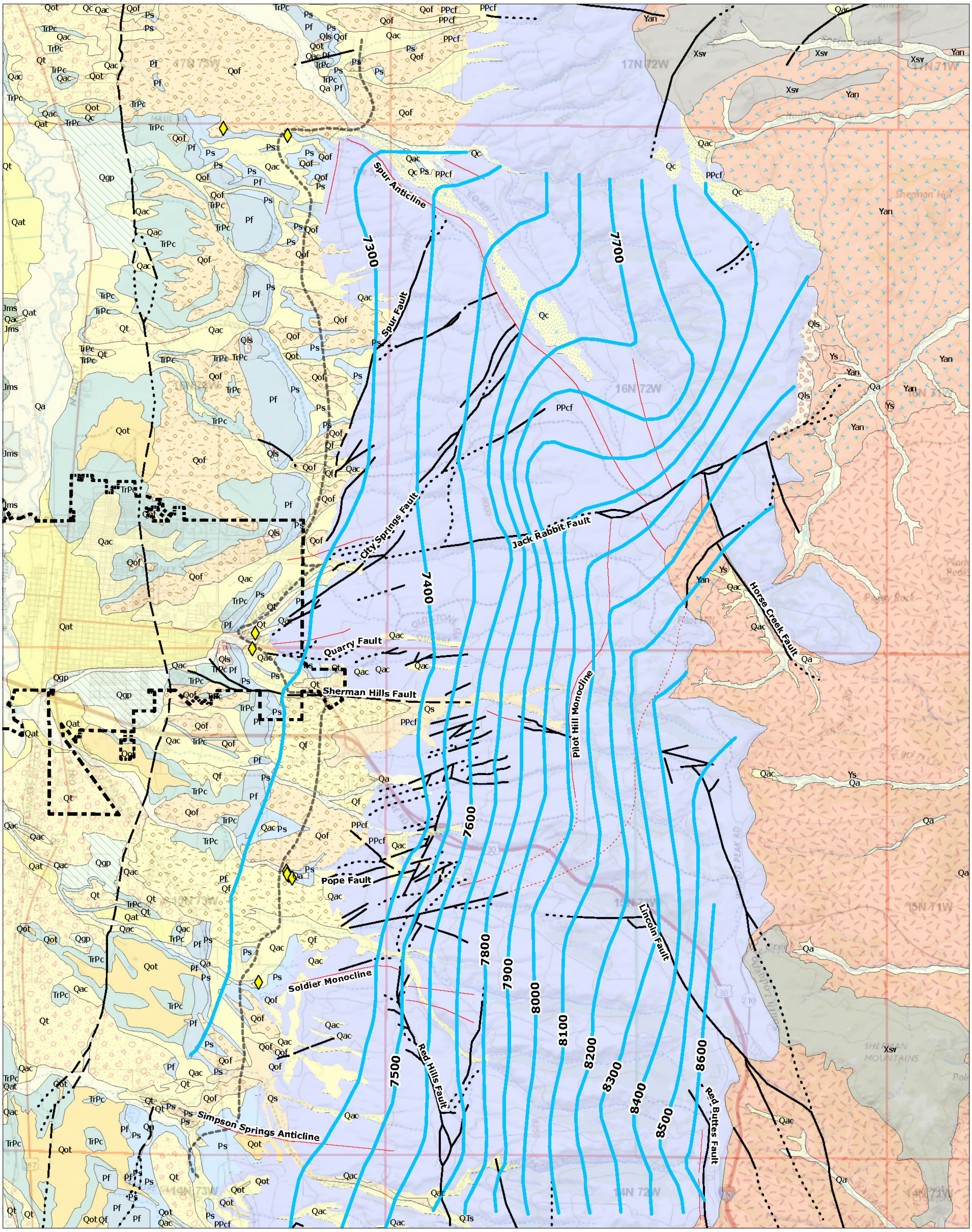
3.2.5 POTENTIOMETRIC SURFACE

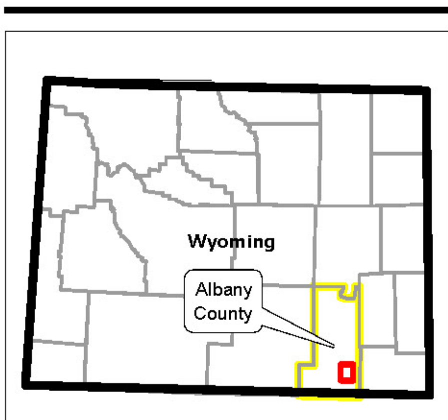
Potentiometric surface maps indicate the hydraulic gradient and the general direction of groundwater flow. Published potentiometric surface maps indicate that groundwater in the Casper Aquifer in the vicinity of Laramie generally flows from east to west- from areas of high elevation at the crest of the Laramie Range toward the lower elevations of the Casper Formation exposure (i.e. range front springs) and further westward into the Laramie basin (Lundy, 1978; Thompson, 1979; WWC, 1997a,b and 2006). As shown on Figure 3-6, the hydraulic gradient has a slight northwest component between Simpson Springs and City Springs (WWC and others, 2006) and is altered locally to a more radial pattern in the vicinity of the City’s municipal wellfields and the springs which discharge large quantities of water from the Casper Aquifer.

While potentiometric surface maps provide a general indication of flow direction within an aquifer, the map does not provide a complete picture of how groundwater flows through the aquifer. Furthermore, it does not identify specific groundwater flow pathways through the sandstone and limestone beds, and does not provide details on how much groundwater flows one way versus another as it moves downgradient. Flow patterns are locally altered by the permeability imparted by fracturing associated with faults and folds, as well as bedding planes. For this reason, these features have a tremendous influence on local groundwater flow pathways and on how much and where groundwater is conveyed through the aquifer. Depending upon how they were formed, faults can have no impact on, prevent, reduce, or enhance groundwater flow along the feature and thus alter how groundwater moves downgradient near that particular fault. The hydrogeologic role of the fault may also vary along any one particular fault, and could preclude flow across it in one area, and enhance flow along the structure elsewhere. The hydrogeologic conditions of each fault in the Laramie area have not been studied in sufficient detail to determine its hydrogeologic characteristics. Likewise, folds such as monoclines and anticlines typically enhance groundwater flow along the structure but have not been sufficiently studied. Given the uncertainty these features impart to groundwater flowpaths, it is reasonable to assume that protecting the entire aquifer recharge area is the best way to protect the downgradient water quality of wells that could be adversely impacted by contaminants.

The hydraulic gradient ranges from a high of approximately 400 feet per mile, on the west flank of the Laramie Range where the saturated thickness of the Casper Aquifer is variable, to 25 feet per mile, where the aquifer is fully saturated and confined by the overlying Satanka Shale (Lundy, 1978). As shown on Figure 3-6, the hydraulic gradient is typically flattest near the western CAPA boundary.

Tremendous variation in groundwater velocity is possible in mixed porous-fractured aquifers due to large variations in porosity, hydraulic conductivity, and hydraulic gradient (natural and pumping induced). Using the porosity and hydraulic conductivity values cited above, and a range of hydraulic gradients (0.075 to 0.0005 ft/ft) derived from Figure 3-6, the average groundwater flow rate was calculated to range between 0.1 and 187 feet/year. In contrast, a maximum groundwater flow velocity in an assumed fracture network along the Jack Rabbit Fault under a hydraulic gradient of 0.07 ft/ft was estimated by Western Water Consultants (1993) to be 7,000 feet/day. For the purposes of aquifer protection and contaminant transport, it should be recognized that groundwater can flow at high velocity through interconnected fracture networks.





Notes
1. Coordinate System: NAD 1983 StatePlane Wyoming East FIPS 4901 Feet
2. Data Sources: USGS, WWC Engineering (2006), Ver Ploeg and Boyd (2007)
3. Background: USGS 7.5 Minute Quadrangle

Legend

- City of Laramie Municipal Wells
- Protective Satanka Shale Thickness
- Municipalities
- PLSS Township
- Fold
- Fault

Geology Units

- Qa - Alluvial deposits
- Qat - Mixed alluvium and terrace deposits
- Qs - Wind-blown deposits
- Qc - Colluvium
- Qac - Mixed alluvium and colluvium
- Qf - Alluvial fan deposits
- Qt - Terrace deposits
- Qls - Landslide deposits
- Qgp - Gypsite deposits
- Qof - Older alluvial fan deposits
- Qot - Older terrace deposits
- QTs - Wind-blown deposits
- Jms - Morrison and Sundance formations undivided
- TrPc - Chugwater Formation
- Pf - Forelle Limestone
- Ps - Satanka Shale
- PPcf - Casper and Fountain formations, undivided
- Ys - Sherman Granite
- Yan - Laramie Mountains anorthosite and norite
- Xsv - Metasedimentary and metavolcanic rocks

0 0.6 1.2 Miles

(At original document size of 11x17)
1:76,483

N

Stantec

Project Location
T16N, R73W
Laramie, Albany Co., WY

Prepared by KAB on 2022-05-12
TR by XXX on 2020-XX-XX
IR by XXX on 2020-XX-XX
227704690

Client/Project
City of Laramie/Albany County
Casper Aquifer Protection Plan Update

Figure No.
3-6

Title
Generalized Casper Aquifer Potentiometric Surface Map (November 2005)

3.2.6 CONFINING CONDITIONS

The sandstone units of the Casper Aquifer along the western flank of the Laramie Range may be either confined or unconfined depending on location, as shown in Figure 3-5. The limestones that separate the sandstone layers have negligible permeabilities if unfractured and can serve as local confining layers that subdivide the Casper Aquifer. Therefore, the individual sandstone members, designated in descending order (epsilon, delta, gamma, beta, and alpha), comprise sub-aquifers within the Casper Aquifer (Figure 3-1 and Figure 3-4). However, the confining ability of the limestones has been compromised in some areas where fractures associated with faults and folds and potentially some fully penetrating wells have created hydraulic connection between the members. At the Spur and Turner wellfields the hydraulic connection between the sandstone layers has been documented via downhole camera surveys, similarity in head values, and response to pumping (WWC 1996; WWC 1997b).

As discussed previously, the Satanka Shale regionally serves as the upper confining layer for the Casper Aquifer. The lower 50 feet of the Satanka Shale is comprised of well-cemented sandstone and sandy shale beds. The brittle nature of that interval and the lithologic similarity to the underlying Casper Formation results in some mixing of groundwater from those units, especially in fractured areas. Where the Satanka Shale has a thickness greater than 50 feet, low permeability shaley strata begin to provide vertical confinement, with the degree of confinement increasing with greater thicknesses of the Satanka Shale. Evidence of confinement includes the discharge of large quantities of groundwater at Simpson, Soldier, Pope, and City Springs. These springs discharge groundwater from the Casper Aquifer by typically passing through more than 50 feet of Satanka Shale. Additionally, differences in hydraulic head of up to 30 feet were observed at the Spur Wellfield, with the head in the Casper Aquifer being greater than the head in the Satanka Shale (WWC, 1997).

3.2.7 VULNERABLE FEATURES AT THE GROUND SURFACE

The Casper Aquifer throughout the recharge area of the CAPA is vulnerable to contamination and subject to the rapid transport of contaminated groundwater to downgradient points of discharge due to: 1) exposed bedrock and thin sandy soil, 2) vertical and horizontal fractures at ground surface and in the subsurface, and 3) a complex interconnected network of porous and fracture permeability throughout the aquifer. These features are ubiquitous and often covered by alluvial materials and soil at the land surface.

However, several features found within the Casper Aquifer in the Laramie area render the aquifer particularly vulnerable to contamination from the ground surface because they facilitate rapid infiltration and conveyance of surface water into the aquifer. These features are candidates for development setbacks and include: drainages, faults, fractures, folds, dissolution features, shallow groundwater, and springs. The basis for assuming these features, along with exposed bedrock and thin soils, can enhance the vulnerability of the Casper Aquifer to contamination is included in the following paragraphs. Existing wells within the CAPA may also render the aquifer vulnerable.

3.2.7.1 DRAINAGES

Most of the recharge to the Casper Aquifer east of Laramie likely occurs in drainages (Figure 3-3). Water tends to shed off the low-permeability limestones that cover the majority of the land surface along the west flank of the Laramie Range. The water drains off the limestones and collects in drainages. As the surface runoff flows through the drainages, rapid recharge occurs as the water crosses permeable sandstones and/or fractures. Where rapid recharge occurs, rapid contamination can also occur.

Notice snowmelt runs off this unfractured gamma limestone member.

Drainages are commonly identified on U.S. Geological Survey topographic maps with solid or dashed blue lines indicating whether they are perennial (solid) or ephemeral (dashed). Not all drainages are so identified, however, particularly those with only occasional flow. Drainages are topographic features that channel surface water and need to be appropriately identified. All of the drainages across the Casper Formation outcrop contribute recharge to the aquifer.

Stormwater runoff from developed areas in the CAPA is a particular concern due to the potential for contaminants being mobilized from these areas into drainages. Such runoff combined with rapid infiltration in the drainage could lead to contamination of the Casper Aquifer. Developed areas include paved roads, paved parking lots, and other development features that can shed contaminants during rainfall or snowmelt events. Detention of stormwater flows from such areas in the drainages could enhance the possibility of aquifer contamination by increasing the likelihood that contaminated stormwater runoff infiltrates the aquifer. Similarly, diverting stormwater runoff from developed areas to drainages may enhance the potential for contamination of the aquifer depending how interconnected the drainage is to the underlying aquifer. Stantec generally recommends that stormwater from these developed areas be diverted to downstream areas west of the Satanka Shale contact with the Casper Aquifer to minimize the potential for introducing contaminants into the aquifer. Diversion may require contribution (financially or other ways) for downstream infrastructure, if it can even be accommodated downstream. Alternatively, the design professional should investigate the local hydrologic and hydrogeologic conditions to route stormwater runoff in a way that minimizes the potential for contamination to the aquifer. This evaluation should include engineering controls that may meet the objectives of the CAPP.

3.2.7.2 FAULTS AND FRACTURES

Faults are fractures or fracture zones along which displacement of strata has occurred. If the displacement has resulted in either breaches in confining beds and/or formation of large secondary permeability, then the Casper Aquifer may be more vulnerable to contamination than in unfaulted areas (Figure 3-3). Where the faults intercept the ground surface, there is the potential for rapid infiltration of surface water into the aquifer. This rapid infiltration, in turn, has the potential for rapid contamination of the aquifer. Fractures or fracture zones lacking displacement can similarly enhance the potential for contamination by facilitating conduit flow, but one key difference between faults and fractures is that fractures are not usually mapped. While some faults may also go unmapped, the lack of mapping of faults, fractures, or fracture zones does not render them innocuous.

While faults are typically mapped as a single line, they frequently do not occur as a discrete feature. Fractures extend variable distances from the mapped fault trace. Lundy (1978) noted that fracture permeability extends tens of feet on either side of faults. WWC (1993) reported that at some faults the fracture zone extends less than 10 feet from the fault trace, while other faults have associated fractures extending 50 to 150 feet from the fault trace. Based on the Sherman Hills Fault investigation, these features may extend 200 to 300 feet from the fault trace (Hinckley Consulting and Wyoming Groundwater, 2015). The aquifer should be considered vulnerable along the mapped fault trace along with areas immediately adjacent to and along the mapped feature. Because of the enhanced permeability associated with faults and associated fracture systems, setbacks from these features should be established by professionals from the structural margins of the respective feature.

While fractures are typically associated with faulting or folding, they also commonly occur in areas that are not directly associated with these features. These open fractures exposed at the ground surface can be associated with any variety of features, such as joints, minor faults, primary faults, folds, bedding surfaces exposed in drainages, etc. Such features can be readily apparent on aerial photos. Fractures in these areas can be open and enlarged by weathering processes where exposed at land surface, and may enhance permeability, aquifer recharge, and the potential for aquifer contamination. However, fractures can also be covered or hidden by topsoil, alluvium, vegetation, and structures among other things, which can make it difficult or impossible to assess their hydrogeologic role. Setbacks defined for these features should be determined on the basis of professional field investigation at the respective development location.

Notice the fractures present in this delta limestone member exposure.

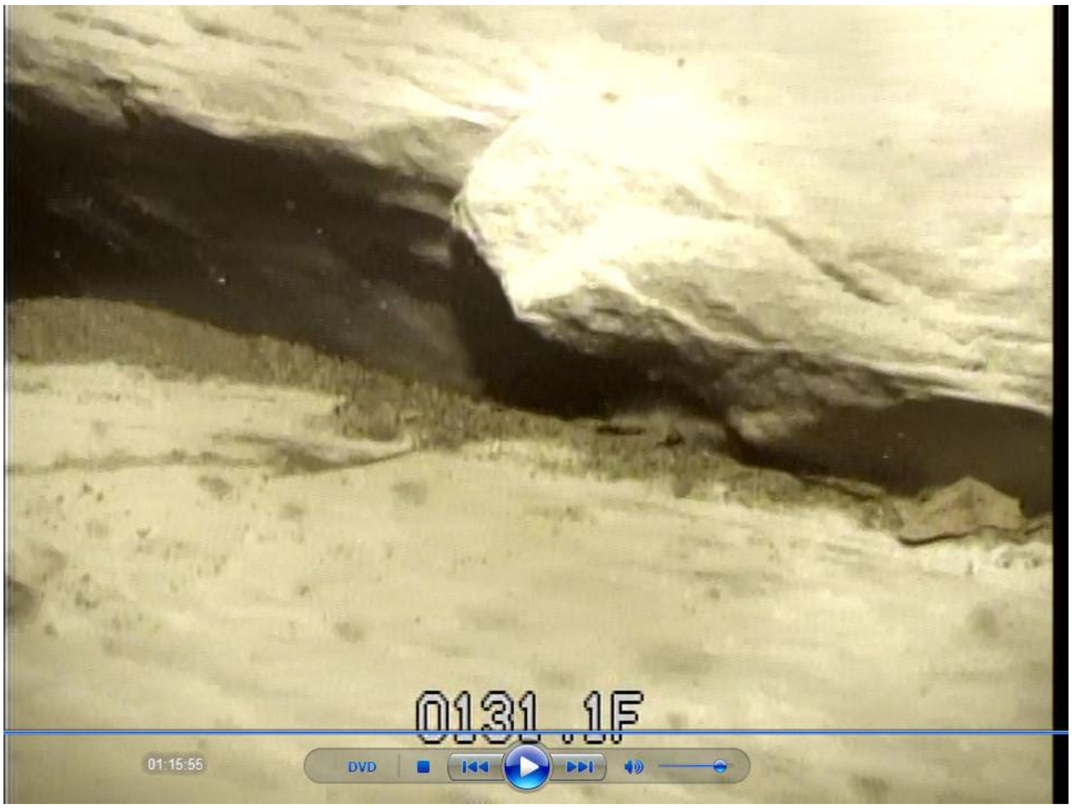
3.2.7.3 FOLDS AND FRACTURES

Folds are bends in the bedding of rocks that result from ductile deformation. Folds found in the Laramie area include anticlines, synclines and monoclines. In many folds, fractures are developed in brittle or competent rocks. These fractures usually occur along the crest of the fold and have the potential for transmitting large quantities of water. Where these fractures extend to the ground surface there is the potential for rapid infiltration of contaminants.

The width of the fractured zone and associated enhanced permeability along each fold varies as a function of dip, tightness, and plunge. Tight folds with steeper dips are likely to have a wider fracture zone along the crest than open folds with shallow dips. The distribution and lateral extent of fracturing associated with folds likely varies between or along structures. The most intense fracturing may or may not always be associated with the crest of the fold. Hence, the aquifer should be considered most vulnerable to contamination along the mapped fold as well as areas immediately adjacent to and along the mapped feature. Because of the enhanced permeability associated with folds and associated fracture systems, setbacks from these features should be established by professionals from the structural margins of the respective feature. Fold crests can be used to establish a centerline of the respective structure but are not to be used as the basis for establishing setbacks.

3.2.7.4 DISSOLUTION FEATURES AND SUBSURFACE FRACTURES

Dissolution features are shafts, tunnels, caves, or enlarged bedding surfaces which were created by groundwater dissolving or eroding sedimentary rocks such as limestone or sandstone. Although dissolution cavities are generally underground and are therefore a less direct pathway for contaminants to enter the aquifer than conduit flow features expressed at the surface, dissolution features and any subsurface fractures or bedding surfaces contribute to the rapid transmission of groundwater and can lead to the rapid dissemination of contaminants that have entered the aquifer. Such dissolution features and open fractures have been observed during drilling and downhole camera surveys at water supply wells in the Laramie area (Hinckley Consulting and Wyoming Groundwater, 2015).



Horizontal opening in the Epsilon member of the Casper Aquifer at the depth indicated in feet in the photo.

3.2.7.5 WELLS

Wells are structures that are drilled and completed to provide water for various uses and can be completed in any aquifer. Any well that is drilled and completed into the Casper Aquifer increases the vulnerability of the aquifer in two ways. The first is that the well itself provides a direct conduit for potential contaminants to reach the aquifer through the screened or perforated zone within the well. All wellheads need to be appropriately sealed to prevent contaminants from being introduced through the well. The second is potentially through the annular space between the well and the borehole wall. The Wyoming State Engineer's Office requires the annular space to be sealed to prevent contamination from entering the aquifer. Poor construction at the time of well installation or deterioration of the sealing material can compromise the seal, potentially allowing contaminants to migrate down to the aquifer through the well bore. Abandoned or orphaned wells completed in the Casper Aquifer particularly present a high risk to the aquifer and should always be properly plugged and abandoned.

3.2.7.6 EXPOSED BEDROCK AND THIN SOILS

Exposed bedrock refers to the surface exposure of the Casper Aquifer (i.e. Casper Formation) which forms an extensive area on the west flank of the Laramie Range. Exposed bedrock of an aquifer that is generally more vulnerable to contamination than the same material buried at depth. Burial of the aquifer material provides an opportunity for some degree of mitigation or natural attenuation of potential contaminants prior to the contaminants entering the aquifer.

In addition, the overall composition of the aquifer materials, physical, chemical, and biological processes affect the time of travel for water to recharge the aquifer. In the upper half of the Casper Formation, specifically the epsilon, delta, and gamma members, the vast majority of the lithology is sandstone and limestone. These eolian sandstones are composed of quartz sand grains and calcium carbonate (calcite) cement. The limestone is entirely calcium carbonate. These lithologies will neutralize acidic water, but other than that, the dominant composition of quartz and carbonate is not chemically reactive and has poor capacity for contaminant adsorption and degradation. The primary player in the natural mitigation of contaminants in the subsurface is the presence of oxygen, organic matter, and clays (i.e. loamy soil, organic-rich claystone and shale) that support processes such as adsorption and biological decay. Oxygen appears to be abundant in the Casper subsurface, but organic-rich lithologies (shale) are conspicuously scarce or absent. The relative abundance of oxygen in the subsurface and lack of anoxic conditions inhibits the natural mitigation of nitrate.

Fractured sandstone and limestone of the Casper Formation exposed at land surface in a drainage.

The exposed sandstone and limestone of the Casper Formation both render the aquifer vulnerable. Areas of exposed sandstones are likely to be vulnerable to contamination because of the sandstone permeability. Where no confining layer is present, rapid infiltration of contaminants from the ground surface to the saturated zone may occur. West of the Casper Aquifer-Satanka Shale contact and away from the springs, with sufficient thickness the overlying Satanka Shale will prevent potential contaminants from entering the aquifer. Exposed limestone also increases the vulnerability of the Casper Aquifer primarily through its ability to shed water and contribute to increased overland flow into the drainages, faults, and fractures. Some exposed limestone surfaces serve to conduct water-borne contaminants to areas where infiltration into the aquifer occurs most effectively.

Soils in the recharge area tend to be thin, are irregularly distributed, and in some places are absent or undeveloped. Without the attenuating effect of a biologically and chemically active soil layer between the land surface and the Casper Aquifer, contamination at the surface poses a larger risk to the aquifer.

3.2.7.7 SHALLOW GROUNDWATER AND SPRINGS

Areas where the depth to groundwater is relatively shallow are also potentially more vulnerable to contamination. Removal of some pollutants (i.e. bacteria) can occur in the vadose zone. Pollutant removal in the vadose zone is attained via biological activity, chemical degradation, adsorption of pollutants to soil, and plant uptake. Shallow groundwater reduces the thickness of the unsaturated soil available to provide treatment, leading to an increased likelihood of groundwater contamination. Areas where groundwater is close to the ground surface have the potential, where no confining layer is present, for rapid transportation of contaminants from the ground surface to the saturated zone. Particularly where faults, fractures, or folds extend to the ground surface, shallow groundwater magnifies the already increased potential for contamination by allowing for even more rapid aquifer recharge.

Stantec recommends shallow groundwater be considered a depth to groundwater of 70 feet or less. Groundwater encountered at shallower depths within the recharge area is more likely to be impacted by contamination from any development due to the shorter distance, less time required to reach the groundwater, and lowest degree of potential contaminant degradation. This depth to water is generally associated with the Epsilon Member of the Casper Aquifer at the western margin of the recharge area where the aquifer is not confined by the Satanka Shale. The Epsilon Member is composed of sandstone that ranges in thickness from 63 feet at City Springs to 73 feet at the Spur Wellfield, and there is no lower permeability limestone caprock. Assuming that vertical fractures hydraulically connect all the Casper Aquifer members, a well completed in the Casper Aquifer with a depth to water of less than 70 feet suggests that a portion of the epsilon sandstone is saturated at that particular location without any protection afforded by the Satanka Shale or a low permeability limestone caprock. Greater depth to water provides some protection where the Satanka Shale confining layer is not present, but distance alone is not sufficient to provide full protection. A setback of at least 100 feet from shallow groundwater is needed to further protect the aquifer.

Intermittent Casper Aquifer spring located approximately one mile below the Happy Jack exit on I-80.

The Casper Aquifer is also particularly vulnerable to contamination at City Springs, Pope Springs, Soldier Springs and Simpson Springs. The aquifer is vulnerable at these spring areas because the Satanka Shale is sufficiently fractured to allow groundwater discharge, and thus provides little to no protection at the discharge points. The City has completed municipal production wells at City, Pope, and Soldier Springs. Because pumping from a municipal well near the spring can capture all the local springflow, the local aquifer and the individual municipal well are highly vulnerable to potential contaminants that might enter the aquifer through the spring fracture network when the wells are pumping. The Casper Aquifer is also vulnerable at other current or historic springs (i.e. Gilmore Gulch, Telephone, Laycock, etc.) present within the recharge area.

More detailed information regarding the geology and hydrogeology of the Casper Aquifer may be obtained from Morgan (1947), Huntoon (1976), Lundy (1978), Huntoon and Lundy (1979), Thompson (1979), WWC (1993, 1994, 1996, 1997a,b and 2006), WWC Engineering and others (2015),and Ver Ploeg (1998, 2009).

3.3 WATER QUALITY OF THE CASPER AQUIFER

Groundwater quality within the Casper Aquifer has been evaluated for multiple water quality parameters by different entities through time. The City of Laramie has been monitoring the quality of its municipal well and spring water. The U.S. Geological Survey and others have assessed the quality of groundwater from various wells and springs within and adjacent to the CAPA. The City of Laramie has also been monitoring nitrate as nitrogen concentrations in Casper Aquifer groundwater through its monitoring well network and completed nitrate assessments of local domestic wells. As used in this document, nitrate and nitrate as nitrogen are synonymous. While the CAP Network has water quality data, none of that data has been included in this summary. Through these efforts, water quality samples have been taken from multiple domestic, municipal, and monitoring wells that were completed for different purposes with differing designs. Any well that has been completed with access to multiple members of the Casper Aquifer likely reflects a more homogenized water quality than a well completed in only one aquifer member. To date, the only wells that were designed and constructed to assess the water quality of specific members of the Casper Aquifer are those completed at Laramie County Community College (LCCC) and Imperial Heights Park (Imperial Heights North, Imperial Heights South, and Triangle). As discussed in Section 6.3.2.8, new monitoring wells should be designed and constructed to assess specific water quality concerns.

The overall water quality and concentration of contaminants in groundwater obtained from the Casper Aquifer depend upon local hydrogeologic conditions and a variety of well completion features. With regard to local hydrogeologic conditions, groundwater quality for different sandstone members may vary depending upon the confining conditions associated with the limestone interbeds and the location of potential contaminant sources in the recharge area. Near faults or fractures that hydraulically connect all the sandstone members of the aquifer, any differences in water quality between the sandstone members may be indistinguishable due to intermixing of the water from the different members. Similarly, well construction and pump placement can affect water quality results because they influence the zone from which the groundwater is obtained. Well features that can influence water quality results include well depth, annular seal presence and integrity, open or screened depth interval, sandstone or limestone member(s) open to the well, post construction changes to the well, and productive zone intervals within the borehole.

The influence of well completion and local hydrogeologic conditions on water quality is perhaps most notable at the City's wells. The wells are completed with open boreholes exposed to multiple sandstone members of the Casper Aquifer. Between 68 and 250 feet of the 700 feet of the Casper Aquifer is exposed within each of the wells. The wells each produce between 475 and 2,500 gpm (WWC Engineering, 2006) because they tap into the conduit flow associated with the faults, folds, and associated fractures networks that integrate multiple members of the aquifer. This hydrologic interconnection blends the water from different members of the aquifer creating a homogenous water quality at the wells. While this is beneficial for reducing their vulnerability to surface sourced contamination, it appears to mask and minimize the impact of any contaminant sources on water quality in the upper Casper Aquifer members across the CAPA. This is particularly relevant as it relates to shallow wells and domestic well owners within the CAPA.

3.3.1 CITY OF LARAMIE WATER QUALITY DATA

Water quality data for the City's municipal wells and springs from 1943 through 2022 are summarized in Table 3-2. These wells obtain groundwater from 68 to 250 feet of the Casper Aquifer and as such represent a homogenized water quality from the different aquifer members. These data obtained from the City of Laramie and others present the general groundwater quality of the Casper Aquifer as illustrated by major cations/anions, total dissolved solids, and selected parameters such as fluoride, iron, hardness, uranium, and radionuclides. These selected parameters are well below Maximum Contaminant Levels (MCLs) established by the Environmental Protection Agency (EPA) for a public water supply. Hinckley and Moody (2015b) noted furthermore that regulated parameters not listed in Table 3-2, such as selenium, arsenic, volatile and semi-volatile compounds, and biological contaminants, are also well below the respective drinking water MCL.

Due to its major cation/anion chemistry, Casper groundwater is classified as calcium-magnesium-bicarbonate type water. The major cation/anion chemistry of the Casper Aquifer produces water with a pleasant taste and is not corrosive to water system infrastructure. The groundwater temperature is approximately 46.5º F. Due to the high combined calcium and magnesium concentrations, the water is very hard. The groundwater is saturated with respect to calcium carbonate; and consequently, a layer of calcium carbonate forms on the interior of well casing and infrastructure piping which serves to reduce the corrosion of metal. There is no evidence of significant biofouling (i.e. iron bacteria) at the Pope, Turner, Spur, or Soldier supply wells after upwards of 78 years of service. The groundwater chemistry is conducive (i.e. no adverse chemical reactions) to blending with surface water in the storage tanks and distribution system (Hinckley and Moody, 2015b).

As a result of the outstanding groundwater quality and current drinking water regulations, the City is not required by the EPA to treat groundwater from the Casper Aquifer. However, per standard minimum water treatment for large municipal systems, the City chlorinates (i.e. disinfection) and fluoridates the groundwater at the Wye building (Soldier and Pope wells), City Springs (Turner wells), and the Spur (Spur wells). The purpose of chlorination in this case is to maintain a residual concentration in the transmission and distribution system rather than to kill bacteria in the source water. Disinfection by-products generated by chlorination are not a problem because of the low concentration of total organic carbon in the groundwater (Hinckley and Moody, 2015b).

Of the major ions, nitrate as nitrogen concentrations in the City’s groundwater supply are a concern given the proximity of residential development and associated septic systems for wastewater disposal. Despite the presence of these systems within the CAPA, nitrate concentrations at the City’s wells and springs have ranged from 0.2 to 2.2 mg/L, and averaged 1.7 mg/L over the period of record. This concentration is significantly below the EPA drinking water standard of 10 mg/L.

Table 3-2: Water Quality of Casper Aquifer Municipal Wells and Springs

Well or Spring Name	Sample Date	pH	Major Cations				Major Anions				Other Key Parameters							Data Source
			Ca	Mg	Na	K	HCO_3	Cl	SO_4	NO_3 as N	F	Fe	U	TDS	Hardness	Gross Alpha	Radium 226+228*	
Spur No. 1	1997	8.0	52	16	2.6	<1.0	215	1.1	6.0	1.6	0.2	<0.05	0.002	300	196	<1.0	<1.0	Hinckley and Moody, 2015b
Spur No. 1	2006	NR	45	15	3.1	0.9	200	1.9	6.1	1.5	0.2	0.028	NA	320	NA	NA	NA	City of Laramie, 2022
Spur No. 1	2014	8.0	47	17	2.6	0.7	220	1.6	5.9	1.5	0.2	<0.02	NA	301	187	2.8	-0.02	Hinckley and Moody, 2015b
Spur No. 1	2021	NR	51	16	2.5	0.6	177	2.1	8.0	1.8	<0.2	<0.079	NA	370	NA	NA	NA	City of Laramie, 2022
Spur No. 2	1997	8.0	52	16	1.9	<1.0	216	<1.0	5.0	1.5	0.2	<0.05	0.001	298	196	<1.0	<1.0	Hinckley and Moody, 2015b
Spur No. 2	2006	NR	47	15	2.1	0.6	200	1.7	4.9	1.5	0.2	<0.02	NA	320	NA	NA	NA	City of Laramie, 2022
Spur No. 2	2014	NA	48	17	2.3	0.7	220	1.4	5.3	1.4	0.2	<0.02	NA	301	190	2.8	-0.02	Hinckley and Moody, 2015b
Spur No. 2	2021	NR	51	16	2.2	0.6	180	<2.0	6.6	1.7	<0.2	<0.079	NA	370	NA	NA	NA	City of Laramie, 2022
City Springs	1973	7.8	52	17	2.1	0.9	233	1.8	6.6	1.4	0.2	0.03	NA	320	200	NA	NA	Hinckley and Moody, 2015b
City Springs	8/4/1976	7.3	52	16	1.9	0.7	227	0.3	6.0	0.9	NA	NA	NA	207	NA	NA	NA	Lundy, 1978
City Springs	2008	8.0	49	17	2.4	0.9	240	2.7	8.3	1.4	0.1	<0.02	NA	326	192	2.7	0.1	Hinckley and Moody, 2015b
Turner Wellfield	4/22/1943	NR	53	18	NA	NA	240	1.2	5.9	1.3	0.1	0.04	NA	215	210	NA	NA	USGS, NWIS 2022
Turner Wellfield	9/28/1944	NR	53	17	NA	NA	240	1.8	3.4	1.5	NA	NA	NA	207	200	NA	NA	USGS, NWIS 2022
Turner Wellfield	5/6/1947	NR	43	17	NA	NA	209	6.0	5.8	NA	NA	NA	NA	202	180	NA	NA	USGS, NWIS 2022
Turner Wellfield	10/22/1951	NR	53	16	1.3	1.0	234	3.0	3.0	1.3	NA	NA	NA	207	200	NA	NA	USGS, NWIS 2022
Turner No. 1 (41T1)	7/26/1976	7.4	49	17	2.0	0.9	233	0.1	6.0	0.4	NA	NA	NA	205	NA	NA	NA	Lundy, 1978
Turner No. 1 (41T1)	12/7/1981	8.2	49	22	2.0	0.7	240	1.5	9.1	0.6	0.2	<0.1	NA	327	213	NA	NA	Hinckley and Moody, 2015b
Turner No. 2	12/7/1981	8.3	35	20	2.0	0.2	210	1.4	6.6	0.2	0.2	NA	NA	276	170	NA	NA	Hinckley and Moody, 2015b
Turner No. 2	2014	7.5	53	17	2.9	0.9	240	4.0	11.0	2.0	0.1	<0.02	0.001	338	202	NA	NA	Hinckley and Moody, 2015b
Turner No. 2	5/17/2016	7.8	44	15	2.1	0.7	190	3.2	10.0	1.7	<0.1	0.524	NA	180	170	NA	NA	Mike Lytle, 2022
Turner No. 2	11/22/2016	7.7	49	18	2.5	0.9	190	3.1	11.0	1.7	0.1	<0.04	NA	180	200	NA	NA	Mike Lytle, 2022
Turner No. 2	8/8/2017	7.8	53	17	2.7	0.7	190	3.2	11.0	1.7	<0.5	<0.079	NA	188	200	NA	NA	Mike Lytle, 2022
Turner No. 2	2/27/2018	7.8	55	18	2.9	0.9	190	4.1	11.0	1.8	<0.5	<0.079	NA	190	210	NA	NA	Mike Lytle, 2022
Turner No. 2	11/19/2019	8.1	53	17	2.5	0.9	192	3.1	10.2	1.7	<0.5	<0.079	NA	190	200	NA	NA	Mike Lytle, 2022
Turner No. 2	11/17/2020	8.0	53	16	2.3	0.8	196	2.8	9.5	1.6	<0.2	<0.079	NA	190	200	NA	NA	Mike Lytle, 2022
Turner No. 2	8/24/2021	8.1	56	17	2.4	0.9	195	3.4	10.2	1.7	<0.2	<0.079	NA	194	211	NA	NA	Mike Lytle, 2022
Turner No. 2	2/15/2022	8.2	53	17	2.4	0.8	191	3.0	9.5	1.7	<0.2	<0.079	NA	187	203	NA	NA	Mike Lytle, 2022
Turner No. 3 (41T3)	4/21/1943	NR	51	18	NA	NA	210	3.0	9.0	2.1	0.2	NA	NA	204	200	NA	NA	USGS, NWIS 2022
Pope Wellfield	4/22/1943	NA	56	15	NA	NA	234	1	5	1.13	0.2	NA	NA	198	200	NA	NA	WWC Engineering 2013; USGS, NWIS 2022
Pope Wellfield	4/22/1958	NA	54	13	3.1	0.6	224	1	10	NA	0.1	NA	0.002	205	190	NA	NA	USGS, NWIS 2022
Pope Wellfield	1973	8.2	54	13	2.1	0.7	222	1.8	5.8	1.6	0.2	0.04	NA	306	188	NA	NA	Hinckley and Moody, 2015b
Pope No. 1	8/12/2020	8.0	62	17	3.8	NA	190	12.0	10.1	2.1	<0.2	<0.079	NA	270	220	NA	NA	Mike Lytle, 2022
Pope No. 2	5/17/2016	7.8	48	13	2.9	0.6	190	11.0	9.2	2.1	<0.1	0.61	NA	190	170	NA	NA	Mike Lytle, 2022
Pope No. 2	8/8/2017	7.8	59	16	4.1	0.5	190	13.0	11.0	2.2	<0.5	<0.079	NA	206	212	NA	NA	Mike Lytle, 2022
Pope No. 2	2/27/2018	7.8	59	17	4.2	0.9	270	11.0	11.0	2.0	<0.5	<0.079	NA	240	220	NA	NA	Mike Lytle, 2022
Pope No. 2	11/19/2019	8.1	59	16	3.8	0.8	190	11.5	9.9	2.1	<0.5	<0.079	NA	200	210	NA	NA	Mike Lytle, 2022

Well or Spring Name	Sample Date	pH	Major Cations				Major Anions				Other Key Parameters							Data Source
			Ca	Mg	Na	K	HCO_3	Cl	SO_4	NO_3 as N	F	Fe	U	TDS	Hardness	Gross Alpha	Radium 226+228*	
Pope No. 2	2/19/2020	8.1	56	16	3.6	0.8	188	10.8	9.8	2.1	<0.2	<0.079	NA	200	200	NA	NA	Mike Lytle, 2022
Pope No. 2	8/24/2021	8.2	64	15	3.7	0.8	192	13.3	10.0	2.2	<0.2	<0.079	NA	211	222	NA	NA	Mike Lytle, 2022
Pope No. 2	2/15/2022	8.2	60	16	4.0	0.8	191	13.4	9.0	2.1	<0.2	<0.079	NA	206	214	NA	NA	Mike Lytle, 2022
Pope No. 4	1981	8.2	51	19	2.0	0.2	230	1.8	0.0	0.8	0.2	NA	NA	308	205	NA	NA	Hinckley and Moody, 2015b
Soldier Spring	4/22/1943	NR	52	17	NA	NA	226	2.0	6.0	1.2	0.2	NA	NA	194	200	NA	NA	USGS, NWIS 2022
Soldier Spring	11/27/1943	NR	50	19	NA	NA	180	3.0	6.0	NA	<0.1	0.1	NA	NA	203	NA	NA	USGS, NWIS 2022
Soldier Spring	2/21/1944	NR	47	16	NA	NA	172	1.0	6.0	NA	0.1	0.1	NA	NA	183	NA	NA	USGS, NWIS 2022
Soldier Spring	9/28/1944	NR	49	15	NA	NA	217	1.8	5.8	2.1	NA	NA	NA	NA	180	NA	NA	USGS, NWIS 2022
Soldier Spring	1973	7.9	50	16	3.7	0.9	220	1.8	8.2	1.7	0.7	0.04	NA	308	191	NA	NA	Hinckley and Moody, 2015b
Soldier Spring	11/22/2016	7.8	51	16	3.4	0.9	180	7.7	12.0	2.1	0.1	<0.04	NA	190	200	NA	NA	Mike Lytle, 2022
Soldier Spring	2/15/2017	7.8	50	16	3.3	0.9	180	8.4	12.0	2.2	0.1	<0.04	NA	190	190	NA	NA	Mike Lytle, 2022
Soldier Spring	2/27/2018	7.8	56	17	3.8	0.9	290	8.4	13.0	2.2	<0.5	<0.079	NA	250	210	NA	NA	Mike Lytle, 2022
Soldier Spring	11/19/2019	8.0	55	16	3.5	0.9	185	8.1	12.4	2.2	<0.5	<0.079	NA	200	200	NA	NA	Mike Lytle, 2022
Soldier Spring	5/20/2020	8.2	58	17	3.7	0.8	187	8.0	12.0	2.1	<0.2	<0.079	NA	200	210	NA	NA	Mike Lytle, 2022
Soldier Spring	8/24/2021	8.0	57	16	3.4	0.9	187	6.5	13.4	2.2	<0.2	<0.079	NA	199	207	NA	NA	Mike Lytle, 2022
Soldier Spring	5/17/2022	8.1	54	16	3.5	0.9	193	7.3	11.6	2.1	<0.2	<0.079	NA	250	200	NA	NA	Mike Lytle, 2022
Soldier No. 1	1997	8.1	58	17	1.9	<1.0	218	3.5	12.0	2.0	0.2	<0.05	<0.001	313	215	<1.0	<1.0	Hinckley and Moody, 2015b
Soldier No. 1	2014	7.6	54	16	3.3	0.9	230	6.4	11.0	2.1	0.1	<0.02	0.001	331	201	1.8	0.4	Hinckley and Moody, 2015b
MCL		*6.5 – 8.5*						*250*	*250*	10	4.0	*0.3*	0.030	*500*		15	5	

Notes:
Ca: Calcium; Mg: Magnesium; Na: Sodium; K: Potassium; HCO3: Bicarbonate; Cl: Chloride; SO4: Sulfate; NO3: Nitrate; F: Fluoride; Fe: Iron; U: Uranium TDS: Total Dissolved Solids
MCL: Maximum Contaminant Level as established by the U.S. Environmental Protection Agency (EPA) for drinking water standards.
Enforceable primary standards in bold type. Nonenforceable secondary standards in italics.
*: Radium 226 was not analyzed in most samples (NA), but when analyzed it is not detected.
Units: All units in mg/L with the following exceptions: pH in standard units, Hardness in mg/l CaCO3; Gross Alpha and Radium in pCi/l
All Lundy (1978) nitrate data converted to nitrate as nitrogen by dividing Table 2 values from his thesis by 4.43.
NA – Not analyzed or reported; sodium and potassium typically reported together for older samples.

3.3.2 LARAMIE AREA CASPER AQUIFER WATER QUALITY

Casper Aquifer groundwater quality data obtained from wells or springs in and near the CAPA that are not owned by the City are summarized in Table 3-3. These wells were completed for a variety of purposes, including stock, domestic, industrial, monitoring, irrigation, and testing, at many places across the CAPA and in the Laramie area. Data presented here represent Casper Aquifer water quality across the area and through the aquifer, Figure 3-7 indicates the locations of the wells and springs included in Table 3-3. These data obtained from various sources noted in the table present the general groundwater quality of the Casper Aquifer in and near the CAPA as illustrated by major cations/anions, total dissolved solids, and selected parameters such as total dissolved solids (TDS) and specific conductance. Due to its major cation/anion chemistry, Casper Aquifer groundwater is classified as calcium-bicarbonate type in the recharge area and calcium-magnesium-bicarbonate type water near the discharge area. Overall, the gross water quality of the aquifer is controlled by dissolution of calcite and dolomite in the aquifer matrix (Lundy, 1978).

Comparison of the water quality data presented in Table 3-2 and Table 3-3 reveals that groundwater obtained by both City and other wells completed in the Casper Aquifer near Laramie is very similar with respect to major ions. The most significant ion is nitrate which averages 1.6 mg/L. Nitrate as nitrogen concentrations at individual wells and springs range from 0.1 to 7.5 mg/L, which in some cases is significantly higher than concentrations found in the City's wells. Concentrations approaching or exceeding 10 mg/L are very concerning in terms of drinking water quality, as detailed in Section 3.3.3 below. Lundy (1978) noted that a source of natural nitrate in groundwater is microbial decomposition of organic matter in the soil zone. Nitrate concentrations vary markedly across the Laramie area.

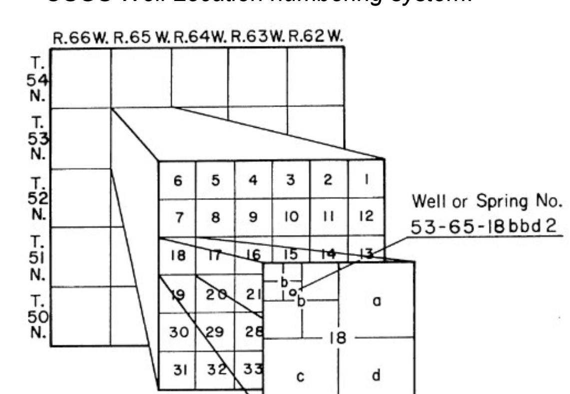
Table 3-3: Water Quality of Casper Aquifer Wells and Springs in or near the Casper Aquifer Protection Area.

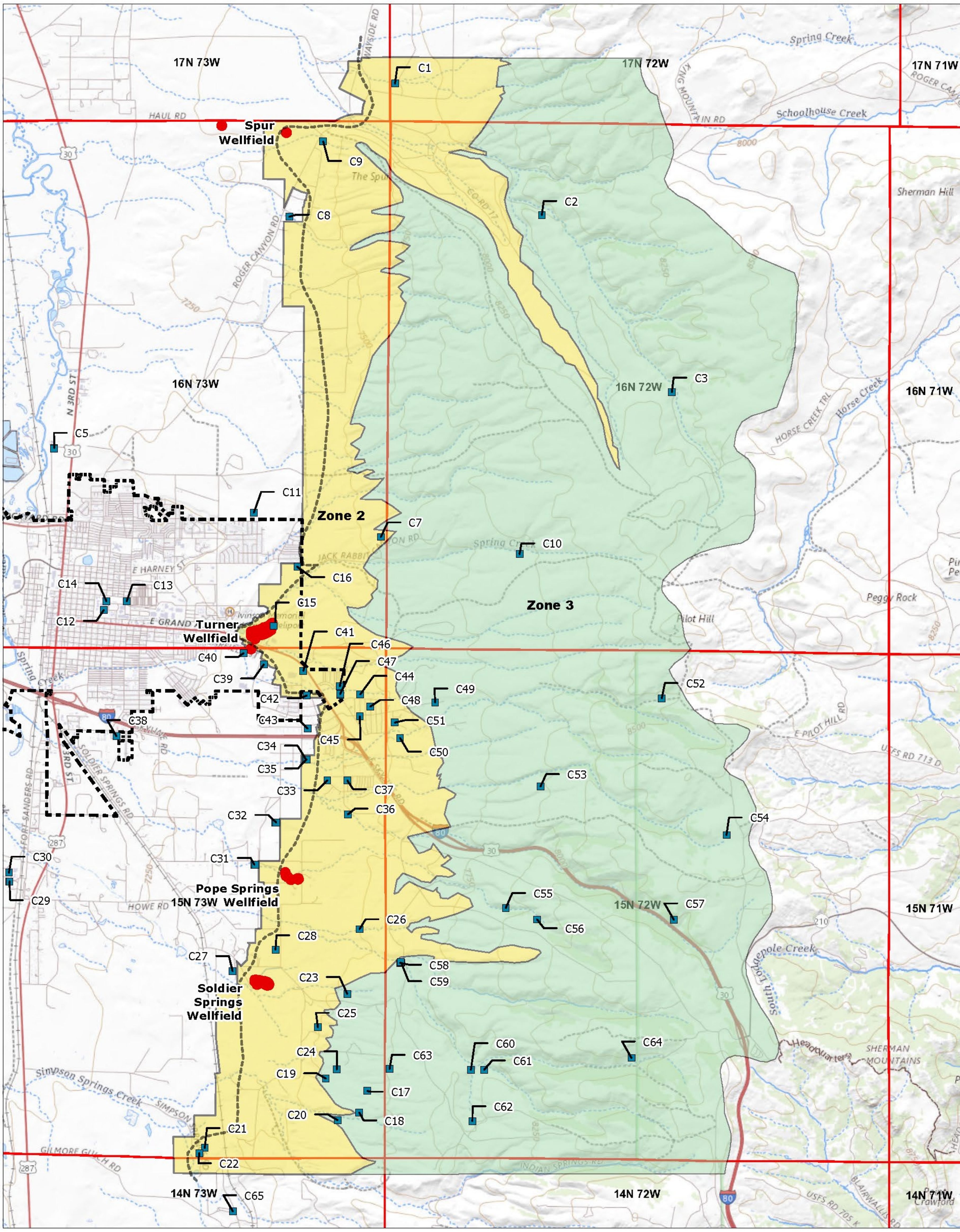
Map ID Number	Well Location (T, R, Sec)	Well Name or Owners Name	Well Depth (ft)	Date Sample Collected	pH	Major Cations				Major Anions				TDS	Specific Conductance	Data Source
						Ca	Mg	Na	K	HCO_3	Cl	SO_4	NO_3-as N			
C1	17-72-31 cbb	Cash	NR	7/15/1976	7.7	40	18	4.1	2.2	215	3.04	8	1.2	203	368	Lundy, 1978
C2	16-72-05 dd	Warren Livestock	>220	7/27/1976	7.7	40	17	3.3	0.88	190	1.76	7	4.1	196	357	Lundy, 1978
C3	16-72-15 cdd	Warren Livestock	200	7/19/1976	7.7	54	15	2	0.46	226	0.59	9	0.7	211	383	Lundy, 1978
C4	16-73-19 dd	Warren Livestock	480	7/23/1976	7.6	44	12	1.9	0.52	195	0.11	5	1.1	178	327	Lundy, 1978
C5	16-73-21 cbc	USBM Retort Well #1	1337	5/31/1969	NA	32	21	4.9	1.6	174	2.9	26	1.15	190	331	USGS, NWIS 2022
C5	16-73-21 cbc	USBM Retort Well #1	1337	7/15/1976	7.6	27	20	4.6	1.05	167	1.38	25	0.9	180	328	Lundy, 1978
C6	16-73-29 bca	Wyo Central #1	1655	8/5/1976	8.6	13	20	5.8	1.22	129	1.68	25	0.2	139	269	Lundy, 1978
C6	16-73-29 bca	Wyo Central #1	1655	6/24/1976	8.3	18	20	7	1.08	146	1.99	27	0.2	159	297	Lundy, 1978
C6	16-73-29 bca	Wyo Central #1	1655	8/5/1976	8	25	20	7	1.39	167	1.98	26	1.2	181	329	Lundy, 1978
C7	16-73-25 dad	D. Dunlavy	>275	6/30/1976	7.8	46	15	1.9	0.61	213	0.1	6	0.1	188	348	Lundy, 1978
C8	16-73-02 ddc1	--	108	4/26/1943	NA	32	33	NA	NA	234	10	32	1.02	240	430	USGS, NWIS 2022
C9	16-73-01 bbc1	Jmathis-1 (Alb7)	200	8/28/2012	7.4	45.3	17	2.67	<1	217	1	5.7	1.7	211	342	Boughton, 2014
C10	16-72-29 dc	Warren Livestock	300 (?)	7/26/1976	7.6	53	11	1.6	0.65	209	0.01	8	0.7	193	353	Lundy, 1978
C11	16-73-26 bdd	Warren Livestock	280	7/16/1976	7.7	40	20	3	0.85	219	0.64	6	1.0	198	361	Lundy, 1978
C12	16-73-33 dba1	--	1015	4/22/1943	NA	36	24	NA	NA	190	2	23	0.63	198	358	USGS, NWIS 2022
C13	16-73-33 add1	--	1240	4/22/1943	NA	30	22	NA	NA	168	2	19	0.11	172	316	USGS, NWIS 2022
C14	16-73-33 acd	Univ. Wyo. #3	878	7/13/1976	8	31	21	6.5	1.25	195	0.77	18	0.3	192	348	Lundy, 1978
C15	16-73-35 dcb	City Springs	--	8/4/1976	7.3	52	16	1.9	0.71	227	0.33	6	0.9	207	378	Lundy, 1978
C16	16-73-35 aaa	Turner No. 3 (41T3)	246	8/6/2014	7.4	54	17	2	<1	248	2	9	1.5	219	338	Wyoming Groundwater, 2014
C17	15-73-36 aac	MCMW#1	380	3/24/2021	8.1	48	17	2	1	226	3	9	1.8	230	494	Mountain Cement, 2022
C18	15-73-36 acd	MCMW#2	380	3/24/2021	8.1	49	16	2	1	230	2	7	1.5	220	434	Mountain Cement, 2022
C19	15-73-36 bab	MCMW#3	190	3/24/2021	8.2	46	18	3	1	223	4	9	1.9	210	490	Mountain Cement, 2022
C20	15-73-36 caa	MCMW#5	163	3/24/2021	8.0	49	16	2	1	231	2	9	1.8	230	453	Mountain Cement, 2022
C21	15-73-34 dd	Test Well #2	430	12/28/2012	7.8	53	19	5	1	212	5	17	2.5	211	372	Weston, 2013
C22	15-73-34 ddc	Monolith Portland Midwest Co.	NR	7/7/1976	6.7	45	16	5.3	0.91	203	4.86	17	1.3	210	379	Lundy, 1978
C23	15-73-25 abb	King #1 (P94793W)	340	3/24/2021	8.3	50	17	3	1	235	4	9	1.8	220	453	Mountain Cement, 2022
C24	15-73-25 cdd	Johnson #2 (P95938W)	360	3/24/2021	8.0	42	22	3	1	244	2	6	1.4	220	518	Mountain Cement, 2022
C25	15-73-25 bcd1	--	250	5/21/1997	7.7	52.5	20.9	3.06	1.02	NA	2.4	10.4	1.8	232	418	USGS, NWIS 2022
C26	15-73-24 aca	Mountain Cement #1 (P72810W)	240	6/8/2021	7.7	57	17	2	<1	226	4	8	<0.1	210	405	Mountain Cement, 2022
C27	15-73-23 cca	Despain #1	200(?)	7/2/1976	7.4	47	16	3.2	0.95	215	2.98	10	0.9	206	375	Lundy, 1978
C28	15-73-23 dba1	Helling #1 (Alb14)	200	9/12/2012	7.5	59.3	15.4	3.28	<1	239	8.6	8.7	2.14	236	401	Boughton, 2014
C29	15-73-17 dcb1	Monolith #1	1629	1/10/1969	NA	31	24	8.3	1.3	180	2.4	37	NA	214	359	USGS, NWIS 2022
C29	15-73-17 dcb	Monolith #1	1629	7/22/1976	7.5	27	22	6.7	1.1	174	1.7	30	0.8	191	343	Lundy, 1978
C30	15-73-17 dbc	Monolith #2	1315	7/23/1976	7.6	35	26	9	1.13	176	0.01	38	1.3	215	366	Lundy, 1978
C31	15-73-14 caa1	--	215	5/26/1941	NA	47	18	NA	NA	235	3.2	1.4	0.7	208	NA	USGS, NWIS 2022
C31	15-73-14 caa1	--	215	4/22/1943	NA	48	20	NA	NA	236	1.0	4.0	1.1	195	NA	USGS, NWIS 2022
C32	15-73-14 aba1	Strom #3	200	4/22/1943	NA	50	19	NA	NA	236	2.0	4.0	1.1	197	364	USGS, NWIS 2022
C32	15-73-14 aba	Strom #3	200	6/30/1976	7.9	48	17	1.7	0.86	221	0.5	6	1.0	202	363	Lundy, 1978
C33	15-73-12 cab1	--	180	5/20/1997	7.7	57.7	17.4	3.99	0.92	NA	6.13	10	2.21	234	420	USGS, NWIS 2022

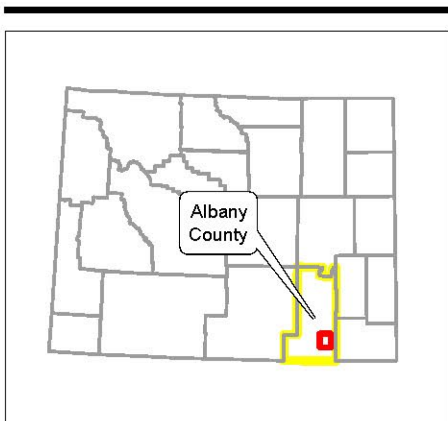
Map ID Number	Well Location (T, R, Sec)	Well Name or Owners Name	Well Depth (ft)	Date Sample Collected	pH	Major Cations				Major Anions				TDS	Specific Conductance	Data Source
						Ca	Mg	Na	K	HCO_3	Cl	SO_4	NO_3-as N			
C34	15-73-12 bcb1	H. Brown	100	8/3/1976	7.4	42	25	2.5	1.28	230	4.25	11	0.2	214	404	Lundy, 1978
C35	15-73-12 bcb2	H. Brown	135	7/23/1976	7.3	49	16	1.9	0.76	223	5.4	7	1.1	208	375	Lundy, 1978
C36	15-73-12 dcc1	--	240	8/5/2013	7.4	51	17	3	<1	222	4.1	8.3	1.8	204	389	USGS, NWIS 2022
C37	15-73-12 dbb	K. Thompson	130	7/21/1976	7.3	51	15	1.6	0.74	229	0.37	6	1.1	208	380	Lundy, 1978
C38	15-73-09 aab	Robinson #1	780	7/21/1976	7.5	43	25	7.1	1.37	244	0.43	28	0.4	242	425	Lundy, 1978
C39	15-73-02 abc	LCCC MW #1	210	1/11/2006	7.67	59.2	20.2	3.5	0.7	238	6	15	2.6	215	405	Wyoming Groundwater, 2017c
C40	15-73-02 bab	Turner #1 (41T1)	236	7/26/1976	7.4	49	17	2	0.85	233	0.11	6	0.4	205	302	Lundy, 1978
C41	15-73-01 bcbb1	Triangle	125.6	9/14/2016	7.4	65	17	6.6	<1	232	14	21	4.49	258	487	USGS, NWIS 2022
C42	15-73-01 cbb	W. Reuland	120	7/21/1976	7.4	50	17	2.1	0.85	228	1.71	8	1.8	214	389	Lundy, 1978
C43	15-73-01 ccc1	--	130	5/20/1997	7.7	58.6	20.2	6.76	1.04	NA	6.69	16.8	4.72	262	470	USGS, NWIS 2022
C44	15-73-01 dba1	Anders #1	175	7/20/1976	7.2	48	12	1.9	0.68	200	0.37	9	1.4	192	348	Lundy, 1978
C45	15-73-01 dca1	--	NR	9/8/1983	7.9	51	13	2.4	0.8	NA	2.5	14	1.6	199	349	USGS, NWIS 2022
C46	15-73-1 bdd	Imperial Heights North	160	4/15/2015	7.8	61	16	4	<1	253	7	11	2.3	354	374	Hinckley Consulting and Wyoming Groundwater, 2015
C47	15-73-01 caa1	Imperial Heights South	116.6	4/15/2015	7.7	74	20	20	1	242	37	25	7.5	427	519	Hinckley Consulting and Wyoming Groundwater, 2015
C47	15-73-01 caa1	Imperial Heights South	116.6	9/13/2016	7.5	67	17	12	1.1	199	31	26	6.29	276	544	USGS, NWIS 2022
C48	15-73-01 dac	K. Endsley	190	7/20/1976	7.1	50	15	1.6	0.72	220	0.01	7	1.2	203	369	Lundy, 1978
C49	15-72-06 db	D. Dunlavy	300	7/20/1976	7.5	57	13	2	0.93	231	0.05	10	1.8	220	393	Lundy, 1978
C50	15-72-07 bba1	Heard #1 (Alb11)	300	9/11/2012	7.3	59.6	14.7	1.66	<1	252	0.7	7.1	1.58	227	391	Boughton, 2014
C51	15-72-06 cc	Warren Livestock	NR	7/20/1976	7.5	44	15	1.5	0.83	210	0.48	8	1.5	194	346	Lundy, 1978
C52	15-72-03 cab	Laycock Spring	--	7/22/1976	7.1	62	5	1.6	0.83	212	0.05	7	0.5	197	357	Lundy, 1978
C53	15-72-08 da	Warren Livestock	177	7/22/1976	7.4	60	15	1.3	0.47	251	0.03	7	1.1	225	408	Lundy, 1978
C54	15-72-14 bbc	Warren Livestock	NR	7/22/1976	7.3	67	0	0.9	0.32	208	0.04	6	1.1	194	343	Lundy, 1978
C55	15-72-20 baa	Warren Livestock	NR	7/2/1976	7.5	59	9	2.2	0.47	215	6.41	7	1.0	210	358	Lundy, 1978
C56	15-72-20 aac	Warren Livestock	NR	7/27/1976	7.5	54	12	1.6	0.96	223	0.37	6	0.8	208	376	Lundy, 1978
C57	15-72-22 bad	Telephone Spring	--	7/22/1976	7	85	5	8.2	0.67	250	25.6	8	3.6	285	502	Lundy, 1978
C58	15-72-19 cbd	MCMW#7	96	6/8/2021	7.8	60	15	2	<1	231	4	7	1.6	210	467	Mountain Cement, 2022
C59	15-72-19 cbd	Warren Livestock (P8769P)	240	8/3/1976	7.3	52	13	1.5	0.58	213	0.16	6	1.1	197	366	Lundy, 1978
C59	15-72-19 cbd	#6 Kassahn Mill (P8769P)	240	6/8/2021	7.8	58	15	2	<1	223	4	7	1.5	220	398	Mountain Cement, 2022
C60	15-72-29 ccc	MCMW#8	62	6/8/2021	7.9	66	14	2	<1	233	3	9	2.1	240	427	Mountain Cement, 2022
C61	15-72-29 ccb	Warren Livestock	80	7/2/1976	7.6	57	12	1.9	0.54	214	0.44	10	1.6	213	378	Lundy, 1978
C62	15-72-32 cbb	MCMW#4	141	6/8/2021	8.0	57	14	2	<1	218	2	12	1.9	230	404	Mountain Cement, 2022
C63	15-72-30 ccc	Waitkus-R	340	3/24/2021	8.0	51	16	3	<1	233	5	9	1.7	230	519	Mountain Cement, 2022
C64	15-72-28 dda	Warren Livestock	165	8/3/1976	7.2	62	6	1.2	0.5	212	0.01	7	1.0	197	359	Lundy, 1978
C65	14-73-02 cbd	Brow #2	215	11/12/2005	8.4	23	15	4.2	0.9	110	7.7	17	3.3	140	270	CBM Associates, 2006

Notes:
Ca: Calcium; Mg: Magnesium; Na: Sodium; K: Potassium; HCO3: Bicarbonate; Cl: Chloride; SO4: Sulfate; NO3: Nitrate as Nitrogen; TDS: Total Dissolved Solids
Units: All units in mg/l with the following exceptions: pH in standard units
All Lundy (1978) nitrate data converted to nitrate as nitrogen by dividing Table 2 values from his thesis by 4.43.
NA – Not analyzed or reported; sodium and potassium typically reported together for older samples.
Specific Conductance in micromhos at 20.5 degrees C for Lundy (1978) and at 25 degrees C for USGS NWIS results
NR – Not reported
See Figure 3-7 for well or spring location

USGS Well Location numbering system:







Legend

- Approximate Well or Spring Locations (C1)
- Municipalities
- Protective Satanka Shale Thickness
- CAPA Zone 1
- CAPA Zone 2
- CAPA Zone 3

0 0.6 1.2 Miles

(At original document size of 11x17)
1:76,032

N

Notes
1. Coordinate System: NAD 1983 StatePlane Wyoming East FIPS 4901 Feet
2. Data Sources: USGS, City of Laramie, WHPA (2008), C1: Well or Spring location number corresponds to Table 3.3
3. Background: USGS 7.5 Minute Quadrangle

Stantec

Project Location
T16N, R73W
Laramie, Albany Co., WY

Prepared by KAB on 2023-02-15
TR by XXX on 2020-XX-XX
IR by XXX on 2020-XX-XX

Client/Project
227704690
City of Laramie/Albany County
Casper Aquifer Protection Plan Update

Figure No.
3-7

Title
Casper Aquifer Water Quality Data Locations

3.3.3 CASPER AQUIFER NITRATE WATER QUALITY ASSESSMENT AND MONITORING

A groundwater supply used to provide drinking water for a public water system does not require treatment (i.e. chlorination, filtration, aeration, blending) unless an individual constituent exceeds an MCL established by the EPA. When a constituent in groundwater consistently exceeds an MCL, the groundwater will need to be treated to comply with safe drinking water standards. As water quality regulations have expanded and changed through the years, it is increasingly difficult for groundwater sources to comply with the MCLs for natural and man-made constituents. However, the Casper Aquifer in the vicinity of Laramie has been a rare exception to this reality. The exceptional groundwater quality of the Casper Aquifer in the vicinity of Laramie and its current compliance with EPA drinking water standards is a characteristic that makes this a unique and valuable resource.

Of the National Primary Drinking Water regulated contaminants, nitrate as nitrogen is the most concerning given that it has been detected at elevated concentrations within the CAPA, particularly east of the Turner Wellfield. Based on nitrate concentrations reported for wells listed in Table 3-3 that lie within Zone 3 of the CAPA as shown on Figure 3-7, the background nitrate as nitrogen concentration for the Casper Aquifer east of Laramie is approximately 1.6 mg/L. These wells lie east and upgradient of developed areas and therefore reflect water quality conditions in the recharge area. WWC (2013) considered nitrate as nitrogen concentrations less than 2 mg/L to be background levels. Elevated nitrate concentrations (4-10.6 mg/L) from drinking water samples within Zone 2 of the CAPA in January 2001 raised concern regarding the septic systems associated with several subdivisions in Albany County (Wittman, 2008). Nitrate as nitrogen is regulated under the Safe Drinking Water Act (SDWA). Nitrate levels in public water systems must remain below a Maximum Contaminant Level (MCL) of 10 mg/L as nitrogen (10 mg/L as N).

Wittman (2008) recommended that a groundwater monitoring program be implemented within the CAPA and the City of Laramie (2009, 2010) completed groundwater sampling for nitrates in 98 domestic wells within the CAPA in 2009 and 2010. Following that testing, the City of Laramie established a groundwater monitoring network that currently consists of 10 wells and began routine nitrate sampling and water level monitoring in 2013. Hinckley Consulting and Wyoming Groundwater (2015) also completed a study of the Sherman Hills Fault in 2015 that included nitrate sampling of several monitoring wells completed northwest of the Sherman Hills Estates subdivision.

In the summer/fall of 2009, the City of Laramie (2009) collaborated with domestic well owners in the recharge area to obtain groundwater samples from 98 domestic wells located within areas identified as Rogers Canyon (east of the Spur Wellfield), East Grand (southeast of Turner Wellfield), Laramie South (south of Pope and Soldier Wellfields), and Happy Jack (southeast of the CAPA). All 98 groundwater samples were analyzed for nitrate-nitrogen (NO3-N) and nine select wells were tested for total/fecal coliform. The nitrate testing results for these samples are included in Table 3-4.

Nitrate concentrations ranged from 0.89 to 19 mg/L for wells within Zone 2. The wells with the highest concentrations of nitrate-nitrogen were located in the East Grand area, where 29% of the wells sampled had nitrate concentrations over 5 mg/L. Three of the sampled wells had nitrate concentrations over 10 mg/L, and were all located in the East Grand area. The average nitrate concentration in the East Grand area was 3.9 mg/L (City of Laramie, 2009), which is higher than the background nitrate as nitrogen concentration of 1.6 mg/L. Only one well outside of the East Grand area had a nitrate-nitrogen concentration above 5 mg/L. Figure 3-8 illustrates the locations of these wells by their respective nitrate concentrations along with the nitrate concentrations for wells and springs listed in Table 3-3. While some elevated concentrations of nitrate are randomly scattered across the CAPA, it is apparent from Figure 3-8 that most of the elevated nitrate concentrations based on the historic nitrate data are present within the subdivisions southeast of the Turner Wellfield north and northeast of I-80. Total/fecal coliform results on all wells tested were negative (City of Laramie, 2009).

During the second sampling event in the spring of 2010, the City of Laramie collaborated with 52 domestic well owners, including 34 from the 2009 study, to sample again for nitrates. Nitrate sampling results for this effort are included in Table 3-4 along with the 2009 data. Results of the testing indicated approximately 9% of the wells in the East Grand area had nitrate concentrations greater than 5 mg/L. The average nitrate concentration in the East Grand area was reported to be 3.2 mg/L (City of Laramie, 2010). The City recommended that monitoring not only continue for nitrate-nitrogen on a biannual basis, but that additional monitoring be conducted for other parameters, including chloride and possibly caffeine and/or nitrogen isotopes to further evaluate the sources of contamination. Nitrate concentrations in the 34 wells sampled in both 2009 and 2010 from Table 3-4 generally appeared to be stable, but were lower in 2010 for EG-18, EG-26, and EG-49,

Other subsequent studies identified similar nitrate concentrations in various media. In 2015 graduate students from the University of Wyoming found that nitrate concentrations in Spring Creek ranged from 8.9 to 10.2 mg/L with a consistent enrichment of the 15N nitrogen isotope in the water and grass, as compared to samples from outside the creek (Stable Isotope Facility, 2016). Similarly in 2014, Laramie High School students working with the UW Stable Isotope Facility found that insects from Spring Creek showed 15N enrichment compared to the same species collected from the Big Laramie River. 15N enrichment indicates the source of the nitrate was either animal or human waste, and the Casper Aquifer Nitrate Study proposal (Stable Isotope Facility, 2016) concluded that residential septic systems were the most likely point of origin.

The City of Laramie currently has a monitoring well network that consists of 10 wells. While most of these were completed for water level monitoring purposes, some of these wells (41T2 and 41T3) were originally completed for municipal supply or other purposes. The locations of the wells are shown on Figure 3-9. Most of the wells are located in close proximity to the Turner Wellfield, but the City also has monitoring wells at both the Spur and Soldier Wellfields along with Simpson Springs and one along I-80. The wells are routinely sampled for nitrate and to obtain water levels in the aquifer. Nitrate sampling results for these wells are included in Table 3-5. Nitrate sample results for most monitoring wells have been comparable to those for the wellfields downgradient. However, several of the wells have exhibited either elevated or varying nitrate concentrations. Nitrate concentrations for 41T3 have varied from 1.4 to 11 mg/L since 2014. Detailed sampling of this well by Wyoming Groundwater (2014) indicated that the higher nitrate concentrations obtained from this well are due to the influence of groundwater from the Satanka Shale mixing with water from the Casper Aquifer. The variability in nitrate concentrations measured in this well is a primary reason for carefully designing and constructing monitoring wells as noted in Section 6.3.2.8. Located at the northwest edge of Sherman Hills Estates, the Imperial Heights South well has had elevated nitrate concentrations of 6.4 to 9.3 mg/L since 2015, while the downgradient Triangle and LCCC wells have had consistent nitrate concentrations of 4.4 to 4.8, and 3.4 to 3.6 mg/L over the same timeframe. The Imperial Heights North and South monitoring wells were installed as part of the 2015 investigation of the Sherman Hills Fault.

Hinckley Consulting and Wyoming Groundwater (2015) completed a hydrogeologic investigation of the Sherman Hills Fault at Imperial Heights Park that involved the drilling, testing, and water quality sampling of three Casper Aquifer monitoring wells and one test hole. The additional purposes of this investigation were to install monitoring wells upgradient of the Turner Wellfield to provide water quality data and assess potential impacts of aquifer water quality due to East Grand area subdivisions. The Triangle well was completed in the upper sandstone of the delta member of the Casper Aquifer to a depth of approximately 126 feet. The Imperial Heights North well was completed in the upper sandstone of the gamma member to a depth of 160 feet. The Imperial Heights South well was completed in the upper sandstone of the delta member to a depth of approximately 117 feet. The Triangle and Imperial Heights South wells provide water quality data from discrete sandstone layers that are beneath septic systems in the East Grand area subdivisions (Wyoming Groundwater and Hinckley Consulting, 2015). Water quality data for these wells are included in Table 3-3 and Table 3-5.

Table 3-4: 2009/2010 Domestic Well Sampling Nitrate Testing Results.

Modified Well Name	Sample Date	NO_3 as N	Data Source
EG-1	8/24/2009	1.5	City of Laramie, 2009
EG-2	8/24/2009	1.7	City of Laramie, 2009
EG-3	8/24/2009	3.1	City of Laramie, 2009
EG-4	8/24/2009	2.2	City of Laramie, 2009
EG-4	8/24/2009	2.2	City of Laramie, 2009
EG-5	8/24/2009	3.3	City of Laramie, 2009
EG-6	8/24/2009	5.9	City of Laramie, 2009
EG-7	8/24/2009	1.4	City of Laramie, 2009
EG-8	8/24/2009	1.4	City of Laramie, 2009
EG-9	8/24/2009	8.4	City of Laramie, 2009
EG-10	8/24/2009	1.5	City of Laramie, 2009
EG-10	4/20/2010	1.6	City of Laramie, 2010
EG-11	8/24/2009	5.7	City of Laramie, 2009
EG-12	8/25/2009	1.6	City of Laramie, 2009
EG-12	5/20/2010	1.5	City of Laramie, 2010
EG-13	8/26/2009	3.1	City of Laramie, 2009
EG-13	4/27/2010	2.8	City of Laramie, 2010
EG-14	8/26/2009	1.8	City of Laramie, 2009
EG-14	5/20/2010	2.6	City of Laramie, 2010
EG-15	8/26/2009	2.8	City of Laramie, 2009
EG-15	8/26/2009	2.7	City of Laramie, 2009
EG-15	5/17/2010	2.4	City of Laramie, 2010
EG-16	8/26/2009	3.6	City of Laramie, 2009
EG-17	8/26/2009	4.7	City of Laramie, 2009
EG-17	5/20/2010	3.6	City of Laramie, 2010
EG-18	8/26/2009	6.9	City of Laramie, 2009
EG-18	4/27/2010	4.5	City of Laramie, 2010
EG-18	4/27/2010	4.5	City of Laramie, 2010
EG-19	8/26/2009	2	City of Laramie, 2009
EG-19	5/20/2010	1.8	City of Laramie, 2010
EG-20	8/26/2009	3.6	City of Laramie, 2009
EG-21	8/26/2009	8.1	City of Laramie, 2009
EG-22	8/26/2009	0.89	City of Laramie, 2009
EG-23	8/26/2009	12.1	City of Laramie, 2009
EG-24	8/31/2009	2.7	City of Laramie, 2009

Modified Well Name	Sample Date	NO_3 as N	Data Source
EG-24	5/17/2010	2.8	City of Laramie, 2010
EG-25	8/31/2009	1.6	City of Laramie, 2009
EG-25	8/31/2009	1.6	City of Laramie, 2009
EG-25	4/12/2010	1.8	City of Laramie, 2010
EG-25	4/12/2010	1.8	City of Laramie, 2010
EG-26	8/31/2009	7.9	City of Laramie, 2009
EG-26	5/20/2010	2.8	City of Laramie, 2010
EG-27	8/31/2009	2.7	City of Laramie, 2009
EG-28	8/31/2009	2	City of Laramie, 2009
EG-28	5/17/2010	2	City of Laramie, 2010
EG-29	9/2/2009	1.6	City of Laramie, 2009
EG-29	5/17/2010	1.4	City of Laramie, 2010
EG-30	9/2/2009	4.2	City of Laramie, 2009
EG-31	9/2/2009	1.3	City of Laramie, 2009
EG-32	9/2/2009	6.3	City of Laramie, 2009
EG-33	9/2/2009	1.9	City of Laramie, 2009
EG-34	9/2/2009	1.2	City of Laramie, 2009
EG-34	9/2/2009	1.2	City of Laramie, 2009
EG-35	9/2/2009	5.7	City of Laramie, 2009
EG-35	4/20/2010	4.9	City of Laramie, 2010
EG-36	9/2/2009	1.6	City of Laramie, 2009
EG-37	9/2/2009	6.4	City of Laramie, 2009
EG-38	9/2/2009	6.8	City of Laramie, 2009
EG-39	9/2/2009	1	City of Laramie, 2009
EG-40	9/1/2009	4.6	City of Laramie, 2009
EG-40	9/1/2009	4.4	City of Laramie, 2009
EG-41	9/1/2009	1.7	City of Laramie, 2009
EG-42	9/1/2009	3.9	City of Laramie, 2009
EG-43	9/1/2009	8	City of Laramie, 2009
EG-44	9/1/2009	3.2	City of Laramie, 2009
EG-45	9/1/2009	1.3	City of Laramie, 2009
EG-46	9/1/2009	1.4	City of Laramie, 2009
EG-47	9/1/2009	1.2	City of Laramie, 2009
EG-48	9/1/2009	1.5	City of Laramie, 2009
EG-49	9/28/2009	10.3	City of Laramie, 2009
EG-49	5/17/2010	7.3	City of Laramie, 2010

Modified Well Name	Sample Date	NO_3 as N	Data Source
EG-50	9/28/2009	1.6	City of Laramie, 2009
EG-51	9/28/2009	1.6	City of Laramie, 2009
EG-51	4/20/2010	2.2	City of Laramie, 2010
EG-52	9/28/2009	4.3	City of Laramie, 2009
EG-53	9/29/2009	1.5	City of Laramie, 2009
EG-54	9/29/2009	4	City of Laramie, 2009
EG-54	9/29/2009	4	City of Laramie, 2009
EG-54	5/17/2010	3.3	City of Laramie, 2010
EG-55	9/29/2009	6.2	City of Laramie, 2009
EG-55	5/17/2010	5.9	City of Laramie, 2010
EG-56	9/29/2009	19	City of Laramie, 2009
EG-57	9/29/2009	1.9	City of Laramie, 2009
EG-58	9/29/2009	7.4	City of Laramie, 2009
EG-59	10/5/2009	5.9	City of Laramie, 2009
EG-59	10/5/2009	5.9	City of Laramie, 2009
EG-60	10/5/2009	8.1	City of Laramie, 2009
EG-61	10/7/2009	2.2	City of Laramie, 2009
EG-62	10/7/2009	1.2	City of Laramie, 2009
EG-63	4/20/2010	2.7	City of Laramie, 2010
EG-63	4/20/2010	2.7	City of Laramie, 2010
EG-64	4/20/2010	3.6	City of Laramie, 2010
EG-65	4/27/2010	5.7	City of Laramie, 2010
EG-66	4/28/2010	1.9	City of Laramie, 2010
EG-66	4/28/2010	1.9	City of Laramie, 2010
EG-67	5/17/2010	4.4	City of Laramie, 2010
EG-67	5/17/2010	4.4	City of Laramie, 2010
EG-68	5/17/2010	1.9	City of Laramie, 2010
EG-69	5/17/2010	1.7	City of Laramie, 2010
EG-70	5/17/2010	1.2	City of Laramie, 2010
EG-71	5/17/2010	4.2	City of Laramie, 2010
EG-72	5/20/2010	4.6	City of Laramie, 2010
EG-73	5/20/2010	4.9	City of Laramie, 2010
EG-74	5/25/2010	4.5	City of Laramie, 2010
EG-75	5/25/2010	3.1	City of Laramie, 2010
EG-76	5/25/2010	1	City of Laramie, 2010
EG-77	5/26/2010	4.8	City of Laramie, 2010

Modified Well Name	Sample Date	NO_3 as N	Data Source
HJ-1	10/7/2009	1.6	City of Laramie, 2009
HJ-1	10/7/2009	1.6	City of Laramie, 2009
HJ-2	10/7/2009	0.44	City of Laramie, 2009
HJ-3	10/7/2009	0.89	City of Laramie, 2009
HJ-3	5/25/2010	0.86	City of Laramie, 2010
HJ-3	5/25/2010	0.83	City of Laramie, 2010
LS-1	9/1/2009	1.9	City of Laramie, 2009
LS-1	5/18/2010	1.8	City of Laramie, 2010
LS-1	5/18/2010	1.8	City of Laramie, 2010
LS-2	9/1/2009	1.8	City of Laramie, 2009
LS-2	4/29/2010	1.9	City of Laramie, 2010
LS-3	9/8/2009	2.2	City of Laramie, 2009
LS-3	5/18/2010	2.3	City of Laramie, 2010
LS-4	9/8/2009	3	City of Laramie, 2009
LS-5	9/8/2009	4.3	City of Laramie, 2009
LS-5	9/8/2009	4.3	City of Laramie, 2009
LS-6	9/8/2009	1.6	City of Laramie, 2009
LS-6	5/4/2010	1.4	City of Laramie, 2010
LS-6	5/4/2010	1.4	City of Laramie, 2010
LS-7	9/8/2009	1.7	City of Laramie, 2009
LS-8	9/8/2009	1.8	City of Laramie, 2009
LS-8	5/18/2010	1.8	City of Laramie, 2010
LS-9	9/8/2009	1.6	City of Laramie, 2009
LS-9	5/18/2010	1.5	City of Laramie, 2010
LS-10	9/8/2009	1.5	City of Laramie, 2009
LS-11	9/8/2009	1.5	City of Laramie, 2009
LS-12	9/8/2009	1.3	City of Laramie, 2009
LS-12	4/29/2010	1.7	City of Laramie, 2010
LS-12	4/29/2010	1.7	City of Laramie, 2010
LS-13	9/8/2009	1.7	City of Laramie, 2009
LS-13	4/29/2010	1.7	City of Laramie, 2010
LS-14	9/8/2009	8.1	City of Laramie, 2009
LS-14	5/4/2010	9.4	City of Laramie, 2010
LS-15	9/8/2009	1.5	City of Laramie, 2009
LS-15	4/29/2010	1.4	City of Laramie, 2010
LS-16	9/28/2009	2.2	City of Laramie, 2009

Modified Well Name	Sample Date	NO_3 as N	Data Source
LS-17	9/28/2009	2.2	City of Laramie, 2009
LS-18	9/28/2009	1.8	City of Laramie, 2009
LS-18	5/18/2010	1.8	City of Laramie, 2010
LS-19	9/28/2009	1.9	City of Laramie, 2009
LS-20	9/28/2009	2.7	City of Laramie, 2009
LS-20	5/26/2010	2.7	City of Laramie, 2010
LS-21	10/7/2009	1.6	City of Laramie, 2009
LS-22	5/4/2010	1.6	City of Laramie, 2010
RC-1	9/22/2009	1.5	City of Laramie, 2009
RC-2	9/22/2009	1.7	City of Laramie, 2009
RC-2	5/20/2010	1.7	City of Laramie, 2010
RC-2	5/20/2010	1.7	City of Laramie, 2010
RC-3	9/22/2009	1.4	City of Laramie, 2009
RC-4	9/22/2009	2.1	City of Laramie, 2009
RC-4	9/22/2009	2.1	City of Laramie, 2009
RC-5	9/22/2009	1.4	City of Laramie, 2009
RC-6	9/22/2009	1.5	City of Laramie, 2009
RC-6	5/18/2010	1.4	City of Laramie, 2010
RC-7	9/22/2009	1.3	City of Laramie, 2009
RC-8	9/23/2009	1.1	City of Laramie, 2009
RC-8	5/18/2010	1	City of Laramie, 2010
RC-9	9/23/2009	1.5	City of Laramie, 2009
RC-10	9/23/2009	1.7	City of Laramie, 2009
RC-10	9/23/2009	1.7	City of Laramie, 2009
RC-11	9/23/2009	0.91	City of Laramie, 2009
RC-12	9/23/2009	1.5	City of Laramie, 2009
RC-13	5/18/2010	2.1	City of Laramie, 2010
RC-14	5/20/2010	1.6	City of Laramie, 2010
	MCL	**10**	

Notes:
NO3: Nitrate
MCL: Maximum Contaminant Level as established by the U.S. Environmental Protection Agency (EPA) for drinking water standards.
Enforceable primary standards in bold type.
Units: All units in mg/l
Results shown for the same well name are either duplicate sample results submitted for QA/QC purposes or results for different sampling years.
Well names are designated by general geographic area as follows: EG - East Grand; HJ - Happy Jack; LS - Laramie South; RC - Rogers Canyon
Figure 3-8 illustrates nitrate concentration results from Tables 3-3 and 3-5 (2009 data only)

Table 3-5: Casper Aquifer Monitoring Well Nitrate Data Summary.

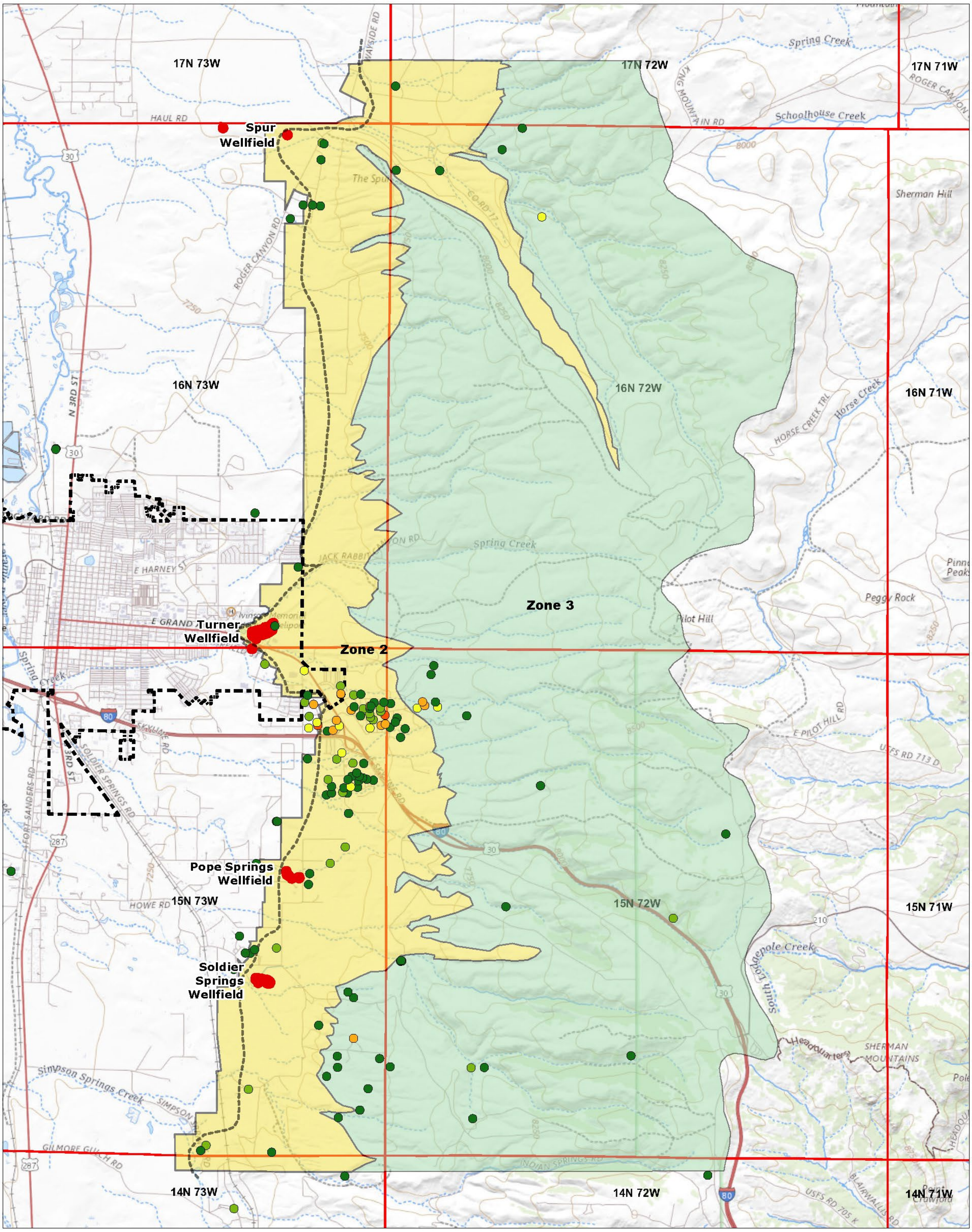
Well or Spring Name	Sample Date	NO_3 as N	Data Source
Simpson MW-1	10/8/2013	2.6	Parkin, 2022
Simpson MW-1	6/6/2014	2.5	Parkin, 2022
Simpson MW-1	9/29/2014	2.5	Parkin, 2022
Simpson MW-1	7/28/2015	2.3	Parkin, 2022
Simpson MW-1	10/7/2015	2.3	Parkin, 2022
Simpson MW-1	6/2/2016	0.2	Parkin, 2022
Simpson MW-1	10/19/2016	2.4	Parkin, 2022
Simpson MW-1	5/30/2017	2.3	Parkin, 2022
Simpson MW-1	10/17/2017	2.4	Parkin, 2022
Simpson MW-1	7/10/2018	2.3	Parkin, 2022
Simpson MW-1	6/25/2019	2.4	Parkin, 2022
Simpson MW-1	11/19/2020	2.4	Parkin, 2022
Simpson MW-1	11/8/2021	2.4	Parkin, 2022
Soldier MW-5	10/8/2013	2.1	Parkin, 2022
Soldier MW-5	6/5/2014	2.0	Parkin, 2022
Soldier MW-5	9/29/2014	1.9	Parkin, 2022
Soldier MW-5	7/28/2015	1.9	Parkin, 2022
Soldier MW-5	10/7/2015	1.8	Parkin, 2022
Soldier MW-5	6/2/2016	0.2	Parkin, 2022
Soldier MW-5	10/13/2016	1.9	Parkin, 2022
Soldier MW-5	5/30/2017	1.9	Parkin, 2022
Soldier MW-5	10/17/2017	2.0	Parkin, 2022
Soldier MW-5	7/10/2018	1.9	Parkin, 2022
Soldier MW-5	6/25/2019	2.0	Parkin, 2022
Soldier MW-5	11/18/2020	2.0	Parkin, 2022
Soldier MW-5	11/8/2021	2.1	Parkin, 2022
Spur MW-6	10/8/2013	1.7	Parkin, 2022
Spur MW-6	6/6/2014	1.6	Parkin, 2022
Spur MW-6	9/29/2014	1.6	Parkin, 2022
Spur MW-6	7/28/2015	1.7	Parkin, 2022
Spur MW-6	10/7/2015	1.6	Parkin, 2022
Spur MW-6	6/2/2016	0.2	Parkin, 2022
Spur MW-6	10/18/2016	1.6	Parkin, 2022
Spur MW-6	5/22/2017	1.6	Parkin, 2022
Spur MW-6	10/18/2017	1.6	Parkin, 2022

Well or Spring Name	Sample Date	NO_3 as N	Data Source
Spur MW-6	7/10/2018	1.5	Parkin, 2022
Spur MW-6	6/25/2019	1.6	Parkin, 2022
Spur MW-6	11/18/2020	1.7	Parkin, 2022
Spur MW-6	11/3/2021	1.8	Parkin, 2022
EQ-1 (WYDOT)	10/8/2013	1.9	Parkin, 2022
EQ-1 (WYDOT)	6/6/2014	3.7	Parkin, 2022
EQ-1 (WYDOT)	9/30/2014	3.3	Parkin, 2022
EQ-1 (WYDOT)	7/29/2015	2.7	Parkin, 2022
EQ-1 (WYDOT)	10/7/2015	2.1	Parkin, 2022
EQ-1 (WYDOT)	6/6/2016	2.1	Parkin, 2022
EQ-1 (WYDOT)	10/19/2016	1.7	Parkin, 2022
EQ-1 (WYDOT)	10/4/2017	1.7	Parkin, 2022
EQ-1 (WYDOT)	7/12/2018	2.1	Parkin, 2022
EQ-1 (WYDOT)	6/26/2019	2.2	Parkin, 2022
EQ-1 (WYDOT)	11/19/2020	1.9	Parkin, 2022
EQ-1 (WYDOT)	11/19/2020	1.9	Parkin, 2022
EQ-1 (WYDOT)	11/8/2021	1.9	Parkin, 2022
41T2	9/29/2014	2.9	Parkin, 2022
41T2	7/29/2015	0.2	Parkin, 2022
41T2	10/7/2015	0.1	Parkin, 2022
41T2	6/3/2016	< 0.05	Parkin, 2022
41T2	10/18/2016	2.9	Parkin, 2022
41T2	5/30/2017	< 0.05	Parkin, 2022
41T2	10/18/2017	< 0.20	Parkin, 2022
41T2	7/11/2018	0.3	Parkin, 2022
41T2	6/25/2019	<0.20	Parkin, 2022
41T2	11/18/2020	<0.20	Parkin, 2022
41T2	11/3/2021	<0.20	Parkin, 2022
41T3	6/5/2014	11**	Parkin, 2022
41T3	6/27/2014	9.9**	Parkin, 2022
41T3	8/6/2014	1.5	Wyoming Groundwater, 2014
41T3	9/29/2014	4.6**	Parkin, 2022
41T3	7/29/2015	5.4**	Parkin, 2022
41T3	10/7/2015	4.4**	Parkin, 2022
41T3	6/3/2016	1.4	Parkin, 2022
41T3	10/18/2016	3.0	Parkin, 2022

Well or Spring Name	Sample Date	NO_3 as N	Data Source
41T3	5/30/2017	2.9	Parkin, 2022
41T3	10/18/2017	2.5	Parkin, 2022
41T3	7/11/2018	8.6	Parkin, 2022
41T3	6/25/2019	5.0	Parkin, 2022
Imperial Heights South	4/13/2015	8.3	Parkin, 2022
Imperial Heights South	10/13/2015	8.7	Parkin, 2022
Imperial Heights South	6/6/2016	8.4	Parkin, 2022
Imperial Heights South	10/12/2016	6.4	Parkin, 2022
Imperial Heights South	5/24/2017	6.8	Parkin, 2022
Imperial Heights South	10/18/2017	7.9	Parkin, 2022
Imperial Heights South	7/12/2018	9.0	Parkin, 2022
Imperial Heights South	11/9/2021	9.3	Parkin, 2022
Imperial Heights North	4/6/2015	1.6	Parkin, 2022
Imperial Heights North	4/23/2015	1.3	Parkin, 2022
Imperial Heights North	6/6/2016	0.1	Parkin, 2022
Imperial Heights North	10/19/2016	< 0.05	Parkin, 2022
Imperial Heights North	5/25/2017	< 0.05	Parkin, 2022
Imperial Heights North	10/18/2017	< 0.20	Parkin, 2022
Imperial Heights North	7/11/2018	< 0.20	Parkin, 2022
Imperial Heights North	6/29/2019	<0.20	Parkin, 2022
Imperial Heights North	11/18/2020	<0.20	Parkin, 2022
Imperial Heights North	11/3/2021	<0.20	Parkin, 2022
Triangle	3/31/2015	4.8	Parkin, 2022
Triangle	10/13/2015	4.6	Parkin, 2022
Triangle	6/6/2016	4.7	Parkin, 2022
Triangle	10/12/2016	4.6	Parkin, 2022
Triangle	5/24/2017	4.4	Parkin, 2022
Triangle	10/18/2017	4.7	Parkin, 2022
Triangle	7/11/2018	4.7	Parkin, 2022
Triangle	6/26/2019	4.7	Parkin, 2022
Triangle	7/9/2020	4.8	Parkin, 2022
Triangle	11/9/2021	4.7	Parkin, 2022
LCCC	7/13/2015	3.4	Parkin, 2022
LCCC	12/8/2015	3.5	Parkin, 2022
LCCC	10/25/2016	3.5	Parkin, 2022
LCCC	8/29/2017	3.4	Parkin, 2022

Well or Spring Name	Sample Date	NO_3 as N	Data Source
LCCC	8/21/2018	3.6	Parkin, 2022
LCCC	9/14/2021	3.5	Parkin, 2022
	MCL	**10**	

Notes:
NO3: Nitrate
MCL: Maximum Contaminant Level as established by the U.S. Environmental Protection Agency (EPA) for drinking water standards.
Enforceable primary standards in bold type. Non-enforceable secondary standards in italics.
Units: All units in mg/l
** - Measurements are anomalously high.

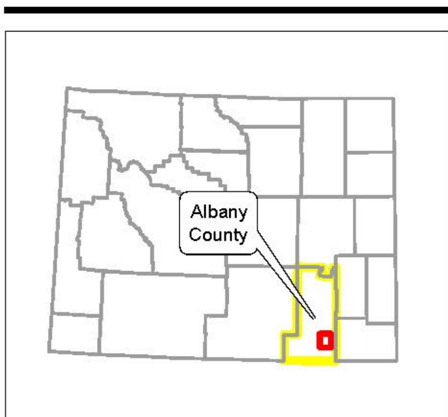


Legend

Approximate Well Location

NO3-N (ppm)

- 0-2
- 2-4
- 4-6
- 6-10
- 10-19
- Municipalities
- Protective Satanka Shale Thickness
- CAPA Zone 1
- CAPA Zone 2
- CAPA Zone 3



Notes
1. Coordinate System: NAD 1983 StatePlane Wyoming East FIPS 4901 Feet
2. Data Sources: USGS, City of Laramie, WHPA (2008), City of Laramie (2009), Table 3.3
3. Background: USGS 7.5 Minute Quadrangle

0 0.6 1.2 Miles
(At original document size of 11x17)
1:76,406

N

Stantec

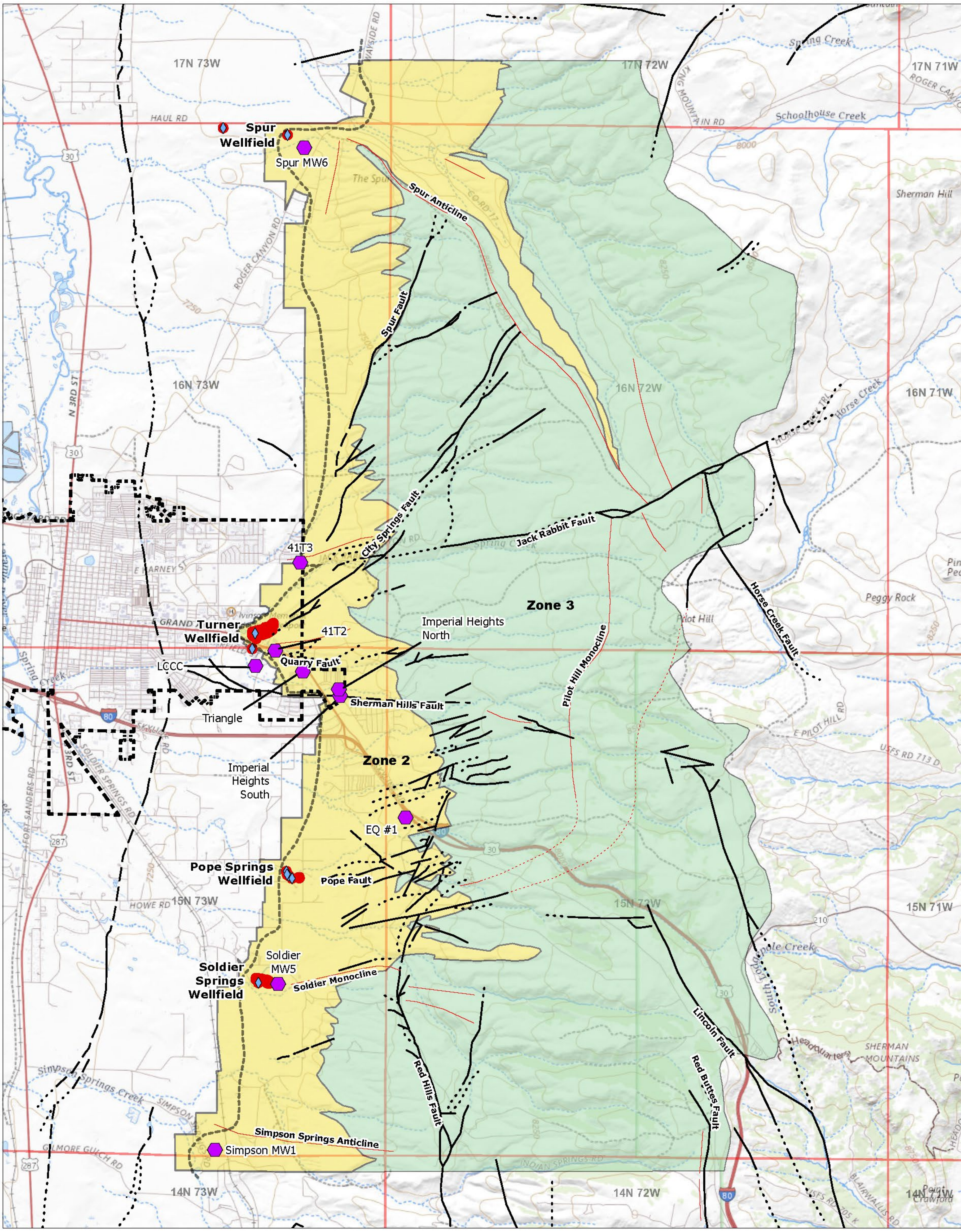
Project Location
T16N, R73W
Laramie, Albany Co., WY

Prepared by KAB on 2023-02-15
TR by XXX on 2020-XX-XX
IR by XXX on 2020-XX-XX
227704690

Client/Project
City of Laramie/Albany County
Casper Aquifer Protection Plan Update

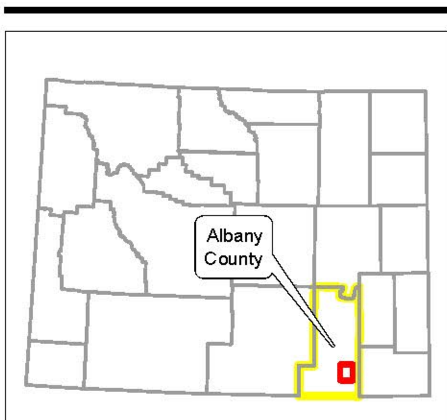
Figure No.
3-8

Title
Historic Casper Aquifer Nitrate Concentrations



Legend

- City of Laramie Municipal Wells
- Existing Monitoring Wells
- Fold
- Fault
- County
- Municipalities
- Protective Satanka Shale Thickness
- CAPA Zone 1
- CAPA Zone 2
- CAPA Zone 3



0 0.6 1.2 Miles

(At original document size of 11x17)
1:76,406

N

Stantec

Project Location
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Prepared by KAB on 2023-02-15
TR by XXX on 2020-XX-XX
IR by XXX on 2020-XX-XX

Client/Project
227704690
City of Laramie/Albany County
Casper Aquifer Protection Plan Update

Figure No.
3-9

Title
Existing Monitoring Well Locations

Notes
1. Coordinate System: NAD 1983 StatePlane Wyoming East FIPS 4901 Feet
2. Data Sources: USGS, Ver Ploeg and Boyd (2007), City of Laramie
3. Background: USGS 7.5 Minute Quadrangle

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Water quality testing of these wells indicated that nitrate concentrations in the Casper Aquifer vary with location and aquifer member. Hinckley Consulting and Wyoming Groundwater (2015) documented that water samples collected during drilling of the Triangle Well indicated that nitrate concentrations ranged from 3.2 to 4.8 mg/L (i.e. mixed samples from multiple sandstone layers). Water samples collected after the Triangle Well was completed in the upper sandstone of the delta member have nitrate concentrations that range from 4.4 to 4.8 mg/L as indicated in Table 3-5. The water quality and hydraulic head data indicated distinct water-bearing units at this location. The highest nitrate concentration was noted in the upper delta sandstone, which in the full borehole is diluted by input from lower concentrations in the epsilon sandstone and lower delta sandstone. Chloride and conductivity values exhibited the same relationship. The higher-permeability strata encountered in the upper delta sandstone appeared to be carrying nitrates sourced from areas upgradient. At the Imperial Heights North well, nitrate concentrations ranged from 1.1 to 1.6 mg/L. Although there may be some reflection of differences in recharge chemistry for the layers penetrated by the North Well, all three values are within the range of typical background concentrations for nitrate. Given the proximity and hydraulic connection with strata across the Sherman Hills Fault, the somewhat higher concentration in the shallower strata of the North Well may be at least partially the result of higher nitrate concentrations moving from the upper delta sandstone across the fault. With respect to Imperial Heights South, nitrate concentrations ranged from 7.5 to 8.3 mg/L, and have subsequently been measured as high as 9.3 mg/L. The 8.3 value was the highest nitrate concentration measured on the project and approached the public water supply drinking water MCL of 10 mg/l. The relatively high values, the small decrease in nitrates with depth, and the proximity to the adjacent subdivisions are all consistent with septic system discharge and residential land use being the primary sources. The delta sandstones specifically were identified as the members receiving effluent from the largest number of septic systems.

Hinckley Consulting and Wyoming Groundwater (2015) concluded the following from this study:

- Residential activity at the Sherman Hills Estates subdivision has impacted groundwater quality at Imperial Heights Park. The Imperial Height South nitrate concentration of 8.3 mg/L and the Middle Borehole (test hole) nitrate concentration of 7.0 mg/L clearly showed that adjacent upgradient residential subdivisions had impacted groundwater quality beneath Imperial Heights Park. Data from these wells are consistent with the results of the City of Laramie's nitrate sampling completed in 2009/2010 in the rural subdivisions along East Grand Avenue, which found elevated nitrate concentrations in the domestic wells of the Sherman Hills Estates subdivision area.

- City Springs and the Turner Wellfield receive a portion of their groundwater discharge from the southeast, including the area beneath the East Grand Avenue subdivisions. The City Springs/Turner Wellfield represents a regional natural discharge point for the Casper Aquifer, enhanced by the pumping of the municipal wells. The area that contributes groundwater to this discharge includes the relatively undeveloped areas to the north, northeast, and east, and the developed areas to the southeast. The latter includes domestic septic systems in the rural subdivisions and the activities associated with residential development in these subdivisions and Imperial Heights. Groundwater in the Casper Aquifer across the southeast recharge area flows generally westward and is deflected northward by the drawdown associated with City Springs/Turner Wellfield. The elevated nitrate concentration at the Triangle Well is a manifestation of this relationship between contaminant source and groundwater flow direction.

Water quality from City Springs/Turner Wellfield reflects the relative contributions of groundwater converging on the springs area from all directions, and from deeper in the aquifer. Thus, groundwater with elevated nitrates is substantially diluted by groundwater arriving from the relatively unimpacted recharge areas and from greater depths (i.e. beta and alpha members) within the aquifer.

3.3.4 USGS 2012 AND 2016 WATER QUALITY SAMPLING RESULTS

The U.S. Geological Survey (USGS) collected water samples from 146 wells across Wyoming between November 2009 through September 2012. Five Casper Aquifer wells in Albany County were included in this sampling effort. Boughton (2014) reported that these 146 wells were completed to depths less than 500 feet for the Wyoming Groundwater Quality Monitoring Network. Water samples from the wells were analyzed for physical characteristics, major ions and dissolved solids, trace elements, nutrients and dissolved organic carbon, uranium, stable isotopes of hydrogen and oxygen, volatile organic compounds, and coliform bacteria. Selected samples also were analyzed for gross alpha radioactivity, gross beta radioactivity, radon, tritium, gasoline range organics, diesel range organics, dissolved hydrocarbon gases (methane, ethene, and ethane), and wastewater compounds. Major cation and anion concentrations for three of these domestic wells (Alb7 (C9), Alb11 (C50), and Alb14 (C28)) are included in Table 3-3 along with well depth and location. In addition, the USGS obtained water samples from three other Casper Aquifer wells between 2013 and 2016. Major cation and anion concentrations for these wells (C36, Imperial Heights South (C47) and the Triangle Well (C41)) are also included in Table 3-3 along with well depth and location. All water quality data compiled through these sampling efforts are included in eight tables within Appendix C.

These sample results indicate the quality of groundwater from these six wells are very similar to analytical results of other Casper Aquifer wells and indicate that dissolved oxygen introduced into the aquifer in the recharge area is not being consumed by chemical or biological process during its journey through the vadose zone and westward through the Casper Aquifer. The concentrations of some analytes are of particular interest as they may indicate local contamination from septic systems or other human activities. Nitrate concentrations at the Triangle (C41) and Imperial Heights South (C47) wells ranged from 4.49 to 6.29 mg/L, but nitrite was not detected. Dissolved oxygen concentrations at these six wells range from 5.3 to 8.8 mg/L, which reflects a high level of oxygenation within the groundwater of the aquifer. The low level of chemical and biological degradation in the Casper Aquifer is similarly indicated by dissolved oxygen concentrations ranging from 7.1 to 10.0 mg/L in the LCCC campus monitoring well (C39) located 1,000 feet southeast of Turner No. 1. The dissolved oxygen concentrations measured from these wells indicate not only that robust oxidizing conditions exist in the Casper Aquifer west of the Casper aquifer recharge area, but also that denitrifying conditions do not exist. Chloride and sulfate concentrations at the Triangle and Imperial Heights South well were elevated relative to the other Casper Aquifer samples. Of the trace metals, barium, manganese, molybdenum, strontium, vanadium, arsenic, and selenium were detected, but at concentrations below EPA drinking water standards. While no organic compounds associated with hydrocarbons were detected at these six wells, the following organic compounds associated with wastewater were detected at very low concentrations in the well(s) noted: DEET in the Triangle Well; Prometon and Phenanthrene in the Triangle and Imperial Heights South wells; and Phenol and Tetrachloroethene in the Imperial Heights South well. DEET is a common active ingredient in insect repellents. Prometon is a pesticide, while Phenanthrene is used to make dyes, explosives, and drugs.

WWC Engineering (2013) suggested sampling for a variety of parameters to further assess the impacts of wastewater on drinking water supplies. These parameters included acetaminophen, caffeine, carbamazepine, coprostanol, E coli, and total inorganic nitrogen. Of these parameters, the USGS sampling of the Triangle and Imperials Heights South wells either did not sample for (acetaminophen, carbamazephine, and total inorganic nitrogen) or did not detect (caffeine, coprostanol, and e coli) these particular parameters.

4 Delineation of the Casper Aquifer Protection Area

This chapter describes Step 2 of the five-step process outlined in the Wyoming WHP guidance document: identify land areas that contribute water to drinking water supplies and that should have some level of protection. Aquifer protection is intended to protect groundwater supplies and drinking water from contamination for present and future uses. The purpose of the delineation process is to define and map the aquifer protection area. An aquifer protection area considers the entire groundwater resource, including both existing and potential groundwater supply development areas. Delineation of the protection area has been conducted using hydrogeologic and aquifer vulnerability mapping techniques to protect the aquifer rather than the more restrictive concept of wellhead protection. Within this framework, this section describes the decisions made to define and map the aquifer protection area for the Casper Aquifer in the Laramie area.

4.1 FUNDAMENTAL FINDINGS

Based on the geologic, hydrogeologic, and water quality data presented in Chapter 3, the following characteristics were viewed as the fundamental conclusions regarding the Casper Aquifer. While the Technical Review Subcommittee of the EAC reached agreement on these characteristics during the original delineation process, Stantec reviewed and updated these as appropriate to include the following:

- Groundwater flow within the Casper Aquifer includes both porous flow (intergranular) and conduit flow (faults, fractures, joints, bedding surfaces, and dissolution features);
- The epsilon and delta members of the Casper Aquifer have higher intergranular permeability than the underlying gamma, beta and alpha members;
- Fractures associated with faults and folds and dissolution along bedding surfaces dramatically enhance the permeability of the sandstones and limestones of the Casper Aquifer;
- The Casper Aquifer is underlain by the Sherman Granite which acts as an aquitard or aquiclude;
- The Casper Aquifer is unconfined or semi-confined over most of the outcrop area of the Casper Aquifer;
- The recharge area for the Casper Aquifer is the entire exposed outcrop area of the Casper Aquifer on the west flank of the Laramie Range. Recharge mechanisms for the Casper Aquifer include direct infiltration from precipitation and snow melt and infiltration of surface water runoff, particularly in natural drainage channels;
- The Casper Aquifer is generally confined where covered by undisturbed Satanka Shale, but the protection afforded the Casper Aquifer begins where the Satanka Shale is more than 50 feet thick;

- The lower 50 feet of the Satanka Shale is in hydraulic connection with the Casper Aquifer;
- The Casper Aquifer is particularly vulnerable to contamination at City, Pope, Soldier, and Simpson Springs where groundwater passes through approximately 36 to 125 feet of fractured Satanka Shale to the land surface. At City Springs and Soldier Springs, the full discharge of the springs is subject to capture when the Turner Wellfield or Soldier No. 1, respectively, is operating; and
- The Casper Aquifer yields groundwater of high quality, but nitrate contamination due to septic systems have resulted in locally elevated nitrate concentrations.

The delineation of the CAPA discussed below is based on present understanding of the hydrogeology and extent of the Casper Aquifer, its recharge mechanics, and the dynamics of groundwater movement within the Casper Aquifer and between the Casper Aquifer and underlying and overlying geologic strata. The current state of hydrogeologic knowledge of the Casper Aquifer is limited to available data and is subject to refinement as new data become available. Stantec amended the western boundary of the CAPA and slightly amended the boundaries of Zone 1 at the Turner Wellfield. The northern, eastern, and southern boundaries remain as identified by previous aquifer protection planning efforts.

Vertically fractured Casper Formation sandstone below limestone caprock.

4.2 DELINEATION METHODS AND PROCESS

The Wyoming WHP guidance document, which was used as a guide to determine appropriate delineation methods for the CAPA, suggests that three different protection areas be established. The protection areas are designated Zones 1, 2, and 3 as shown on Figure 1-3. While the WHP guidance document provided delineation methods that have been applied to the City of Laramie municipal supply wells, the aquifer protection areas delineated here also protect the Casper Aquifer and drinking water for domestic well owners within the CAPA.

Zone 1 protection areas are to be established around each of the municipal wells. The purpose of the Zone 1, or Accident Prevention Zone, is to prevent the accidental introduction of contaminants into the aquifer in the immediate vicinity of the well. The Wyoming WHP Guidance Document indicates that the Zone 1 protection area is to be a fixed radius of 50 or 100 feet, depending upon well completion and vulnerability to contamination. However, these radii are minimum distances and can be increased to provide additional protection if necessary. Each domestic well also has a comparable “Zone 1” protection area because Wyoming DEQ Chapter 25 requires a minimum 100-foot setback from both on-property and neighboring septic absorption fields used for wastewater disposal. These areas are not shown on Figure 1-3.

Zones 2 and 3 are designated the Attenuation and Remedial Action Zones, respectively. The purpose of Zone 2 is to protect the municipal well from contact with pathogenic microorganisms and to allow for remediation or clean-up of a spill that may occur in the vicinity of the wellhead. Zone 2 is typically based on a 2-year groundwater time of travel. The purpose of Zone 3 is to protect the aquifer from contaminants that may migrate to the municipal well and to allow time for remediation of the contaminant or replacement of the water resource. Zone 3 is typically based on a 5 year groundwater time of travel. For the Casper Aquifer near Laramie, vulnerability mapping, instead of time of travel methods were used to delineate the protection areas for Zone 2 or Zone 3. While formally applicable to public water supply wells, Zones 2 and 3 also provide the relevant mapping and protective measures for domestic wells within the CAPA.

The Casper Aquifer in the Laramie area is a dual porosity, anisotropic, fractured sandstone and limestone aquifer with no apparent hydrogeologic or flow boundaries between wellfields. The Casper Aquifer has the potential for rapid recharge and transport of groundwater over large distances. These factors, combined with a lack of detailed hydrogeologic data over large parts of the aquifer and the extreme expense of gaining appropriate data, limit the use of numerical or semi-analytical delineation methods for defining protection areas based on time of travel (EPA, 1991). Consequently, hydrogeologic and vulnerability mapping methods were used to delineate the CAPA.

Where the aquifer yielding water to wells and springs is characterized by fracture or conduit flow, Zone 3 is delineated first and is defined by flow system boundaries. Zone 3 is delineated using hydrogeologic mapping techniques that identify those parts of the aquifer that might reasonably be expected to yield water to the municipal wells. After creating Zone 3, vulnerability was used to delineate Zone 2. The Zone 2 delineation identifies those areas that are particularly vulnerable to contamination within the larger area delineated by hydrogeologic mapping. In recognition of the impracticality of strictly defining Zone 2 using vulnerable features such as faults, drainages, and exposed bedrock, and the potential for rapid groundwater flow in the fractured Casper Aquifer, Zone 3 will continue to be managed the same as Zone 2 until research or data recommend otherwise.

The CAPA was based on the review of existing data which allowed for the determination of the geologic boundaries of the Casper Aquifer and the areas within those boundaries that require different levels of protection. The CAPA delineation is dependent on three primary factors:

- The amount of available information regarding aquifer characteristics;
- The accuracy of the existing information; and
- The delineation methodology selected and applied in the process.

Published information concerning the Casper Aquifer in the Laramie area was reviewed and updated with the most recent published and unpublished information available from mapping, drilling and aquifer testing. The aquifer protection area delineation that follows represents Stantec's view of the best representation of the aquifer protection area required for the Casper Aquifer based on our review of the geologic and hydrogeologic information available. This work builds upon and complements the work completed by Wittman (2008) for the City of Laramie and the Albany County Planner (2011).

4.2.1 ZONE 1 PROTECTION AREA

Many of the municipal wells serving the City of Laramie are drilled in the immediate vicinity of springs. The springs are located at topographic lows where the potentiometric surface of the Casper Aquifer intersects topography or where weaknesses in the confining layer are breached and groundwater from the Casper Aquifer can flow up through the overlying Satanka Shale to the ground surface. At many locations the springs are not distinct, but are visible as large, wet grassy areas. When the City wells are not pumped for extended periods of time the springs flow; however, when the municipal wells are pumped and the cone of depression associated with pumping propagates to the springs, a reversal of gradient occurs and the springs cease to flow. When the reversal of gradient occurs, groundwater moves from the spring site to the well. Additionally, any contaminants introduced in the immediate vicinity of the springs can follow the same pathway as the groundwater and be pumped by the well into the municipal water system. To adequately protect the wells that provide drinking water to the City of Laramie, as shown in Figure 4-1, the Zone 1 protection areas were delineated by establishing a 100 foot radius around the municipal wells and historic spring areas. Each domestic well also has an effective "Zone 1" protection area because Wyoming DEQ Chapter 25 requires a minimum 100 foot setback from both on-property and neighboring septic absorption fields used for wastewater disposal. The public water supply well for Tumbleweed Express (EPA Water System No. WY5601724) also lies within the CAPA.

The delineation procedures followed for each of the municipal wellfields are described below.

4.2.1.1 SPUR WELLFIELD

The Zone 1 protection areas for the Spur No. 1 and No. 2 wells have each been established as 100 foot radii around each well. The radii have been assigned to protect the aquifer in the vicinity of the wells, where the Casper Aquifer occurs at a shallow depth. There are no springs at the Spur Wellfield requiring Zone 1 protection.

4.2.1.2 CITY SPRINGS AND TURNER WELLFIELD

The Zone 1 protection area for the Turner wellfield was completed through field mapping around City Springs by Wittman (2008) and using the buried collection pipe and spring boxes south of Turner No. 2 identified by Hinckley and Moody (2015a). It also includes the area around the spring at the north end of the automobile dealer located at 3609 Grand Avenue (Laramie Ford) (WWC Engineering and others, 2015). Wittman (2008) used a Global Positioning Satellite (GPS) receiver to map the depression associated with the location of the historic City Springs location, spring boxes, and the Turner No. 1 and No. 2 wells. A 100 foot buffer was drawn around each of the mapped or identified features, and the resulting polygons were then combined where overlap occurred.

4.2.1.3 POPE WELLFIELD

The Zone 1 protection areas for the Pope Wellfield were defined by field mapping with a GPS unit by Wittman (2008). The now- abandoned cistern, which was constructed over the historic location of Pope Springs, was mapped and a 100 foot buffer created around that feature. Each of the four wells comprising the Pope Wellfield was assigned a 100 foot radius for the Zone 1 protection area. The protection areas for the wells and cistern do not overlap; however, the five delineated zones comprise the Zone 1 protection area for the wellfield.

4.2.1.4 SOLDIER SPRING AND WELLFIELD

The Zone 1 protection area for the Soldier Spring and Wellfield was defined through field mapping by Wittman (2008). A GPS receiver was used to map the depression associated with the historic location of Soldier Springs, present day Soldier Springs, and the Soldier No. 1 Well. A 100 foot buffer was then drawn around the edge of the depression and the water supply well.

4.2.2 ZONE 2 AND 3 PROTECTION AREAS

As described in the WHP Guidance document, vulnerability mapping is used to subdivide the aquifer outside of Zone 1 into a Zone 2 area that may require a greater degree of protection than Zone 3. The Zone 2 delineation identifies those areas that are particularly vulnerable to contamination within the larger area delineated by hydrogeologic mapping. As discussed previously, there are numerous features such as faults, folds, exposed bedrock, drainages, and shallow depth to groundwater that make the Casper Aquifer vulnerable to contamination. For example, the WDEQ identified four faults – City Springs, Jackrabbit, Quarry, and Sherman Hills – that appeared to have a reasonably high potential to allow adverse impact to municipal springs and wells. WDEQ suggested that unless there is geologic and/or hydrogeologic evidence to convincingly demonstrate that there is no increased vulnerability (i.e. due to cementation, etc.) related to these faults, then these faults must be included in Zone 2. However, these vulnerable features are distributed throughout the CAPA in a complex geometry, such that Zone 2 boundaries defined by these features would be highly irregular and extremely difficult to manage effectively (Wittman, 2008).

The Technical Review Subcommittee agreed that the CAPA should be divided into two sub-areas designated as the Primary Protection Area (Zone 2) and the Secondary Protection Area (Zone 3) with Zone 2 to receive a higher level of protection than Zone 3, but they have been treated with an equal level of protection for reasons noted here. A modified and more practical approach was used by the Technical Review Subcommittee to delineate Zone 2. The outcrop area of the delta and epsilon members of the Casper Aquifer was designated as Zone 2 based on the following considerations:

- The intergranular permeability of the sandstones in the delta and epsilon members is greater than the intergranular permeability of the underlying alpha, beta and gamma members;
- The shallower depth to groundwater near the west edge of the Casper Aquifer outcrop;
- Outcrops of the delta and epsilon members lie in close proximity to the municipal groundwater supply wells for the City of Laramie; and
- The municipal groundwater supply wells and springs for the City of Laramie are completed primarily in the epsilon and delta members of the Casper Aquifer.

Because the delta member is one of the most permeable of the five sandstone members, the Technical Review Subcommittee agreed in 1999 to extend the east boundary of Zone 2 200 feet east of the base of the delta sandstone outcrop. This provides a buffer to prevent contaminants from directly entering the exposed edge of the delta member of the Casper Aquifer. In those situations, in which the 200 foot buffer creates an enclosed or nearly enclosed area of Zone 3, the entire area was designated as Zone 2. The westernmost edge of the line marks the boundary.

All faults in the recharge area were not included in Zone 2 because not all faults have hydrogeologic characteristics that increase aquifer susceptibility to contamination or increase contamination risk to the municipal water supply wells. There are other features, such as exposed sandstone, that are of a more immediate concern. Including every known fault into Zone 2 would be unnecessarily proscriptive to development. In recognition of the impracticality of strictly defining Zone 2 using vulnerable features such as faults, drainages, and exposed bedrock, and the potential for rapid groundwater flow in the fractured Casper Aquifer, Stantec recommends Zone 3 continue to be managed in the same way as Zone 2 until research or data indicate otherwise. In addition, site-specific investigations designed to identify vulnerable features are recommended for any proposed development or proposed new use in Zone 2 or Zone 3. In essence, the level of protection in Zone 3 will be enhanced to equal the level of protection established in Zone 2.

With Zone 2 defined as the outcrop area of the delta and epsilon members, including the protective Satanka Shale thickness line and western boundary, the remainder of the CAPA, east of the delta member to the topographic divide of the Laramie Range, is designated as Zone 3.

4.2.3 PROTECTION AREA BOUNDARIES

As mentioned earlier, in an aquifer with conduit flow characteristics, Zone 3 is delineated using hydrogeologic mapping techniques that identify those parts of the Casper Aquifer that are expected to yield water to the municipal wells. Any residential wells that lie within Zones 2 and 3 of the CAPA benefit from the protective measures implemented to protect the City’s drinking water wells. This section describes the delineation of the east, west, south, and north boundaries of the CAPA. Figure 1-3 shows the location of the CAPA boundaries.

These boundaries represent the limits of the CAPA as defined for the City of Laramie's existing and future wellfields. They do not represent barriers to groundwater flow through the aquifer, and do not represent the limits of the Casper Aquifer along the west side of the Laramie Range. As additional Casper Aquifer water sources are brought online to serve the City, the boundaries should be revised to reflect the additional portions of the aquifer that need to be protected for those sources.

4.2.3.1 DELINEATION OF THE EASTERN BOUNDARY

The east boundary of the CAPA is located at the topographic divide along the crest of the Laramie Range. This determination is based on the following rationale:

- The Sherman Granite generally serves as an aquiclude under the Casper Aquifer;
- The topographic divide is generally very close to the easternmost outcrop of the Casper Aquifer, which is the contact between the Casper Aquifer and the underlying Sherman Granite; and
- The topographic divide of the Laramie Range is generally coincident with the groundwater divide based on the presence of springs that discharge along the contact between the Casper Aquifer and the Sherman Granite. Consequently, groundwater in the Casper Aquifer east of the topographic divide probably flows eastward.

4.2.3.2 DELINEATION OF THE WESTERN BOUNDARY

The western boundary of the CAPA is located west of the contact between the Satanka Shale and the Casper Formations. While the original western boundary was designated as a 75-foot-thick line of Satanka Shale, Wittman (2008) recognized that there were places where this western boundary did not accurately reflect local known Satanka Shales thickness conditions based on various wells and local geologic mapping. Therefore, Wittman (2008) relocated the western boundary west of the 75-foot-thick line of Satanka Shale and aligned the western boundary with township and/or section lines to accommodate known and other potential errors and to provide an additional buffer. This effort was intended to ensure that at least 75 feet of Satanka Shale were overlying the Casper Aquifer across the western boundary until a more accurate location of the western boundary could be located.

Existing hydrogeologic data acquired since the Casper Aquifer Protection Plan was last updated were evaluated to reassess the western boundary location. The alignment of the western boundary has been revised after careful consideration of the effectiveness of the Satanka Shale as a hydrogeologic confining layer over the Casper Aquifer and areas where the confining properties of the Satanka Shale have clearly been compromised by faults or folds. The following observations of spring and well data indicate that at least the lower 50 feet of the Satanka Shale is permeable, can be in hydraulic connection with the Casper Aquifer, and that additional Satanka Shale thickness is needed to provide aquifer protection in some areas:

- The base of the Satanka Shale is composed of interbedded fractured shale and sandstone.

- The water at City Springs, Pope Springs, Soldier Springs, and Simpson Springs flows from the Casper Aquifer to the land surface through approximately 74, 65, 36, and 125 feet, respectively, of Satanka Shale, presumably via vertical fractures.
- Water levels measured in Section 1, Township 15 North, Range 73 West reveal only a small difference in hydraulic head between the basal Satanka Shale and the Casper Aquifer.
- Only where the Satanka Shale has an undisturbed thickness greater than 50 feet at distance from the City's springs and wellfields does this low permeability shaley strata provide vertical confinement, with the degree of confinement increasing with greater thicknesses of the Satanka Shale.

Based on the above data, Stantec agrees with the Technical Review Subcommittee of the 1999 EAC that the Casper Aquifer may be vulnerable to contamination if 50 feet or less of undisturbed Satanka Shale lies between the Casper Aquifer and the ground surface. Because conditions in the lower Satanka Shale vary from place to place and the benefits of the overlying Satanka Shale are judged to start at 50 feet, the Technical Review Subcommittee agreed in 1999 that at least 75 vertical feet of undisturbed Satanka Shale (50 percent more than the thickness of the zone of apparent connectivity) was needed to effectively protect the Casper Aquifer from contaminants that may be spilled or introduced at or near the ground surface. Stantec agrees with the assessment that at least 75 feet of undisturbed Satanka Shale is needed to protect the aquifer in undisturbed areas and to provide an appropriate margin for error in aquifer protection. However, in locations where the confining ability of the Satanka Shale has been disturbed or compromised through faulting and/or folding, the thickness of Satanka Shale needed to protect the aquifer must be increased as appropriate based on local hydrogeologic conditions. At City Springs, for example, a 100 foot thickness is more appropriate to protect the aquifer given the hydraulic connection between the City's wells and adjacent springs. At Simpson Springs, 150 feet is appropriate based on spring locations, drilling data, and hydrologic communication observed during aquifer testing.

The western boundary of the CAPA was revised on the basis of geologic and hydrogeologic conditions associated with local water wells, springs, and recent geologic mapping, including wells and other data that were not available in 2008. Geologic and hydrogeologic reports and well logs along with site-specific investigation reports prepared by professional geologists were reviewed and used to assist in determining the Satanka Shale thickness along the original 75 foot Satanka thickness line. To supplement these data, Stantec compiled and reviewed Wyoming State Engineer's Office (various) well completion reports to determine the well location and thickness of Satanka Shale that each well encountered. The Wyoming State Engineer's Office has required well drillers to submit GPS locations for wells they complete since 2006, and prior to that time required subdivision, lot and block locations. In Stantec's delineation of the western boundary of the CAPA, data from water wells that were only located to quarter sections were generally not used, unless accurate locational data from other sources were provided for these wells. These locational data were used for wells located along or near the original 75 foot Satanka thickness line to map well locations and identify Satanka Shale thickness excluding any overlying sedimentary cover that is prevalent in the area. Between the Spur and Turner Wellfields where few if any wells exist, local geologic mapping of the Forelle Limestone was used to estimate a 75 foot thickness of Satanka Shale based on the dip of the Forelle Limestone and an assumed Satanka Shale thickness of 300 feet. Casper Formation dips from recent geologic mapping were reviewed, but generally not used, because the Casper Formation contact with the overlying Satanka Shale is largely covered by younger sediments along the western margin of the Laramie Range. At City Springs and Simpson Springs, the hydrologic connection between the City's wells and springs was used as the basis for incorporating more than 75 feet of Satanka Shale in those areas. Based on these data and drawing upon physical observations during drilling or pumping operations, the protective Satanka Shale thickness line was contoured where 75 feet of Satanka Shale, or more where that thickness was deemed insufficient, was construed. This line replaces the original 75 foot Satanka thickness line. Data that were used to prepare this alignment are presented in Appendix D.

Because precise location of 75 feet of the overlying Satanka Shale is inherently uncertain and to allow for effective implementation of the CAPP, the west boundary of the CAPA was moved to the west of the protective Satanka Shale thickness line and aligned with property boundaries and/or township or section lines. As well as creating an easily administered boundary line, the revised western boundary provides an additional buffer to the protective Satanka Shale thickness line to provide protection of the Casper Aquifer. With this revision of the western boundary, Spur No. 2 is the only well that lies outside of the APO/APOZ.

4.2.3.3 DELINEATION OF THE SOUTHERN BOUNDARY

As indicated by Wittman (2008), the reasoning for the placement of the southern boundary is as follows:

The springs along the base of the west flank of the Laramie Range, including City Springs, Pope Springs, Soldier Springs, Simpson Springs and others further south, are the surface manifestations of the intersections of east-west trending structural features and a confining bed. The geologic structures contain fractures that allow for the rapid transmission of water downgradient to the point where the water level in the Casper Aquifer intersects a confining layer and the aquifer acquires its maximum saturated thickness (i.e. the potentiometric surface intersects the ground surface). The elevations of the springs increase to the south, with the City Springs being lowest in elevation. This means that the entire Casper Aquifer south of the City Springs has the potential to contribute water to City Springs. However, the southern springs, which are higher in elevation, do not cease flowing during the year. While there is not a flow system boundary in the Casper Aquifer between any of the springs, there is a significant difference in permeability in the rocks that contribute water to the springs, such that the non- fractured rocks have permeabilities that are orders of magnitude less than the fractured rocks. It has long been asserted that the faults and folds in the Casper Aquifer act as “collectors” of groundwater. Groundwater flowing downgradient through the low-permeability rocks that encounters the fractured rocks preferentially moves downgradient in the fracture system and is discharged at the springs. A small quantity of water may cross the fractured zones, but the vast majority of the water is discharged at the springs. As such, the east-west trending structures, such as Simpson Springs Anticline, that feed water into springs are thought to act as localized hydrogeologic drains. In the case of the Sherman Hills Fault, Hinckley Consulting and Wyoming Groundwater (2015) concluded that groundwater flows across the fault at Imperial Heights Park.

The City of Laramie owns Monolith Ranch, which contains Simpson Springs and associated surface water rights. Simpson Springs will likely be one of the next sources of groundwater supply development by the City of Laramie (WWC, 2006; WWC Engineering and others, 2015). In order to protect future water sources, the south boundary was delineated to include Simpson Springs.

4.2.3.4 DELINEATION OF THE NORTHERN BOUNDARY

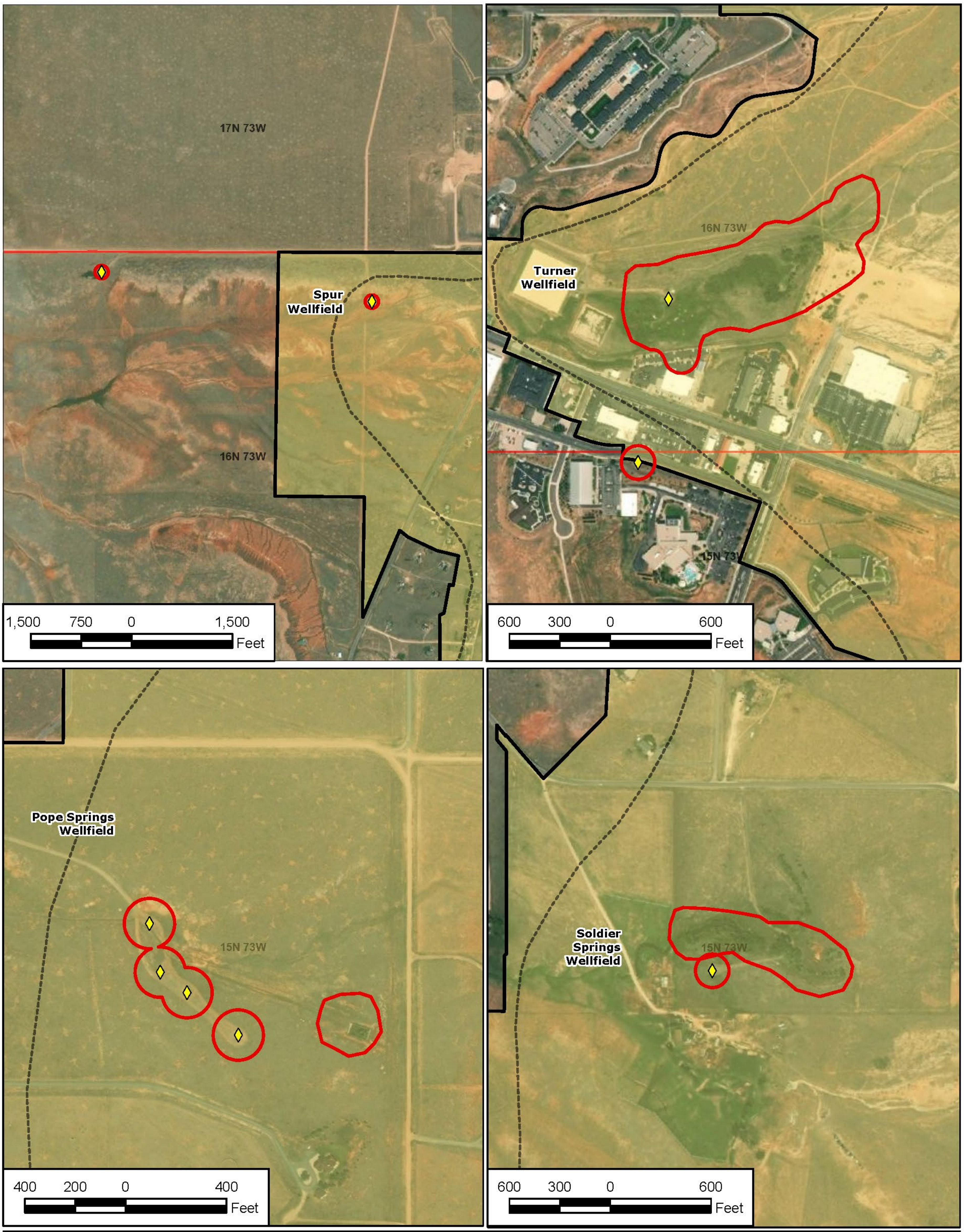
The reasoning for the placement of the north boundary is as follows:

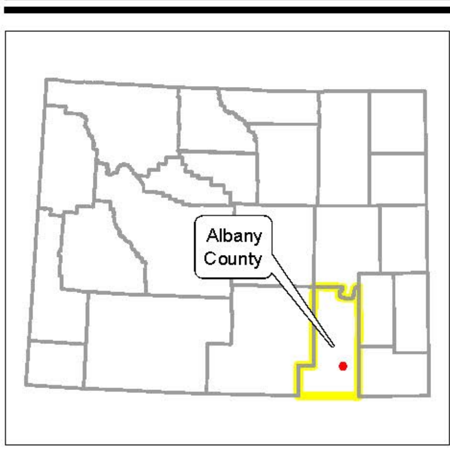
Pump testing of the Spur wells indicates that the majority of the water is derived from the Casper Aquifer from fractures along the crest of the Spur Anticline (WWC, 1997). Aquifer parameters determined from observation wells indicate that the transmissivity of the aquifer between the Spur wells and observation well C-105 approximately 1.5 miles north is approximately 432,000 gpd/ft, which is extremely high. The data also indicate that the aquifer between the two wells ranges from confined to leaky. Geologic mapping of the area north of the Spur wells indicates the presence of small faults that trend east-west, but there are no surface discharges. Therefore, it is assumed that the Casper Aquifer is relatively isotropic north of the Spur wells.

Using the wellhead protection area model (Blandford, Huyakorn, and Wu, 1991), with inputs of: the above transmissivity, confined conditions, aquifer thickness of 700 feet, porosity of 15%, hydraulic gradient of 0.001, long-term pumping rate of 975 gpm, model run time of 5 years, and direction of flow from the north, the result is a capture zone that extends approximately 3,200 feet north of the Spur wells. This capture zone represents a worst-case scenario because it assumes that all of the water is being derived from the north and ignores the contribution of water from the Spur Anticline. Extending the boundary to a point 4,800 feet north of Spur Well No. 2 provides a 50 percent factor of safety.

4.2.4 AQUIFER PROTECTION AREA MAPS

The Aquifer Protection Map, developed using the procedures outlined in the Delineation Process section, is presented as Figure 1-3. Zone 1 areas around the City's wells and springs are shown on Figure 4-1 at a larger scale to allow for easier identification.





Legend

- Protective Satanka Shale Thickness
- City of Laramie Municipal Wells
- CAPA Zone 1
- CAPA Zone 2
- CAPA Zone 3
- PLSS Township

N

Notes
1. Coordinate System: NAD 1983 StatePlane Wyoming East FIPS 4901 Feet
2. Data Sources: USGS, City of Laramie and WHPA (2008)
3. Background: USGS 7.5 Minute Quadrangle

Stantec

Project Location
T16N, R73W
Laramie, Albany Co., WY

Prepared by KAB on 2023-02-14
TR by XXX on 2020-XX-XX
IR by XXX on 2020-XX-XX

Client/Project
227704690
City of Laramie/Albany County
Casper Aquifer Protection Plan Update

Figure No.
4-1

Title
Casper Aquifer Protection Area Zone 1 Delineations

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4.2.5 FUTURE MODIFICATIONS TO THE CASPER AQUIFER PROTECTION AREA BOUNDARIES

The locations of CAPA and zone boundaries should be amended in the future as more information becomes available. Changes to these boundaries should only be allowed:

- When a site-specific investigation and peer review indicates significant variation from the assumptions presented herein;
- When anyone along the western boundary provides sufficient geologic and hydrogeologic data indicating their property or any portion thereof is underlain by 75 feet or more of undisturbed Satanka Shale thickness and presents an administrable survey line; and
- When additional geologic and hydrogeologic data have been acquired by qualified water resource professionals licensed by the State of Wyoming to facilitate the update and to support changes in the boundary.

The Laramie Planning Division and Albany County Planning Department should review the proposed boundary changes and make a recommendation to the Albany County Planning & Zoning and Laramie Planning Commission. The recommendation should include the basis and documentation for the change and any additional information to support the need for a proposed modification to the CAPA. This submittal should include the property or properties affected by the change.

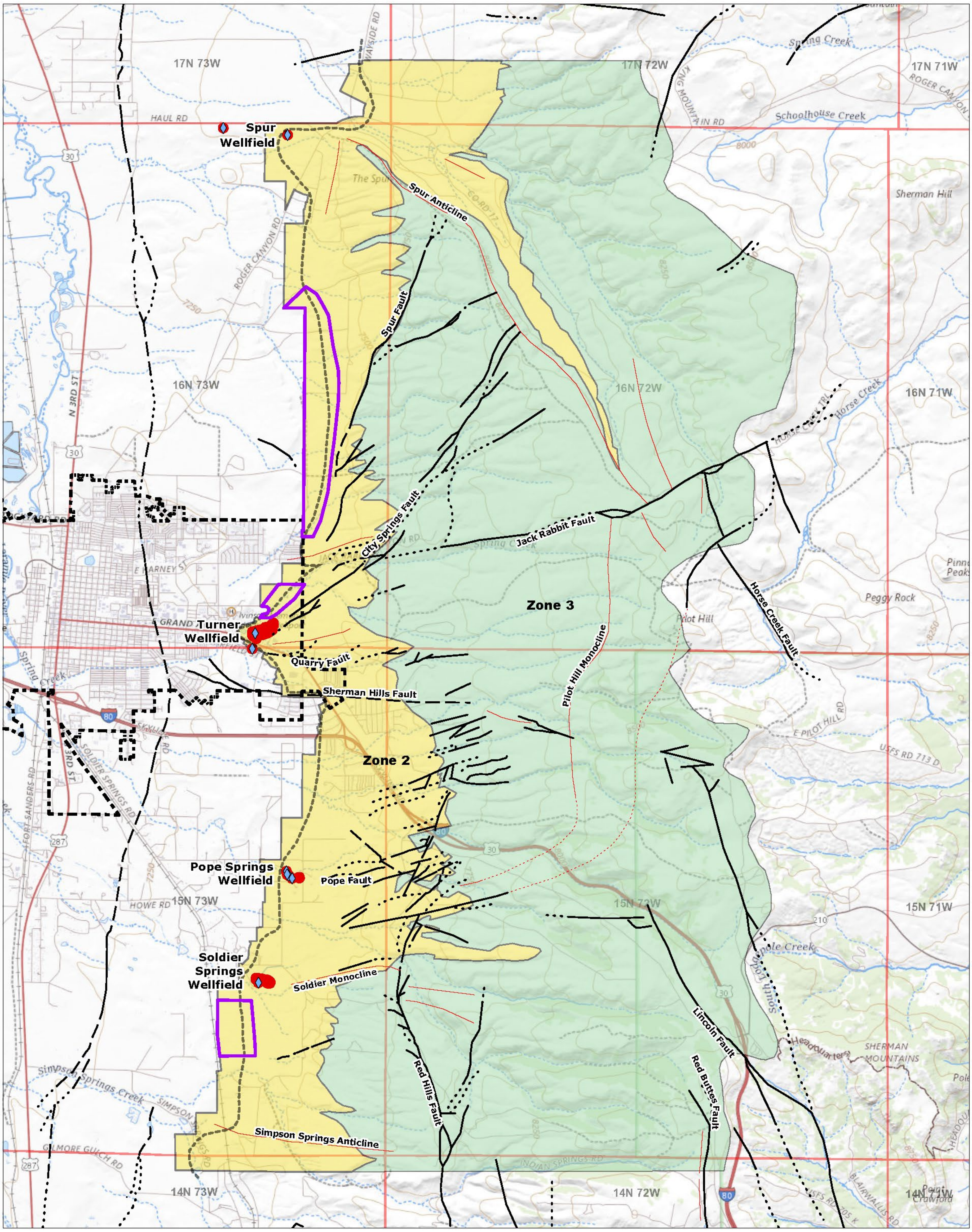
The alignment of the western boundary could be reviewed by the City or County through a land use planning process with regard to any particular property within the APO or APOZ, respectively. If a developer, property owner, or interested party of any property along the western boundary wanted to challenge the location of the western boundary, the City or County should require the acquisition of site specific geologic and hydrogeologic data to accompany a site-specific investigation. Once these data are acquired, such data coupled with recommendations from licensed professionals may serve as a basis for modifications to the western boundary and/or a waiver for CAPA restrictions for the appropriate property. For instance, there are several areas along the western boundary where drilling data are absent and the protective Satanka Shale thickness was estimated based on rock formation dips, as shown on Figure 4-2. These are areas that are particularly ripe for further investigation.

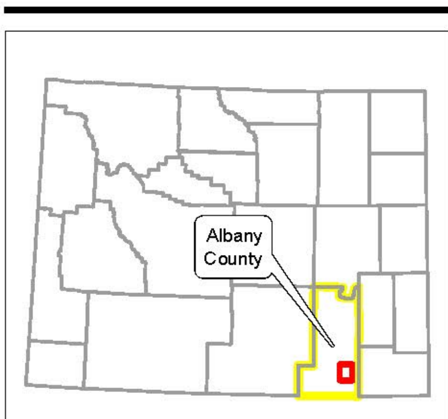
Should the City or the County request a third-party review of the applicant's data and data acquisition methods, this review should be conducted by a licensed professional, independent of the property or the applicant in question. This third-party review could be completed at the applicant's expense. The retained third party reviewer would consider the data presented by the Applicant and make a recommendation to the City and/or the County. The City and County could employ the same third-party professional or could individually employ their own third party professional.

As part of this application process, Stantec recommends that the City and County consider the following guidance for the completion of a hydrogeologic investigation to be included with the site-specific investigation (SSI) to justify an adjustment of the western boundary. Given the complex geology in the area, the number of test holes that would be required depends on (1) the size of the property; (2) the complexity of the local geologic stratigraphy and structure; (3) the nature of the proposed development; and (4) any known factors that might define the local hydrogeologic conditions as they affect the downward migration of contaminants. Each test hole should be drilled to define the thickness and hydrogeologic properties of the Satanka Shale overlying the Casper Aquifer. Geologic and hydrogeologic data from a water well completed at the subject property by a Wyoming licensed well driller could be submitted in lieu of or in addition to drilling other test holes as needed.

Data submitted for the hydrogeologic investigation should include, but not necessarily be limited to the following: a map of drilled locations and drill location coordinates; geologic logs for each borehole or water well completed on the property; thickness and characteristics of the unconsolidated material overlying the Satanka Shale, thickness of the Satanka Shale, geologic and hydrogeologic characteristics of the Satanka Shale, depth at which groundwater is encountered, the volume of groundwater produced (gpm) during drilling, and the electrical conductivity of the produced groundwater at different depth intervals above the top of the Casper Formation. Drill cuttings over 10-foot intervals should be maintained by the applicant and made available to the City or County for their review upon request. Unless completed as a water well permitted with the Wyoming State Engineer’s Office, the test holes should be drilled, plugged, and abandoned by a Wyoming licensed well driller.

In order for a test hole to provide adequate information to support a determination, it is recommended that such drill holes be completed using hollow stem auger and/or air-rotary methods. Alternate drilling methods that provide these data could also be used. Where less than 75 feet of Satanka Shale is present, the test hole should be drilled approximately 20 feet into the Casper Formation and then terminated. Where the Satanka Shale is anticipated to be more than 75 feet thick, the test hole could be terminated at a depth of approximately 100 feet, unless the Casper Formation was encountered at a shallower depth. The test hole would then be terminated 20 feet into the Casper Formation.





Legend

- City of Laramie Municipal Wells
- County
- Municipalities
- PLSS Township
- Protective Satanka Shale Thickness
- CAPA Zone 1
- CAPA Zone 2
- CAPA Zone 3
- Fold
- Fault
- Areas where additional drilling data would be helpful

0 0.6 1.2 Miles

(At original document size of 11x17)
1:76,406

N

Notes
1. Coordinate System: NAD 1983 StatePlane Wyoming East FIPS 4901 Feet
2. Data Sources: USGS, Ver Ploeg and Boyd (2007), Ver Poeg (2007a, 2007b, 2009)
3. Background: USGS 7.5 Minute Quadrangle

Stantec

Project Location
T16N, R73W
Laramie, Albany Co., WY

Prepared by KAB on 2023-02-15
TR by XXX on 2020-XX-XX
IR by XXX on 2020-XX-XX

Client/Project
227704690
City of Laramie/Albany County
Casper Aquifer Protection Plan Update

Figure No.
4-2

Title
Potential Areas for Exploration Drilling

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4.2.6 RECOMMENDED ADDITIONAL CITY AND/OR COUNTY INVESTIGATIONS

To aid in refining the CAPA delineation and to increase the understanding of the Casper Aquifer, the following investigations should be undertaken.

Top Priority

1. Assess potential improvements to routine measurement and monitoring of spring discharge, particularly at City Springs and Soldier Springs. Such improvements could include upgrading the flowmeter at City Springs, installing select monitoring wells to allow SCADA water level access, and installing staff gages. The purpose of these potential improvements is to improve real time springflow monitoring.

2. Perform aquifer testing of Turner Nos. 1 and 2 and Soldier No. 1 wells. The purpose of these tests is to evaluate pumping rates that do not capture the full flow of City Springs or Soldier Springs, and thereby reduce the potential for contaminants to be introduced into the aquifer through the spring conduits when the springs are not flowing. The testing may result in a pumping scheme that would allow for extended periods of simultaneous pumping of both Turner wells.

3. Conduct annual sampling of water from the Turner and Soldier Springs wellfields for Microparticulate Analysis and fecal coliform soon after the pumps are turned on in the spring depending upon the wellfield operation.

4. Design a plan for the construction of additional monitoring wells and expand the current groundwater monitoring network to obtain additional information regarding aquifer water levels, source sustainability, groundwater production resiliency, and water quality trends.

Next in Priority

1. Regularly update the maps and tables of Satanka Shale thickness along the western boundary based on the geologic and hydrogeologic reports of local professional geologists, engineers, and water well drillers and site-specific investigations.

2. Prepare an inventory of Casper Aquifer wells based on the records available from the Wyoming State Engineer's Office. The database should include well location, permit number, permitted well yield, use, construction details on annular seals, and statements of completion.

3. Conduct test hole drilling in areas where no drilling data are available. Test holes should be drilled in these areas to assess the thickness and hydrogeologic properties of the Satanka Shale overlying the Casper Aquifer under the following conditions: 1) the properties lie west of the Satanka Shale contact with the Casper Formation, and 2) no water wells or test holes providing geologic or hydrogeologic data have been drilled within 1,000 feet. Figure 4-2 illustrates the locations of these areas.

4. Establish routine measurement of water levels and water quality in wells completed in the Casper Aquifer in the Laramie area and update potentiometric surface maps periodically.

5. Delineate the 100-year floodplains within the CAPA. A comprehensive assessment for aquifer protection purposes would provide a more complete overview of potential flood conditions. The South of Laramie Drainage Master Plan has done some flood estimation work for major drainages east of the City but has not included delineations.

6. Research recharge mechanisms and vulnerability of the Casper Aquifer to contamination from the ground surface. Based on well hydrographs, this could be accomplished through field discharge assessments of snowmelt runoff conditions in drainages noted during March, April, and May.

7. Conduct tracer test of major faults and folds associated with City Springs, Soldier Springs and the associated municipal wells. The best way to accomplish this would be to strategically install a series of monitoring wells at different points along the particular faults and folds, inject the tracer at one of the upgradient wells, and then monitor the downgradient wells for the tracer.

8. Investigate the degree of hydraulic interaction between the Casper Aquifer and the overlying Satanka Shale. This investigation could be completed using a series of test holes and temporary test wells.

5 Contaminant Source Inventory

This chapter presents the Contaminant Source Inventory as indicated in Section III of Wyoming's WHP Program Guidance Document (1998).

5.1 INTRODUCTION

The objective of completing a source inventory is to identify all potential and existing sources of contamination that may threaten drinking water supply wells within the CAPA. Existing sources are facilities that are known to have caused groundwater contamination. Potential sources are those that may cause groundwater contamination under certain circumstances but, to date, are not known to have caused contamination.

Groundwater contamination can occur many different ways. The routine use of liquid and solid waste disposal facilities is a common source. Septic systems associated with rural subdivision development are the only current documented source of contamination that has impacted water quality in the CAPA. Other sources of groundwater contamination generally involve one or more of the following: the misuse and improper disposal of liquid and solid wastes; the illegal dumping of household, commercial, or industrial chemicals; the accidental spilling of chemicals from trucks, railways, aircraft, handling facilities, and storage tanks; and the improper siting, design, construction, operation, or maintenance of agricultural, residential, municipal, commercial, and industrial land uses. Contaminants also can be derived from atmospheric pollutants, such as airborne sulfur and nitrogen compounds, which are created by smoke, flue dust, aerosols, and automobile emissions, fall as acid rain, and infiltrate through the soil.

The inventory process includes the following steps.

1. Maintain a base map to locate existing and potential sources.
2. Obtain available information on existing and potential sources:
   a) Determine and record existing data;
   b) Identify likely sources for further study;
   c) Investigate unknown sources; and
   d) Verify accuracy and reliability of the information gathered.
3. Describe contaminant sources within the aquifer protection area and complete Source Identification forms for each existing and potential source of contamination identified.
4. Develop the Source Inventory list from completed Source Identification forms.
5. Prioritize sources within the aquifer protection area for management purposes.
6. Transfer source location and information to aquifer protection area delineation maps.

7. Update, refine and expand Source Inventory Information.

5.2 APPROACH

The Environmental Advisory Committee Contaminant Source Identification Subcommittee (CSIS) began its inventory in 1998. The mission of this subcommittee was to identify existing and potential sources of contamination to the groundwater supply of the City of Laramie. The CSIS was also charged with prioritizing the inventory list to aid in the formation of necessary aquifer area management strategies. The CSIS used the geologic map adapted from Don A. Lundy (1978) for the base map of this original inventory. It is a topographic base map with detailed geologic mapping. Zones 2 and 3 of the CAPA were overlaid onto this map.

The original source inventory was completed using several methods of study. In 1998, databases and published information were used by the University of Wyoming Geography and Recreation Department's Planning Program (UW Planning Program) to survey subdivisions in 16 sections due east of the City of Laramie. Two graduate students within the UW Planning Program completed a contaminant inventory of over 50 sections within the protection area for a master thesis (Hallgarth, 2001) and an EAC intern project (Powell, 2000). The graduate students collected and verified their inventories by field searches, windshield surveys, and door-to-door surveys with the use of a GPS and geographic information systems (GIS) computer applications. The UW Planning Program submitted two class reports to the EAC in 2000; Build-out Scenarios-Casper Aquifer Recharge Area 1999-2010 and Terrain Analysis of the Casper Aquifer Protection Area, Laramie, WY (August 2000 and September 2000). The Albany County Assessor's office also contributed source inventory information based on their land-ownership files, one and five-meter resolution satellite imagery, and GIS applications.

The UW Planning Program class project (University of Wyoming, Department of Geography and Recreation, 1999a) examined land use activities in an area east of the City of Laramie by a windshield survey. The land-uses included residential areas, commercial sites, industrial facilities, transportation networks, forestry activities, mining operations, and agricultural practices. This information is reported in an unpublished document (University of Wyoming, Department of Geography and Recreation, 1999b).

An independent inventory of contaminant sources in the CAPA was performed in June 2004 as part of a state funded Source Water Assessment for Laramie. The Source Water Assessment is part of Wyoming's SWAP.

In November 2007, Wittman and the City of Laramie Planning Division updated the list of potential contaminant sources. This update was conducted in conjunction with the revision of the CAPP. Wittman utilized existing databases from the WDEQ and the City of Laramie Planning Division conducted a windshield survey of the area.

The CSIS, Wittman, and City of Laramie Planning Division researched existing data sources and identified potential contaminant sources located within the protection area. Existing sources were verified by a windshield survey. Research included looking at regulatory reporting requirements such as the following:

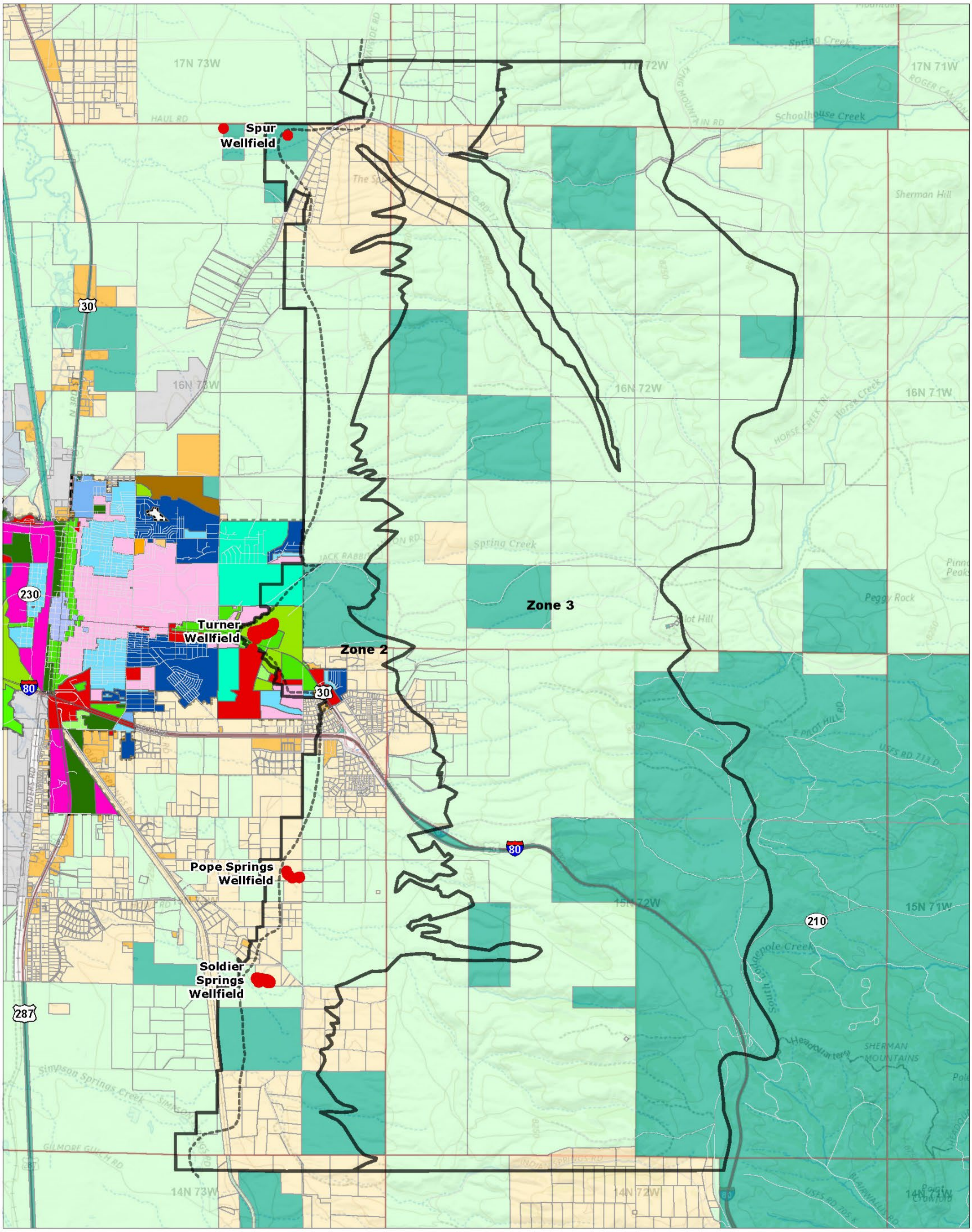
- Resource Conservation and Recovery Act (RCRA) Subtitle C

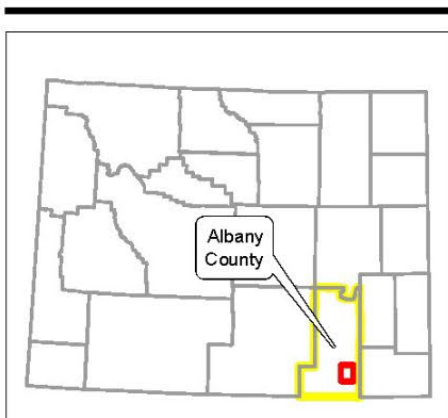
- RCRA Subtitle I
- Superfund Amendments and Reauthorization Act (SARA) Title III
- Underground Injection Control (UIC)
- National Pollution Discharge Elimination System (NPDES)
- Spill Prevention Control and Countermeasure (SPCC)

The following regulatory databases were also reviewed:

- Toxic Chemical Release Inventory (TRI)
- CERCLA Information System (CERCLIS)
- Hazardous Waste Data Management System (HWDMS)
- RCRA Information System (RCRIS)
- Waste Management Permit Compliance System
- Hazardous Material Incident Reporting System
- Underground Storage Tanks Case History File
- The Pollution Prevention Information Clearinghouse (PPIC)
- Federal Reporting Data System (FRDS)
- Leaking Underground Storage Tank database (LUST)
- Groundwater Pollution Control Program database

In April and May 2022, Stantec updated the list of potential contaminant sources. This update was conducted in conjunction with the current revision of the CAPP. Stantec utilized available databases from the WDEQ and U.S. EPA to complete this assessment. The regulatory lists above were reviewed as part of this investigation. Stantec also completed both a virtual windshield survey using the street view feature in Google Earth where photos were available to verify the sites, and a visual windshield survey in May 2022. Several of the sites listed in Table 5-1 have changed names since the 2008 CAPP update. Figure 5-1 provides County and City land use and zoning designations in the CAPA.





Notes
1. Coordinate System: NAD 1983 StatePlane Wyoming East FIPS 4901 Feet
2. Data Sources: USGS, Albany County, City of Laramie
3. Background: USGS 7.5 Minute Quadrangle

Legend

- Municipalities
- PLSS Township
- Protective Satanka Shale Thickness
- CAPA Zone 1
- CAPA Zone 2 and 3

City Zoning

- AG Agriculture
- B1 Limited Business
- B2 General Business
- BIR
- C2 Commercial Wholesale
- DC
- I1 Light Industrial
- I2 Industrial
- LM Light Manufacturing
- LR Low Density Residential
- NB Neighborhood Business
- O Open Zone
- R1 Low Density Residential
- R2 Medium Density Residential
- R2M Medium Density Residential w/ Independent Mobile Home
- R3 Multi-family
- R3-PUD Planned Unit Development
- TO
- <all other values>

County Zoning

- Agriculture
- Commercial
- Exempt
- Industrial
- Residential

0 0.6 1.2 Miles

(At original document size of 11x17)
1:76,483

N

Stantec

Project Location
T16N, R73W
Laramie, Albany Co., WY

Prepared by KAB on 2023-02-15
TR by XXX on 2020-XX-XX
IR by XXX on 2020-XX-XX

Client/Project
227704690
City of Laramie/Albany County
Casper Aquifer Protection Plan Update

Figure No.
5-1

Title
Albany County Land Use and City of Laramie Zoning

5.3 POTENTIAL SOURCES OF CONTAMINATION

The contaminant source inventory was updated in 2022. Of all the inventoried contaminant sources, residential septic systems at the east end of Grand Avenue are currently the only documented source that has contaminated the Casper Aquifer and resulted in nitrate concentrations that exceed the EPA primary drinking water standard of 10 mg/L in some domestic wells (City of Laramie, 2009). Source Identification Forms and Form IV for potential contaminant sources are included in Appendix E. Due to the complexity of the CAPA and the fact that Zone 2 and Zone 3 are managed as one unit, the potential contaminant sources for all CAPA Zones have been listed together on the Source ID and Inventory List. The potential sources of contamination that have been identified are listed in Table 5-1 from high to low priority. Several sites that lie outside Zone 2 are included because they lie in close proximity to the western boundary.

Table 5-1: Contaminant Source Inventory - Updated April 2022

Map Number*	Nature of Site and Site Name	Site Address/Location	Potential Source	Delineation Zone	Priority**
	Residential Areas	T15N, R73W: Sec 1, S2 &Sec 1 S2 NW4 (Sherman Hills, Imperial Heights, Laramie Plains); Sec 12 (Country Meadows, Sundial Acres, Valley View). T15N, R73W: Sec 14 SE4; Sec 13; Sec 23 E; Sec 24. T15N, R73W: Sec 23 E2; Sec 26 E2; Sec 25; Sec 24, Sec 35; Sec 36.	Septic systems (except for Imperial Heights), household hazardous wastes, pesticides, and fertilizers	Zones 2, 3	High
	Interstate 80	T15N, R73W: Sec 1 W2; Sec 12 NE4; T15N, R72W: Sec 7 NW4; Sec 18 N2; Sec 17 N2; Sec 16 S2; Sec 21 NE4; Sec 22; Sec 27 E2; Sec 26 NW4	Hazardous waste spill, road salts	Zones 2, 3	High
	Springs	T16N, R73W: Sec 35 S2. T15N, R73W: Sec 14 E2; maybe Sec 13. T15N, R73W: Sec 23 S2; Sec 26 N2; Sec 24 W2.	Conduit for contaminants	Zone 1	High
	Wells (municipal, monitoring, orphaned, abandoned, test, domestic)	Throughout the CAPA.	Conduit to groundwater	Zones 1, 2, 3	High
36	Country Meadow Estates	T15N, R73W: Sec 12 NW, 4746 East Skyline Drive	Residential wastewater discharge	Zone 2	High
9	Automobile Dealership Laramie GM Auto Center	T16N, R73W: Sec 35 S2 3600 E. Grand Ave.	UST (removed), Automotive waste, hazardous waste generator	Zones 1 and 2	High
10	Automobile Dealership Laramie Ford	T16N, R73W: Sec 35 S2 3609 E. Grand Ave.	Detail Shop, Automotive wastes, UST (removed 1991)	Zones 1 and 2	High
11	Gas Station Tumbleweed Express	T15N, R73W: Sec 1 SW4, NE4 4700 Bluebird Lane	Active UST and fueling operations	Zone 2	High
	Union Pacific Railroad	Traverses the CAPA	Potential for derailment and hazardous waste spill	Zones 2, 3	High
13	UST Pilot Hill Radio Repeater	T15N, R 72W, Sec 10	Two 560-gallon diesel tanks (1 removed)	Zone 3	Medium

Map Number*	Nature of Site and Site Name	Site Address/Location	Potential Source	Delineation Zone	Priority**
14	Urban run-off Dollar Tree, Leap, Snowy Range Academy, Express Pharmacy, Imperial Heights, East Grand Avenue	4005 4027 and 4037 E. Grand St.	Urban run-off	Zone 2	Medium
15	Urban run-off & auto services Wal-Mart Supercenter #1412	T16N, R73W: Sec 35 SW4, SE4 4308 Grand Ave.	Oils, antifreeze, fertilizers, urban run-off	Zone 2	Medium
	Transportation routes	Grand Avenue, and all other roads aside from I-80 located in the CAPA.	Increase salinity, hydrocarbons, hazardous materials	Zone 2, 3	Medium
16	Medical Facility Premier Bone & Joint	1909 Vista Drive	Medical wastes	Zone 2	Medium
17	Animal Health Center	4619 Bobolink Ln	Medical wastes	Zone 2 (Outside, but close to western boundary)	Medium
35	Union Pacific Railroad	T14N, R73W, Sec 11	Train derailment	Zone 2	Medium
18	AT&T Communications	3450 Wyatt Court	Unknown, potential backup generator with UST	Zone 2	Medium
	Quarries (Abandoned and Active)	Throughout CAPA	Quarry activities (refueling spills, residue from blasting compounds-diesel fuel and ammonium nitrate)	Zones 2, 3	Medium
	Rifle Range Laramie Rifle Range Corporation	T16N, R73W: Sec 12 N2	Lead bullets	Zone 2, 3	Low
	Municipal Sewer Lines	T15N, R73W: Sec 1	Nitrates, fecal coliform	Zone 2	Low
	Mosquito Spraying	Throughout CAPA	Bti and Malathion @ 3 ounces/acre	Zone 2, 3	Low

Map Number*	Nature of Site and Site Name	Site Address/Location	Potential Source	Delineation Zone	Priority**
24	Silver Spur Equestrian Center (Potentially closed to the public)	25 Domino Road	Animal wastes	Zone 2	Low
26	UST (Underground Storage Tank) J. T. Peele	2038 Skyline Drive	3,000 gallon diesel tank (removed 1989)	Zone 2	Low
27	UST Sherman Hill Microwave Site	13 Miles West on Happy Jack Road and Exit 323 on I-80	350 gallon gasoline tank (removed 1994)	Zone 3	Low
28	Wastewater Discharge Mountain Cement Company (Etchepare Quarry)	T15N, R72W, Sec 30 and 31	NPDES Mineral Mining Discharge, Construction Sand and Gravel	Zone 3	Low
29	Wastewater Discharge Ninth Street Pit #2	T17N, R73W, Sec 36	NPDES Mineral Mining Discharge, Construction sand and gravel	Zone 2 (Outside, but close to western boundary)	Low
30	Avery Feedlot	3630 Howe Road T15N, R73W, Sec 26	Animal Wastes	Zone 2	Low
31	Walgreen Dental Arts	3421 E. Garfield St.	Dental wastes	Zone 2 (Outside, but close to western boundary)	Low
32	Auto Center Detail Shop	3424 E. Garfield St.	Auto wastes, solvents	Zone 2 (Outside, but close to western boundary)	Low
33	Jacoby Golf Course	3501 Willet Drive	Pesticides, fertilizers	Zone 2 (Outside, but close to western boundary)	Low
34	TW-1 (Casper Aquifer Recharge Injection Well)	T16N, R73W, Sec 26	Casper Aquifer recharge injection well	Zone 2	Low

Map Number*	Nature of Site and Site Name	Site Address/Location	Potential Source	Delineation Zone	Priority**
37	Grease Monkey	225 Wister Drive	Oil, antifreeze, solvents	Zone 2 (Outside, but close to western boundary)	Low
	Agricultural land use	Throughout the CAPA	Animal wastes, pesticides, fertilizers	Zones 2, 3	Low

* Sources without a map number are depicted on the maps (**Figure 5-2a, 5-2b, 5-2c, and 5-2d**) in other manners. For example, septic systems are represented by green squares.

** Priority qualitatively determined based on distance from municipal wellheads, groundwater flow direction considerations, and types of contaminants present.

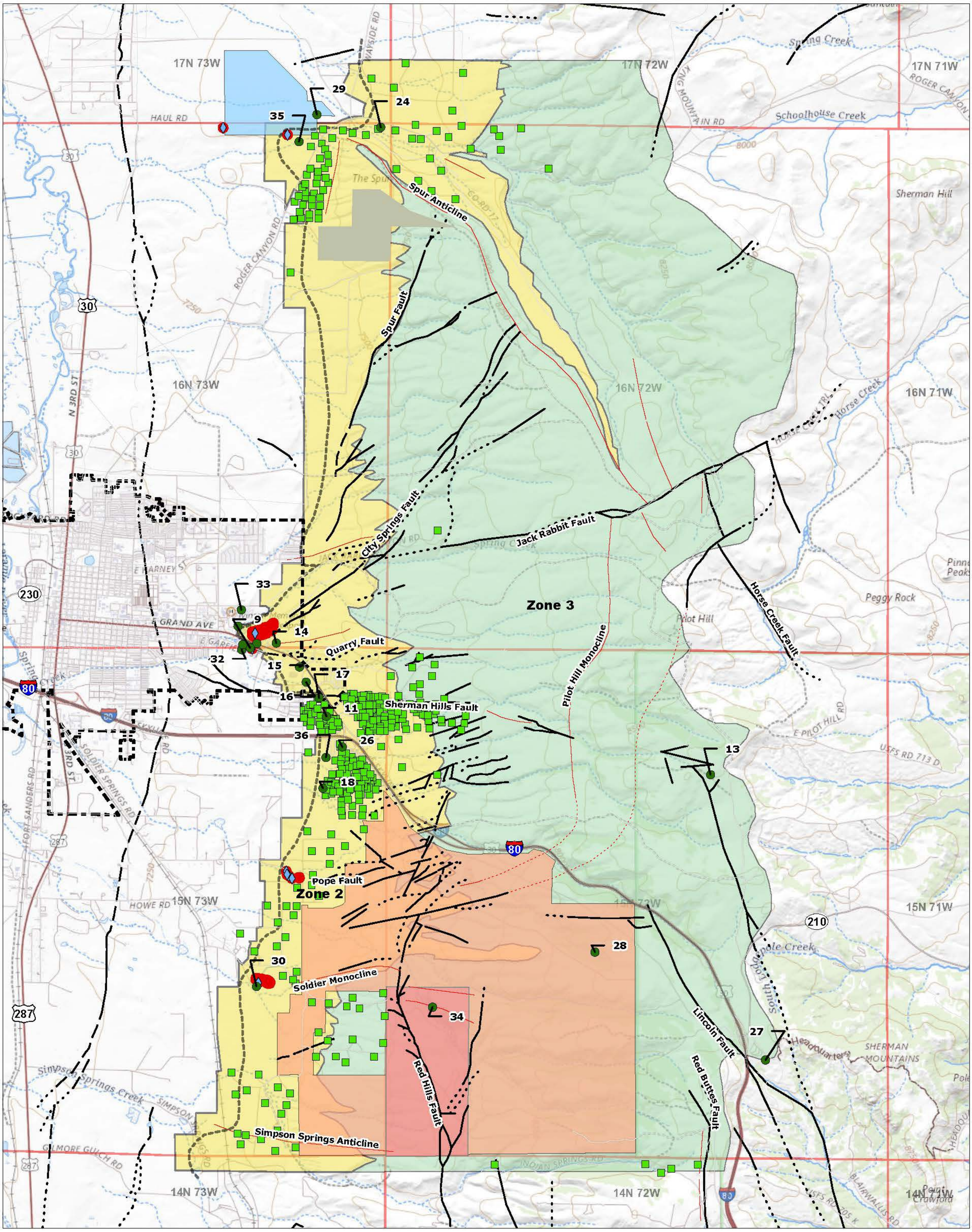
5.3.1 ZONE 1 POTENTIAL SOURCES OF CONTAMINATION

The only potential contaminant source within or close to Zone 1 is the Laramie GM auto center (3600 E. Grand Ave.) near Turner No. 1. Laramie Ford (3609 E. Grand Ave.) lies between Turner Nos. 1 and 2, and is partially within Zone 1. Grease Monkey (225 Wister Drive) is located northwest of the City's water storage tank just outside of Zone 2, but in close proximity to the Turner Wellfield.

Domestic well owners also have a role in protecting water quality. Wyoming has over 90,000 rural wells supplying 75 percent of Wyoming's residents with drinking water. While the Wyoming State Engineer's Office regulates permitting and construction requirements, no government agency regulates or regularly tests private well water quality. Homeowners are responsible for inspecting their wells regularly for damage and testing water quality. Regular inspection can help detect many well issues, but there are steps that help prevent damage or contamination. Septic systems are a known potential source of contamination and should be pumped every three to five years to prevent overflows from seeping into the groundwater. It's also important to prevent contamination from chemicals, such as pesticides or fertilizers. Additional information can be obtained from the University of Wyoming Extension's *Barnyards and Backyards* at the following link:
http://www.uwyo.edu/barnbackyard/_files/documents/magazine/2018/fall/0918domesticwell.pdf

5.3.2 ZONES 2 AND 3 POTENTIAL SOURCES OF CONTAMINATION

Potential sources of contamination are listed in the contaminant source inventory (Table 5-1) and shown on Figure 5-2a. Figures 5-2b, 5-2c, and 5-2d provide a closer look at the potential contaminant sources around Spur, Turner, and Pope and Soldier wellfields, respectively. Figure 5-3 illustrates the locations of subdivisions near or within the aquifer protection area that use septic systems.



Legend

- Septic System
- Potential Contaminants
- City of Laramie Municipal Wells
- County
- Municipalities
- Protective Satanka Shale Thickness
- PLSS Township
- CAPA Zone 1
- CAPA Zone 2
- CAPA Zone 3
- Rifle Range Boundary

Mining Boundaries

- Regular Mine Permit - Other Minerals
- Small Mine Permit
- Active Mining Area for Mountain Cement

0 0.6 1.2 Miles

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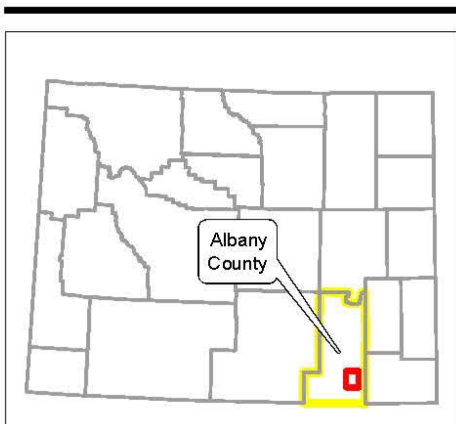
N



Notes

1. Coordinate System: NAD 1983 StatePlane Wyoming East FIPS 4901 Feet
2. Data Sources: USGS, Albany County, WHPA (2008), USEPA Wyoming DEQ
3. Background: USGS 7.5 Minute Quadrangle

Stantec

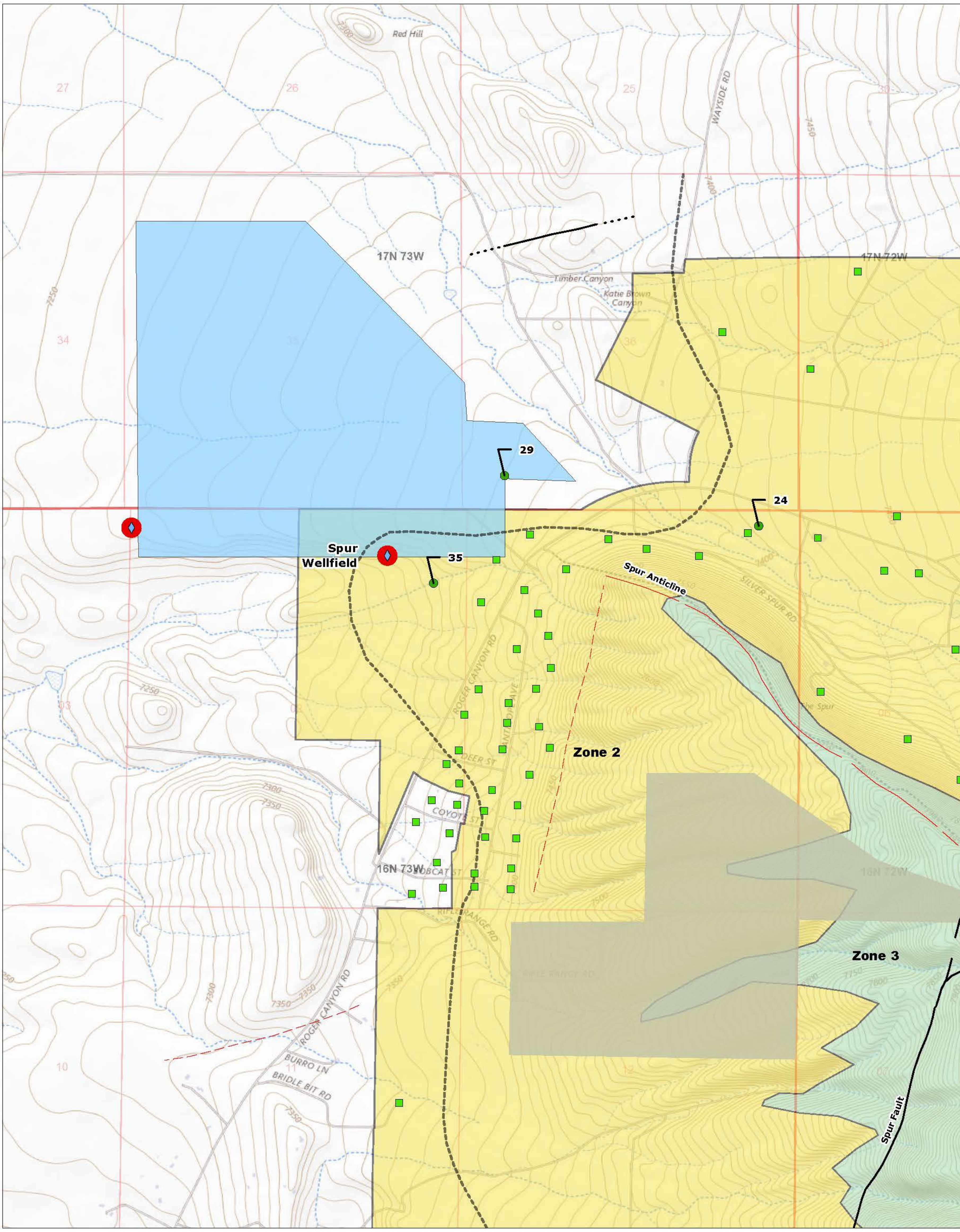
Project Location
T16N, R73W
Laramie, Albany Co., WY

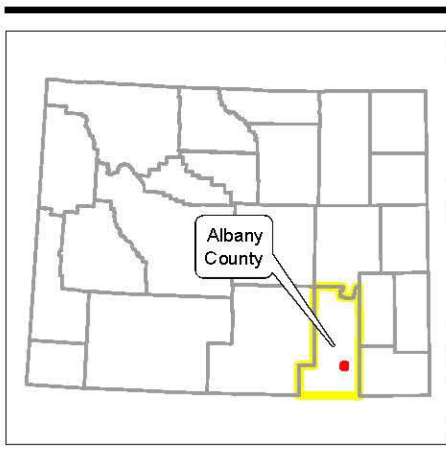
Prepared by KAB on 2023-02-15
TR by XXX on 2020-XX-XX
IR by XXX on 2020-XX-XX

Client/Project
227704690
City of Laramie/Albany County
Casper Aquifer Protection Plan Update

Figure No.
5-2a

Title
Potential Contaminant Sources and Septic Systems in the CAPA





Legend

- Potential Contaminants
- City of Laramie Municipal Wells
- County
- Municipalities
- PLSS Township
- PLSS Section
- Protective Satanka Shale Thickness
- CAPA Zone 1
- CAPA Zone 2
- CAPA Zone 3
- Rifle Range Boundary

Mining Boundaries

- Small Mine Permit

0 800 1,600 Feet

(At original document size of 11x17)
1:19,200

N

Stantec

Notes
1. Coordinate System: NAD 1983 StatePlane Wyoming East FIPS 4901 Feet
2. Data Sources: USGS, Albany County, WHPA (2008), USEPA, Wyoming DEQ, Ver Ploeg (2007a)
3. Background: USGS 7.5 Minute Quadrangle

Project Location
T16N, R73W
Laramie, Albany Co., WY

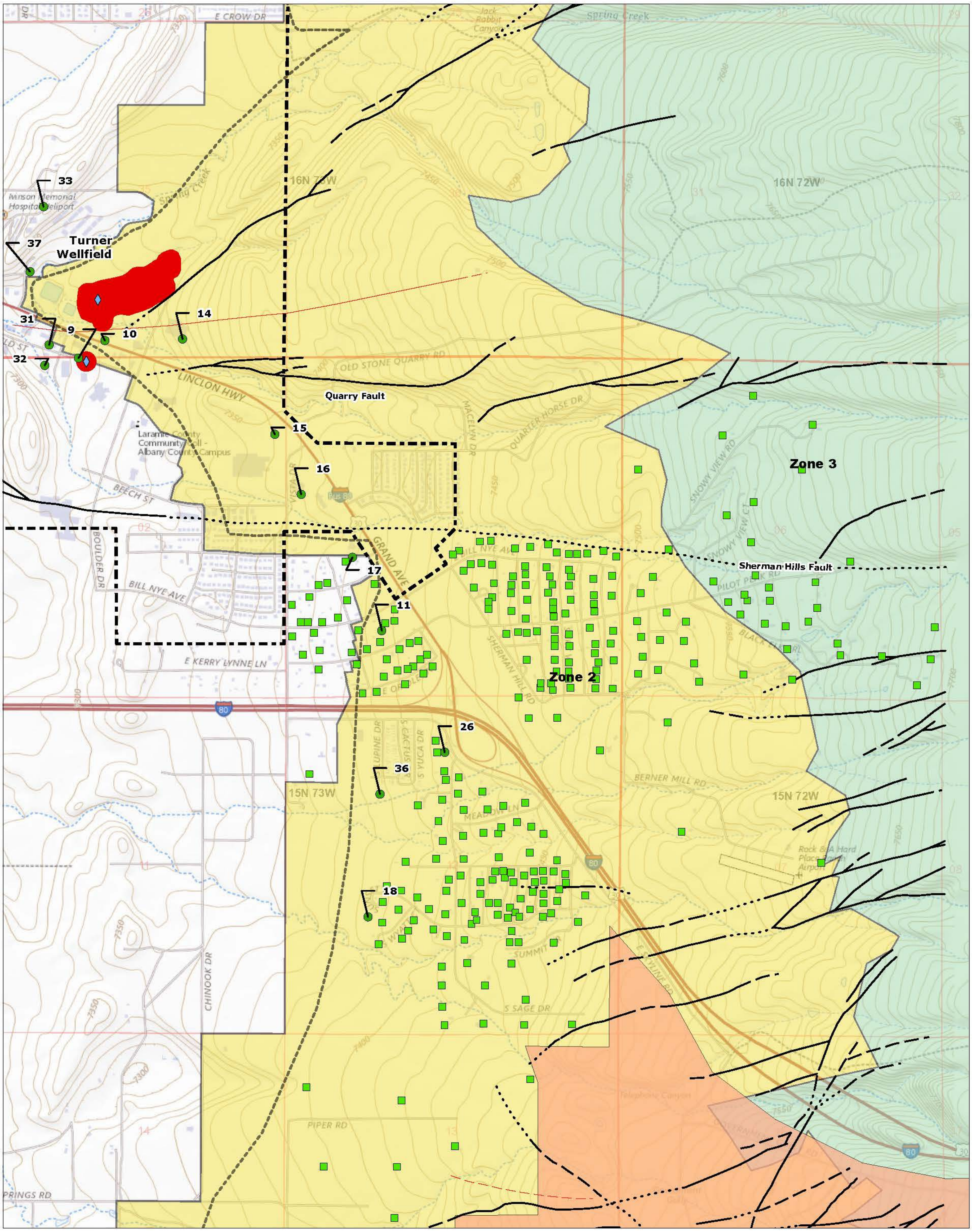
Prepared by KAB on 2022-10-28
TR by XXX on 2020-XX-XX
IR by XXX on 2020-XX-XX

Client/Project
227704690
City of Laramie/Albany County
Casper Aquifer Protection Plan Update

Figure No.
5-2b

Title
Potential Contaminant Sources and Septic Systems near Spur Wellfield

V:\2277\active\227704690\03_data\gis_cad\gis\pro\CAPP UPDATE 2022\CAPP UPDATE 2022.aprx Revised: 2022-10-28 By: kberglund



Legend

- Potential Contaminants
- City of Laramie Municipal Wells
- County
- Municipalities
- PLSS Township
- PLSS Section
- Protective Satanka Shale Thickness
- Rifle Range Boundary
- CAPA Zone 1
- CAPA Zone 2
- CAPA Zone 3

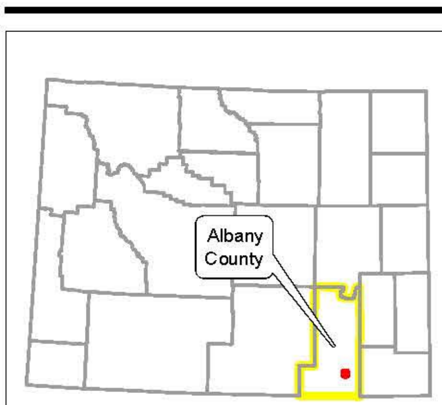
Mining Boundaries

- Regular Mine Permit - Other Minerals

0 800 1,600 Feet

(At original document size of 11x17) 1:19,200

N



Notes

1. Coordinate System: NAD 1983 StatePlane Wyoming East FIPS 4901 Feet
2. Data Sources: USGS, Albany County, WHPA (2008), USEPA, Wyoming DEQ, Ver Ploeg (2009)
3. Background: USGS 7.5 Minute Quadrangle

Stantec

Project Location
T16N, R73W
Laramie, Albany Co., WY

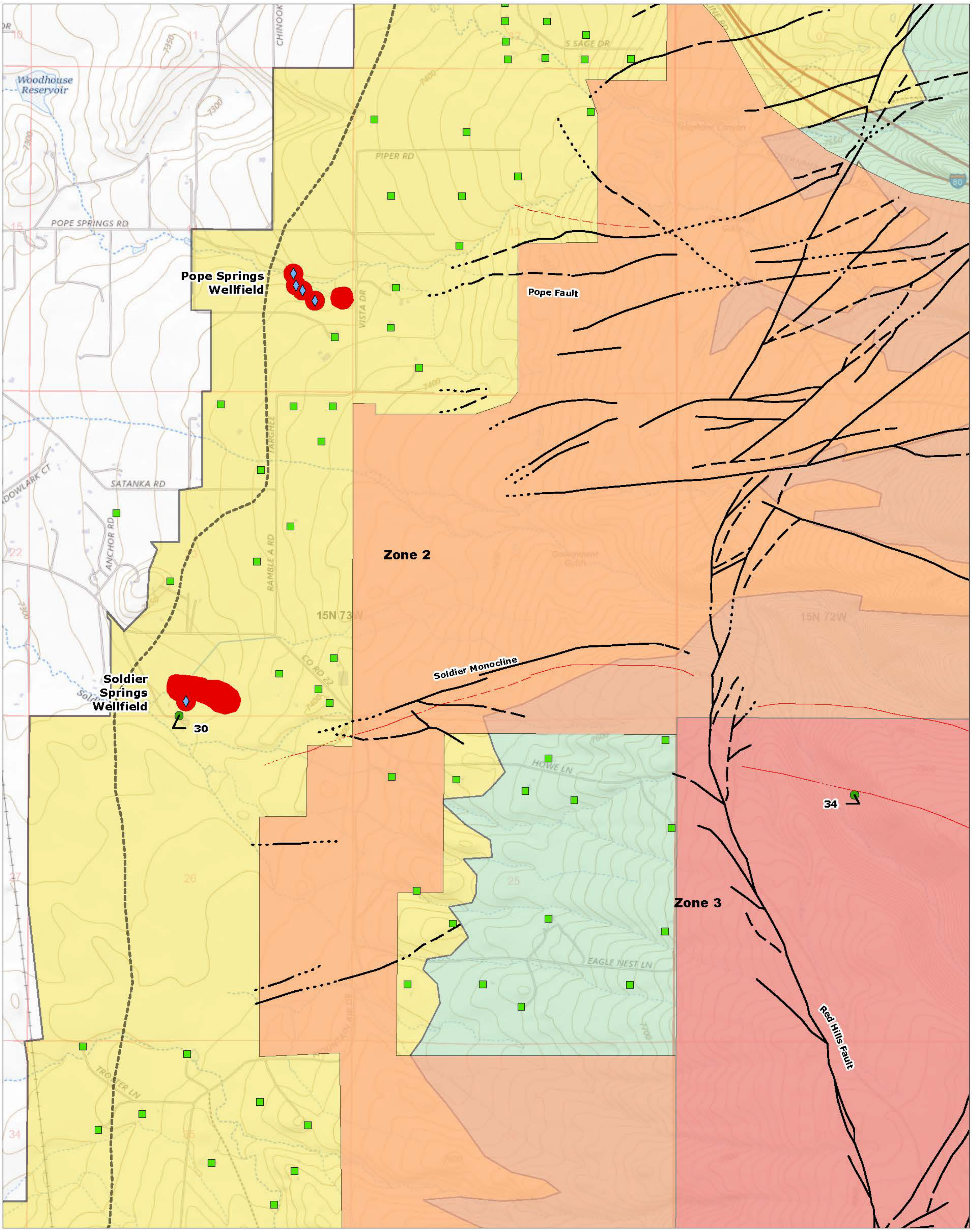
Prepared by KAB on 2023-02-15
TR by XXX on 2020-XX-XX
IR by XXX on 2020-XX-XX

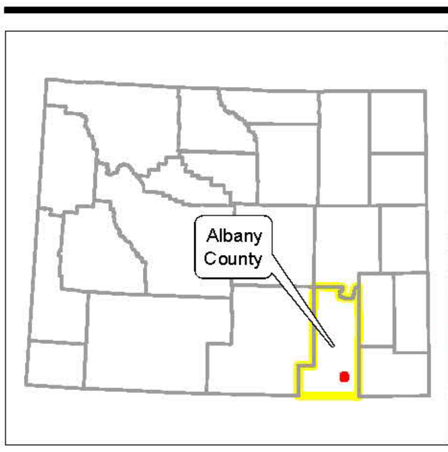
Client/Project
227704690
City of Laramie/Albany County
Casper Aquifer Protection Plan Update

Figure No.
5-2c

Title
Potential Contaminant Sources and Septic Systems near Turner Wellfield

V:\2277\active\227704690\03_data\gis_cad\gis\pro\CAPP UPDATE 2022\CAPP UPDATE 2022.aprx Revised: 2023-02-15 By: kberglund





Legend

- Septic System
- Potential Contaminants
- City of Laramie Municipal Wells
- County
- Municipalities
- PLSS Township
- PLSS Section
- Protective Satanka Shale Thickness
- Rifle Range Boundary
- CAPA Zone 1
- CAPA Zone 2
- CAPA Zone 3

Mining Boundaries

- Regular Mine Permit - Other Minerals
- Active Mining Area for Mountain Cement

0 800 1,600 Feet

(At original document size of 11x17)
1:19,906

N

Stantec

Project Location
T16N, R73W
Laramie, Albany Co., WY

Prepared by KAB on 2022-10-28
TR by XXX on 2020-XX-XX
IR by XXX on 2020-XX-XX

227704690

Client/Project
City of Laramie/Albany County
Casper Aquifer Protection Plan Update

Figure No.
5-2d

Title
Potential Contaminant Sources and Septic Systems near Pope Springs and Soldier Springs Wellfields

Notes
1. Coordinate System: NAD 1983 StatePlane Wyoming East FIPS 4901 Feet
2. Data Sources: USGS, Albany County, WHPA (2008), USEPA, Wyoming DEQ, Ver Ploeg (2009)
3. Background: USGS 7.5 Minute Quadrangle

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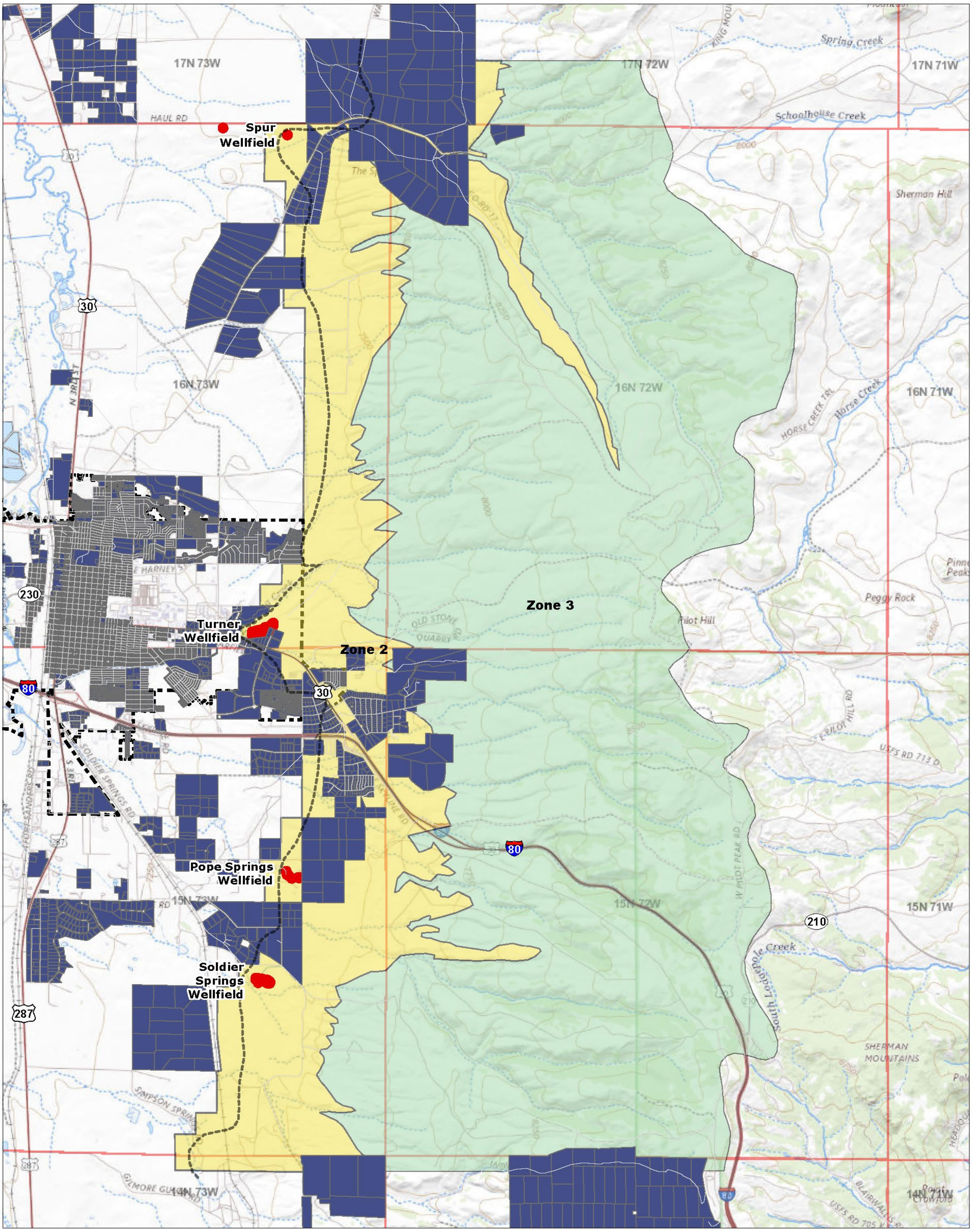

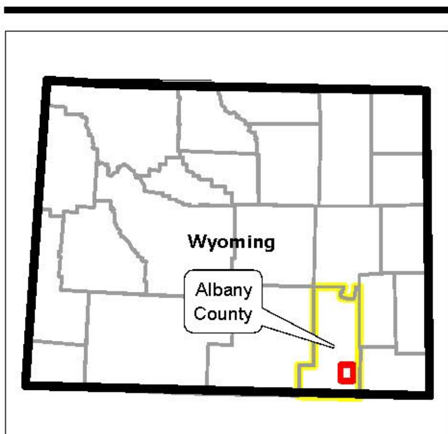

Legend

- County
- Municipalities
- PLSS Township
- Albany County Subdivisions
- Protective Satanka Shale Thickness
- CAPA Zone 1
- CAPA Zone 2
- CAPA Zone 3

Notes
1. Coordinate System: NAD 1983 StatePlane Wyoming East FIPS 4901 Feet
2. Data Sources: USGS, Albany County
3. Background: USGS 7.5 Minute Quadrangle

0 0.6 1.2 Miles
(At original document size of 11x17)
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N

Stantec

Project Location
T16N, R73W
Laramie, Albany Co., WY

Prepared by KAB on 2022-05-12
TR by XXX on 2020-XX-XX
IR by XXX on 2020-XX-XX
227704690

Client/Project
City of Laramie/Albany County
Casper Aquifer Protection Plan Update

Figure No.
5-3

Title
Albany County Subdivisions within the Casper Aquifer Protection Area

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General categories of contaminant sources are described below. Management strategies for each of the potential sources of contamination are discussed in Chapter 6.

- **Transportation corridors.** Hazardous materials are transported along these routes, and if spills were to occur, such spills could contaminate the Casper Aquifer in a single event. Automobile wastes and petroleum products associated with transportation routes can accumulate over time and be periodically introduced into the aquifer through storm runoff.
- **Residential land use.** Septic systems over the Casper Aquifer recharge area are of particular concern because vulnerable features may provide a direct route for sewage effluent to enter the aquifer and because geologic materials other than the Satanka Shale that cover the Casper do not protect the aquifer. Nitrates, nitrites, bacteria, and other household wastes are all potential contaminants associated with septic systems. According to the Wisconsin Department of Health Services (2019), high nitrate levels can cause blue baby syndrome, increase the risk of thyroid disease, affect pregnant women resulting in neural tube defects in babies (birth defects), and increase the risk of colon cancer. Additionally, every house over the Casper Aquifer generates household hazardous wastes and if improperly disposed these hazardous wastes may also enter the aquifer. Fertilizers and pesticides may enter the aquifer either through runoff into drainages or through leaching into groundwater if improperly applied.
- **Wildfires.** Wildfires as a source of volatile organic compounds (VOCs) in drinking water had not really been considered until the Tubbs Fire burned through large swaths of Santa Rosa, California, in 2017. After the blaze, drinking water samples from municipal supplies had levels of several VOCs, including benzene, above state and federal exposure limits. The recent 2021 Marshall Fire in Colorado is currently being studied for the environmental effects of wildfires. The blaze left nearly 1,000 homes and businesses destroyed and thousands of residents displaced. A typical residential home contains plastics and other items that can release VOCs when burned.
- **Wells.** All wells completed in the Casper Aquifer provide a direct pathway for contaminants to enter the Casper Aquifer. Orphaned or improperly abandoned wells need to be identified and properly plugged and abandoned to protect the aquifer. Wells that remain in operation should be appropriately capped and sealed at the wellhead to prevent contaminants from entering the aquifer via the well annulus or the interior of the well casing. Wells constructed in accordance with Wyoming SEO and DEQ requirements by Wyoming licensed water well drillers are a lower risk to the aquifer than orphaned or abandoned, uncapped, or improperly constructed wells as long as they are properly maintained.
- **Underground and aboveground storage tanks (UST and AST).** USTs and ASTs often store petroleum products or other hazardous materials and leaks may go undetected for some time. Due to the materials stored in these tanks, they are considered a potential contaminant source.
- **Stormwater and urban runoff.** Heavy metals, automobile fluids, pesticides, and fertilizers are all contaminants found in stormwater and urban runoff. Stormwater and urban runoff are

typically associated with parking lots, buildings, and roadways. As the stormwater and urban runoff reach drainages and infiltrate the aquifer, associated contaminants are introduced into groundwater.

- **Commercial land use.** Some commercial land uses store, use, and/or generate hazardous materials that if improperly handled may contaminate the aquifer. Storm runoff is generated from impervious areas, and pesticides and fertilizers used by these businesses may be introduced to the Casper Aquifer.
- **Limestone quarries.** Limestone quarries use fuel and blasting materials that if improperly handled may contaminate the aquifer. The blasting materials are consumed during the detonation but could contaminate the aquifer either if improperly handled or stored, or if the actual blast did not consume all of the material.
- **Agricultural land use.** Waste from commercial concentrated livestock facilities and applications of fertilizers and pesticides pose a risk from agricultural land use to the Casper Aquifer. General livestock grazing poses much less of a threat to groundwater than commercial concentrated animal feeding operations (AFO).
- **Miscellaneous uses.** There are other uses within the CAPA which have the potential to contaminate the Casper Aquifer. These uses produce the following contaminants: animal wastes, medical wastes, pesticides, fertilizers, lead, and hazardous materials.

Since 2013, the study of contaminants of emerging concern (CECs) in ambient groundwater in urbanized areas has advanced significantly. CECs are chemicals that are not commonly monitored or regulated in the environment. Examples of CEC chemical classes include prescription and over-the-counter pharmaceuticals, fire retardants, pesticides, personal-care products, hormones, and detergents. Some CECs are human-made, some are naturally occurring, and some also are endocrine disruptors. Although specific public drinking water standards have not been promulgated for many of these substances, aquifer protection management strategies should seek to minimize their occurrence in the Casper Aquifer as part of a general concern for water quality. Management strategies for these should be implemented when their regulatory status changes. The following categories include some additional information on some of these substances.

- **Perfluoroalkyl and polyfluoroalkyl substances (PFAS)**. These substances are a group of man-made chemicals that include Perfluorooctane Sulfonate (PFOS) and Perfluorooctanoic Acid (PFOA). These elements have a negative effect on the health of those exposed to them. Used as early as the 1940s, PFAS were once thought of as beneficial because of their ability to repel fire, water, oil, and stains. Since PFAS functioned as great repellents, companies used them to produce a variety of products, including stain- and water-resistant fabrics, non-stick products, polishes, waxes, paints, cleaning products, and fire-fighting foams among others. These chemicals are not well researched but have been found to cause cancer or affect the liver, immune system, cholesterol levels, and thyroid. The presence of PFAS has been recognized across the United States and Canada as a contaminant that is both pervasive and mobile in groundwater with potential serious health effects. In December 2021, the U.S. EPA published the final fifth Unregulated Contaminant Monitoring Rule, which will require sample collection of drinking water supplies for 29 PFAS between 2023 and 2025. In addition, the EPA is moving towards establishing Maximum Contaminant Levels for five PFAS under the Safe Drinking Water Act (EPA, 2021). Sources for these compounds include, but are not limited to, landfills, septic systems, industrial activities, and oil and gas operations. Trihydro (2019) identified a couple locations in Laramie where PFAS may be present, but both of these lie west of the CAPP and no testing has confirmed its presence.

- **Endocrine Disruptors**. In the last two decades there has been a growing awareness of the possible adverse effects in humans and wildlife from exposure to chemicals that can interfere with the endocrine system. These effects can include: developmental malformations, interference with reproduction, increased cancer risk; and disturbances in the immune and nervous system function. Growing scientific evidence shows that humans, domestic animals, and fish and wildlife species have exhibited adverse health consequences from exposure to environmental chemicals that interact with the endocrine system. To date, such problems have been detected in domestic or wildlife species with relatively high exposure to: organochlorine compounds (i.e, 1,1,1- trichloro-2,2-bis(p-chlorophenyl) ethane (DDT) and its metabolite dichorodiphenyldichloroethylene (DDE); polychlorinated biphenyls (PCBs), and dioxins); and some naturally occurring plant estrogens (EPA, 2022).

- **Microplastics**. Plastics have become ubiquitous in natural and built environments which has caused concern regarding potential harms to human and aquatic life. Microplastics (plastic particles ranging in size from 5 mm to 1 nm) and nanoplastics (plastic particles smaller than 1 nm) have been found in every ecosystem on the planet from the Antarctic tundra to tropical coral reefs. The wide range of particle sizes, densities, and compositions pose a challenge for researchers because there is not a single method that can be used to characterize the wide variety of micro and nanoplastic particles. There is a pressing need to develop and standardize collection, extraction, quantification, and identification methods for micro/nanoplastics to improve reliability, consistency and comparability across studies.

5.3.3 FUTURE UPDATES TO THE CONTAMINANT SOURCE INVENTORY

To ensure that the contaminant source inventory continues to be updated on a regular basis, the assigned City/County staff should incorporate new sources into the inventory as development occurs. The enumeration of these data should be included in the site-specific investigations submitted to the City and County. The Albany County Planning Department and the Laramie Planning Division will provide the information to the assigned City/County staff. Federal and state databases regarding potential contaminant sources should be accessed once a year to include the latest information in the inventory. When the CAPP is updated, a windshield survey should be conducted to inventory and verify contaminant sources.

5.4 SEPTIC SYSTEMS AND NITRATES

5.4.1 CONVENTIONAL SEPTIC SYSTEM OPERATION

According to the EPA Decentralized Systems Technology Fact Sheets (EPA, 2000) a typical septic tank system consists of a septic tank and a below-ground absorption field (also called a drain field or leach field). The septic tank is an underground, watertight vessel installed to receive wastewater from the home. It is designed to allow the solids to settle out, float, and separate from the liquid, to allow for limited digestion of organic matter, and to store the solids. The septic tank produces three products including scum, sludge, and effluent. In a well-functioning septic system, the effluent is clarified liquid that is passed on for further treatment and dispersal into the soil through the leach field. A leach field helps distribute the effluent evenly across an area. The soil below the leach field provides limited treatment and degradation of the septic tank effluent. A small portion of the effluent is used by plants or evaporates from the soil.

A conventional septic tank installation.

Septic systems are designed to release wastewater effluent to the subsurface, and even functioning systems that work as designed allow contaminants into the underlying vadose zone and aquifer. Common contaminants from domestic wastewater include organic and inorganic matter, viruses and bacteria, and nutrients including nitrogen and phosphorus. Conventional septic systems are designed to remove solids such as sludge and scum, but are not designed to treat for other contaminants associated with household wastewater such as nutrients like nitrogen (EPA, 2000). Nitrogen occurs in the forms of organic nitrogen in the wastewater influent to the septic system. This nitrogen is converted to ammonium in anaerobic conditions in a conventional septic tank. The effluent from the septic system going into the leach field contains nitrogen in mostly the form of ammonium. Nitrification of the ammonium occurs in the soil in aerobic conditions forming nitrate. Nitrate can be utilized by plant or microbes to a limited degree depending on the depth of the plant root zones. Nitrates remaining are highly mobile in soil due to the nitrate ion being negatively charged where it can easily travel through the soil toward groundwater.

The EPA (2002) noted that the limited ability of conventional septic systems to achieve enhanced nitrate reductions and the difficulty in predicting soil nitrogen removal rates means that systems sited in drinking water aquifers or near sensitive aquatic areas should incorporate additional nitrogen removal technologies prior to final soil discharge. For additional information about conventional septic systems, the University of Wyoming Extension office has published a helpful article on septic systems in its *Barnyards and Backyards* (2012) publication, which is included in Appendix F.

5.4.2 NITRATES IN DRINKING WATER

Nutrient pollution, including nitrogen and phosphorus, is one of the US's most widespread and potentially costly contaminants degrading the quality of groundwater (EPA, 2022). Nitrogen comes from a variety of sources including animal wastes, fertilizers, and municipal sewage treatment plants. Stormwater runoff from impervious surfaces is a way for nitrogen to be mobilized to either surface waters or groundwater sources via infiltration. Another way nitrogen can contaminate groundwater is from domestic wastewater systems such as septic systems. Nitrate-nitrogen is the common drinking water contaminant of concern that can be found in groundwater below conventional septic systems. Regions with karst terrain, fractured bedrock, or sandy soils are at particular risk for movement of bacteria, viruses, nitrate-nitrogen, and other pollutants to groundwater (EPA, 2002). Nitrate is a form of nitrogen that is relatively stable and highly soluble making it highly mobile with water infiltrating downward from the leach field of a septic system (EPA, 2022).

WWC Engineering (2013) reported that conventional septic systems are a common source of nitrate. Nitrogen in the organic form of ammonium makes up the majority of nitrogen from households. Ammonium exits from a septic tank into the leach field, typically at concentrations around 45 mg/L-N. In the leach field a process called nitrification biologically transforms the ammonia into nitrate. Nitrate can be utilized by plant or microbes to a limited degree depending on the depth of the plant root zones, which is why leach fields are typically utilized to distribute the effluent out of septic systems. Nitrate can be transformed in the soil column prior to reaching an aquifer by another biological process called denitrification which ultimately transforms nitrate into nitrogen gas. This process requires soils with high moisture content, low oxygen content and high amounts of organic carbon to occur. Reduction of nitrogen to nitrogen gas through soil-based systems is limited due to the lack of anaerobic conditions and a carbon source several feet below the leach field. The EPA (2002) indicated that denitrification has been found to be significant in the saturated zone only in rare instances where carbon or sulfur deposits are present. These conditions do not typically exist in the Laramie area and little decomposition of nitrate by denitrification is expected to occur. Hence the primary method for reducing the nitrate concentrations from conventional septic systems is though dilution by recharge from rain and snow melt. Since precipitation and recharge rates are low in the Laramie area, relatively large lot sizes are currently required to provide enough recharge to dilute nitrate concentrations to a safe level to lessen the risk of contaminating a nearby well.

Nitrate is regulated under the Safe Drinking Water Act (SDWA) where nitrate levels in public water systems must remain below a Maximum Contaminant Level (MCL) of 10 mg/L as nitrogen (N). Nitrate is considered an acute contaminant which is immediately dangerous to human health at levels above the MCL. Some nitrate does exist naturally in groundwater at low concentrations, typically below 3 mg/L-N (EPA, 2022). Any measurement of nitrate at or above 10 mg/L in drinking water is considered a violation of the MCL. Public water systems which violate the nitrate MCL must notify the public of the violation in order to protect public health. The EPA can fine a utility for exceeding the nitrate MCL and take legal action to force its compliance with the regulation. Private wells are not regulated under the SDWA. However, the health risk to infants and adults from nitrate contamination is no different for private wells than for public wells. Private wells containing unsafe levels of nitrate can be treated, typically using costly advance water treatment technologies such as reverse osmosis membranes (WWC Engineering, 2013).

To protect public health, the Wisconsin Department of Health Services (2019) has reported that nitrate concentrations in excess of 10 mg/L may cause adverse health effects as described below:

- **Blue Baby Syndrome** - Nitrate can affect how our blood carries oxygen. Nitrate can turn hemoglobin (the protein in blood that carries oxygen) into methemoglobin. High levels can turn skin to a bluish or gray color and cause more serious health effects like weakness, excess heart rate, fatigue, and dizziness. Nitrate can affect babies more seriously because their smaller bodies are more greatly affected by the presence of nitrates affecting oxygen uptake. When nitrate levels are high, water should not be given to babies less than 6 months old or used to make infant formula.

- **Birth Defects** - With regard to pregnant women, high levels of nitrate in drinking water may cause neural tube defects (a type of birth defect). The neural tube turns into the brain and spine in an unborn baby. Neural tube defects can occur very early in pregnancy. When nitrate levels are high, women who are or may become pregnant should immediately stop using the water for drinking and preparing foods that use a lot of water.

- **Thyroid Disease** - High levels of nitrate in drinking water may increase the risk of thyroid disease. Nitrate can affect how the thyroid functions by blocking the uptake of iodine. The thyroid needs iodine to make hormones. Low levels of thyroid hormone levels can cause fatigue, weight gain, dry skin, hair loss, and goiters (enlarged thyroid).

- **Colon Cancer** - High levels of nitrate in drinking water may increase the risk of colon cancer. Nitrate may enhance the cancer potential of other compounds or may turn into cancer-causing chemicals. Nitrate in drinking water has not been shown to increase the risk of other kinds of cancer. When nitrate levels are high, everyone should avoid long-term use of the water for drinking and preparing foods that use a lot of water.

5.4.3 EAST LARAMIE WASTEWATER FEASIBILITY STUDY

Wittman (2008) recommended that the City of Laramie and Albany County work cooperatively to develop an East Laramie/Albany Wastewater Feasibility Study in an effort to assess groundwater quality impacts from residential septic systems. WWC Engineering (WWC) completed the study and provided a characterization and risks of the existing nitrate impacts to the Casper Aquifer, several mitigation options including improvements to the existing septic systems, installing individual holding tanks for the septic systems, a decentralized wastewater treatment system, and sewage collection and treatment by the City (WWC, 2013). WWC also recommended the installation of a groundwater monitoring network designed to be an early warning system for contamination arising from septic systems east of Laramie.

Based on the City of Laramie’s nitrate sampling in 2009 and 2010, WWC (2013) concluded private drinking water wells in the East Grand area, particularly wells located in Laramie Plains Subdivision area and south and west of I-80, had been impacted to varying degrees or were at risk of contamination by nitrate originating from septic systems. Nitrate is consistently present at higher levels in the East Grand area than in the other areas tested. Based on the initial round of nitrate sampling, approximately 65% of the East Grand area wells that were sampled showed nitrate contamination, with 4% of the wells exceeding the drinking water MCL. Of the wells sampled in the other areas (Laramie South, Happy Jack, Rogers Canyon), approximately 20% showed nitrate contamination. Within the East Grand area, WWC indicated all wells in the Laramie Plains Subdivision area had been impacted by nitrate, with all wells having nitrate concentrations greater than 2 mg/L, and 50% having concentrations greater than 5 mg/L. Southwest of the I-80 interchange, WWC reported that wells in that area had been strongly impacted by nitrate with approximately 70% of wells having nitrate concentrations over 2 mg/L.

Although the mean nitrate concentrations at all the municipal wellfields still remain below the 2.0 mg/L threshold at which anthropogenic contamination is likely, the apparent increasing trends at the Turner and Soldier wellfields and the sporadic occurrences of concentrations of 2.0 mg/L or greater suggest possible impacts at all except the Pope Wellfield.

The groundwater monitoring network WWC proposed consisted of installing wells near the City wellfields, and included a plan for testing the groundwater samples for alkalinity, chloride, nitrate, pH, dissolved oxygen, temperature, specific conductance, and fecal coliform. WWC also recommended that at wells where nitrate contamination was detected, additional parameters could be monitored in the groundwater. The additional parameters included acetaminophen, caffeine, carbamazepine, coprostanol, E coli and total inorganic nitrogen.

5.4.4 SEPTIC SYSTEM IMPACT ASSESSMENT

Wenck Associates (Wenck) conducted a vadose zone monitoring program to assess septic leach field denitrification within the CAPA (Wenck Associates, 2019). The CAPA is particularly susceptible to contamination from properly functioning septic systems due to the permeability and lithologic characteristics of the aquifer, exposure of the Casper Formation at land surface, and thin soil cover as the formation dips westward toward the Laramie Basin. Sampling of the septic tank effluent indicated Total Nitrogen concentrations of 80 to 89 mg/L with ammonium concentrations of 70.9 to 94.4 mg/L. The purpose of the study was to evaluate how effective conventional septic systems and the underlying strata (vadose or unsaturated zone) were in removing nitrate prior to reaching the Casper Aquifer. The objectives for the study included the following:

1. Assess the effectiveness of a conventional septic system and the underlying low carbon soils in removing nitrate and other associated contaminants from septic effluent prior to reaching the Casper Formation.

2. Identify nitrate concentrations that will exist after treatment by the septic system, leach field, and shallow soils; and,

3. Provide a specific analysis of the performance of the monitored septic facility.

The unsaturated zone monitoring lysimeters were installed below a functional conventional septic and leach field system within the Sherman Hills Estates subdivision at the western edge of the CAPA. Of the 11 suitable sites identified, only two of the 7 landowners contacted in that area expressed interest and willingness to allow the study to be done on their system. Accordingly, Albany County was able to obtain consent from one of the landowners to conduct the study. The Casper Formation was encountered at a depth of 25 feet below sand and gravel deposits. Six borings were drilled and three angled borings had lysimeters installed to allow for porewater sampling under the septic system infiltrators. The depths of the lysimeters ranged from five to 35 feet with the two deepest lysimeters installed into the Casper Formation. Soil samples from all six borings were submitted for laboratory analyses along with effluent samples collected from the septic tank. Results of the study indicated the following:

1. The leachfield biomat and vadose zone, on average, at this particular site was approximately 39% efficient in removing nitrogen (all forms) from the septic tank effluent to a depth of 35 feet through a combination of adsorption, denitrification processes, and/or dilution at different depths.

2. While both the vadose zone moisture monitoring data and the soil sampling results indicated the vadose zone was capable of removing some nitrogen from the septic effluent, nitrate concentrations entering the unsaturated Casper Formation 25 feet below ground surface were consistently high (51 to 63 mg/L). These conditions indicated that the vadose zone did not

remove sufficient nitrogen to protect the Casper Formation and by inference the Casper Aquifer from nitrate contamination.

This study confirmed that a functioning conventional septic system within the CAPA does not sufficiently reduce the nitrogen load to protect the Casper Aquifer. Wenck also made several recommendations for Albany County's consideration, including using these data to evaluate septic system design requirements in the CAPA and estimating nitrate loading to the Casper Aquifer to evaluate appropriate residential density for future development.

5.4.5 CASPER AQUIFER NITRATE LOADING STUDY

Using data obtained from the septic system impact study, Wenck completed a nitrate loading study of the discharge associated with current and future build-out scenarios in the CAPA to simulate their effects on the Casper Aquifer (Wenck Associates, 2020). The City commissioned Wenck to develop a broader understanding of the potential cumulative nitrate loading effects given different residential lot sizes within the CAPA. For modeling purposes, Wenck separated the CAPA into five aquifer blocks, each corresponding to a wellfield or spring which serves the City. Using the available hydrogeologic and water quality data, a simple mass balance loading model (WDEQ Chapter 23, Appendix A) was applied separately to each of these aquifer blocks to assess potential impacts at the City's wellfields under both current (2020) and future build out scenarios. Future build out scenarios were based on residential lot sizes of 2, 5, and 35 acres based on the Albany County Zoning Districts set forth in the Albany County Zoning Resolution.

Results of the modeling completed for both current and future build-out scenarios indicated the following:

1. Under current buildout conditions, City wellfields and springs at the western edge of each of the five modeled aquifer blocks generally had nitrate concentrations remaining below 5 mg/L. Nitrate concentrations at the City's wells with no further buildout are anticipated to remain below U.S. EPA MCL Drinking Water Standards.

2. Modeling of current buildout conditions yielded nitrate water quality concentrations similar to measured values as exhibited downgradient at the current wellfields, particularly for the Spur Wellfield, Soldier Springs Wellfield, and Simpson Springs. Modeled nitrate concentrations at Turner and Pope Springs Wellfields were elevated by comparison with water quality data from these wellfields.

3. Future build-out modeling under agricultural zoning suggests that development of the CAPA under a 35-acre lot spacing would raise nitrate concentrations, but that nitrate concentrations would remain below 10 mg/L.

4. Results of the future build-out modeling scenarios indicate that the Pope Springs, Soldier Springs, and Simpson Springs modeled aquifer blocks are unlikely to be adversely impacted as modelled, as long as the Pilot Hill parcels and those currently owned by Mountain Cement remain undeveloped. Under this assumption, there was little developable land within these aquifer blocks to significantly affect downgradient nitrate concentrations.

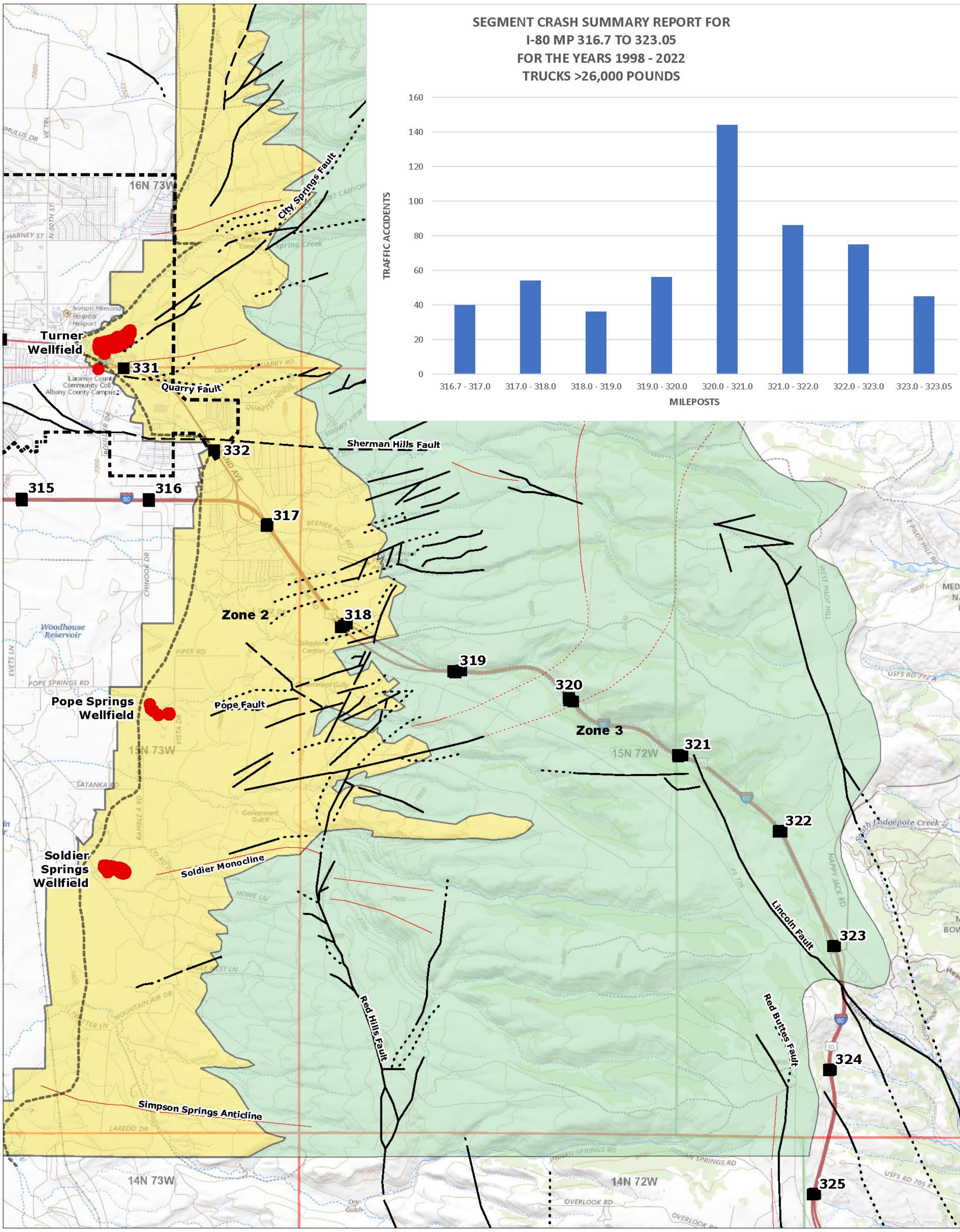
5. Rural residential zoning (5 acres per dwelling unit) and development of the Spur and Turner Wellfield blocks could lead to nitrate concentrations that exceed 10 mg/L.
6. Both the Turner and Spur Wellfields could be adversely impacted if small lot residential lot spacings of 2 acres were extended through the developable lands in these areas.

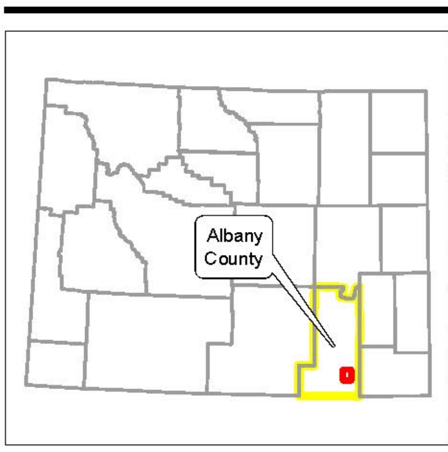
Stantec recommends Albany County adopt a 35-acre minimum lot size across the CAPA. Any additional development of the CAPA on the basis of either 2- or 5-acre residential lots using conventional septic systems enhances the potential for further contamination of the Casper Aquifer.

5.5 INTERSTATE 80

Transport of hazardous materials along I-80 has historically been categorized as a threat with a high likelihood and great potential severity of damage to the Casper Aquifer (see Table 7-1). I-80, from milepost 323 to 317, cuts through the Casper Aquifer exposing the aquifer to contamination from spills. Figure 5-4 shows the number of crashes on I-80 that involved a semi-tractor and trailer from 1998 to 2022 according to Wyoming Department of Transportation (WYDOT). WYDOT personnel estimated that 25% of semi-tractors and trailers haul hazardous materials (Mulcare, personal communication). The implementation of variable speed limits in 2011 along with changes to the pavement surface have had a positive impact on reducing crash rates, and therefore, reduced the likelihood of contaminant impacts due to crashes. The severity of any potential impact still depends upon the type and amount of contaminant released along with where the release occurs.

In addition to hazardous materials, stormwater run-off from I-80 carries oil, grease, metal particles from tires and brake pads, and other automotive fluids and particles from the road over the recharge area. The stormwater may then infiltrate into the Casper Aquifer along with any associated contaminants. Wittman (2008) identified I-80 as posing a substantial risk, a high likelihood and greatest potential severity of damage to the Casper Aquifer. Accordingly, the City of Laramie and Albany County prepared a Request for Proposal (RFP) and awarded a contract to conduct a study of I-80 in regard to protection of the Casper Aquifer (Trihydro, 2011). Additionally, the University of Wyoming conducted an Airborne Electromagnetic Geophysical study to characterize the aquifer parameters, model groundwater flow, and evaluate the threat to nearby water sources from possible spills on I-80 (Smith and Carr, 2021).





Legend

- I-80 Mile Marker
- County
- Municipalities
- PLSS Township
- Protective Satanka Shale Thickness
- Fold
- Fault
- CAPA Zone 1
- CAPA Zone 2
- CAPA Zone 3

0 0.4 0.8 Miles

(At original document size of 11x17)
1:50,688

N

Stantec

Project Location
T16N, R73W
Laramie, Albany Co., WY

Prepared by KAB on 2023-02-15
TR by XXX on 2020-XX-XX
IR by XXX on 2020-XX-XX

Client/Project
227704690
City of Laramie/Albany County
Casper Aquifer Protection Plan Update

Figure No.
5-4

Title
Crashes Involving Semi-Trucks and Tractors per Highway Mile from 1998-2022

Notes
1. Coordinate System: NAD 1983 StatePlane Wyoming East FIPS 4901 Feet
2. Data Sources: USGS, Wyoming Department of Transportation
3. Background: USGS 7.5 Minute Quadrangle

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5.5.1 ALBANY COUNTY I-80 TELEPHONE CANYON CASPER AQUIFER PROTECTION STUDY

Trihydro Corporation conducted a study that expanded on the recommendations that were provided in the Wittman (2008) CAPP (Trihydro, 2011). Their report discusses the geology and hydrogeology of the corridor, existing drainage infrastructure, accident data, potential contaminants of concern, and other factors that could contribute to release and/or mobilization of contaminants. The report also provided recommendations to reduce the likelihood of an accident, engineering options to reduce the severity of a potential contaminant release and proposed a monitoring well network along the corridor.

Trihydro determined that the majority of the trucks hauling hazardous materials contained petroleum products, mainly gasoline and diesel fuel. Trihydro also obtained accident reports and spill information from the WYDOT and the WDEQ, respectively. From their analyses, they determined that the most vulnerable location for contaminant impacts to the Casper Aquifer was between Mileposts 317 and 319 because of high density fracturing in this area. In contrast, Trihydro determined that the area that was most susceptible to accidents was between mileposts 319 and 322, upgradient of the fractured area. Trihydro also recommended a groundwater monitoring network be developed to establish baseline water quality conditions and to sample if an impact did occur. Finally, Trihydro made other recommendations that WYDOT could implement including variable speed limits (VSLs) and installing an alternative road surface.

A VSL is a regulatory or recommended speed limit that changes according to weather and other factors. The VSLs between Laramie and Cheyenne became operational in October 2011. A study funded by WYDOT showed that crashes between Laramie and Cheyenne had been reduced by 24% after VSLs were implemented (Saha, et al, 2019). This study examined the interaction between roadway geometric characteristics and adverse weather conditions and their impact on crash occurrence on rural variable speed limit freeway corridors through mountainous terrain. Establishing VSLs was a positive step to reduce hazardous material spills along I-80.

Variable speed limit sign locations along I-80.

After the I-80 study was completed, Trihydro prepared two plan sets (dated January 2015) that address installing a monitoring well network and engineering controls, including channel improvements. The proposed work has not yet been initiated. It is our understanding that Trihydro requested access to complete a geotechnical investigation and surveying in Section 18 Township 15 North, Range 72 West and Section 13, Township 13 North, Range 73 West from the adjacent property owner (Mountain Land & Cattle Company, LLC (MLCC) to complete the channel improvements (Albany County I-80 Telephone Canyon Aquifer Protection Pond and Monitoring Well Design Project). In a letter dated May 5, 2014, from MLCC's attorney, access was denied (Edwards, M.H., 2014). While Albany County considered doing this work, the City of Laramie confirmed that no channel improvements nor groundwater monitoring network related to this project has been installed (Parkin, 2022).

Hinckley Consulting (Hinckley) also provided comments regarding the Trihydro's 2011 study and subsequent 2015 channel designs. Hinckley (2022) was concerned that the Trihydro report did not include any actual observations of surface water flow and infiltration in the canyon. Hinckley describes the seasonality of the flowing (both perennial and ephemeral) springs in the canyon, the I-80 system of grates, pipes, culverts that directs the pavement runoff in the adjacent channels, and where it infiltrates into the Casper Aquifer. Overall, Hinckley questioned the efficacy of constructing any type of "capture facility" within I-80 Telephone Canyon and asserted that any attempts to install engineered containment structures within the canyon to capture a hazardous material release (most likely gasoline or diesel fuel) would not be productive. Stantec agrees with these conclusions.

5.5.2 AIRBORNE ELECTROMAGNETIC GEOPHYSICAL (AEM) STUDY ALONG THE I-80 CORRIDOR

The University of Wyoming (Smith and Carr, 2021) collected airborne electromagnetic and airborne magnetic data for a study area between I-80 and Soldier Springs groundwater well. The data were processed to create a resistivity model and to characterize the potential differences in water movement within the different layers of the aquifer. The resistivity layers were then assigned hydrogeologic properties to create a groundwater flow and contaminant transport model of the area.

Modeled flow paths suggested that the municipal well at Soldier Springs was not vulnerable to spills along I-80, given current pumping rates or passive artesian flows. However, residents relying on Casper Aquifer groundwater living outside of the Laramie municipal service area between mile markers 317 and 318/319 could be affected. Particle tracking of contamination released along the I-80 corridor traveled a distance of 2.5 to 3 miles downgradient and intersected multiple privately owned wells.

The modeling conducted as part of the AEM study used particle tracking to help understand the vulnerability of wells in the modeled area to contamination released along I-80. Particle tracking models provide larger capture areas related to groundwater flow paths since they do not account for natural attenuation of contaminants within the aquifer. They also provide a steady state solution and should not be relied upon to estimate potential contaminant impacts to the city wells.

5.5.3 GROUNDWATER MODELING ALONG I-80

Smith and Carr (2021) developed a groundwater flow model based on the integration of geologic, geophysical, and hydrologic data around the I-80 corridor, southeast of Laramie. This groundwater flow model was the first attempt at numerically modeling groundwater movement within this area of the aquifer and was informed and constrained by airborne geophysical data. The airborne geophysical data were used to map electrical resistivity with depth and space across the survey area, resulting in the definition of five hydrogeophysical layers within the aquifer.

Using this model, Smith and Carr (2022) completed additional modeling of various scenarios. Average resistivities of these hydrogeophysical layers were correlated to saturation, porosity, and permeability of the aquifer. Combining these average resistivities with mapped geology and historic hydrologic data allowed for a model of groundwater flow predicting recharge and potential threats to the Casper Aquifer to be created. The following scenarios were run on the model to investigate risks and remediation strategies:

1. No pumping – where does water move in model under background conditions?
2. Possible Remediation Pumping Well Locations in response to a contaminate spill on I-80
3. How does flow in the aquifer shift if Soldier Springs pumps out of the deepest aquifer layer?
4. Where do Pope and Soldier draw water from at maximum pumping rates?
5. Increase pumping conditions between average and maximum at Pope and Soldier Wells
6. Changing Yearly Recharge (20% more and 20% less)

7. How high of a pumping rate is needed at Soldier No. 1 to capture groundwater from the area beneath I-80?

Results of the modeling effort indicated the following:

1. Continue to limit pumping at Pope Springs, and if necessary, Pope can be used for a remediation well at 100 – 200 gpm.

2. Pumping Soldier Springs at 4.5 million gallons per day (mgd) would pull from the interstate corridor. Additionally, a combined rate of 4.5 mgd out of Pope and Solder would draw groundwater from the I-80 corridor.

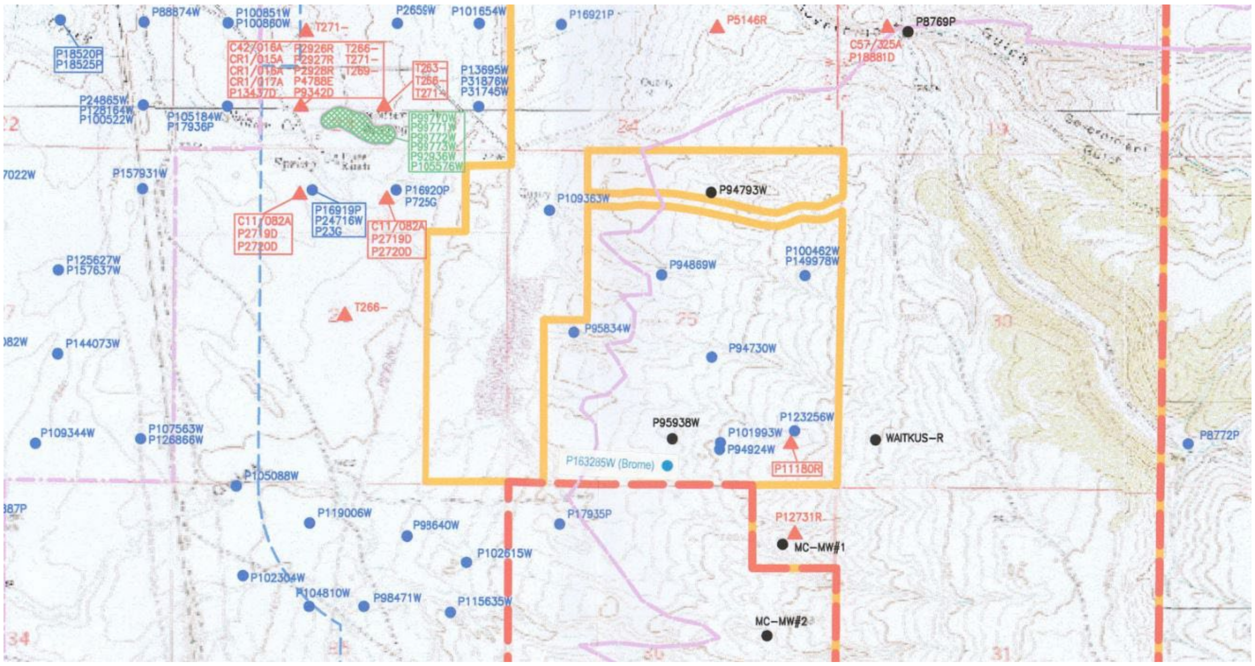
3. According to this model, keeping pumping rates lower than 25% above average at Soldier Springs should keep any contaminants spilled on the interstate from being pulled in by Soldier Springs. Additionally, Soldier Springs draws water from near mile marker 323. A monitoring well near here is a recommended location for informing an understanding of potential contamination of the Soldier Springs source.

If the City or County wants to better understand contaminant transport within the aquifer and the likelihood of contamination for municipal or private groundwater wells due to a spill along I-80, Stantec recommends that additional groundwater modeling be performed. The existing models do not account for natural absorption or attenuation within the aquifer, which likely resulted in overly large groundwater capture areas and travel distance estimates. To better characterize the vulnerability of groundwater wells to spills, a contaminant fate and transport model can be used. These models are created to account for more realistic contaminant degradation within the aquifer and could be built from the existing groundwater model that the City and County already own. Modeling can also be performed over a wider area to better characterize other potential contaminant sources.

5.6 LIMESTONE QUARRIES

Permitted active limestone quarries exist east of the Turner, Soldier, and Pope Wellfields, and south of Simpson Springs. The two quarries (Mountain Cement, PT0298 and Cemex, PT00658) were permitted and are regulated by WDEQ/LQD. Both quarries mine limestone from the Casper Formation for the production of Portland cement. Mountain Cement is located within a large portion of the CAPA south of I-80. While the Cemex mine is located south of the CAPA, it is located approximately four miles south of Simpson Springs. Stantec reviewed the permit files at the LQD office in Cheyenne on April 7, 2022. As the Mountain Cement quarry is the only mine within the CAPA, the following discussions only pertain to this mine. The Cemex mine permit was only reviewed for planning purposes in the event the CAPA is moved further south. Currently, Mountain Cement operations consist of four areas: Piper Quarry North, Piper Quarry South, Warren Quarry, and Etchepare Quarry.

The limestone quarries remove the overburden (material not suitable for cement) and expose the underlying limestone in areas (<100 acres) within the CAPA. Explosive storage, blasting, large truck traffic, and bulk fuel storage occurs within the CAPA. Some of the Mountain Cement quarries are located near faults (Red Hills Fault) and the blasting process has the potential to generate contaminants and induce additional fracturing. One of the more substantial threats posed by limestone quarrying occurs in the bulk storage of fuel. However, the refueling areas are lined by an impermeable layer that can contain the entire volume of the largest possible release, include a spill kit, and are “dish shaped” to fully contain a spill. Additionally, the quarry operations are permitted and regulated by the State. The active quarry area(s) are secured by fencing and gates that restrict access and reduce the potential for intentional contamination. Upon completion, the mined areas are reclaimed using the overburden removed at the beginning of the process and long-term impacts of quarry should be minimal.



Water well locations near the Etchepare Quarry southeast of Laramie.

Stantec reviewed the mine permit for Mountain Cement and its most recent annual report. The mine has been operational since 1975, and the mine permit was last updated in 2013. Overall, the permit had been amended nine times since the original permit. The Hydrology Section (D6) of their permit document contained a statement regarding the importance of the CAPP, and the permit stressed the importance of not impacting the Casper Aquifer. The annual report for the mine covered the March 2021 to March 2022 time period. During this time, Mountain Cement conducted quarterly groundwater monitoring at 14 wells. Ten of the monitoring wells were recently drilled and constructed between 2017 and 2019. The samples collected for these wells were analyzed for total dissolved solids, total alkalinity, nitrate plus nitrite, cations, anions, dissolved metals, total metals, and total petroleum hydrocarbons (TPH). For the 2021-2022 reporting period, the nitrate plus nitrite levels were all below 2 mg/L and TPH concentrations were not above the method reporting limit. The quarterly water quality data are available from the WDEQ -LQD.

It should be noted that an active sand and gravel mine is located along the northern boundary of the CAPA north of the Spur Wellfield. Hamaker Excavation Inc. operates the 9th Street Pit (Small Mine Permit SP0842). The permit was approved in August 2020, and the permit area is 600.7 acres. No adverse impacts are anticipated from this mining operation given its location.

6 Contaminant Management Plan

This chapter describes Step 4 of the five-step process: the Contaminant Management Plan as suggested by Wyoming's WHP Guidance Document (1998).

6.1 INTRODUCTION

The purpose of the CAPP is to identify and minimize the existing and potential contaminant threats to the groundwater supply. To meet this goal, effective management of identified sources of existing and potential contamination must be implemented. A wide variety of management strategies can be employed depending on the threat to the water supply and public acceptance of the proposed strategies.

This Contaminant Management Plan (CMP) presents recommendations for managing existing and potential contaminant sources identified within the CAPA. The CMP is organized into sections, as follows:

- An overview of potential management strategies and approaches considered;
- Detailed discussion of suggested management strategies for each type of contaminant source; and
- Prioritized management strategies with an implementation schedule.

6.2 OVERVIEW OF POTENTIAL MANAGEMENT STRATEGIES AND APPROACHES

There are a number of potential management strategies that may be considered for the protection of the Casper Aquifer. These strategies include both regulatory and non-regulatory approaches. Management strategies should be compatible and consistent with other existing management approaches and should not conflict with existing local ordinances, state, or federal laws or regulations. Other factors to be considered when selecting management strategies are the cost and benefit of implementation, availability of staff and expertise, and legal considerations as identified by City and County legal staff. Most importantly, there must be community support for the management strategies and the adopted approach must effectively provide the degree of control or risk reduction desired for the CAPA. Potential concerns relating to the protection of the Casper Aquifer should be thoroughly considered relative to each potential management strategy prior to selection to ensure that only the most suitable management controls are implemented. If regulations are adopted, they should directly address the management of existing and future contaminant sources. Regulations should also include enforcement procedures and penalties, and should contain a severability clause to allow a court of law to strike down part of an ordinance without invalidating the whole ordinance. Both the City and County have included such measures in their regulations. Most successful plans, according to the U.S. EPA, include both regulatory and non-regulatory strategies (EPA, 1995).

The following is an overview of the non-regulatory and regulatory management strategies that the EAC, TAC, City of Laramie Planning Division, Albany County Planning Department, Wittman (2008), and Stantec considered in developing the recommendations presented in this CMP.

6.2.1 NON-REGULATORY MANAGEMENT STRATEGIES

6.2.1.1 PUBLIC EDUCATION AND INVOLVEMENT

Public education and involvement build support for regulatory and voluntary protection efforts such as water conservation, household hazardous waste recycling and disposal, septic system installation operation and maintenance, and water- quality monitoring. Education can include: press releases; press conferences; newsletters, meetings and workshops; voluntary committee work; class field trips to the aquifer and to municipal water and waste treatment facilities; and brochures on water protection and the hazards of abandoned and uncapped wells. Education may be the most effective and economic means of altering activities that pose a threat to the Casper Aquifer. When people are aware that their activities can pollute groundwater, they may be more careful.

Education regarding the requirements adopted by the City and County within the CAPA can also serve to protect both current and future residents of the area by encouraging informed decision making when it comes to purchasing or developing property. One potential pathway to such protections would be encouraging realtors, real estate agent groups, and/or mortgage lenders to provide potential homebuyers and developers with a summary of any ordinances or resolutions related to the CAPA that could affect land use or market prices and could influence the decision to buy a home in the area. The information provided should include the preamble and executive summary of this CAPP, a map of the APO/APOZ extent, the map illustrating historic nitrate concentrations in the APO/APOZ, and the table of prohibited activities. The document should also include a website address to the current CAPP document on both the City and County websites and a website address for the Albany County parcel viewer where they can interactively view a property of interest relative to the APO/APOZ boundaries. In additional to realtors, this abbreviated CAPP document could be distributed to the public through both City and County websites and referenced in City and County correspondence with residents. Stantec also recommends that City and County officials notify residents of any potential incentives or funding assistance that could help homeowners implement aquifer protection behaviors or technologies.

6.2.1.2 GROUNDWATER QUALITY MONITORING

Sampling public and private wells throughout the CAPA for selected contaminants through a long-term monitoring effort can aid in assessing water quality in the Casper Aquifer. Monitoring can be used to measure the effectiveness of the CAPP and serve as an early warning system for contamination of the aquifer. There was some success toward this effort after Wittman completed the CAPP in 2008, but maintaining momentum toward continuing that effort has been difficult. While 98 wells were sampled in 2009 with landowner permission, only 34 of those wells were sampled in 2010 along with 18 new wells. Any future efforts to complete such monitoring will at a minimum require voluntary participation of local residents, agreeable analyte selection, confidentiality in test result reporting, an understanding of the contaminant threat, agreement on the value of the monitoring effort, and sufficient funding.

6.2.1.3 BEST MANAGEMENT PRACTICES (BMPS)

Best Management Practices (BMPs) are methods to conduct everyday activities in the CAPA in a manner that will reduce the threat of contaminating the groundwater. A list of BMPs for single-family residences is included in Appendix G.

6.2.1.4 HOUSEHOLD HAZARDOUS WASTE COLLECTION PROGRAMS

People generate household hazardous waste every day. Items as common as cleaning solvents, paint, batteries, automotive oil and antifreeze can become hazardous waste. Because these items are potentially hazardous, they should not be placed in a garbage can or waste container. If not properly disposed of, these products may contaminate the soil, surface water, and groundwater. Therefore, household hazardous waste collection programs should continue to be made available to the community in order to reduce the quantity of household hazardous waste being disposed of improperly. A program that allows Laramie and Albany County residents the opportunity to protect their water supply from household wastes and other potential household contaminants should be continued and expanded to increase its accessibility.

The City of Laramie currently accepts household hazardous waste at the City landfill by appointment only. The City requires a 24 hour notice when making an appointment so they can have staff ready to serve the local residents. The residents can drop off items Monday - Friday between 9:00 am - 12:00 pm and 1:00 pm - 4:00 pm. Disposal is free for items such as antifreeze, lead acid batteries/rechargeable batteries, flammables, fuels, fluorescent light bulbs, oil-based paint, pesticides/herbicides, solvents, and toxins/poisons.

6.2.1.5 LAND ACQUISITION PROGRAMS

The local government can acquire land that is within the CAPA as protection from land uses that may adversely affect the groundwater. Six ways to acquire or protect property within the CAPA are presented here.

6.2.1.5.1 Purchase

Purchase of land is perhaps the most effective means of managing potential contaminant sources; however, it can also be the most expensive. In the summer of 2017, the current owners of Warren Livestock LLC offered to sell a portion of their property to the people of Albany County with an agreed upon intent of maintaining the land as open space, providing wildlife habitat, aquifer protection and non-motorized recreational access for the benefit of all of southeastern Wyoming. The Albany County Commissioners responded to overwhelming public support for the idea by signing a purchase agreement and establishing the Pilot Hill Committee to manage the process of securing the land and raising funds for management and low impact development of the area. The Laramie community rallied knowing that this land would directly connect Laramie neighborhoods to almost nine square miles of open space in the foothills and to over 65,000 additional acres of National Forest Lands in the Laramie Range. In 2020, land transactions were completed resulting in acquisition of portions of the Pilot Hill parcels owned by the University of Wyoming, the Wyoming Office of State Lands, and the U.S. Bureau of Land Management. The Pilot Hill properties are collectively managed by the non-profit Pilot Hill, Inc., in partnership with the Wyoming Game and Fish Department.

6.2.1.5.2 Donation

Landowners may donate property to potentially reduce or eliminate estate or capital gains taxes and may have the ability to deduct, over time, the entire value of the donation from federal and other tax obligations.

6.2.1.5.3 Conservation Easements

Landowners can grant an easement that protects land from development by dedicating all or a portion of the property to open space or limiting development uses. Landowners retain ownership of the land, giving up development rights of their property either voluntarily or for compensation.

6.2.1.5.4 Land Exchanges

A land exchange is a transaction other than sale that transfers land from one owner to another. In terms of the CAPA, land owned by the City of Laramie or Albany County would be traded for private land, for which the public's control is deemed important to protecting the Casper Aquifer. The exchange may involve surface rights or subsurface mineral rights or both. The exchange may include a financial payment to equalize the value of the trade.

6.2.1.5.5 Transfer of Development Rights

A transfer of development rights allows landowners to separate their rights to develop the land, as permitted by zoning, from other rights associated with the land. The landowner can sell those development rights to, for instance, a land conservation fund, ensuring that development would not occur. A landowner would gain cash value for development rights yet keep the land in a less-intensive use and continue to enjoy lower property taxes. Transfer of development rights could also include higher density development on one portion of the land while keeping the rest of the land undeveloped.

6.2.1.5.6 Memorandum of Agreement or Understanding (MOA/MOU)

A MOA/MOU serves as a legal agreement between two or more parties and can be written such that it guarantees specific action or prohibits certain activities. A MOA/MOU may be expensive to enforce but offers the advantage of being capable of dealing with site-specific sources of contamination in a timely manner.

6.2.2 REGULATORY MANAGEMENT STRATEGIES

Ordinances/resolutions are the primary form of regulatory management strategies. They are designed to protect the public health and welfare of the community, manage development and land use practices that could contaminate or reduce aquifer recharge, and assure the availability of water supplies for the area. Ordinances/resolutions usually have the same goals as a MOA/MOU and are open to public input and comment. The process of passing an ordinance/resolution, and addressing the diversity of public concerns, may result in considerable time and effort to pass the ordinance/resolution. Additionally, once an ordinance/resolution is passed, resources must be devoted to monitoring and enforcement.

Because most of the CAPA is located outside Laramie city limits, the City and County will need to act cooperatively to regulate activities of concern. Potential regulatory management strategies include: zoning regulations, subdivision regulations and codes, and licensing.

6.2.2.1 ZONING REGULATIONS

Zoning regulations segregate different and possible conflicting activities into different areas of a community and are an effective mechanism for shaping future development. A limitation is that Wyoming statutes provide broad grandfather protection for non-conforming uses. The City of Laramie revised their Zoning Districts of the City's Unified Development Code on March 2, 2021, while Albany County's revised regulations pertinent to the aquifer protection area were approved under the Albany County Zoning Resolution on February 21, 2023. The City and County Comprehensive Plans designate the CAPA as residential and agricultural land use, which are the least intensive uses allowed.

The Laramie Comprehensive Plan was adopted by the Laramie Planning Commission on June 13, 2007, and the Laramie City Council on August 21, 2007. Pursuant to Wyoming statute, the Albany County Planning and Zoning Commission and the Albany County Board of Commissioners agreed with the plan on May 17, 2007 and June 5, 2007, respectively. The Laramie Comprehensive Plan replaces the 1995 Land Use Element. On August 5, 2008, the Board of County Commissioners approved the Albany County Comprehensive Plan.

6.2.2.1.1 Overlay Zoning

A flexible and precise zoning ordinance can include overlay zoning that creates a mapped district that sets additional requirements over and above those in the underlying zoning district. For example, an Aquifer Protection Overlay (APO) zone (APOZ) may be applied to the CAPA within the City and County to require site-specific investigations for all proposed developments.

6.2.2.1.2 Prohibition of Various Land Uses

The City and County have identified prohibited land uses in the CAPA such as gas stations, landfills, and facilities that store or dispose of hazardous materials. A list of recommended additional prohibited activities can be found in Table 6-1. A complete list of current prohibited activities is included in Appendix H.

6.2.2.1.3 Special Permitting

Special permitting and engineering controls may be required within the CAPA to regulate uses and structures which may negatively impact water and land quality, such as underground storage tanks (USTs) and aboveground storage tanks (ASTs).

6.2.2.1.4 Large Lot Zoning

Large lot zoning will limit the potential for degrading groundwater quality by reducing the density of household buildings and on-site wastewater treatment systems within the CAPA. Most Albany County land within the CAPA is currently zoned for agricultural use, but as shown on Figure 5-1, there are some areas designated for residential or commercial development as well as areas that are exempt. The

County's Agricultural Zoning District is presented in Chapter 3, Section 2.A of the Albany County Zoning Resolution, and limits lot sizes to 35 acres and only allows one dwelling unit on the lot. Albany County currently requires a minimum lot size of 35 acres for any new subdivisions within the CAPA.

6.2.2.1.5 Cluster/Planned Unit Development (PUD) Design

Cluster/PUD design allows for an area of small lot development within the City in association with a conservation easement as a way to limit the overall development density to a level consistent with the goal of protecting the Casper Aquifer. Additional benefits of allowing Cluster/PUD designs are reduced costs to the developer, greater flexibility for the developer, open space amenities for residents of the associated small, developed lots, and potential to avoid vulnerable features while still maintaining development potential.

6.2.2.1.6 Growth Controls/Timing

Limitations on the number of building permits issued annually or an outright development moratorium based on a community's physical and financial capabilities. Using growth controls and timing would help limit the number of septic systems and would allow time for infrastructure to catch up with development.

6.2.2.1.7 Performance Standards

Establishing "critical" threshold limits as a standard for acceptability (i.e. septic system effluent limits).

6.2.2.1.8 Eminent Domain

While not preferred or easy, the City or County could potentially acquire privately owned property provided they pay for the property. The Fifth Amendment to the U.S. Constitution requires the governing entity provide just compensation to the owner of the private property to be taken. A variety of property rights are subject to eminent domain, such as air, water, and land rights. The governing entity takes private property through condemnation proceedings. Throughout these proceedings, the property owner has the right of due process. This approach should be considered as a last resort if justified.

6.2.2.1.9 Annexation

Annexation and bringing development into City limits so that City services are provided would aid in protection of the aquifer and eliminate the use of septic systems associated with development in that particular part of the County. However, annexation would be considered by the City on a case by case basis as to whether it was in the City's or County's best interests to pursue, following the statutory requirements. As is customary and historically practiced, annexation is generally driven by the property owner unless there is a significant compelling issue.

6.2.2.1.10 Subdivision Regulations and Codes

Subdivision regulations fine-tune zoning bylaws, resolutions, and ordinances, and focus primarily on engineering concerns rather than land use. Subdivision regulations may include the following techniques:

Performance Standards

Performance standards may be used to limit the impact of development on water quality. Performance standards could include standards for stormwater runoff, sewage effluent standards, on-site septic engineering controls, and residential BMPs that may reduce contaminants that enter stormwater. Performance standards can be enacted during any stage of development including during the site-specific investigations.

Groundwater Impact Assessment (GIA)

Many proposed subdivisions are required to do a GIA as it pertains to potential nitrate contamination. A GIA describes the existing condition of the groundwater resource and identifies potential effects of the proposed development on the CAPA. A GIA could be required with the initial subdivision review to allow the governing bodies to understand the impacts of the development on the CAPA. Such studies for proposed subdivisions in Wyoming are subject to WDEQ review under Chapter 23 regulations.

Site Design and Operating Standards

The purpose of these standards is to regulate the design, construction, and ongoing operation of various land-use activities. This would be accomplished by imposing specific physical requirements, such as the use of double-walled storage tanks for hazardous materials, and by providing standards so that structures will not adversely affect water quality. Groundwater quality can be enhanced through requirements such as vegetated buffer zones, natural landscaping, stringent percent cover standards and alternative roadway designs.

Inspections of Septic Systems

When construction of an individual sewage disposal system has been completed, except for backfilling, the Albany County water and wastewater engineer conducts an inspection of the installation. The final inspection is to verify that the system is installed in accordance with Albany County regulations and the permit. Existing septic systems may be inspected at regular intervals.

6.2.2.2 LICENSING

Licensing regulations require design and construction activities within an area of special concern be conducted by qualified firms. Qualifications can be established by a state, county, or local licensing authority.

6.2.2.2.1 Professional Licensing

The State of Wyoming regulates many professions including engineering, geology, water well drilling contractors, and water well pump installation contractors. These professions can directly impact aquifer protection within the context of the CAPA.

6.2.2.2.2 Construction Contractor Licensing

The City of Laramie presently licenses contractors responsible for building construction within the city limits. Similarly, the County licenses commercial contractors who install and repair on-site wastewater treatment systems. Design standards and requirements for construction of on-site wastewater treatment systems can be communicated to contractors through the various licensing processes.

6.3 RECOMMENDED MANAGEMENT STRATEGIES FOR EXISTING AND POTENTIAL CONTAMINANT SOURCES IDENTIFIED WITHIN THE CAPA

Potential and existing contaminant sources were identified in Chapter 5 of the CAPP. This section describes recommended management strategies for each CAPA Zone and type of potential contaminant source. Implementation of strategies is the responsibility of the Laramie City Council, Albany County Board of Commissioners, and other governmental agencies.

6.3.1 ZONE 1

A Zone 1, or Accident Prevention Zone, is established around each municipal well and spring area as a 100-foot radius as described in Chapter 4. These zones should be managed to prevent the accidental or purposeful introduction of contaminants into the Casper Aquifer in the immediate vicinity of municipal wells. The City should control and maintain the security of these critical areas.

6.3.1.1 ZONE 1 RECOMMENDATIONS

6.3.1.1.1 Purchase of Land

It is recommended that the City of Laramie purchase all land within Zone 1. This recommendation currently applies to Spur No. 2 and Turner No. 2. By purchasing the land, the City of Laramie is able to control the land use and restrict access to Zone 1. Under certain circumstances, the City should also consider purchasing the land immediately adjacent to Zone 1 areas. Once the land has been purchased, the City should consider annexing the purchased property. Annexation gives the City jurisdictional control over the area.

6.3.1.1.2 Zoning

The City and County's current zoning regulations restrict all development within Zone 1. Since this area is in close physical proximity to the municipal drinking water wells, it has been protected with strong measures. Wyoming DEQ Chapter 25 requirements for domestic wells implement a 100 foot setback from septic leach fields.

6.3.1.1.3 Security

If not done already, all Zone 1 areas should be protected and secured with fencing and padlocked gates with access allowed only for emergency and authorized personnel. All fencing at the municipal wellfields should be regularly inspected when the wellheads are visited and repaired as needed to maintain site security. If not already completed, signs should be placed that indicate Zone 1 is a restricted area. Since not all wells are fenced, the highest priority for Zone 1 security should be to fence and secure the Pope Spring wells. The security fence at City Springs should be replaced or improved as needed. The City currently owns the property where the future Simpson wellfield will be developed. Once water supply wells are constructed in this area, the wellheads should be fenced appropriately and signage placed.

6.3.2 ZONES 2 AND 3

Zone 2 and Zone 3 are designated as the primary and secondary zones of protection, respectively. Conduit flow occurs throughout Zones 2 and 3 as described in Chapter 4 and allows for rapid groundwater flow through interconnected fractures, faults, joints, bedding surfaces, and dissolution features. Natural drainages in the CAPA also play an important role in groundwater recharge as described in Chapter 4. Due to the conduit flow features and natural drainages throughout Zones 2 and 3, these zones should be managed in the same manner. Currently, these two zones are managed with the same level of protection and this management style should continue. The rest of this section describes management strategies for Zones 2 and 3 and provides a discussion of specific management strategies for specific potential contaminant sources.

6.3.2.1 ZONING REGULATIONS

Probably the most important mechanism to protect the Casper Aquifer is adequate zoning. An ordinance or resolution, as discussed previously, provides a mechanism to address land use and development. It is important to regulate land use and development intensity within the CAPA because human activities are often the cause of water-quality degradation.

Albany County and the City of Laramie each have an Aquifer Protection Overlay (APO) Zoning Resolution or Ordinance, respectively. The Albany County Board of Commissioners approved its current APOZ Zoning Resolution on February 21, 2023. The City of Laramie approved its Zoning Districts (APO) for the City’s Unified Development Code on March 2, 2021. Given differences in the zoning regulations, Stantec has presented some recommendations in the following sections to address these differences or to place additional measures within these areas. The importance of the Casper Aquifer to both Albany County residents and the City of Laramie necessitates that consistent regulation be incorporated into management strategies. The current County APOZ Resolution and City APO Ordinance along with maps of the APO/APOZ areas are included in Appendix H. The City ordinance was incorporated into the Unified Development Code while the County resolution was incorporated into the Albany County Zoning Resolution.

6.3.2.2 ZONING REGULATIONS RECOMMENDATIONS

6.3.2.2.1 Prohibited Activities

Specific activities and land uses have contributed to groundwater contamination throughout the United States (EPA, 1997, Hallgarth, 2001, Brown, 2016, and URS Group, 2021). Based on the approved regulations in Appendix H, the City and County have already placed significant restrictions on many activities to protect the Casper Aquifer. The intent of prohibiting these particular activities is to keep land use consistent with typical residential or agricultural use and to limit the amounts of potential contaminants within the CAPA. It is not to discourage or prevent residents from pursuing hobbies, animal boarding, etc. consistent with living in the county. Stantec recommends that the additional activities and land uses listed in Table 6-1 be prohibited in Zones 2 and 3 of the CAPA. The list of prohibited activities is unlikely to include all future proposed land development that has the potential to adversely impact water quality in the Casper Aquifer. Therefore, the governing bodies should review all developments or use changes within the CAPA.

Table 6-1. Recommended Additional Prohibited Activities

Prohibited Activity ***The following activities are recommended to be prohibited in the APO/APOZ zone:***	**Examples of Prohibited Activities** ***The following are examples of businesses or activities which may conduct the prohibited activity.***	**Applies to Albany County, the City of Laramie, or both**
1. Commercial animal feeding operations where a) animals have been, are, or will be stabled or confined and fed or maintained for a total of 45 days or more in any 12-month period and b) crops, vegetation, forage growth, or post-harvest residues are not sustained in the normal growing season over any portion of the lot or facility. Such operations include more than 1,000 animal units per facility or more than 10 animal units per acre on a parcel containing less than 35 acres.	Feedlot, stockyards, animal feeding operations regulated under the EPA's National Pollutant Discharge Elimination System (NPDES) program.	Both (This replaces the existing prohibited activity for the City and County)
2. Commercial golf courses or intensely managed turf that use high water demand grasses and large quantities of fertilizers/herbicides/pesticides in its operation.	Golf course, driving range, or sod farm.	Both (add to Albany County list and replaces existing prohibited activity for the City)

6.3.2.2.2 Setback From Vulnerable Features

As discussed in Chapter 3, there are several characteristics of the Casper Aquifer that render it vulnerable to contamination. Some of these characteristics are discrete features on the ground surface that should be protected by a required setback. Stantec recommends that a minimum 100 foot setback from all the following features be required for all new development or improvements to existing development:

- Folds, faults, fractures, springs, shallow groundwater, and/or other evidence of physical features at the ground surface that enhance the potential for rapid infiltration and aquifer contamination. The basis for the feature presence and location will be established from research and field mapping completed by licensed professionals through the site-specific investigation.
- Wells of any kind completed in the Casper Aquifer. All wells present a direct conduit to the aquifer. While domestic wells that are properly sealed present a lesser threat, uncapped, unsealed, improperly sealed, and abandoned or orphaned wells present a high risk to the aquifer.

- Perennial, intermittent, and ephemeral drainages as established in the field.

While the City enacted in Chapter 15.08.40 of the Uniform Development Code that a 100 foot setback be established for all development near vulnerable features, the County has principally regulated this with respect to on-site wastewater disposal in the Albany County Zoning Resolution. Stantec recommends that Albany County amend its regulations to require a site-specific investigation be included for all new development or proposed new uses within the APOZ. With this approach, a Wyoming licensed professional engineer or geologist will have to assess the proposed development property and identify any vulnerable features that would require setbacks. The site-specific investigation will enable the City/County governing bodies to identify the potential impacts, if any, that the proposed development may have on the Casper Aquifer and allow them to approve, conditionally approve, or deny the application.

6.3.2.3 SITE-SPECIFIC INVESTIGATIONS

Within the large geographic areas defined as Zones 2 and 3, features have been identified that may render the Casper Aquifer particularly vulnerable to contamination. Both the City and County require that site-specific investigations (SSI) be conducted when development is proposed within Zones 2 and 3. The City of Laramie’s SSI requirements are codified in Chapter 15.08.40 of the Laramie Unified Development Code. Albany County’s SSI requirements are codified in Chapter 3, Section 3, D.9. of the Albany County Zoning Resolution. Development is defined by Wyoming statute, and for purposes of aquifer protection, is generally considered any use or modification of the natural land surface that may increase the vulnerability of the Casper Aquifer to contamination.

The purposes of the site-specific investigation are to determine the vulnerability of the aquifer to contamination by the proposed development as a result of the presence of vulnerable features, and to identify, as a minimum, the potential impacts of the proposed development(s) on the Casper Aquifer. A specific objective of an SSI is to identify the location of vulnerable features and associated setbacks that define the developable area on the subject property. The reasoning for requiring site-specific investigations is that the presence of one of these vulnerable features on a particular property does not necessarily mean that aquifer contamination will occur or is more likely, but rather it has the potential for increasing the vulnerability. Additionally, a combination of these features may result in significantly greater vulnerability.

These site-specific investigations are to be completed as part of the permitting process by a Wyoming licensed professional engineer or professional geologist who, by experience and/or by training has the required skills in the areas of groundwater evaluation, geologic formation analysis, engineering controls and hazard mitigation, and the science of contaminant transport. The proposed development and site-specific investigation and peer review should present or demonstrate how aquifer protection will be degraded, maintained or enhanced. The professional completing and the professional reviewing the investigation should clearly state whether each recommends approval or non-approval of the proposed development without using subjective terms (i.e. minimal, low, moderate or high impact).

There are differences between the SSI requirements of the City and County in their regulations. Stantec recommends adoption of a single set of site-specific investigation requirements for both entities as presented in Table 6-2. These SSI requirements should be applied within Zones 2 and 3 to all new development and proposed new uses, and a final report should be completed and submitted as part of each investigation. Considering the limited risks presented to the aquifer by the development of single-family houses on 35 acre lots, it is conceivable that an exemption could be granted by the county in such circumstances. In that case, a site plan should be provided showing the proposed development on a recent USGS topographic map and setbacks from vulnerable features. Stantec further recommends that the City and County develop and maintain consistent GIS datasets on the Albany County parcel viewer for geologic maps, Casper Aquifer potentiometric surface maps, CAPA extent and zones, City and County zoning, and buffered surface water features (marshes, perennial drainages, intermittent drainages, ephemeral drainages, creeks, and other bodies of water) and groundwater features (faults, folds, etc.) indicating approximate required setbacks. These datasets could be used by professionals working on the SSIs and viewed by interested parties.

Table 6-2: Site-Specific Investigation Content Recommendations.

No.	Recommendation
1	A document search will be completed to determine the presence of mapped faults, folds, fractures, and other vulnerable features on the proposed development at the subject property. This research will include at a minimum a review of the CAPP and available topographic, geologic, and hydrogeologic maps and reports as needed.
2	A site narrative will be included that includes historical information on previous land use, contaminant releases or any known contamination of any part of the property, existing or abandoned wells, underground storage tanks, and septic systems as well as any other improvements or information relevant to the potential for aquifer contamination under the proposed use.
3	An onsite investigation will be conducted to verify the presence or absence of vulnerable features as defined in subsection 15.08.040.A.7.a (City Unified Development Code) or Chapter 3, Section 3,D.5.a (Albany County Zoning Resolution) that were not previously identified through the document search. This investigation will also consider any other geologic, hydrologic, hydrogeologic, or geotechnical conditions that could potentially compromise water quality beneath the subject property. A summary of the field inspection shall include a written report, maps identifying the vulnerable features, and the distance and direction of the nearest wells and vulnerable features that could potentially impact water quality beneath the subject property.
4	Where subsurface wastewater disposal is proposed within the APOZ, documentation shall be provided that the facility will comply with the County's Design and Construction Standards for Small Wastewater Facilities and Regulations for Permit to Construct, Install or Modify Small Wastewater Facilities and all applicable Wyoming DEQ standards.
5	A site plan will be provided to show the proposed development, use, and zoning of the property relative to identified vulnerable features. The site plan will include existing and proposed topographic contours or show the proposed development on the most recent U.S. Geological Survey 7.5' Topographic Quadrangle map. The site plan will indicate site conditions for a distance of at least 200 feet beyond any proposed development in all directions. The site plan must show existing and proposed structures, proposed small wastewater systems as applicable, parking areas, retention or detention ponds, water wells, driveways, landscaping areas, setbacks, surface and subsurface drainage facilities, potential contaminant storage locations and methods of storage, above ground storage tanks, utilities, roads, and stormwater management facilities. If any vulnerable features are found on the property to be developed, then the site plan must show any proposed facilities, as applicable, with a minimum 100 foot setback from those vulnerable features identified.
6	A map(s) will be included to illustrate the subject property showing soils, marshes, perennial drainages, intermittent drainages, ephemeral drainages, creeks, and other bodies of water on the subject property.

No.	Recommendation
7	A geologic map(s) will be provided to show the surface distribution/location of alluvium and to depict the types of exposed bedrock, faults, folds, fractures, and other evidence of conduit flow on the subject property that were identified either from existing reports or from the onsite investigation. The map must also include the locations of all existing and abandoned wells and any other vulnerable features identified near the proposed development.
8	The depth 149 roundater will be determined and presented. Water level(s) in a well on the subject property are preferable for determining depth to groundwater. Water levels from wells on adjoining properties may be used if a well has not been drilled on the subject property. If a well is not available for obtaining water levels, then maps depicting the potentiometric surface of the Casper Aquifer at the subject property may be used. No new wells are required to be drilled for the purpose of determining the potentiometric surface.
9	An evaluation will be included of the proposed water supply and wastewater systems that includes the potential for contamination impacts of the systems to the Casper Aquifer and its recharge area and the adequacy of the systems, as applicable. Within the APOZ, the evaluation of the wastewater system will consider the potential impacts of effluent on any member of the Casper Formation. Items such as floor drains and plumbing schematics and the locations of potential contaminants, waste storage, and liquid transfer area locations shall be provided.
10	To the extent not prohibited by City and County Prohibited Activities Tables, a list will be provided of potential contaminants and amounts stored, generated or handled on the subject property.

6.3.2.4 APPROVAL FOR DEVELOPMENT WITHIN THE APO/APOZ

While the City has enacted conditions for approval of development within Chapter 15.08.040 of the Unified Development Code, Stantec recommends that Albany County likewise permit development or new uses only if the following criteria are met:

1. The proposed type of development and area in which the development is proposed meets the standards of this chapter.
2. No vulnerable feature, as described above, exists within 100 feet of the proposed development;
3. A site-specific investigation has been completed and a report of the findings submitted to the appropriate governing body. The county shall review, approve or require additional data collection on a site specific basis;
4. A Wyoming licensed professional engineer, professional geologist, hydrologist, or other qualified designee who, by experience and/or by training has the required skills in the areas of groundwater evaluation, geologic formation analysis, and the science of contaminant transport, other than the professional that performed the site- specific investigation, must review the site-specific investigation and verify that the proposed development meets the requirements of the ordinance/resolution. Engineers who are directly employed by the County should not conduct the peer reviews. When review of the site-specific investigation is conducted by an outside professional, the County may be reimbursed for the cost of the review by the developer or applicant.

In review of the site-specific investigation, the qualified professional will assess and determine whether the site and development plans meet the overall objectives of the Casper Aquifer Protection Plan and the ordinance or resolution, whichever is applicable. Stantec recommends these approval conditions be added to the Albany County Zoning Resolution in Chapter 3, Section 3.D as well as the existing list of requirements to obtain a zoning certificate in Chapter 5, Section 7.D.5.d.

The City and County should retain an independent, qualified consultant to conduct reviews of development proposals within the CAPA for their respective jurisdictions. These reviews will provide the City and County staff, City Planning Commission, Albany County Planning and Zoning Commission, County Commissioners, and City Council with the rationale required to either approve, conditionally approve, or deny the proposed developments. As discussed in this chapter, site-specific investigations will identify the potential risks to the Casper Aquifer, and integrate aquifer protection into the proposed development. Upon completion of a site-specific investigation, the City and County will use the retained independent consultant to assess the potential impact of the proposed development on the Casper Aquifer by conducting a peer review by a qualified professional who is familiar with the CAPP and applicable ordinances/resolutions. While the reviews would be conducted using local government funds, the government entities may be able to recover the costs to review development plans through increased application fees or other measures. Development within the CAPA should include residential BMPs that are proven effective for the local hydrogeologic conditions.

The County and the City should attach conditions to the approval of a development to ensure protection of groundwater quality as appropriate. Conditions may include further evaluation, reasonable technical improvements, monitoring or other mitigation measures deemed necessary. The County should develop a mechanism to ensure that the conditions of approval are enforced.

6.3.2.5 DESIGN STANDARDS FOR ON-SITE WASTEWATER TREATMENT/SEPTIC SYSTEMS

On-site wastewater treatment systems and septic systems have been identified as facilities where contaminants are likely concentrated and can be more easily identified and managed as opposed to non-point contaminant sources, such as stormwater runoff. Therefore, the installation and proper functioning of on-site wastewater treatment systems and septic systems is one of the most effective methods to protecting aquifer water quality. Septic systems over the Casper Aquifer recharge area are of particular concern because geologic materials other than the Satanka Shale that cover the Casper Aquifer do not provide sufficient contaminant reduction to protect the aquifer (Wenck, 2019), and because some residential septic systems in the area have been documented as contaminating the aquifer resulting in nitrate concentrations that exceed the EPA primary drinking water standard of 10 mg/L in some domestic wells (City of Laramie, 2009). Both the City and County require, by regulation, that installation, design, repair, and removal of septic systems located within the CAPA be in accordance with plans and specifications prepared by and certified by a professional engineer skilled in the science of wastewater disposal and licensed to practice in the State of Wyoming. The County should not allow professional geologists to complete this work when Wyoming DEQ Chapter 25 regulations do not.

Treatment systems such as septic systems require regular inspection and maintenance to ensure proper septic system function and thereby contribute to aquifer protection measures to the extent possible with the respective system. A poorly functioning septic system may result in reduced treatment efficiency and waste totally bypassing any form of treatment before seeping into the soil. Inspections can include checking for damage or cracks in the piping leading up to the septic tank, watertightness of the tank, clogs in the tank and the leach field, sludge and scum levels, and function of equipment such as pump, level floats, and alarms. Finding, repairing and/or replacing septic systems are key to promoting and enhancing aquifer protection in the CAPA.

A septic tank needs to be pumped out when solids make up over two-thirds the volume of the tank. The rate of accumulation of sludge will depend on the tank size, number of people in the household, water habits, and other use factors. Septic systems should be inspected and pumped out at least once every five years or on a more frequent schedule recommended by a County licensed wastewater pumper/hauler. Pumping will prevent solids, oils, and grease from building up to a level where these waste materials will be washed out into the leach field and/or clog leach field lines. If upon inspection by licensed pumper/hauler that there is no significant solids accumulation, pumping can be deferred. The owner will need to provide proof the sludge level in the septic tank is no more than two-thirds full to qualify for deferment of pumping. A database regarding the septic systems and their pumping and inspection schedules should be maintained and updated by the City and County GIS to maintain records and track schedules.

Albany County maintains authority to inspect new and replaced septic systems and leach fields, prior to backfilling, to verify proper installation and confirm design information stated in the permit application. Albany County has a Wastewater Inspection Form through the Planning Department and can be found in Appendix F. Existing septic systems are subject to inspections to verify they are in operational condition as intended in the original design. Condition inspections of a septic system should also occur ideally once every five years or when the property is transferred to ensure that baffles are operating correctly, that no leaks are occurring, to check the levels of sludge and scum in the tank, and signs for a damaged leach field such as damp spots or spongy grass over leach field area. An inspection could be waived if the seller can provide documentation of inspections completed within the last three years.

6.3.2.5.1 Connection to Municipal or District Sewage Collection Lines

The City has codified its regulations with regard to connecting to a municipal wastewater system in Chapter 15.08.040 of the Unified Development Code. Wittman (2008) recommended that an East Laramie/Albany County Wastewater Feasibility Study be conducted to evaluate the feasibility and cost effectiveness of installing different types of systems. The focus of this investigation was on areas east of Laramie, particularly along or adjacent to Grand Avenue, where septic systems are currently in use within the CAPA. The study was completed by WWC Engineering (2013) and a report was prepared. The results of the study are discussed in Sections 5.4.3 and 6.3.3.1.2.

6.3.2.5.2 Exception from 100 Foot Setback from Vulnerable Features for Infrastructure

The City of Laramie further codified that the construction of sewer and water lines that are connected to either a centralized wastewater or water system or the City of Laramie's wastewater or water system be allowed within the CAPA and exempted from 100 foot setbacks from vulnerable features. The City and County should consider adoption of construction and engineering standards for utilities and infrastructure that meet the aquifer protection goals of the Plan. Exceptions may also include other general utilities used specifically to serve local developments such as electric lines, gas lines for heating, cable television, and telephone lines. Roads may also be excepted if appropriate stormwater drainage and management is included.

6.3.2.6 PRE-EXISTING NONCONFORMING USES

A pre-existing nonconforming use is a use prohibited by regulation, but which was in place prior to the property being included in the APO/APOZ. Both the City and County have codified their regulations regarding these uses (grandfathered prohibited activities), but there are some differences in allowing expansion and in acquiring information from these facilities. Pre-existing nonconforming uses may continue in the same location but should not be expanded in size, quantity, or scope. If the pre- existing nonconforming use is damaged, they are required to be repaired and may resume at the same location, size, and scope, provided that after the repairs are complete, the best available control technology is in place to prevent hazardous materials from entering the Casper Aquifer.

Stantec strongly recommends that such nonconforming uses not be allowed to expand given the potential for aquifer contamination due to these current uses. The City has established a set of criteria within Chapter 15.08.040 of the Unified Development Code to allow such expansions, which generally includes the following:

- A site-specific investigation is completed.
- The development is approved by the governing body.
- Control technology built into the expansion that will mitigate any increased risk to the Casper Aquifer.

Stantec recommends that the City remove this regulation and not allow expansion of non-conforming uses under any circumstances. These uses are already prohibited due to the contaminant risk they present to the aquifer. The contaminant risk associated with these uses should be minimized as much as possible.

Stantec recommends that Albany County continue to not allow expansion of nonconforming uses and adopt the following requirements for pre-existing nonconforming uses to the extent their statutory authority allows:

- The alteration or addition to any existing building or structure for the purpose of affecting any change in use be prohibited.
- Not discharge any substance or material to the ground in the APOZ unless the discharge is permitted by law.

Stantec also recommends that Albany County add the following provision to Chapter 3, Section 6.D.2 of the Albany County Zoning Resolution to limit the intensity of use of a pre-existing non-conforming use: If the owner/operator of a non-conforming use fails to comply with other local, state or federal requirements for a period of twenty-four consecutive months, all subsequent use shall be brought into compliance with the scope and intensity of the uses for the district in which the use is located.

6.3.2.7 PROPER PLUGGING AND ABANDONMENT OF UNUSED WELLS

Improperly constructed wells with inadequate annular seals and abandoned wells provide a direct conduit to the Casper Aquifer. If a contaminant were introduced into the well or reached the wellhead of an improperly constructed well, it would immediately enter the groundwater system. Both the City and County have adopted regulations within the CAPA to require the plugging and abandonment of such wells per State of Wyoming requirements when identified as no longer being in use. If well construction information indicates a well was improperly or inadequately sealed, the City or County should encourage residents to improve the annular seal.

Stantec recommends that all wells, including but not limited to groundwater pumping wells and monitoring wells, that are no longer in use by the owner be properly plugged and abandoned by a Wyoming licensed water well driller in accordance with Chapter 26, Section 11 of the Wyoming Department of Environmental Quality Rules and Regulations. The City and County should work with local residents to identify orphaned or abandoned wells and identify appropriate funding options to assist in sealing these wells.

6.3.2.8 GROUNDWATER QUALITY MONITORING

Currently, the City of Laramie monitors all municipal production wells on an annual basis for major microorganisms, disinfectants, disinfection byproducts, inorganic chemicals, organic chemicals, and radionuclides as required by EPA. Water-quality results are compared to historical levels. If the results show that concentrations have increased over historical levels, the water is immediately re-sampled. If the second sample again shows higher concentrations, more detailed sampling is undertaken, and a study is initiated to identify the source of contamination. Water levels are measured continuously at all of the municipal production wells and at Spur monitoring wells #7, #8, #10, #11, and #12.

In addition to these wells, the City has identified 10 wells that are included in its current groundwater monitoring network. This monitoring effort has been a significant step in understanding local water quality conditions, particularly related to nitrate concentrations. These wells generally focus on monitoring water level and nitrate concentrations upgradient from of the Spur, Turner, and Soldier Wellfields, and monitoring has been ongoing since 2013. Current and proposed locations for additional monitoring wells are shown on Figure 6-1 and described further below. Aside from the systematic, aquifer wide nitrate monitoring event in 2009, there has not been a systematic, aquifer-wide, long-term groundwater monitoring network established to assess water quality conditions across the CAPA.

As discussed further in this section, there is an important difference between a monitoring well completed for water quality purposes and a groundwater supply well for drinking water. With respect to surface-sourced contaminants, water supply wells are deliberately designed and constructed to avoid the highest concentrations of potential contaminants, which are most likely to occur at or near the water table. Water supply wells used for monitoring purposes may underestimate contaminant concentrations due to how they are constructed relative to where contaminants are most likely to be found within an aquifer. In contrast, properly designed and completed groundwater-quality monitoring wells assess the impact of surface-sourced contaminants.

All of the potential contaminant sources outlined in Chapter 5 may have measurable impacts on water quality but there are not enough data available to assess water quality trends. Groundwater monitoring should be used to establish changes to baseline water quality and to improve understanding of the impacts from existing and future development on the Casper Aquifer. One major concern includes the septic systems associated with several subdivisions in Albany County, particularly those east and southeast of the Turner Wellfield. Wastewater effluent from these subdivisions may have measurable impacts to the community's groundwater supply and a regular monitoring program should be in place for at least nitrates. While septic systems are a concern, all potential contaminant sources should be monitored through the systematic and long-term study of water quality in the Casper Aquifer. The groundwater monitoring network can assess the water quality and quantity near potential contaminant sources.

6.3.2.8.1 Groundwater Monitoring Recommendations

GROUNDWATER MONITORING PROGRAM

Based on the monitoring network that the City has established, Stantec recommends that the City and County develop and maintain a monitoring program to routinely collect groundwater samples and water levels throughout the CAPA. This program should supplement baseline water quality data, and as time progresses, evaluate changes in groundwater quality and water levels over time. The baseline data collected from this program can be used to set standards for quantifying contamination in the Casper Aquifer. A systematic monitoring program has a secondary benefit of increasing understanding of the Casper Aquifer and can be used for education. The City of Laramie should continue to evaluate water-quality at the City wells in the current manner while comparing current results to historical concentrations and initiating additional sampling when results show increased concentrations.

A good monitoring program can provide an 'early warning' to the arrival of contaminated groundwater at a municipal supply well or to domestic wells. The monitoring wells should be located throughout Zones 2 and 3 such that detection would provide enough lead time to either mitigate the in-coming contamination before it can reach a municipal well or to arrange for an alternate drinking water supply or treatment. As shown on Figure 6-1, the locations of the wells should be distributed through the recharge area to assess overall aquifer conditions. Additional wells, particularly domestic wells, could be added to the proposed monitoring well network with landowner consent, but should be carefully selected. New monitoring wells are preferred. Critical to the collection of high-quality, interpretable, water quality data is the careful design and construction of dedicated monitoring wells in specific sandstone layers (members) that are subject, or may be subject, to direct input from upgradient sources of contamination. For instance, an I-80 spill of some LNAPL headed straight for the Soldier No. 1 well could be completely missed if a domestic well screened 100 feet below the water table in a different member of the Casper were used for monitoring purposes.

The groundwater-monitoring program should include periodic monitoring of groundwater for suspected or known contaminants (i.e. nitrate and nitrite from septic systems or petroleum products from vehicles on I-80). Monitoring should include a program for voluntary testing of residential wells, particularly for nitrates within the East Grand area and for hydrocarbons near the Tumbleweed gas station, and creation of permanent monitoring wells within Zones 2 and 3. Incentive plans for residents who allow testing of their well might evoke more interest in such a program.

DESIGN A PLAN FOR GROUNDWATER MONITORING PROGRAM

Stantec recommends that the City and County collaborate to design and implement a plan for a long-term groundwater monitoring network and sampling program. Initiating a long-term, aquifer-wide groundwater monitoring program is a high priority. The City has previously implemented short duration nitrate studies to understand nitrate concentrations across the aquifer and the findings of these studies were used in creating our recommendations in Appendix J. Given the breadth and results of the 2009, 2010, and 2015 studies, Stantec recommends the City and County implement a robust groundwater monitoring program.

The City has established a fund to facilitate construction of monitoring wells and those funds should continue to be used toward implementation of this program. Appendix J includes a description of Stantec's recommended groundwater monitoring program that could in some respects be implemented very quickly. This program builds upon the network that the City has been monitoring but provides additional details regarding the locations of existing wells to include in the network as well as proposed locations for new wells. It also seeks to use information for monitoring wells that already exist within the aquifer that are being monitored by the State of Wyoming and Mountain Cement. The focus of the plan is on understanding long term aquifer trends to facilitate planning and response to aquifer conditions. Current and proposed locations for additional monitoring wells are shown on Figure 6-1.

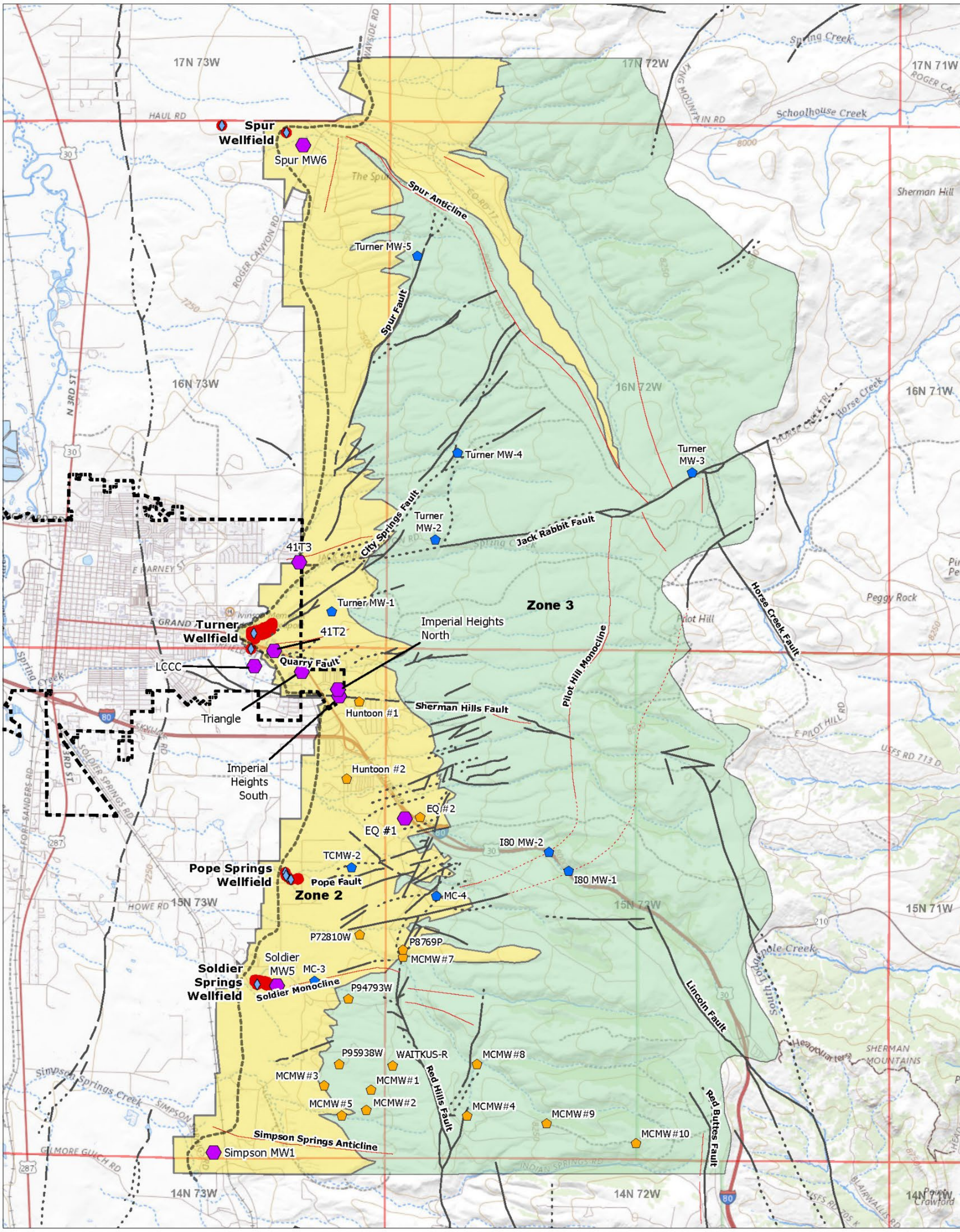
As noted above, the City has established a small monitoring network of 10 wells that have been monitored since approximately 2013. These wells have been monitored for water level and periodically for nitrate. Stantec envisions that this network could be supplemented with both existing and future monitoring wells. The City has also been monitoring one of two monitoring wells that were installed along I-80 in 1995 by the Wyoming Department of Transportation (Wyoming Groundwater LLC, 2017a). The two monitoring wells could be used to monitor for potential groundwater impacts from I-80. One well (EQ#1) was sampled for benzene, toluene, ethylbenzene, xylenes (BTEX) and total petroleum hydrocarbons (TPH) on October 4, 2017. The results of the laboratory analyses show that these compounds were not detected above the reporting limit. As discussed in Section 5.6, Mountain Cement has a groundwater monitoring network of 14 wells for their mining operations at the Etcheparre Quarry and the groundwater quality data are public records that can be obtained through the WDEQ. The mining company is required to submit an Annual Report to the WDEQ/LQD, and the quarterly water quality monitoring results are summarized in that document.

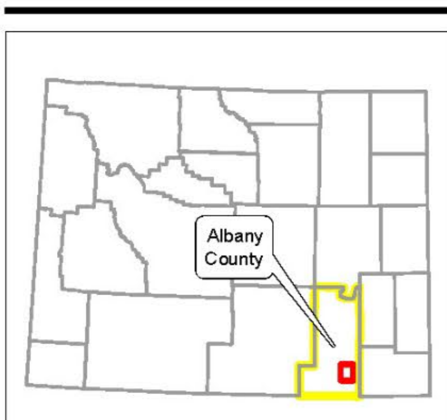
MONITORING WELL COMPLETIONS

There is an important difference between a monitoring well for water quality purposes and a groundwater supply well for drinking water. With respect to surface-sourced contaminants, water supply wells are deliberately designed and constructed in a manner that avoids the highest concentrations of potential contaminants, which are most likely to occur at or near the water table. Water supply wells used for monitoring purposes may underestimate contaminant concentrations due to how they are constructed relative to where contaminants are most likely to be found within an aquifer. For this reason, future monitoring wells need sufficient planning, design, detailed geologic logging, and water sampling so that the wells are designed and completed to assess the contaminant of interest in different areas of the Casper Aquifer, and potentially the overlying Satanka Shale. While groundwater can be obtained from any well, the value of a monitoring well lies in its ability to monitor water quality for the particular analyte in the most effective and efficient manner. Stantec recommends that all future dedicated monitoring wells be designed accordingly.

To achieve that objective, monitoring well design needs to consider the following factors:

- Permanent monitor wells should not provide conduits for surface or near-surface contaminants to migrate into the aquifer along their casings. Complete sealing against the borehole down to the target interval is recommended.
- Permanent monitor wells should not provide opportunities for groundwater migration between water-bearing zones of different water quality. Monitoring well completion should be designed to isolate a single zone within each well, and to seal the well through all other intervals.
- Permanent monitor wells should allow periodic sampling of the discrete water-bearing zones of most importance to the transport of contaminants through the larger aquifer. Well completions need to be targeted at specific sandstone members that are subject to or may be subject to upgradient contaminant sources. For existing contaminants, zones demonstrated to carry the highest contaminant concentrations would be targeted for monitoring.
- Permanent monitor wells should be designed to accommodate seasonal and long-term fluctuations in water levels without going dry. Monitoring well open intervals should extend sufficiently below the current water level to allow for future water-level declines.
- Permanent monitor wells should retain maximum opportunity for further investigation in the future. Recommended completions through the target zones should be “open hole” if possible, to retain direct access to the formation for geophysical tools, downhole video, etc.





Legend

- City of Laramie Municipal Wells

Monitoring Wells

- Proposed (To Be Built)
- Proposed (Existing)
- Existing
- Fold
- Fault
- Municipalities
- Protective Satanka Shale Thickness
- CAPA Zone 1
- CAPA Zone 2
- CAPA Zone 3

Notes
1. Coordinate System: NAD 1983 StatePlane Wyoming East FIPS 4901 Feet
2. Data Sources: USGS, Ver Ploeg and Boyd (2007), City of Laramie
3. Background: USGS 7.5 Minute Quadrangle

0 0.6 1.2 Miles
(At original document size of 11x17)
1:76,032

N

Stantec

Project Location
T16N, R73W
Laramie, Albany Co., WY

Prepared by KAB on 2023-02-15
TR by XXX on 2020-XX-XX
IR by XXX on 2020-XX-XX

Client/Project
227704690
City of Laramie/Albany County
Casper Aquifer Protection Plan Update

Figure No.
6-1

Title
Existing and Proposed Monitoring Well Locations

6.3.2.9 GENERAL EDUCATION AND PLAN IMPLEMENTATION

One of the most effective ways to manage the CAPA is through education of the public, both private citizens and businesses. Educational programs can build support for regulatory or voluntary protection efforts, such as water conservation, household hazardous waste disposal, septic system types and maintenance, and water quality monitoring. Educational tools include press releases, press conferences, newsletters, meetings, workshops, voluntary committee work, class field trip to municipal water and waste treatment facilities, and brochures on water protection and the hazards of abandoned and uncapped wells. The CAPP is a first step in protecting the Casper Aquifer, but in order to be effective, the CAPP has to be understood, appreciated, and implemented. Unless a specific person is appointed to handle this responsibility, the City and County will need to continue to coordinate to implement the CAPP.

6.3.2.9.1 General Education Recommendations

Wittman (2008) recommended that a joint City/County staffer be assigned to implement the CAPP. This person should be responsible for implementing the CAPP and serve as a liaison between the City and County. The assigned City/County staff should report their activities annually to the Laramie Planning Division and Albany County Planning Department. In addition, the EAC should continue to provide guidance, advice, and support to assigned City/County staff as well as receive an annual progress report. Currently, no one person has been assigned to implement the CAPP. The Natural Resources Manager with the City of Laramie and Planning Director with Albany County will continue their collaborative efforts to implement the CAPP.

These assigned City/County staff will be the public contact for information regarding the CAPP and CAPA. The staff will be responsible for providing public education to both adults and children including such topics as water conservation and protection, disposal of hazardous wastes, BMPs, septic system types and management, and general groundwater education. The groundwater monitoring program should be used to educate the public about water quality and water levels in the Casper Aquifer.

6.3.2.10 BEST MANAGEMENT PRACTICES

Residential BMPs are designed to minimize groundwater contamination by reducing the possibility of introducing contaminants into the Casper Aquifer. Appendix G includes BMPs for residential land use.

6.3.2.10.1 BMP Recommendations

The BMP list should be continuously updated and provided to residents and residential developers in the CAPA. It is recommended that the County Planning Department and Laramie Planning Division have additional and more detailed BMP guidelines available for the public to review and for residential developers to incorporate into their design.

6.3.2.11 HOUSEHOLD HAZARDOUS WASTES

Currently the City of Laramie and Albany County work together to provide recycling and disposal services for household hazardous wastes. In the past, volunteer organizations have hosted bi-annual collections but found it difficult to consistently operate. Therefore, the Solid Waste Division (SWD) has taken over this task and hosts collection days in the spring and fall. The SWD maintains information on disposal and recycling on their website and through their office.

6.3.2.11.1 Household Hazardous Waste Recommendations

The City and County should continue to work together and provide recycling and disposal of household hazardous wastes through the SWD. These collection days should be advertised in the Laramie Boomerang, on the City and County websites, and through general education opportunities. The SWD should pursue funding to allow them to recycle pesticides and herbicides in addition to paints and batteries.

As previously stated, the City of Laramie currently accepts household hazardous waste at the landfill by appointment only. The appointment only requirement should be eliminated, and residents should be able to drop off wastes without the need for an appointment. The facility should also be open on weekends when most people would be interested in dropping off household hazardous waste. Restricted times or appointment only drop offs will only encourage illegal dumping.

6.3.3 SPECIFIC CONTAMINANT SOURCE MANAGEMENT

6.3.3.1 SEPTIC SYSTEMS

Albany County continues to work under a delegation agreement with the WDEQ to regulate small wastewater systems within the County. The County has established a permitting process for septic systems and issued the specifications, Albany County Design and Construction Standards for Small Wastewater Facilities and Regulations for Permit to Construct, Install or Modify Small Wastewater Facilities. In addition to these design standards, Albany County has proposed to require that all new and replacement septic systems located within Zone 2 of the Casper Aquifer APOZ meet the WDEQ standards for septic systems that discharge to the same aquifer that supplies a public water supply well. As part of the permitting process, the septic system design and site plan are submitted for review by the Albany County Wastewater Engineer. Permitted septic systems in Albany County are then added to a GIS database denoting their location and associated permits. The GIS database should continue to be used as a comprehensive planning tool.

The following sections present current local and state regulations, wastewater discharge/treatment alternatives that have been considered, advanced treatment units, septic system enforcement in other jurisdictions, and Stantec recommendations for wastewater systems.

6.3.3.1.1 Current Regulations

In Albany County currently, no established criteria trigger the requirement for advanced treatment systems. For property owners installing new or replacement systems within Zone 2 of the Casper Aquifer APOZ, the septic system design must be completed by a Wyoming licensed Professional Engineer (PE) and meet WDEQ Chapter 25 standards for septic systems which require additional treatment. Albany County is familiar with advanced treatment systems that remove additional nitrogen, such as the “Advantex” sewage treatment system, which has been installed in the county where additional treatment has been needed. In the event a new or replacement septic system requires an advanced treatment system, the Albany County Water and Wastewater Engineer is to be notified. The majority of the CAPA is outside of Laramie City limits, so currently all rural homeowners within the CAPA use an on-site small wastewater system. Management of septic systems is a high priority because 1) subdivisions within Zones 2 and 3 have systems that are over 40 years old which generally exceeds the average lifespan of a septic system, 2) new subdivisions would be located upgradient from Laramie's wellfields, and 3) residential wells are susceptible to contamination from septic systems due to proximity.

Wyoming DEQ requirements for septic systems that discharge to the same aquifer that supplies a public water supply well are stringent but are not easily enforceable or measurable. WDEQ requires any system that disposes wastewater through land application or subsurface filtration will not impact an underground source of water for existing uses such as domestic use (WDEQ, 2014). In Section 7, Table 4 of Chapter 25 of the WDEQ Water Quality Rules and Regulations, small wastewater systems that discharge into the same aquifer that supplies a public water supply well and are located within Zone 1 or 2 (attenuation) of a public water supply are required to provide additional treatment. This additional treatment requires systems to be designed to reduce nitrates to less than 10 mg/L of NO_3- as N and provide a 4-log removal of pathogens before the discharge leaves the property boundary of each small wastewater system. Though these requirements will protect aquifer water quality, conventional septic systems are typically not capable of reducing nitrates to less than 10 mg/L of NO_3- as N even at the leach field. In the Albany County area, Wenck (2019) reported that a properly functioning conventional septic system and leach field removed around 39% of nitrate as mentioned in Section 5.4.4 of this plan. This reduction is not sufficient to reduce nitrate concentrations to less than 10 mg/L of NO_3- as N either below the leach field or at the property boundary.

According to the Chapter 25 Rule Making, Responses to Public Comments for WWAB meeting on June 14, 2013, the advanced treatment definition was deleted from Chapter 25 of the Wyoming Water Quality Rules and Standards. Currently, there is no guidance from WDEQ on the implementation of advanced treatment systems other than that the design has to be designed and reviewed by a licensed Wyoming Professional Engineer.

6.3.3.1.2 East Laramie Wastewater Feasibility Alternatives

Wittman (2008) recommended that the City of Laramie and Albany County work cooperatively to develop an East Laramie/Albany Wastewater Feasibility Study in an effort to assess groundwater quality impacts from residential septic systems. WWC completed the study and provided several mitigation options including improvements to the existing septic systems, installing individual holding tanks for the septic systems, a decentralized wastewater treatment system, and sewage collection and treatment by the City (WWC, 2013).

The following sections present the alternatives considered along with their feasibility and associated costs.

IMPROVING EXISTING SEPTIC SYSTEMS

WWC evaluated four mitigation options under this category, including:

- the use of septic system additives
- frequent septic system pumping

- aeration system retrofits
- drain field replacements.

WWC indicated that none of the above improvements would enhance nitrogen removal or reduce risk, and as such they did not prepare any conceptual designs or make recommendations to improve the existing surveyed systems.

HOLDING TANKS

WWC believed that converting existing septic system to holding tanks that would include sensors that would allow the owner to know when pumping was needed would reduce nitrate loading to the Casper Aquifer. Although converting to holding tanks was a viable mitigation option at a cost of $2,000,000.00, the long-term costs (30 years) for regular holding tank pumping could exceed $300,000,000.00 (2013 dollars) for all 350 septic systems in service at that time.

DECENTRALIZED WASTEWATER TREATMENT SYSTEM

WWC described a decentralized wastewater treatment system in its recommendations. Specifically, they addressed an Orenco brand Advantex system. The system makes use of septic tanks at homes to pre-treat domestic wastewater, by settling solids. The septic tank effluent is then pumped to a central location for secondary treatment. WWC believed that effluent pumping was a more cost-effective way than gravity sewers to collect wastewater at a central location. Secondary treatment, in the case of the Advantex system evaluated for this study, would be achieved via a recirculating media filter. A recirculating media filter was described as conceptually similar to a recirculating sand filter. In the case of Advantex, the media was a synthetic fabric, upon which biological growth would be maintained. It is the biological activity in the mat that treats wastewater. This biological activity is associated with nitrification. The system includes modular, pre-manufactured recirculating fabric media pods. Disposal of the treated liquid could possibly be to the surface or underground; onsite or at a remote location where denitrification can occur. WWC envisioned that a local sewer district or other legal entity would need to be setup.

The treated effluent could possibly be disposed of in several ways, each having different permitting requirements, including (1) by underground disposal (UIC permit), (2) surface discharge (WYPDES) or (3) to the City of Laramie water treatment system. At the time, WWC did not know if this option would be viable. The planning level total project cost for this option was $13,000,000.00 (2013 dollars).

SEWAGE COLLECTION AND TREATMENT BY CITY

Under this scenario, a new sewage system would be developed to convey flows from the east Laramie rural septic system users to the existing Laramie wastewater treatment plant (WWTP). WWC assumed 350 homes would be connected to the City’s system assuming an average sewer flow of 86,254 gpd, and a peak sewer flow of 198,384 gpd. The total planning level cost estimate for this option was approximately $22,750,000.00, which did not include any upgrades to the WWTP.

WWC also provided recommendations for funding options for the last two options. WWC did not believe the holding tank option was viable given the long-term operating costs. All of the three options would reduce the nitrate loading to the Casper Aquifer, but funding, policy issues and other unknown factors could limit the viability.

6.3.3.1.3 CENTRALIZED WASTEWATER TREATMENT SYSTEMS

A centralized wastewater treatment system involves shared infrastructure including a sewage collection system serving multiple developments at a time and a wastewater treatment facility. The wastewater treatment facility is sized for the system and can be designed to target contaminants of concerns such as nitrates to reduce contaminant levels to a safe level to be discharged into the environment. Centralized wastewater treatment can be achieved either utilizing existing infrastructure such as the sewer system serving the City of Laramie or in the formation of local sewer districts. The City of Laramie Sewer Master Plan will be a good resource in determining the viability of a new or existing development connecting to the city sewer system. Sewer districts can range in sizes from serving a single subdivision to a large area comprised of multiple subdivisions and developments depending on the agreed upon district boundaries. Centralized wastewater treatment systems have the added benefit of qualifying for several existing public funding programs such as the Wyoming State Revolving Fund.

6.3.3.1.4 Advanced Treatment Units

Advanced treatment units refer to septic systems for residential use that have additional technology to treat wastewater to a higher degree than a conventional septic system. To address the high levels of nitrate in the Casper Aquifer associated with rural subdivisions within Zone 2 of the APOZ, advanced treatment units will be needed to meet current regulatory standards and protect aquifer water quality. Advanced treatment units promote the biological process of nitrification within the septic system as opposed to conventional septic systems which rely on these reactions to occur naturally in the leach field and soil alone. In Section 5.4.4 of this Plan, the Septic System Impact Assessment showed that a functioning conventional septic system and leach field only removed around 39% of nitrate that percolated through the vadose zone. Without the use of advanced treatment units that include denitrification, achieving less than 10 mg/L-N of nitrate at the property boundary would not be typically possible.

Advanced treatment units employ several technologies used in nitrogen removal, including but not limited to, aeration chambers and media filters. These units not only address nitrates, but also allow for additional removal of BOD and TSS resulting in a cleaner effluent compared to conventional septic systems. For purposes of the CAPP, the Total Nitrogen removal performance percentage for Advanced treatment units is recommended to be a minimum of 60% removal at the septic system effluent after a review of current technologies available and Wenck’s (2019) septic system impact study. The percent reduction applies to the effluent upon discharge to the leachfield. Alternatively, advanced treatment units could be considered systems that are capable of reducing septic system effluent Total Nitrogen concentrations to less than 25 mg/L. The State of Maryland (2021) compiled testing results of multiple advanced treatment unit models based on their mean total nitrogen reduction, and their cost of purchase, installation, and 2 years of operations and maintenance. Table 6-3 includes information on some of their vetted models, costs, and nitrogen reduction test results along with their availability in Wyoming as of July 2022. As seen in the table, advance treatment systems provide a larger reduction in Total Nitrogen.

Table 6-3. Estimated Cost and Availability of Several Advanced Treatment Units

Model	Estimated Average Maryland Purchase, Installation, and Maintenance Cost (2 years)	Total Nitrogen Reduction %	Estimated Wyoming Purchase, Installation, and Maintenance Cost (2 years)	Estimated Delivery Time (July, 2022)
Fuji Clean CEN5	$12,244	77	Not Available	Not Available
Fuji Clean CEN7	$16,140	77	Not Available	Not Available
Hydro Action AN series	$15,104	66	$28,308	One Month
Septitech M400D	$17,794	67	$32,247	Available off the shelf currently
AdvanTex AX20RT	$21,130	76	$24,393	3-4 Months

The complete results of the Maryland treatment unit study are included in the documentation included in Appendix I along other pertinent information related to the drivers and incentives to reduce nitrogen in source water including advanced treatment unit operational concepts. Currently, these advanced treatment unit products are available for installation and use in Wyoming. The list in Table 6-3 is not exhaustive and does not include all models available for purchase and installation in Wyoming. To streamline the conventional septic system design and approval process, WDEQ publishes a list of approved septic tank models that could be used in an Onsite Wastewater Treatment System. Septic tank models and systems were selected from their proven past applications in Wyoming. No advanced treatment units are currently on WDEQ's approved list. However, the same approach used for conventional septic tank models could be applied to the advanced treatment units if WDEQ is amenable to the process. Advanced treatment system providers should be encouraged to submit a permit application for the review of their product's performance in Wyoming or in environments similar to Wyoming's climate and soil characteristics.

The implementation of an advanced treatment unit is similar to a conventional system. The already established site suitability study requirement under Chapter 25 of the WDEQ Septic Tanks, Soil Absorption Systems, and Other Small Wastewater Systems guidance is suitable for advanced treatment units. The site selected for the septic system and soil absorption system must be in an area where the effective soil depth is at least 4 feet below the bottom of the soil absorption system and away from fractured rock or highly permeable material. Slope and percolation rates for the absorption system/ leach field will be evaluated the same way. Soil testing should also be considered to determine the nitrogen natural attenuation potential of the soil. Ideally, the soil should be high in carbon and moisture to house bacteria that can further transform nitrate into nitrogen gas through nitrification and denitrification. WDEQ prefers to allow soil loading reductions to be evaluated within the permit applications through variance request with supporting documentation.

It should be noted that though advanced treatment units do have additional processes that increase treatment efficiencies and remove nutrients, these units may not completely eliminate contaminants from discharged effluent that reaches the Casper Aquifer.

6.3.3.1.5 Septic System Enforcement in Other Jurisdictions

Surrounding states have implemented guidance and regulations for on-site wastewater treatment systems to specifically protect groundwater from nitrate contamination. The following section briefly explains how the states of Idaho and Montana administer their programs to require additional treatment to protect aquifers. Common methods include establishing criteria to define areas vulnerable to nitrogen contamination and treatment standards, criteria for septic system site selection, treatment requirements for Total Nitrogen in the effluent of the septic system, and a list of vetted/pre-approved treatment technologies that can meet the treatment requirements.

STATE OF IDAHO

The State of Idaho lays out guidance for septic systems under the State of Idaho Department of Environmental Quality – Technical Guidance for Individual and Subsurface Sewage Disposal Systems (Sept 2022). The Idaho Department of Environmental Quality (IDEQ) reviews subsurface sewage disposal methodologies and products, operation and maintenance entities; and provides continuing education and technical support, design guidance, site inspection requirements, system review, approval of on-site wastewater systems, and operating compliance requirements.

The State of Idaho has identified nitrate to be the limiting factor in determining on-site wastewater system design and placement because it is the most mobile constituent of concern in domestic wastewater. IDEQ lists On-site wastewater systems approved for total nitrogen reduction for Nitrate Priority areas which are vulnerable to nitrate contamination. These on-site wastewater systems are categorized as Extended Treatment Package Systems which are exactly the same categorization as Advanced Treatment Units which utilize additional treatment technologies to achieve enhanced treatment after primary clarification occurs in an appropriately sized septic tank. IDEQ regularly updates their list of approved wastewater treatment technologies with treatment limits, designer requirements, O&M requirements, drain field guidance including soil and groundwater separation requirements, and other design guidance on their Technical Guidance Manual. Table 6-4 shows approved products for nitrogen reduction and their projected treatment efficiencies.

Table 6-4: Excerpt from IDEQ Guidance for On-site Wastewater Systems approved for total nitrogen reduction.

System or Manufacturer Product and Model	Total Nitrogen Reduction from influent to effluent [a] (%)	Avg. Total Nitrogen concentration of effluent [a] (mg/L)	Minimum Source Water Alkalinity[b] (mg/L)
Public Domain Systems			
Intermittent Sand Filters (ISF)	15[c]	38	108
Recirculating Gravel Filters (RGF)	40[c]	27	189
Extended Treatment Package Systems			
AquaKlear (245-series)	59[e]	20	216
Cons. Treat. Syst. (Nayadic) M	30	32	156
Jet Inc. J-500	32[d]	31	163
SeptiTech STAAR	55[e,f]	20	100
Orenco–AdvanTex	65[e,f]	16	269
BioMicrobics RetroFAST	65[f]	16	110
BioMicrobics MicroFAST	65[f]	16	110
BioMicrobics BioBarrier MBR	79[f]	9	100
Norweco–Singulair 960 series	65[d]	16	269
Norweco–Singulair TNT	65[d]	16	269

a. Quantifiable values (milligram per liter [mg/L]) will indicate compliance with the qualitative total nitrogen reduction limit expressed as a percentage (%) reduction.
b. Minimum recommended source water alkalinity to support nitrification in the denitrification process. Use of water softeners is not recommended due to potentially detrimental effects on the biological processes.
c. Literature value
d. Idaho testing
e. Third-party data
f. National Science Foundation data

Manufacturers seeking approval to be put on the list of approved systems must submit NSF Standard 245 approvals, reports, and associated data or equivalent third-party standards which prove the product can meet at least 50% reduction for Total Nitrogen. All submissions for septic system permits will still be submitted to DEQ review and require signature by a PE licensed in the State. Treatment systems installed are expected to be capable of reducing Total Nitrogen to at least 27 mg/L measured at the effluent discharge to the drain field. A greater total nitrogen reduction level may be required depending on the outcome of the Nutrient-Pathogen (NP) evaluation. NP evaluations are designed to determine the appropriate number of on-site wastewater treatment systems on a given parcel of land and guide the placement and level of treatment required that will not significantly degrade the quality of local water resources. NP evaluations are required for areas identified in the Wetland and Waterways Overlays, or where there is evidence of groundwater within 10 feet of the ground surface at some time of the year, evidence of soil depth to fractured bedrock is 10 feet or less on the parcel, the proposed development includes food service, commercial, or industry facility, or the proposed development is within an area identified where the groundwater nitrate as N concentration is 5 mg/L or higher.

In order to be approved, the NP evaluation must demonstrate the proposed on-site wastewater treatment system(s) will not significantly impact groundwater or surface water quality beyond an increase of 1.0 mg/L of nitrate or less above existing background levels. Additional information on how IDEQ administers their on-site wastewater program can be found in Appendix I and the State of Idaho Department of Environmental Quality: Technical Guidance for Individual and Subsurface Sewage Disposal Systems (Sept 2022).

STATE OF MONTANA

The State of Montana provides regulations and guidance through the *Circular DEQ 4, Montana Department of Environmental Quality (MDEQ), 2013*. MDEQ prohibits degradation of high-quality state waters, outlining procedures for: determining which activities will degrade high quality waters; department review and decision making; determining the required water quality protection practices if degradation is authorized; and public review and appeal of department decisions.

The determination of the most appropriate water quality protection practices including type of septic system depends on the result of the site evaluation which includes the following elements.

A. Soil profile

B. Soil permeability

C. Depth to groundwater, bedrock, or other limiting layer

D. Land slope and topographic position

E. Flooding potential

F. Amount of suitable area available

G. Setback distances

MDEQ lists specific treatment requirements for areas deemed vulnerable to nitrogen pollution. Criteria that cause nonsignificant changes in water quality related to nitrogen pollution, including groundwater in the uppermost aquifer underlying the petition area, must demonstrate that one of the following conditions is met:

A. Predicted concentrations of Nitrate at the boundary of any applicable mixing zone shall not exceed the following limits. A standard mixing zone is where discharge to groundwater occurs from infiltration, drain fields, injections, leakage, or seepage from land application.

    i. 7.5 mg/L nitrates for sources other than domestic sewage

    ii. 5.0 mg/L nitrates for domestic sewage discharged from a conventional septic system

    iii. 7.5 mg/L for domestic sewage discharged from a septic system using level two treatment

    iv. 7.5 mg/L nitrate for domestic sewage discharged from conventional septic system where nitrate levels exceeds 5.0 mg/L primarily from sources other than human wastes.

B. Data from groundwater samples collected at least three years apart from the same 15 wells indicate a statistically significant increase of no greater than 1.0 mg/L in nitrate as nitrogen concentrations in the uppermost aquifer.

C. Within 90 days after receipt of the information required in B (above), the department shall issue a preliminary decision as to whether the petitioner has satisfied the requirements in B (above), and describe the reasons for either granting or denying the petition. The preliminary decision must be mailed to the petitioner and to all landowners or persons with a contract interest in land within the petition area and must include:

   i. A description of the petition area

   ii. A summary of the basis for the preliminary decision including any modifications to the boundaries of the petition area

   iii. A description of the procedures for public participation of the opportunity to comment prior to the department's final decision on the petition

   iv. The ending dates of the comment period and the address where comments will be received

   v. Procedures for requesting a hearing

   vi. The name and telephone number of a person to contact for additional information

If the site of development is not able to meet the requirements above, then the site is deemed to be an area vulnerable to nitrogen pollution and on-site wastewater treatment systems must meet the following treatment requirements:

Table 6-5: MDEQ Nitrogen Reducing Subsurface Wastewater Treatment System Requirements.

Treatment Level	Treatment Requirements
Level 1a	At least 50 % nitrogen removal or Less than 30 mg/L Total Nitrogen effluent concentration
Level 1b	At least 50 % nitrogen removal or Less than 40 mg/L Total Nitrogen effluent concentration
Level 2	At least 60 % nitrogen removal or Less than 24 mg/L Total Nitrogen effluent concentration

Source: Rules of Montana (ARM) 17.30.702(9)(10) and (11)

Similar to IDEQ, MDEQ reviews subsurface sewage disposal methodologies and products, operation and maintenance entities; and provides design guidance, site inspection requirements, system review, approval of on-site wastewater systems, and operating compliance requirements. Minimum standards and lists of approved advanced wastewater treatment technologies and their design criteria can be found under Circular DEQ-4 Montana Standards for Subsurface Wastewater Treatment Systems. MDEQ also has a list of technologies and models which meet treatment levels in the above table. Additional references on on-site wastewater treatment systems from Montana can be found in Appendix I.

The installation cost difference of different on-site wastewater systems compared to conventional septic systems can be found in Table 6-6 provided from the Montana On-Site Wastewater Treatment System State regulations. It should be noted the installation costs listed in Table 6-6 are from 2006.

Table 6-6: Typical Installation Costs of Onsite Systems Compared to Conventional Septic.

Type of Onsite System	Installation Cost	% Cost Increase from Conventional Treatment
Conventional Septic Tank	$2,000-$6,000 ($4,000 average)	--
Absorption Trenches	$4,000-$7,000	38%
Elevated/Mound Systems	$7,000-$12,000	138%
Intermittent sand/media filters	$5,000-$10,000	88%
Recirculating sand/media filters	$8,000-$11,000	138%
Aerobic Treatment Units	$3,000-$6,000	13%
Constructed Wetlands	$10,000-$20,000	275%

Source: Montana On-Site Wastewater Treatment Systems State Regulations, 2019

6.3.3.1.6 Septic System Recommendations Within the APO/APOZ

Given the results of the investigations completed since the last CAPP update, current and recently proposed regulations regarding development and septic systems within the CAPA strongly favor aquifer protection. The Albany County Zoning Resolution has placed additional requirements on the use of septic systems within the CAPA compared to what is required elsewhere in the county. These requirements are presented in Chapter 3, Section 3.D of the resolution and a few highlights include the following:

1. Design by a Wyoming licensed professional engineer and inspection by the Albany County wastewater engineer before backfilling.
2. Setbacks of 100 feet from vulnerable features in the Casper Formation that are identified at the property.
3. A lot size of 35 acres with one dwelling on for all new subdivisions within the APOZ.

Stantec presents the following recommendations for consideration:

1. The City should update its Sewer Master Plan to address increasing sewer capacity east of Laramie as needed.

   a. Identify areas where connection to existing sewer system in Laramie is possible and evaluate feasibility (engineering, cost, impact to aquifer, etc.) of possible extensions related to the objectives of the Casper Aquifer Protection Plan Update

2. The City and County should include the formation of sewer districts as a viable wastewater management option for residential wastewater.

3. The City and County should work together to determine incentives, grants, and other financial opportunities for areas where existing on-site septic systems will eventually need to be replaced with advanced treatment units.

   a. The City and County should consider prioritizing replacement of conventional septic systems in high priority areas based on septic system density and evidence of groundwater impacts as funding mechanisms, available funds, and landowner willingness allow.

4. The County should adopt a 35 acre minimum lot size across the CAPA. Any additional development of the CAPA on the basis of either 2 or 5 acre residential lots using conventional septic systems enhances the potential for further contamination of the Casper Aquifer.

5. The County should require the use of advanced treatment units for new septic systems and for replacement septic systems which are failing or have failed within any portion of the CAPA where the lot size is less than 35 acres. Using this approach will continue to protect the Casper Aquifer and allow for additional low density residential development within the area.

   a. Failing or failed systems that need to be replaced can be characterized by, but not necessarily limited to: 1) damage to the septic tank resulting in leakage, 2) failure of individual system components such as infiltrators, baffles, pumps, level sensors, and damage to piping, and 3) soggy spots or standing water indicating clogging of the leach field. Any incidence of a septic system or any of its components exhibiting signs of failure or impending failure are to be reported by the septage pumper/hauler to the Albany County Wastewater Engineer on a form provided by that office and copied to the Albany County Planning Office.

   b. If an evaluation of a failing system suggests a repair, the repair must meet current code requirements and the repair plan is to be reviewed by the permitting authority before any work can proceed.

   c. If the system and/or its components are deemed by the permitting authority to not be repairable, then the system must be replaced with an advanced treatment unit.

6. Further study of the efficacy of advanced treatment units in the CAPA may find that lot sizes of less than 35 acres can be accommodated within acceptable water quality impacts. The study should investigate applications in Wyoming or similar environments including but not limited to soil carbon content, dissolved oxygen, and moisture investigations and applicability to household wastewater strengths generated in a Wyoming household.

7. The County should require that advanced treatment units be considered systems that are capable of reducing septic system effluent Total Nitrogen concentrations to less than 25 mg/L or remove a minimum of 60% of Total Nitrogen as measured at the discharge point to the leachfield.

    a. Additional studies are recommended to determine levels of Total Nitrogen which can be safely discharged from on-site wastewater systems, such as septic systems, without significantly degrading aquifer water quality. The development should not cause concentrations of Total Nitrogen to increase above concentrations prior to the development. This study should be done by a qualified professional who has a background in geology, hydrogeology, soil science, geochemistry, or related engineering disciplines.

    b. Treatment technologies should be piloted, reviewed, and have their results posted to help homeowners find systems that will meet the treatment standard.

8. The County should modify its design and construction standards for small wastewater facilities to include regulations and guidance for advanced treatment units within the CAPA.

9. The County should require inspections once every five years in addition to when a property is transferred to ensure that baffles within the septic tank are operating correctly, that no leaks are occurring, and to check the levels of sludge and scum in the tank. An inspection when the property is transferred could be waived at the County's determination if the seller can provide documentation of inspections within the last three years and pumping of the septic tank.

10. The County should require pumping of septic systems not less than once every five years and maintained on a regular schedule set by a County licensed septage hauler. If upon inspection by licensed pumper/hauler there is no significant solids accumulation, pumping can be deferred one year. The owner will need to provide proof that the sludge level in the septic tank is no more than two-thirds full to qualify for deferment of pumping.

6.3.3.2 INTERSTATE 80 (I-80)

Transport of hazardous materials along I-80 has historically been categorized as a threat with a high likelihood and great potential severity of damage to the Casper Aquifer. I-80, from milepost 323 to 317, cuts through the Casper Aquifer exposing the aquifer to contamination from spills. This section addresses potential management strategies related to the interstate.

6.3.3.2.1 Interstate 80 Recommendations

PRE-INCIDENT EMERGENCY RESPONSE STRATEGIES

Since hazardous material spills along I-80 are a potential risk to the aquifer, the City/County should continue to take steps to reduce the likelihood and risk of this threat. It should be noted that no large hazardous materials spill (i.e. fuel release) has occurred on I-80. It is Stantec's opinion that an accident/fuel release in the upper Telephone Canyon would most likely not affect any of the City's wells. However, the City of Laramie, Albany County, and WYDOT should be prepared to respond quickly and appropriately to a hazardous material spill to prevent contaminants from reaching the aquifer. Having appropriate contacts and contracts in place to facilitate spill mitigation is recommended. In order to prepare for such an incident, training of emergency response personnel and a test of the emergency response system should be conducted annually. It is recommended that Albany County Emergency Response Coordinator be involved in the CAPP process. Reliable contracts to quickly obtain vac-truck services, booms, other spill response supplies may be the most important pre-incident response strategy. The EPA provides some tabletop training modules via their website and these could be used by local personnel. Additionally, the emergency response personnel may find it helpful to contact WDEQ or EPA Region 8 to assist in training exercises.

POST-INCIDENT EMERGENCY RESPONSE STRATEGIES

The City planned to issue a Request for Qualifications to prepare a hazardous spill response plan. For now and until this response plan is prepared and adopted, the Wyoming Highway Patrol should notify the Laramie / Albany County Records and Communications (LARC) Center, which would in turn notify the Laramie Fire Department, Albany County Sheriff’s Office, and Public Works Department that a spill has occurred. The LARC Center is the division of the Laramie Police Department that provides emergency 9-1-1 dispatching and consolidated records services for all Albany County residents. The initial response strategies may include:

- Responding agencies appraise extent and severity of spill and begin/coordinate the initial containment/mitigation efforts.
- Responding agencies notify Albany County Emergency Coordinator who may initiate use of the CAPP Contingency Plan.
- Public Works Department will begin testing the monitoring wells along the I-80 corridor.
- WDEQ will be notified and requested to provide additional spill mitigation assistance, as needed.

6.3.3.3 ROAD CHEMICAL APPLICATION

WYDOT uses several mixtures on Wyoming roads–both before and after snowstorms – such as salt sand, salt brine, magnesium chloride and ice slicer (a complex chloride, mostly sodium chloride). These chemicals may enter the groundwater after deicing materials are used on I-80 and other transportation corridors in the CAPA. However, because numerous hazardous materials are transported along I-80 and these materials pose a greater risk to the Casper Aquifer than high salinity, there must be a balance between safety for drivers and the increased risks of accidents compared to the water-quality risk from road salts.

6.3.3.3.1 Road Chemical Application Recommendations

MONITORING

Monitoring should include sampling for chloride and electrical conductivity at all monitoring wells along I-80. Due to the high volume of traffic along this corridor, it is not feasible to eliminate deicing materials, and therefore, monitoring is the best management strategy.

6.3.3.4 SPRINGS

Springs have been identified throughout the CAPA and provide a direct pathway from the ground surface to the Casper Aquifer. Most prominent are the historic springs located adjacent to the City's water supply wells. The historic springs, made up of City Springs, Pope Springs, and Soldier Springs, flow periodically and springflow is subject to capture when the municipal wells are pumping and lower water levels at the springs. This makes the historic springs a direct conduit to groundwater and the City of Laramie's drinking water (WWC, 2006).

City of Laramie water utility staff takes the potential for reverse surface flow or springflow capture very seriously. When a well is started near City, Pope, or Soldier Springs, surface flow in the area is monitored very closely. For example, the artesian flow at City Springs is reduced slowly to allow the surface water discharged from the spring to drain away from the area through the Spring Creek channel. Pump run times are managed to maintain separation in time and distance from the pump intake and the surface water as it is allowed to drain away down Spring Creek (Lytle, 2022).

Other ephemeral springs have been identified in upland areas. Ephemeral springs, particularly when not flowing, provide a direct conduit to the Casper Aquifer. A spring in Telephone Canyon along I-80 is especially significant because it presents a direct pathway to the Casper Aquifer from hazardous material spills on I-80. Hinckley Consulting has been observing the surface water conditions in the Telephone Canyon 1-80 right-of-way since 2015 and provided their observations in a memorandum (Hinckley, 2022). Hinckley reported one generally perennial spring, Telephone Spring, at MP 321.5, a major intermittent spring at MP 321.6, a minor intermittent spring at MP 323.1, and scattered minor intermittent seeps from roadcuts where downward infiltrating water locally encounters low-permeability strata in the formation.

All springs, flowing or not, put the aquifer at some degree of risk because springs by definition are where the aquifer meets the land surface. Springs are groundwater discharge points; the flow of water is up and out. Because springs discharge water there is some hydraulic protection from light non-aqueous phase liquids (LNAPL). LNAPLs are liquids that are sparingly soluble in water and less dense than water. For example, oil, gasoline, and/or diesel fuel are LNAPLs because they "float" on top of water and do not mix with water. However, if a dense non-aqueous phase liquid (DNAPL) were introduced at a spring or anywhere else, the DNAPL may contaminate the Casper Aquifer. DNAPLs are liquids that are denser than water and do not dissolve or mix easily in water. Many chlorinated solvents, such as trichloroethylene, are DNAPLs. Because the DNAPL is denser than water, it may enter the aquifer and be transmitted along the same pathways as water.

6.3.3.4.1 Springs Recommendations

EDUCATION

Public education will increase awareness of how springs may provide a potential pathway for migration of contaminants from a surface source to the Casper Aquifer. Springs located in undeveloped upland areas, away from contaminant sources, present less of a vulnerability. Through education, the City and County should work to ensure that land use practices in the vicinity of springs, particularly those near the City wellfields, are protective of the aquifer.

LAND PURCHASES AND REGULATIONS

The historic springs adjacent to the City's municipal supply wells fall within the Zone 1 delineation. Stantec recommends the City purchase land within Zone 1 where they do not currently own the property. Whenever possible, the City should also purchase land adjacent to Zone 1 at the Turner wellfield. Direct hydrologic communication between the Turner wells and City Springs necessitates strong protection of these springs. Furthermore, Stantec recommends that all Casper Aquifer springs within the CAPA be identified as vulnerable features to establish appropriate setbacks.

6.3.3.5 WELLS

A well completed in the Casper Aquifer could provide a direct conduit for the introduction of contaminants into the aquifer. Wells, whether for public water supply, stock watering, irrigation or domestic use, must comply with the well construction standards from the Wyoming State Engineer's Office (SEO) or the WDEQ. The SEO provides well design requirements in their Regulations and Instructions, Part III, Water Well Minimum Construction Standards. The WDEQ does not regulate the construction of domestic wells, but Chapter 26, and Chapter 12, Section 9 of Wyoming Water Quality Rules and Regulations apply to the construction of public drinking water supply wells. Properly installed wells permitted by the SEO and installed by Wyoming licensed water well drillers are a lower potential threat to the aquifer than orphaned or abandoned wells, uncapped or improperly constructed wells, etc.

Not all wells are equal threats to aquifer protection, but all wells must be properly cared for to minimize the potential for aquifer contamination. Contaminants can enter the aquifer directly through the well if the wellhead is not capped and sealed, and through cracks or openings along the well casing if the well has a poor or no annular seal. Contaminants may also reach the wells through the aquifer due to vertical fractures in the sandstone and limestone that allow contaminants to migrate away from their sources, or by conveyance along an impermeable limestone bed to nearby, downdip wells.

6.3.3.5.1 Wells Recommendations

EDUCATION

Education will increase awareness of how private wells may be a pathway for contaminants. Of particular importance is that wells should be properly capped (i.e. locked or bolted closed) to prevent unauthorized direct access to the interior of the well, and properly sealed when constructed to minimize the potential for contamination from the land surface. Both the City and County have prohibited water wells that are not capped or are poorly constructed. Information in the form of a brochure should be prepared and distributed to inform residents of the importance of properly capping, constructing, and abandoning wells. Additional information can be obtained from the University of Wyoming Extension's *Barnyards and Backyards* at the following link: http://www.uwyo.edu/barnbackyard/_files/documents/magazine/2018/fall/0918domesticwell.pdf. The County and City should use similar techniques to educate the owners of the existing wells in the area about proper well maintenance and require proper well abandonment when a well is no longer needed. Through education, the City and County should work to ensure that all non-municipal water wells constructed in the CAPA are capped and completed with a surface seal.

6.3.3.6 ABANDONED WELLS

Proper abandonment of wells is imperative in protecting the Casper Aquifer. Improperly abandoned wells are particularly hazardous because the well is a conduit that leads directly from the ground surface into the groundwater. The locations of improperly abandoned wells are often unknown making accidental introduction of contaminants more likely. Both the City and County require that abandoned or unused wells be properly plugged and abandoned.

6.3.3.6.1 Abandoned Wells Recommendations

PUBLIC EDUCATION

Assigned City/County staff should contact owners of improperly abandoned wells when they become aware of them. The landowner should first be advised of the hazards posed by an improperly abandoned well and instructed on the proper methods of plugging a well. The WDEQ and the SEO should also be advised of the presence of an abandoned well for the enforcement of existing regulations.

Information in the form of a brochure should explain that abandoned and improperly constructed wells may serve as a conduit for surface contamination to reach groundwater. The brochure should provide information on how to properly plug and abandon a well.

6.3.3.7 UNDERGROUND INJECTION CONTROL (UIC) WELLS

Classes I, II, III, IV, V, and VI UIC wells as defined in WDEQ Chapter 27 would cause groundwater or aquifer degradation due to their inherent use. However, some types of UIC wells are beneficial. WDEQ Chapter 27 lists beneficial uses as Class V subclasses 5B2, 5B3, 5B4, 5B5, 5B6, and 5B7. Beneficial uses include but are not limited to remediating groundwater, replenishing groundwater in an aquifer, or confining contaminants inside the aquifer. Class V 5E3, 5E4, and 5E5 UICs are types of wastewater disposal systems which are permitted by WDEQ, are appropriate alternatives to septic systems, and may help protect groundwater quality. Class V 5A1 (i.e. direct heat reinjection facilities) and 5A2 (i.e. heat pump/air conditioner return flow facilities) are also wells that may be harmless as long as no additives are used when injecting water into the aquifer. Currently there are no UIC wells (other than Class V 5A1 and 5A2 wells) in the CAPA.

The environmental effects of ground-source heat pumps were described by Mehnert (2004). The primary impact for these types of systems is the leakage of circulating fluid. The circulating fluid is typically water or a water/antifreeze solution. Because the inherent use of these systems could cause groundwater degradation, it is important to regulate even allowed UIC wells. The City and County both prohibit almost all UIC wells as noted in the prohibited activities lists in Appendix H and do not allow the use of additives in those UIC wells that are allowed.

6.3.3.8 HAZARDOUS MATERIALS SPILLS ALONG UNION PACIFIC RAILROAD (UPRR)

The Union Pacific Railroad (UPRR) Hermosa spur line crosses a portion of Zone 2 south of Laramie. Thousands of rail and tanker cars carrying hazardous material use this line annually. Table 5-1 details two derailments in T15N, R73W: Sec 26 SW1/4, SW1/4; Sec 35 W1/2 and T14N, R73W: Sec 2 W2; Sec 11 W1/2. The EPA Facility Detail Report lists a train derailment (EPA Registry Id: 110042267542) at

UPRR MP 556 located just south of Simpson Springs. In contrast to the trucks on I-80, the volume and variety of materials that would be transported by UPRR would be greater in each case. However, the Hermosa spur line probably is not used for transporting gasoline or diesel fuel.

6.3.3.8.1 Hazardous Materials Spills Along UPRR Recommendations

MEMORANDUM OF AGREEMENT OR UNDERSTANDING (MOA/MOU)

The City and County need to establish a notification protocol with the UPRR Risk Management Communication Center in case of a spill along the Hermosa Line within Zone 2. It is important that UPRR understands that if a spill occurs in this area, groundwater contamination prevention measures should be taken immediately. The UPRR has strict requirements for working around their tracks and an actual emergency would be handled by UPRR’s emergency response contactor.

EMERGENCY RESPONSE TRAINING

Communication between UPRR, the City and the County is the most effective means of managing the threat of contamination from derailment. Establishing clear lines of communication prior to an accident will decrease the response time of the City and County. Emergency response drills should be conducted with the City, County, and UPRR that include a hazardous material spill along the UPRR so that the lines of communication are in place prior to an emergency. As needed for a response along I-80, the UPRR should have reliable contacts to quickly obtain vac-truck services, booms, other spill response supplies. Again, this may be the most important pre-incident response strategy for a spill along I-80 and a train derailment.

SIGNS

Signs indicating the CAPA and emergency phone numbers should be posted along railroad rights-of-way in the CAPA.

6.3.3.9 QUARRIES

Permitted active limestone quarries exist east of the Turner, Soldier, and Pope Wellfields, and south of Simpson Springs. The two quarries (Mountain Cement, PT0298 and Cemex, PT00658) were permitted and are regulated by WDEQ/LQD. Both quarries mine limestone from the Casper Formation for the production of Portland cement.

6.3.3.9.1 Quarries Recommendations

EXISTING REGULATIONS

Limestone quarries are regulated by Wyoming state law and regulations and the existing regulations should be used to protect the Casper Aquifer. Currently, the regulations include the Wyoming Environmental Quality Act, Title 35, Chapter 11 and WDEQ water quality rules and regulations.

MONITORING

Stantec recommends the City and County come to an agreement with Mountain Cement and add the 14 mine permit monitoring wells in this area to the monitoring well network for the CAPA. Water level and water quality data upgradient of the Pope and Soldier Springs Wellfields are already being collected and are readily available for these wells from the WDEQ-LQD. Continued monitoring of the limestone quarries will help minimize the potential impacts from quarrying that are identified. Stantec recommends the City and County contact the mine to see if they would be willing to complete their total petroleum hydrocarbon (TPH) analysis with a method that has a lower detection limit such as EPA method 8015B. This method is one of the most commonly used analytical methods in determining the extent of TPH impacts on soil and groundwater, specifically diesel range organics (DROs) and gasoline range organics (GROs).

PERMITTING

The City/County should request that the WDEQ-LQD review and approve all applications for permits to mine or quarry within the CAPA in light of the CAPP. The City and the County should take advantage of the opportunity to review any new mining permits or proposed expansion of the existing quarries though the public comment phase of the mine's permitting actions.

6.3.3.10 LANDFILLS AND DUMPS

Landfills and dumps may have materials that could contaminate the aquifer. Landfills are permitted waste disposal sites where the wasted material is placed in trenches, compacted, and covered with compacted soil to reduce the ability of water to infiltrate into the buried waste. A properly operated landfill covers the waste every day with compacted soil. The Laramie Landfill is located approximately two miles west of the CAPA which is considered to be a safe distance. The general groundwater flow direction is westward and any groundwater beneath the Laramie Landfill will flow away from the CAPA.

Dumps are a broad category of unpermitted waste disposal sites receiving material that may range from innocuous items such as broken rock or glass to contaminants such as used oil. Currently, there are no known dumps in the CAPA. The annual clean-up day appears to be accomplishing the desired effect of eliminating illegal dumping.

6.3.3.10.1 Landfills and Dumps Recommendations

CLEAN-UP DAYS

The County hosts annual clean-up days which allows residents to bring items to the Laramie Landfill or local collection sites for free. It is recommended that these annual clean-up days continue and that large-scale advertisement of this collection event occur to encourage all City and County residents to participate.

DISCOVERY AND REMOVAL

The Albany County Nuisance Resolution, County Zoning Resolution, and City Unified Development Code prohibit landfills and dumps within the CAPA. Upon identification of illegal sites, WDEQ should be contacted and asked to investigate the scene. The owners of the dumps should be contacted and informed of their responsibility to rid the community of said nuisance. Albany County or the City could also contact local law enforcement to have them assist with getting these issues resolved.

6.3.3.11 LARAMIE RIFLE RANGE

The Laramie Rifle Range Corporation (LRRC) operates a shooting sports facility within the CAPA on approximately 320 acres located in Sections 1 and 12, Township 16 North, Range 73 West. The establishment of the facility predates adoption of the CAPP by the City and County.

The operation of the LRRC facility is important to the residents of Laramie and Albany County. This facility serves the residents in the County who are interested in shooting sports and serves to protect the welfare and safety of the general public by providing a safe location for the discharge of firearms. In 1998, the City developed the Spur Wellfield which is located approximately 1 mile northwest of the LRRC facility. The area surrounding the facility is also experiencing increased rural residential development that obtains drinking water from the Casper Aquifer.

The primary concern regarding the LRRC is the use of lead bullets and the possible leaching of lead from the bullets into groundwater. Lead adheres to iron minerals, organic matter, and clay materials. Generally, lead does not leach into groundwater due to its tendency to adsorb onto solid materials, and consequently, lead contamination is contained to the top six inches of soil (Lin et al, 1995; Voigt, 2007).

6.3.3.11.1 Laramie Rifle Range Recommendations

MONITORING AND INVESTIGATION

The risk of contamination to Albany County residents and Laramie's water supply as a result of activities at the LRRC is unknown but based upon mobility studies the risk is likely low. However, the area should be included in the groundwater monitoring program to determine if any lead is leaching into the groundwater. The soils around the shooting areas should also be tested to determine the depth of lead contamination, if any.

If the monitoring indicates that lead has leached into the groundwater and/or is present in large quantities in the soil, further investigations should be initiated. The study should include more detailed sampling of the soils and groundwater. The investigation should further provide recommendations for monitoring, mitigation strategies (i.e. BMPs, design and operation standards, etc.) and ultimately, remediation of the site, if it is determined that operation of the facility poses a significant threat to the Casper Aquifer.

6.3.3.12 SEWER LINES

While sewer lines are preferable to septic systems in the CAPA, sewer lines may leak or break. However, through design and inspections, the likelihood of groundwater contamination can be reduced.

6.3.3.12.1 Sewer Lines Recommendations

DESIGN

As sewer lines are extended out to other areas of the CAPA or as existing lines are replaced, the sewer lines should be engineered by Wyoming licensed professionals in such a way as to reduce the possibility of any leakage or aquifer contamination. Any engineering techniques that meet the objectives of the CAPP or that use best practices, technologies, and engineering approaches should be considered to provide the highest level of protection.

INSPECTIONS

The City should video larger sewer mains that serve various subdivisions within the CAPA starting with the Imperial Heights Subdivision. This will ensure that the sewer lines that serve such subdivisions do not leak, including and very importantly the sewer line which underlies Grand Avenue and crosses the Quarry Fault. A break in the sewer main near the Quarry Fault could have serious impacts on water quality at the Turner Wellfield. As other subdivisions in the CAPA are placed on centralized wastewater systems, inspections should occur in these subdivisions as well. If portions of the CAPA are served by utilities other than the City, part of the utility's responsibility should include regular inspections for leaks and repairs as necessary. Stantec recommends sewer line videos be completed every five years, and if it is newer pipe, then approximately every 10 years.

6.3.3.13 STORMWATER RUNOFF

Paved parking lots and other sources of urban runoff in the CAPA may contribute contaminated runoff that infiltrates into the Casper Aquifer. Rainwater collects oil and grease from paved surfaces, motor vehicles, metal particles from tires and brake pads, and may carry these pollutants across the recharge area or into storm drains, that eventually flow to the Laramie River. If allowed to infiltrate, stormwater also provides a source of recharge to the Casper Aquifer.

City of Laramie Engineering is beginning the process of creating stormwater regulations and a design manual for the City. As part of this work the consultant will evaluate the need for special stormwater requirements for development in the Casper Aquifer Protection Area (CAPA) as recommended by Casper Aquifer Protection Plan (Wittman, 2008). That plan recommended that “stormwater management and engineering become part of development standards in the CAPA.” It is anticipated that development of the regulations and design manual will make recommendations for stormwater management requirements within the CAPA. For example, certain types of development could be incentivized to utilize stormwater management practices that emphasize infiltration (to aid in aquifer recharge), while other types of development may require stormwater management practices that prevent storm runoff from infiltrating (to protect aquifer quality).

6.3.3.13.1 Stormwater Runoff Recommendations

DESIGN STANDARDS

Even though the City of Laramie currently does not come under any federal stormwater management requirements, the City has recognized that stormwater management and engineering should be part of development standards in the CAPA. The County and City Engineering departments should provide design standards and recommendations for use within the CAPA that reduces the pollution load and, if possible, provide recharge benefits. Additionally, the Engineering departments should base their design standards and recommendations on the latest research in regard to stormwater management in arid aquifer protection zones.

6.3.3.14 UNDERGROUND STORAGE TANKS (UST)

USTs pose a high risk to groundwater due to the nature of materials stored within these vessels and the inability to readily see leaks except through secondary detection methods. Due to the high risk posed, USTs will remain prohibited in the CAPA. The Tumbleweed Express, located at 4700 East Bluebird Lane, lies within the CAPA, but was grandfathered to allow continued operation. Although not within the CAPA, numerous UST releases have occurred at former and existing services stations located along East Grand Avenue, but west of 30th Street and the CAPA. These sites were included in the WDEQ-Storage Tank Program (WDEQ-STP) and had remediation systems installed to remediate the impacted soil and groundwater. Stantec identified a potential UST for a backup generator for a communication building located near 3450 Wyatt Court. This site was field verified on May 11, 2022, but Stantec was not able to enter the private property. The outside of the building had a hazardous material placard.

6.3.3.14.1 UST Recommendations

EXISTING REGULATIONS

The current County Zoning Resolution and City Unified Development Code prohibit installation of all new underground storage tanks within the CAPA. This prohibition should not apply to the repair, maintenance, or replacement of existing USTs, if secondary containment is added. Existing USTs are also regulated by the WDEQ Storage Tank Program. All USTs are to be designed and operated according WDEQ Chapter 1 standards.

6.3.3.15 ABOVEGROUND STORAGE TANKS (AST)

ASTs are generally used to store fuel and leaks from tanks storing hazardous materials may pose a threat to drinking water.

6.3.3.15.1 AST Recommendations

DESIGN AND LOCATION STANDARDS

ASTs are to be designed and operated according to WDEQ Chapter 1 standards.

EDUCATION

Owners of ASTs should be given information on best management practices of ASTs to ensure proper installation and monitoring procedures.

EXISTING REGULATIONS

The current County Zoning Resolution and City Unified Development Code prohibit installation of all new above ground storage tanks within the CAPA, unless enclosed in secondary containment. This prohibition should not apply to the repair, maintenance, or replacement of existing ASTs, if enclosing secondary containment is added. Existing ASTs are also regulated by the WDEQ Storage Tank Program.

6.3.3.16 PESTICIDE AND FERTILIZER APPLICATION

Businesses and residents within the CAPA apply pesticides and fertilizers to landscaped areas. These chemicals have the potential to leach into the groundwater, especially if applied improperly.

The City Parks and Recreation Division, Mosquito Control Program conducts aerial applications of bacillus thuringiensis israelensis (Bti) each May. Bti is a bacterial-based mosquito control product that is harmless to humans, other mammals, birds, and fish. The City's larval control program applies Bti to wet areas and wetlands that are known to be mosquito breeding habitats. The City's mosquito control program also includes aerial application of ultra-low concentrations of malathion in June. The aerial applications of Bti and malathion occasionally occur within the CAPA.

6.3.3.16.1 Pesticide and Fertilizer Application Recommendations

LANDSCAPING REQUIREMENTS

New developments within the CAPA are recommended to landscape using native plants, BMPs, low maintenance and low water vegetation, and xeriscape concepts. Native vegetation will reduce the amount of pesticides, herbicides, and fertilizers that need to be applied. The City and County Planning commissions should be aware of the benefits and encourage the use of native and xeriscape landscaping. Xeriscape concepts will also reduce water consumption and should be encouraged.

EDUCATION

Residents and businesses within the CAPA should be educated regarding the use of native plants to reduce the need for watering and chemical use. Additionally, landscaping businesses should be educated and encouraged to provide native landscaping services. The local government entities should lead by example and initiate native landscaping throughout their facilities and open space, just as was done at Imperial Heights Park.

All individuals, organizations, and government departments using fertilizers, herbicides, pesticides, or insecticides are required by federal law to apply it according to the manufacturers' specifications. Brochures should be developed to promote the proper or, preferably, reduced application, of pesticides, insecticides, herbicides, fertilizers, or organic alternatives.

6.3.3.17 AGRICULTURE

Agriculture, particularly livestock grazing, is the dominant land use within the CAPA. Agriculture zoning is the least intensive land use within Albany County. Livestock grazing is a source of potential contamination because the waste produced by the animals may enter the groundwater. Where there are uncapped wells or thin soils, there is a greater potential for wastes to enter the Casper Aquifer. High concentrations of animals also increase the risk of contamination. Particularly, commercial feedlots and confined animal feeding operations may have large amounts of waste which can enter the groundwater system and contribute to nitrate and bacterial contamination. Both the City and County have recognized the potential for adverse groundwater impacts from such facilities and prohibit such operations within the CAPA. Stantec recommends that the City and County clarify their prohibitions with regard to these operations.

Any animal feeding operation that requires regulation under the EPA's National Pollutant Discharge Elimination System (NPDES) program should be prohibited within the CAPA.

Smaller operations that do not fall under this program have been observed within the CAPA and should be allowed to continue provided they comply with Albany County regulations and the CAPP. During a windshield survey of a potential contaminant source, Stantec observed a cattle ranch operation serving approximately 30-100 cows at 3630 Howe Road (T15N, R73W, Section 26), that was near Soldier Spring. This facility is too small to be regulated by DEQ under concentrated animal feeding operations (CAFO) rules. Other small operations such as animal boarding/shelter facilities should be allowed to continue operation.

6.3.3.18 MEDICAL WASTES

There are several businesses in Zone 2 which produce medical wastes. The contamination from medical wastes was deemed a low threat in the contaminant inventory. In addition to businesses, many residences have prescription drugs or other medicines that should be disposed of properly.

6.3.3.18.1 Medical Waste Recommendations

EXISTING REGULATIONS

Existing regulations should be used to manage medical waste sources. The disposal and handling of medical wastes in Wyoming is regulated by the Occupational Health and Safety Administration of the Department of Employment.

EDUCATION

Residents within the CAPA should be educated regarding the Wyoming Medication Donation Program (WMDP). The WMDP reduces medication waste and improves medication access for low-income Wyoming residents who lack adequate prescription drug insurance coverage. WMDP's central location acts as a mail-order pharmacy that uses donated medications to fill prescriptions for eligible patients at no cost to recipients. This location also processes all incoming donations and performs safe medication disposal to reduce drug diversion while positively impacting the environment. Within Albany County, medications may be donated through the Public Health Department and disposed of at the Detention Center and the Walmart Pharmacy.

6.3.3.19 EXISTING NONCONFORMING USE

Nonconforming uses are uses which are prohibited by current regulations but were in place before the regulation took effect. There are some businesses along the east end of Grand Avenue that may be nonconforming.

6.3.3.19.1 Existing Nonconforming Use Recommendations

EXISTING REGULATIONS

The City and County should use existing regulations, such as State UST regulations and the City/County Zoning Resolution and Unified Development Code, to manage nonconforming uses within the CAPA.

Stantec recommends not allowing expansion of such nonconforming uses within the CAPA. If not already in place, Stantec recommends groundwater monitoring of these uses to indicate whether contaminants from these sources may or have entered the aquifer so that appropriate remedial action may be taken.

EDUCATION

The City and County should continue to educate all business owners about the importance of pollution prevention practices, BMPs, and to inform them about the CAPA and CAPP.

6.3.3.20 LAND ACQUISITION

Land acquisition may be used as a management strategy to protect the most sensitive areas of the CAPA. Land acquisition, as stated previously, includes: purchasing, donations, conservation easements, land exchanges, transfer of development rights, and MOA/MOU.

6.3.3.20.1 Land Acquisition Recommendations

PURCHASING

It is recommended that the City of Laramie purchase all land within Zone 1 of the CAPA that it does not already own. The City should also consider purchasing land in Zone 2 that is adjacent to Zone 1 at the Turner Wellfield and at Spur No. 2. Purchasing land in these areas will ensure protection of the most critical areas within the CAPA. Once purchase is accomplished, annexation of these areas can be considered on a case-by-case basis. The Pilot Hill Recreation Area and the Pilot Hill Wildlife Management Area were excellent examples of prudent planning to protect the Casper Aquifer.

CONSERVATION EASEMENTS AND OTHER LAND ACQUISITION MECHANISMS

It is recommended that the City and County work towards a conservation easement program that will allow landowners to set aside a portion of their land and by so doing protect that land from development. Donation of land is another mechanism for the City and County to protect sensitive areas from development. Receipt of transferred development rights and partnership into land exchanges will also allow the City and County additional control over specific land areas and ultimately provide protection to the Casper Aquifer.

WORK WITH LANDOWNERS

The City and County governments should work with CAPA landowners to shift development rights, change density requirements in specific areas, purchase land, and/or obtain conservation easements. While it is highly unlikely that all of the CAPA will come under public ownership, the landowners within the CAPA have natural incentives to protect the groundwater in order to protect their investment. These landowners should be viewed as valuable partners in protecting groundwater.

6.4 RECOMMENDED MANAGEMENT STRATEGIES FOR IMPLEMENTATION

Implementation of management strategies is the responsibility of the Laramie City Council and Albany County Board of Commissioners. This section summarizes recommendations for managing potential contaminant sources. Since the previous CAPP was approved, the Laramie City Council and Albany County Board of Commissioners have implemented or completed the following items:

1. Established an overlay zoning district for the CAPA and incorporated almost all the recommendations of the 2008 CAPP update into current City and County regulations.
2. Established a systematic groundwater monitoring program for the Casper Aquifer at the City of Laramie production wells.
3. Created a permanent staff position to develop and oversee an on-site wastewater management program within the CAPA.
4. Consistently and thoroughly inspected new on-site wastewater treatment facilities.
5. Provided annual training and licensing for wastewater system installers, pumpers, and haulers.
6. Had wastewater system contractors complete inspections of on-site wastewater treatment facilities upon property transfers.
7. Established requirements for two-compartment septic tanks for new or replacement construction of on-site wastewater treatment systems.
8. Collected household hazardous wastes on a semi-annual basis.
9. WYDOT resurfaced Interstate 80 in Telephone Canyon with skid reducing pavement and installed variable speed limits signs.
10. Had many site-specific investigations completed to assess potential impacts to the Casper Aquifer from proposed development.
11. Completed the 2009 and 2010 aquifer wide nitrate assessment studies.
12. Completed the 2011 I-80 Telephone Canyon Study.
13. Completed the 2013 East Laramie/Albany County Wastewater Feasibility Study.
14. Completed the 2015 Sherman Hills Fault Study.
15. Completed the 2018 Septic System and 2020 nitrate loading studies.

The following management strategies in Table 6-7 are recommended for consideration and implementation by the Laramie City Council and Albany County Board of Commissioners. The table indicates which entity the recommendation applies to based on whether City and/or County code would need to be amended. An 'X' in the column below the City or County column indicates that acceptance of the recommendation requires amendment of the respective entity's regulations. The regulations necessary to implement the objectives and recommendations of this CAPP will be developed through the respective procedures of Albany County and the City of Laramie. None of the recommendations contained herein constitute land use regulation until formally considered, amended as appropriate, and formally adopted by the respective government entities.

Table 6-7. Recommended Management Strategies.

No.	Recommendation	City of Laramie	Albany County
1	Approve the updated CAPA to replace the APO and APOZ in City and County regulations	X	X
2	Approve the additional prohibited activities presented in Table 6-1 by City ordinance and County resolution	X	X
3	Purchase all remaining Zone 1 and immediately surrounding lands at Spur No. 2 and Turner No. 2	X	
4	Add all wells and current and historic Casper Aquifer springs to the list of vulnerable features	X	X
5	Require a minimum 100-foot setback from all vulnerable features for all development		X
6	Adopt a 35-acre minimum lot size across the CAPA.		X
7	Approve the updated site-specific investigation requirements for all proposed new development or new uses	X	X
8	Enact conditions for approval within the APOZ to the Albany County Zoning Resolution		X
9	Amend current regulations to disallow expansion of nonconforming uses	X	X
10	Expand the existing groundwater monitoring well network, and design and implement an expanded groundwater monitoring program	X	X
11	Conduct annual household hazardous waste disposal days	X	X
12	Update the Sewer Master Plan to address increasing sewer capacity east of the City of Laramie	X	
13	Work to determine incentives, grants, and other financial opportunities for areas where existing septic systems will eventually need to be replaced with advanced treatment units.	X	X
14	Require the use of advanced treatment units for new septic systems and for replacement septic systems which are failing or have failed within any portion of the CAPA where the lot size is less than 35 acres.		X
15	Require that advanced treatment units be considered systems that are capable of reducing septic system effluent Total Nitrogen concentrations to less than 25 mg/L or remove a minimum of 60% of Total Nitrogen as measured at the discharge point to the leachfield.		X
16	Modify design and construction standards for small wastewater facilities to include regulations and guidance for advanced treatment units within the CAPA.		X

No.	Recommendation	City of Laramie	Albany County
17	Require septic system inspections once every five years in addition to when the property is transferred. Such an inspection should ensure that baffles are operating correctly, that no leaks are occurring, and to check the levels of sludge and scum in the tank. An inspection when property is transferred could be waived at the County's determination if the seller can provide documentation of inspections within the last three years and pumping of the septic tank.		X
18	Require pumping of septic systems not less than once every five years and maintained on a regular schedule set by a County licensed septage hauler		X
19	Further study of the efficacy of advanced treatment units in the CAPA.		X

6.5 FUTURE CONTAMINANT CONSIDERATIONS

When evaluating future environmental concerns in Albany County and the City of Laramie, the data used by the EAC, the Albany County Planning and Zoning Commission, Laramie Planning Commission, other government officials, and any hired consultants need not be limited to the contaminant sources, land uses and other information used in this CAPP. Any contaminant sources, future growth, future land use and any other information affecting the CAPP should be considered as changes occur and the CAPP is updated.

7 Contingency Plan

This chapter describes formation of a Contingency Plan in the event of a serious shortage or contamination of groundwater supplies. Water supply planning for population growth was recently addressed through the 2015 Laramie Water Master Plan completed by WWC Engineering and others (2015). Some details from that study are included here. Potential future changes in precipitation, water quality, and annual recharge to the Casper Aquifer due to climactic variables should be evaluated under various scenarios during the next water master planning process along with alternatives the community should consider. This evaluation should also include recommended groundwater production and conservation strategies for drought scenarios.

7.1 INTRODUCTION

The Contingency Plan described in this chapter addresses problems that need to be overcome in the event of a water supply shortage or a contamination incident that impacts the system's ability to supply an adequate quantity of safe drinking water to the public. A contingency plan to help provide potable water to the public during water supply emergencies is critical to any drinking water protection program. The contingency plan defines a chain of command and creates descriptions of individual roles and responsibilities during an emergency. Evaluating potential emergency situations and developing appropriate responses prior to an event can reduce reaction times and reduce the risk of making inappropriate decisions that result in further harm or extend the emergency. Local residents on domestic wells are also encouraged to have contingency plans for dealing with these issues.

It should be noted that Laramie citizens have always been very cooperative when dealing with water availability issues from drought in 2002 to other adverse conditions. When asked to conserve as needed, the citizen response was quick and effective. The recommendations presented in this section should be considered a starting point that can be adapted to better address the actual issue as it develops and the response of the local community.

7.1.1 CONTINGENCY PLAN ORGANIZATION

The Contingency Plan is comprised of the following elements: (1) present water source capacity and water demand; (2) chain of command and areas of responsibilities during an emergency; (3) short-term emergency responses, including water conservation and decontamination; and (4) the development of new groundwater sources in response to long-term shortages or the loss of an existing source.

7.1.2 CONTINGENCY PLAN FORMATION

The Contingency Plan was originally formed by the Contingency Planning Subcommittee of the EAC using the following guidance documents:

- Guide to Ground-Water Supply Contingency Planning for Local and State Governments, Technical Assistance Document, EPA 440/6-90-003, May 1990.
- Wyoming Wellhead Protection Program Guidance Document, Version 3.1, June 1998.

The Contingency Plan was updated in 2007 by Wittman and in 2022 by Stantec.

7.2 CONTINGENCY PLAN DISTRIBUTION

It is recommended that the Contingency Plan be incorporated into the Albany County Municipal Emergency Operations Plan as part of the Hazardous Materials Incident Response Annex managed by the County Emergency Management Coordinator. A copy of the Contingency Plan should be available at the Laramie Planning Division, the Albany County Planning Office, and online.

The water demand and source inventory tables and emergency response team roster should be reviewed and updated every two years. The Contingency Plan should also be modified as changes occur in the water system infrastructure.

Water demand and source inventory data should be reviewed and updated with the same methodology used for previous water supply master plan studies (WWC, 1995, 2006; WWC Engineering and others, 2015) or using the best data available at the time of review. Data should be confirmed with the City Utility Manager. An updated Contingency Plan should be reviewed and signed by the City Utility Manager, the County Emergency Management Coordinator, the Albany County Planning Director, and the Public Works Director to ensure that the most current information has been incorporated into the Contingency Plan.

The Albany County Exercise Design Team tested the Contingency Plan in 2000 with a table-top exercise and in 2001 with a full-scale exercise. The full-scale exercise was held on the summit of Interstate 80 (I-80) near the east boundary of Zone 3 and simulated a diesel spill within the CAPA. The exercise was attended by all emergency response agencies and City/County officials. Similar table-top exercises have been conducted by City and County officials since that time.

Full-scale emergency response exercises should be conducted as directed by the Emergency Management Coordinator. After each full-scale exercise, the Contingency Plan should be updated with the information learned from the exercise to ensure that the most effective and efficient Contingency Plan is in place. Updating the Contingency Plan should be conducted by the assigned City/County staff in cooperation with the Emergency Management Coordinator and City Utility Manager.

7.3 EMERGENCY LIKELIHOOD AND SEVERITY CHART

Table 7-1 evaluates potential threats by assigning estimates for both likelihood and severity. Events are ranked according to their likelihood to occur and the impact on the water system, (i.e. severity). The estimations were made by a Hazards Staff Geologist at the Wyoming State Geological Survey in 2007. The likelihood of wildfire has increased over the last couple decades and the City has dealt with its own share of wildfire impacts.

Table 7-1: Emergency Likelihood and Severity Chart for Laramie Regional Drinking Water Protection Program.

Type of Emergency	Likelihood (10-High – 1-Low)	Severity (10-High – 1-Low)	Remarks
NATURAL			
Drought	6	6	Long-term drought could affect water quality
Flood	5	4	Does occur – further study warranted
Ice & Snowstorm	8	4	
Wind	7	2	
Earthquake	5	5	
Fire	6	5	
MAN-MADE			
Spill/Chemical Contamination	6	10	I-80 and UPRR spills addressed
Sabotage	5	8	Heightened security recommended
Power Outage	5	3	
Operator Error	4	3	
Equipment Failure	5	4	
Explosion	1	5	
Vandalism	7	8	Heightened security recommended

Albany County (2019) also ranked the hazards listed in Table 7-1 along with others as part of their hazard mitigation plan. The hazards were ranked on the basis of planning team input and public perception of risk. The highest ranked hazards for the City of Laramie included winter storms and hazardous material releases, but drought, flood, and wildland fire were ranked equally high within Albany County.

7.4 CITY OF LARAMIE WATER DEMANDS AND SOURCE INVENTORY

Table 7-2 shows the historic and projected water demand in million gallons per day (mgd). Table 7-3 shows the existing source capacity of the water system operated by the City of Laramie. This information is from the City of Laramie Public Utilities division (Lytle, personal communication) and the Laramie Water Management Strategy Level II (WWC, 2006). WWC Engineering and others (2015) reported that the overall capacity of the water supply infrastructure (17.47 mgd peak) exceeds the existing needs (15.41 mgd) by about 13 percent. At the 2050 planning horizon, with the water treatment plant full use of the existing water right (9.25 mgd), the capability of supplies are approximately 20.25 mgd, which slightly exceeds the planning peak day demand of 19.7 mgd.

WWC Engineering and others (2015) report that on the chance that a large increase in demand is realized through unexpected population growth, a new industrial demand, or another unforeseen circumstance, the City would have to choose a resource to develop further, either groundwater or surface water. Options for additional resource development have been extensively studied. The 2006 Water Management Plan included a summary of the probable resource development options available to the City. Since that report was prepared, additional information regarding the potential for groundwater development has been gathered, including preliminary aquifer testing at Simpson Springs, and the operation of the Spur Wellfield.

Table 7-2: City of Laramie Water Demand.

Year	Season[1,2]	Average Day (mgd)	Peak Day (mgd)
2000	Winter	4.2	8.0
	Summer	10.5	14.1
2006	Winter	3.5	6.9
	Summer	9.2	12.3
2011	Winter	3.5	7.8
	Summer	8.1	10.8
2016	Winter	3.3	5.3
	Summer	7.8	10.3
2021	Winter	3.1	4.3
	Summer	8.0	10.3

[1]winter months: November, December, January, February, and March

[2]summer months: June, July, and August

*All values from City of Laramie water operations production data (Lytle, personal communication).

Table 7-3: City of Laramie Water Capacity Inventory.

Source	Winter Capacity (mgd)		Summer Capacity (mgd)[1]	
	Average	Peak^^	Average	Peak^^
Laramie River	2.5	6.8	6.0	6.5
Turner Wellfield	1.7	4.0	2.4	4.5
Pope Wellfield*	1.3	4.2	1.3	4.2
Soldier Wellfield*	1.2	1.2	1.2	1.2
Spur Wellfield**	2.0	4.0	2.0	4.0
Total (mgd)	8.7	20.2	12.9	20.4

*These Pope and Soldier Wellfields must be considered together for a contamination event due to connectivity. The peak capacity of both wellfields producing simultaneously is 4.5 mgd which is limited by the hydraulic capacity of the transmission line (Lytle, personal communication).

**See the Spur wellfield condition of use agreement at the City of Laramie Public Works Department/Utilities Division.

^^Peak capacity values were obtained from maximum production levels and direct conversation with City of Laramie Water Utilities Division.

[1] Summer capacity data updated with information from WWC Engineering and others (2015).

7.5 ALTERNATIVE POTABLE SHORT-TERM EMERGENCY WATER SUPPLIES AND COORDINATING AGENCIES

Emergency agencies that might assist in the distribution of short-term emergency potable (i.e. drinking) water are listed below (see Emergency Notification Roster for contact information).

- National Guard
- American Red Cross
- Salvation Army
- Culligan Water Systems
- Smith Beverages
- Through local coordination there may be additional sources of water from private wells.
- An emergency water conservation ordinance would be activated for Laramie residents to conserve water limited to essential uses necessary for survival.

The federal and state governments have no responsibility to provide their towns/cities with potable water. Consequently, it is the responsibility of local municipal government to coordinate and assist in the procurement of emergency potable water.

7.6 WATER DISTRIBUTION SYSTEM AND STORAGE FACILITIES

Maps of the water distribution system and storage systems are maintained by the City of Laramie Public Works Department and special district offices. Requests for updates may be directed to the City Engineering Division at (307) 721-5250 and appropriate district offices.

All inspections, decontamination, and reconstruction of the water distribution system are performed in accordance with the American Public Health Association Standard Methods, which is prepared by the American Public Health Association, the American Water Works Association (AWWA) and Water Environment Federation. The Utility Manager maintains a copy and is responsible for the appropriate implementation of the AWWA procedures.

7.7 EMERGENCY RESPONSE

Albany County and the City of Laramie have an emergency notification protocol in place. In the event of a water supply emergency, a call to 911 will invoke dispatch of the County Emergency Management Coordinator.

The County Emergency Management Coordinator assumes the following assignments in preparation for or during an emergency.

- Coordinate responsible personnel for Contingency Plan formation and training (see Emergency Notification Roster at the end of this chapter).

- Maintains channel of communication with Incident Command, which is an on-site Emergency Operation Center vehicle.
- Coordinates channels of command, responsibilities, and designates alternate staff or teams in accordance with the Hazardous Materials Incident Response Annex of the City of Laramie Fire Department.
- Makes contact with the Wyoming Office of Homeland Security, WDEQ, Wyoming Highway Patrol, a local Professional Geologist practicing hydrogeology, and other state and federal agencies that are deemed necessary and responsible for coordinating and providing emergency relief.
- Activates the Emergency Operations Center (EOC), if necessary.
- Coordinates authorization to hire consultants to perform remediation or source removal projects.
- Coordinates review and exercising of a water conservation program in conjunction with the Director of Public Works and elected and appointed City and County officials.
- Coordinates all emergency functions with Incident Command, and if necessary, assigns a Public Information Officer (PIO) to work with Incident Command.

7.8 WATER SHORTAGE CONTINGENCY PLANS AND SCENARIOS

The Contingency Plan will be implemented, at the discretion of the County Emergency Management Coordinator, when groundwater production wells or surface water systems are rendered inoperable as a consequence of direct contamination or potential contamination, or other disaster shortage. The County Emergency Management Coordinator will coordinate this effort with the Public Works Director, the Utility Manager, the City Manager, and elected and appointed City, County, and special district officials. Water supply planning to provide for growing population is a separate process from the contingency planning envisioned here.

Contamination of wells or the water treatment plant will result in the isolation or shut down of the affected supply source at the discretion of water utility operators based on their understanding of the contamination event and local groundwater flowpaths. In the event of a permanent denial of use for a city well(s) or the water treatment plant, new drinking water sources will be developed. The siting, development, and financing of establishing new permanent drinking water sources are described in the Laramie Water Management Plan Level II (WWC, 2006). The water management plan can be reviewed in the Utility Division Manager's office. The following is a brief review of water supply development procedures:

- Development of additional water sources focuses on two different sources: surface water and groundwater. Methods for developing surface water include adding pipelines from the Laramie River to the water treatment plant, pressurizing the pipes into town to handle the increased water supply, or developing a non-potable irrigation system for City parks and golf courses.

- The Casper Aquifer is the principal groundwater source in the region capable of providing sufficient supplies of water for municipal use. This source can be developed in two ways: drilling new wells or increasing production from existing wells. There are a number of prospects for further development of the Casper Aquifer described in the 2015 Laramie Water Master Plan (WWC Engineering and others, 2015). An example of a high priority future groundwater prospect is Simpson Springs, located on the City- owned Monolith Ranch south of Laramie.

The following Contingency Plan elements are listed in the recommended order of implementation. The County Emergency Management Coordinator will implement these recommendations with the Public Works Director and the Utility Manager. With any contamination scenario, all Contingency Plan elements should be chosen in consideration of the duration of the contamination event and loss of the water supply.

- Set priorities for water use (i.e. drinking and food preparation, for facilities such as hospital, medical clinics, veterinary facilities, etc.).
- Water use restrictions that can be voluntary or mandatory depending on the severity of the situation. If public health is an immediate issue, the Emergency Broadcast System should be invoked. For example, in 1997 the 24-inch water transmission line was out of service for one week, and a short-term voluntary request proved it is possible to almost halve water demand with public cooperation (Wes Bressler, personal communication, 1999).
- Expected shortfalls of up to 25 percent of the anticipated water supply or less can be handled by public notification and a request for voluntary cooperation or compliance.
- Expected shortfalls greater than 25 percent of anticipated water supply may require mandatory controls to provide minimum delivery to the entire population.
- Increase production from the Laramie River - when conditions permit.
- Increase production from unaffected wells or wellfields - where and when conditions permit.
- Import and distribution of bottled water - Consult emergency notification roster for bottled water suppliers and emergency assistance agencies for possible help with distribution.
- Obtain and operate a temporary water treatment unit - This unit must be requested by the Governor through WEMA.
- Ensure redundancy in the water treatment plant and process train.
- Implement the next phase of the City’s current water source development or treatment options (WWC Engineering and others, 2015) based upon characteristics and projected duration of water supply shortage.

7.9 POTENTIAL CONTAMINANT SCENARIOS AND SPILL CONTINGENCY PLAN

7.9.1 POTENTIAL SCENARIOS

Three potential scenarios were analyzed to determine the impacts on water availability and are described below:

7.9.1.1 SCENARIO 1

The Laramie River is contaminated upstream of the Water Treatment Plant potentially by a forest fire in the watershed. Such contamination could potentially create a temporary loss of the Water Treatment Plant or reduction in its treatment capacity. This scenario would also apply in the event of a short or long term drought that either limits or eliminates diversions and treatment of surface water.

7.9.1.2 SCENARIO 2

A hazardous material is spilled on I-80 close to the Grand Avenue/I-80 interchange. This scenario could lead to a loss of the Turner Wellfield.

7.9.1.3 SCENARIO 3

A hazardous material is spilled on I-80 between the rest area and the bottom of Telephone Canyon which could result in the loss of Pope Springs and Soldier Springs wellfields.

7.9.1.4 SUMMARY

Table 7-4 presents these three scenarios which have been identified as the most likely incidents to cause a disruption to the City of Laramie's drinking water supply. These scenarios are considered as priorities for planning purposes. Planners should be aware that different scenarios will require the use of different response equipment, personnel and procedures to allow formation of appropriate response approaches.

Supply totals were tabulated by adding the existing water sources average and peak capacity from Table 7-3 and excluding the contaminated water source (Table 7-4). For example, in scenario #3 (loss of Pope Springs and Soldier Springs wellfields) the average winter supply total = 6.2 mgd. This was tabulated by adding 2.5 mgd (Laramie River winter capacity average) + 1.7 mgd (Turner Wellfield winter capacity average) + 2.0 mgd (Spur Wellfield winter capacity average) = 6.2 mgd average winter supply total. The average and peak day supply total numbers from Table 7-4 are then subtracted from Laramie's average and peak day demands from Table 7-2 (the highest demands from 2000-2021 were used so that the worst-case scenario was analyzed). Deficiencies were calculated and are shown in Table 7-5.

Water deficiencies shown in Table 7-5 are based upon average and peak capacities. Pumping at peak capacities is not sustainable over the long-term. If a well(s) were inoperable due to contamination, the remaining wells are unable to pump at peak capacities beyond 40 to 50 days. Therefore, the average capacity should be considered the long-term capacity of the water systems. Over the long-term, average capacities may be unable to deliver during peak times and additional supplies may be required.

Table 7-4: Potential Shortages Associated with Possible Contamination Scenarios.

Scenario #1 – Contamination of the Laramie River upstream of the water treatment plant **Potential Impact: Loss of water treatment plant**			
WINTER DAILY AVERAGE (mgd)		WINTER PEAK DAY (mgd)	
Supply	6.2	Supply	13.4
Demand	4.2	Demand	8.0
Shortage	none	Shortage	none
SUMMER DAILY AVERAGE (mgd)		SUMMER PEAK DAY (mgd)	
Supply	6.9	Supply	13.9
Demand	10.5	Demand	14.1
Shortage	3.6	Shortage	0.2
Scenario #2 – Spill occurs on I-80 (proximate to Grand Avenue/I-80 interchange) **Potential Impact: Loss of Turner Wellfield**			
WINTER DAILY AVERAGE (mgd)		WINTER PEAK DAY (mgd)	
Supply	7.0	Supply	16.2
Demand	4.2	Demand	8.0
Shortage	none	Shortage	none
SUMMER DAILY AVERAGE (mgd)		SUMMER PEAK DAY (mgd)	
Supply	10.5	Supply	15.9
Demand	10.5	Demand	14.1
Shortage	none	Shortage	none
Scenario #3 – Spill occurs on I-80 (between rest area and bottom of Telephone Canyon) **Potential Impact: Loss of Pope Springs and Soldier Springs wellfields depending on location of spill**			
WINTER DAILY AVERAGE (mgd)		WINTER PEAK DAY (mgd)	
Supply	6.2	Supply	14.8
Demand	4.2	Demand	8.0
Shortage	none	Shortage	none
SUMMER DAILY AVERAGE (mgd)		SUMMER PEAK DAY (mgd)	
Supply	10.4	Supply	15.0
Demand	10.5	Demand	14.1
Shortage	0.1	Shortage	none

Notes: Mitigation may prohibit migration of contaminants to Soldier Springs Wellfield in Scenario 3. The greatest values of demand and supply for average and peak day for winter and summer between the years 2000-2011 were considered.

Table 7-5: Water Deficiency Compared to Average and Peak Demands in Winter and Summer.

Scenario	Deficiency for Average Day Demand (mgd)		Deficiency for Peak Day Demand (mgd)	
	Winter	Summer	Winter	Summer
#1 Loss of water treatment plant	--	3.6	--	0.2
#2 Loss of Turner Wellfield	--	--	--	--
#3 Loss of Pope Springs and Soldier Springs wellfields	--	0.1	--	--

7.9.2 SPILL CONTINGENCY PLAN

A spill of potentially hazardous substances along I-80 has the highest likelihood and highest severity of damage to Laramie's groundwater supply, the Casper Aquifer. It is recommended that a mock disaster simulating a spill along I-80 be used to test, evaluate, and refine the following Contingency Plan outline. Such spill response simulations are being pushed statewide by the state, and occurred in 2022 through the Albany County Emergency Management Agency with state funding. Table 7-6 provides a checklist of elements from the following Contingency Plan section that would be implemented in each of the different scenarios.

7.9.2.1 SPILL CONTINGENCY PLAN ELEMENTS

1. The County Emergency Management Coordinator will notify the Transportation Department, the Water Department, UPRR, the Fire Department, WEMA, the Albany County Commissioners, the Laramie City Manager, the City Council, the Laramie Mayor and other relevant agencies and officials, as well as submit a preliminary news release.

2. If the spill occurs within the CAPA, mitigation strategies will be rapidly employed.

3. The County Emergency Management Coordinator should immediately direct the Utility Manager to take all available courses of action to shut off and isolate potentially contaminated wells from the water system and employ a 24 hour alert with testing of proximate sources and distribution systems.

4. Assess the possibility of using absorbent materials or isolating the contaminant material on the highway and railroad culvert systems. Assistance may be requested from the WYDOT and UPRR to implement these maneuvers.

5. The County Emergency Management Coordinator will notify all affected well owners through available means.

6. Once an initial assessment of the emergency is obtained, directives to a designated contractor to proceed with further mitigation or decontamination should be ordered by the County Emergency Management Coordinator, if necessary.

7. The County Emergency Management Coordinator, in cooperation with the Public Works Director and elected City Officials, should implement a water conservation program, and order alternative potable water supplies, if necessary (see section on Water Shortage Contingency Plan and Scenarios).

8. News releases should be issues by the Public Information Officer, providing all necessary public information regarding the drinking water supply and at minimum, encouraging water conservation (see Press Release Template at end of section).

9. The need for extended periods of increased groundwater production should be assessed in consultation with the Director of Public Works, elected and appointed City and County and special district officials, State and Federal environmental agencies, and implemented, if necessary.

Table 7-6: Contingency Plan Elements for Scenarios with Inadequate Supply.

SCENARIO	CONTINGENCY PLAN ELEMENT								
	1	2	3	4	5	6	7	8	9
Scenario #1: Summer Daily Average and Peak						X	X	X	X
Scenario #3: Summer Daily Average and Peak	X	X	X	X	X	X	X	X	X

7.9.3 SOURCES OF FUNDS AND DISASTER RELIEF

Financing for developing or cleaning up water sources due to spills, sabotage, or other man-made activities would most likely entail the City of Laramie hiring a consultant to perform the work, and then seeking compensation from the responsible parties.

7.9.3.1 LOCAL EMERGENCY FUND RESERVES

Since legal compensation, as well as disaster relief funds, can take up to a year (or more) to receive, reserved funds should be an integral part of Laramie's Municipal Water System Emergency Preparedness effort.

7.9.3.2 GOVERNOR'S CONTINGENCY FUND

In 1989, the Governor of Wyoming established provisions which allow the Governor's Contingency Fund to be utilized for containment, cleanup, and disposal of substances posing an imminent threat to the health, safety or welfare of humans, wildlife and/or waters of the State (including groundwater). These funds are available only when immediate action is required or the responsible party is unknown. The funding must be requested from the Governor and the WDEQ Director.

7.9.3.3 POLLUTION REVOLVING FUND

Limited federal funding may be available through the Pollution Revolving Fund, administered by the U.S. Coast Guard, for the reimbursement of state and federal costs related to the containment, removal, mitigation, and disposal of oil releases. In addition, EPA may provide limited funds to ensure timely initiation of containment action when use of the Pollution Revolving Fund is not authorized. Requests for EPA funds must come from the Governor. Additional information is available in the Wyoming Oil and Hazardous Substances Pollution Contingency Plan (1989) and Section 311(k) of the Clean Water Act.

7.9.3.4 LEGAL COMPENSATION

Generally, the burden of the cost of clean-up following a contamination incident rests with the responsible party. The County/City Attorney should be directed to pursue legal remedies whenever possible.

7.9.3.5 FEDERAL EMERGENCY MANAGEMENT AGENCY (FEMA)

In the event of a major disaster, FEMA may provide mobile telecommunications, operational support, life support, and power generation assets for the on-site management of the disaster. Requests should be made through the Wyoming Office of Homeland Security.

7.10 RECOMMENDATIONS IN THE CONTINGENCY PLAN

- Full-scale field exercises should be conducted every five years with intervening years used for annual table-top exercises.
- After each full-scale field exercise, the Contingency Plan should be updated with the information learned from the exercise to ensure that the most effective and efficient Contingency Plan is in place. Updating the Contingency Plan should be conducted by the Water Outreach Coordinator in cooperation with the Emergency Management Coordinator.

7.11 PRESS RELEASE TEMPLATE

The following notice regards:

1. Potential contamination of the City of Laramie's water supply
2. Municipal water shortage

It is vital that all residents of Laramie observe the following water use restrictions until further notice:

The characteristics and potential public health hazards associated with this contaminant are as follows:

City personnel are taking the following steps to address this problem:

For further information, please contact ____
at this phone number:____

A press conference is scheduled for ____
to be held at ____

News updates will be provided as additional information becomes available.

Time:_____________________ **Date:**____
Signed:

Distribution:	**FAX**	**PHONE**
Laramie Daily Boomerang	721-2973	742-2176
Branding Iron	766-4027	766-6190
KOWB	742-4576	745-4888
KUWR (Wyoming Public Radio)	766-6184	766-4240
KRQU	745-7397	745-5208
Bresnan Cable		745-7333
KCGWY		745-9242
KIMX		745-5208
KOCA		745-0937
City TV – Channel 11		721-5226

7.12 EMERGENCY NOTIFICATION ROSTER

Table 7-7: Emergency Notification Roster (as of August 1, 2022).

POSITION/AGENCY	CONTACT/NAME	ROLES	WORK PHONE	HOME PHONE
Wyoming Office of Homeland Security	Lynn Bud -Director George Nykun - Deputy Director	Respond/Guidance	307-777-4663	
Federal Bureau of Investigation	Michael Schneider	Respond/Guidance	303-629-7171	
Wyoming DEQ Herschler Bldg. Cheyenne, WY 82002	Joe Hunter Emergency Coordinator General line	Respond/Guidance	(307) 777-5885 (307) 777-7781	(page) 432-1108 (cell) 631-2880
National Response Center Washington D.C.	Emergency Line	Respond/Guidance	(800) 424-8802	
US EPA Region VIII	Emergency Line	Respond/Guidance	(303) 312-6054	
County Emergency Management Coordinator Hazard Assessment Coordinator Fire Department	Steph Baker	Guidance/ Coordination Respond/Guidance	911 721-1815	
Assistant Emergency Management Coordinator Albany County Sheriff	Kate Allred	Respond/Guidance	721-1896	
Water Treatment Supervisor	Mike Lytle	Respond/Guidance	745-9536	
City Public Works Director	Brooks Webb	Guidance	721-5241 Direct 721-5230 Ad. Assist	
Operations Superintendent		Respond/Guidance	721-5281 Direct 721-5280 Ad. Assist	
Chief of Police	Brian Browne	Guidance	721-3547	
Wyoming Highway Patrol	Dispatch	Respond/Guidance	911 800-442-9090	
Wyoming Department of Transportation		Respond/Guidance	745-2100	

POSITION/AGENCY	CONTACT/NAME	ROLES	WORK PHONE	HOME PHONE
Union Pacific Railroad Risk Management Communication Center		Respond	(888) 877-7267	
County Commission Chairman	Pete Gosar	Guidance	721-2568	
City Manager	Janine Jordan	Guidance	721-5226 (Exec. Assist.)	
Bottled Water	Culligan Anheuser-Busch	Respond	745-3893 (314) 577-2000	721-8929 (after hrs)
News Media Boomerang KOWB KUWR (Wyoming Public Radio) KRQU Branding Iron Bresnan Cable KIMX KCGWY KOCA Channel 11			742-2176 745-4888 766-4265 745-5208 766-6190 745-7333 745-5208 745-9242 745-0937 721-5226	
EAC Technical Committee		Guidance	721-5230	

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APPENDIX A

2000 Joint Resolution of Support

JOINT RESOLUTION NO. 2000-02 OF SUPPORT

RESOLUTION SUPPORTING THE ENVIRONMENTAL ADVISORY COMMITTEE'S (EAC) DEVELOPMENT OF THE LARAMIE REGIONAL DRINKING WATER PROTECTION PROGRAM

WHEREAS, the EAC has prepared a Delineation Report and Delineation Map which identify land areas that contribute water to public drinking water supplies for the Laramie Regional Drinking Water Protection Area; and

WHEREAS, the EAC has prepared a Contingency Plan which addresses problems that the City of Laramie's public water supply system may need to overcome in the event of water supply shortages or a contamination incident that impacts the system's ability to supply an adequate quantity of safe drinking water to the public; and

WHEREAS, the Laramie City Council and the Albany County Board of County Commissioners request the EAC to proceed with developing an Aquifer Area Management Plan that will make recommendations on how to manage the existing potential sources of contamination identified within the aquifer protection area and to ensure that future land-use activities do not pose a threat to the water quality of the most permeable parts of the Casper aquifer in the Laramie Regional Drinking Water Protection area; and

WHEREAS, the Laramie City Council and the Albany County Board of County Commissioners wish to thank the EAC members for all their hard work and effort in developing the comprehensive Delineation Report, Delineation Map, and the Contingency Plan.

NOW THERFORE, BE IT RESOLVED, by the Laramie City Council and the Albany County Board of County Commissioners that the City of Laramie and Albany County accept the Delineation Report, Delineation Map, and the Contingency Plan of the Laramie Regional Drinking Water Protection Program as written.

PASSED AND APPROVED this 4th day of January, 2000.

David F. Williams, Mayor and
President of the Laramie City
Council, Laramie, Wyoming

ATTEST:

Sue Morris-Jones, CMC
City Clerk

Pat Gabriel, Chairman
Albany County Board of County
Commissioners

ATTEST:

Jackie Gonzales
Albany County Clerk

APPENDIX B

1999 EAC Delineation Report for the Casper Aquifer Protection Area, Laramie, Wyoming

B

Delineation Report Version 1.0

DELINEATION REPORT
for the
CASPER AQUIFER PROTECTION AREA

LARAMIE, WYOMING

TECHNICAL REVIEW SUBCOMMITTEE OF THE
ENVIRONMENTAL ADVISORY COMMITTEE

PREPARED FOR:
CITY OF LARAMIE AND ALBANY COUNTY, WYOMING

June, 1999

Respectfully submitted by the Technical Review Subcommittee:

Keith E. Clarey, P.G. (TriHydro Corporation)

Dr. Thomas Edgar, P.E. (University of Wyoming)

Paul G. Etchepare, Jr. (Warren Livestock)

J. Joel Farber, P.G. & P.E. (Consultant)

Dr. Peter Huntoon, P.G. (University of Nevada at Las Vegas)

Todd Jarvis, P.G. (Weston Engineering, Inc.)

Ben Jordan (Weston Engineering, Inc.)

Chris Moody, P.G. (Western Water Consultants, Inc.)

Dr. Lisa Stillings, P.G. (U.S. Geological Survey)

Todd Jarvis is the liaison to The Environmental Advisory Committee.

Keith E. Clarey, P.G.

Dr. Thomas V. Edgar, P.E.

J. Joel Farber, P.G. & Professional Engineer

Dr. Peter Huntoon, P.G.

Todd Jarvis, P.G.

Chris Moody, P.G.

Dr. Lisa Stillings, P.G.

DELINEATION REPORT
for the
CASPER AQUIFER PROTECTION AREA

LARAMIE, WYOMING

TECHNICAL REVIEW SUBCOMMITTEE OF THE
ENVIRONMENTAL ADVISORY COMMITTEE

PREPARED FOR:
CITY OF LARAMIE AND ALBANY COUNTY, WYOMING

June, 1999

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1.1.1 A National Perspective

Public drinking water supplies have always influenced the location and development of communities by both defining and directing their growth. Historically, the location of a good source of drinking water was a key factor in determining the location of centers of population. Safe drinking water is essential to the quality of community life because of the link between public health and the quality of the public water supply.

Since the 1986 Amendments to the Safe Drinking Water Act, which established the Wellhead Protection Program (WHP), the United States Environmental Protection Agency (EPA) has supported states and communities in their efforts to protect their sources of drinking water. The EPA Source Water Protection (SWP) goal is that "by the year 2005, 60 percent of the population served by community water systems will receive their water from systems with SWP programs in place under both WHP and watershed protection programs" (EPA, 1997).

Groundwater protection programs in the United States and Canada all follow a similar five-part program guided by public participation; which includes:

1. Forming a local Drinking Water Protection Committee;

2. Identifying land areas that contribute water to public water supplies;

3. Inventorying existing and future potential sources of contamination;

4. Developing a management program to deal with identified existing and future contaminant sources; and

5. Preparing a contingency plan to address contamination incidents and other water supply emergencies.

This report focuses strictly on part two, “identifying land areas that contribute water to public drinking water supplies”. This investigation has been conducted using the broader approach of aquifer protection rather than the more restrictive concept of wellhead protection.

1.1.2 A Regional Perspective

Although several other Wyoming communities have initiated groundwater protection programs, those communities have relied on outside expertise to develop and implement these programs. In contrast, the Laramie Regional Drinking Water Protection Program has adopted a “do-it-yourself” approach, as advocated in “Wyoming’s Wellhead Protection Program Guidance Document” (Wyoming Department of Environmental Quality, 1997). The Laramie Program utilizes the volunteer efforts of over 25 city and county residents divided into five subcommittees, each assigned a task from the groundwater protection program described above. The subcommittee which delineated the aquifer protection area consists of hydrologists, geoscientists, engineers, and others with technical training and background in groundwater protection. Thus, the Laramie Regional Drinking Water Protection Program is proof that community residents can develop Source Water Protection plan for a minimal investment.

1.1.3 A Local Perspective

Approximately 65 percent of the City of Laramie and the South Laramie Water and Sewer District drinking water supplies are derived from wells and springs tapping the Casper aquifer. Many residents who live outside the Laramie municipal area rely on groundwater for 100 percent of their drinking water supplies.

The Casper Formation is exposed along the west side of the Laramie Range (east of the City of Laramie) and is vulnerable to contamination for the following reasons:

- Points of withdrawal (municipal and domestic wells) are in proximity to the recharge area;
- The aquifer is fractured and has extensive exposures of porous sandstones. These fractures are commonly found in topographic drainages where surface water is concentrated prior to recharging the aquifer; and
- Interstate - 80 (I-80) cuts through the entire thickness of the Casper Formation.

Any Aquifer Protection Program must be responsive to the needs and the development of the local community. As such, the Aquifer Protection Plan will be revisited in the future. As new data on the Casper aquifer become available, future workers may decide to revise the aquifer delineation map presented in this report.

Differences between wellhead and aquifer protection programs are summarized below. Additional information may be obtained from the Laramie Regional Drinking Water Protection Program Web page at <**lariat.org/Aquifer/index.html**> and from references listed at the end of this report.

1.2 HISTORY OF THE LARAMIE DRINKING WATER PROTECTION PROGRAM

The City of Laramie was successful in obtaining a grant from the EPA to develop a WHP Plan in 1993. Western Water Consultants, Inc. (WWC) developed the initial approach to delineating WHP areas based on hydrogeologic mapping and development of time-of-travel contours near mapped faults (WWC, 1993). The EPA grant required development of a WHP ordinance, and a draft was completed in late 1996 (City of Laramie, 1996). Citizens voiced numerous concerns at this time, based upon (1) the prescriptive nature of the ordinance, (2) the dependence of the 1993 WHPA upon the location of identified faults, and (3) the exclusion of limestone quarries, located within the Casper Formation, from the WHPA (for example, see Huntoon, 1996).

As a result of citizen concerns and challenges to the proposed WHP ordinance, the City Council and County Commissioners instructed the Laramie Environmental Advisory Committee to develop an Aquifer Protection Program. The primary goal of the program was to develop and implement the Laramie Regional Drinking Water Protection Program for the Casper aquifer.

1.3 WELLHEAD VERSUS AQUIFER PROTECTION

1.3.1 Wellhead Protection Areas

The delineation of a Wellhead Protection Area (WHPA) is an important means of directly and immediately safeguarding the public water supply (Witten and Horsley, 1995). As defined in the 1986 federal Safe Drinking Water Act amendments, a WHPA is "the surface and subsurface area surrounding a water well or wellfield, supplying a public water system, through which contaminants are reasonably likely to move toward and reach such water well or wellfield." Pumping wells within an aquifer will affect the natural movement of groundwater by drawing water to the well. WHPAs are those land areas that contribute groundwater (and potential contaminants) to the pumping wells. In this sense, WHPAs are subsets of the larger, aquifer system (Figure 1-1).

1.3.2 Aquifer Protection Areas

The 1996 Safe Drinking Water Act amendments promote Source Water or "Aquifer" Protection. Aquifer protection will usually encompass a larger area than Wellhead Protection, and thus provides even greater safety for public water supplies over the long term. Wellhead Protection protects the area surrounding a water well or wellfield, while Aquifer Protection protects a larger portion of the whole aquifer, and will likely extend beyond operating wellfields (Figure 1-1). By protecting a larger portion of the aquifer, it is expected that groundwater available to users (from storage and/or recharge in other parts of the aquifer) will be safeguarded from contamination.

The protection of an aquifer requires an understanding of the extent of both the aquifer and its overlying and upgradient lands from which its water is derived (Witten and Horsley, 1995). The delineation of aquifer protection area boundaries is independent of the effects of pumping wells and is more directly related to the natural hydrologic flow patterns. Both surface water and groundwater flow conditions must be factored into the delineation of an aquifer protection area.

2.0 GEOLOGY AND HYDROGEOLOGY OF THE CASPER AQUIFER

The following sections summarize the geology and hydrogeology of the Casper aquifer as it pertains to the delineation of a protection area for the aquifer. The discussion emphasizes the following hydrogeologic elements of the Casper aquifer:

- geologic and stratigraphic description of the region; and
- hydraulic relationship between overlying and underlying rock units.

2.1 GEOLOGY AND GEOLOGIC HISTORY

The Casper Formation is comprised of sandstone interbedded with limestone and shale (Figure 2-1) exposed on the western slope of the Laramie Range, east of the City of Laramie (Figure 2-2). It is approximately 700 feet thick and is informally subdivided from the bottom to the top into five members, named alpha through epsilon, each of which consists of a sandstone layer bounded at the top by a regionally continuous limestone.

The Casper Formation is located below the Satanka Shale and above the Fountain Formation and the underlying Sherman Granite. The Permian Satanka Shale is predominantly red shale with interbedded siltstone and sandstone layers and is approximately 250 to 320 feet thick in the Laramie area. The lower 20 feet of the Satanka Shale has abundant red and white sandstones similar to the underlying Casper Formation. The Satanka Shale is exposed at the base of the Laramie Range near the eastern corporate limits of the City of Laramie.

The Pennsylvanian Fountain Formation is an irregularly distributed sedimentary unit which is thin (less than 50 feet) to absent in the Laramie area (Lundy, 1978). For this document, it will be considered a part of the alpha unit of the Casper aquifer (Figure 2-1).

The Precambrian Sherman Granite is a crystalline igneous rock generally exposed east of the crest of the Laramie Range (Figure 2-2). It was formed by the slow cooling of magma (liquid rock) and is a large mass of interlocking minerals. This is in contrast to the overlying formations which are layered sedimentary rocks derived from chemical precipitation and deposition of detrital material.

During the period of uplift that created the Laramie Range, these rock formations were tilted approximately 3-5 degrees to the west and locally folded and faulted as indicated on Plate I. Folding occurs mostly as east-west trending anticlines and monoclines that plunge to the west. Faulting consists of numerous normal and reverse faults that trend in many directions (Lundy, 1978 and Ver Ploeg, 1996). Not all faults can be observed at the ground surface due to small displacement or to coverage by overlying deposits, such as windblown sand, alluvium and colluvium. In most cases, the faults and folds observed in the Casper Formation do not propagate vertically through the entire thickness of the overlying Satanka Shale. Exceptions are the Sherman Hill and Laramie faults in which offset lithology indicates shearing through the Satanka Shale.

2. 2 HYDROGEOLOGY

The movement of groundwater in the Laramie area occurs primarily in the lateral direction within the permeable layers and, to a lesser extent, in the vertical direction along fractures. The permeabilities within the Casper sandstones are very large in contrast to the overlying and underlying strata. Consequently, hydraulic communication between the formations is limited, and the formations are generally considered distinct hydrostratigraphic units.

2.2.1 Hydrogeology of the Casper Aquifer

The term Casper Formation is used here to describe the geologic material that comprises the unit. The term Casper aquifer is used when describing the water bearing and transmission characteristics of the formation even where the Casper Formation is unsaturated.

As listed in the Glossary, an aquifer is "a formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield sufficient, economical quantities of water to wells and springs." This definition can be interpreted to include only the saturated portion of a formation. For purposes of the Laramie Regional Drinking Water Protection Program, the definition of the Casper aquifer must be expanded to include both the saturated and unsaturated (vadose zone) parts of the Casper Formation. As shown in Figure 2-3, the upper part of the Casper aquifer is unsaturated on the west slope of the Laramie Range. The unsaturated thickness of the Casper aquifer decreases from east to west. During recharge events, the vadose zone transmits water from the surface to the underlying saturated material. In this manner, the entire Casper Formation constitutes the Casper aquifer to account for the recharge, storage, movement and discharge of water.

The saturated portion of the aquifer is relatively thin at the crest of the range and gradually thickens westward toward the Satanka-Casper contact. A short distance west of this contact, the entire thickness of the Casper Formation is saturated and the Casper aquifer attains its maximum thickness as a confined, artesian aquifer due to the confining properties of the overlying Satanka Shale.

East of where the Casper Formation is fully saturated, the exposed sandstone units may be confined or unconfined depending on their location, as shown in Figure 2-3. The limestones that separate the sandstones have negligible permeabilities and serve as local confining layers that define subaquifers within the Casper aquifer. Therefore, the informal members, designated in descending order (epsilon, delta, gamma, beta, and alpha), comprise subaquifers within the Casper aquifer (Figure 2-2).

2.2.2 Hydrogeology of the Sherman Granite

The Sherman Granite, as used here, includes associated granite gneiss and other metamorphic lithologies underlying the Casper Formation. Unaltered Sherman Granite has extremely low intergranular or intercrystalline permeability. Like most granites, permeability within the Sherman Granite is limited to where the granite is extensively weathered and/or fractured by faults and joints. Many domestic wells obtain drinking water from the granite, but well yields are typically small and dependent on fractures.

To date, there has not been a systematic study of the hydrogeology of the Sherman Granite and its hydraulic relationship to the Casper aquifer. Because of the much lower permeability and limited storage capacity of fractures in the Sherman Granite compared to the sandstones of the Casper Formation, the Sherman Granite is treated here as a confining unit below the Casper aquifer.

However, if faults in the Casper Formation are continuous between the two units, there may be some hydraulic connection between them. Preliminary chemical analyses of strontium concentrations and isotopic ratios from waters within the Casper aquifer suggest there may be some mixing between waters of the Sherman Granite and the Casper aquifer (Frost and Toner, 1996). It is believed that any hydraulic connection is minor due to the small permeability of the unfractured crystalline rock and the limited storage capacity of fractures. Therefore, the Sherman Granite will be assumed to be an aquitard or aquiclude (see Glossary).

2.2.3 Hydrogeology of the Satanka Shale

The hydraulic relationship between the Satanka Shale and the Casper aquifer is a critical element in the delineation of a protection area for the Casper aquifer. The hydrogeology of the Satanka Shale has not been studied in detail, but observations made during studies of the Casper aquifer provide some data regarding the hydraulic relationship between the Satanka Shale and the underlying Casper aquifer (Lundy, 1978; Huntoon and Lundy, 1979; WWC, 1993, 1994, 1997a,b and Weston, 1995).

Taken in its entirety, the Satanka Shale is a regional confining layer above the Casper aquifer. However, the permeable sandstones in the Satanka Shale provide water to many domestic and stock wells in the Laramie area. Approximately 300 feet of shale, siltstone, and sandstone isolates the Casper aquifer from overlying aquifers including permeable beds within the Satanka Shale.

The hydraulic head in the Casper aquifer is typically 20 to 40 feet greater than the heads in the permeable layers within the Satanka Shale. The Casper aquifer is confined where overlain by the Satanka Shale (JMM, 1989; WWC 1993, 1994, 1997a,b; and Weston, 1995). Hydraulic separation between the Casper aquifer and permeable layers in the Satanka Shale has been documented during pumping tests conducted at the Spur Wellfield, LaPrele Park Prospect, and the Turner Wellfield where no observable head declines occurred in the monitored intervals in the Satanka Shale as the Casper aquifer was pumped (WWC, 1993, 1996, 1997a,b).

Important for the Laramie Regional Drinking Water Protection Program is the fact that fractures in the lower 50 feet of the Satanka Shale can be permeable. In contrast to the observations above, there are some localities where groundwater from the Casper aquifer has been observed to flow upward into the lower 50 feet of the Satanka Shale at Simpson, Soldier, and Pope Springs (Plate I). Consequently, to be safe, the protection provided for the Casper aquifer is extended to the lower 50 feet of the Satanka Shale.

More detailed information regarding the geology and hydrogeology of the Casper aquifer may be obtained from Morgan (1947), Huntoon (1976), Lundy (1978), Huntoon and Lundy (1979), Thompson (1979), WWC (1993, 1994, 1996) and Ver Ploeg (1996).

3.0 PHYSICAL CHARACTERISTICS OF THE CASPER AQUIFER

This section summarizes the physical characteristics of the Casper aquifer as it pertains to the delineation of a protection area for the Casper aquifer. The discussion emphasizes the following hydrologic elements of the Casper aquifer:

- groundwater flow patterns;
- permeability characteristics;
- recharge area; and
- geologic features that enhance the vulnerability of the aquifer to contamination.

3.1 GROUNDWATER FLOW PATTERNS

As shown on published potentiometric surface maps, groundwater in the Casper aquifer in the vicinity of Laramie generally flows from east to west, from areas of high elevation at the crest of the Laramie Range toward lower elevations within the Laramie Basin (Lundy, 1978; Thompson, 1979). This pattern is altered locally to a more radial pattern close to the City's municipal wellfields and the springs, which discharge large quantities of water from the Casper aquifer. Flow patterns are also locally altered to some degree by the permeability imparted by fracturing associated with faults and folds.

3.2 PERMEABILITY CHARACTERISTICS

There are two types of permeability in the Casper aquifer: (1) intergranular permeability; and (2) conduit flow. Intergranular permeability refers to the ability to transmit water through the pore spaces between individual grains in the undeformed aquifer. In the Casper aquifer, the sandstones have large intergranular permeability whereas the limestones have negligible permeability. Ground water flow through the sandstone matrix is slow, with calculated velocities approaching 0.8 feet per day (WWC, 1993). The permeability of the limestones is several orders of magnitude less than the sandstones.

The intergranular permeability of the sandstones that comprise the five members of the Casper Formation is variable, with the greatest permeability occurring in the epsilon and delta members and the lowest permeability in the alpha member. The variation is due to the greater abundance of very fine sand, silt, and calcite cement that fill the pore spaces in the lower sandstones. Intergranular permeability is responsible for providing water to wells on the order of 1 to 100 gallons per minute (gpm).

Conduit flow refers to the flow of water through cavities or fractures associated with dissolution, faults, folds, joints, and partings along bedding planes. Conduit flow is typically orders of magnitude greater than intergranular permeability, and is capable of yielding large quantities of water to wells, as demonstrated by the Laramie municipal wells. Production from the municipal wells that penetrate the fractured aquifer is on the order of 1,500 to 2,500 gpm. These high-yield wells tap fractures associated with faults and folds that have deformed the Casper Formation. At the Spur and Turner wellfields, where the aquifer has been fractured, the upper and lower members of the Casper Formation are hydraulically connected with each other through the fractures.

Specific permeability enhancements associated with the faults and folds in the Casper aquifer shown on Plate I cannot be determined with certainty; some structures may enhance aquifer permeability while others may reduce permeability. Although the effects that each structure has on aquifer permeability are not known, it is important to recognize the hydraulic complexity imparted to the Casper aquifer by geologic structures such as faults and folds.

3.3 RECHARGE AREA

Recharge refers to the replenishment of the Casper aquifer by the infiltration of water derived from rainfall and snowmelt through the unsaturated zone. This process occurs to some degree wherever the Casper Formation is exposed at the surface. Consequently, the entire surface exposure of the Casper Formation is assumed to be the recharge area for the Casper aquifer.

Lundy (1978) observed surface water infiltrating directly into the exposed gamma sandstone which has relatively large intergranular permeability; whereas, surface water tends to shed off exposed limestones, which have low permeability. In addition to infiltration into the porous sandstones, infiltration into the subsurface is enhanced by fractures, joints, and faults exposed at the surface, particularly in drainage channels eroded along fracture zones.

Careful examination of water level data by WWC (1997b) during a storm event showed increases in water levels in most of the monitoring wells observed during the pumping test of the Spur production wells located in Township 16N, Range 73W. The change in water levels appeared to be in response to a change in head in the recharge area.

3.3.1 Tritium Data

Tritium is used to age-date groundwater. Tritium dating is based on detecting the existence of tritium produced in atmospheric hydrogen bomb tests in the 1950's and 1960's in a water sample. Dr. Carol Frost and Rachel Toner of the University of Wyoming measured tritium concentrations in Casper aquifer water collected from a variety of domestic and municipal wells in the Laramie area. The presence of tritium indicates that the groundwater was exposed at the surface during the 1950's. These analyses indicate that Casper water withdrawn from the Turner Wellfield and Soldier Springs is young, with most of the water having been recharged within the last 43 years. Water less than 43 years of age was also detected at a domestic well in Sherman Hills Estates (Frost and Toner, 1996).

This research indicates that the well and spring water in the Laramie municipal supply is young, inasmuch as the water being produced from the aquifer was recharged within approximately the last 40 years. This suggests that water travels quickly through the aquifer, making it vulnerable to contamination. It is likely that a contamination event would affect the municipal well supply within a few decades, at most.

4.0 DELINEATION METHODS

Hydrogeologic mapping was used to delineate the protection area for the Casper aquifer. This procedure is often the most appropriate method for aquifer protection, whereas mathematical/analytical procedures are often more appropriate for wellhead protection. The protection area for the Casper aquifer in the Laramie area was based on the review of existing data which allowed the determination of the geologic boundaries of the aquifer and the areas within those boundaries that require different levels of protection.

This section presents a flowchart (Figure 4-1) that describes the decision-making process used to define the aquifer protection area. An aquifer protection area delineation is dependent on three primary factors:

- The amount of available information regarding aquifer characteristics;
- The accuracy of the existing information; and
- The delineation methodology selected and applied in the process.

Known information concerning the Casper aquifer in the Laramie area was reviewed, often by the authors of the original documents, and updated with the most recent information available from mapping, drilling and aquifer testing, both published and unpublished. The aquifer protection area delineation that follows represents the consensus view of the Technical Review Subcommittee as the best representation of the aquifer protection area required for the Casper aquifer. The decision-making process described in Figure 4-1 was used to reach this consensus of opinion.

5.0 DELINEATION PROCESS

The purpose of aquifer protection is to safeguard the public water supplies for both present and future uses. The purpose of the delineation process is to define and map the aquifer protection areas. An aquifer protection area considers the entire groundwater resource including both existing and potential groundwater supply development areas. Within this framework, this section describes the decisions made by the Technical Review Committee to define and map the aquifer protection areas for the Casper aquifer in the Laramie area.

5.1 Fundamental Assumptions

Based on the information presented in Sections 2 and 3, the following were viewed as the fundamental assumptions about the Casper aquifer. The Technical Review Subcommittee reached a unanimous consensus on these issues during the delineation process:

- Groundwater flow within the Casper aquifer includes both porous flow (intergranular) and conduit flow (faults, fractures, joints, and dissolution cavities);
- The epsilon and delta members of the Casper Formation have higher permeability than the underlying gamma, beta and alpha members;
- The Casper aquifer is underlain by the Sherman Granite which acts as an aquitard or aquiclude;
- The Casper aquifer is unconfined or semi-confined in most of the outcrop area of the Casper Formation;
- The recharge area for the Casper aquifer is the entire exposed outcrop area of the Casper Formation along the western slope of the Laramie Range. Recharge mechanisms for the Casper aquifer include direct infiltration from precipitation and snow melt and infiltration of surface water run-off, particularly in natural drainage channels;
- The aquifer generally is confined when covered by the Satanka Shale; and
- The lower 50 feet of the Satanka Shale is fractured and in hydraulic connection with the Casper Formation.

Based on these assumptions, the Technical Review Committee agreed on the locations of the current boundaries of the aquifer protection areas and recommended a procedure to be followed when modifying the boundaries in the future.

The aquifer protection delineation discussed below is based on the Technical Review Committees' present understanding of the hydrogeology and extent of the Casper aquifer, its recharge mechanics and the dynamics of groundwater movement between the aquifer and underlying and overlying geologic strata. The current state of hydrogeologic knowledge of the Casper aquifer is limited to available data, and is subject to refinement as new data are collected and become available.

5.2 DELINEATION OF THE EASTERN BOUNDARY

5.2.1 Geologic Considerations

The Sherman Granite crops out high on the east side of the Laramie Mountains. The Casper Formation is exposed on both the eastern and western sides of the summit. Eastward draining springs are located above the exposed granite in the Casper Formation. For these springs to exist, there must be flow in the easterly direction on the east flank of the range.

5.2.2 Hydrologic Considerations

The eastern boundary of the Casper aquifer protection area is located at the topographic divide along the crest of the Laramie Range. This determination is based on the following rationale:

- The Sherman Granite serves as a confining layer under the Casper aquifer;
- The topographic divide is generally very close to the easternmost outcrop of the Casper Formation, which is the contact between the Casper Formation and the underlying Sherman Granite; and
- The topographic divide of the Laramie Range is generally coincident with the groundwater divide based on the presence of springs that discharge along the contact between the Casper Formation and the Sherman Granite. Consequently, groundwater stored in the Casper Formation east of the topographic divide probably flows eastward.

The eastern boundary shown on Plate I is the topographic divide.

5.3 DELINEATION OF THE WESTERN BOUNDARY

The western boundary of the Casper aquifer protection area is located west of the contact between the Satanka and the Casper Formations. The western boundary of the protection area was selected after careful consideration of the effectiveness of the Satanka Shale as a hydrogeologic confining layer over the Casper aquifer.

5.3.1 Geologic Considerations

The Satanka Shale was described in Section 2.0. It is important to note that:

- The base of the Satanka Shale is interbedded fractured shale and sandstone;
- Both the Casper Formation and the Satanka Shale are locally fractured and faulted due to structural deformation; and
- The extent of structural deformation in the Casper Formation and the Satanka Shale is variable both geographically and stratigraphically in the Laramie Basin.

5.3.2 Hydrologic Considerations

The existing hydrogeologic data were evaluated and a determination was made that the Satanka Shale generally acts as a confining layer for the Casper aquifer in the Laramie Basin. While the data distribution is less than ideal and is subject to multiple working hypotheses, the following observations of spring and well data indicate that the lower 50 feet of the Satanka Shale can be permeable and in hydraulic connection with the Casper aquifer.

- The water at Simpson Springs flows from the Casper aquifer through approximately 50 feet of fractures in the basal Satanka Shale; and

- Water levels measured in T15N, R73W, Section 1 reveal only a small difference in hydraulic head between the Satanka Shale and the Casper Formation.

The Technical Review Committee is concerned that the Casper aquifer may be vulnerable to contamination if 50 feet or less of Satanka lies between the Casper Formation and the ground surface. The Technical Review Committee agreed that at least 75 vertical feet of Satanka Shale (50 percent more than the thickness of the zone of apparent connectivity) is needed to safely and effectively shield the Casper aquifer from contaminants that may be spilled or introduced at or near the ground surface.

The actual location of the western boundary for the protection area is the distance from the Casper-Satanka contact that provides 75 feet of shale cover when the dip of the formation and slope of the ground surface are considered. Figure 5-1 illustrates the procedure to predict the offset of the western boundary from the contact. As the dip in the Satanka becomes greater, the offset distance gets shorter. The stratigraphic remainder of the Satanka Shale is considered to be an effective confining layer above the Casper aquifer.

The western boundary of the protection area is the easternmost edge of the line indicated in Plate I.

5.4 DELINEATION OF THE PRIMARY AND SECONDARY AQUIFER PROTECTION AREAS

The Technical Review Committee agrees that the total outcrop of the Casper Formation should be divided into two subareas, designated as the Primary Protection Area, and the Secondary Protection Area. The Primary Protection Area, owing to its greater natural vulnerability and to the greater number of existing wells, should have a greater degree of protection than the Secondary Protection Area.

The outcrop area of the delta and epsilon sandstone members of the Casper Formation was designated to be the Primary Protection Area based on the following considerations:

- The intergranular permeability of the delta and epsilon sandstone members is much greater than the intergranular permeability of the underlying alpha, beta, and gamma members;

- There is proximity of outcrops of the delta and epsilon sandstone members of the Casper Formation to the municipal groundwater supply wells for the City of Laramie; and

- The primary stratigraphic location of the municipal groundwater supply wells and springs for the City of Laramie are the epsilon and delta members of the Casper Formation.

Because the delta sandstone member is one of the most permeable of the five members, the Technical Review Committee agreed to extend the eastern boundary of the Primary Protection Area 200 feet east of the base of the delta sandstone outcrop. This provides a buffer to prevent contaminants from directly entering the exposed edge of the delta member of the Casper Formation. In those situations in which the 200 foot buffer creates an enclosed or nearly enclosed area of Secondary Protection Area, the entire area will be designated as a Primary Protection Area. The westernmost edge of the line will mark the boundary.

The remainder of the area of outcrop of the Casper Formation, easterly to the topographic divide of the Laramie Range, is designated as the Secondary Aquifer Protection Area.

5.5 NORTH AND SOUTH BOUNDARIES OF THE AQUIFER PROTECTION AREA

The north and south boundaries of the aquifer protection areas have been arbitrarily defined as the extent of the mapped area as shown on Lundy's (1978) geologic base map. As development occurs in these areas, the Aquifer Protection Boundaries should be extended using the same criteria developed above.

6.0 AQUIFER PROTECTION MAP

The Aquifer Protection Map, developed using the procedures outlined in Section 5, is presented as Plate I. Plate I is also presented on the Laramie Regional Drinking Water Protection Program Web page at <**lariat.org/Aquifer/index.html>**. If discrepancies exist between the Plate and the Web page, the Plate will remain the controlling document.

Plate I shows the limits of both the Primary and Secondary Aquifer Protection Areas. The actual boundary between the two areas is the western side of the line indicated on Plate I.

7.0 DATA SHORTFALLS AND FUTURE RECOMMENDATIONS

7.1 LIMITATIONS OF THE DELINEATION

The delineation of the Aquifer Protection Areas described above is limited to the Casper aquifer. Other aquifers, although significant to local groundwater supplies, are not considered in this delineation report.

Protection area boundaries were established based on the consensus of the Technical Review Committee that examined available reports and data pertinent to the description of the aquifer and the delineation of the contributing recharge area. The Technical Review Committee comprised people with intimate knowledge of the land and water resources of the area, including professionals in the fields of geology, engineering, and earth science.

The northern and southern extents of the Aquifer Protection Area were selected arbitrarily as the limit of the area evaluated by Lundy (1978). As the Laramie Regional Drinking Water Protection Program matures and new sources of water are developed along with review of new hydrogeologic data, areas to the north and south should undergo the same protection as the region outlined in this report.

7.2 SITE SPECIFIC MODIFICATIONS TO THE PLAN

While establishing boundaries for the aquifer protection area, the Technical Review Committee recognized that the location of zone boundaries may be altered in the future as more information becomes available. Site specific changes to the boundaries of the aquifer protection area should only be allowed:

- When a site investigation shows significant variation from the assumptions presented herein; and
- Based on the recommendations of a qualified water resource professional licensed by the State of Wyoming to practice engineering and/or geology.

In any determination, the criteria established in this report should be consistently applied to any proposed modification to the protected areas.

7.3 REVISING AND UPDATING THE PLAN

The Wyoming Wellhead Protection (WHP) Program Guidance Document requires that a local Wellhead Protection Plan must be updated every two years. Following this guideline, revisions to the Aquifer Protection Areas should be made when new information is available concerning:

Hydrologic characteristics of the Casper aquifer;

Changes in water supply, or pumping volumes;

New potential sources of contamination;

Changes in land use within the delineated protection areas;

New management strategy development or implementation;

Contingency planning and emergency response; and/or

Planning or developing of new water supplies.

7.4 SPECIAL AREAS OF CONSIDERATION

There are several areas within the delineated zone that require special consideration.

7.4.1 Transportation Corridors

Interstate-80 is located in a particularly vulnerable area of the Casper aquifer. Special contingency planning provisions should be developed to ensure that potential impact to the water supply is minimized in case of vehicular accidents or accidental spills. Similar considerations should be made for railroad lines and pipelines.

7.4.2 The Existing Wellfields

The Turner Wellfield is located adjacent to Grand Avenue. The wells were drilled through the Satanka Shale to the beta member of the Casper Formation. The Satanka Shale comprises layered shale, siltstone and sandstone. It is possible that water could infiltrate into an upper sandstone unit and flow into the well. A safety zone of at least a 100-foot radius should be established around each of the wellheads (based on the Wyoming WHP Guidance Document) to reduce the possibility of this source of contamination.

Pope Springs and Soldier Springs are two naturally occurring artesian springs that are fed, in part, by fracture flow in the lower Satanka Shale. Subsequently, these springs have been developed by construction of wells. A similar safety zone should also be established around each wellhead in the wellfields to preclude accidental contamination of the wells.

Many land and home owners in the area could be impacted by contamination upgradient of their wells. The Laramie Regional Drinking Water Protection Program will help minimize the potential impact of contaminants both on and off of their property. It is recommended that homeowners be educated concerning the importance of avoiding conducting potentially hazardous activities within a 100-foot radius of their private wells. Eliminating septic systems, fertilizer applications, and other chemical releases (e.g., automotive fluids) within 100 feet of wells will serve to protect private water supplies in the area, as well as Laramie’s municipal water supply.

7.5 POTENTIAL CONTAMINATION FROM CURRENT LANDHOLDERS IN THE AQUIFER PROTECTION ZONES

The possibility of contamination from current landholders in the protected areas does exist. Potential sources of contamination include nitrates from applied fertilizers, herbicides, pesticides, effluent from septic systems and accidental and/or intentional releases of chemicals. These and other potential sources can be identified during the contaminant inventory conducted as a separate phase of the Laramie Regional Drinking

Water Protection Program. It may be reasonable for the City and County to determine the existence of, and lateral extent of, any potential contaminant deemed a viable threat to the city's water supplies.

7.6 PROJECTED LAND USE

It has been assumed that the projected land uses will be similar to current practice (i.e., residential and agricultural). Even light industry is restricted to several distinct locations. Any change to this condition should be evaluated to prevent potential detriment to the aquifer.

Much of the area regarded for protection is currently being subdivided for residential development. In 1997, the Wyoming State Legislature approved legislation that provides for review of planned water supply and sewer systems for proposed new subdivisions by the Department of Environmental Quality (WDEQ) and the Wyoming State Engineer's Office (SEO). The WDEQ and SEO are tasked with reviewing applications submitted though County Commissions to determine the adequacy and safety of the planned systems.

The application process, which is described in a document published by the WDEQ/Water Quality Division, entitled "Wyoming's Subdivision Program, Guidance Document (1998)", should be followed by the Albany County Commission for new subdivisions proposed in the Aquifer Protection Areas.

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Chapter
3

Delineation Report (Version 2.0)

Introduction

Drinking Water Protection Programs

National Perspective

Public drinking water supplies have always influenced the location and development of communities by both defining and directing their growth. Historically, the location of a good source of drinking water was a key factor in determining the location of centers of population. Safe drinking water is essential to the quality of community life because of the link between public health and the quality of the public water supply.

Since the 1986 Amendments to the Safe Drinking Water Act, which established the Wellhead Protection (WHP) Program, the United States Environmental Protection Agency (EPA) has supported states and communities in their efforts to protect their sources of drinking water. The EPA Source Water Protection (SWAP) goal is that "by the year 2005, 60 percent of the population served by community water systems will receive their water from systems with SWAP programs in place under both WHP and watershed protection programs" (EPA, 1997).

As part of Wyoming's Source Water Assessment and Protection Program, a source water assessment for Laramie was completed in June 2004 (Trihydro, 2004). The SWAP program is a two-part program consisting of source water assessments and source water protection plans. The groundwater portion of the Laramie source water assessment was derived, in large part, from information provided in this delineation report while the CAPP addresses the groundwater protection plan component. The City is working on developing a protection plan for the surface water supply (Laramie River).

Groundwater protection programs in the United States and Canada all follow a similar five-part program guided by public participation, which includes:

- Forming a local Drinking Water Protection Committee;
- Identifying land areas that contribute water to public water supplies;
- Inventorying existing and future potential sources of contamination;
- Developing a management program to deal with identified existing and future contaminant sources; and
- Preparing a contingency plan to address contamination incidents and other water supply emergencies.

This chapter focuses strictly on, "identifying land areas that contribute water to public drinking water supplies". The delineation of these land areas has been conducted using the broader approach of aquifer protection rather than the more restrictive concept of WHP as explained later in the chapter.

Local Perspective

Although several other Wyoming communities have initiated groundwater protection programs, those communities have relied on outside expertise to develop and implement these programs. In contrast, the Laramie Regional Drinking Water Protection Program (LRDWPP) has adopted a “do-it-yourself” approach, as advocated in *Wyoming’s Wellhead Protection Program Guidance Document* (Wyoming Department of Environmental Quality, 1998). The LRDWPP utilizes the volunteer efforts of over 25 city and county residents divided into five subcommittees, each assigned a task from the groundwater protection program described above. The subcommittee which delineated the aquifer protection area consists of hydrologists, geoscientists, engineers, and others with technical training and background in groundwater protection. Thus, the Laramie Regional Drinking Water Protection Program is proof that community residents can develop a source water protection plan for a minimal investment.

Approximately 50 percent of the City of Laramie and the South Laramie Water and Sewer District drinking water supplies are derived from wells and springs tapping the Casper aquifer. Many residents who live outside the Laramie municipal area rely on groundwater for 100 percent of their drinking water supplies.

The Casper Formation, which provides water to the City of Laramie and Laramie area residents, is exposed along the west side of the Laramie Range (east of the City of Laramie) and is vulnerable to contamination for the following reasons:

- Points of withdrawal (municipal and domestic wells) are in proximity to the recharge area;
- The aquifer is fractured and has extensive exposures of porous sandstones;
- There are existing areas of residential and commercial development on the recharge area and the potential for additional future development in the recharge area; and
- Interstate 80 (I-80), across which numerous hazardous substances are transported each day, cuts through the entire thickness of the Casper Formation.

Any aquifer protection program must be responsive to the needs and the development of the local community. For a community to remain viable and support development it must have a safe source of drinking water. As such, the aquifer protection plan is a dynamic document and will be revisited in the future. As new data on the Casper aquifer become available, future committee members may decide to revise the aquifer protection area delineation presented in this report.

History of the Laramie Regional Drinking Water Protection Program

The City of Laramie was successful in obtaining a grant from the EPA in 1993 to develop a WHP Plan. Western Water Consultants, Inc. (WWC) of Laramie developed the initial approach to delineating WHP areas for the City’s municipal wellfields at City, Pope, and Soldier Springs. The delineations were based on hydrogeologic mapping and time-of-travel contours defined by major faults and assumed hydraulic behavior of faults and folds (WWC, 1993). The EPA grant required development of a WHP ordinance, and a draft was completed in late 1996 (City of Laramie, 1996). Citizens voiced numerous concerns at that time, based upon (1) the prescriptive nature of the ordinance, (2) the dependence of the 1993

WHPA upon the location of identified faults, and (3) the exclusion of limestone quarries, located within the Casper Formation, from the WHPA.

As a result of citizen concerns and challenges to the proposed WHP ordinance, the Laramie City Council and Albany County Commissioners instructed the Laramie/Albany County Environmental Advisory Committee (EAC) to develop an aquifer protection program consistent with the goals of the LRDWPP for the Casper aquifer. The aquifer protection program provides a higher level of safety for public water supplies because it includes the entire aquifer resource and its users in the vicinity of the City of Laramie, rather than focusing solely on the municipal wellfields.

In 1998 the first delineation of the aquifer protection area was developed by the EAC Technical Review Subcommittee. The subcommittee comprised engineers, geologists, hydrogeologists, and one citizen at large. The subcommittee developed consensus regarding a delineation method and the plan was signed by the Technical Review Subcommittee members on July 25, 1999. The delineation report was presented at a joint work session of the Albany County Commissioners and the Laramie City Council. Both governing bodies gave approval of the delineation through Joint Resolution N. 2000-02 on January 4, 2000, which was desired before work continued on subsequent chapters of the plan. A copy of the resolution is contained in Appendix A.

The delineation chapter was later submitted to the Wyoming Department of Environmental Quality-Water Quality Division (DEQ) for preliminary approval of the delineation methods. DEQ staff stated that three deficiencies in the delineation needed to be addressed. The three deficiencies were:

- The lack of a Zone 1 protection area for each supply source;
- Clear identification of Zone 2 and Zone 3 protection areas and the basis for the northern and southern boundaries of the protection areas did not comply with the criterion for the WHP Guidance Document; and
- The lack of a higher level of protection for faults and other vulnerable features.

This version, Version 2.0, of the delineation report has been prepared in an attempt to meet the requirements of the DEQ and to aid in completing a plan that is both protective of the aquifer and readily implemented. A copy of the first aquifer protection plan delineation report, Version 1.0, is contained in Appendix B in its entirety to preserve the integrity of the initial delineation report.

Geology and Hydrogeology of the Laramie Area

The basic geology of an area is described by the structure and stratigraphy of the rocks. Structure refers to the distribution of rock units on the ground surface and in the subsurface. This distribution is determined by the original processes of rock formation and by later events that move and deform the rock. Stratigraphy refers to the composition and sequence of the rock units. Together, structure and stratigraphy define the framework of the earth materials that control the occurrence and movement of groundwater.

Structural Setting

Regional Setting

The City of Laramie and the wells and springs serving the City are located within the Laramie structural basin. The basin is a broad, north-plunging, asymmetrical syncline that is bounded on the west by the Medicine Bow Mountains, on the east by the Laramie Range and on the south by the Front Range. To the north the Laramie basin is bounded by a series of anticlines rather than by mountain ranges.

Local Setting

The Laramie Range, which bounds the Laramie basin on the east, lies immediately east of the City limits. The range was uplifted by compressional forces during the Laramide orogeny between 75 and 50 million years ago. In the Laramie area, this uplift resulted in generally uniform stratigraphic dips of between 3 and 5 degrees to the west, with the rocks striking nearly north-south. However, the uplift was not entirely uniform and faults and folds locally interrupt the dip regime (Lundy, 1978).

Faults

There are two fault types in the Laramie area. The apparent oldest set of faults is the reverse faults and monoclines, which were associated with the compression and uplift of the Laramie Range. There are also normal faults, with associated folds, which were formed by extensional stress. Lundy (1978) and VerPloeg (1998) have mapped the locations of faults in the Laramie area. Mapping in the Laramie area by VerPloeg is continuing at the present time through the efforts of the Wyoming State Geological Survey.

In most cases, the faults and folds observed in the Casper Formation do not propagate vertically through the entire thickness of the overlying Satanka Shale. Exceptions are the Sherman Hill and Laramie faults, in which offset lithologies indicate shearing through the lower, more brittle part of the Satanka Shale.

Reverse Faults:

The Horse Creek, Red Hills and Laramie Faults are all reverse faults. Lundy (1978) also indicates that the Spur and Pilot Hill monoclines are cored by reverse faults. The reverse faults tend to have north to northwest trends and are steeply dipping. These features were the result of northeasterly compressional stresses (VerPloeg, 1998). The offset along the fault planes range up to 250 feet and most of the faults have upward offset on the west side of the structure (Lundy, 1978). Folding of the sedimentary rocks extends away from the fault plane on the Horse Creek reverse fault a distance of less than 50 feet (Lundy, 1978). The width of the deformation associated with the fault reportedly increases in some areas but no widths are provided.

Normal Faults:

Several major normal faults are mapped in the Laramie area. These faults include the Lincoln, Soldier, Pope, Sherman Hills, Quarry, Jackrabbit, City Springs and Spur faults. These major faults trend northeast to east-west. The faults were probably the result of relaxation of the compressional stresses that formed the reverse faults (VerPloeg, 1998). Numerous minor faults also occur in the Laramie area. Many of these are mapped; however, others may exist but have small displacements and/or are covered by Quaternary alluvial and colluvial deposits. There are no apparent trends in the orientation of the minor faults. The displacement across the normal faults ranges from a few inches to as much as 200 feet (Lundy, 1978), with most of the faults having downward displacement on the south block (VerPloeg, 1998). The dip on the fault plane of the normal faults are steep, ranging from 60 to 80 degrees (Lundy, 1978). Lundy (1978) reports that the rocks adjacent to the faults are folded in zones tens of feet wide and the offsets on the folds are approximately the same as the offset on the faults.

Folds

Folding in the Laramie area predominantly occurs as east-west trending, west-plunging anticlines and monoclines. The Simpson Springs anticline and the Spur Monocline are examples of east-west trending folds in the Laramie area. There are also numerous folds mapped by Lundy (1978) and VerPloeg (2000) that are associated with faults. These structural features include the Horse Creek, Jackrabbit, Soldier and Quarry monoclines.

Specific Structural Features

As early as 1976 the potential role of faults and folds in supplying groundwater to historic springs and municipal wellfields in the Laramie area was recognized (Huntoon, 1976). The occurrence of springs and the large production characteristics at each of the municipal wellfields are believed to be related to a particular fault, fold or fault/fold system. The discussion that follows provides a cursory overview of the faults and folds associated with the historic springs and municipal wellfields in the Laramie area.

The Spur Anticline trends northwest to southeast and has a northwest plunge. Dips on the north side of the anticline range from 30 to 50°, while the dips on the south side vary from 4 to 10° (WWC, 1997). The anticline is cored by a high-angle reverse fault and has a stratigraphic displacement of up to 250 feet (Lundy, 1978). This structural feature was targeted by the City during development of the Spur wellfield.

The City Springs Fault is a normal fault with downward relative displacement on the northwest side of the fault. The fault trends northeast-southwest and has measured stratigraphic displacements of between 20 and 150 feet (Lundy, 1978). The Spur Fault is a northeast-southwest trending normal fault. Displacement along the Spur Fault ranges from 50 to 200 feet, with the downward relative displacement being on the northwest side of the fault (Lundy,1978). The Spur Fault intercepts the City Springs Fault approximately one-mile northwest of the City Springs. Jackrabbit Fault is an east-west trending fault that grades eastward into a monocline. Downward displacement on the fault is to the south and ranges from 30 to 80 feet (Lundy, 1978). Jackrabbit and City Springs Faults intersect approximately two miles northwest of the City Springs. The Quarry Fault is also an east-west trending normal fault that is mapped as occurring in conjunction with a monocline (Lundy, 1978). The displacement of the fault is downward to the south and has a maximum displacement of 60 feet (Lundy, 1978). The western terminus of the Quarry and City Springs Faults converge in the vicinity of City Springs.

The Pope wellfield is located near the western end of the Pope Fault. The stratigraphic displacement is up on the north side of the fault. The total displacement of the Pope Fault has not been measured.

The Soldier Fault is an east-west trending normal fault that grades into a monocline on its eastern end. The fault has a measured displacement of 40 feet downward on the northern side of the structure (Lundy, 1978).

Stratigraphy

In the Laramie area several geologic units are present. Those units that are of concern include the sequence from the Sherman Granite to the Satanka Shale. The following section provides a summary of these units.

Precambrian Rocks

The Precambrian Sherman Granite is a coarsely-crystalline igneous rock which is predominantly exposed east of the crest of the Laramie Range (Figure 3-2). It was formed by the slow cooling of magma (liquid rock) and is a large mass of interlocking minerals. Other Precambrian rocks in the Laramie area include granite, gneiss, anorthosite and gabbro, which are intruded by the Sherman Granite. These rock types are in contrast to the overlying formations that are layered sedimentary rocks derived from chemical precipitation and deposition of detrital material.

Fountain Formation

The Pennsylvanian Fountain Formation is an irregularly distributed sedimentary unit which is thin (less than 50 feet) to absent in the Laramie area (Lundy, 1978). It is comprised of continental, arkosic sandstone, with minor amounts of siltstone. Where the Fountain Formation is present it unconformably overlies the Precambrian basement rocks. Because the unit is not locally continuous, where it is present, it is grouped with the overlying Casper Formation in this report.

Casper Formation

The Pennsylvanian-Permian Casper Formation unconformably overlies the Fountain Formation, where the Fountain is present or the Precambrian basement rocks where the Fountain is absent. The Casper Formation is comprised of marine and eolian sandstones, interbedded with marine limestone and minor amounts of shale (Figure 3-1). Limestone comprises approximately 15 percent of the formation. The Casper Formation is exposed on the western slope of the Laramie Range, east of the City of Laramie (Figure 3-2). It is approximately 700 feet thick and is informally subdivided from the bottom to the top into five members, designated alpha through epsilon, each of which consists of a sandstone layer bounded at the top by a regionally continuous limestone (Lundy, 1978).

Satanka Shale

The Permian Satanka Shale unconformably overlies the Casper Formation and is predominantly red shale with interbedded siltstone and sandstone layers and is approximately 250 to 320 feet thick in the Laramie area. The lower 20 feet of the Satanka Shale has several thin red and white sandstone beds, which are lithologically similar to the sandstones of the underlying Casper Formation. The Satanka Shale is exposed along the western margin of the Laramie Range, near the eastern corporate limits of the City of Laramie.

Hydrostratigraphy

The term “formation” is used in this report to describe the lithologic materials that comprise the unit. The term “aquifer” is used to describe the water bearing and transmission characteristics of the formation, even where the formation is unsaturated. As listed in the Glossary, an aquifer is “a formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield sufficient, economical quantities of water to wells and springs.” This definition can be interpreted to include only the saturated portion of a formation. Figure 3-3 provides a general description of the hydrogeologic role of the formations present in the Laramie area. The following sections provide a detailed description of the hydraulic role of the geologic units in the Laramie area.

Sherman Granite

Unaltered Sherman Granite has practically no intergranular or intercrystalline permeability. Like most crystalline rocks, permeability within the Sherman Granite is limited to areas where the granite is extensively weathered and/or fractured by faults and joints (Richter, 1981). Groundwater movement within the Sherman Granite is typified by conduit flow. Many domestic wells obtain drinking water from the granite, but well yields are typically small and dependent on the permeability of the fractures. Short-term pump tests of wells completed in the Sherman Granite indicate that the minimum yield is zero, where the rocks are not fractured, and the maximum anticipated yield is approximately 20 gallons per minute in weathered or fractured granite (WSEO Records, various).

To date, there has not been a systematic study of the hydrogeology of the Sherman Granite and its hydraulic relationship to the overlying Casper aquifer. Because of the much lower permeability and limited storage capacity of fractures in the Sherman Granite compared to the sandstones of the Casper Formation, the Sherman Granite is treated here as a confining unit below the Casper aquifer.

However, if faults in the Casper Formation are continuous between the two units, there may be some hydraulic connection between them. Preliminary chemical analyses of strontium concentrations and isotopic ratios from groundwaters within the Casper aquifer suggest there may be some mixing of groundwaters of the Sherman Granite and the Casper aquifer (Frost and Toner, 1996). It is believed that any hydraulic contribution from the Sherman Granite to the Casper aquifer is minor due to the impermeable nature of the unfractured crystalline rock and the limited storage capacity of fractures where they occur in the granite. Therefore, the Sherman Granite is characterized as an aquitard or aquiclude (see Glossary).

Satanka Shale

The hydraulic relationship between the Satanka Shale and the underlying Casper aquifer is a critical element in the delineation of a protection area for the Casper aquifer. The hydrogeology of the Satanka Shale has not been studied in detail, but observations made during studies of the Casper aquifer provide some data regarding the hydraulic relationship between the Satanka Shale and the underlying Casper aquifer (Lundy, 1978; Huntoon and Lundy, 1979; WWC, 1993, 1994, 1997a,b; and Weston, 1995).

Taken in its entirety, the Satanka Shale is a regional confining layer overlying the Casper aquifer. However, permeable sandstones in the Satanka Shale provide water to many domestic and stock wells in the Laramie area. Approximately 300 feet of interbedded shale, siltstone and sandstone isolates the Casper aquifer from overlying aquifers, including permeable beds within the Satanka Shale.

The hydraulic head in the Casper aquifer is typically 20 to 40 feet greater than the head in the permeable layers within the Satanka Shale. The Casper aquifer is confined where overlain by a sufficient thickness of the Satanka Shale (JMM, 1989; WWC 1993, 1994, 1997a,b; and Weston, 1995). Hydraulic separation between the Casper aquifer and permeable layers in the Satanka Shale has been documented during pumping tests conducted at the Spur Wellfield, LaPrele Park Prospect and the Turner Wellfield, where no observable head declines occurred in the monitored intervals in the Satanka Shale as the Casper aquifer was pumped (WWC, 1993, 1996, 1997a,b).

Important for the Laramie Regional Drinking Water Protection Program is the fact that interconnected fractures in the lower 50 feet of the Satanka Shale can be permeable. In contrast to the observations above, there are some localities where groundwater from the Casper aquifer has been observed to flow upward into the lower 50 feet of the Satanka Shale at Simpson, Soldier and Pope Springs (Plate I). Consequently, it is assumed that the lower 50 feet of the Satanka Shale is in hydraulic communication with the Casper aquifer.

Casper Aquifer

The Casper aquifer is the hydrogeologic unit that supplies water to the wells and springs utilized by the City of Laramie as a drinking water resource. The Sherman Granite provides an effective lower confining layer for the Casper aquifer and the low permeability shales of the Satanka Shale provide an effective upper confining layer, where there is a sufficient thickness. The permeabilities within the Casper sandstones are very large in contrast to the overlying and underlying geologic unit. The Casper aquifer is bounded above and below by effective confining units and is the sole source of groundwater for the wells and springs. The discussion of the hydrogeology of the Casper aquifer is expanded in the following sections.

Extent of the Aquifer

The Casper aquifer is those parts of the Casper Formation that are fully saturated with water. As shown in Figure 3-4 the upper part of the Casper Formation is unsaturated on the west slope of the Laramie Range. The unsaturated thickness of the Casper Formation generally decreases from east to west. While the entire thickness of the Casper is not saturated except where it is confined by the Satanka Shale there is some thickness of the Casper Formation that is saturated throughout the majority of the outcrop. The aquifer therefore extends from the crest of the Laramie Range to the east into the Laramie basin. While the aquifer is present throughout the Laramie basin, for the purposes of this protection program the western edge of the aquifer is presumed to be coincident with the 1,000 milligrams per liter (mg/L) Total Dissolved Solids (TDS) contour mapped by Richter (1981). In the vicinity of Laramie, this contour is approximately nine miles west of the city limits. This proposed western boundary is established because water with a TDS greater than 1,000 mg/L is not suitable for municipal use and provides a reasonable boundary for the aquifer. The Casper aquifer extends approximately 50 miles north-northwest of Laramie before it is interrupted by a thrust fault. To the south of Laramie, the Casper aquifer extends past the Wyoming-Colorado border, a distance of at least 21 miles.

Depth and Saturated Thickness of Aquifer

The Casper Formation crops out from the crest of the Laramie Range west to where it is covered by the overlying Satanka Shale. In the vicinity of Laramie the outcrop is approximately four to five miles wide from east to west (see Plate 1). Assuming an average dip of 4°, the estimated depth to the top of the Casper aquifer near the western city limits of Laramie is approximately 1,500 feet.

The saturated thickness of the Casper aquifer varies significantly throughout the aquifer. Generally the saturated part of the aquifer is relatively thin at the crest of the Laramie Range and gradually thickens westward towards the contact of the Casper and Satanka. The minimum saturated thickness is nearly zero along the crest of the Laramie Range and the maximum saturated thickness is 600 feet immediately west of the Casper-Satanka contact according to Thompson (1979) and 700 feet thick near the Spur wellfield according to WWC (1997). However, the deep canyons and elevated regions along the flank of the Laramie Range result in irregular saturated thicknesses in the aquifer. An isopach map of the saturated thickness and depth to water in the Casper aquifer is available for review in the Albany County Planning Office in the County Courthouse. The map was created from readily available data. There is a paucity of data available because of a low spatial concentration of wells and because the hydraulic head in the wells has not been measured at the same time. As funding becomes available, it is anticipated that measurements will be taken from the wells and the maps will be updated.

Media Type and Groundwater Flow Characterization

The Casper aquifer is comprised of two media types; porous sandstone and fractured sandstone and limestone. Flow within these materials includes both porous and conduit flow. Porous flow occurs within the unfractured, permeable sandstones of the Casper aquifer. Conduit flow occurs within both the sandstones and limestones where the permeabilities has been enhanced by fractures and/or dissolution.

The intergranular permeability of the sandstones that comprise the five members of the Casper Formation is variable, with the greatest permeability occurring in the epsilon and delta members and the lowest permeability in the alpha member. The variation is due to the greater abundance of very fine sand, silt and calcite cement that fill the pore spaces in the lower sandstone members. Intergranular permeability is responsible for providing water to wells on the order of 1 to 100 gallons per minute (gpm).

Conduit flow refers to the flow of water through cavities or fractures associated with dissolution, faults, folds, joints, and partings along bedding planes. Conduit flow is typically orders of magnitude greater than intergranular permeability and is capable of yielding large quantities of water to wells, as demonstrated by the Laramie municipal water supply wells and associated springs. Production from the municipal wells that penetrate the fractured aquifer is on the order of 1,500 to 2,500 gpm. These high-yield wells tap fractures associated with faults and folds that have deformed the Casper Formation. At the Spur and Turner wellfields, where the rocks have been extensively fractured, the upper and lower members of the Casper Formation are hydraulically connected with each other through the fracture network.

Porosity

The intergranular porosity of the rocks comprising the Casper aquifer varies significantly. Lundy (1978) reports that the porosity of the well-cemented sandstones are approximately 22 percent, while the porosity of the epsilon sandstone ranges from 15 to 30 percent. The average porosity of the sandstones is 19 percent according to Lundy (1978). No porosity values are available for the limestones within the Casper aquifer. The porosity is extremely low where the limestones are not fractured but secondary porosity does exist where they are fractured. WWC (1993) estimates that the average effective porosity of the fractures within the Casper Formation is 0.02 percent.

Hydraulic Conductivity, Transmissivity, and Storativity

Pump testing of wells completed in the Casper aquifer in the Laramie area demonstrates that there are significant variations in the permeabilities of the sandstones comprising the Casper aquifer. Lundy (1978) indicates that the hydraulic conductivity of the epsilon member ranges from 1.3 to 2.6 feet per day (transmissivity= 600 to 970 gallons per day per foot (gpd/ft)) and the hydraulic conductivity of the gamma member is approximately 1.5 feet per day (transmissivity= 435 gpd/ft). The hydraulic conductivity of the aggregate members alpha through epsilon ranges from 0.21 to 0.32 feet per day (transmissivity= 900 to 1,390 gpd/ft) and of the aggregate members gamma through epsilon ranges from 0.11 to 0.13 feet per day (transmissivity= 315 to 375 gpd/ft).

The most striking variation in permeabilities within the Casper aquifer are observed when comparing fractured versus unfractured aquifer media. The hydraulic conductivity of the Casper aquifer where unfractured ranges from 0.10 to 2.6 feet per day (transmissivity= 135 to 970 gpd/ft). Where the aquifer is fractured the hydraulic conductivity ranges from 17 to 40 feet per day (transmissivity= 8.23×10^4 to 1.95×10^5 gpd/ft) (Lundy, 1978).

Testing of the Spur Wells by WWC (1997) indicated that the transmissivity of the Casper aquifer varied significantly in relatively small distances. The transmissivity varied from 1.4×10^5 to 6.4×10^5 gpd/ft. All of the reported transmissivities were calculated from drawdowns in monitoring wells located close to the Spur anticline. Pump tests conducted on the Turner Well No. 41T1 yielded a hydraulic conductivity of 14 feet per day (transmissivity = 6.81×10^4 gpd/ft) (WWC, 1993). In both the Spur and Turner well testing events, the drawdown was shown to be highly anisotropic, with the greatest drawdown occurring parallel to the geologic structure. The testing indicates that the greatest permeability occurs along the structure and that the permeability decreases significantly short distances from the structure.

Storage coefficients for the Casper aquifer are highly variable. Those reported by Lundy (1978) range from 0.001 to 0.006, which indicates the aquifer is confined to slightly leaky. Pump test data at the Spur wellfield indicate that the storage coefficient varies from 0.01 to 0.0091 (WWC, 1997). However, the storage coefficient for the wells changed significantly with time during pumping, which may be the result of the effects of partial penetration or from varying degrees of interconnection via fracture systems. A storage coefficient was calculated by WWC from barometric efficiency data collected from the Spur wellfield. The resulting storage coefficient was 5×10^{-4}, which indicates that the aquifer is confined at that location (WWC, 1997). The fact that the static water level in the Spur wells is significantly above the top of the Casper Formation also provides evidence that the aquifer is confined at that location.

Specific permeability enhancements associated with all of the faults and folds in the Casper aquifer shown on Plate I cannot be determined with certainty; some structures may enhance aquifer permeability while others may reduce permeability. Although the effects that each structure has on aquifer permeability are not known, it is important to recognize the hydraulic complexity imparted to the Casper aquifer by geologic structures such as faults and folds.

Recharge

Recharge refers to the replenishment of the Casper aquifer by the infiltration of water derived from rainfall and snowmelt through the unsaturated zone. This process occurs to some degree wherever the Casper Formation is exposed at the surface. Consequently, the entire surface exposure of the Casper Formation is assumed to be the recharge area for the Casper aquifer.

Lundy (1978) observed surface water infiltrating directly into the exposed gamma sandstone which has relatively large intergranular permeability; whereas, surface water tends to shed off exposed limestones, which generally have low permeability. In addition to infiltration into the porous sandstones, infiltration into the subsurface is enhanced by fractures, joints and faults exposed at the surface, particularly in drainage channels eroded along fracture zones. It is assumed that the vast majority of recharge to the Casper Formation occurs in drainages. Lundy (1978) indicates that recharge primarily occurs during the months of March through August, during which time spring runoff and summer storms occur. The average annual recharge to the Casper aquifer is estimated to be 1.4 inches per year (Lundy, 1978). However, the annual recharge is highly variable. Recharge to the Casper aquifer during the winter of 1983-1984, which was a documented El Nino year, was the greatest magnitude on record. The water levels in the Huntoon #1 monitoring well increased by 21 feet. The spring snowfall in 1984 was significantly greater than average and melted slowly, which maximized infiltration of the snowmelt. The hydrograph of the Huntoon #1 monitoring well, which was included in the 1941 Turner Well No. 2 Evaluation Report (WWC, 1996) indicates that the average spring recharge raises the water level in the Casper aquifer by approximately one foot.

Careful examination of water level data by WWC (1997) during a violent summer storm showed temporary increases in water levels in most of the monitoring wells observed during the pumping test of the Spur production wells located in Township

16 North, Range 73 West. The change in water levels was rapidly dissipated and the drawdown in the wells quickly returned to the pre-storm levels. The transient event had no long-term effects on water levels in the aquifer, which may indicate that summer storm events do not contribute significantly to recharge of the Casper aquifer.

In an effort to provide relative ages of groundwater contained within the Casper aquifer, Dr. Carol Frost and Rachel Toner collected samples from the Casper aquifer from a number of wells and springs in the Laramie area for tritium analyses (Toner, 1999). Tritium is often used to obtain relative age of groundwater and is a hydrogen isotope that was created in large quantities in the 1950's and 1960's as a result of above-ground testing of nuclear weapons. Tritium has a short half-life and has not been produced in large quantities since above-ground nuclear weapons testing was discontinued in the 1960's. Thus, the presence of tritium in groundwater samples indicates that the groundwater was exposed at the surface subsequent to the 1950's. The analyses do not provide the means of determining the exact age of a water sample; but rather provide a maximum potential age of the water, if tritium is detected.

The analyses of water samples collected by Toner detected the presence of tritium in samples collected from sites east of Third Street. This indicates that the groundwater in the Casper aquifer east of Third Street has been recharged within the past several decades. Water collected from the Wyoming Research Institute (WRI) Casper well, located west of Third Street, had no detectable tritium which indicates that the water withdrawn from the WRI well was recharged prior to the 1950's.

Hydraulic Gradient

Published potentiometric surface maps indicate that groundwater in the Casper aquifer in the vicinity of Laramie generally flows from east to west, from areas of high elevation at the crest of the Laramie Range toward lower elevations within the Laramie basin (Lundy, 1978; Thompson, 1979; WWC, 1993 and 1997). The gradient has a slight northwesterly component between Simpson Springs and City Springs according to the potentiometric map created by Thompson (1979) and is altered locally to a more radial pattern in the vicinity of the City's municipal wellfields and the springs, which discharge large quantities of water from the Casper aquifer. Flow patterns are also locally altered to some degree by the permeability imparted by fracturing associated with some faults and folds.

The hydraulic gradient ranges from a high of approximately 400 feet per mile where the aquifer is unsaturated to 25 feet per mile where the aquifer is fully saturated and confined by the overlying Satanka Shale (Lundy, 1978).

Confining Conditions

East of where the Casper Formation is fully saturated, the exposed sandstone units may be confined or unconfined depending on their location, as shown in Figure 3-4. The limestones that separate the sandstones have negligible permeabilities and serve as local confining layers that define subaquifers within the Casper aquifer. Therefore, the informal members, designated in descending order (epsilon, delta, gamma, beta, and alpha), comprise subaquifers within the Casper aquifer (Figure 3-2). However, the confining ability of the limestones may be compromised where fractures from faults and folds have created hydraulic connection between the members (WWC, 1993 and 1997).

Regionally, the Satanka Shale serves as the upper confining bed for the Casper aquifer. The lower 50 feet of the Satanka Shale is comprised of well-cemented sandstone beds. The brittle nature of that interval and the lithologic similarity to the underlying Casper Formation results in some mixing of groundwater from those units, especially in fractured areas. Where the Satanka Shale has thicknesses greater than 50 feet, shaley strata provide confinement, with the degree of confinement increasing with greater thicknesses of the Satanka Shale. Evidence of confinement includes the discharge of large quantities of water at Simpson, Soldier, Pope and City Springs. Additionally, differences in hydraulic head of up to 30 feet were observed at the Spur Wellfield, with the head in the Casper aquifer being greater than the head in the Satanka Shale (WWC, 1997).

Vulnerable Features

Several features found within the Casper Formation in the Laramie area render it potentially vulnerable to contamination at the ground surface. Throughout much of the surface area of the Casper Formation protection is provided for the aquifer by either overlying soils, low permeability limestones, several tens to hundreds of feet of unsaturated rocks and/or low permeability shale. Features that cause weakness for possible natural protection include: faults, folds, fractures, shallow depths to groundwater and drainages. The basis for consideration of these features as potentially vulnerable features is included in the following paragraphs.

Faults

Faults are fractures or fracture zones along which displacement of strata has occurred. If the displacement has resulted in either breaches in confining beds and/or development of large secondary permeability, then the aquifer may be more vulnerable to contamination than in unfaulted areas. Where the faults intercept the ground surface and have large apertures there is the potential for rapid infiltration of surface water into the aquifer. This rapid infiltration, in turn, has the potential for rapid contamination of the aquifer. Kleinfelder (1996) indicates that the aperture of fractures must be greater than one centimeter for rapid movement of groundwater to occur. The potential for contamination of the aquifer as a result of rapid infiltration is magnified in areas where groundwater is shallow.

While faults are typically mapped as a single line they frequently do not occur as a discrete feature. Fractures extend variable distances from the major fault trace. WWC (1993) reports that at some faults the fracture zone extends less than 10 feet from the fault trace, while other faults have associated fractures extending 50 to 150 feet from the fault trace.

Folds

Folds are bends in the bedding of rocks that result from ductile deformation. Folds found in the Laramie area include anticlines, synclines and monoclines. In many folds, fractures are developed in brittle or competent rocks. These fractures usually occur along the crest of the fold and have the potential for transmitting large quantities of water. Where these fractures extend to the ground surface there is the potential for rapid transmission of contaminants. As with faults, the potential for contamination along the crests of folds is magnified where groundwater occurs at a shallow depth.

Exposed Bedrock

Exposed bedrock that comprises an aquifer serving a public water system is generally more vulnerable to contamination than the same materials buried at a depth. Burial of the aquifer materials provides the opportunity for some degree of mitigation of potential contaminants prior to the contaminants entering the aquifer. In some locations sufficient thicknesses of low-permeability materials effectively prevent the downward migration of contaminants into the aquifer.

Drainages

Drainages are the site of most of the recharge occurring to the Casper aquifer east of Laramie. Water tends to shed off of the low-permeability limestones that cover the majority of the land surface along the western flank of the Laramie Range. The water drains off the limestones and collects in drainages. As the runoff flows through the drainages, rapid recharge occurs as the water crosses permeable sandstones and/or fractures. Where rapid recharge occurs, rapid contamination can also occur.

Shallow Depth to Groundwater

Areas where the depth to groundwater is relatively shallow are also potentially vulnerable to contamination. With all other factors being equal, there is the potential for greater natural remediation where the depth to groundwater is deep. Areas where groundwater is close to the ground surface have the potential, where no confining layer is present, for rapid transport of contaminants from spills of hazardous substances.

More detailed information regarding the geology and hydrogeology of the Casper aquifer may be obtained from Morgan (1947), Huntoon (1976), Lundy (1978), Huntoon and Lundy (1979), Thompson (1979), WWC (1993, 1994, and 1997a,b) and Ver Ploeg (1996).

Well Data

Well data, as required by the Wyoming WHP Guidance Document, are provided in Table 3-1. The data are derived from City of Laramie Public Works Department files and from the well construction reports.

Pump Data

Pump data for the Laramie municipal wells, as required by the Wyoming WHP Guidance Document, are provided in Table 3-2. The data were gathered from City of Laramie Public Works Department Files and from well construction reports.

Delineation Methods

The Wyoming WHP guidance document, which was used to determine appropriate delineation methods for this plan, requires that three different protection areas be established. The protection areas are labeled Zones 1, 2, and 3 as shown on Figure 3-5.

Zone 1 protection areas are to be established around each of the water supply sources. The purpose of the Zone 1, or Accident Prevention Zone, is to prevent the accidental introduction of contaminants into the aquifer in the immediate vicinity of the well. The Wyoming WHP Guidance

Document indicates that the Zone 1 protection area is to be an arbitrary fixed radius of 50 or 100 feet, depending upon well completion and vulnerability to contamination. However, these radii are minimum distances and can be increased to provide additional protection if necessary.

Zones 2 and 3 are entitled the Attenuation and Remedial Action Zones, respectively. The purpose of Zone 2 is to protect the well from contact with pathogenic microorganisms and to allow for remediation or clean up of a spill that may occur in the vicinity of the wellhead. Zone 2 is typically based on a 2-year time of travel. The purpose of Zone 3 is to protect the aquifer from contaminants that may migrate to the well and to allow time for remediation of the contaminant or replacement of the water resource. Zone 3 is typically based on a 5-year time of travel. For the Casper aquifer near Laramie, times of travel were not used to delineate the protection areas.

Where the aquifer yielding water to wells and springs is characterized by fracture or conduit flow, the Zone 3 delineation is delineated before Zone 2 and is defined by flow system boundaries. Hydrogeologic mapping is used to identify those parts of the aquifer that might reasonably be expected to yield water to the municipal wells. After creating Zone 3, vulnerability mapping was used to delineate Zone 2. The Zone 2 delineation identifies those areas that are particularly vulnerable to contamination within the larger area delineated by hydrogeologic mapping.

The Casper aquifer in the Laramie area is an anisotropic, fractured sandstone and limestone aquifer that has no apparent hydrogeologic or flow boundaries between wellfields, and has the potential for rapid transport of groundwater over large distances. These factors, combined with a lack of data and the extreme expense of gaining appropriate data, limits the ability to utilize numerical or semi-analytical delineation methods for creating protection areas based on times of travel (EPA, 1991). To delineate protection areas for the Casper aquifer, hydrogeologic and vulnerability mapping was used.

The protection area for the Casper aquifer in the Laramie area was based on the review of existing data which allowed for the determination of the geologic boundaries of the aquifer and the areas within those boundaries that require different levels of protection. The aquifer protection area delineation is dependent on three primary factors:

- The amount of available information regarding aquifer characteristics;
- The accuracy of the existing information; and
- The delineation methodology selected and applied in the process.

Published information concerning the Casper aquifer in the Laramie area was reviewed, often by the authors of the original documents, and updated with the most recent published and unpublished information available from mapping, drilling and aquifer testing. The aquifer protection area delineation that follows represents the consensus view of the Technical Review Subcommittee as the best representation of the aquifer protection area required for the Casper aquifer.

Delineation Process

The purpose of aquifer protection is to safeguard the public water supplies for both present and future uses. The purpose of the delineation process is to define and map the aquifer protection areas. An aquifer protection area considers the entire groundwater resource, including both existing and potential groundwater supply development areas. Within this framework, this section describes the decisions made by the EAC Technical Review Subcommittee to define and map the aquifer protection areas for the Casper aquifer in the Laramie area.

Fundamental Findings

Based on the information presented above, the following characteristics were viewed as the fundamental conclusions regarding the Casper aquifer. The Technical Review Subcommittee reached agreement on these issues during the original delineation process:

- Groundwater flow within the Casper aquifer includes both porous flow (intergranular) and conduit flow (faults, fractures, joints and dissolution cavities);
- The epsilon and delta members of the Casper Formation have higher primary permeability than the underlying gamma, beta and alpha members;
- Fractures associated with faults, folds and bedding planes dramatically enhance the permeability of the sandstones and limestones of the Casper aquifer;
- The Casper aquifer is underlain by the Sherman Granite which acts as an aquitard or aquiclude;
- The Casper aquifer is unconfined or semi-confined in most of the outcrop area of the Casper Formation;
- The recharge area for the Casper aquifer is the entire exposed outcrop area of the Casper Formation along the western slope of the Laramie Range. Recharge mechanisms for the Casper aquifer include direct infiltration from precipitation and snow melt and infiltration of surface water run-off, particularly in natural drainage channels;
- The aquifer generally is confined when covered by the Satanka Shale; and
- The lower 50 feet of the Satanka Shale is fractured and in hydraulic connection with the Casper Formation.

Based on the above criteria, the Technical Review Subcommittee agreed on the locations of the east and west boundaries of the Zone 2 and 3 aquifer protection areas. The effort undertaken by the Technical Review Subcommittee in the time frame 2000 to 2002 added a delineation of the north and south boundaries of the Zone 2 and 3 protection areas, Zone 1 delineations for each of the city of Laramie groundwater supply sources, and provisions for conducting site-specific delineations.

The aquifer protection delineation discussed below is based on the Technical Review Subcommittee's present understanding of the hydrogeology and extent of the Casper aquifer, its recharge mechanics and the dynamics of groundwater movement between the aquifer and underlying and overlying geologic strata. The current state of hydrogeologic knowledge of the Casper aquifer is limited to available data and is subject to refinement as new data are collected and become available.

Zone 1 Protection Area

Many of the municipal wells serving the City of Laramie are drilled in the immediate vicinity of springs. The springs are located at topographic lows where the potentiometric surface of the Casper aquifer intersects topography or where weaknesses in the confining layer are breached and groundwater from the Casper aquifer can move up through the overlying Satanka Shale to the ground surface. At many locations the springs are not distinct, but are visible as large, wet grassy areas. When the wells are not pumped for extended periods of time the springs flow; however, when the municipal wells are pumped and the cone of depression associated with pumping propagates to the springs a reversal of gradient occurs and the springs cease to flow. When the reversal of gradient occurs groundwater moves from the spring site to the well. Additionally, any contaminants introduced in the immediate vicinity of the springs can follow the same pathway as the groundwater and be pumped by the well into the municipal water system. To adequately protect the wells that provide drinking water to the City of Laramie the Zone 1 protection areas were created to be large enough to encompass the springs that are in the immediate vicinity of the wells. The delineation procedures followed for each of the water supply sources are described below.

Spur Wellfield

The Zone 1 protection areas for the Spur Wells have each been established as 100-foot radii around each well. The radii have been assigned to conservatively protect the aquifer in the vicinity of the wellheads, where the Casper aquifer occurs at a shallow depth.

Turner Wellfield

The Zone 1 protection area for the Turner wellfield was completed through field mapping. A Global Positioning Satellite (GPS) receiver was used to map the depression associated with the location of the historic City Springs location, the locations of the spring boxes at the site that are dug into the Casper aquifer and the Turner wells. A 100-foot buffer was then drawn around each of the mapped features and the resulting polygons were then combined where overlap occurred.

Pope Wellfield

The Zone 1 protection areas for the Pope wellfield was also completed using mapping with a GPS unit. The now-abandoned cistern, which was constructed over the Pope Springs was mapped and a 100-foot buffer was created around that feature. Each of the four wells comprising the Pope wellfield has also been assigned a 100-foot radius for the Zone 1 protection area. The protection areas for the wells and cistern do not overlap; however, the five delineated zones comprise the protection area for the wellfield.

Soldier Wellfield

The Zone 1 protection area for the Soldier wellfield was completed through field mapping. A GPS receiver was used to map the depression associated with the location of the historic Soldier Springs location and the Soldier well. A 100-foot buffer was then drawn around the edge of the depression and the water supply well.

The locations of the Zone 1 protection areas are depicted in Figure 3-6.

Delineation of the Eastern Boundary of Zone 3

The eastern boundary of the Casper aquifer protection area is located at the topographic divide along the crest of the Laramie Range. This determination is based on the following rationale:

- The Sherman Granite serves as a confining layer under the Casper aquifer;
- The topographic divide is generally very close to the easternmost outcrop of the Casper Formation, which is the contact between the Casper Formation and the underlying Sherman Granite; and
- The topographic divide of the Laramie Range is generally coincident with the groundwater divide based on the presence of springs that discharge along the

contact between the Casper Formation and the Sherman Granite. Consequently, groundwater stored in the Casper Formation east of the topographic divide probably flows eastward.

The eastern boundary shown on Plate I is the topographic divide on the crest of the Laramie Range.

Delineation of the Western Boundary of Zone 3

The western boundary of the Casper aquifer protection area is located west of the contact between the Satanka and the Casper Formations. The western boundary of the protection area was selected after careful consideration of the effectiveness of the Satanka Shale as a hydrogeologic confining layer over the Casper aquifer.

The existing hydrogeologic data were evaluated and a determination was made that the Satanka Shale generally acts as a confining layer for the Casper aquifer in the Laramie area. While the data distribution is less than ideal, the following observations of spring and well data indicate that the lower 50 feet of the Satanka Shale can be permeable and in hydraulic connection with the Casper aquifer.

- The base of the Satanka Shale is composed of interbedded fractured shale and sandstone;
- The water at Simpson Springs flows from the Casper aquifer through approximately 50 feet of fractures in the basal Satanka Shale; and
- Water levels measured in Section 1, Township 15 North, Range 73 West reveal only a small difference in hydraulic head between the Satanka Shale and the Casper Formation.

Based on the above data, the Technical Review Subcommittee believes that the Casper aquifer may be vulnerable to contamination if 50 feet or less of Satanka lies between the Casper Formation and the ground surface. The Technical Review Subcommittee agreed that at least 75 vertical feet of Satanka Shale (50 percent more than the thickness of the zone of apparent connectivity) is needed to safely and effectively shield the Casper aquifer from contaminants that may be spilled or introduced at or near the ground surface.

The actual location of the western boundary for the protection area is the distance from the Casper-Satanka contact that provides 75 feet of Satanka shale cover when the dip of the formation and slope of the ground surface are considered. Figure 3-7 illustrates the procedure to predict the offset of the western boundary from the contact. As the dip in the Satanka becomes greater, the offset distance gets shorter. The stratigraphic remainder of the Satanka Shale is considered to be an effective confining layer above the Casper aquifer.

The western boundary of the protection area is the easternmost edge of the line indicated in Plate I.

Delineation of the North and South Boundaries of Zone 3

South Boundary

The southern boundary of Zones 2 and 3 extends from the intersection of the western Zone 2 boundary and the Simpson Springs anticline, as mapped by Ver Ploeg (1999). The boundary then follows the crest of the anticline to the mapped eastern limit of the anticline then proceeds due east to the crest of the Laramie Range, which is the eastern boundary of Zone 3.

The reasoning for the placement of the southern boundary is as follows:

The springs along the base of the west flank of the Laramie Range, including City Springs, Pope Springs, Soldier Springs, Simpson Springs and others further south, are the surface manifestations of the intersections of east-west trending structural features and a confining bed. The geologic structures contain fractures that allow for the rapid transmission of water downgradient to the point where the water level in the Casper aquifer intersects a confining layer and the aquifer is full (i.e. the potentiometric surface intersects the ground surface). The elevations of the springs increase to the south, with the City Springs being lowest in elevation. This means that the entire Casper aquifer south of the City Springs has the potential to contribute water to City Springs. However, the southern springs, which are higher in elevation, do not cease flowing during the year and we do not observe a draining of the aquifer from south to north, which would indicate that the groundwater is flowing north. While there is not a flow system boundary in the Casper aquifer between any of the springs, there is a significant difference in permeability in the rocks that contribute water to the springs, such that the non-fractured rocks have permeabilities that are orders of magnitude less than the fractured rocks. It has long been asserted that the faults and folds in the Casper aquifer act as “collectors” of groundwater. Groundwater flowing downgradient through the low-permeability rocks that encounters the fractured rocks preferentially moves downgradient in the fracture system and is discharged at the springs. A small quantity of water may cross the fractured zones, but the vast majority of the water is discharged at the springs. As such, the east-west trending structures that feed water into springs act as localized hydrogeologic boundaries.

The boundary is provided on Plate 1.

North Boundary

The reasoning for the placement of the northern boundary is as follows:

Pump testing of the Spur wells indicates that the majority of the water is derived from the Casper aquifer from fractures along the crest of the Spur Anticline (WWC, 1997). Aquifer parameters determined from observation wells indicates that the transmissivity of the aquifer between the Spur wells and observation well C-105 is approximately 4.32×10^5 gallons per day per foot, which is extremely high. The data also indicates that the aquifer between the two wells is confined to leaky. Geologic mapping of the area north of the Spur wells indicates the presence of small faults that trend east-west, but there are no surface discharges to indicate the aquifer is highly transmissive along the faults. Therefore, it appears that the aquifer is relatively isotropic north of the Spur wells.

Using the WHPA model (Blandford, Huyakorn, and Wu, 1991), with inputs of: the above transmissivity, confined conditions, aquifer thickness of 700 feet, porosity of 15%, hydraulic gradient of 0.001, long-term pumping rate of 975 gpm, model run time of 5 years, and direction of flow from the north, the result is a capture zone that extends approximately 3,200 feet north of the wells. This capture zone represents a worst-case scenario because it assumes that all of the water is being derived from the north and ignores the contribution of water from the Spur Anticline. Extending the boundary to a point 4,800 feet north of Spur Well No. 2 provides for a 50 percent factor of safety.

The northern boundary is depicted on Plate 1.

Delineation of the Primary and Secondary Protection Areas

The Technical Review Subcommittee agreed that the total outcrop of the Casper Formation should be divided into two sub-areas, designated as the Primary Protection Area and the Secondary Protection Area. The Primary Protection Area, owing to its greater natural vulnerability and to the greater number of existing wells, should have a greater degree of protection than the Secondary Protection Area. The Primary Protection Area is equivalent to Zone 2 of the WHP Guidance Document and the Secondary Protection Area corresponds to Zone 3 for the same document.

The outcrop area of the delta and epsilon sandstone members of the Casper Formation was designated to be the Primary Protection Area (Zone 2) based on the following considerations:

- The intergranular permeability of the delta and epsilon sandstone members is greater than the intergranular permeability of the underlying alpha, beta and gamma members;
- The shallower depth to groundwater near the western edge of the Casper outcrop;
- There is proximity of outcrops of the delta and epsilon sandstone members of the Casper Formation to the municipal groundwater supply wells for the City of Laramie; and
- The primary stratigraphic location of the municipal groundwater supply wells and springs for the City of Laramie are the epsilon and delta members of the Casper Formation.

Because the delta sandstone member is one of the most permeable of the five members, the Technical Review Subcommittee agreed to extend the eastern boundary of the Primary Protection Area 200 feet east of the base of the delta sandstone outcrop. This provides a buffer to prevent contaminants from directly entering the exposed edge of the delta member of the Casper Formation. In those situations in which the 200-foot buffer creates an enclosed or nearly enclosed area of Secondary Protection Area, the entire area will be designated as Zone 2 or the Primary Protection Area. The westernmost edge of the line will mark the boundary.

All faults in the recharge area were not included in Zone 2 because not all faults are of the same potential hazard to city wells. There are other features, such as exposed sandstone, that are of a more immediate concern. Including every known fault into Zone 2 would be unnecessarily proscriptive to development. Because of these considerations, site-specific studies are recommended in Zone 2 and Zone 3.

The Wyoming DEQ identified four faults that appeared to have a reasonably high potential to allow adverse impact to municipal springs and wells. These faults are City Springs Fault, Jackrabbit Fault, Quarry Fault, and Sherman Hills Fault. It was suggested that unless there is geologic/hydrogeologic evidence or documentation to convincingly demonstrate that there is no increased vulnerability (e.g. due to cementation, etc) related to these faults, then they must be included in Zone 2. These fault complex locations are approximate and are simplified for ease of representation.

The remainder of the area of outcrop of the Casper Formation, easterly to the topographic divide of the Laramie Range, is designated as Zone 3 or the Secondary Aquifer Protection Area.

Site-Specific Delineations as a Result of Potentially Vulnerable Features

Within the large geographic areas defined as Zones 2 and 3, features have been identified that may render the Casper aquifer vulnerable to contamination. Typically vulnerable features are included within the Zone 2 protection area. However, not all of these features render the aquifer vulnerable to the same degree in all areas. To reduce the potential of having excessively proscriptive, and therefore untenable management strategies enacted where there is no need, it is recommended that site-specific studies be conducted when development occurs within Zones 2 and 3. Development here is defined as any modification to the natural land surface that may result in the introduction of contaminants and/or increasing the vulnerability of the aquifer to contamination. These site-specific studies will be conducted by a licensed professional geologist and/or engineer during the permitting phase. The purpose of the site-specific study will be to determine the vulnerability of the aquifer to contamination by the proposed development as a result of the presence of the following features on the subject property: faults, folds, drainages and shallow groundwater.

The reasoning for requiring site-specific studies is that the presence of one of these features on a particular property does not necessarily mean that aquifer contamination will occur or is more likely to occur, but rather it has the potential for increasing the vulnerability. Additionally, a combination of these features may result in significantly greater vulnerability.

The initial investigation for the site-specific delineation will consist of a literature search and 100-year flood plain delineation, if necessary. The investigator will consult available geologic mapping, including Lundy (1978), VerPloeg (1996, a, b) and any other readily available geologic mapping from the University of Wyoming Geology Library and the Wyoming Geological Survey, to determine the presence of mapped faults and/or folds on the subject property. Drainages passing through the subject property will be assessed for the potential for contributing to groundwater contamination. Where 100-year flood plain mapping is unavailable, the professional geologist and/or engineer will calculate the 100-year flood plain for the drainage. The flood plain mapping will be provided on a site map with a scale not to exceed 1 inch equals 200 feet.

The initial site investigation will also include an assessment of the depth to groundwater on the property. An attempt should be made to determine the groundwater at its highest annual elevation, which typically occurs in late spring. Water level(s) in a well on the site property are preferable for determining depth to groundwater. Water levels from wells on adjoining properties may be used if a well has not been drilled on the subject property. If a well is not available for obtaining water levels then maps depicting the potentiometric surface of the Casper aquifer may be used. Mapping from Lundy (1978), Thompson (1979) and Western Water Consultants (1993 and 1997), or newer mappings are accepted for determining the depth to groundwater. The depth to groundwater should be contoured across the building site at a scale not to exceed 1 inch equals 200 feet.

After conducting the site investigation, a brief report of the findings should be developed that provides an assessment of the presence and the vulnerability of the features listed above. If none of the features are found on the subject property then the site assessment will be considered complete.

For installation of on-site small wastewater facilities (e.g., septic systems) the cumulative potential effects of the new system, plus surrounding and upgradient systems, should be determined through nitrate-loading or fate and transport modeling as set forth in the DEQ Subdivision Rule.

If any of the above features are found on the property to be developed, then the site plan should show any proposed facilities with a 100 foot setback from any of the vulnerable features and not within the delineated 100-year floodplain. If the features are outside of setbacks, then the process is complete.

The setbacks recommended by the EAC are similar to those required for the Edwards Aquifer Protection Plan (EAPP) for the Texas Natural Resource Conservation Commission (Chapter 213 Edwards Aquifer and Chapter 285 On-site Sewage Facilities, see: www.tnrcc.state.tx.us/EAPP). The EAPP defines sensitive or recharge features as being "permeable geologic or manmade features located on the recharge zone where: a) a potential for hydraulic interconnectedness between the surface and the Edward Aquifer exists; and b) rapid infiltration to the subsurface may occur". The EAPP has special requirements for development such as on-site sewage facilities in the recharge zone whereby they require separation distance to recharge features be 50 feet for septic tanks and 150 feet for a leachfield.

If the facilities fall within the established setbacks then the property owner has two potential options. These options are set forth in Chapter 3, Section 17 of the DEQ-Water Quality Division Rules and Regulations (DEQ, 1999), which are as follows:

> "All other applications for a permit to construct a treatment works, disposal systems or other facility capable of causing or contributing to pollution shall contain the following:
>
> a) Documentation that the facility poses no threat to groundwater. If an applicant proposes a facility of this nature and can provide documentation, a subsurface investigation is not required. The documentation shall consist of data which demonstrates that:
>
> Facility construction will not allow a discharge to groundwater by direct or indirect discharge, percolation, or filtration; or
>
> The quality of wastewater will not cause any violation of groundwater standards; or
>
> Existing soils or geology will not allow a discharge to groundwater.
>
> (b) If the documentation required above cannot be provided, a subsurface study shall be provided … to demonstrate the groundwater standards contained in applicable Wyoming Water Quality Rules and Regulations are adhered to…"

Aquifer Protection Area Maps

The Aquifer Protection Map, developed using the procedures outlined in the Delineation Process Section, is presented as Plate I and on Figure 3-5. Plate I shows the boundaries of both the Primary and Secondary Aquifer Protection Areas. The boundary between the two areas is the western side of the line indicated on Plate I. Figure 3-6 shows the Zone 1 boundaries on a smaller scale allowing for easier identification.

Written Description of Aquifer Protection Areas

Zone 1 Protection Areas

Spur Wellfield

The Zone 1 protection areas for the Spur Wells consist of a 100-foot arbitrary fixed radius around each of the wells.

City Springs Wellfield

The Zone 1 protection area for Turner Well No. 1 consists of a 100-foot arbitrary fixed radius. The Zone 1 protection area for Turner Well No. 2 is an irregularly shaped polygon that includes the well, historic spring boxes and the topographic low associated with the historic natural discharge points for the City Springs. The protection area has a maximum length of 320 feet in the north-south direction and a maximum length of 680 feet in the east-west direction.

Pope Wellfield

The Zone 1 protection areas for the Pope Wellfield consists of 100-foot fixed radii to Pope Well Nos. 1, 2, 3, and 4. The protection areas for Pope Well Nos. 2 and 3 have been merged because they have overlap. The Zone 1 protection area for the wellfield also includes a 100-foot setback from the edges of the cistern that is located over the historic Pope Springs.

Soldier Wellfield

The Zone 1 protection areas for the Soldier Wellfield are comprised of a 100-foot arbitrary fixed radius around the Soldier Well wellhead and a 100-foot setback from the topographic depression associated with the historic Soldier Springs. The maximum length of the protection area is 200 feet in the north-south direction and 600 feet in the east-west direction.

Zone 2 Protection Area

The Zone 2 protection area is an irregularly shaped area that has a maximum east-west width of approximately 17,000 feet and a maximum north-south length of 71,000 feet.

Zone 3 Protection Area

The Zone 3 protection area is an irregularly shaped area that has a maximum east-west width of approximately 26,500 feet and a maximum north-south length of 71,000 feet.

Available Data Limitations and Future Recommendations

Site Specific Modifications to the Plan

While establishing boundaries for the aquifer protection area, the Technical Review Subcommittee recognized that the location of zone boundaries may be altered in the future as more information becomes available. Site specific changes to the boundaries of the aquifer protection area should only be allowed:

- When a site investigation shows significant variation from the assumptions presented herein; and

- Based on the recommendations of a qualified water resource professional licensed by the State of Wyoming to practice engineering and/or geology.

In any determination, the criteria established in this report should be consistently applied to any proposed modification to the protected areas.

Recommended Investigations

To aid in refining the aquifer protection delineation process and to increase our understanding of the Casper aquifer, the Technical Review Subcommittee recommends that future studies be undertaken. The studies, in no particular order include:

- Tracer tests of major faults associated with the City springs and wells;

- Delineation of 100-year flood plains within the Zones 2 and 3 protection areas;

- Establishing routine measurement of water levels and water quality in wells completed in the Casper aquifer in the Laramie area and development of potentiometric maps;

- Research of recharge mechanisms and vulnerability analysis of aquifer to contamination from the ground surface;

- Investigation of degree of hydraulic interaction between the Sherman Granite and Casper aquifer; and

- Investigation of degree of hydraulic interaction between the Casper aquifer and the Satanka Shale.

Revising and Updating the Plan

The Wyoming Wellhead Protection (WHP) Program Guidance Document requires that a local Wellhead Protection Plan must be updated every two years. This will be ensured by having EAC members with expertise in engineering, hydrology, and geology. Members of the EAC will have knowledge of site-specific studies and other professional studies. The City Utility Division Manager (UDM) has regular contact with the University of Wyoming through other projects and duties and can keep abreast of any current research projects that could affect the aquifer protection plan.

Every two years, the UDM will have a meeting with professional geologists, engineers, and University of Wyoming professors who conduct work in the protection area. These professionals will be asked to present any findings relevant to the protection area. This Casper Aquifer Protection Plan (CAPP) will be modified, if necessary, based upon these meetings. A new delineation map will be developed if changes are significant, otherwise the delineation map will be annotated or appended.

Following this guideline, revisions to the Aquifer Protection Areas should be made when new information is available concerning:

- Hydrologic characteristics of the Casper aquifer;

- Changes in water supply, or pumping volumes; and/or

- Planning or developing of new water supplies.

The chairman of the EAC will draft a letter every two years advising DEQ and anyone else who has a copy of the APP of all changes in the plan. Updated tables or pages will be sent, as appropriate. EAC subcommittees and the UDM will be responsible for reviewing these changes based on personal and professional knowledge, as well as active investigation. The UDM will be responsible for incorporating changes to the CAPP master copy.

Significant technical changes will be reviewed and approved by three Wyoming licensed professional engineers or geologists.

The APP may at some point be converted to a .pdf file and put on the Internet. This medium could be another way to disseminate updates.

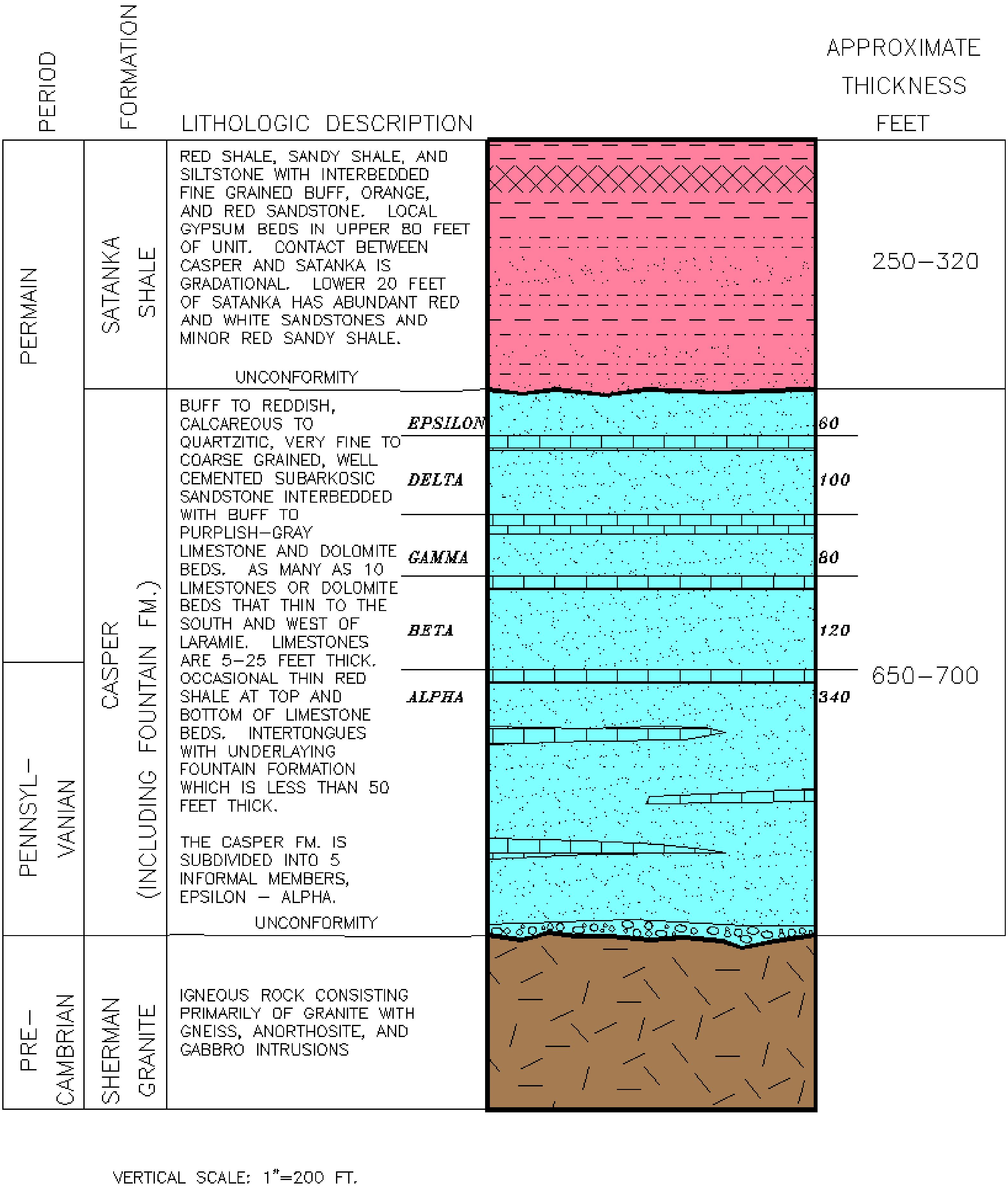


Figure 3-1 Stratigraphic Column in the Vicinity of Laramie

Casper Aquifer Protection Program
Adapted from: WWC (1997)
Ver Ploeg (1995)

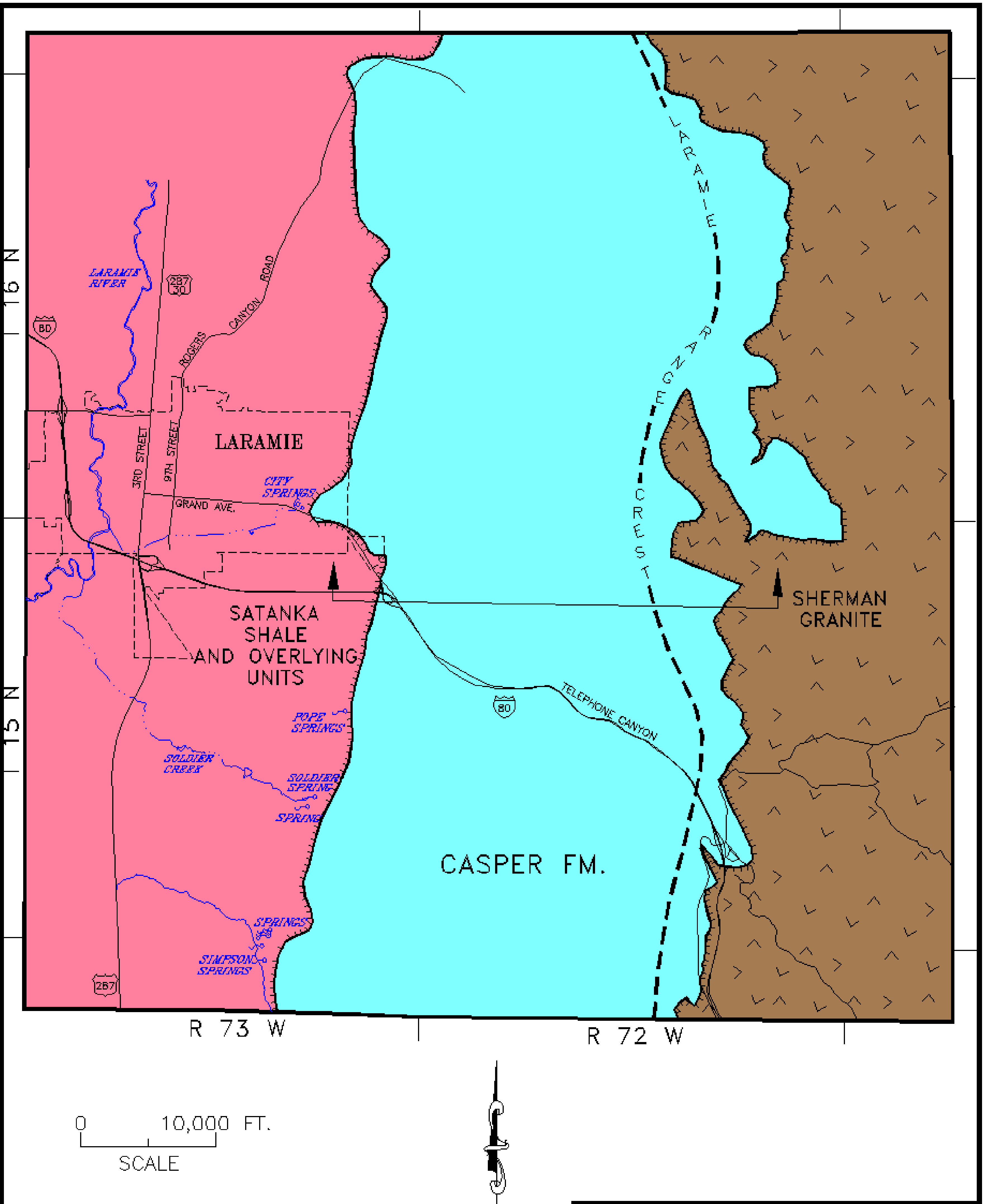
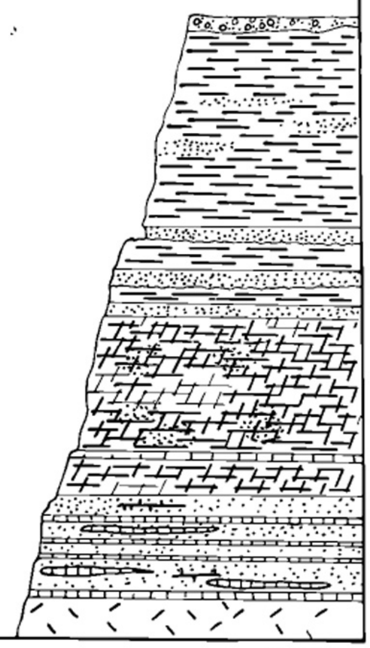


Figure 3-2 General Outcrop Area of the Casper Aquifer

Casper Aquifer Protection Program
Adapted from: WWC (1993a)

Age	Formation	Thickness (feet)	Water Supply
QUARTERNARY	ALLUVIUM	0-45	Contains small amounts of water
CRETACEOUS	UNDIVIDED	6500	Water yield depends on lithology. Majority of section is shale, and yields no water or small amounts of highly mineralized water. Some sandstones, notably in the Frontier formation and the Mesaverde Group, yield good water supplies to wells.
	CLOVERLY	115-236	Sands contain highly mineralized water.
JURASSIC	MORRISON	135-220	Highly mineralized but potable water.
	SUNDANCE	0-200	Contains water, but limited areal extent.
TRIASSIC	CHUGWATER	1100-1200	Sulfate-rich water. Used for irrigation water and for stock watering north and south of Laramie.
PERMIAN	FORELLE	9-25	Yields little or no water.
	SATANKA	230-300	Sulfate-rich water used for stock watering.
	CASPER	500-700	Most important aquifer in area Supplies water to wells and large springs on west flank of Laramie Rng.
PENNSYLVANIAN	FOUNTAIN	20-50	Included in "Casper Aquifer"
PRECAMBRIAN	UNDIVIDED		Yields small amounts of water.

Lithology



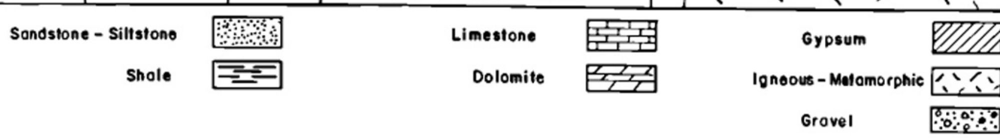


Figure 3-3 Hydrogeologic Role
Of Formation

Casper Aquifer Protection Program
Thompson (1979)

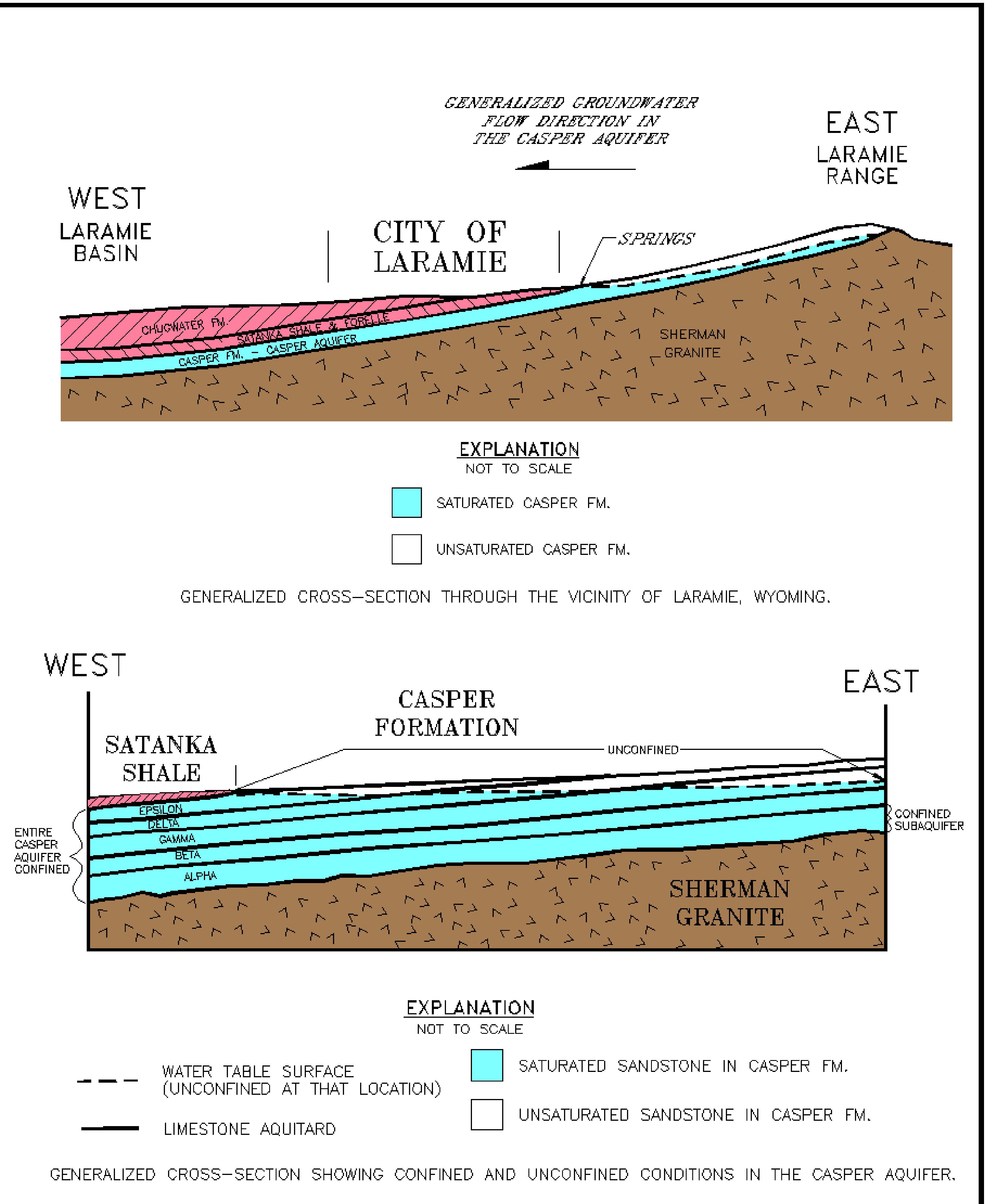
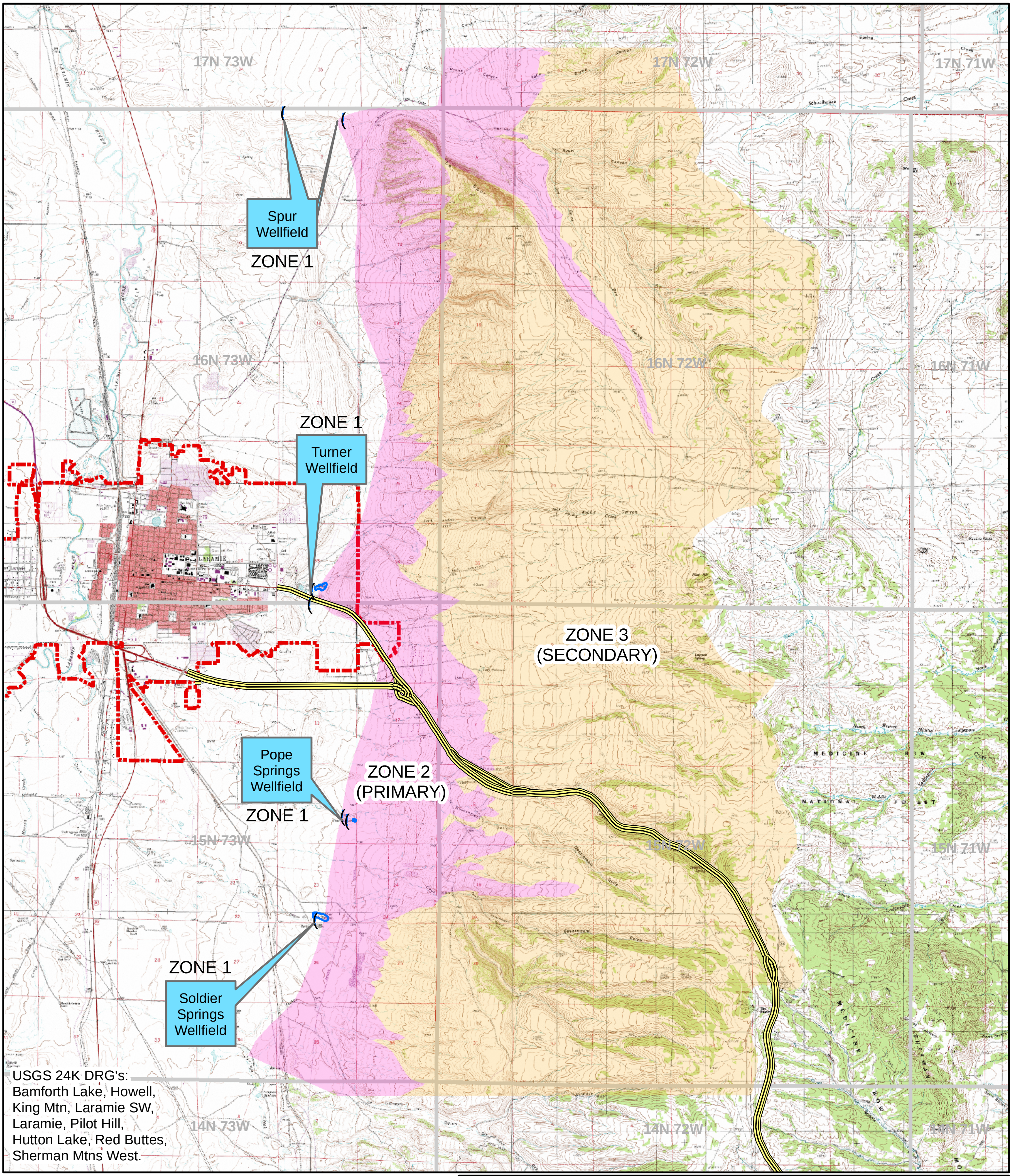


Figure 3-4 General Schematic Cross-Sections

Casper Aquifer Protection Program
Adapted from: WWC (1993)



1868
LARAMIE

November 2006
Contact:
Shawn Kraft - IT Division - GIS
307-721-5249

Casper Aquifer Protection Area Zones
Figure 3-5

CASPER AQUIFER PROTECTION AREA ZONES

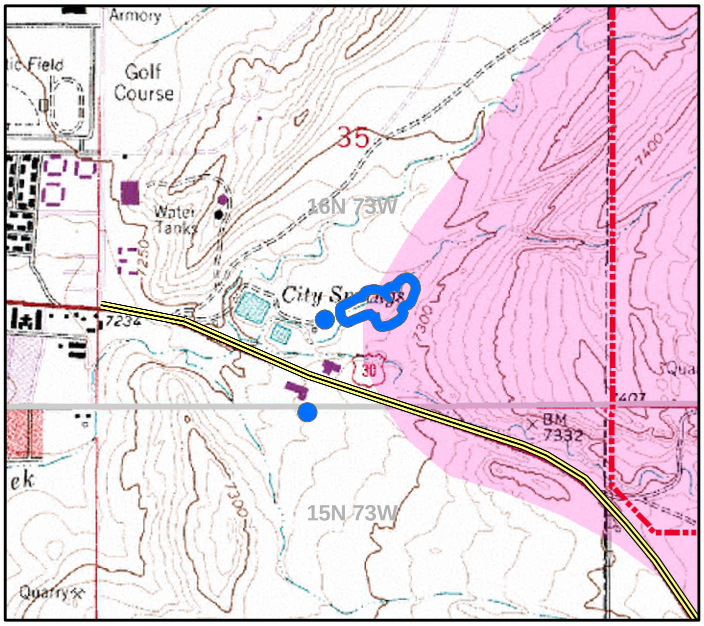
- ZONE 1
- ZONE 1
- ZONE 2 PRIMARY
- ZONE 3 SECONDARY
- CITY OF LARAMIE

1

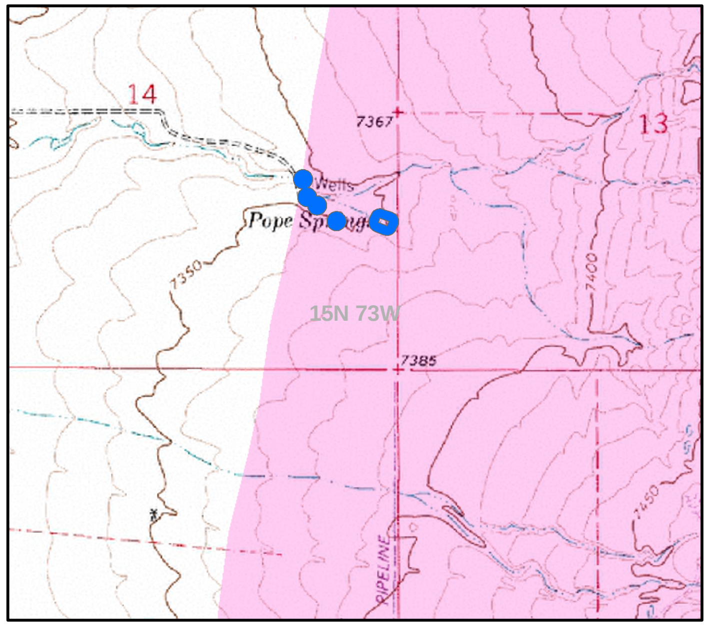
1:100,000

0 2,500 5,000 10,000
Feet

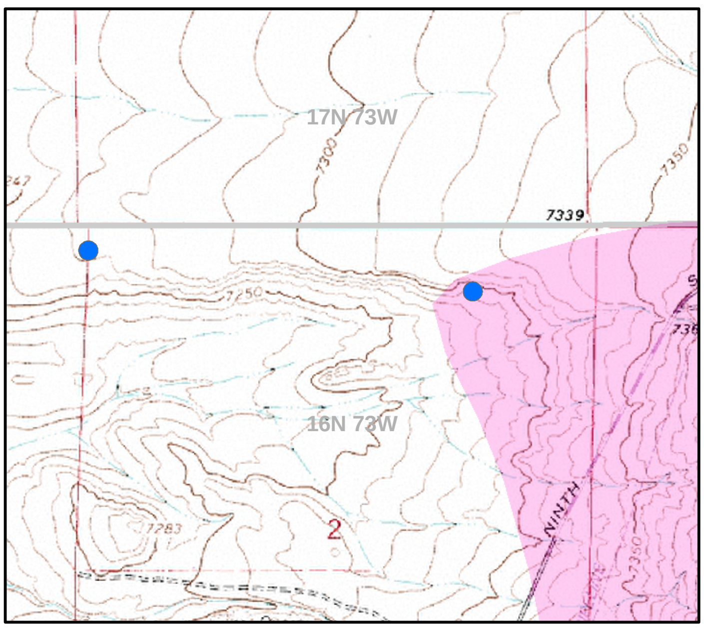
TURNER WELLFIELD



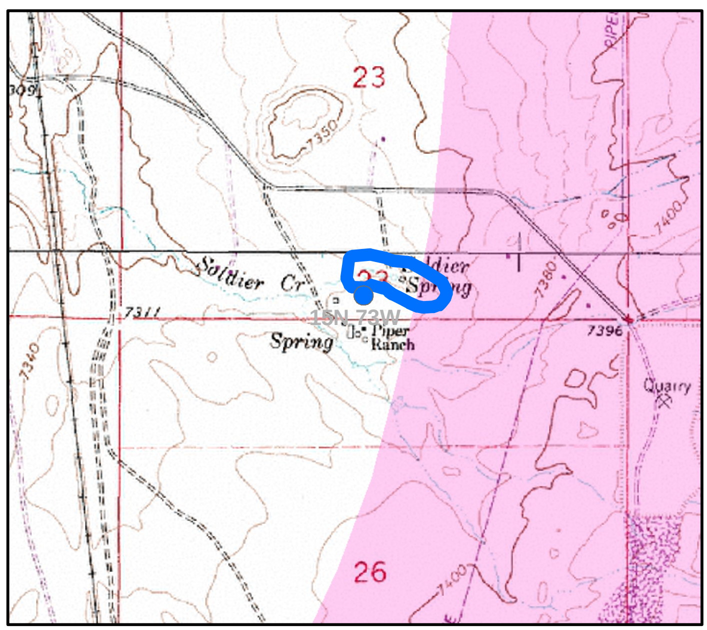
POPE SPRINGS WELLFIELD



SPUR WELLFIELD



SOLDIER SPRINGS WELLFIELD



LARAMIE

November 2006
Contact:
Shawn Kraft - IT Division - GIS
307-721-5249

Casper Aquifer Protection Area Zone 1 Delineation (Accident Prevention Zone)

Figure 3-6

CITY OF LARAMIE

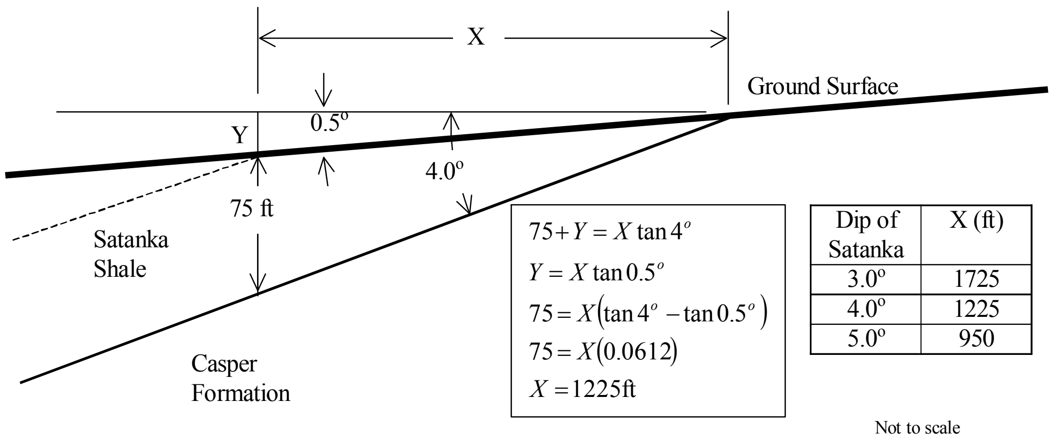
CASPER AQUIFER PROTECTION AREA ZONES

- ZONE 1
- ZONE 1
- ZONE 2 PRIMARY
- ZONE 3 SECONDARY

1

1:24,000

0 500 1,000 2,000
Feet



$$75 + Y = X \tan 4^{o}$$
$$Y = X \tan 0.5^{o}$$
$$75 = X\left(\tan 4^{o} - \tan 0.5^{o}\right)$$
$$75 = X(0.0612)$$
$$X = 1225\text{ft}$$

Dip of Satanka	X (ft)
3.0°	1725
4.0°	1225
5.0°	950

Figure 3-7. Determination of Offset Distances as a Function of Dip of the Satanka Shale.

Table 3-1 City of Laramie Municipal Well Data

Well Name	UW Permit #	Location	Year Drilled	Elevation	Lithologic Log Location	Well Radius	Total Depth	Screen Length	Screened Intervals	Screen Type	Pumping Rates	SEO Adjud pump rate
Soldier Wellfield												
Soldier #1	105576	T15N R73W Sec23 SE, SW	1997	7322.9'	WSEO	24"	289'	20.3"	44.1-64.4	Slot	1450gpm	1800gpm
Turner Wellfield												
Turner #1	55507	T15N R73W Sec14 NE,SE	1982	7273'	WSEO	16"	240'	NA	NA	NA	1750gpm	1400gpm
1st ENL Turner #1	61724	T15N R73W Sec14 NE,SE	1982	7273'	WSEO	16"	240'	NA	NA	NA	1750gpm	800gpm
2nd ENL Turner #1	72689	T15N R73W Sec14 NE,SE	1982	7273'	WSEO	16"	240'	NA	NA	NA	1750gpm	300 gpm
		*Under UW permit numbers 55507, 61724, and 72689, the City of Laramie is adjuducated a total of 2500gpm from Turner #1										
Turner #2	55508	T16N R73W Sec35 SE,SW	1982	7266'	WSEO	16"	350'	NA	NA	NA	1250gpm	1400gpm*
1st ENL Turner #2	59131	T16N R73W Sec35 SE,SW	1982	7266'	WSEO	16"	350'	NA	NA	NA	1250gpm	200gpm*
		*Under permit numbers 55508 and 59131, the City of Laramie is adjudicated a total of 1600gpm from Turner #2										
Pope Wellfield												
Pope #1	153	T15N R73W Sec14 NE,SE	1937	7335.5'	WSEO	8"	156'	NA	NA	NA	220gpm	600gpm
Pope #2	154	T15N R73W Sec14 NE,SE	1938	7338.8'	WSEO	8"	162'	NA	NA	NA	520gpm	600gpm*
1st ENL Pope#2	72690	T15N R73W Sec14 NE,SE	1938	7338.8'	WSEO	8"	162'	NA	NA	NA	675gpm	75gpm*
Pope #3	155	T15N R73W Sec14 NE,SE	1939	7338.8'	WSEO	15"	158'	NA	NA	NA	600gpm	600gpm^^
1st ENL Pope#3	55505	T15N R73W Sec14 NE,SE	1939	7338.8'	WSEO	15"	158'	NA	NA	NA	600gpm	250gpm^^
2nd ENL Pope#3	72691	T15N R73W Sec14 NE,SE	1939	7338.8'	WSEO	15"	158'	NA	NA	NA	600gpm	50gpm^^
Pope #4	55506	T15N R73W Sec14 NE,SE	1982	7351'	WSEO	16"	350'	NA	NA	NA	1500gpm	1750gpm>>
1st Enl Pope#4	72692	T15N R73W Sec14 NE,SE	1982	7351'	WSEO	16"	350'	NA	NA	NA	1500gpm	50gpm>>
			*Under UW permit numbers 154 and 72690, the City of Laramie s adjudicated a total of 675gpm from Pope #2									
			^^Under UW permit numbers 155,55505, and 72691, the City of Laramie if adjudicated a total of 900gpm from Pope #3									
			>>Under UW permit numbers 55506 and 72692, the City of Laramie is adjudicated a total of 1800gpm from Pope#4									
Spur Wellfield												
Spur #1	106547	T16N R73W Sec2 NE,NE	1997	7290.65'	WSEO	16"	305'	NA	NA	NA	1400gpm	1400gpm
Spur #2	107279	T16N R73W Sec2 NW,NW	1997	7270'	WSEO	16"	323'	NA	NA	NA	1400gpm	1400gpm

Table 3-2 Pump Data

Well Name	Pump Type	Pump Make	Pump Model	Pump Setting (Feet)	Pump Capacity (GPM)	Motor Make	Motor Model	Motor Rating (HP)	Year Installed
Spur #1	Line-Shaft Turbine	Floway	12JKH	86	1400	G.E.	VHS	100	1997
Spur #2	Line-Shaft Turbine	Floway	12JKH	76	1400	G.E.	VHS	100	1997
Turner #1	Line-Shaft Turbine	Aurora Verti-Line	V82-70503	80	2500	G.E.	JTJ930342	40	1981
Turner #2	Line-Shaft Turbine	Aurora Verti-Line	V82-70502	88	1600	G.E.	JTJ930341	40	1981
Pope #1	Line-Shaft Turbine	Aurora Verti-Line	V82-70504	55	550	G.E.	BV83131	7.5	1982
Pope #2	Line-Shaft Turbine	Peerless	193178	42	675	G.E.	N/A	15	1967
Pope #3	Line-Shaft Turbine	Aurora Verti-Line	V82-70500	62	900	G.E.	AVJ120301	40	1982
Pope #4	Line-Shaft Turbine	Aurora Verti-Line	V32-70501	80	1800	G.E.	GTJ729339	75	1982
Soldier #1	Line-Shaft Turbine	Floway	14DKH	46	1970	U.S. Motors	VHS	75	1997

All information collected from pump and motor sales sheets, SEO Completion Reports, Operation and Maintenance Manuals, and the 1998 EPA Sanitary Survey for Albany County.

Table 3-2 Pump Data

Well Name	Pump Type	Pump Make	Pump Model	Pump Setting (feet)	Pump Capacity (GPM)	Motor Make	Motor Model	Motor Rating (HP)	Year Installed
Spur #1	Line-Shaft Turbine	Floway	12JKh	76	1700	G.E.	VHS	100	2000
Spur #2	Line-Shaft Turbine	Floway	12JKh	86	1700	G.E.	VHS	100	2000
Turner #1	Line-Shaft Turbine	Aurora Verti-Line	V82-70503	80	2100	G.E.	JTJ930342	40	1981
Turner #2	Line-Shaft Turbine	Flowserve	14EMM	93	1600	G.E.	JTJ930341	40	2004
Pope #1	Line-Shaft Turbine	Aurora Verti-Line	V82-70504	55	450	G.E.	BV83131	7.5	1982
Pope #2	Line-Shaft Turbine	Peerless	193178	60	650	G.E.	N/A	10	1962
Pope #3	Line-Shaft Turbine	Aurora Verti-Line	V82-70500	62	1150	G.E.	AVJ120301	40	1982
Pope #4	Line-Shaft Turbine	Aurora Verti-Line	V82-70501	80	2000	G.E.	GTJ729339	75	1982
Soldier #1	Line-Shaft Turbine	Floway	14DKH	43	1970	U.S. Motors	VHS	75	1998

APPENDIX C

USGS Water Quality Analytical Sampling Results

Table 1–1. Analyses for physical characteristics measured in groundwater samples collected for the Wyoming Groundwater-Quality Monitoring Network and other wells, November 2009 through September 2016.

[Five-digit number in parentheses following the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. mg/L, milligrams per liter; CO_3, carbonate; HCO_3, bicarbonate; $CaCO_3$, calcium carbonate; nm, nanometers; NTRU, nephelometric turbidity ratio unit; --, not analyzed or reported; E, estimated]

Hydrogeologic unit	County	U.S. Geological Survey site identification number	Site name	Date of sampling (month/day/year)	Temperature, water, degrees Celsius (00010)	pH, total, field, standard units (00400)	Specific conductance, total, microsiemens per centimeter at 25 degrees Celsius (00095)	Dissolved oxygen, total (mg/L) (00300)	Oxidation reduction potential, relative to the standard hydrogen electrode (millivolts) (63002)	Alkalinity, dissolved, fixed endpoint (pH 4.5) titration, laboratory (mg/L as $CaCO_3$) (29801)	Alkalinity, filtered, inflection-point titration method (incremental titration method), field (mg/L as $CaCO_3$) (39086)	Carbonate, filtered, inflection-point titration method (incremental titration method), field (mg/L as CO_3) (00452)	Bicarbonate, filtered, inflection-point titration method (incremental titration method), field (mg/L as HCO_3) (00453)	Turbidity, total, broad band light source (400–680 nm), detectors at multiple angles including 90 +-30 degrees, ratiometric correction, NTRU (63676)
Casper aquifer	Albany	410715106002701	ALB9	8/29/2012	10.5	7.2	380	2.0	158	143	157	0.3	190	0.38
Casper aquifer	Albany	411519105323601	ALB14	9/12/2012	8.8	7.5	401	8.8	128	191	197	0.6	239	0.47
Casper aquifer	Albany	411727105305901	ALB11	9/11/2012	8.7	7.3	391	7.8	114	204	207	0.6	252	0.53
Casper aquifer	Albany	412332105321201	ALB7	8/28/2012	10.3	7.4	342	8.6	104	179	179	0.6	217	0.45
Casper aquifer	Albany	412439105360801	ALB8	8/28/2012	12.4	7.4	2,030	1.7	176	145	142	0.4	173	1.57
Casper aquifer	Albany	411638105314001	C36	8/5/2013	12.5	7.4	389	8.2	151	193	183	0	222	0.20
Casper aquifer	Albany	411809105321701	C41	9/14/2016	9.5	7.4	487	8.0	50	200	191	0	232	0.10
Casper aquifer	Albany	411754105314601	C47	9/13/2016	9.6	7.5	544	5.3	41	186	164	0	199	0.50

Table 1–2. Analyses for major ions measured in groundwater samples collected for the Wyoming Groundwater-Quality Monitoring Network and other wells, November 2009 through September 2016.

[Five-digit number in parentheses following the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. mg/L, milligrams per liter; SiO_2, silicon dioxide; °C, degrees Celsius; --, not analyzed or reported; E, estimated; <, less than]

Hydrogeologic unit	County	U.S. Geological Survey site identification number	Site name	Date of sampling (month/day/ year)	Calcium, dissolved (mg/L) (00915)	Calcium, total (mg/L) (00916)	Magnesium, dissolved (mg/L) (00925)	Magnesium, total (mg/L) (00927)	Sodium, dissolved (mg/L) (00930)	Sodium, total (mg/L) (00929)	Potassium, dissolved (mg/L) (00935)	Potassium, total (mg/L) (00937)	Chloride, dissolved (mg/L) (00940)	Sulfate, dissolved (mg/L) (00945)	Fluoride, dissolved (mg/L) (00950)	Silica, dissolved (mg/L as SiO_2) (00955)	Silica, total (mg/L as SiO_2) (00956)	Dissolved solids dried at 180° C, dissolved (mg/L) (70300)
Casper aquifer	Albany	410715106002701	ALB9	8/29/2012	54.6	--	8.22	--	11.8	--	2.44	--	18.6	26.1	0.5	13.7	14.0	234
Casper aquifer	Albany	411519105323601	ALB14	9/12/2012	59.3	--	15.4	--	3.28	--	<1.00	--	8.6	8.7	<0.2	8.61	8.48	236
Casper aquifer	Albany	411727105305901	ALB11	9/11/2012	59.6	--	14.7	--	1.66	--	<1.00	--	0.7	7.1	<0.2	8.66	8.74	227
Casper aquifer	Albany	412332105321201	ALB7	8/28/2012	45.3	--	17.0	--	2.67	--	<1.00	--	1.0	5.7	0.2	9.15	9.36	211
Casper aquifer	Albany	412439105360801	ALB8	8/28/2012	178	--	97.1	--	151	--	2.61	--	25.4	967	0.4	12.5	12.6	1,640
Casper aquifer	Albany	411638105314001	C36	8/5/2013	51	--	17.0	--	3	--	< 1.0	--	4.1	8.3	0.1	8.6	8.9	204
Casper aquifer	Albany	411809105321701	C41	9/14/2016	65	--	17.0	--	6.6	--	< 1.0	--	14	21	< 0.1	10	E 11	258
Casper aquifer	Albany	411754105314601	C47	9/13/2016	67	--	17.0	--	12	--	1.10	--	31	26	< 0.1	12	E 12	276

[1]Quantified concentration in the environmental sample is less than five times the maximum concentration in a blank sample.

[2]Relative percent difference (RPD) between the groundwater sample and replicate sample is greater than 20 percent.

Table 1–3. Analyses for trace elements measured in groundwater samples collected for the Wyoming Groundwater-Quality Monitoring Network and other wells, November 2009 through September 2016.

[Five-digit number in parentheses following the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. µg/L, micrograms per liter; <, less than; --, not analyzed or reported; E, estimated]

					Metals																																				Metalloids							
Hydrogeologic unit	County	U.S. Geological Survey site identification number	Site name	Date of sampling (month/day/year)	Aluminum, dissolved (µg/L) (01106)	Aluminum, total (µg/L) (01105)	Barium, dissolved (µg/L) (01005)	Barium, total (µg/L) (01007)	Beryllium, dissolved (µg/L) (01010)	Beryllium, total (µg/L) (01012)	Cadmium, dissolved (µg/L) (01025)	Cadmium, total (µg/L) (01027)	Chromium, dissolved (µg/L) (01030)	Chromium, total (µg/L) (01034)	Cobalt, dissolved (µg/L) (01035)	Cobalt, total (µg/L) (01037)	Copper, dissolved (µg/L) (01040)	Copper, total (µg/L) (01042)	Iron, dissolved (µg/L) (01046)	Iron, total (µg/L) (01045)	Lead, dissolved (µg/L) (01049)	Lead, total (µg/L) (01051)	Lithium, dissolved (µg/L) (01130)	Lithium, total (µg/L) (01132)	Manganese, dissolved (µg/L) (01056)	Manganese, total (µg/L) (01055)	Molybdenum, dissolved (µg/L) (01060)	Molybdenum, total (µg/L) (01062)	Nickel, dissolved (µg/L) (01065)	Nickel, total (µg/L) (01067)	Silver, dissolved (µg/L) (01075)	Silver, total (µg/L) (01077)	Strontium, dissolved (µg/L) (01080)	Strontium, total (µg/L) (01082)	Thallium, dissolved (µg/L) (01057)	Thallium, total (µg/L) (01059)	Vanadium, dissolved (µg/L) (01085)	Vanadium, total (µg/L) (01087)	Zinc, dissolved (µg/L) (01090)	Zinc, total (µg/L) (01092)	Antimony, dissolved (µg/L) (01095)	Antimony, total (µg/L) (01097)	Arsenic, dissolved (µg/L) (01000)	Arsenic, total (µg/L) (01002)	Boron, dissolved (µg/L) (01020)	Boron, total (µg/L) (01022)	Selenium, dissolved (µg/L) (01145)	Selenium, total (µg/L) (01147)
Casper aquifer	Albany	410715106002701	ALB9	8/29/2012	<100	<100	84.2	86.1	<1.0	<1.0	<0.2	<0.2	<5.0	<5.0	<2.0	<2.0	49.3	45.9	<100	<100	<1.0	<1.0	--	--	<2.0	<2.0	5.3	5.0	<4.0	<4.0	<0.50	<0.50	242	246	<0.30	<0.30	<10.0	<10.0	<50	<50	<1.0	<1.0	<4.0	<4	<100	<100	1.0	<1.0
Casper aquifer	Albany	411519105323601	ALB14	9/12/2012	<100	<100	226	226	<1.0	<1.0	<0.2	<0.2	<5.0	<5.0	<2.0	<2.0	<5.0	<5.0	<100	<100	<1.0	<1.0	--	--	<2.0	<2.0	<5.0	<5.0	<4.0	<4.0	<0.50	<0.50	164	163	<0.30	<0.30	<10.0	<10.0	<50	<50	<1.0	<1.0	<4.0	<4	<100	<100	<1.0	<1.0
Casper aquifer	Albany	411727105305901	ALB11	9/11/2012	<100	<100	191	192	<1.0	<1.0	<0.2	<0.2	<5.0	<5.0	<2.0	<2.0	<5.0	<5.0	<100	<100	<1.0	<1.0	--	--	<2.0	<2.0	<5.0	<5.0	<4.0	<4.0	<0.50	<0.50	122	123	<0.30	<0.30	<10.0	<10.0	<50	<50	<1.0	<1.0	<4.0	<4	<100	<100	<1.0	<1.0
Casper aquifer	Albany	412332105321201	ALB7	8/28/2012	<100	<100	134	138	<1.0	<1.0	<0.2	<0.2	<5.0	<5.0	<2.0	<2.0	<5.0	<5.0	<100	<100	<1.0	<1.0	--	--	<2.0	<2.0	5.0	<5.0	<4.0	<4.0	<0.50	<0.50	172	176	<0.30	<0.30	<10.0	<10.0	<50	<50	<1.0	<1.0	<4.0	<4	<100	<100	<1.0	<1.0
Casper aquifer	Albany	412439105360801	ALB8	8/28/2012	<100	<100	6.5	8.1	<1.0	<1.0	<0.2	<0.2	<5.0	<5.0	<2.0	<2.0	<5.0	<5.0	<100	[2]135	<1.0	<1.0	--	--	<2.0	3.2	10.7	10.2	<4.0	<4.0	<0.50	<0.50	4,840	5,150	<0.30	<0.30	14.2	20.7	<50	<50	<1.0	<1.0	<4.0	<4	790	798	7.2	4.8
Casper aquifer	Albany	411638105314001	C36	8/5/2013	< 100	< 100	360	370	< 1.0	< 1.0	< 0.20	< 0.20	< 5.0	< 5.0	< 2.0	< 2.0	< 5.0	< 5.0	< 100	< 100	< 1.00	< 1.00	--	--	< 2.0	< 2.0	7.6	< 5.0	< 4.0	< 4.0	< 0.50	< 0.50	170	180	< 0.30	< 0.30	< 10	< 10	< 50	< 50	< 1.0	< 1.0	< 4.00	< 4.0	< 100	< 100	< 1.0	< 1.0
Casper aquifer	Albany	411809105321701	C41	9/14/2016	< 100	< 100	270	280	< 1.0	< 1.0	< 0.20	< 0.20	< 5.0	< 5.0	< 2.0	< 2.0	< 5.0	< 5.0	< 100	< 100	< 0.50	< 0.50	--	--	< 2.0	< 2.0	6.1	7.2	< 4.0	< 4.0	< 0.50	< 0.50	200	200	< 0.50	< 0.50	E 12	12	< 50	< 50	< 0.50	< 0.5	1.7	2.2	< 100	< 100	1.1	< 1.0
Casper aquifer	Albany	411754105314601	C47	9/13/2016	< 100	< 100	260	270	< 1.0	< 1.0	< 0.20	< 0.20	< 5.0	< 5.0	< 2.0	< 2.0	< 5.0	< 5.0	< 100	< 100	< 0.50	< 0.50	--	--	< 2.0	3.1	6.3	7.9	< 4.0	< 4.0	< 0.50	< 0.50	190	200	< 0.50	< 0.50	E 14	10	< 50	< 50	< 0.50	< 0.5	2	2.5	< 100	< 100	1.7	< 1.0

Table 1–4. Analyses for nutrients and dissolved organic carbon measured in groundwater samples collected for the Wyoming Groundwater-Quality Monitoring Network and other wells, November 2009 through September 2016.

[Five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. mg/L, milligrams per liter; N, nitrogen; P, phosphorus; <, less than; --, not analyzed or reported; E, estimated]

Hydrogeologic unit	County	U.S. Geological Survey site identification number	Site name	Date of sampling (month/day/year)	Ammonia, dissolved (mg/L as N) (00608)	Nitrate plus nitrite, dissolved (mg/L as N) (00631)	Nitrite, dissolved (mg/L as N) (00613)	Nitrate, dissolved (mg/L as N) (00618)	Orthophosphate, dissolved (mg/L as P) (00671)	Phosphorus, dissolved (mg/L as P) (00666)	Phosphorus, total (mg/L as P) (P00665)	Total nitrogen (nitrate + nitrite + ammonia + organic-N), dissolved (mg/L) (62854)	Total nitrogen (nitrate + nitrite + ammonia + organic-N), total (mg/L) (62855)	Organic carbon, dissolved (mg/L) (00681)
Casper aquifer	Albany	410715106002701	ALB9	8/29/2012	<0.050	--	<0.005	0.704	0.040	--	--	--	0.852	2.22
Casper aquifer	Albany	411519105323601	ALB14	9/12/2012	<0.050	--	<0.005	2.14	0.033	--	--	--	1.94	0.727
Casper aquifer	Albany	411727105305901	ALB11	9/11/2012	<0.050	--	<0.005	1.58	0.018	--	--	--	E1.43	0.596
Casper aquifer	Albany	412332105321201	ALB7	8/28/2012	<0.050	--	<0.005	1.7	0.020	--	--	--	1.47	0.600
Casper aquifer	Albany	412439105360801	ALB8	8/28/2012	<0.050	--	<0.005	[2]1.11	[2]0.025	--	--	--	1.39	1.54
Casper aquifer	Albany	411638105314001	C36	8/5/2013	--	--	--	--	--	--	--	--	1.75	0.59
Casper aquifer	Albany	411809105321701	C41	9/14/2016	< 0.01	4.49	< 0.001	4.49	0.01	0	--	4.55	--	1.06
Casper aquifer	Albany	411754105314601	C47	9/13/2016	< 0.01	6.29	< 0.001	6.29	0.016	0	--	6.76	--	1.58

[1]Quantified concentration in the environmental sample is less than five times the maximum concentration in a blank sample.

[2]Relative percent difference (RPD) between the groundwater sample and replicate sample is greater than 20 percent.

Table 1–5. Analyses for radionuclides and environmental isotopes measured in groundwater samples collected for the Wyoming Groundwater-Quality Monitoring Network and other wells, November 2009 through September 2016.

[Five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. pCi/L, picocuries per liter; µg/L, micrograms per liter; ± , plus or minus; csu, 1-sigma combined standard uncertainty; ssLc, sample-specific critical level; $\delta^{18}O$, oxygen-18/oxygen-16 isotopic ratio; $\delta^{2}H$, deuterium/protium isotopic ratio; --, not analyzed or reported; <, less than; E, estimated; R, values less than the ssLc are reported as not detections]

Hydrogeologic unit	County	U.S. Geological Survey site identification number	Site name	Date of sampling (month/day/year)	Radionuclides								Environmental isotopes			
					Gross alpha radioactivity, filtered, thorium-230 curve (pCi/L) (04126)		Gross beta radioactivity, filtered, cesium-137 curve (pCi/L) (03515)		Radon, unfiltered (pCi/L) (82303)		Uranium (natural), filtered (µg/L) (22703)	Uranium (natural), unfiltered (µg/L) (28011)	$\delta^{18}O$, unfiltered, per mil (82085)	$\delta^{2}H$, unfiltered, per mil (82082)	Tritium, unfiltered (pCi/L) (07000)	
Casper aquifer	Albany	410715106002701	ALB9	8/29/2012	--	--	--	--	--	--	5	5.2	-16.5	-127	--	--
Casper aquifer	Albany	411519105323601	ALB14	9/12/2012	--	--	--	--	--	--	1	1	-17.3	-130	--	--
Casper aquifer	Albany	411727105305901	ALB11	9/11/2012	--	--	--	--	--	--	0.8	0.8	-16.2	-122	--	--
Casper aquifer	Albany	412332105321201	ALB7	8/28/2012	--	--	--	--	--	--	2.1	2	-18.1	-138	--	--
Casper aquifer	Albany	412439105360801	ALB8	8/28/2012	--	--	--	--	--	--	35.2	33.9	-16.4	-128	--	--
Casper aquifer	Albany	411638105314001	C36	8/5/2013	--	--	--	--	--	--	1.1	1.1	-17.02	-129	--	--
Casper aquifer	Albany	411809105321701	C41	9/14/2016	R 0.7	--	1.8	--	280	--	1	1	--	--	15.3	--
Casper aquifer	Albany	411754105314601	C47	9/13/2016	R 0.8	--	1.2	--	255	--	1.1	1.1	--	--	11.8	--

Table 1–6. Analyses for organic compounds (volatile organic compounds, gasoline range and diesel range organics, and dissolved hydrocarbon gases) measured in groundwater samples collected for the Wyoming groundwater-quality monitoring network and other wells, November 2009 - September 2016.

[Five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. µg/L, micrograms per liter; C10-C36, 10 to 36 carbon atoms; mg/L, milligrams per liter; <, less than; --, not analyzed or reported; detections in **bold** type and underlined; E, estimated]

Hydrogeologic unit	County	U.S. Geological Survey site identification number	Site name	Date of sampling (month/day/ year)	1,2,3-Trichloropropane, total (µg/L) (77443)	1,2-Dibromo-3-chloropropane, total (µg/L) (38760)	1,2-Dibromo-3-chloropropane, total (µg/L) (82625)	1,2-Dibromoethane, total (µg/L) (30203)	1,2-Dibromoethane, total (µg/L) (77651)	1,2-Dichloroethane, total (µg/L) (32103)	1,2-Dichloropropane, total (µg/L) (34541)	1,3-Dichloropropane, total (µg/L) (77173)	1,4-Dichlorobenzene, total (µg/L) (34571)
Casper aquifer	Albany	410715106002701	ALB9	8/29/2012	<0.25	<0.25	--	<0.25	--	<0.25	<0.25	<0.25	<0.25
Casper aquifer	Albany	411519105323601	ALB14	9/12/2012	<0.25	<0.25	--	<0.25	--	<0.25	<0.25	<0.25	<0.25
Casper aquifer	Albany	411727105305901	ALB11	9/11/2012	<0.25	<0.25	--	<0.25	--	<0.25	<0.25	<0.25	<0.25
Casper aquifer	Albany	412332105321201	ALB7	8/28/2012	<0.25	<0.25	--	<0.25	--	<0.25	<0.25	<0.25	<0.25
Casper aquifer	Albany	412439105360801	ALB8	8/28/2012	<0.25	<0.25	--	<0.25	--	<0.25	<0.25	<0.25	<0.25
Casper aquifer	Albany	411638105314001	C36	8/5/2013	< 0.25	--	< 0.25	--	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25
Casper aquifer	Albany	411809105321701	C41	9/14/2016	< 0.25	--	< 0.25	--	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25
Casper aquifer	Albany	411754105314601	C47	9/13/2016	< 0.25	--	< 0.25	--	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25

Constituents that were not analyzed or were below laboratory detection limits: 1,1,2-Trichloro-1,2,2-trifluoroethane, total (77652); 1,2,3,4-Tetramethylbenzene, total (49999); 1,2,3,5-Tetramethylbenzene, total (50000); 1,2,3-Trimethylbenzene, total (77221); 1,2-Dichloroethene (cis & trans), total (45617); 1-Chlorobutane, total (77923); 2-Ethyltoluene, total (77220); Bromoethene, total (50002); Chloroacetonitrile, total (50003); Nitrobenzene, total (34447); Pentachloroethane, total (81501); tert-Butyl ethyl ether, total (50004); trans-1,4-Dichloro-2-butene, total (73547).

3-Chloropropene, total recoverable (µg/L) (78109)	Acrylonitrile, total recoverable (µg/L) (34215)	Bromomethane, total recoverable (µg/L) (30202)	Bromomethane, total recoverable (µg/L) (34413)	Carbaryl, filtered (0.7-micron glass fiber filter), recoverable (µg/L) (82680)	Carbon disulfide, total (µg/L) (77041)	*cis* -1,3-Dichloropropene, total recoverable (µg/L) (34704)	Iodomethane, total recoverable (µg/L) (49262)	Iodomethane, total recoverable (µg/L) (77424)	*trans* -1,3-Dichloropropene, total recoverable (µg/L) (34699)	1,1,1,2-Tetrachloroethane, total recoverable (µg/L) (77562)	1,1,1-Trichloroethane, total (µg/L) (34506)	1,1,2,2-Tetrachloroethane, total (µg/L) (34516)	1,1,2-Trichloroethane, total (µg/L) (34511)	1,1-Dichloroethane, total (µg/L) (34496)
--	<0.25	<1.0	--	--	<0.25	<0.25	<1	--	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
--	<0.25	<0.50	--	--	<0.25	<0.25	<0.500	--	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
--	<0.25	<0.50	--	--	<0.25	<0.25	<0.500	--	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
--	<0.25	<1.0	--	--	<0.25	<0.25	<1	--	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
--	<0.25	<1.0	--	--	<0.25	<0.25	<1	--	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
< 0.25	< 0.2	--	< 0.25	--	< 0.25	< 0.25	--	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25
< 0.25	< 0.2	--	< 0.25	< 0.16	< 0.25	< 0.25	--	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25
< 0.25	< 0.2	--	< 0.25	< 0.16	< 0.25	< 0.25	--	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25

1,1-Dichloroethene, total (µg/L) (34501)	1,1-Dichloropropene, total (µg/L) (77168)	1,2,3-Trichlorobenzene, total (µg/L) (77613)	1,2,4-Trichlorobenzene, total (µg/L) (34551)	1,2,4-Trimethylbenzene, total (µg/L) (77222)	1,2-Dichlorobenzene, total (µg/L) (34536)	1,3,5-Trimethylbenzene, total (µg/L) (77226)	1,3-Dichlorobenzene, total (µg/L) (34566)	2,2-Dichloropropane, total (µg/L) (77170)	2-Chlorotoluene, total (µg/L) (77275)	4-Chlorotoluene, total (µg/L) (77277)	4-Isopropyltoluene, total (µg/L) (30341)	4-Isopropyltoluene, total (µg/L) (77356)	Acetone, total (µg/L) (81552)
<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	--	<1.0
<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	--	<1.0
<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	--	<1.0
<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	--	<1.0
<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	--	<1.0
< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	--	< 0.25	< 1.0
< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	--	< 0.25	V 0.7
< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	--	< 0.25	V 0.5

Benzene, total (µg/L) (34030)	Bromobenzene, total (µg/L) (81555)	Bromochloromethane, total (µg/L) (73085)	Bromochloromethane, total (µg/L) (77297)	Bromodichloromethane, total (µg/L) (32101)	Chlorobenzene, total (µg/L) (34301)	Chloroethane, total (µg/L) (34311)	Chloromethane, total (µg/L) (30201)	Chloromethane, total (µg/L) (34418)	*cis* -1,2-Dichloroethene, total (µg/L) (77093)	Dibromochloromethane, total (µg/L) (32105)	Dibromomethane, total (µg/L) (30217)
<0.25	<0.25	<0.25	--	<0.25	<0.25	<0.25	<0.25	--	<0.25	<0.25	<0.25
<0.25	<0.25	<0.25	--	<0.25	<0.25	<0.25	<0.25	--	<0.25	<0.25	<0.25
<0.25	<0.25	<0.25	--	<0.25	<0.25	<0.25	<0.25	--	<0.25	<0.25	<0.25
<0.25	<0.25	<0.25	--	<0.25	<0.25	<0.25	<0.25	--	<0.25	<0.25	<0.25
<0.25	<0.25	<0.25	--	<0.25	<0.25	<0.25	<0.25	--	<0.25	<0.25	<0.25
< 0.25	< 0.25	--	< 0.25	< 0.25	< 0.25	< 0.25	--	< 0.25	< 0.25	< 0.25	< 0.25
< 0.25	< 0.25	--	< 0.25	< 0.25	< 0.25	< 0.25	--	< 0.25	< 0.25	< 0.25	< 0.25
< 0.25	< 0.25	--	< 0.25	< 0.25	< 0.25	< 0.25	--	< 0.25	< 0.25	< 0.25	< 0.25

Dichlorodifluoromethane, total (µg/L) (34668)	Dichloromethane, total (µg/L) (34423)	Diesel range organic compounds (extended carbon range C10-C36), total (mg/L) (63746)	Diethyl ether, total (µg/L) (81576)	Diisopropyl ether, total (µg/L) (81577)	Ethane, total (µg/L) (82045)	Ethene, total (µg/L) (82044)	Ethyl methacrylate, total (µg/L) (73570)	Ethyl methyl ketone, total (µg/L) (81595)	Ethylbenzene, total (µg/L) (34371)	Gasoline range organic compounds, total (µg/L) (49892)	Hexachlorobutadiene, total (µg/L) (39702)	Hexachloroethane, total (µg/L) (34396)	Isobutyl methyl ketone, total (µg/L) (78133)	Isopropylbenzene, total (µg/L) (77223)	Methane, total (µg/L) (76994)
<0.25	<0.25	[1]**0.045**	<0.25	--	<0.57	<0.40	--	<1.0	<0.25	<20	<0.25	<0.25	<1.0	<0.25	<0.22
<1.0	<0.25	<0.020	<0.25	--	<0.57	<0.40	--	<1.0	<0.25	<20	<0.25	<0.25	<1.0	<0.25	<0.22
<1.0	<0.25	<0.020	<0.25	--	<0.57	<0.40	--	<1.0	<0.25	<20	<0.25	<0.25	<1.0	<0.25	<0.22
<0.25	<0.25	<0.020	<0.25	--	<0.57	<0.40	--	<1.0	<0.25	<20	<0.25	<0.25	<1.0	<0.25	<0.22
<0.25	<0.25	[1]**0.022**	<0.25	--	<0.57	<0.40	--	<1.0	<0.25	<20	<0.25	<0.25	<1.0	<0.25	<0.22
< 1.0	< 0.25	< 0.020	< 0.250	--	< 0.6	< 0.4	--	< 0.5	< 0.25	< 20	< 0.25	--	< 0.2	< 0.25	< 0.2
< 1.0	< 0.25	< 0.020	< 0.250	--	< 5.0	< 5.0	--	< 0.5	< 0.25	< 20	< 0.25	--	< 0.5	< 0.25	< 2.0
< 1.0	< 0.25	0.03	< 0.250	--	< 5.0	< 5.0	--	< 0.5	< 0.25	< 20	< 0.25	--	< 0.5	< 0.25	< 2.0

Methyl acrylate, total (µg/L) (49991)	Methyl acrylonitrile, total (µg/L) (81593)	Methyl methacrylate, total (µg/L) (81597)	Methyl *tert* -butyl ether, total (µg/L) (78032)	Methyl *tert* -pentyl ether, total (µg/L) (50005)	*meta* - and *para* - Xylene, total (µg/L) (85795)	Naphthalene, total (µg/L) (34696)	*n* -Butyl methyl ketone, total (µg/L) (77103)	*n* - Butylbenzene, total (µg/L) (77342)	*n* - Propylbenzene, total (µg/L) (77224)	*o* - Xylene, total (µg/L) (77135)	*sec* - Butylbenzene, total (µg/L) (77350)	Styrene, total (µg/L) (77128)	*tert* - Butylbenzene, total (µg/L) (77353)	Tetrachloroethene, total (µg/L) (34475)	Tetrachloromethane, total (µg/L) (32102)	Tetrahydrofuran, total (µg/L) (81607)
<0.25	--	--	<0.25	--	<0.50	<0.25	<1.0	<0.25	<0.25	<0.25	<0.25	<0.25	<0.50	<0.25	<0.25	<0.25
<0.25	--	--	<0.25	--	<0.50	<0.25	<1.0	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	--
<0.25	--	--	<0.25	--	<0.50	<0.25	<1.0	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	--
<0.25	--	--	<0.25	--	<0.50	<0.25	<1.0	<0.25	<0.25	<0.25	<0.25	<0.25	<0.50	<0.25	<0.25	<0.25
<0.25	--	--	<0.25	--	<0.50	<0.25	<1.0	<0.25	<0.25	<0.25	<0.25	<0.25	<0.50	<0.25	<0.25	<0.25
< 0.2	< 0.2	--	< 0.25	--	< 0.50	< 0.25	< 0.2	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	--
< 0.2	< 0.2	--	< 0.25	--	< 0.50	< 0.25	< 0.5	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	--
< 0.2	< 0.2	--	< 0.25	--	< 0.50	< 0.25	< 0.5	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	--

Toluene, total (µg/L) (34010)	*trans* -1,2-Dichloroethene, total (µg/L) (34546)	Tribromomethane, total (µg/L) (32104)	Trichloroethene, total (µg/L) (39180)	Trichlorofluoromethane, total (µg/L) (34488)	Trichloromethane, total (µg/L) (32106)	Vinyl chloride, total (µg/L) (39175)	Xylene (all isomers), total (µg/L) (81551)
<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<1.0
<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<1.0
<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<1.0
<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<1.0
<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<1.0
< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 1.0
< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.5
< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.5

Table 1–7. Analyses for organic compounds (wastewater compounds) measured in groundwater samples collected for the Wyoming Groundwater-Quality Monitoring Network and other wells, November 2009 through September 2016.

[Five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property; µg/L, micrograms per liter; DEET, *N*,*N*-diethyl-*meta*-toluamide; --, not analyzed or reported; <, less than; E, estimated; detections in **bold** type and underlined]

Hydrogeologic unit	County	U.S. Geological Survey site identification number	Site name	Date of sampling (month/day/year)	1,4-Dichlorobenzene, dissolved (µg/L) (34572)	Bromacil, dissolved (µg/L) (04029)	Camphor, dissolved (µg/L) (62070)	Carbaryl, dissolved (µg/L) (82680)	Carbazole, dissolved (µg/L) (62071)	Chlorpyrifos, dissolved (µg/L) (38933)	DEET, dissolved (µg/L) (62082)	Diazinon, dissolved (µg/L) (39572)	Metalaxyl, dissolved (µg/L) (50359)	Metolachlor, dissolved (µg/L) (39415)	*p*-Cresol, dissolved (µg/L) (62084)	Prometon, dissolved (µg/L) (04037)	1-Methylnaphthalene, dissolved (µg/L) (62054)	2,6-Dimethylnaphthalene, dissolved (µg/L) (62055)
Casper aquifer	Albany	410715106002701	ALB9	8/29/2012	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Casper aquifer	Albany	411519105323601	ALB14	9/12/2012	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Casper aquifer	Albany	411727105305901	ALB11	9/11/2012	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Casper aquifer	Albany	412332105321201	ALB7	8/28/2012	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Casper aquifer	Albany	412439105360801	ALB8	8/28/2012	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Casper aquifer	Albany	411638105314001	C36	8/5/2013	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Casper aquifer	Albany	411809105321701	C41	9/14/2016	< 0.040	< 0.36	< 0.044	< 0.16	< 0.030	< 0.16	0.01	< 0.16	< 0.12	< 0.028	< 0.08	E 0.03	< 0.022	< 0.06
Casper aquifer	Albany	411754105314601	C47	9/13/2016	< 0.040	< 0.36	< 0.044	< 0.16	< 0.030	< 0.16	< 0.06	< 0.16	< 0.12	< 0.028	< 0.08	E 0.05	< 0.022	< 0.06

2-Methylnaphthalene, dissolved (µg/L) (62056)	3-*beta*-Coprostanol, dissolved (µg/L) (62057)	3-Methyl-1H-indole, dissolved (µg/L) (62058)	3-*tert*-Butyl-4-hydroxyanisole, dissolved (µg/L) (62059)	4-Cumylphenol, dissolved (µg/L) (62060)	4-*n*-Octylphenol, dissolved (µg/L) (62061)	4-Nonylphenol (sum of all isomers), dissolved (µg/L) (62085)	4-Nonylphenol diethoxylate (sum of all isomers), dissolved (µg/L) (62083)	4-*tert*-Octylphenol diethoxylate, dissolved (µg/L) (61705)	4-*tert*-Octylphenol monoethoxylate, dissolved (µg/L) (61706)	4-*tert*-Octylphenol, dissolved (µg/L) (62062)	5-Methyl-1H-benzotriazole, dissolved (µg/L) (62063)	9,10-Anthraquinone, dissolved (µg/L) (62066)	Acetophenone, dissolved (µg/L) (62064)	Acetyl hexamethyl tetrahydro naphthalene, dissolved (µg/L) (62065)	Anthracene, dissolved (µg/L) (34221)	Benzo[*a*]pyrene, dissolved (µg/L) (34248)	Benzophenone, dissolved (µg/L) (62067)	*beta*-Sitosterol, dissolved (µg/L) (62068)
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< 0.036	< 1.8	< 0.036	--	< 0.060	< 0.06	< 2	< 5.0	< 1.0	< 1.0	< 0.14	< 1.2	< 0.16	< 0.4	< 0.028	< 0.010	< 0.06	< 0.08	< 4
< 0.036	< 1.8	< 0.036	--	< 0.060	< 0.06	< 2	< 5.0	< 1.0	< 1.0	< 0.14	< 1.2	< 0.16	< 0.4	< 0.028	< 0.010	< 0.06	< 0.08	< 4

beta - Stigmastanol, dissolved (µg/L) (62086)	Caffeine, dissolved (µg/L) (50305)	Cholesterol, dissolved (µg/L) (62072)	Cotinine, dissolved (µg/L) (62005)	Dibromochloromethane, dissolved (µg/L) (34307)	D-Limonene, dissolved (µg/L) (62073)	Fluoranthene, dissolved (µg/L) (34377)	Hexahydrohexamethyl cyclopentabenzopyran, dissolved (µg/L) (62075)	Indole, dissolved (µg/L) (62076)	Isoborneol, dissolved (µg/L) (62077)	Isophorone, dissolved (µg/L) (344090	Isopropylbenzene, dissolved (µg/L) (62078)	Isoquinoline, dissolved (µg/L) (62079)	Menthol, dissolved (µg/L) (62080)	Methyl salicylate, dissolved (µg/L) (62081)	Naphthalene, dissolved (µg/L) (34443)	Phenanthrene, dissolved (µg/L) (34462)	Phenol, dissolved (µg/L) (34466)	Pyrene, dissolved (µg/L) (34470)	Tetrachloroethene, dissolved (µg/L) (34476)
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< 2.6	< 0.06	< 2.0	< 0.800	--	< 0.08	< 0.024	< 0.052	< 0.08	< 0.08	< 0.032	< 0.30	< 0.8	< 0.32	< 0.044	< 0.040	E 0.008	< 0.16	< 0.042	< 0.12
< 2.6	< 0.06	< 2.0	< 0.800	--	< 0.08	< 0.024	< 0.052	< 0.08	< 0.08	< 0.032	< 0.30	< 0.8	< 0.32	< 0.044	< 0.040	0.041	E 0.12	< 0.042	E 0.02

Tribromomethane, dissolved (µg/L) (34288)	Tributyl phosphate, dissolved (µg/L) (62089)	Triclosan, dissolved (µg/L) (62090)	Triethyl citrate, dissolved (µg/L) (62091)	Triphenyl phosphate, dissolved (µg/L) (62092)	Tris(2-butoxyethyl) phosphate, dissolved (µg/L) (62093)	Tris(2-chloroethyl) phosphate, dissolved (µg/L) (62087)	Tris(dichloroisopropyl) phosphate, dissolved (µg/L) (62088)
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< 0.10	< 0.16	< 0.20	< 0.16	< 0.12	< 0.8	< 0.10	< 0.16
< 0.10	< 0.16	< 0.20	< 0.16	< 0.12	< 0.8	< 0.10	< 0.16

Table 1–8. Analyses for bacteria measured in groundwater samples collected for the Wyoming Groundwater-Quality Monitoring Network and other wells, November 2009 through September 2016.

[Five-digit number in parentheses below the constituent name is the U.S. Geological Survey parameter code used to uniquely identify a specific constituent or property. MI, fluorogen 4-Methylumbelliferyl-β-Dgalactopyranoside and chromogen Indoxyl-β-D-glucuronide agar; MF, differential membrane filter; colonies/100 mL, colonies per 100 milliliters; <, less than; k, non-ideal colony count; E, estimated; --, not analyzed or reported]

Hydrogeologic unit	County	U.S. Geological Survey site identification number	Site name	Date of sampling (month/day/ year)	*Escherichia coli* , MI MF method, colonies/100 mL (90901)	Total coliform, MI MF method, colonies/100 mL (90900)
Casper aquifer	Albany	410715106002701	ALB9	8/29/2012	<1 k	<1 k
Casper aquifer	Albany	411519105323601	ALB14	9/12/2012	<1 k	E5 k
Casper aquifer	Albany	411727105305901	ALB11	9/11/2012	<1 k	<1 k
Casper aquifer	Albany	412332105321201	ALB7	8/28/2012	<1 k	<1 k
Casper aquifer	Albany	412439105360801	ALB8	8/28/2012	<1 k	<1 k
Casper aquifer	Albany	411638105314001	C36	8/5/2013	< 1	44
Casper aquifer	Albany	411809105321701	C41	9/14/2016	< 1	< 1
Casper aquifer	Albany	411754105314601	C47	9/13/2016	< 1	< 1

APPENDIX D

Western Boundary Revision Geologic Data

1 Western Boundary Revision Geologic Data

Stantec revised the western boundary of the Casper Aquifer Protection Area (CAPA) based on geologic and hydrogeologic data acquired since the last CAPP update in 2008. The original western boundary of the CAPA was calculated to be the line where at least 75 feet of Satanka Shale was overlying the Casper Aquifer. WHPA (2008) extended that boundary to the west primarily on section, quarter-section, and quarter-quarter section lines to provide continuous protection between Zones 1 and 2, to provide an additional buffer to the calculated 75 foot line because there were known places where the line was inaccurate, and to provide easier implementation. The current western boundary was amended to account for a protective Satanka Shale thickness of at least 75 feet, and aligned primarily with property boundaries and some section lines as appropriate west of the protective Satanka Shale thickness line to allow for easier implementation and property administration.

This purpose of this appendix is to document the data that were used and how those data were processed to revise the protective Satanka Shale thickness line and western boundary. Generally, the protective Satanka Shale thickness line was revised on the basis of geologic and hydrogeologic data. The line has replaced the original 75 feet of Satanka Shale thickness line of the original western boundary in the CAPA. The current western boundary was revised on the basis of recent property lines.

1.1 SATANKA SHALE THICKNESS DETERMINATION

The protective Satanka Shale thickness line was determined from geologic and hydrogeologic data acquired from professional geologic reports, local water wells, springs, professional geologic mapping, and site specific investigations. Satanka shale thicknesses from these data were plotted in GIS and the Satanka Shale thickness contoured to identify where at least 75 feet of Satanka Shale overlay the Casper Formation. Only well data that had both accurate locations and good geologic logs were used to identify Satanka Shale thicknesses. Water well logs and site specific investigation data that were used to determine the location of the protective Satanka Shale thickness line are listed in Tables D-1, and D-2, respectively. The locations of these points are shown by Map ID number on Figures D-1a through D-1c. Satanka Shale thicknesses at these points are shown with respect to local geologic conditions and the protective Satanka Shale thickness line on Figures D-2a through D-2d.

As indicated in Table D-1, many data originated with water well completion reports on file with the Wyoming State Engineer's Office. Data from several site specific investigations as noted in Table D-2 were also used. Karl Taboga provided surveyed locations for water wells that he had located using a handheld GPS to prepare his Casper Aquifer potentiometric surface map in November 2005. Well completion reports for these wells on file with the Wyoming State

Engineer's Office were reviewed to identify Satanka Shale thickness. To supplement these wells, Stantec compiled and reviewed Wyoming State Engineer's Office well completion reports for wells along the original 75 foot Satanka Shale thickness line to determine the well location and thickness of Satanka Shale that each well encountered. Geologic materials overlying the Satanka Shale were not included in preparing this determination. Wells that did not have lithologic logs or provide sufficient geologic information to determine the Satanka Shale contact with the Casper Formation were not used. Aside from the well information obtained from Karl Taboga, Stantec focused on water wells completed since 2006 when the Wyoming State Engineer's Office began requiring drillers to submit GPS locations for wells they completed. Data for water wells completed prior to that time were also used to the extent that they could be located on the basis of reported subdivision, lot and block locations; street addresses; aerial imagery; property data; and in some cases quarter quarter section locations. Water wells that were only located to quarter quarter sections were generally not used, unless accurate locational data from other sources were provided or could be determined.

While water wells are generally present across much of the western boundary area, there is one area in particular where water well data were not used to make this determination. Between the Spur and Turner Wellfields, local geologic mapping of the Forelle Limestone was used to estimate a 75 foot thickness of Satanka Shale above the Casper Formation based on the dip of the Forelle Limestone and an assumed Satanka Shale thickness of 300 feet. Casper Formations dips from recent geologic mapping were reviewed, but generally not used, because the Casper Formation contact with the overlying Satanka Shale is largely covered by younger sediments along the western margin of the Laramie Range. Furthermore, the Casper Formation contact with the Satanka Shale in this area is not always clear as the upper member of the Casper Formation in this area has been eroded is covered. The Forelle Limestone ridge offered the best geologic contact from which to make this assessment in this area.

At City Springs and Simpson Springs, Stantec recognized that more than 75 feet of Satanka Shale is needed to protect the Casper Aquifer. A shale thickness of 100 or 150 feet is more realistic at City Springs due to the hydrologic communication between the City's Turner Wellfield and City Springs. Approximately 150 feet was recognized at Simpson Springs given potential for hydraulic communication future production wells and the local springs.

1.2 WESTERN BOUNDARY REVISION

Based on the protective Satanka Shale thickness line, Stantec identified the revised western boundary for the CAPA. The protective Satanka Shale thickness line is presented on Figures D-2a through D-2d along with the Satanka Shale thicknesses identified at various points and local geologic conditions. As shown on Figures D-3a through D-3c, Stantec used the protective Satanka Shale thickness line and current property boundaries from April 2022 to identify a revised western boundary line that is illustrated on these figures. The western boundary was generally selected as the western edge of the property that the protective Satanka Shale thickness line crossed. In some places, the western boundary remains along section lines because those better reflected the limits of the area needing aquifer protection than did existing property lines or were used previously.

Table D-1. Satanka Shale Thickness Data Points from SEO Well Data

Map ID	Well Name	Water Right Number[1]	Satanka Shale Thickness (ft)	Uses[2]	Twn	Rng	Sec	Qtr-Qtr	Longitude	Latitude	Appropriation (GPM)	Total Well Depth (Ft)	Static Water Level (Ft)	Priority Date	Summary Water Right Status
1	TURNER #3	P158.0C	91	MUN_GW	016N	073W	35	NE1/4NE1/4	-105.54076	41.31906	25	246.2	69.6	3/10/1942	Cancelled
2	LOWER TIE CITY #1	P1178.0W	0	MIS	015N	072W	23	NE1/4SW1/4	-105.4359	41.25364	60	50	1.5	4/21/1964	Incomplete
3	YELLOW PINE #1	P1179.0W	0	MIS	015N	072W	24	NW1/4SE1/4	-105.413116	41.253628	7.5	79	52	4/21/1964	Unadjudicated
4	UPPER TIE CITY #2	P1180.0W	0	MIS	015N	072W	23	SE1/4SW1/4	-105.43587	41.2499	4.5	69	19	4/21/1964	Incomplete
5	SUMMIT REST AREA #1	P2181.0W	0	MIS	015N	072W	26	SE1/4SW1/4	-105.43746	41.23652	15	222	27.38	3/25/1968	Fully Adjudicated
6	SUMMIT REST AREA #2	P2181.0W	0	MIS	015N	072W	26	SE1/4SW1/4	-105.434088	41.236446	8	202	24.55	3/25/1968	Fully Adjudicated
7	KNOWLTON #2	P36531.0W	203	DOM_GW; STK	015N	073W	14	NE1/4NW1/4	-105.548306	41.275098	15	307	-4	3/9/1977	Complete
8	BONE AND JOINT #1	P39294.0W	5	MIS	015N	073W	1	SW1/4NW1/4	-105.537592	41.301211	20	140	64	7/25/1977	Fully Adjudicated
9	POPE #4	P55506.0W	65	MUN_GW	015N	073W	14	NE1/4SE1/4	-105.540501	41.266705	1750	350.00	31	01/30/1981	Fully Adjudicated
10	TURNER #1	P55507.0W	103.7	MUN_GW	015N	073W	2	NE1/4NW1/4	-105.549791	41.306099	1400	240	6	1/30/1981	Fully Adjudicated
11	TURNER #2	P55508.0W	74	MUN_GW	016N	073W	35	SE1/4SW1/4	-105.549146	41.30877	1400	350	-4	1/30/1981	Fully Adjudicated
12	TURNER #3	P59132.0W	175	MON	015N	073W	2	NE1/4NW1/4	-105.552075	41.306236	0	350	-4	29887	Abandoned
13	U S F S #1A	P68183.0W	0	MON	015N	072W	23	NE1/4NE1/4	-105.42634	41.26057	0	31	-1	8/13/1984	Abandoned
14	U S F S #2	P71442.0W	0	STK	015N	072W	14	SW1/4SE1/4	-105.43117	41.2643	2	25	13	11/6/1985	Complete
15	SUTHERLAND #2	P74491.0W	61	DOM_GW; STK	016N	073W	01	SW1/4SW1/4	-105.5368	41.38197	13	220.00	98	04/22/1987	Complete
16	PREMER #3	P81186.0W	192	STK	017N	073W	25	NE1/4SW1/4	-105.530532	41.416141	10	240	90	11/7/1989	Complete
17	SUMMIT #5	P81908.0W	0	MON	015N	072W	35	NE1/4NE1/4	-105.42622	41.23139	0	38.5	30	2/28/1990	Cancelled
18	BORGIALLI #1	P82974.0W	0	DOM_GW	016N	072W	6	NE1/4NE1/4	-105.502246	41.39582	10	380	218	7/17/1990	Complete
19	ADLER #1	P87531.0W	4	DOM_GW	016N	072W	6	NE1/4NW1/4	-105.508963	41.395827	10	310	150	4/8/1992	Complete
20	MERRILL #1	P88874.0W	355	DOM_GW	015N	073W	22	NE1/4SE1/4	-105.561764	41.253956	13	415	0	7/20/1992	Complete
21	HAYWARD #1	P89939.0W	8	DOM_GW; STK	016N	072W	6	NW1/4NW1/4	-105.513759	41.392847	10	320	135	10/26/1992	Complete
22	HARRIS #1	P91385.0W	0	DOM_GW	016N	072W	6	SE1/4SW1/4	-105.5128	41.38083	10	340	160	4/29/1993	Complete
23	PAUL-JUDY #1	P92077.0W	80	DOM_GW	015N	073W	23	NE1/4NW1/4	-105.54714	41.25536	20	200	40	6/17/1993	Complete
24	HONKEN #1	P92885.0W	0	DOM_GW; STK	015N	072W	7	SW1/4NW1/4	-105.516934	41.292608	7	320	155	9/14/1993	Complete
25	HONKEN #2	P92886.0W	0	DOM_GW; STK	015N	072W	6	SW1/4SW1/4	-105.515102	41.294919	10	340	162	9/14/1993	Complete
26	DOLAN #1	P92916.0W	0	DOM_GW	015N	072W	6	NW1/4SW1/4	-105.516419	41.298186	10	280	145	8/25/1993	Complete
27	SOLDIER MW #1	P92936.0W	13	MON	015N	073W	23	SW1/4SE1/4	-105.545421	41.250051	0	130	16.35	9/27/1993	Complete
28	SPUR RIDGE EQ	P94193.0W	18	DOM_GW; MIS; STK	016N	072W	6	NW1/4NW1/4	-105.516889	41.394752	15	340	145	12/20/1993	Incomplete
29	COLLING #2	P94642.0W	0	DOM_GW	015N	072W	6	SW1/4SW1/4	-105.51525	41.294014	10	340	145	3/2/1994	Complete
30	HOKABE #1	P95044.0W	0	DOM_GW; STK	015N	072W	6	SE1/4SW1/4	-105.514991	41.292337	7	320	152	4/23/1994	Complete
31	MEANS 1	P95263.0W	0	DOM_GW; STK	016N	072W	6	SW1/4NE1/4	-105.509354	41.390061	10	360	150	5/6/1994	Complete
32	MW-1	P95553.0W	59	MON	016N	073W	2	NW1/4NE1/4	-105.543243	41.393499	0	220	9.46	5/24/1994	Complete
33	MW-2	P95554.0W	75	MON	016N	073W	2	NW1/4NE1/4	-105.544109	41.393898	0	160	17.37	5/24/1994	Complete
34	MW-3	P95555.0W	88	MON	016N	073W	2	NE1/4NE1/4	-105.543048	41.395066	0	240	55.54	5/24/1994	Complete
35	TW-1	P95556.0W	52	MON	016N	073W	2	NE1/4NE1/4	-105.541747	41.39436	0	300	28	5/24/1994	Complete
36	HELLING #1	P96058.0W	95	DOM_GW; STK	015N	073W	23	NW1/4SE1/4	-105.54361	41.25528	20	200	35	7/8/1994	Complete
37	STEINER #1	P96067.0W	0	DOM_GW; STK	015N	072W	6	NE1/4SW1/4	-105.518259	41.296128	10	300	115	7/13/1994	Complete
38	KING SHIPPING TRAP	P96155.0W	0	STK	017N	072W	31	NE1/4NE1/4	-105.50172	41.40895	10	370	278	7/29/1994	Complete
39	HEARD #1	P96994.0W	0	DOM_GW	015N	072W	7	NW1/4NW1/4	-105.51638	41.291033	10	300	128	9/19/1994	Complete
40	UW QUARRY MONITOR #1	P97756.0W	0	MON	016N	072W	5	NW1/4NW1/4	-105.49857	41.3931	0	300	224.3	11/14/1994	Complete
41	TURNER #1 (1941)	P98011.0W	118.5	MON	015N	073W	2	NE1/4NW1/4	-105.550155	41.306148	0	238	3.1	12/16/1994	Complete
42	LARAMIE EAST #1	P98131.0W	14	MON	015N	072W	7	SW1/4SW1/4	-105.51711	41.278927	0	325	181.7	1/9/1995	Complete
43	FLOCK 1	P98190.0W	0	DOM_GW; STK	016N	072W	3	NE1/4NW1/4	-105.458035	41.395633	4	460	322	1/18/1995	Complete
44	ROWDIE #2	P98422.0W	105	DOM_GW	016N	073W	01	SW1/4SW1/4	-105.5373	41.38077	10	195.00	99	03/07/1995	Incomplete
45	ANIMAL CENTER NO. 1 WELL	P99001.0W	97	MIS	015N	073W	01	NW1/4SW1/4	-105.53588	41.29723	20	150.00	54	04/28/1995	Fully Adjudicated
46	PINECONE #1	P99073.0W	0	DOM_GW	015N	072W	6	SW1/4SW1/4	-105.518265	41.294173	10	320	147	5/2/1995	Complete
47	SOLDIER MW-2	P99770.0W	10	MON	015N	073W	23	SW1/4SE1/4	-105.545838	41.248936	0	70	10.5	7/17/1995	Complete
48	SOLDIER MW-3	P99771.0W	23	MON	015N	073W	23	SW1/4SE1/4	-105.546764	41.248208	0	85	13.8	7/17/1995	Complete
49	SOLDIER MW-4	P99772.0W	29	MON	015N	073W	23	SW1/4SE1/4	-105.547771	41.249132	0	100	1.6	7/17/1995	Complete
50	SOLDIER MW-5	P99773.0W	4	MON	015N	073W	23	SW1/4SE1/4	-105.54327	41.248925	0	100	44.3	7/17/1995	Complete
51	SHFCA-1	P99778.0W	300	MON	015N	073W	2	SE1/4NW1/4	-105.5523	41.300824	0	360	18.4	7/17/1995	Complete
52	SHFCA-2	P99779.0W	230	MON	015N	073W	2	SW1/4SE1/4	-105.544012	41.299233	0	295	24.4	7/17/1995	Abandoned
53	D. OLSON	P100005.0W	307	DOM_GW	015N	073W	15	SE1/4SE1/4	-105.55914	41.26676	15	390	3	8/10/1995	Complete
54	BENCH HEART #2	P100860.0W	151	DOM_GW	015N	073W	23	NW1/4SW1/4	-105.547212	41.253016	15	215	8	11/7/1995	Complete
55	BARNARD #1	P101371.0W	0	DOM_GW	016N	072W	6	SE1/4NW1/4	-105.51289	41.38807	10	340	168	1/22/1996	Complete
56	RINKER #1	P101738.0W	207	DOM_GW	015N	073W	23	SW1/4NW1/4	-105.55528	41.25889	15	280	-4	3/15/1996	Complete
57	OSTRANDER #1	P101743.0W	115	DOM_GW	016N	073W	02	NE1/4SE1/4	-105.5385	41.38339	10	240.00	80	03/11/1996	Complete
58	PESTOTNIK WELL #2	P102189.0W	0	DOM_GW	015N	072W	6	SW1/4SW1/4	-105.516678	41.294017	10	320	150	5/1/1996	Complete
59	YORK #1	P102304.0W	96	DOM_GW	015N	073W	35	SW1/4NW1/4	-105.552991	41.229404	13	160	51	5/17/1996	Complete

Map ID	Well Name	Water Right Number[1]	Satanka Shale Thickness (ft)	Uses[2]	Twn	Rng	Sec	Qtr-Qtr	Longitude	Latitude	Appropriation (GPM)	Total Well Depth (Ft)	Static Water Level (Ft)	Priority Date	Summary Water Right Status
60	K3	P102668.0W	53	DOM_GW	016N	073W	01	NW1/4SW1/4	-105.5363	41.38436	10	210.00	95	06/17/1996	Complete
61	SOMES SUMMIT #1	P104443.0W	90	DOM_GW	015N	073W	35	NE1/4SW1/4	-105.55005	41.22465	10	300	155	11/6/1996	Complete
62	HALSEY #1	P104497.0W	0	DOM_GW	015N	072W	6	SW1/4SW1/4	-105.516779	41.295169	10	340	161	11/21/1996	Complete
63	ABERNETHY #1	P104810.0W	4	DOM_GW	015N	073W	35	SE1/4NW1/4	-105.55006	41.2281	13	170	79	1/10/1997	Complete
64	SIMPSON MW-1	P105082.0W	44	MON	015N	073W	34	SE1/4SE1/4	-105.556938	41.220616	0	125.00	24.44	02/27/1997	Complete
65	BOWEN #1	P105086.0W	20	DOM_GW; STK	016N	073W	01	NW1/4SW1/4	-105.5358	41.38614	25	240.00	96	03/03/1997	Complete
66	TROTTER 3	P105088.0W	91	DOM_GW	015N	073W	35	NW1/4NW1/4	-105.554567	41.233371	10	150	58	3/3/1997	Complete
67	SPUR MW-4	P105336.0W	236	MON	016N	073W	2	NW1/4NE1/4	-105.555547	41.395867	0	300	10.5	3/7/1997	Complete
68	SPUR MW-5	P105337.0W	281.5	MON	016N	073W	2	NE1/4NE1/4	-105.537957	41.396062	0	380	80.2	3/7/1997	Complete
69	SPUR MW-6	P105338.0W	19.5	MON	016N	073W	2	NE1/4NE1/4	-105.537927	41.392019	0	200	66.63	3/7/1997	Complete
70	SOLDIER #1	P105576.0W	36	MIS	015N	073W	23	SE1/4SW1/4	-105.548048	41.248759	1800	289	2	2/27/1997	Incomplete
71	SPUR MW #7	P106525.0W	0	MON	016N	073W	1	NW1/4NW1/4	-105.534983	41.394004	0	220	104	6/26/1997	Complete
72	SPUR MW #8	P106526.0W	21	MON	016N	073W	1	SW1/4NW1/4	-105.53531	41.388187	0	200	107.75	6/26/1997	Complete
73	SPUR MW #9	P106527.0W	119	MON	016N	073W	2	NW1/4SE1/4	-105.542828	41.386649	0	220	23.91	6/26/1997	Complete
74	SPUR MW #10	P106528.0W	51	MON	016N	073W	12	NW1/4NW1/4	-105.537477	41.378798	0	195	104.22	6/26/1997	Complete
75	SPUR MW #11	P106529.0W	115	MON	016N	073W	1	NW1/4NE1/4	-105.527358	41.395839	0	260	118.43	6/26/1997	Complete
76	SPUR MW #12	P106530.0W	0	MON	016N	072W	6	NE1/4NW1/4	-105.51275	41.3932	0	297	140.35	6/26/1997	Incomplete
77	SPUR #1	P106547.0W	54	MUN_GW	016N	073W	2	NE1/4NE1/4	-105.542265	41.394367	2500	305	30.9	12/1/1994	Fully Adjudicated
78	SA 4-2	P108473.0W	70	DOM_GW; STK	016N	073W	01	NW1/4SW1/4	-105.5384	41.386	10	200.00	67	01/22/1997	Complete
79	GLADNEY #1	P108503.0W	229	DOM_GW; STK	016N	073W	11	SW1/4SE1/4	-105.54535	41.36645	13	375	95	12/11/1997	Complete
80	SCHILT #1	P110152.0W	237	DOM_GW	015N	073W	14	SW1/4SW1/4	-105.556398	41.256627	13	300	14	5/22/1998	Complete
81	HAYDEN-WING #1	P110663.0W	0	DOM_GW	015N	072W	6	SE1/4NW1/4	-105.513932	41.303028	13	340	161	6/23/1998	Complete
82	Burman 1	P110850.0W	0	DOM_GW	016N	072W	5	SE1/4NW1/4	-105.49382	41.38796	10	460	320	7/7/1998	Complete
83	Stimson #1	P111480.0W	14	DOM_GW	015N	073W	35	SE1/4SW1/4	-105.55004	41.22102	10	300	170	8/18/1998	Complete
84	MCREYNOLDS #1	P114485.0W	125	DOM_GW	016N	073W	02	SE1/4SE1/4	-105.5389	41.3823	25	240.00	78	03/16/1999	Complete
85	SPUR #2	P115181.0W	236	MUN_GW	016N	073W	3	NE1/4NE1/4	-105.556932	41.395523	2500	323	10.7	3/10/1999	Fully Adjudicated
86	BARROWS #1	P118568.0W	0	DOM_GW	015N	072W	6	NW1/4SW1/4	-105.517121	41.297028	10	320	141	8/31/1999	Complete
87	SILVER SPRINGS 1	P119006.0W	10	DOM_GW; STK	015N	073W	35	NE1/4NW1/4	-105.548005	41.233038	25	200	81	9/17/1999	Complete
88	SIMON-WARREN #1	P124855.0W	295	MIS; STK	016N	073W	23	SE1/4SW1/4	-105.55016	41.33749	150	440	56	4/11/2000	Fully Adjudicated
89	VISSER #1	P125275.0W	0	DOM_GW	015N	073W	12	SW1/4NE1/4	-105.52623	41.28628	25	200	95	5/9/2000	Complete
90	Bailey #1	P127380.0W	230	DOM_GW	016N	073W	11	SW1/4NE1/4	-105.545	41.3725	25	320	72	8/2/2000	Complete
91	DUSTIN #2	P128164.0W	208	DOM_GW	015N	073W	22	SE1/4SE1/4	-105.558196	41.249046	25	280	3	8/18/2000	Complete
92	LAYCOCK SPRING WELL # 1	P131638.0W	0	DOM_GW; STK	015N	072W	7	NW1/4NE1/4	-105.507523	41.289578	0	400	182	12/26/2000	Complete
93	BENSON # 1	P136005.0W	0	DOM_GW	015N	072W	6	SW1/4SW1/4	-105.518405	41.292724	10	360	160	6/26/2001	Complete
94	MATHIS # 1	P136519.0W	0	DOM_GW; STK	016N	072W	5	NE1/4NW1/4	-105.49384	41.39303	10	320	209	7/11/2001	Complete
95	JAY ECKHARDT-1	P143036.0W	310	DOM_GW; STK	016N	073W	11	NW1/4SE1/4	-105.54726	41.36449	10	380	90	3/7/2002	Complete
96	P. PARKER # 1	P144073.0W	290	DOM_GW; STK	015N	073W	27	NW1/4SE1/4	-105.56389	41.23972	10	360	45	4/24/2002	Complete
97	SA 4-3	P144697.0W	32	DOM_GW; STK	016N	073W	01	NW1/4SW1/4	-105.5375	41.38751	10	200.00	66	06/12/2002	Complete
98	ENDSLEY-1	P148210.0W	137	DOM_GW	016N	073W	02	SE1/4SE1/4	-105.5393	41.38002	10	240.00	91	11/25/2002	Complete
99	BRECHT #1	P148804.0W	0	DOM_GW	014N	072W	3	NE1/4SE1/4	-105.44321	41.20963	3	600	122	1/15/2003	Complete
100	WM. HANSEN # 1	P150325.0W	0	DOM_GW	015N	072W	7	SW1/4NW1/4	-105.515366	41.285825	10	340	154	4/8/2003	Complete
101	JENSEN # 1	P150508.0W	131	DOM_GW	016N	073W	02	SE1/4SE1/4	-105.5404	41.38272	10	200.00	65	04/22/2003	Complete
102	BURRO #19	P151582.0W	112	DOM_GW	016N	073W	11	SE1/4SW1/4	-105.549471	41.367741	10	182	112	6/3/2003	Complete
103	TYLER #1	P152021.0W	115	DOM_GW	016N	073W	02	NE1/4SE1/4	-105.54	41.38392	8	220.00	74	06/16/2003	Complete
104	PAULING #1	P154361.0W	148	DOM_GW	016N	073W	02	SE1/4SE1/4	-105.541	41.38107	10	260.00	72	10/10/2003	Complete
105	HOBERG #1	P157931.0W	301	DOM_GW; STK	015N	073W	27	NE1/4NE1/4	-105.56611	41.24556	13	460	37	4/13/2004	Complete
106	ROTH 1	P159096.0W	0	DOM_GW; STK	015N	072W	6	SE1/4SE1/4	-105.505273	41.294299	15	400	210	5/17/2004	Complete
107	JAYCOX #2	P162173.0W	26	DOM_GW; STK	016N	072W	6	NE1/4NW1/4	-105.513046	41.395981	10	400	190	9/7/2004	Complete
108	WALGREN #1	P163598.0W	68	DOM_GW	015N	073W	35	SW1/4SW1/4	-105.55486	41.22211	10	360	171	11/5/2004	Complete
109	MONIZ #1	P165492.0W	122	DOM_GW	016N	073W	11	NE1/4SE1/4	-105.54667	41.37028	13	320	92.5	2/11/2005	Complete
110	R. VALENTINE #1	P166898.0W	310	DOM_GW	016N	073W	11	SW1/4SW1/4	-105.55495	41.36649	10	400	38	4/21/2005	Complete
111	T. WEBER #1	P167415.0W	0	DOM_GW	016N	072W	5	NW1/4NE1/4	-105.488734	41.395804	10	680	418	5/4/2005	Complete
112	21 BOBCAT	P168840.0W	132	DOM_GW	016N	073W	2	SE1/4SE1/4	-105.539624	41.381043	10	260	84	7/5/2005	Complete
113	CORNERSTONE #1	P170191.0W	18	DOM_GW	015N	073W	01	SE1/4SW1/4	-105.5299	41.29292	18	160.00	87	09/28/2005	Complete
114	LCCC - WW NO. 1 WELL	P170575.0W	124	MIS	015N	073W	2	NW1/4NE1/4	-105.547329	41.303221	180	263	18.1	10/19/2005	Fully Adjudicated
115	LCCC - WW NO. 2 WELL	P170576.0W	122	MIS	015N	073W	2	NW1/4NE1/4	-105.54709	41.303022	180	223	18.4	10/19/2005	Fully Adjudicated
116	KINGHILL WELL - 1	P173596.0W	288	DOM_GW	015N	073W	2	NW1/4NW1/4	-105.553167	41.30355	25	360	48	3/16/2006	Complete
117	WEIBEL - 7	P174186.0W	89	DOM_GW; STK	015N	073W	23	NE1/4SW1/4	-105.54895	41.254467	15	160	25	4/18/2006	Complete
118	KUHN #2	P175165.0W	143	DOM_GW	015N	073W	12	NW1/4NW1/4	-105.535861	41.289881	25	240	12	6/1/2006	Complete
119	M & M #1	P175461.0W	12	DOM_GW	015N	073W	13	NE1/4SW1/4	-105.531806	41.269306	25	300	100	6/27/2006	Complete
120	SPOON BAR #2	P177444.0W	0	DOM_GW; STK	014N	073W	1	NW1/4SW1/4	-105.535567	41.211417	10	400	193	9/29/2006	Complete
121	ASAY #1	P177556.0W	66	DOM_GW	015N	073W	23	NW1/4SW1/4	-105.553678	41.254303	10	150	15	10/16/2006	Complete

Map ID	Well Name	Water Right Number[1]	Satanka Shale Thickness (ft)	Uses[2]	Twn	Rng	Sec	Qtr-Qtr	Longitude	Latitude	Appropriation (GPM)	Total Well Depth (Ft)	Static Water Level (Ft)	Priority Date	Summary Water Right Status
122	MEYEN #1	P178882.0W	25	DOM_GW	015N	073W	12	NW1/4NW1/4	-105.536667	41.289861	20	300	12	12/18/2006	Complete
123	CRONK 16	P180389.0W	89	DOM_GW	016N	073W	02	NE1/4SE1/4	-105.538	41.38445	15	220.00	89	03/13/2007	Complete
124	HOWE 5	P181556.0W	144	DOM_GW	015N	073W	23	SW1/4NW1/4	-105.553833	41.255683	16	240	2	6/11/2007	Complete
125	ASAY #2	P182697.0W	126	DOM_GW	015N	073W	23	NE1/4SW1/4	-105.551033	41.25385	10	200	42	8/7/2007	Complete
126	J.J.J. #1	P182698.0W	0	DOM_GW	015N	073W	12	SE1/4SW1/4	-105.52915	41.2803	15	240	85	8/7/2007	Complete
127	JEFF & I #1	P183143.0W	0	DOM_GW	015N	073W	12	SE1/4SW1/4	-105.529366	41.277349	15	260	92	9/4/2007	Complete
128	SIMPSON SPRINGS - 1	P184649.0W	135	DOM_GW; STK	015N	073W	34	SE1/4SE1/4	-105.561233	41.219017	15	240	18	1/9/2008	Complete
129	ISAAK #1	P186197.0W	171	DOM_GW	015N	073W	23	SE1/4NW1/4	-105.5524	41.2568	20	240	6	3/28/2008	Complete
130	SWIERCZEK-1	P186967.0W	0	DOM_GW	015N	073W	13	NE1/4NW1/4	-105.531483	41.2745	15	180	92	5/22/2008	Complete
131	AUKERMAN - 1	P190321.0W	0	DOM_GW	015N	073W	12	SE1/4SW1/4	-105.52915	41.279183	15	200	85	5/13/2009	Complete
132	LAZY 8 WELL	P190448.0W	0	DOM_GW; STK	016N	073W	01	NW1/4SW1/4	-105.5335	41.38567	10	260.00	146	05/12/2009	Complete
133	SIMPSON NO. 1	P192087.0W	125	IRR_GW; MUN_GW; STK	014N	073W	3	NE1/4NE1/4	-105.560988	41.217956	25	820	0	8/7/1997	Cancelled
134	SIMPSON NO. 2	P192088.0W	115	IRR_GW; MUN_GW; STK	015N	073W	64	SE1/4SE1/4	-105.559015	41.222033	1	430	3.5	8/7/1997	Cancelled
135	THANSEN-1	P195078.0W	0	DOM_GW	016N	073W	01	NW1/4SW1/4	-105.5342	41.38353	20	260.00	144	03/01/2011	Complete
136	SUNSET ACRES - 33	P198831.0W	87	DOM_GW	016N	073W	01	NW1/4SW1/4	-105.5367	41.38306	15	200.00	110	09/05/2012	Complete
137	TIMBER CANYON RANCH LOT 53	P202434.0W	111	DOM_GW	017N	073W	36	NW1/4SE1/4	-105.52678	41.40175	15	200	122	7/10/2014	Complete
138	VISTA & GRAND MONITOR WELL	P203337.0W	23	MON	015N	073W	1	SW1/4NW1/4	-105.538066	41.302484	0	156.8	49.3	1/15/2015	Complete
139	IMPERIAL HEIGHTS PARK NORTH MONITOR WELL	P203338.0W	0	MON	015N	073W	1	SE1/4NW1/4	-105.53013	41.29939	0	160	84.6	1/15/2015	Complete
140	IMPERIAL HEIGHTS PARK SOUTH MONITOR WELL	P203339.0W	0	MON	015N	073W	1	NE1/4SW1/4	-105.52948	41.29831	0	163	88.9	1/15/2015	Complete
141	WYATT-3421	P203765.0W	43	DOM_GW	015N	073W	12	NE1/4SW1/4	-105.53158	41.28181	18	123	63	4/20/2015	Complete
142	BIG HOLLOW NO. 1	P204024.0W	103	DOM_GW	015N	073W	14	SW1/4NE1/4	-105.543611	41.273278	15	200	22	6/10/2015	Complete
143	ZDEBERARD-1	P204165.0W	0	DOM_GW	015N	073W	12	SE1/4SW1/4	-105.52889	41.27844	15	160	77	7/9/2015	Complete
144	DAY - 44	P204573.0W	256	DOM_GW; STK	017N	073W	36	NE1/4NW1/4	-105.530805	41.40775	15	340	121	9/18/2015	Complete
145	HAMEL-1	P205108.0W	57	DOM_GW	015N	073W	23	NE1/4NE1/4	-105.541555	41.261956	15	123	42	2/11/2016	Complete
146	HAGERMAN-1	P206075.0W	73	DOM_GW	015N	073W	13	NW1/4NW1/4	-105.536764	41.274388	15	140	48	8/18/2016	Complete
147	VISTA BUTTES 1	P206160.0W	148	DOM_GW	015N	073W	11	NE1/4NE1/4	-105.539142	41.288586	25	150	24	9/6/2016	Complete
148	BECK-4	P206595.0W	34	DOM_GW	015N	073W	23	NE1/4NE1/4	-105.539978	41.260522	15	120	50	12/14/2016	Complete
149	SWECKARD-WF2A1	P206985.0W	10	DOM_GW	015N	073W	12	NE1/4SW1/4	-105.52913	41.283458	15	140	68	3/28/2017	Complete
150	ISAAK-1	P207196.0W	180	DOM_GW	015N	073W	11	SE1/4NE1/4	-105.542033	41.286897	15	257	0	5/3/2017	Complete
151	DIETZEL-1479	P207800.0W	147	DOM_GW	015N	073W	11	SE1/4NE1/4	-105.539361	41.287656	22	202	12	8/9/2017	Complete
152	JACOBY RIDGE TEST WELL	P208505.0W	252	MON	016N	073W	35	NW1/4NE1/4	-105.543944	41.319722	0	756.5	53.98	12/11/2017	Complete
153	HAMEL PRAIRIES END - 5	P208793.0W	45	DOM_GW	015N	073W	23	NE1/4NE1/4	-105.541797	41.260228	25	123	50	4/6/2018	Complete
154	BURGESS - 1	P208795.0W	262	DOM_GW; STK	015N	073W	14	NW1/4SW1/4	-105.5534996	41.26895464	25	322	0	4/6/2018	Complete
155	THE GINTHER GEYSER	P209154.0W	50	DOM_GW	015N	073W	23	SW1/4NE1/4	-105.546689	41.255439	25	142	22	6/5/2018	Complete
156	BUCKMICHAEL - 1	P209157.0W	108	DOM_GW	017N	073W	29	NE1/4SE1/4	-105.543919	41.258828	15	122	52	6/5/2018	Complete
157	KOBULNICKY-1	P209271.0W	181	DOM_GW	015N	073W	11	SE1/4NE1/4	-105.542222	41.285658	15	242	1	6/22/2018	Complete
158	RUNDBERG -1	P209957.0W	162	DOM_GW	015N	073W	11	SE1/4NE1/4	-105.540828	41.285133	15	240	6	10/22/2018	Complete
159	UW 2019 TEST-MONITOR WELL B	P210668.0W	94	TST	016N	073W	35	NE1/4NE1/4	-105.53867	41.32028	0	800	66.71	5/2/2019	Cancelled
160	ULLRICH - 1	P210752.0W	178	DOM_GW	015N	073W	11	SE1/4NE1/4	-105.542656	41.284656	15	262	2	5/24/2019	Complete
161	LUCKE CLARK - 1	P211433.0W	204	DOM_GW	015N	073W	11	SW1/4NE1/4	-105.543806	41.285806	15	262	0	9/20/2019	Complete
162	SHEETS PRAIRIE - 2	P211463.0W	31	DOM_GW; STK	015N	073W	23	NE1/4NE1/4	-105.538944	41.262144	15	122	59	9/20/2019	Complete
163	CJZITEK - 1	P212499.0W	73	DOM_GW	015N	073W	1	SW1/4SW1/4	-105.534033	41.29195	15	162	65	6/9/2020	Complete
164	BAUMAN - 2	P212583.0W	297	DOM_GW	015N	073W	10	SE1/4SE1/4	-105.558931	41.279319	25	537	Artesian	6/22/2020	Incomplete
165	BENNETT PAGE - 1	P212861.0W	161	DOM_GW	015N	073W	11	SE1/4NE1/4	-105.540331	41.285739	15	242	10	8/6/2020	Complete
166	GONZALES LAZY J NO 1	P212979.0W	102	DOM_GW	015N	073W	23	NW1/4NE1/4	-105.545461	41.2623	25	180	35	8/20/2020	Incomplete
167	BASTIAN NO 2303	P212997.0W	123	DOM_GW	015N	073W	1	SW1/4SW1/4	-105.53785	41.294369	25	202	47	8/20/2020	Incomplete
168	UW 2019 WELL A	P213495.0W	56	MIS	016N	073W	25	SW1/4SW1/4	-105.53757	41.32264	700	420	61.65	11/14/2019	Incomplete
169	MCGEE VISTA BUTTES 5	P213536.0W	185	DOM_GW	015N	073W	11	SW1/4NE1/4	-105.543517	41.284911	22	262	4	11/17/2020	Complete
170	SWECKARD 2207	P213653.0W	0	DOM_GW	015N	073W	1	NW1/4SE1/4	-105.527539	41.296161	22	262	4	12/14/2020	Incomplete
171	BIG HUHNKS CASPER 1	P213926.0W	298	MIS	016N	073W	9	SW1/4SE1/4	-105.583531	41.365539	100	980	Artesian	1/15/2021	Incomplete
172	KILLPACK 1	P214195.0W	304	DOM_GW	015N	073W	11	SE1/4NW1/4	-105.54951	41.28743	25	380	10	3/29/2021	Incomplete
173	MASON VISTA BUTTES	P214214.0W	192	DOM_GW	015N	073W	11	SW1/4NE1/4	-105.5437	41.287	15	262	5	3/29/2021	Incomplete
174	SHIERLOCK 4	P214462.0W	255	DOM_GW	015N	073W	14	NW1/4SW1/4	-105.554539	41.266819	25	330	Artesian	4/22/2021	Incomplete
175	LOZANO 9A	P214723.0W	304	DOM_GW	016N	073W	11	SW1/4SW1/4	-105.555381	41.365539	15	500	0	6/8/2021	Incomplete
176	OTTO EAGLES NEST 1	P214764.0W	0	DOM_GW	015N	073W	25	NE1/4SW1/4	-105.532331	41.238189	25	480	241	6/8/2021	Incomplete
177	LEVIN 7	P214854.0W	0	DOM_GW	016N	072W	6	NE1/4SW1/4	-105.512419	41.385981	25	260	142	6/22/2021	Incomplete
178	WILLIAMS 40	P215634.0W	48	DOM_GW	017N	073W	36	NE1/4SE1/4	-105.52366	41.40524	25	202	120	8/27/2021	Incomplete

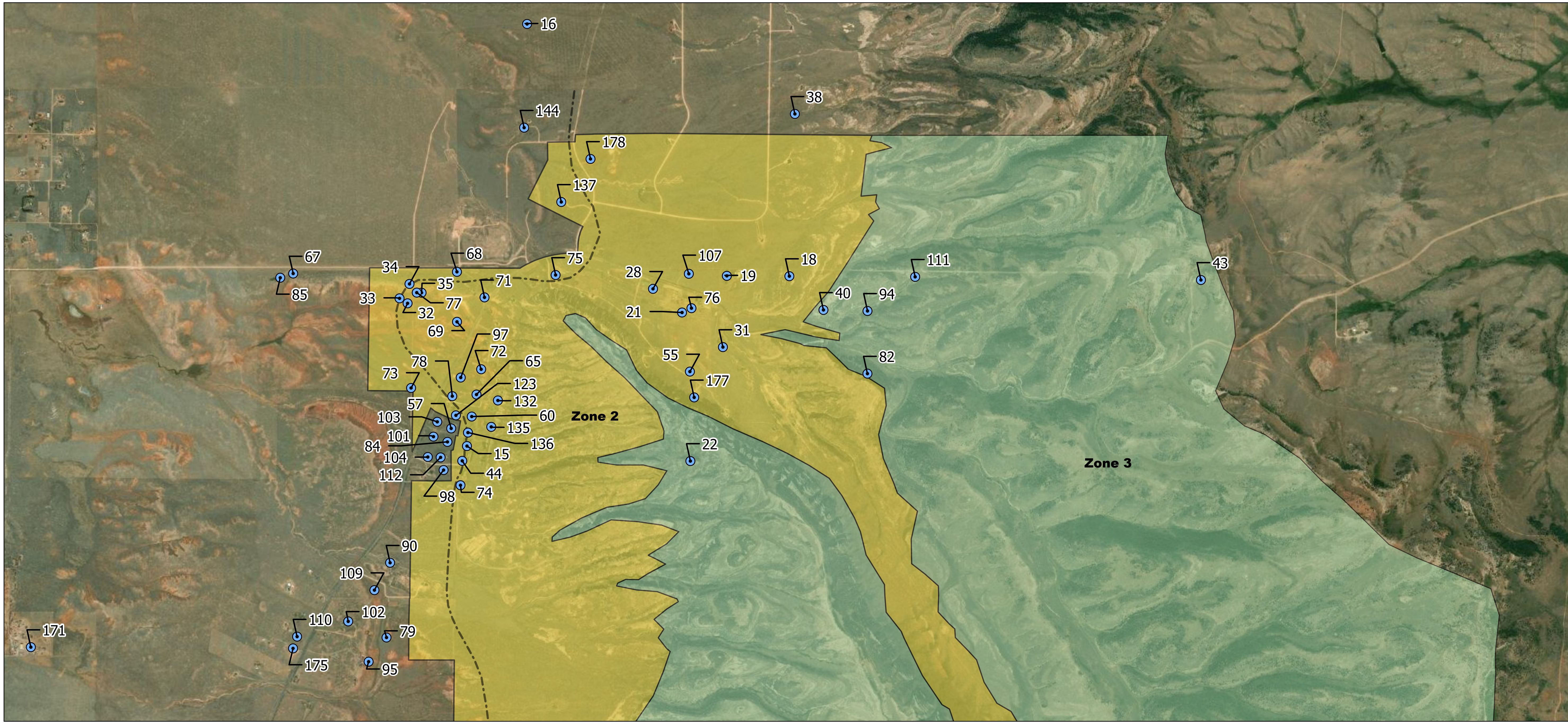
Notes:

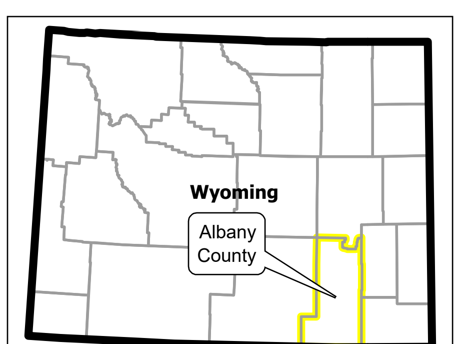
1 - P(Permit); **W**(Well); **C**(Statement of Claim)

2 - DOM(Domestic Supply); **DOM_GW**(Domestic -- Ground Water); **IRR_GW**(Irrigation -- Groundwater); **MIS**(Miscellaneous); **STK**(Stock); **MUN**(Municipal -- Ground Water); **MON**(Monitor, Observation); **TST**(Test Well)

Table D-2. Satanka Shale Thickness Data Points from Site Specific Investigations

Map ID	Site Name	SSI Consultant	Satanka Shale Thickness (ft)	Source of Information	Longitude	Latitude
179	City of Laramie Northside Tank Project	Trihydro (2017)	0	Site on Casper Fm. Outcrop	-105.52877	41.33472
180	Indian Heights Subdivision	Weston Engineering (2021)	95	Estimated based on dip calculation of Satanka Fm. and mapping done by Ver Ploeg (2009)	-105.5382	41.32732
181	Upland Heights B4 and B5	WWC Engineering (2018)	0	Site on Casper Fm. Outcrop	-105.54509	41.30894
182	City of Laramie Foundation	Trihydro (2018)	30	Onsite test boring TH-1	-105.53082	41.2967
183	Laramie Church of Christ	Weston Engineering (2014)	250	Estimated based on MW 82T3 and dip calculation of Satanka Fm.	-105.55215	41.30545
184	4700 Bluebird Lane ("Tumbleweed" gas station)	Weston Engineering (2019)	61	Structure contour map developed by consultant based on SEO well data	-105.53235	41.29555
185	Laramie Community College Albany County Campus Class Room Additions	WWC Engineering (2016)	99	LCCC MW NO. 1, On-site monitoring well	-105.54732	41.30398
186	Laramie Community College Albany County Campus Class Room Additions	WWC Engineering (2016)	112	LCCC IW NO.1, On-site withdrawal well	-105.5471	41.30374





Legend

- SEO Well Data Points (Table D-1)
- SSI Data Points (Table D-2)
- Protective Satanka Shale Thickness
- CAPA Zone 2
- CAPA Zone 3
- Municipalities

0 1,500 3,000 Feet

(At original document size of 11x17)
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Notes
1. Coordinate System: NAD 1983 StatePlane Wyoming East FIPS 4901 Feet
2. Data Sources: Stantec, WY SEO Database, City of Laramie, Albany County
3. Background: Maxar (2021)
4. Data points are labeled according to Map ID number from Tables D-1 and D-2.

Stantec

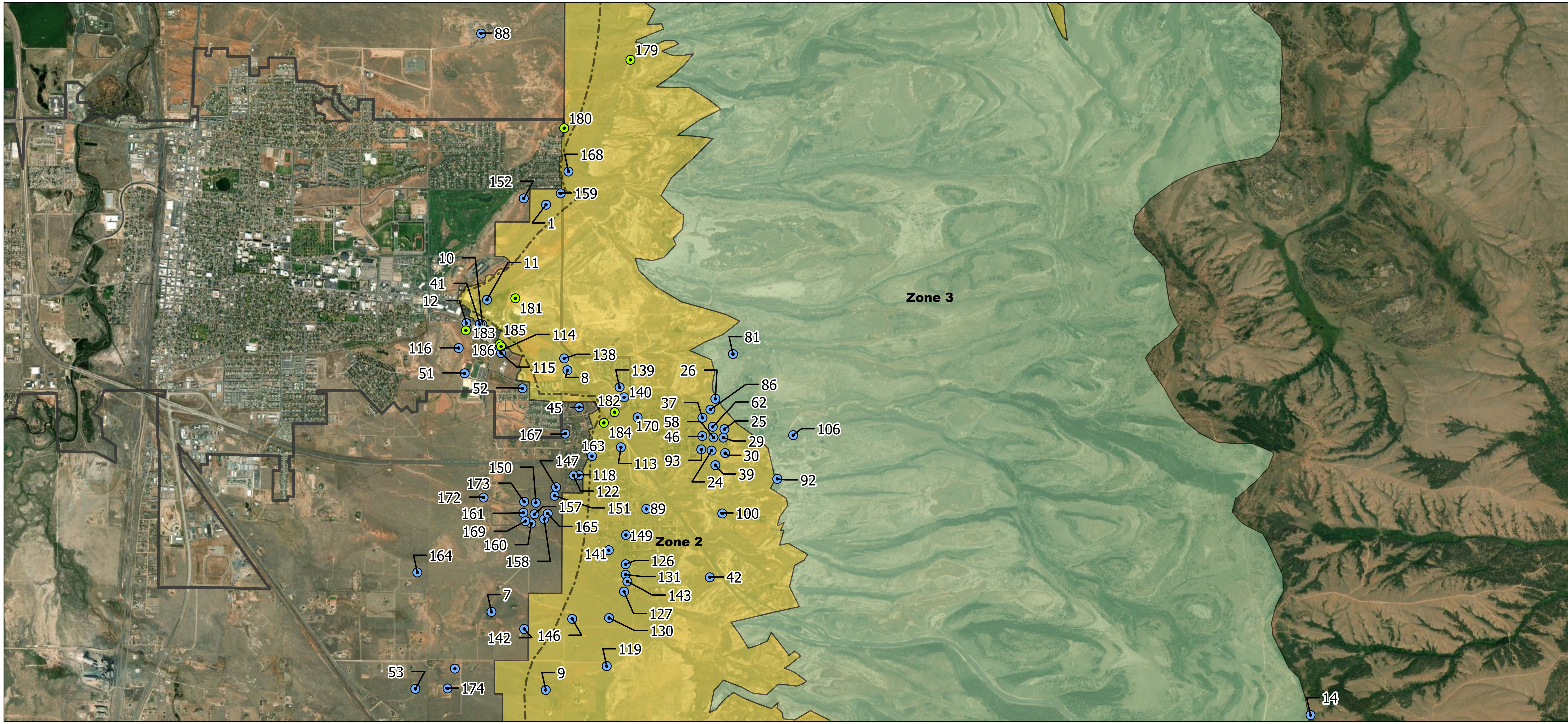
Project Location
T16N, R73W
Laramie, Albany Co., WY

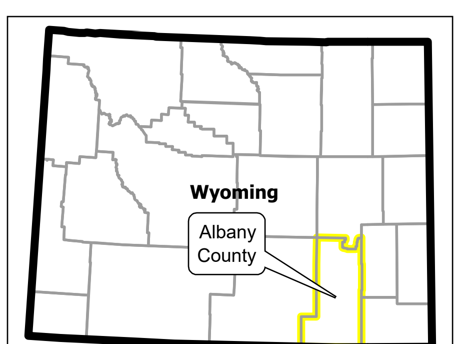
Prepared by FT on 2022-05-10
TR by XXX on 2020-XX-XX
IR by XXX on 2020-XX-XX

Client/Project
227704690
City of Laramie/Albany County
Casper Aquifer Protection Plan Update

Appendix No.
D-1a

Title
Satanka Shale Thickness Data Point Map ID's





Legend

- SEO Well Data Points (Table D-1)
- SSI Data Points (Table D-2)
- Protective Satanka Shale Thickness
- CAPA Zone 2
- CAPA Zone 3
- Municipalities

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Notes
1. Coordinate System: NAD 1983 StatePlane Wyoming East FIPS 4901 Feet
2. Data Sources: Stantec, WY SEO Database, City of Laramie, Albany County
3. Background: Maxar (2021)
4. Data points are labeled according to Map ID number from Tables D-1 and D-2.

Stantec

Project Location
T16N, R73W
Laramie, Albany Co., WY

Prepared by FT on 2022-05-11
TR by XXX on 2020-XX-XX
IR by XXX on 2020-XX-XX

Client/Project 227704690
City of Laramie/Albany County
Casper Aquifer Protection Plan Update

Appendix No.
D-1b

Title
Satanka Shale Thickness Data Point Map ID's

Page 1 of 1

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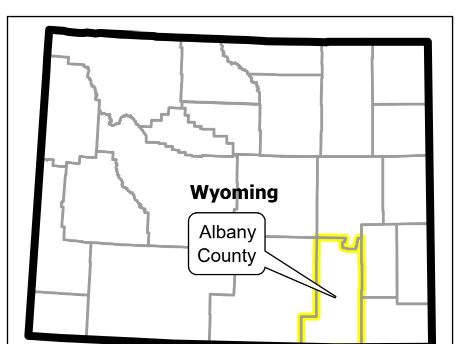


Legend
- SEO Well Data Points (Table D-1)
- SSI Data Points (Table D-2)
- Protective Satanka Shale Thickness
- CAPA Zone 2
- CAPA Zone 3
- Municipalities

0 1,500 3,000 Feet
(At original document size of 11x17)
1:36,000

N

Notes
1. Coordinate System: NAD 1983 StatePlane Wyoming East FIPS 4901 Feet
2. Data Sources: Stantec, WY SEO Database, City of Laramie, Albany County
3. Background: Maxar (2021)
4. Data points are labeled according to Map ID number from Tables D-1 and D-2.

Stantec

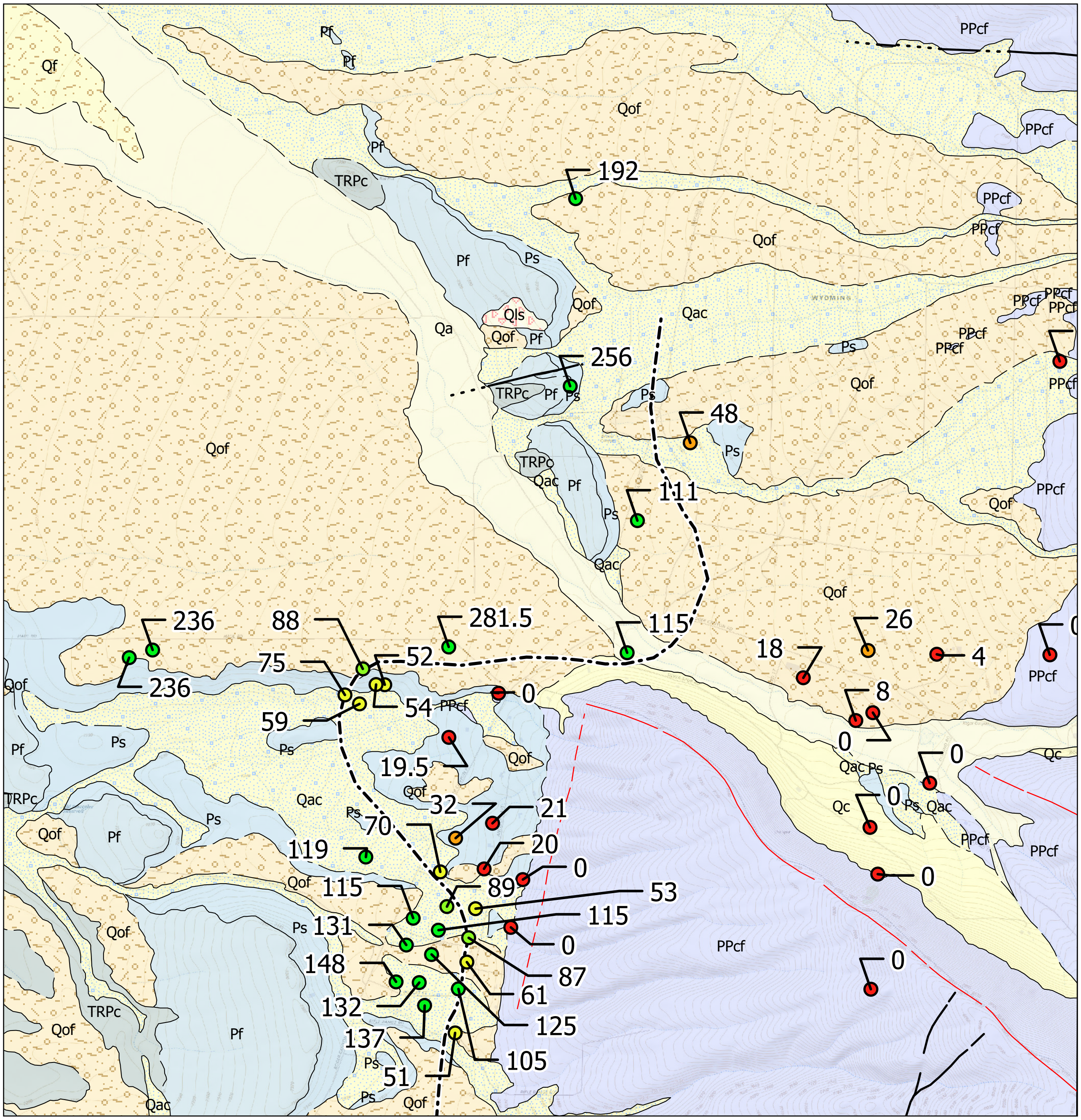
Project Location
T16N, R73W
Laramie, Albany Co., WY

Prepared by FT on 2022-05-11
TR by XXX on 2020-XX-XX
IR by XXX on 2020-XX-XX

Client/Project
227704690
City of Laramie/Albany County
Casper Aquifer Protection Plan Update

Appendix No.
D-1c

Title
Satanka Shale Thickness Data Point Map ID's



Legend

Satanka Thickness Data Points (Table D-1 and D-2)

- 0 - 25 ft
- 25 - 50 ft
- 50 - 75 ft
- 75 - 100 ft
- > 100 ft
- Protective Satanka Shale Thickness
- Municipalities

Geologic Units

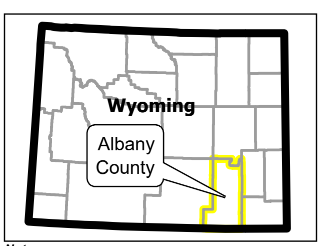
- Qa - Alluvial deposits
- Qc - Colluvium
- Qac - Mixed alluvium and colluvium
- Qf - Alluvial fan deposits
- Qls - Landslide deposits
- Qof - Older alluvual fan deposits
- TRPc - Chugwater Fm.
- Pf - Forelle Limestone
- Ps - Satanka Shale
- PPcf - Casper and Fountain Fm.

Contacts

- Known Contact
- Inferred Contact

Faults and Folds

- Fault
- Concealed fault
- Inferred fault location
- Fold
- Concealed fold
- Inferred fold location



Notes

1. Coordinate System: NAD 1983 StatePlane Wyoming East FIPS 4901 Feet

2. Data Sources: Stantec, WY SEO Database, City of Laramie, Albany County

3. Background: Ver Ploeg, A.J., 2007, Geologic map of the Howell quadrangle, Albany County, Wyoming: Wyoming State Geological Survey Map Series 75, scale 1:24,000., USGS TNM Topo Base Map (2021)

4. Data points labeled according to Satanka Shale thickness from Tables D-1 and D-2. See Figures D-1a through D-1c for Map ID number.

0 1,250 2,500 Feet

(At original document size of 8.5x11)
1:30,000

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Stantec

Project Location
T16N, R73W
Laramie, Albany Co., WY

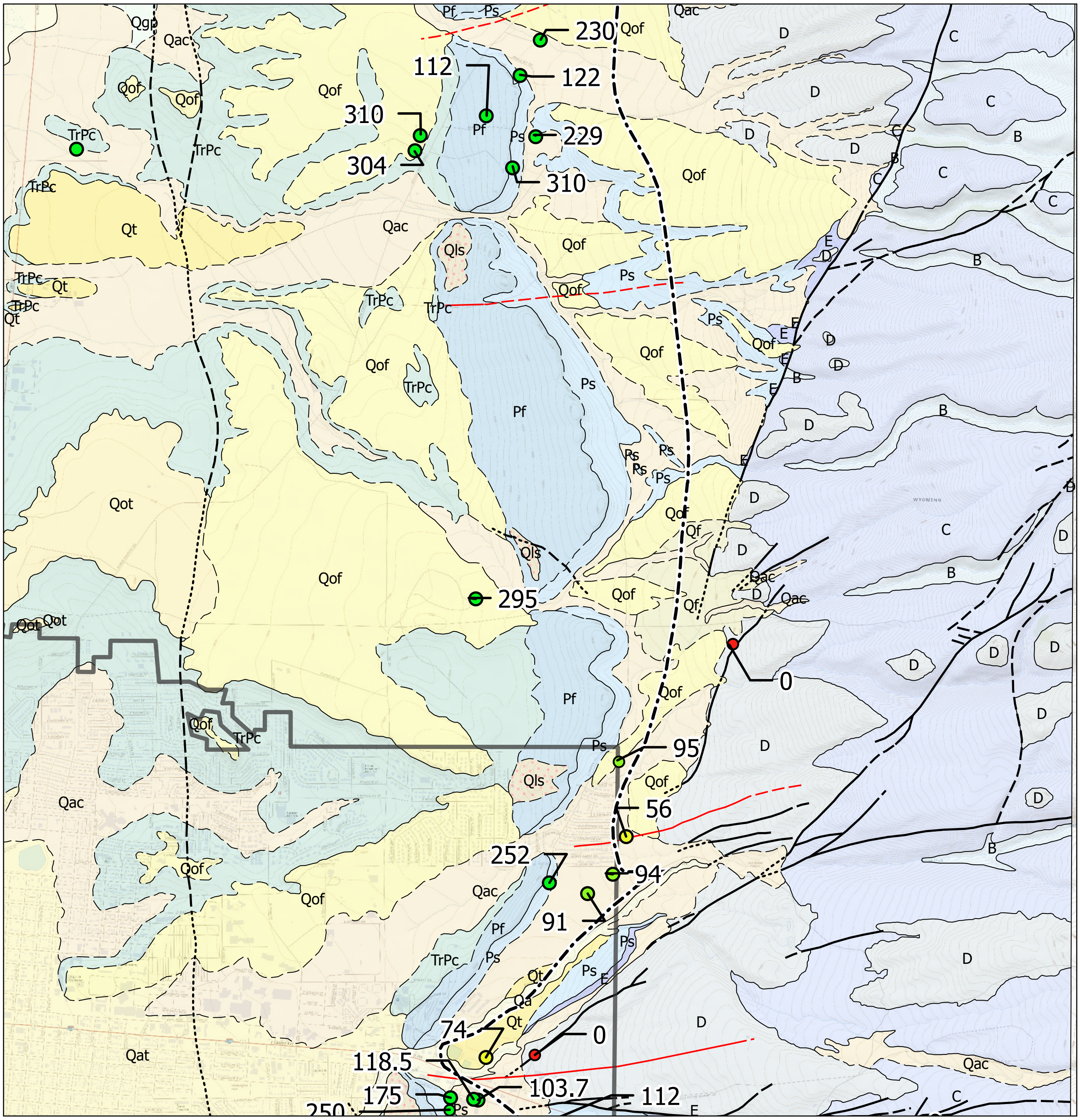
Prepared by FT on 2022-05-11
TR by XXX on 2020-XX-XX
IR by XXX on 2020-XX-XX

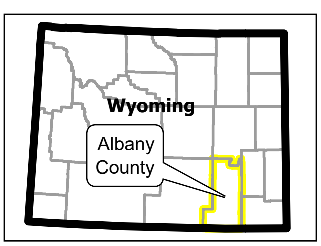
Client/Project
City of Laramie/Albany County
Casper Aquifer Protection Plan Update

227704690

Appendix No.
D-2a

Title
Satanka Shale Thickness Data Points with Geology





Legend

Satanka Thickness Data Points (Table D-1 and D-2)

- 0 - 25 ft
- 25 - 50 ft
- 50 - 75 ft
- 75 - 100 ft
- > 100 ft
- Protective Satanka Shale Thickness
- Municipalities

Geologic Units

- Qa - Alluvial deposits
- Qac - Mixed allucium and colluvium
- Qat - Mixed alluvium and terrace deposits
- Qf - Alluvial fan deposits
- Qt - Terrace Deposits
- Qls - Landslide deposits
- Qgp - Gypsite deposits
- Qof - Older alluvial fan deposits
- Qot - Older terrace deposits
- TrPc - Chugwater Fm.
- Pf - Forelle Limestone
- Ps - Satanka Shale
- E - Epsilon member of the Casper Fm.
- D - Delta member of the Casper Fm.
- C - Gamma member of the Casper Fm.
- B - Beta member of the Casper Fm.

Contacts

- Known contact
- Inferred contact

Faults and Folds

- Fault
- Approx. fault location
- Concealed fault
- Fold
- Approx. fold location

0 1,750 3,500 Feet

(At original document size of 8.5x11)
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Notes

1. Coordinate System: NAD 1983 StatePlane Wyoming East FIPS 4901 Feet
2. Data Sources: Stantec, WY SEO Database, City of Laramie, Albany County
3. Background: Ver Ploeg, A.J., 2009, Revised geologic map of the Laramie quadrangle, Albany County, Wyoming: Wyoming State Geological Survey Map Series 50, version 1.0, scale 1:24,000., USGS TNM Topo Base Map (2021)
4. Data points labeled according to Satanka Shale thickness from Tables D-1 and D-2. See Figures D-1a through D-1c for Map ID number.

Stantec

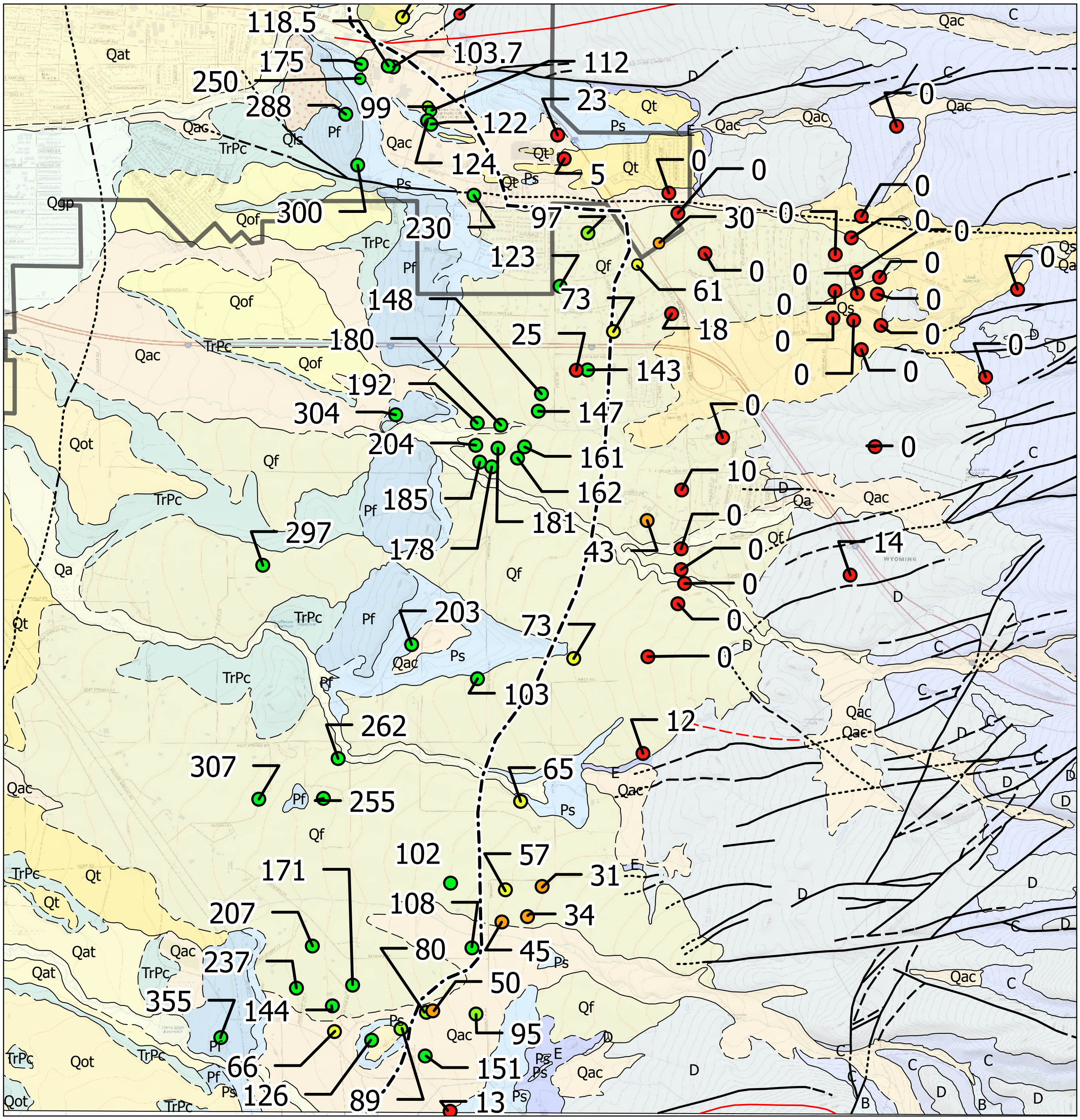
Project Location
T16N, R73W
Laramie, Albany Co., WY

Prepared by FT on 2022-05-11
TR by XXX on 2020-XX-XX
IR by XXX on 2020-XX-XX

Client/Project
227704690
City of Laramie/Albany County
Casper Aquifer Protection Plan Update

Appendix No.
D-2b

Title
Satanka Shale Thickness Data Points with Geology



Legend

Satanka Thickness Data Points (Table D-1 and D-2)

- 0 - 25 ft
- 25 - 50 ft
- 50 - 75 ft
- 75 - 100 ft
- > 100 ft
- Protective Satanka Shale Thickness
- Municipalities

Geologic Units

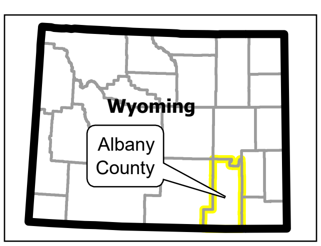
- Qa - Alluvial deposits
- Qs - Windblown sand deposits
- Qac - Mixed allucium and colluvium
- Qat - Mixed alluvium and terrace deposits
- Qf - Alluvial fan deposits
- Qt - Terrace Deposits
- Qls - Landslide deposits
- Qgp - Gypsite deposits
- Qof - Older alluvial fan deposits
- Qot - Older terrace deposits
- TrPc - Chugwater Fm.
- Pf - Forelle Limestone
- Ps - Satanka Shale
- E - Epsilon member of the Casper Fm.
- D - Delta member of the Casper Fm.
- C - Gamma member of the Casper Fm.
- B - Beta member of the Casper Fm.

Contacts

- Known contact
- Inferred contact

Faults and Folds

- Fault
- Approx. fault location
- Concealed fault
- Fold
- Approx. fold location



0 1,500 3,000 Feet

(At original document size of 8.5x11)
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Notes

1. Coordinate System: NAD 1983 StatePlane Wyoming East FIPS 4901 Feet
2. Data Sources: Stantec, WY SEO Database, City of Laramie, Albany County
3. Background: Ver Ploeg, A.J., 2009, Revised geologic map of the Laramie quadrangle, Albany County, Wyoming: Wyoming State Geological Survey Map Series 50, version 1.0, scale 1:24,000., USGS TNM Topo Base Map (2021)
4. Data points labeled according to Satanka Shale thickness from Tables D-1 and D-2. See Figures D-1a through D-1c for Map ID number.

Stantec

Project Location
T16N, R73W
Laramie, Albany Co., WY

Prepared by FT on 2022-05-11
TR by XXX on 2020-XX-XX
IR by XXX on 2020-XX-XX

Client/Project
227704690
City of Laramie/Albany County
Casper Aquifer Protection Plan Update

Appendix No.
D-2c

Title
Satanka Shale Thickness Data Points with Geology

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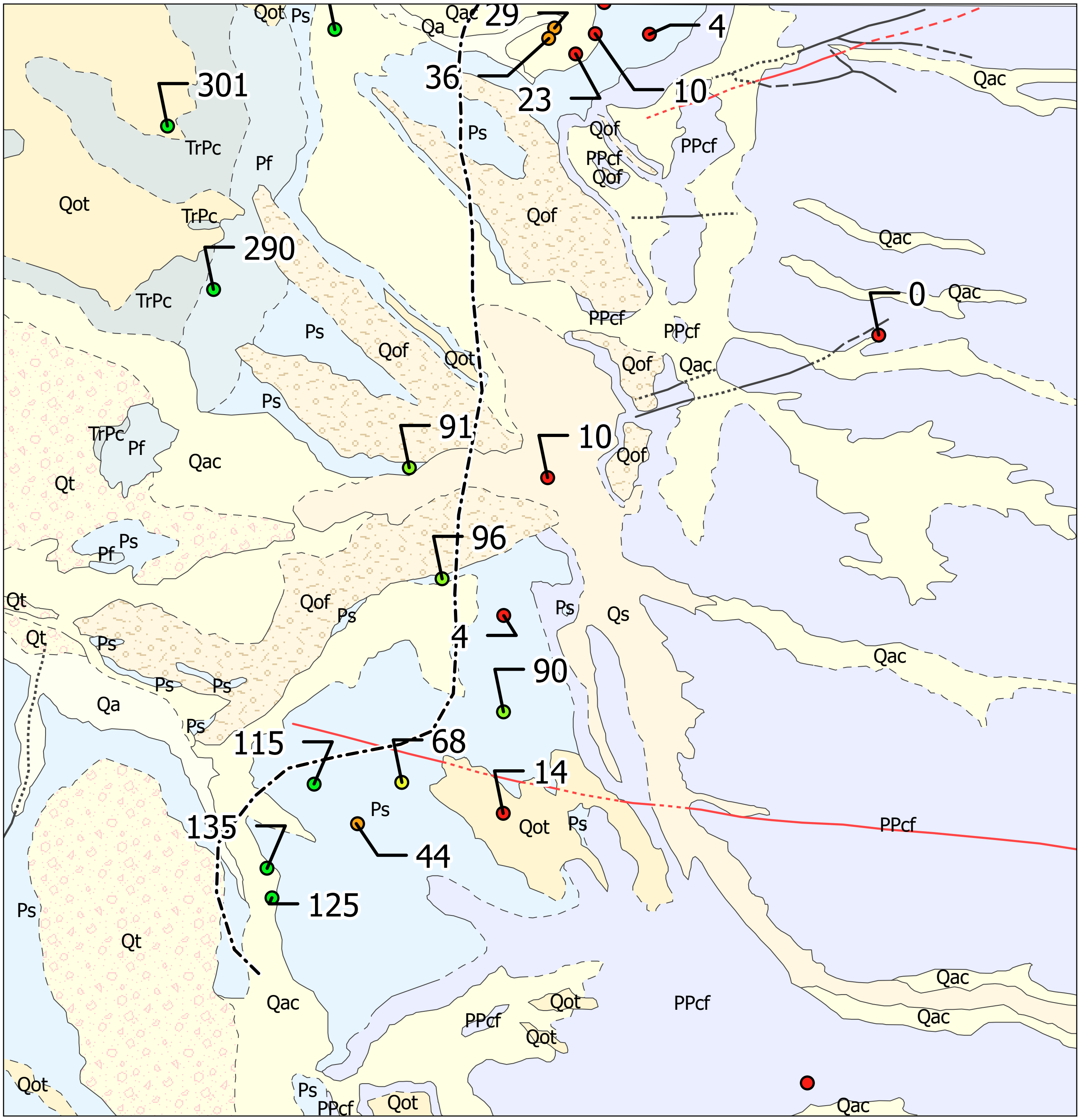

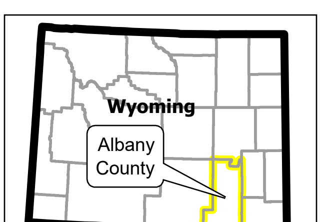

Legend

Satanka Thickness Data Points (Table D-1 and D-2)

- 0 - 25 ft
- 25 - 50 ft
- 50 - 75 ft
- 75 - 100 ft
- > 100 ft
- Protective Satanka Shale Thickness
- Municipalities

Geologic Units

- Qa - Alluvial deposit
- Qac - Mixed alluvium and colluvium
- Qs - Windblown sand deposits
- Qt - Terrace deposits
- Qof - Older alluvial fan deposits
- Qot - Older terrace deposits
- TrPc - Chugwater Fm.
- Pf - Forelle Limestone
- Ps - Satanka Shale
- PPcf - Casper and Fountain Fm.

Faults and Folds

- Fault
- Approx. fault location
- Concealed Fault
- Fold
- Approx. fold location
- Concealed fold

Contacts

- Known contact
- Inferred contact

0 1,000 2,000 Feet

(At original document size of 8.5x11)
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N

Notes

1. Coordinate System: NAD 1983 StatePlane Wyoming East FIPS 4901 Feet
2. Data Sources: Stantec, WY SEO Database, City of Laramie, Albany County
3. Background: Ver Ploeg, A.J., 2007, Geologic map of the Red Buttes quadrangle, Albany County, Wyoming: Wyoming State Geological Survey Map Series 76, scale 1:24,000., USGS TNM Topo Base Map (2021)
4. Data points labeled according to Satanka Shale thickness from Tables D-1 and D-2. See Figures D-1a through D-1c for Map ID number.

Stantec

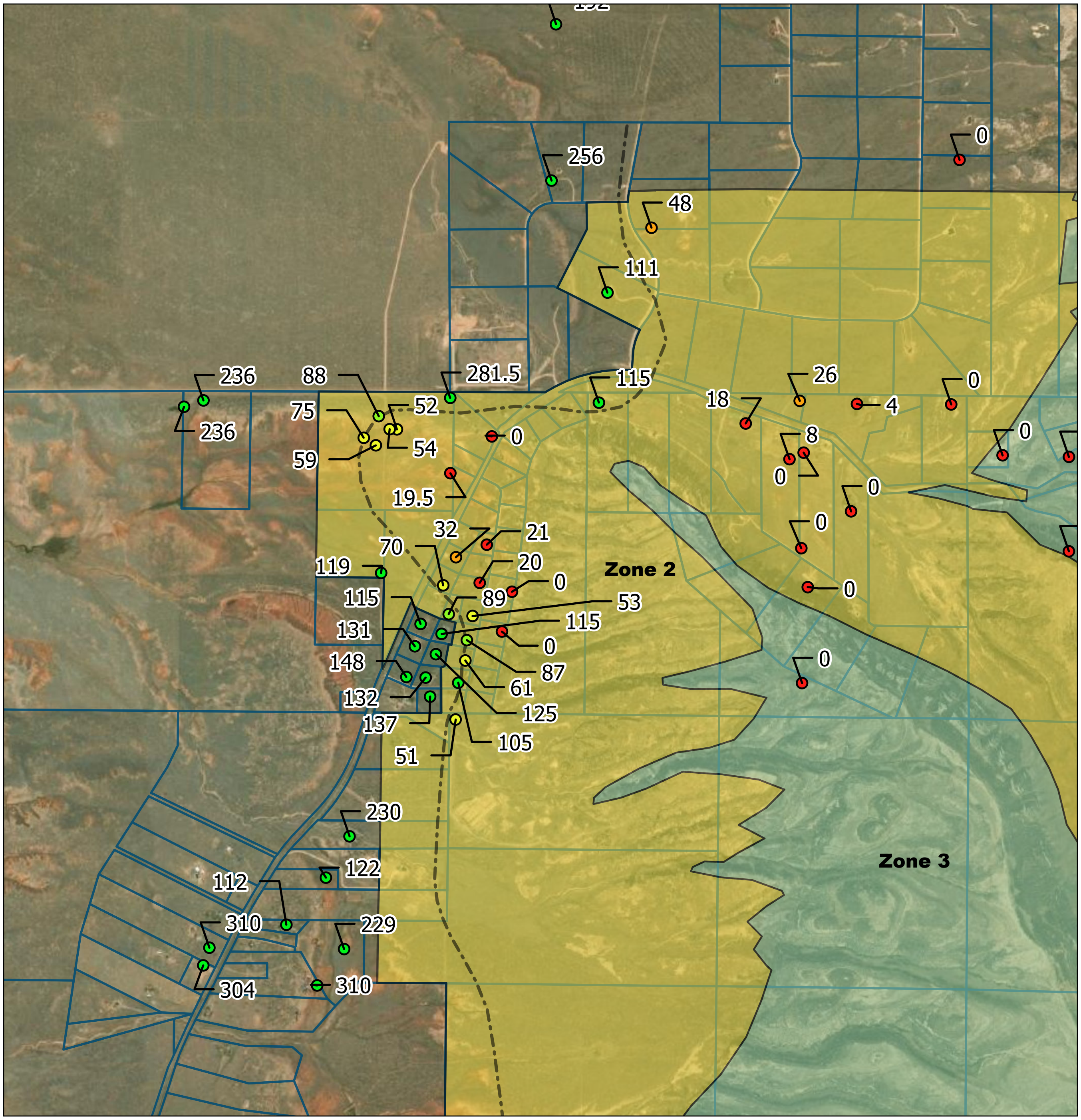
Project Location
T16N, R73W
Laramie, Albany Co., WY

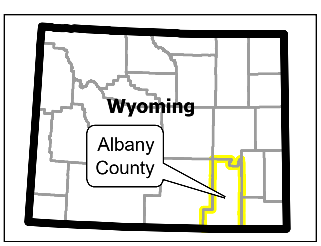
Prepared by FT on 2022-05-11
TR by XXX on 2020-XX-XX
IR by XXX on 2020-XX-XX

Client/Project
227704690
City of Laramie/Albany County
Casper Aquifer Protection Plan Update

Appendix No.
D-2d

Title
Satanka Shale Thickness Data Points with Geology





Legend

Satanka Thickness Data Points (Table D-1 and D-2)

- 0 - 25 ft
- 25 - 50 ft
- 50 - 75 ft
- 75 - 100 ft
- > 100 ft
- Protective Satanka Shale Thickness
- CAPA Zone 2
- CAPA Zone 3
- Municipalities
- Ownership (as of 4/18/22)

0 1,500 3,000 Feet

(At original document size of 8.5x11)
1:36,000

N

Notes
1. Coordinate System: NAD 1983 StatePlane Wyoming East FIPS 4901 Feet
2. Data Sources: Stantec, WY SEO Database, City of Laramie, Albany County
3. Background: Maxar (2021)
4. Data points are labeled according to Satanka Shale thickness from Tables D-1 and D-2. See figures D-1a through D-1c for Map ID number.

Stantec

Project Location
T16N, R73W
Laramie, Albany Co., WY

Prepared by FT on 2022-05-11
TR by XXX on 2020-XX-XX
IR by XXX on 2020-XX-XX

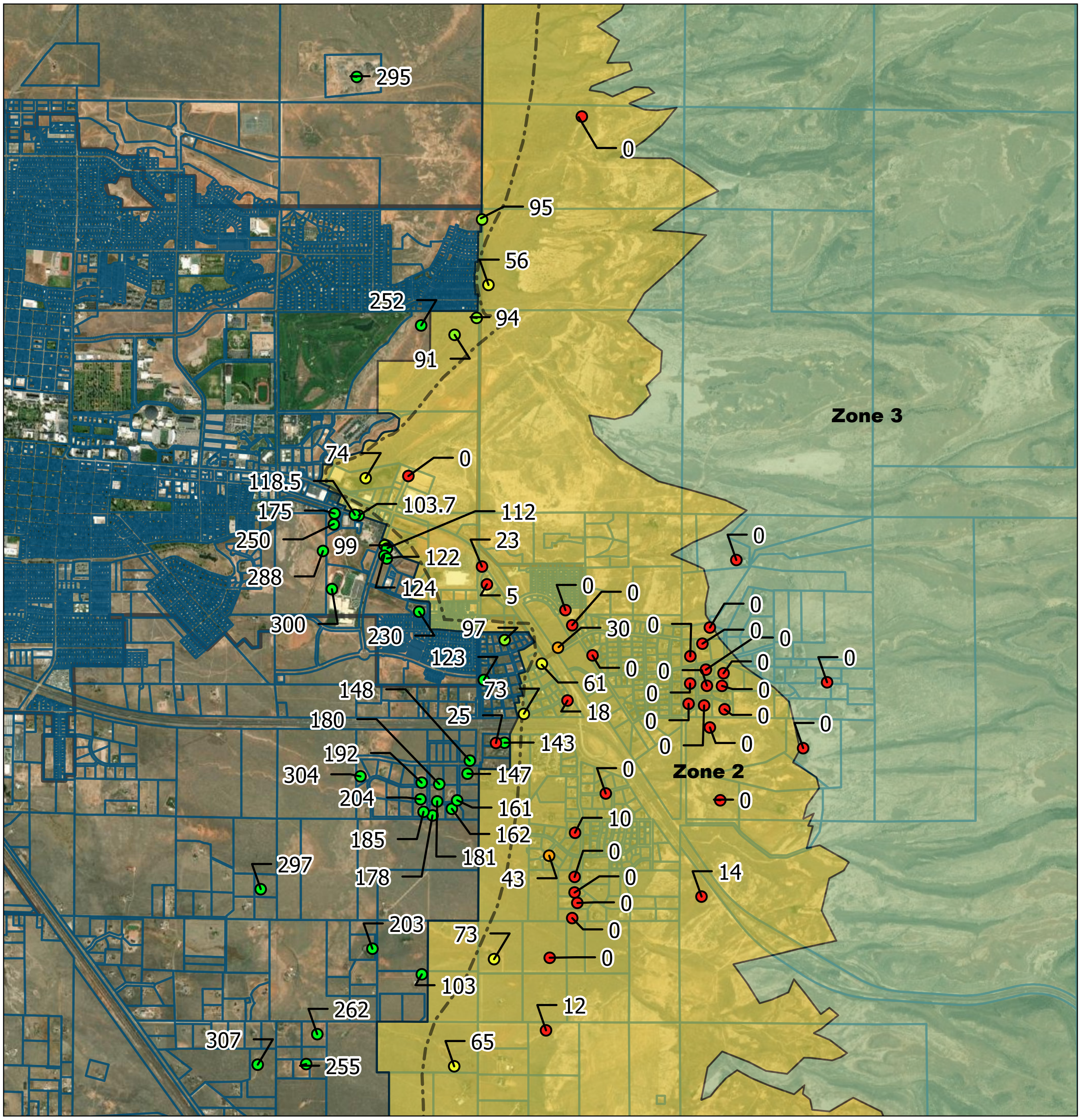
Client/Project
City of Laramie/Albany County
Casper Aquifer Protection Plan Update

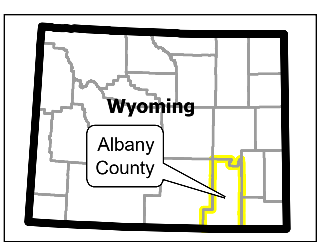
227704690

Appendix No.
D-3a

Title
Satanka Shale Thickness Data Points with Ownership

\\corp.ads\data\Virtual_Workspace\workgroup\2277\active\227704690\03_data\gis_cad\gis\pro\CAPP UPDATE 2022\CAPP UPDATE 2022.aprx Revised: 2022-05-11 By: frtremblay





Notes
1. Coordinate System: NAD 1983 StatePlane Wyoming East FIPS 4901 Feet
2. Data Sources: Stantec, WY SEO Database, City of Laramie, Albany County
3. Background: Maxar (2021)
4. Data points are labeled according to Satanka Shale thickness from Tables D-1 and D-2. See figures D-1a through D-1c for Map ID number.

Legend
Satanka Thickness Data Points (Table D-1 and D-2)
- 0 - 25 ft
- 25 - 50 ft
- 50 - 75 ft
- 75 - 100 ft
- > 100 ft
- Protective Satanka Shale Thickness
- CAPA Zone 2
- CAPA Zone 3
- Municipalities
- Ownership (as of 4/18/22)

0 2,000 4,000 Feet
(At original document size of 8.5x11)
1:48,000

N

Stantec

Project Location
T16N, R73W
Laramie, Albany Co., WY

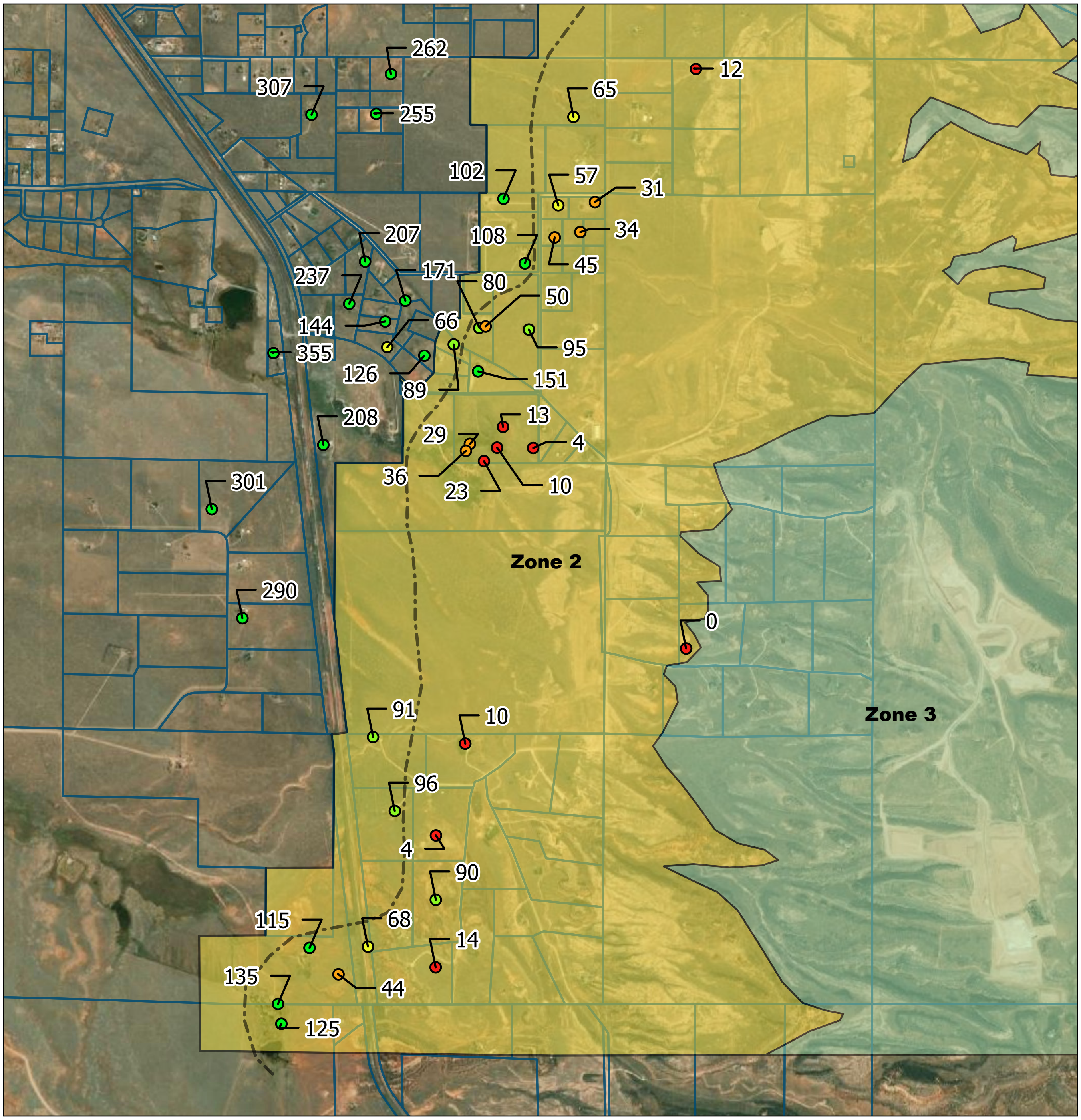
Prepared by FT on 2022-05-11
TR by XXX on 2020-XX-XX
IR by XXX on 2020-XX-XX

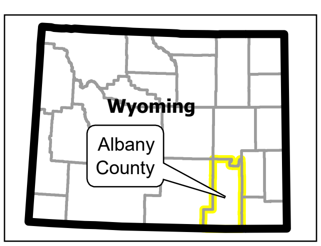
Client/Project
227704690
City of Laramie/Albany County
Casper Aquifer Protection Plan Update

Appendix No.
D-3b

Title
Satanka Shale Thickness Data Points with Ownership

\\corp.ads\data\Virtual_Workspace\workgroup\2277\active\227704690\03_data\gis_cad\gis\pro\CAPP UPDATE 2022\CAPP UPDATE 2022.aprx Revised: 2022-05-11 By: frtremblay





Legend

Satanka Thickness Data Points (Table D-1 and D-2)

- 0 - 25 ft
- 25 - 50 ft
- 50 - 75 ft
- 75 - 100 ft
- > 100 ft
- Protective Satanka Shale Thickness
- CAPA Zone 2
- CAPA Zone 3
- Municipalities
- Ownership (as of 4/18/22)

Notes
1. Coordinate System: NAD 1983 StatePlane Wyoming East FIPS 4901 Feet
2. Data Sources: Stantec, WY SEO Database, City of Laramie, Albany County
3. Background: Maxar (2021)
4. Data points are labeled according to Satanka Shale thickness from Tables D-1 and D-2. See figures D-1a through D-1c for Map ID number.

0 1,500 3,000 Feet
(At original document size of 8.5x11)
1:36,000

N

Stantec

Project Location
T16N, R73W
Laramie, Albany Co., WY

Prepared by FT on 2022-05-11
TR by XXX on 2020-XX-XX
IR by XXX on 2020-XX-XX

Client/Project
227704690
City of Laramie/Albany County
Casper Aquifer Protection Plan Update

Appendix No.
D-3c

Title
Satanka Shale Thickness Data Points with Ownership

\\corp.ads\data\Virtual_Workspace\workgroup\2277\active\227704690\03_data\gis_cad\gis\pro\CAPP UPDATE 2022\CAPP UPDATE 2022.aprx Revised: 2022-05-11 By: frtremblay

APPENDIX E

Contaminant Inventory

Source Identification Form

City/Town	Laramie WY
EPA PWS ID#	5600029
Well Name	
WHPA Zone #	Zones 2, 3
Type of Survey	Windshield and Field Survey

Site Information

Site Name/ Owner	Laramie Rifle Range
Site Location	T16N, R73W: Sec12 N1/2
Nature of Property	Commercial

Potential and Known Sources of Contamination

Potential Source	Code	Quantity	Comments	Priority
1) Lead bullets	N/A	N/A	soluble lead	Low

Source Identification Form

City/Town	Laramie WY
EPA PWS ID#	5600029
Well Name	All Wellfields
WHPA Zone #	Zone 2, 3
Type of Survey	Windshield Survey and Albany County Assessors Database

Site Information

Site Name/ Owner	Residential Areas
Site Location	various
Nature of Property	Residential and Industrial

Potential and Known Sources of Contamination

Potential Source	Code	Quantity	Comments	Priority
1) Septic systems	0019	455	nitrates, fecal coliform	High
2) Sewer lines	0021	various	nitrates, fecal coliform	Low
3) Water supply wells	0039	455	serve as contaminant conduit to aquifer	High
4) Abandoned wells	0040	3	serve as contaminant conduit to aquifer	High
5) Livestock waste disposal areas	0010	various	nitrates, fecal coliform	Medium
6) Public utilities	0110	N/A	gas lines, oils, solvents	Low
7) Mosquito sprays	0027	N/A	malathion @ 3 oz/acre	Low
8) Common household products	0016	various	various hazardous household materials in open dump areas near residences	Low
9) Lawns and gardens	0017	N/A	fertilizers and herbicides	Low

Source Identification Form

City/Town	Laramie WY
EPA PWS ID#	5600029
Well Name	All Wellfields
WHPA Zone #	Zone 2, 3
Type of Survey	Windshield Survey

Site Information

Site Name/ Owner	Interstate 80
Site Location	T15N, R73W: Sec1,12; T15N, R72W: Sec7, 18, 17, 16, 21,22, 26, 27
Nature of Property	Government

Potential and Known Sources of Contamination

Potential Source	Code	Quantity	Comments	Priority
1) Transport of various hazardous materials	0083	various	hazardous material spills and fuel spills by an accident	High
2) Highway- I-80	0028	1	de-icing	Low

Source Identification Form

City/Town	Laramie WY
EPA PWS ID#	5600029
Well Name	Turner Wellfield
WHPA Zone #	Zone 1
Type of Survey	Windshield Survey

Site Information

Site Name/ Owner	City Springs
Site Location	T16N, R73W: Sec35 S1/2
Nature of Property	other

Potential and Known Sources of Contamination

Potential Source	Code	Quantity	Comments	Priority
1) Water	0002	1	springs serve as conduit for contaminants to potentially enter the aquifer	High

Source Identification Form

City/Town	Laramie WY
EPA PWS ID#	5600029
Well Name	Pope Wellfield
WHPA Zone #	Zone 1
Type of Survey	Windshield Survey

Site Information

Site Name/ Owner	Pope Springs
Site Location	T15N, R73W: Sec14 E1/2
Nature of Property	other

Potential and Known Sources of Contamination

Potential Source	Code	Quantity	Comments	Priority
1) Water from springs	0002	1	springs serve as conduit for contaminants to potentially enter the aquifer	High

Source Identification Form

City/Town	Laramie WY
EPA PWS ID#	5600029
Well Name	Soldier #1
WHPA Zone #	Zones 1, 2, 3
Type of Survey	Windshield Survey

Site Information

Site Name/ Owner	Soldier Springs
Site Location	T15N, R73W: Sec23 S1/2; Sec26 N1/2; Sec24 W1/2
Nature of Property	other

Potential and Known Sources of Contamination

Potential Source	Code	Quantity	Comments	Priority
1) Water from springs	0002	1	springs serve as conduit for contaminants to potentially enter the aquifer	High

Source Identification Form

City/Town	Laramie WY
EPA PWS ID#	5600029
Well Name	Pope and Solider wellfields
WHPA Zone #	Zones 2, 3
Type of Survey	Field Survey

Site Information

Site Name/ Owner	Union Pacific Railroad - Hermosa/ Spur Line
Site Location	T15N, R73W: Sec26 SW1/4, SW1/4; Sec35 W1/2; T14N, R73W: Sec2 W1/2; Sec11 W1/2
Nature of Property	Commercial and Industrial

Potential and Known Sources of Contamination

Potential Source	Code	Quantity	Comments	Priority
1) Transported chemicals and hazardous material	0083	various	chemical and hazardous material spills are possible	Medium
2) Railroad tracks	0074	1	creosote seepage from ties	Low

Source Identification Form

City/Town	Laramie WY
EPA PWS ID#	5600029
Well Name	All Wellfields
WHPA Zone #	Zones 2, 3
Type of Survey	Field Survey

Site Information

Site Name/ Owner	Quarries/ Mountain Cement
Site Location	T16N, R73W; T15N, R72W; T15N, R73W
Nature of Property	Industrial

Potential and Known Sources of Contamination

Potential Source	Code	Quantity	Comments	Priority
1) Surface mining operations	0101	4	Refueling spills, residue from blasting compounds (diesel fuel & ammonium nitrate)	Low

Source Identification Form

City/Town	Laramie WY
EPA PWS ID#	5600029
Well Name	All Wellfields
WHPA Zone #	Zone 1, 2, 3
Type of Survey	Windshield Survey, County Assessor's Office, State Engineers Office

Site Information

Site Name/ Owner	Wells
Site Location	Throughout CAPA
Nature of Property	Residential, municipal, stock, irrigation, monitoring

Potential and Known Sources of Contamination

Potential Source	Code	Quantity	Comments	Priority
1) wells	0039	Approximately 400	Wells serve as conduit for contaminants to potentially enter the aquifer	Medium

Source Identification Form

City/Town	Laramie WY
EPA PWS ID#	5600029
Well Name	All Wellfields
WHPA Zone #	Zone 3
Type of Survey	UST database

Site Information

Site Name/ Owner	Pilot Hill Radio Repeater
Site Location	T15N, R72W: Sec10 NE1/4, SE1/4
Nature of Property	Commercial

Potential and Known Sources of Contamination

Potential Source	Code	Quantity	Comments	Priority
1) underground storage tank	0078	1 active, 1 removed	Diesel	Medium

Source Identification Form

City/Town	Laramie WY
EPA PWS ID#	5600029
Well Name	Turner Wellfield
WHPA Zone #	Zone 2
Type of Survey	Windshield Survey

Site Information

Site Name/ Owner	Dollar Tree, LEAP, Snowy Range Academy, Express Pharmacy
Site Location	4005 and 4027 E. Grand Ave.
Nature of Property	Commercial

Potential and Known Sources of Contamination

Potential Source	Code	Quantity	Comments	Priority
1) Storm water runoff	0032	1	urban runoff, gasoline, oil, road salt	Medium

Source Identification Form

City/Town	Laramie WY
EPA PWS ID#	5600029
Well Name	Turner Wellfield
WHPA Zone #	Zone 2
Type of Survey	Windshield Survey

Site Information

Site Name/ Owner	Premier Bone and Joint Centers
Site Location	1909 Vista Drive
Nature of Property	Commercial

Potential and Known Sources of Contamination

Potential Source	Code	Quantity	Comments	Priority
1) Medical facility	0068	1	Medical wastes	Medium

Source Identification Form

City/Town	Laramie WY
EPA PWS ID#	5600029
Well Name	Turner Wellfield
WHPA Zone #	Zone 2
Type of Survey	Windshield Survey

Site Information

Site Name/ Owner	Animal Heath Center
Site Location	4619 Bobolink Ln
Nature of Property	Commercial

Potential and Known Sources of Contamination

Potential Source	Code	Quantity	Comments	Priority
1) Veterinary service	0080	1	Medical wastes	Medium

Source Identification Form

City/Town	Laramie WY
EPA PWS ID#	5600029
Well Name	Soldier Springs Wellfield
WHPA Zone #	Zone 2
Type of Survey	Windshield Survey

Site Information

Site Name/ Owner	AT&T Communications
Site Location	3450 Wyatt Court
Nature of Property	Commercial

Potential and Known Sources of Contamination

Potential Source	Code	Quantity	Comments	Priority
1) UST	0078	1	Diesel (?)	Medium

Source Identification Form

City/Town	Laramie WY
EPA PWS ID#	5600029
Well Name	All Wellfields
WHPA Zone #	Zone 2, 3
Type of Survey	Windshield Survey
Site Information	
Site Name/ Owner	Transportation routes
Site Location	Throughout CAPA
Nature of Property	Government

Potential and Known Sources of Contamination

Potential Source	Code	Quantity	Comments	Priority
1)transportation routes	0028	1	De-icing materials, automotive wastes	Low

Source Identification Form

City/Town	Laramie WY
EPA PWS ID#	5600029
Well Name	Turner Wellfield
WHPA Zone #	Zone 2
Type of Survey	UST database
Site Information	
Site Name/ Owner	J. T. Peele
Site Location	2038 Skyline Drive
Nature of Property	Commercial

Potential and Known Sources of Contamination

Potential Source	Code	Quantity	Comments	Priority
1) underground storage tank	0078	1	3,000 gallon diesel tank, removed 1989	Low

Source Identification Form

City/Town	Laramie WY
EPA PWS ID#	5600029
Well Name	Pope and Soldier wellfields
WHPA Zone #	Zone 3
Type of Survey	UST database
Site Information	
Site Name/ Owner	Sherman Hill Microwave Site
Site Location	13 miles W on Happy Jack Road and Exist 323 on I-80
Nature of Property	Commercial

Potential and Known Sources of Contamination

Potential Source	Code	Quantity	Comments	Priority
1) underground storage tank	0078	1	350 gallon gasoline tank (removed 1994)	Low

Source Identification Form

City/Town	Laramie WY
EPA PWS ID#	5600029
Well Name	Pope and Soldier wellfields
WHPA Zone #	Zone 3
Type of Survey	NPDES database
Site Information	
Site Name/ Owner	Etchepare Quarry (Mountain Cement)
Site Location	T15N, R72W: Sec 21
Nature of Property	Commercial

Potential and Known Sources of Contamination

Potential Source	Code	Quantity	Comments	Priority
1) Wastewater discharge	N/A	1	NPDES mineral mining discharge, construction sand and gravel	Low

Source Identification Form

City/Town	Laramie WY
EPA PWS ID#	5600029
Well Name	Spur Wellfield
WHPA Zone #	Zone 2
Type of Survey	NPDES database
Site Information	
Site Name/ Owner	Ninth Street Pit #2
Site Location	T17N, R73W, Sec 36: SW1/4, SW1/4
Nature of Property	Commercial

Potential and Known Sources of Contamination

Potential Source	Code	Quantity	Comments	Priority
1) Wastewater discharge	N/A	1	NPDES mineral mining discharge, construction sand and gravel	Low

Source Identification Form

City/Town: Laramie WY
EPA PWS ID#: 5600029
Well Name: Pope and Soldier Springs Wellfield
WHPA Zone #: Zone 2
Type of Survey: Windshield Survey

Site Information
Site Name/ Owner: Avery Feed lot
Site Location: T15N, R73W: Sec 26
Nature of Property: Commercial

Potential and Known Sources of Contamination

Potential Source	Code	Quantity	Comments	Priority
1) Livestock Waste Disposal Area	0010	1	nitrates, fecal	Medium

City/Town: Laramie WY
EPA PWS ID#: 5600029
Well Name: Turner Wellfield
WHPA Zone #: Zone 2
Type of Survey: Windshield Survey

Site Information
Site Name/ Owner: Walreen's Dental Arts
Site Location: 3421 E. Garfield St.
Nature of Property: Commercial

Potential and Known Sources of Contamination

Potential Source	Code	Quantity	Comments	Priority
1) Dental office	0068	1	Medical wastes	Low

Source Identification Form

City/Town: Laramie WY
EPA PWS ID#: 5600029
Well Name: Turner Wellfield
WHPA Zone #: Zone 2
Type of Survey: Windshield Survey

Site Information
Site Name/ Owner: Auto Center Detail Shop
Site Location: 3424 E. Garfield St.
Nature of Property: Commercial

Potential and Known Sources of Contamination

Potential Source	Code	Quantity	Comments	Priority
1) Auto detailing shop	0048	1	Solvents, automotive wastes, detergents, paints	Medium

Source Identification Form

City/Town: Laramie WY
EPA PWS ID#: 5600029
Well Name: Turner Wellfield
WHPA Zone #: Zone 2
Type of Survey: Windshield Survey

Site Information
Site Name/ Owner: Jacoby Golf Course
Site Location: 3501 Willet Drive
Nature of Property: Commercial

Potential and Known Sources of Contamination

Potential Source	Code	Quantity	Comments	Priority
1) Golf course	0058	1	fertilizers and herbicides	Medium

Source Identification Form

City/Town: Laramie WY
EPA PWS ID#: 5600029
Well Name: All Wellfields
WHPA Zone #: Zone 2, 3
Type of Survey: Windshield Survey, County Assessor's Office

Site Information
Site Name/ Owner: Agricultural Land Use
Site Location: Throughout CAPA
Nature of Property: Agricultural

Potential and Known Sources of Contamination

Potential Source	Code	Quantity	Comments	Priority
1) Livestock waste disposal areas	0010	Multiple	Livestock sewage wastes, nitrates	Low
2) Chemical storage areas and containers	0012	Multiple	Pesticide and fertilizers residues	Low
3) Agricultural wells	0014	Multiple	Pesticides, fertilizers, bacteria, nitrates	Low

Source Identification Form

City/Town: Laramie WY
EPA PWS ID#: 5600029
Well Name: All Wellfields
WHPA Zone #: Zone 2
Type of Survey: Windshield Survey

Site Information

Site Name/ Owner: Urban Runoff/ Super Wal-Mart
Site Location: T16N, R73W: Sec35 SW1/4, SE1/4
Nature of Property: Commercial

Potential and Known Sources of Contamination

Potential Source	Code	Quantity	Comments	Priority
1) Storm water drains	0032	1	urban runoff, gasoline, oil, road salt	Medium
2) Auto repair shop	0048	1	waste oils, solvents	Low

Source Identification Form

City/Town: Laramie WY
EPA PWS ID#: 5600029
Well Name: All Wellfields
WHPA Zone #: Zone 2
Type of Survey: Field Survey

Site Information

Site Name/ Owner: Municipal Sewer Lines
Site Location: T15N, R73W: Sec1
Nature of Property: Government

Potential and Known Sources of Contamination

Potential Source	Code	Quantity	Comments	Priority
1) Municipal sewer lines	0029	various	nitrates, fecal coliform, treatment chemicals	Low

Source Identification Form

City/Town: Laramie WY
EPA PWS ID#: 5600029
Well Name: Turner Wellfield
WHPA Zone #: Zone 2
Type of Survey: Windshield Survey

Site Information

Site Name/ Owner: Car Dealership-Laramie GM Auto Center
Site Location: 3600 E. Grand Avenue
Nature of Property: Commercial

Potential and Known Sources of Contamination

Potential Source	Code	Quantity	Comments	Priority
1) Car dealership	0052	1	automotive wastes, waste oils, solvents, miscellaneous wastes	High

Source Identification Form

City/Town: Laramie WY
EPA PWS ID#: 5600029
Well Name: Turner Wellfield
WHPA Zone #: Zone 2
Type of Survey: Windshield Survey

Site Information

Site Name/ Owner: Car Dealership-Laramie Ford
Site Location: 3609 Grand Avenue
Nature of Property: Commercial

Potential and Known Sources of Contamination

Potential Source	Code	Quantity	Comments	Priority
1) Car dealership	0052	1	automotive wastes, waste oils, solvents, miscellaneous wastes	High

Source Identification Form

City/Town: Laramie WY
EPA PWS ID#: 5600029
Well Name: All Wellfields
WHPA Zone #: Zone 2, 3
Type of Survey: Interview

Site Information

Site Name/ Owner: Mosquito Spraying
Site Location: Throughout CAPA
Nature of Property: Government

Potential and Known Sources of Contamination

Potential Source	Code	Quantity	Comments	Priority
1) Mosquito spraying	0027	Multiple	Pesticides (Bti, Malathion)	Low

Source Identification Form

City/Town	Laramie WY
EPA PWS ID#	5600029
Well Name	All Wellfields
WHPA Zone #	Zone 2
Type of Survey	Windshield Survey

Site Information

Site Name/ Owner	Gas Station-Tumbleweed Express
Site Location	4700 Bluebird Lane
Nature of Property	Commercial

Potential and Known Sources of Contamination

Potential Source	Code	Quantity	Comments	Priority
1) Gasoline service station	0062	1	UST	High

Source Identification Form

City/Town	Laramie WY
EPA PWS ID#	5600029
Well Name	Spur Wellfield
WHPA Zone #	Zone 2
Type of Survey	Windshield Survey

Site Information

Site Name/ Owner	Equine Riding Facility
Site Location	25 Domino
Nature of Property	Commercial

Potential and Known Sources of Contamination

Potential Source	Code	Quantity	Comments	Priority
1) Equine riding facility	0010	1	Animal wastes	Low

Form IV:

<u>Potential and Known Source Hazard, Controls, Assessment and Management</u>
is provided as a worksheet to list existing controls and possible management strategies to ensure that potential and known sources identified within the Aquifer Protection Plan are adequately managed.

Potential Source #: **1 -Residential Areas throughout CAPA**
Priority Rank: High

Potential Source Type: Septic systems and residential wells, household hazardous wastes, pesticides, fertilizers
Map ID #: NA
Strategy: Groundwater monitoring program, overlay zoning, licensing of contractors, household hazardous wastes collections, education

Potential Source #: **2 – Interstate-80**
Priority Rank: High
Potential Source Type: Hazardous materials spill, deicing materials
Map ID #: NA
Strateg Groundwater monitoring program, mitigation measures study, signs

Potential Source #: **3- Springs**
Priority Rank: High
Potential Source Type: Conduit to groundwater
Map ID #: NA
Strategy: Groundwater monitoring program, overlay zoning, sunset on development of conventional on-site septic systems., signs

Potential Source #: **4-Wells**
Priority Rank: High
Potential Source Type: Conduit to groundwater
Map ID #: NA
Strategy: Groundwater monitoring program, overlay zoning, sunset on development of conventional on-site septic systems, signs, well sealing and abandonment

Potential Source #: **5-Laramie GM Auto Center**
Priority Rank: High
Potential Source Type: UST, automotive waste generator
Map ID #: 9
Strategy: Groundwater monitoring program, overlay zoning, education

Potential Source #: **6-Laramie Ford**
Priority Rank: High
Potential Source Type: UST, automotive waste generator
Map ID #: 10
Strategy: Groundwater monitoring program, overlay zoning, education

Potential Source #: **7-Tumbleweed Express**
Priority Rank: High
Potential Source Type: UST
Map ID #: 11
Strategy: Groundwater monitoring program, overlay zoning, education

Potential Source #: **8-Union Pacific Railroad**
Priority Rank: Medium
Potential Source Type: Hazardous materials spill
Map ID #: NA
Strategy: Signs, MOA/MOU, education

Potential Source #: **9-Pilot Hill Radio Repeater**
Priority Rank: Medium
Potential Source Type: UST
Map ID #: 13
Strategy: Overlay zoning, education

Potential Source #: **10-Dollar Tree, LEAP, Snowy Range Academy, Express Pharmacy**
Priority Rank: Medium
Potential Source Type: Urban runoff
Map ID #: 14
Strategy: Overlay zoning, education, stormwater design, groundwater monitoring program

Potential Source #: **11-Wal-Mart Supercenter**
Priority Rank: Medium
Potential Source Type: Urban runoff, automotive wastes
Map ID #: 15
Strategy: Overlay zoning, education, stormwater design, groundwater monitoring program

Potential Source #: **12-Premier Bone & Joint**
Priority Rank: Low
Potential Source Type: Medical wastes
Map ID #: 16
Strategy: Education, existing regulations

Potential Source #: **13-Animal Heath Center**
Priority Rank: Low
Potential Source Type: Medical wastes
Map ID#: 17
Strategy: Education, existing regulations

Potential Source #: **14-AT&T Communications**
Priority Rank: Medium
Potential Source Type: UST
Map ID#: 18
Strategy: Overlay zoning, education, existing regulations

Potential Source #: **15-Quarries**
Priority Rank: Low
Potential Source Type: Fuel spills, blasting materials
Map ID #: NA
Strategy: Groundwater monitoring program, overlay zoning, MOU/MOA

Potential Source #: **16-Laramie Rifle Range**
Priority Rank: Low
Potential Source Type: Soluble lead
Map ID #: NA
Strategy: Education

Potential Source #: **17-Municipal Sewer Lines**
Priority Rank: Low
Potential Source Type: Nitrates, bacteria
Map ID #: NA
Strategy: Overlay zoning, inspections

Potential Source #: **18-Mosquito Spraying**
Priority Rank: Low
Potential Source Type: Bti and Malathion
Map ID #:
Strategy: Education

Potential Source #: **19-Silver Spur Equestrian Center**
Priority Rank: Low
Potential Source Type: Animal wastes
Map ID #: 24
Strategy: Education, groundwater monitoring program

Potential Source #: **20-Transportation Routes**
Priority Rank: Low
Potential Source Type: Road salts
Map ID #: NA
Strategy: Education, groundwater monitoring program

Potential Source #: **21-J. T. Peele**
Priority Rank: Low
Potential Source Type: UST (removed 1989)
Map ID #: 26
Strategy: Overlay zoning, education

Potential Source #: **22-Sherman Hill Microwave Site**
Priority Rank: Low
Potential Source Type: UST (removed 1994)
Map ID #: 27
Strategy: Overlay zoning, education

Potential Source #: **22-Etchepare Quarry (Mountain Cement)**
Priority Rank: Low
Potential Source Type: NPDES Wastewater discharge
Map ID #: 28
Strategy: Education

Potential Source #: **22-Ninth Street Pit #2**
Priority Rank: Low
Potential Source Type: NPDES Wastewater discharge
Map ID #: 29
Strategy: Education

Potential Source #: **23-Avery Feed Lot**
Priority Rank: Medium
Potential Source Type: Nitrates, fecal coliform
Map ID #: 30

Strategy: Education, existing regulations

Potential Source #: **24-Walgreen Dental Arts**
Priority Rank: Low
Potential Source Type: Medical wastes
Map ID #: 31
Strategy: Education, existing regulations

Potential Source #: **25-Auto Center Detail Shop**
Priority Rank: Medium
Potential Source Type: Automotive wastes, solvents
Map ID #: 32
Strategy: Overlay zoning, education

Potential Source #: **26-Jacoby Golf Course**
Priority Rank: Medium
Potential Source Type: Pesticides, fertilizers
Map ID #: 33
Strategy: Overlay zoning, education, stormwater design, groundwater monitoring program

Potential Source #: **27-Agricultural Land Use**
Priority Rank: Low
Potential Source Type: Animal wastes, fertilizers, pesticides
Map ID #: NA
Strategy: Overlay zoning, education, groundwater monitoring program

Potential Source #: **28-TW-1**
Priority Rank: Low
Potential Source Type: Injection well for Aquifer Recharge
Map ID #: 34
Strategy: Overlay zoning, well ownership

Potential Source #: **29-Union Pacific Railroad**
Priority Rank: Medium
Potential Source Type: Hazardous materials release due to derailment
Map ID #: 35
Strategy: Overlay zoning, education, groundwater monitoring program

Susceptibility Assessment	**September 14, 2001 (Wellhead Protection)**		**Source:** City of Laramie 2000						
	Spur #1	**Spur #2**	**Soldier #1**	**Turner #1**	**Turner #2**	**Pope #1**	**Pope #2**	**Pope #3**	**Pope #4**
Part I: System Information									
Well Owner	City Of Laramie	City Of Laramie	City Of Laramie	City Of Laramie	City Of Laramie	City Of Laramie	City Of Laramie	City Of Laramie	City Of Laramie
City	Laramie	Laramie	Laramie	Laramie	Laramie	Laramie	Laramie	Laramie	Laramie
County	Albany	Albany	Albany	Albany	Albany	Albany	Albany	Albany	Albany
PWS Name	City Of Laramie	City Of Laramie	City Of Laramie	City Of Laramie	City Of Laramie	City Of Laramie	City Of Laramie	City Of Laramie	City Of Laramie
PWS ID#	5600029	5600029	5600029	5600029	5600029	5600029	5600029	5600029	5600029
Well Depth	305'	323'	289'	240'	350'	156'	162'	158'	350'
Source Name	Spur #1	Spur #2	Soldier #1	Turner #1	Turner #2	Pope #1	Pope #2	Pope #3	Pope #4
SEO Permit #	UW 106547	UW 107279	UW 105576	P55507W * see notes	P55508W *see notes	P153C	P154C *see notes	P155C *see notes	P55506W *see notes
Connections	n/a	n/a	n/a	7138 (1998)	7138 (1998)	n/a	n/a	n/a	n/a
Population Served	n/a	n/a	n/a	26,400 residents	26,400 residents	30,747 residents	??	??	??
Location	T16N, R73W,S2, NE,NE	T16N,R73W,S2,NW,NW	T15N,R73W,S23,SE,SW	T15N,R73W,S14,NE,SE	T16N,R73W,S35,SE,SW	T15N,R73W,S14,NE,SE	T15N,R73W,S14,NE,SE	T15N,R73W,S14,NE,SE	T15N,R74W,S14,NE,SE
	41,23',40", 105,32',32"	41,23',44",105,33',22"	41,14',56", 105,32',53"	41,18',40",105,31',39"	41,20',03", 105,31',53"	41,16',15", 105,31',55"	41,16',19", 105,31',08"	41,16',13", 105,31',58"	41,16',19", 105,31',05"
	(Survey EPA 1998)	(Survey EPA 1998)	(Survey EPA 1998)	(Survey EPA 1998)	(Survey EPA 1998)	(Survey EPA 1998)	(Survey EPA 1998)	(Survey EPA 1998)	(Survey EPA 1998)
Part II: Well Construction and Aquifer Characteristics									
Date Constructed	8/16/1997	11/10/1997	6/9/1997	9/1/1982	8/1/1982	about 6/37	about 6/15/38	Early summer 1939	8/1/1982
Well Driller	Watson Well-Rob Watson	Watson Well	Johnson's P and E-Shepard	Watson Well	Watson Well	Unknown	Unknown	Unknown	Watson Well
Type of Well	Air Rotary Drill	Air Rotary Drill	Air Rotary Drill	Drill	Air Rotary Drill	Drill	Drill	Drill	Drill
SEO Completion Report?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Mean Pumping Rate	1400 gpm	1400 gpm	1450 gpm (SEO permits 1800gpm)	2500 gpm **see notes	1600 gpm **see notes	220 gpm	520 gpm **see notes	900 gpm **see notes	1750 gpm **see notes
Treated?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Chlorinated?	Yes, 0.6-0.7mg/L	Yes, 0.6-0.7mg/L	Yes, 0.6-0.7mg/L	Yes, 0.6-0.7 mg/L	Yes, 0.6-0.7 mg/L	Yes, 0.6-0.7 mg/L	Yes, 0.6-0.7 mg/L	Yes, 0.6-0.7 mg/L	Yes, 0.6-0.7 mg/L
Wellhead Elevation	7292.33 ft (well log)	7271.48 ft (well log)	7322.97 ft (well log)	7273 ft (well log)	7266 ft (well log)	7335.5 ft (well log)	7338.8 ft (well log)	7338.8 ft (well log)	7351 ft (well log)
Depth to Top of Screened Interval	n/a	n/a	44.1 ft	n/a	n/a	n/a	n/a	n/a	n/a
Depth to Groundwater	31.11 ft below wellhead	11.15 ft below wellhead	2.0 ft above wellhead	6.0 ft below wellhead		15.5 ft below wellhead	12 ft below wellhead	13 ft below wellhead	31 ft below wellhead
Determined how?	Well log	Well log	Well log	Well log	Well log	Well log	Well log	Well log	Well log
Flowing Well or Spring?	No	No	Yes	No	Yes	No	No	No	No
Shut-in pressure	n/a	n/a	5.6 psi, 13 ft above wellhead	n/a	0.65 psi, 1.5 above w.h.	n/a	n/a	n/a	n/a
Surface Impoundment, etc.?	n/a	n/a	Yes	n/a	Yes	??	??	??	??
Evidence of a confining layer?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
>20 ft depth to groundwater?	No	No	Yes	Yes	Yes	No	No	No	Yes
Accident Prevention Zone	100 ft radius	100 ft radius	100 ft radius	100 ft radius	100 ft radius	100 ft radius	100 ft radius	100 ft radius	100 ft radius
Wellhead Control and Access	Enclosed in wellhouse	Enclosed in wellhouse	Enclosed in wellhouse-fenced	Enclosed in wellhouse	Enclosed in wellhouse	Enclosed in wellhouse	Enclosed in wellhouse	Enclosed in wellhouse	Encolsed in wellhouse
Surface Casing and Annular Seal									
Surface Casing Present?	Yes	Yes	Yes	Yes	Yes	Unknown	Unknown	Unknown	Yes
Depth of Surface Casing	18'	40.5'	20.3'	100'	100'	n/a	n/a	n/a	100'
Casing Material	.375" steel	.375" steel	Cement	Steel	Cement	n/a	n/a	n/a	cement
Annular Seal Present?	Yes	Yes	Yes	Yes	n/a	Yes	n/a	n/a	n/a
Depth of Annular Seal	80.5'	256'	79.5'	100'	n/a	64.0'	n/a	n/a	n/a
Annular Seal Material	cement	cement	.25"-.375" steel	cement, gravel pack	n/a	8" thick cement	n/a	n/a	n/a
Surface Seal and Well Opening									
Surface (protective) Casing Present?	Yes	Yes	Yes	Yes	Yes	Yes	Open Hole	Yes	Yes
Height of casing above ground	1.8'	0'	24"	12"	12"	12"	13"	11"	12"
Surface Casing Material	Steel 16"diam.,0.375"wall	Steel 16"dia,.375" wall	Steel, 16" dia	Steel, 16" dia	16" dia, ASTM A53 Grd B	n/a	64' of 8"-unknown material	66' of 15"-unknown material	100' of 16" diam, ?
Well Cap in Place?	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Well Cap Locked?	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Surface Seal Present?	Yes	Yes	Yes	n/a	n/a	n/a	n/a	n/a	n/a
Surface Seal Material	Cement	Cement	Cement	n/a	n/a	n/a	n/a	n/a	n/a

Part III: Assessment of Water Quality									
All potential contaminant sources within the *Accident Prevention Zone and Zones 2,3*	abandoned water wells, septic systems	abandoned water wells, septic systems	abandoned water wells, septic systems, dumps	pesticide application, abandoned water wells, septic systems	pesticide application, abandoned water wells, septic systems	pesticide application, abandoned water wells, septic systems, biosolid application	pesticide application, abandoned water wells, septic systems, biosolid application	pesticide application, abandoned water wells, septic systems, biosolid application	pesticide application, abandoned water wells, septic systems, biosolid application
Water Quality Records Since 1986									
Nitrate as N	No records	No records	2.10 ppm (CCR 2021)	2.18 ppm (CCR 2021)	2.18 ppm (CCR 2021)	2.16 ppm (CCR 2021)	2.16 ppm (CCR 2021)	2.16 ppm (CCR 2021)	2.16 ppm (CCR 2021)
VOC's	No records	No records	0	0	0	0	0	0	0
SOC's (Pesticides, etc.)	No records	No records	0	0	0	0	0	0	0
Bacterial Contamination	No records	No records	never detected	never detected	never detected	never detected	never detected	never detected	never detected
	Spur #1	**Spur #2**	**Soldier #1**	**Turner #1**	**Turner #2**	**Pope #1**	**Pope #2**	**Pope #3**	**Pope #4**
Part IV: Geographic or Hydrologic Factors Contributing to a Non-Circular Zone of Contribution									
Evidence of a potential hydrologic barrier?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Aquifer Material:									
Logs, reports reviewed for faulting, etc.?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Do sources indicate faults,fractures and/or karst conditions?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Do sources indicate primarily *course sand and gravel*?	No	No	No	No	No	No	No	No	No
Are high-capacity wells within the *Accident Prevention Zone and the WHPA*?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Extraction wells pumping at >500 gal/min?	Yes, in Zone 2	Yes, Zone 2	Yes, Zone 2	Yes, APZ and Zone 2	Yes, APZ and Zone 2	Yes, APZ and Zone 2	Yes, APZ and Zone 2	Yes, APZ and Zone 2	Yes, APZ and Zone 2
Groundwater recharge wells or heavy irrigation within the *APZ*?	No	No	No	No	No	No	No	No	No
NOTES:									
*				Turner #1: 1st ENL Permit #5600029, 2nd ENL Permit #72689	Turner #2: 1st ENL Permit #P59131W		Pope #2: 1st ENL Permit #72690	Pope #3: 1st ENL Permit #55505, 2nd ENL Permit #72691	Pope #4: 1st ENL Permit # 72692
**				Original well appropriation for 1400 gpm, 1st ENL for 800 gpm, and 2nd ENL for 300 gpm, for a total of 2500 gpm.	Original well appropriation for 1400 gpm, 1st ENL for 200 gpm, for a total of 1600 gpm.		Original well appropriation for 600 gpm, 1st ENL for 75 gpm, for a total of 675 gpm.	Original well appropriation for 600 gpm, 1st ENL for 250 gpm, 2nd ENL for 50 gpm, for a total of 900 gpm.	Original well appropriation for 1750 gpm, 1st ENL for 50 gpm, for a total of 1800 gpm.

APPENDIX F

Conventional Septic Systems

Avoiding an expensive

Understanding and maintaining your septic system

Selecting or maintaining a septic system is a consideration most people do not have to worry about when they live in town. But if you're one of the many rural homeowners who have a septic system, then understanding how they work and what you need to do to maintain them may prevent the occasional – but very exasperating – problem.

How it works

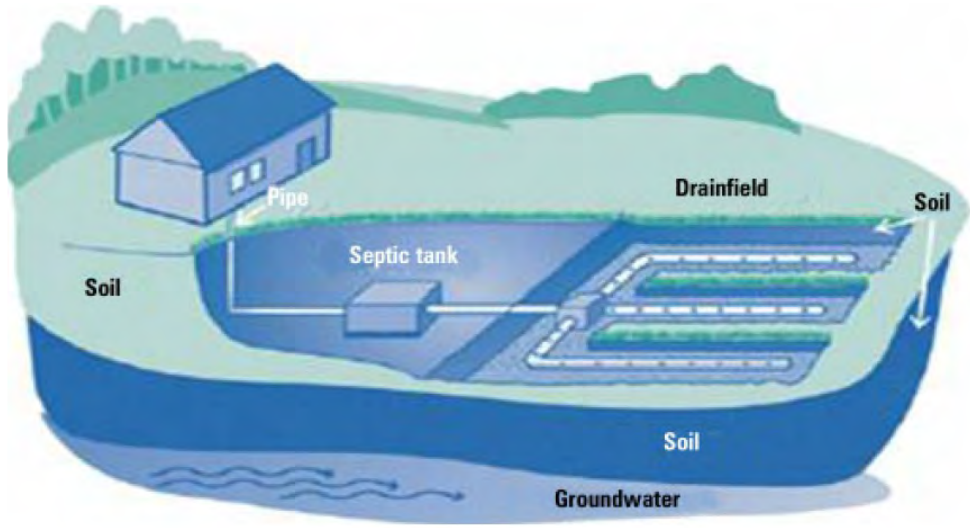
Everything that goes down any of the drains in your house (sinks, toilets, baths, showers, washing machines, etc.) travels first to the septic tank. The septic tank is a large-volume, watertight tank that provides initial treatment of household wastewater by intercepting solids and "sinkable" organic matter before disposal of the wastewater (effluent) to the drain field.

The construction and operation of a septic tank is fairly simple but provides numerous important functions through a complex interaction of physical and biological processes. The essential functions of the septic tank are to receive all wastewater from the house, separate solids from the wastewater flow, cause reduction and decomposition of accumulated solids, provide storage for the separated solids (sludge and scum), and pass the clarified wastewater (effluent) out to the drain field for final treatment and disposal.

As stated, the main function of the septic tank is to remove solids from the wastewater and provide an effluent relatively free of sludge for disposal to the drain/leach field. The septic tank provides a relatively inactive body of water where the wastewater is retained long enough to let the solids separate by both settling and flotation. This process is often called primary treatment and results in three products: scum, sludge, and effluent. Scum is an extraneous matter or impurities risen to or formed on the surface of a liquid often as a foul filmy covering. Sludge is a slushy mass, deposit, or sediment as precipitated solid matter produced by water and sewage treatment processes that usually lies at the bottom of the septic tank. Effluent is the wastewater that is discharged or flows out of a septic system.

A septic system is normally powered by nothing but gravity. Water flows down from the house to the

STINK



tank and down from the tank to the drain field.

As new water enters the tank, it displaces the water that's already there. This water flows out of the septic tank and into a drain field. A traditional drain field is made of perforated pipes buried in trenches filled with gravel. A typical drain field pipe is 4 inches in diameter and is buried in a trench that is 4 to 6 feet deep and 2 feet wide. Gravel fills the bottom 2 to 3 feet of the trench and dirt covers the gravel. The water is slowly absorbed and filtered by the ground in the drain field. The size of the drain field is determined by how well the ground absorbs water and the number of bedrooms in your home.

This is a traditional septic system. There are several other designs that can be utilized for areas with specific challenges such as high ground water levels, heavy clay soils, steep slopes, etc.

Gravity fed system in a trench configuration. A plastic (poly) tank and distribution box are used with this system.

New properties

Before you purchase a piece of property, make sure that the soil characteristics are suitable for the installation of a septic system. Nothing is worse than being stuck with a piece of heaven not suitable for a septic system. To find out about your soil, you can hire a professional to take soil samples or you can contact your local UW Extension office to find out how to collect a proper sample yourself. Samples are then submitted to a lab for analysis (see the "Soils" section). Ask the local planning and zoning department about wastewater disposal issues. Most county and state health departments or environmental quality agencies require that homeowners apply for a septic permit prior to construction.

In most Wyoming counties, residents should check with their county government about obtaining permits before constructing a septic system. Residents in a few Wyoming counties must obtain small wastewater permits from the Wyoming Department of Environmental Quality.

At a minimum, the permitting agency should perform a site evaluation, which includes a trench inspection and soil test, and determine if there is high ground water or impermeable layers. A percolation test determines the soil's water absorption capability, a vital characteristic for properly functioning septic systems. A geologist, professional engineer, sanitarian, or the property owner most often performs this. Improper percolation tests could result in an inadequately sized drain field or a costly oversized field. Owners must also make sure the property is large enough to have a replacement area if the first system fails. The property owner is responsible for providing the necessary equipment, such as a backhoe, for these tests. The overseeing agency will not provide the equipment.

Sites with impermeable soils, high clay content, or shallow bedrock will not absorb and treat septic effluent readily. Sites with steep slope (greater than 15 percent) may also pose challenges. These limiting site conditions may require special septic design and construction practices to avoid failure. County and state personnel can discuss options with you and your contractor. Poor septic system siting or design can lead to premature failure of the system.

Septic/small wastewater system permits contain valuable information such as the age of the system, size of the tank and drain field, and location. They can also be a part of the lending process at the bank.

Conventional gravity fed septic system with concrete tank and distribution box. Drainfield is a bed configuration with graveless chambers.

Commonly when a drainfield fails, effluent can be seen surfacing in the area.

Maintenance

Septic systems do not last forever – many are designed to last around 20 years with proper maintenance. Having your septic system pumped out at regular intervals (information about this is contained Table 1) is an important part of that maintenance. Neglecting to have your system pumped on the recommended schedule, excessive household chemical use, or sending excessive wastewater to a septic tank at one time can shorten the life of your leach field, resulting in system failure. Septic systems are designed to break down and discharge household wastewater at a rate that allows it to it be adequately treated by microbes in the soil. If your septic system fails, along with creating a stinky, expensive mess, it can also be a source of contamination for surface and ground water (aka your drinking water source).

Maintenance of septic systems comes in two parts. First, the sludge layer that accumulates on the bottom of the tank must be pumped out and hauled away regularly (Table 1). The frequency depends on the household occupancy and tank size. The second part involves the bacteria that are necessary for digesting organic solids in the floating (scum) layer. Moderation should be the rule when soaps, detergents, bleaches, or other household cleaners are disposed in septic systems. Certain household products and wastes should never be dumped down drains because they can directly contaminate ground water: excessive amounts of grease, paints or solvents, petroleum products, flammable liquids, paint strippers, and other volatile cleaners. Commercially available septic system cleaners containing organic cleaners or active agents, such as sodium hydroxide (lye) or potassium hydroxide, can disrupt the operation of the system and cause ground water pollution.

An inspection by a licensed contractor can tell you when to pump. A contractor will measure scum, liquid effluent, and sludge layers in the septic tank. The sludge depth will determine pumping frequency, generally every three to five years; however, if you have a large household, increase your pumping frequency (see Table 1). The U.S. Environmental Protection Agency has an excellent maintenance schedule (www.epa.gov/owm/septic/pubs/septic_sticker.pdf) you can use to record septic maintenance activities.

Other keys to getting the most out of your septic system

Knowing where the tank and leach field are located is a critical step in the maintenance process. Look for line cleanouts or tank risers that provide access to the septic system without digging. If unable to locate

Table 1
How often to pump (numbers in table are in years):

Suggested Pumping Interval (years)						
	Number of Persons Living in Home					
Tank Size in Gallons	1	2	3	4	5	6
1,000	12	6	4	3	2	2
1,250	16	8	5	3	3	2
1,500	19	9	6	4	3	3

Risers on a concrete tank.

Gravity fed system in a trench configuration. A plastic (poly) tank and distribution box are used with this system.

An effluent filter reduces the possibility of solids moving out of a tank and clogging a leach field.

these components, consider having a licensed contractor inspect the system with a sewer camera.

Driving and Parking Over a Septic System Plan parking areas and driving routes so they will not interfere with a septic system. The weight from vehicles can collapse pipes, septic tanks, and leaching chambers requiring costly excavation and repair. Driving and parking on a leach field also compacts soil, reducing its ability to effectively treat effluent. During winter, be mindful that driving over sewer pipes can increase frost penetration, resulting in the inconvenience and expense of repairing frozen plumbing.

Tree Roots Many commercial products claim to prevent roots from clogging pipes, but nothing takes the place of careful landscaping practices. To prevent septic system damage, do not place a leach field near trees and shrubs, and plant only grass or shallow-rooted perennials and annuals around a septic system. If you buy a property with an existing septic and leach field and there are trees in the leach field already, it would be recommended to consider having a licensed contractor inspect the system with a sewer camera or at the least carefully watch your leach field for any signs of failure including surface ponding of water and sewage. If this happens, the leach field will need to be replaced and the new field located away from these plants.

Flushing Foreign Objects Down the Drain We have probably all had that sinking feeling when an object accidentally drops into the toilet. Once flushed, removing that toy truck can be costly and time consuming. For households with small children, prevent unwanted objects from going down the drain by installing toilet seat locks. Other notorious septic system cloggers include diapers, baby wipes, paper products other than toilet paper, cat litter, cigarettes, coffee grounds, feminine products, etc. Purchase toilet paper labeled "Septic Safe." Excess kitchen grease will congeal in the sewer line, causing blockages and backups. Kitchen grease does not break down in the tank – it accumulates, filling the tank quicker, and ultimately shortens the time until it will need to be pumped. Dispose of kitchen grease, after it has properly cooled, in the trash rather than down the drain. The goal is to reduce the amount of solids entering the tank. Whatever is put in, will have to be pumped out!

Failure to Install According to Local Codes Local codes and regulations help ensure proper installation practices and protect public health. A poorly installed system will not work effectively and will fail early. A properly installed septic system will be designed according to your specific site conditions (soil types, bedrock, ground water, slope). Finally, local regulations protect surface and ground water quality. A septic system that does not conform to regulations can potentially affect the health and safety of you and your neighbors. Test your household well regularly! For information, contact commercial water testing laboratories, or the Wyoming Department of Agriculture Analytical Services at 307-742-2984.

Salts/Chemicals: Water Softeners, Washing Machines, Cleaning Products Excessive use of household chemicals or salts from a malfunctioning water softener disrupts the natural bacterial action necessary for wastewater treatment. *Moderate amounts* of household cleansers and detergents should not pose a problem; however, dispose of solvents, pesticides, herbicides, motor oil, antifreeze, and paint through a household hazardous waste collection facility rather than down the drain.

Organic Overloading Garbage disposals contribute excessive amounts of solids, which do not break down in the septic tank, requiring it to be pumped more frequently. Try creating a compost pile for fruit and vegetable scraps, coffee grounds, etc., and properly dispose of kitchen waste that shouldn't go into compost, such as meat scraps and fat. The goal with a septic system is to prevent accelerated leach field failure from solids moving into the field. Consider installing sink strainers, hair traps in drains, lint traps on washing machines, and an effluent filter (see photo) at the outlet of the septic tank. These devices reduce the possibility of solids moving out of the tank and clogging the leach field prematurely.

Hydraulic Overloading Hydraulic overloading occurs when too much water enters the septic system at one time, resulting in wastewater backing into drains or effluent surfacing in your yard. Being conservative with water use can prevent hydraulic overloading.

- Ensure all plumbing fixtures are in good working order. No drips or leaks!

- Replace aging fixtures with new water-saving toilets, shower heads, and faucets.
- Adequately space showers, laundry, dishwashing, and other high-volume water uses so they do not coincide with one another, which may flood the septic tank and push solids into the leach field.
- If possible, avoid using a water softener since backwash will enter the septic tank and can cause hydraulic overloading. Oversize your septic tank and leach field if a water softener is in use.

Conclusions and Contacts

There are many steps to ensure a properly sited, correctly installed, regularly maintained septic system. Done properly, your system should last 20 or more years. There are an abundance of situations or mishaps that can occur with property you may buy or property you already own when it comes to septic systems and leach fields. Please contact your local county planning department for more information on these situations. They will be able to tell you if you need to hire a contractor or if an inspector can conduct a site visit.

This section was adapted from material in the following articles (all can be found on barnyardsandbackyards.com):

"A Guide to septic systems," Spring 2005 *Barnyards & Backyards* magazine. Article author Michelle Cook.

"Prevent a stink by checking septic system considerations before buying," Summer 2006 *Barnyards & Backyards* magazine. Article author April Gindulis.

"Top reasons for septic system failure and how to prevent them," Summer 2008 *Barnyards & Backyards* magazine. Article author Author Mila Ready.

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planning@co.albany.wy.us
www.co.albany.wy.us/planning.aspx

Wastewater Inspection Form

Pumper/Inspector Information

Pumper/Inspector		Inspection Date	
Email		Phone	
Address/Location of System			

Owner Information

Owner(s)			
Mailing Address			
Email		Phone	

Signatures

Owner Signature (Required)	
Pumper/Inspector Signature (attach report* in lieu of signature)	

System Information

Installation Date		Installer		Date Last Pumped	
Tank Size, Material, Manufacturer, and Overall Condition					
Tank Compartments		Amount of Sewage Removed from Tank			

1. Any back flow, root intrusion, evidence of flooding? ☐ yes ☐no If yes, please describe: ______________________________
2. Tank lids secure and watertight? ☐ yes ☐ no
3. Baffles in working condition? ☐ yes ☐no
4. Is the system in compliance with Albany County Regulations ☐yes ☐no
   If ***"not in compliance",*** describe the actions that will be taken to comply: ______________________________
5. Attach a general description of the system (type of system, size of leach field, etc.).
6. Attach a rough sketch of the system layout relative to the building(s) served. Please include as much information as possible If surfacing of wastewater is observed, indicate the location and any other aspect of concern.
7. It is recommended that this septic system is pumped/serviced in________years.

***If the pumper creates a separate inspection report on company letterhead, please attach. This inspection form must be filled out regardless of whether the pumper uses their company form.**

2/2022

APPENDIX G

Best Management Practices for Single Family Residences

1 INTRODUCTION

The actions we take each day, in and around our homes, may have a profound effect on our drinking water quality. Small amounts of pollution from many different sources can significantly affect our groundwater resource. Yard maintenance, waste storage, car washing and maintenance, and improper septic system use and maintenance are some of the activities that can adversely impact water quality. The best management practices (BMPs) discussed in this section are practical ways to keep our drinking water from becoming polluted in the first place. It is recommended that all residences within the Aquifer Protection Area use these BMPs.

2 SEPTIC SYSTEMS

The U.S. Environmental Protection Agency estimates that 30 percent of U.S. households use septic tanks or other on-site wastewater treatment methods (EPA, 1999). Conventional septic systems are designed to operate indefinitely if properly maintained. However, if a septic system is not well maintained, its functional life may be 20 years or less. Maintaining your system is a good investment compared to the expense and inconvenience of replacing a failed system. Conducting regular inspections and maintenance for 20 years will typically cost one-fifth to one-tenth as much as removing and replacing the system at the end of the 20-year period. (EPA, 1999). Symptoms of a failing septic system include strong odors, ponding of improperly treated wastewater, and backup of wastewater into the home. Less obvious is the measurable decline in water quality that occurs when a system is not operating properly. By conducting regular inspections and maintenance, you may avoid the greater expense and property disruption of replacing a failed system.

2.1 BEST MANAGEMENT PRACTICES

Have your system inspected once every two years and pumped at least every three years, or more frequently if the inspection indicates that pumping is necessary.

- Avoid placing solvents, poisons, and other household chemicals into the septic system or household drains. These substances may kill the beneficial bacteria within the tank and drain field; they may also contaminate drinking water.
- Dispose of garbage in the trashcan rather than using an in-sink “garbage disposal.”
- Avoid organic solvents marketed as septic system cleaners or substitutes for sludge pumping (e.g. Krane Products: Septic Helper or Septic 2000). Some communities have ordinances forbidding the use of these substances, because the chemicals can migrate to the groundwater causing aquifer contamination.

- Avoid putting solids or greasy material down drains or toilets: paper towels, cigarettes, cat litter, feminine hygiene products, and residual cooking fat should be placed in the garbage.
- Install low volume plumbing fixtures to prevent overloading the system.
- If you are not a full-time resident, consider installing a composting toilet in lieu of a traditional septic system. Septic drain fields used seasonally often develop incomplete biological mats, which lowers system performance.

3 AUTOMOBILE WASHING

Most residents wash their cars in the driveway or on the street. Wash waters typically flow to a storm drain or ditch, which discharges storm water directly to the nearest drainage, stream, or lake.

3.1 BEST MANAGEMENT PRACTICES

- Wash your car directly over your lawn or make sure the wash water drains to a vegetated area. This allows the water and soap to soak into the ground instead of running off into a local water body.
- Ideally, no soaps or detergents should be used, but if you do use one, select one without phosphates.
- Commercial products are available that allow you to clean a vehicle without water. They were developed for areas where water is scarce, so a water saving benefit is realized as well as reduced pollution.
- Use a nozzle on your hose to save water.
- Do not wash your car if rain is expected.
- **Consider not washing your car at home. Take it to a commercial car wash that has a recycle system and discharges wastewater to the sanitary sewer for treatment.**

4 AUTOMOBILE MAINTENANCE

Some of us are "weekend mechanics". We enjoy the cost savings of changing our own oil and antifreeze, and generally making our car perform its best. There are many potentials for storm water pollution associated with these activities, however, the following BMPs will help you minimize pollution while servicing your car.

4.1 BEST MANAGEMENT PRACTICES

- Recycle all oils, antifreeze, solvents and batteries. Motor Oil / Gear Oil is not accepted at the Landfill. Motor Oil/Gear Oil may be taken to the City Streets Shop or to many of the automotive parts retailers in town.
- After you change oil in your vehicle, pour the liquid into a clean, unbreakable container with a good sealable cap, such as a one-gallon plastic jug. Do not mix the used oil with water or other products. Used antifreeze should be drained into a sturdy container. Contact Laramie Landfill/Recycling Center (307-721-5279) for further instructions and disposal times.
- The best way to dispose of used automotive batteries is to return your old battery to the company from whom you are purchasing a new one. Automotive batteries are also accepted at the Laramie landfill. Alkaline batteries may be placed in your normal trash. Nickel cadmium (NiCad) or lithium rechargeable batteries should be recycled at the Laramie Landfill/Recycling Center.
- Solvents such as paint thinner can be reused by allowing the solids to settle to the bottom of the container, then pouring off the clear liquid into a well-labeled container for reuse later. The solids can then be dried and thrown away.
- The City of Laramie accepts Household Hazardous Waste at the landfill by appointment only. They require 24 hours' notice when making an appointment so they can have staff available. They are open Monday - Friday between 9:00 am - 12:00 pm and 1 pm - 4 pm. In addition, there are local businesses that may pay you for some of your "waste products."
- Never dump new or used automotive fluids or solvents on the ground, in a storm drain or street gutter, or in a water body. Eventually, they will make their way to the Laramie River.
- Frying and cooking oil is not accepted at the Landfill. Green barrels for cooking oils are located behind the Moose Lodge at 409 S. 3rd Street.
- Do not mix wastes. The chlorinated solvents in some carburetor cleaners can contaminate a huge tank of used oil, rendering it unsuitable for recycling. Always keep your wastes in separate containers that are properly labeled and store them out of the weather.
- Use care in draining and collecting antifreeze to prevent accidental spills. Spilled antifreeze can be deadly to cats and dogs that ingest it.
- Perform your service activities on concrete or asphalt or over a plastic tarp to make spill cleanup easier. Keep a bag of kitty litter on hand to absorb spills. Sprinkle a good layer

on the spill, let it absorb for a little while and then sweep it up. Place the contaminated litter in a plastic bag, tie it up, and dispose of it in your regular garbage. Take care not to leave kitty litter out in the rain; it will form a sticky goo that is hard to clean up.

- If you are doing bodywork outside, be sure to use a tarp to catch material resulting from grinding, sanding and painting. Dispose of this waste by double bagging in plastic and placing in your garbage.

5 STORAGE OF SOLID WASTES AND FOOD WASTES

Improper storage of food and solid waste at residences can lead not only to water pollution problems, but problems with neighborhood pets and vermin as well. Following the BMPs listed below can help keep your property a clean and healthy place to live.

5.1 BEST MANAGEMENT PRACTICES

- All waste containers kept outside should have lids.
- Leaking waste containers should be replaced.
- Store waste containers under cover if possible, or on grassy areas.
- Inspect the storage area regularly to pick up loose scraps of material and dispose of them properly.
- Recycle as much as you can.
- Purchase products that have the least amount of packaging materials.
- Compost biodegradable materials such as grass clippings and vegetable scraps instead of throwing them away. Your flowerbeds will love the finished compost, and we won't fill up our landfills so quickly. See the section on composting for BMPs relating to that activity.

6 COMPOSTING

Composting is a positive activity as long as some commonsense rules outlined below are followed. If you choose to compost, the following BMPs should be utilized.

6.1 BEST MANAGEMENT PRACTICES

- Compost piles must be located on an unpaved area where runoff can soak into the ground or be filtered by grass and other vegetation.

- Compost piles should be located in an area of your yard not prone to water ponding during storms, and should be kept well away from water bodies and drainage paths.
- Avoid putting hazardous or non-decomposable waste in the pile.
- Build covered bins of wood, chicken wire or fencing material to contain compost so it can't be washed away. Albany County Cooperative Extension Office at 721-2571 to get free composter designs and materials lists.
- A fun alternative to traditional composting is worm composting. You can let worms do all the work for you by keeping a small vermiculture box just outside your kitchen. For more information on getting started with worms, contact the Albany County Cooperative Extension Office at 721-2571 or visit the Albany County Public Library.

7 YARD MAINTENANCE AND GARDENING

This section deals with yard maintenance activities. Over watering, over fertilizing, improper herbicide application and improper disposal of trimmings and clippings can all contribute to serious water pollution problems. Following the BMPs listed below will help alleviate pollutant runoff.

7.1 BEST MANAGEMENT PRACTICES

- Follow the manufacturer's directions exactly for mixing and applying herbicides, fungicides and insecticides, and use them sparingly. Never apply when it is windy or when rain is expected. Never apply over water, within 100 feet of a wellhead, or adjacent to streams or other water bodies. Triple-rinse empty containers, using the rinsate for mixing your next batch of spray, and then double-bag and dispose of the empty container in your regular garbage.
- Never dispose of grass clippings or other vegetation in or near storm drains, natural drainages, streams, or lakes.
- Follow manufacturer's directions when applying fertilizers. More is not better, either for your lawn or for local water bodies. Never apply fertilizers over water or adjacent to ditches, streams or other water bodies. Remember that organic fertilizers have a slow release of nitrogen, and less potential to pollute than synthetic fertilizers. • Save water and prevent pollution problems by watering your lawn sensibly. Lawns and gardens typically need the equivalent of 1" of rainfall per week. You can check on how you're doing by putting a wide mouth jar out where you're sprinkling and measure the water with a small plastic ruler. Over watering to the point of runoff can carry polluting nutrients to the nearest water body.

- Consider planting a vegetated buffer zone adjacent to any water bodies on your property. Call the Laramie Rivers Conservation District at 307-721-0072 for advice and assistance in developing a planting plan.
- Make sure all fertilizers and pesticides are stored in a covered location. Rain can wash the labels off of bottles and convert 50 pounds of fertilizer into either a solid lump or a river of nutrients.
- Compost all yard clippings, or use them as mulch to save water and keep down weeds in your garden. See the Composting section for more information.
- Practice organic gardening and virtually eliminate the need to use pesticides and fertilizers. Contact Albany County Cooperative Extension at 721-2571 for information and classes on water-friendly gardening.
- Pull weeds instead of spraying and get some healthy exercise, too. If you must spray, use the least toxic formulations that will get the job done.
- Work fertilizers into the soil instead of letting them lie on the ground surface exposed to the next rainstorm.

8 HOT TUB AND POOL CLEANING AND MAINTENANCE

Despite the fact that we immerse ourselves in it, the water from pools and hot tubs is far from chemically clean. Nutrients, pH, and chlorine can adversely affect fish and wildlife in water bodies. Following these BMPs will ensure the cleanliness of your pool and the environment.

8.1 BEST MANAGEMENT PRACTICES

- Pool and hot tub water should be dechlorinated if it is to be emptied into a ditch, on the ground, or a lawn or to the storm drainage system. Contact your chemical supplier to obtain the neutralizing chemicals you will need. The rate of flow into the ditch or drainage system should be regulated so that it does not cause problems such as erosion, surcharging or flooding. Water discharged to the ground or a lawn should not cross property lines and or produce runoff. If you live in a sewered area, you must discharge pool water to the sanitary sewer.
- If pool and hot tub water cannot be dechlorinated, it should be discharged to the sanitary sewer. Prior to draining, the wastewater treatment plant must be notified to ensure they are aware of the volume of discharge and the potential effects of chlorine levels. A pool service company can help you determine the frequency of cleaning and backwash of filters.

- Diatomaceous earth used in pool and hot tub filters should never be disposed of in surface waters, on the ground, into storm drainage systems or septic systems. Dry it out as much as possible; bag it in plastic and dispose of at the landfill.

9 HOUSEHOLD HAZARDOUS MATERIAL USES, STORAGE, AND DISPOSAL

Once we really start looking around our houses, the amount of hazardous materials we have on site is a real eye-opener. Oil-based paints and stains, paint thinner, gasoline, charcoal starter fluid, cleaners, waxes, pesticides, fingernail polish remover, and wood preservatives are just a few that most of us have around the house.

When products such as these are dumped on the ground or in a storm drain, they can be washed directly to receiving waters where they can harm fish and wildlife. They can also infiltrate into the ground and contaminate drinking water supplies. The same problem can occur if they are disposed of with your regular garbage; the containers can leak at the landfill and contaminate groundwater. The same type of contamination can occur if hazardous products are poured down a sink or toilet into a septic system or the City sewer system. Many compounds will "pass through" the wastewater treatment plant without treatment and contaminate receiving waters, or they can harm the biological process used at the treatment plant, reducing overall treatment efficiency. With such a diversity of hazardous products present in all homes in Albany County, a large potential for serious environmental harm exists if improper methods of storage, usage and disposal are employed. Using the following BMPs will help keep these materials out of our soils, sediments and waters.

9.1 BEST MANAGEMENT PRACTICES

- Dispose of hazardous materials and their containers properly. Never dump products labeled as poisonous, corrosive, caustic, flammable, inflammable, volatile, explosive danger, warning, caution or dangerous outdoors, in a storm drain, into sinks, toilets or drains.
- With some products, disposal can be avoided altogether if you can purchase a small volume of the material, so that none is left over. If you have extra at the end of project, you may be able to find a friend or neighbor who can use it.
- Household hazardous wastes are accepted at the Laramie landfill during the summer months
- Check containers containing hazardous materials frequently for signs of leakage. If a container is rusty and has the potential of leaking soon, place it in a secondary container before the leak occurs and prevent a clean-up problem.

- Store hazardous materials containers under cover and off the ground. Keep them out of the weather to avoid rusting, freezing, cracking, labels being washed off, etc. Hazardous materials should be stored out of the reach of children. Never transfer to or store these materials in food or beverage containers that could be misinterpreted by a child as something to eat or drink.
- Keep appropriate spill cleanup materials on hand. Kitty litter is good for many oil-based spills.
- Ground cloths and drip pans must be used under any work outdoors that involves hazardous materials such as oil-based paints, stains, rust removers, masonry cleaners, and others bearing label warnings as outlined above.
- Latex paints are not a hazardous waste but are not accepted in liquid form at the landfill. To dispose, leave uncovered in a protected place until dry, then place in the garbage. If you wish to dry waste paint quickly, just pour kitty litter in the can to absorb the paint. Once paint is dry, leave the lid off when you place it in the garbage so your garbage collector can see that it is no longer liquid.
- Use less toxic products whenever possible.
- If an activity involving the use of a hazardous material can be moved indoors out of the weather, then do so. Make sure you can provide proper ventilation, however. Follow manufacturer’s directions in the use of all materials. Over-application of yard chemicals, for instance, can result in the washing of these compounds into receiving water bodies. Never apply pesticides when rain is expected.
- When hazardous materials are in use, place the container inside a tub or bucket to minimize spills.

10 RESIDENTIAL WELLHEAD MAINTENANCE

The following suggestions are taken from the DEQ’s 1998 Rural Wellhead Protection Fact Sheet:

Existing wells must be maintained and operated correctly to prevent well deterioration and aid in preventing contamination of your water supply. Similar to your car or tractor, your well needs regular maintenance. This maintenance includes simple measures, such as, keeping the wellhead area clean and accessible, and moving any pollutants as far away from the well as possible. Other more extensive measures may involve hiring a qualified pump installer or well technician to inspect the operation of the pump and the integrity of the well casing. Many problems can be prevented by following proper well design and installation practices during the construction of the well. Your well should also be sampled regularly to verify that no contaminants are present in the water.

10.1 BEST MANAGEMENT PRACTICES

General procedures for protecting your water supply wells should include use of backflow preventers and plastic nurse tanks and maintaining a slope or curb that directs surface runoff away from the wellhead. Minimum maintenance on a well should include an annual check of the well and any treatment system. It is your responsibility to maintain your well in good condition to protect the quality of groundwater.

10.1.1 BACKFLOW PREVENTERS

If you mix pesticides or fertilizers in tanks next to your wellhead or do fertigation and/or chemigation at irrigation wellheads, a backflow prevention device is required. Fertigation is the process of adding fertilizers to irrigation water at the wellhead. Chemigation is the addition of chemicals such as pesticides to irrigation water at the wellhead. Chemigation at a wellhead is not recommended, and it may require the issuance of a Chapter III Permit from the Wyoming Department of Environmental Quality, Water Quality Division (WDEQ/WQD).

A backflow prevention device will prevent chemicals from flowing back into the well or back-siphoning, which can directly contaminate the groundwater when the well pump is turned off. Simple backflow preventers are also recommended for common household water uses such as laundry tubs, sinks, dishwashers, washing machines, and outside hydrants used to fill tanks. Maintaining an air gap between the hoses/ faucets and the well will prevent the backflow of contaminated water. Any household appliances that require a cross-connection between potable and non-potable water need to have backflow preventers.

10.1.2 NURSE TANKS

It is highly recommended that any fertilizers, pesticides, or other chemicals be mixed and loaded in an area that is as far away from the wellhead as feasible; a minimum distance of 100 ft. is recommended. The use of inexpensive nurse tanks is recommended to allow mixing in the field. They can be filled with water at the wellhead and transported to the field far from the wellhead for mixing. Sprayer tanks can then be filled from the nurse tanks in the field. Nurse tanks and chemical storage containers should be thoroughly rinsed before being stored or thrown away. The rinsing water should be disposed of in an acceptable manner, such as applying it to fields at normal application rates.

10.1.3 SURFACE WATER PROTECTION

A finished cement cap is typically placed at the wellhead. The cement cap is sloped away from the well to prevent water from surface runoff accumulating at the top of the casing. If an existing well does not have this cement cap, it is recommended that a cap be installed to a depth extending just below the frost line. The ground surface needs to be built up and mounded around the wellhead. If water accumulates and ponds in a low area near the well, berms or curbs need to be placed in appropriate locations surrounding the well to divert runoff from the wellhead. Soil berms and mounds need to be checked periodically and repaired as needed.

10.1.4 WELL MAINTENANCE

Regular maintenance checks should be completed on your well. You may need to disinfect your well, pressure tanks, and distribution system. Artesian or flowing wells normally require more maintenance because the valves and casings must prevent leakage and withstand the pressure exerted by the water.

10.1.5 WELL DISINFECTION

Before drilling, a contractor should disinfect all bits, tools, pumps and any other material that may enter the drill hole during the drilling process. All filter pack material and drilling water should be disinfected. A common disinfection chemical treatment is chlorination, which normally requires some type of agitation to effectively kill bacteria. The contractor should also disinfect the well, pump, and piping after completion of the well. The process of disinfecting a well involves the addition of a disinfection agent, such as a form of chlorine like calcium hypochlorite or sodium hypochlorite tablets, combined with physical agitation to disinfect the entire well borehole. After agitation, the disinfecting solution should be left in the well for at least four hours. The piping, storage tanks, pump, pressure tanks, and distribution system should also be disinfected by pumping the disinfecting solution into the system and leaving it in the system for at least two hours. Before placing the well system back into service the chlorine residue needs to be flushed from the system.

10.1.6 WELL YIELD

Every well should have a pump test done after it is installed. The owner of the well should keep copies of these tests and any other well records. Information about your well may be available from the Wyoming State Engineer's Office ((307) 777-6150). Periodically, the well performance should be tested by measuring the highest sustainable well pumping rate in gallons per minute for a period of continuous pumping. If 10 - 15% reductions are measured in yield, the cause(s) of decreased yield need to be identified and corrected. If a 25% or greater reduction in yield is measured, the money required to fix the problems may be better applied to the installation of a new well.

The type of aquifer that a well is installed in will affect how frequently maintenance is required to increase well yields. Shallow wells located in alluvial sands and gravels will require more frequent maintenance. Municipal water supply wells in alluvial aquifers require maintenance every 2 - 5 years. Reductions in well yields may be caused by the following problems: 1) plugging of the screen or the formation around the well caused by incrustation or biofouling; 2) plugging of formation by fine particles; 3) pumping sand; 4) collapse of well casing or screen; and 5) a damaged pump.

10.1.7 WELL REHABILITATION

Correcting the problems described above will typically require a qualified water well contractor. Many of the problems described above may be prevented by following proper well design and installation practices. The procedure for cleaning up plugging caused by mineral deposits requires treating the well with strong acids that should only be attempted by qualified well technicians. Biofouling may be prevented by disinfecting all downhole equipment and materials during well installation. Physical plugging of wells and the pumping of sand can be prevented by proper well design and thorough well development during installation. Adding polyphosphates or surfactants added to a well, combined with thorough physical agitation will help to remove fine material from the formation. Corrosion of a well casing and screen can be prevented by using the correct well casing materials. Installation of cathodic protection may be required on existing wells to reduce corrosion rates. Well pumps may be damaged in wells without well screens and/or filter packs or wells with improperly sized well screens and/or filter packs. Replacing the pump in an improperly constructed well is not a good solution, since the new pump will eventually fail. A better alternative may be to replace the screen or place an inner screen in the well. If it is difficult and expensive to improve the performance of an existing well, it may be wiser and more economical to drill a new well.

10.1.8 WELL SAMPLING

Well water should be sampled on at least an annual basis. Sample your well any time you think a health problem may be caused by a disease producing microorganism in your water supply, or if you notice significant changes in the taste, smell, or color of the water. At a minimum, the laboratory should analyze for the following parameters: pH, nitrates, ammonia, total coliform bacteria, and total dissolved solids. If you suspect any other contaminants, such as hydrocarbons from petroleum leaks or spills, or spills of pesticide liquids, include these specific parameters in the test. If any parameters in your well exceed acceptable limits, always retest immediately to verify the first test.

The state of Wyoming has two state laboratories (see References/Contacts) in Cheyenne and Laramie that will analyze your samples. Your UW Cooperative Extension Service (UWCES) county office or local health department should have a current listing of local private laboratories that will also conduct water analyses.

If your water system contains over (1) coliform bacteria per 100 milliliters, it may not be safe to drink due to bacteriologic contamination. Contact a qualified well contractor to disinfect your well; tanks, and distribution system. If the sample was taken at your water tap, the bacteria may be present within your pressure tank or distribution system. Exposure of the well or piping system is sometimes necessary in order to perform various procedures such as repairs or maintenance. Please remember that whenever the well or piping system is exposed, it may be invaded by foreign matter that contains bacteria. The well system should be disinfected prior to placing it back into service.

All back-siphoning occurrences or major spills or leaks must be reported to the WDEQ/WQD. To report and receive assistance, please call the 24-hr Emergency Contact of the DEQ/Water Quality Department, at (307) 777-7501. If you are calling between 8 a.m. - 5 p.m., please ask to talk with someone concerning the spill response program.

11 REFERENCES/CONTACTS

REFERENCES

DRINKING WATER QUALITY STANDARDS

U.S. Environmental Protection Agency's Safe Drinking Water Hotline. Call toll free 1-800-426-4791 from 8:30 A.M. to 5:00 P.M. Eastern Time.

CONTACTS

STATE/FEDERAL AGENCIES

Wyoming Dept. of Environmental Quality, Water Quality Division, 200 West 17th Street, Cheyenne, WY 82002, (307)777-7937.

Wyoming State Engineers Office, 122 W. 25th St., Cheyenne, WY 82001, (307)777-6150.

Geological Survey of Wyoming, 1000 East University Avenue, Laramie, WY 82071-3008, (307)766-2286.

U.S. Geological Survey, Water Resources Division, 521 Progress Circle, Suite 6, Cheyenne, WY 82007, (307)778-2931.

U.S. Environmental Protection Agency, Region VIII, 1595 Wynkoop Street, Denver, CO 80202-1129, 1-800-227-8917.

University of Wyoming Water Data Systems,1000 East University Avenue, Laramie, WY 82071-3067, (307)766-6651.

STATE LABORATORIES/ INFORMATION

Wyoming Department of Agriculture Analytical Services Laboratory, 1174 Snowy Range Road, Laramie, WY 82070. (307) 742-2984.

Wyoming Department of Health/Preventative Medicine Division - Public Health Laboratory, 208 South College Avenue, Cheyenne, WY 82007 (307)777-7431.

APPENDIX H

City of Laramie and Albany County Zoning Regulations

Albany County Zoning Resolution

Adopted: August 1, 1997

General Update Adopted
July 21, 2015 and Effective
October 1, 2015

Amendments:
October 6, 2015 – Portable Storage Structures
October 20, 2015 – On Premise Signs
April 19, 2016 – Correction of Errors
June 20, 2017 – Zoning Certificate Process
August 1, 2017 – Application Withdrawal
November 5, 2019 – Landscaping Standards
September 15, 2020 – Wind Energy Regulations
October 6, 2020 – Solar Energy Regulations
March 2, 2021 – Wind Energy Regulations
July 6, 2021 – Site Plan Standards
January 1, 2023 – Zoning District Amendments
February 21, 2023 – Aquifer Protection Overlay Zone Amendments

b. Operating Hours: Business shall not be open to the public between the hours of 10 p.m. and 6 a.m.

F. Commercial (C)

1. Purpose: The purpose of the C zone is primarily to allow for commercial uses within the County. A mix of uses will be allowed in this zone including both commercial and residential uses. These areas should be located near major roads and have water and sewer available (on-site or connected to centralized systems).

2. Minimum Lot Frontage Width: One hundred (100) feet.

3. Minimum Setbacks: Commercial structures must be set back ten (10) feet from side and rear property lines and fifty (50) feet from frontage property lines. If an on-site water well is employed, it must be 50 feet from all property lines. If an on-site sewage disposal system is employed, setbacks shall be in accordance with the County Resolution entitled “Design and Construction Standards for Small Wastewater Facilities and Regulations for Permit to Construct, Install or Modify Small Wastewater Facilities”.

G. Industrial (I)

1. Purpose: The I zone will be for areas or lands determined appropriate for industrial uses. These uses include the use of land or buildings requiring substantial applications of skill, capital, machinery, or labor in transforming materials into other suitable forms, qualities, or properties.

2. Minimum Lot Size: One (1) acre

3. Minimum Lot Frontage Width: Two hundred (200) feet.

4. Minimum Setbacks: Principal and accessory structures must be set back ten (10) feet from all property lines. Setbacks for water wells shall be fifty (50) feet from all property lines. Setbacks for sewage disposal systems shall be in accordance with the County Resolution entitled “Design and Construction Standards for Small Wastewater Facilities and Regulations for Permit to Construct, Install or Modify Small Wastewater Facilities”.

Section 3. Overlay Zones. This section establishes overlay zones which may include more than one (1) underlying zoning district and/or overlay zone. Development, subdivision, or uses within an overlay zone must meet the additional standards of the overlay, in addition to the underlying zoning standards.

A. Floodplain Overlay. The Floodplain Overlay is established by the most recent Flood Insurance Rate Maps (June 16, 2011) provided by the Federal Emergency Management Agency. Any structure that will be built within the delineated Floodplain Overlay shall obtain a Floodplain Development Permit from the Albany County Planning Department prior to approval of an application for a Zoning Certificate and/or application for Small Wastewater Treatment Facility. A Floodplain Development Permit will be issued in accordance with the currently enacted Flood Damage Prevention Resolution (June 7, 2011).

B. 201 Intergovernmental Agreement Overlay. The "Intergovernmental Agreement for Laramie Wastewater Treatment Facilities and Collection System" is a cooperative agreement between the City of Laramie, Albany County, and the South of Laramie Water and Sewer District (Effective November 1, 1997). This agreement establishes specific standards for the construction of sewage collection lines, and establishes standards for requiring connection to the City of Laramie sewer lines. See the agreement for the specific standards and jurisdictional boundaries.

C. Neighborhood Conservation Overlay Zone (NCOZ).

1. Purpose: The purpose of the NCOZ is to avoid creating non-conforming structures and lots for platted properties in existence prior to the adoption of the Albany County Zoning Resolution in 1997. Future subdivisions of land in this overlay zone must meet the standards of the underlying zone.

2. Minimum Lot Size: Existing lots under the minimum lot size standard for the underlying zone are considered to be legal lots and within the standards of these regulations.

3. Minimum Lot Frontage: None.

4. Minimum Setbacks: No setback is required for principal or accessory structures. Setbacks for new water wells shall be a minimum of fifty (50) feet from all property lines. Setbacks for new sewage disposal systems shall be in accordance with the County Resolution entitled "Design and Construction Standards for Small Wastewater Facilities and Regulations for Permit to Construct, Install or Modify Small Wastewater Facilities".

5. Land Uses: Land uses shall conform to those allowed and conditionally permitted in the underlying zone designation (see land use table).

D. Aquifer Protection Overlay Zone.

1. Purpose. The purpose of the Aquifer Protection Overlay Zone (APOZ) is to prevent degradation to the water quality within the Casper Aquifer.

2. These regulations incorporate the findings of Albany County's Casper Aquifer Protection Plan (CAPP) and its updates. Approximately fifty (50) to sixty (60) percent of the City of Laramie's municipal water supply and one hundred (100) percent of the water to approximately four hundred fifty (450) rural residences come from wells and springs in the Casper Aquifer. The delineated recharge area

of the Casper Aquifer in the Laramie area encompasses approximately seventy-nine (79) square miles that lie east of the City and extends to the crest of the Laramie Range, with the northern boundary approximately six (6) miles north and the southern boundary six (6) miles south of City limits. The City of Laramie has municipal well fields which draw water from this area. The Casper Formation is exposed along the west side of the Laramie Range and is vulnerable to contamination because:

a. Points of withdrawal (municipal and domestic wells) are in close proximity to the recharge area;

b. The Casper Aquifer recharge area is fractured and has extensive exposures of porous sandstones;

c. There are existing areas of residential and commercial development on the recharge area and there is a potential for additional future development in the recharge area; and

d. Interstate 80 (I-80), across which numerous hazardous substances are transported each day, cuts through the entire thickness of the Casper Formation.

e. The Casper Aquifer is comprised of the saturated portions of the Casper Formation which consists of approximately seven hundred (700) feet of marine and eolian sandstones interbedded with marine limestone and minor amounts of shale. The Sherman Granite provides an effective lower confining layer for the Casper Aquifer and the low permeability of the Satanka Shale provides an upper confining layer where there is sufficient thickness. In general, the Satanka Shale effectively retards the flow of water upward out of the Casper Aquifer and the flow of water downward to the Casper Aquifer.

3. Because the bottom fifty (50) feet of the Satanka Shale may be fractured and in hydraulic communication with the underlying Casper Aquifer, the City of Laramie/Albany County Environmental Advisory Committee - Technical Advisory Subcommittee (June, 1999) recommended that a minimum seventy-five (75) foot vertical thickness of Satanka Shale be present above the Casper Formation to provide an adequate safety factor to reduce the risk of potential contamination to the Casper Aquifer. These regulations hereby incorporate the Technical Advisory Subcommittee’s recommendation as the basis for defining the APOZ.

4. Definitions. For the purpose of the Aquifer Protection Overlay Zone (APOZ) regulations, the following words and terms shall have the meanings specified herein:

   a. **Aquifer Protection Overlay Zone (APOZ) Development:** Any modification to the natural land surface that may result in the introduction of contaminants and/or increasing the vulnerability of the aquifer to contamination.

   b. **Best Available Control Technology:** Use of equipment and management practices to provide the maximum possible reduction in the release, or possibility of release, of hazardous materials into the Casper Aquifer.

   c. **Improvement Site**: The area that will receive improvements such as structures, a septic system, roads, driveways, or other alterations to the existing land.

   d. **Hazardous Material**:

      (i) Any hazardous substance as defined in 40 CFR 302.4 and listed therein at Table 302.4;

      (ii) Any hazardous waste as defined in Wyoming law including, but not limited to, the Wyoming Department of Environmental Quality Hazardous Waste Rules and Regulations as may be amended from time to time;

      (iii) Any pesticides as defined in Wyoming law; or

      (iv) Any oil or petroleum. This definition does not include natural gas or propane used for heating homes or businesses or other common residential uses.

   e. **Person**: Any individual, developer, homeowner's association, group, business, corporation, partnership, governmental body, or any other legal entity.

   f. **Vulnerable Feature**: Any physical feature that reduces the natural protection of the aquifer at or near the ground surface including faults, folds, open fractures that extend to the ground surface; shallow depth to groundwater (any location where no effective confining layer is present over the water-bearing strata within the Casper Formation and the depth to water is less than seventy (70) feet); exposed bedrock; and drainages.

   g. Other words used in these APOZ regulations shall be defined by the usage in the Albany County Casper Aquifer Protection Plan, other County land use regulations or by the common definition.

5. Aquifer Protection Overlay Zone Established.

a. There is established within the unincorporated area of Albany County an Aquifer Protection Overlay Zone (APOZ). The APOZ is the area where the upper boundary of the Casper Formation is not covered by at least seventy-five (75) feet of the overlying Satanka Formation naturally in place, regardless if the reduction in thickness of the Satanka Formation is due to natural causes or is man-made.

   Delineation of the APOZ is based upon the CAPP approved by the Board of County Commissioners on January 4, 2011. All property within Zones 1, 2, and 3 are zoned APOZ. The APOZ boundary is defined and depicted in the Official Albany County Zoning Maps.

b. APOZ Boundary Amendments. The APOZ boundary may be amended based upon the CAPP and its updates and as otherwise provided by these APOZ regulations in accordance with W.S. § 18-5-202 and the Wyoming Administrative Procedure Act, W.S. §§ 16-3-101 through -115. The zoning district amendment provisions and procedures of Section 5 of this Chapter are inapplicable to APOZ boundary amendments.

c. Exclusions. Previously surveyed parcels may be excluded from the APOZ upon clear and convincing evidence of the presence of at least seventy-five (75) feet of undisturbed Satanka Formation overlaying the Casper Formation beneath the parcel. Evidence shall be based upon publicly available data and provided by a Wyoming-licensed professional geologist or engineer with appropriate expertise.

   1) An application for exclusion shall be made by the landowner on a form provided by the Albany County Planning Department.

   2) The County may submit the evidence to a different qualified professional for review. Reasonable costs of professional consultation to the County shall be reimbursed by the exclusion applicant to the County.

   3) Any exclusion shall be approved by a vote of the Board of County Commissioners. If approved, the APOZ boundary shall be modified accordingly.

d. All development located within the APOZ shall meet the requirements of these regulations.

e. Where the boundary line of the APOZ divides a lot, the requirements established by these regulations shall apply only to the portion of the lot that is located within the APOZ.

f. Where these regulations are less strict or silent as to a particular issue, any APOZ Developments shall conform to the requirements of the underlying zoning district(s) in which the APOZ Development is located.

6. Prohibited Activities.

a. Development, except that which is proposed by the City of Laramie for the protection and usage of City of Laramie water wells, is prohibited in Zone 1 of the APOZ, and

b. No property within any zone of the APOZ may be used for any use listed in the Table of Prohibited Activities set forth below or otherwise prohibited or limited by operation of these APOZ regulations.

Table of Prohibited Activities

	Prohibited Activity **The following activities are prohibited in the APOZ:**	**Examples of prohibited activities**
1.	Activities involving any equipment for the storage or transmission of any hazardous material to the extent that it is not pre-empted by federal law.	Petroleum pipelines or gasoline stations.
2.	The discharge to groundwater of any regulated waste.	
3.	Commercial car or truck washes, unless all waste waters from the activity are lawfully disposed of through a connection to a Publicly Owned Treatment Works or centralized wastewater treatment system.	Car or truck washes, detail shops or car dealership.
4.	Commercial and home occupation/home business production or refining of chemicals, including without limitation, hazardous materials or asphalt.	Chemical, petroleum, or asphalt manufacturer.
5.	Commercial and home occupation/home business clothes or cloth cleaning service which involves the use, storage, or disposal of hazardous materials, including without limitation, dry-cleaning solvents.	Dry cleaner.
6.	Commercial and home occupation/home business clothes or cloth cleaning service for any activity that involves the cleaning of clothes or cloth contaminated by hazardous material, unless all waste waters from the activity are lawfully disposed of through a connection to	Industrial laundry.

	a Publicly Owned Treatment Works or centralized wastewater treatment system.	
7.	Commercial generation of electrical power by means of fossil fuels except generation by means of natural gas or propane.	
8.	Commercial and home occupation/home business production or fabrication of metal products, electronic boards, electrical components, or other electrical equipment involving the use, storage or disposal of any hazardous material or involving metal plating, metal cleaning or degreasing of parts or equipment with industrial solvents, or etching operations.	Metal foundry, metal finisher, metal machinist, metal fabricator, metal plating, electronic circuit board, electrical components or other electrical equipment manufacturer.
9.	Commercial and home occupation/home business on-site storage of oil, petroleum or gasoline for the purpose of wholesale or retail sale.	Bulk plant.
10.	Commercial and home occupation/home business embalming or crematory services which involve the use, storage or disposal of hazardous material.	Funeral home or crematory.
11.	Commercial and home occupation/home business furniture stripping operations which involve the use, storage or disposal of hazardous materials.	Furniture stripper.
12.	Commercial and home occupation/home business furniture finishing operations which involve the use, storage or disposal of hazardous materials.	Furniture repair.
13.	Storage, treatment, or disposal of hazardous waste permitted under Wyoming law.	Hazardous waste treatment, storage or disposal facility.
14.	Commercial and home occupation/home business of any biological or chemical testing, analysis or research which involves the use, storage or disposal of hazardous material.	Laboratory: biological, chemical, clinical, educational, product testing or research.
15.	Commercial and home occupation/home business involving pest control.	Lawn care or pest control service.

16.	Commercial and home occupation/home business salvage operations of metal or vehicle parts.	Metal salvage yards, vehicle parts, salvage yards or junk yards.
17.	Commercial and home occupation/home business photographic finishing which involves the use, storage, or disposal of hazardous materials.	Photographic finishing laboratory.
18.	Commercial and home occupation/home business printing, plate making, lithography, photoengraving or gravure, which involves the use, storage or disposal of hazardous materials.	Printer or publisher.
19.	Commercial and home occupation/home business pulp production, which involves the use, storage or disposal of any hazardous materials.	Pulp, paper or cardboard manufacturer.
20.	Accumulation or storage of waste petroleum products, waste anti-freeze or spent lead-acid batteries.	Recycling facility which accepts waste oil, spent anti-freeze or spent lead-acid batteries.
21.	Commercial and home occupation/home business production or processing of rubber, resin cements, elastomers or plastic, which involves the use, storage or disposal of hazardous materials.	Rubber, plastic, fabric coating, elastomer or resin cement manufacturer.
22.	Storage of pavement de-icing chemicals unless storage takes place within a weather-tight waterproof structure.	Salt or de-icing storage facilities.
23.	Commercial and home occupation/home business accumulation, storage, handling, recycling, disposal, reduction, processing, burning, transfer or composting of solid waste.	Solid waste facility or intermediate processing center. Landfill or dumps on residential or commercial property.
24.	Commercial and home occupation/home business finishing or etching of stone, clay, concrete or glass products or painting of clay products which involves the use, storage, or disposal of hazardous materials.	Stone, clay or glass products manufacturer.
25.	Commercial and home occupation/home business dying, coating or printing of textiles, or tanning or finishing of	Textile mill, tannery.

	leather, which involves the use, storage, or disposal of hazardous materials.	
26.	Commercial and home occupation/home business involving the repair or maintenance of automotive or marine vehicles or internal combustion engines of vehicles, the use, storage or disposal of hazardous materials, including solvents, lubricants, paints, brake or transmission fluids or the generation of hazardous wastes.	Vehicle service facilities which may include: new or used car dealership, automobile body repair or paint shop, aircraft repair shop, automobile radiator, or transmission repair; small-engine repair; boat dealer; recreational vehicle dealer; motorcycle dealer; truck dealer; truck stop; diesel service station; automotive service station, municipal garage, employee fleet maintenance garage or construction equipment repair or rental.
27.	Commercial and home occupation/home business of on-site storage of hazardous materials for the purpose of wholesale or retail sale.	Wholesale trade, storage or warehousing of hazardous substances, hazardous wastes, oil or petroleum.
28.	Commercial and home occupation/home business production or treatment of wood, veneer, plywood, or reconstituted wood, which involves the use, storage or disposal of any hazardous material.	Manufacturer of wood veneer, plywood or reconstituted wood products.
29.	All Underground Injection Control (UIC) wells except Class V subclasses 5B2, 5B3, 5B4, 5B5, 5B6, 5B7, 5E3, 5E4, and 5E5 and Class V subclasses 5A1 and 5A2, if 5A1 and 5A2 facilities do not use any additives, as	Underground injection control facilities.

	defined in WDEQ/WQD Division Rules and Regulations, Chapter 16.	
30.	Water wells which are not capped. Water wells which are not cased at least to the top of the production zone with the annular space sealed from the top of the production zone to the surface, or in accordance with the state engineer's requirements or recommendations, whichever is stricter.	
31.	Application of pesticides and herbicides which do not conform to label instructions and Wyoming Environmental Pesticide Control Act of 1973.	
32.	Application of fertilizer at greater than the agronomic uptake rate of the vegetation fertilized.	
33.	Commercial and home occupation/home business quarrying and sand and gravel mining unless the operations are conducted pursuant to valid permits issued by the Wyoming Department of Environmental Quality, Bureau of Land Management or other federal or state regulatory agency.	
34.	Above ground storage of any hazardous material, including oil and petroleum, unless enclosed in secondary containment.	Agricultural gasoline storage.
35.	Commercial and home occupation confined animal feeding operations (CAFO's) as designated by the permitting authority (Wyoming Department of Environmental Quality).	Concentrated animal feeding operation or stockyards.
36.	Commercial and home occupation/home business cemeteries.	Cemeteries of all types.

7. Minimum Lot Size: Minimum lot size within the APOZ shall be 35 acres, with one dwelling. Parcels smaller than 35 acres, as of the date of the adoption of these regulations, shall be allowed one dwelling.

8. Setbacks from vulnerable features.

   a. Vulnerable features requiring a setback include:

      1) Faults, folds, or open fractures that extend to the ground surface;

2) Shallow depth to ground water; and

3) Drainages.

b. No person shall install, maintain, or use any on-site wastewater treatment system or wastewater storage system or any private connection to a public wastewater system within one hundred (100) feet of a vulnerable feature in the Casper Formation which requires a setback. However, this setback may be lessened upon approval of the County Wastewater Engineer if documentation that the facility poses no significant threat to groundwater is provided. This documentation must be provided by a professional engineer or geologist, licensed in Wyoming, and should include the following:

1. Evidence that no other location exists on the property that can meet the required setback standards;

2. Evidence that ensures no significant threat to groundwater will occur due to the installation of the proposed wastewater system; and

3. If recommended, mitigation methods needed to protect the groundwater are installed (e.g. installation of an advanced wastewater system as defined by Wyoming Department of Environmental Quality).

c. Additional location and setback constraints may be established as determined by the results of Site Specific Investigation Chapter 3, Section 3, D. for the specifically proposed APOZ Development.

9. Site Specific Investigations (SSI).

a. An SSI shall be required with applications for a zoning certificate, subdivision permit, conditional use, or zoning district amendment. Zoning certificate applications requiring an SSI shall be approved by the Board of County Commissioners.

b. SSI Purpose. The purpose of the SSI is to determine the vulnerability of the Casper Aquifer to contamination by the proposed APOZ Development. The SSI shall be completed by a professional engineer or geologist with appropriate expertise, licensed in the State of Wyoming.

c. The SSI and report shall include the following:

i. A search to determine the presence of Vulnerable Features on the Improvement Site;

ii. A site narrative including historical information relating to previous land use, existing or abandoned wells, known contamination of any part of the property, underground tanks, septic systems, utilities, and any other improvements on the Improvement Site;

iii. An on-site investigation to determine the presence of Vulnerable Features not previously identified and of any other hydrogeologic conditions relevant to the potential for compromising aquifer water beneath the area considered on the Site Plan;

iv. Where subsurface wastewater disposal is proposed, documentation that the facility must comply with Albany County's Design and Construction Standards for Small Wastewater Facilities and Regulations for Permit to Construct, Install or Modify Small Wastewater Facilities and all applicable Wyoming DEQ standards;

v. A delineation of the one hundred (100) year floodplain on the subject property, if none is indicated on the FEMA Flood Insurance Rate Map, and deemed necessary by the Albany County Planning Department;

vi. A determination of any necessary mitigation measures or setbacks, as a result of features or conditions as identified by iii, above;

vii. A determination of the depth to groundwater on the Improvement Site. An attempt should be made to determine the groundwater at its highest annual elevation, which typically occurs in late spring. Water level(s) in a well on the site property are preferable for determining depth to groundwater. Water levels from wells on adjoining properties may be used if a well has not been drilled on the subject property. If a well is not available for obtaining water levels, then maps depicting the potentiometric surface of the Casper Aquifer at the subject property may be used;

viii. An assessment and mitigation plan for any impacts to the Casper Aquifer caused by storm water run-off;

ix. Evaluation of the potential impact of septic system effluent on any member of the Casper Formation, for proposals involving subsurface waste disposal;

x. A map illustrating the geologic formations on the Improvement Site including the location of all existing and abandoned wells. A potentiometric surface of the Casper Aquifer may be included on this map; and

xi. A Site Plan shall be provided for the Improvement Site that shall extend one hundred fifty (150) feet from the Improvement Site in all directions, showing existing and planned structures, proposed small wastewater systems, and other improvements (including but not limited to roads, driveways, and utilities; landscaping improvements shall indicate whether pesticides, fertilizers or herbicides will be used). Any other information necessary to make an accurate analysis of the property shall be included on the Site Plan.

d. A professional engineer, geologist, or other qualified professional licensed in the State of Wyoming, other than the professional that performed the investigation, will review the Site Specific Investigation (SSI). Reasonable costs of professional consultation to the County shall be reimbursed to the County by the property owner. The technical review will include the following:

i. Qualifications of the individual and/or firm completing the review;

ii. Verification that the SSI includes all information required in Chapter 3, Section 3, D, 9;

iii. Assessment of compliance with state, federal and local regulatory authorities;

iv. Assessment of whether the recommendations of the SSI will mitigate potential negative impacts to the aquifer;

v. A review of the veracity and validity of the technical information provided in the SSI;

vi. Identification of any errors or omissions within the SSI and of elements of the SSI that need clarification, modification, or further consideration; and

vii. An analysis of the quality and consistency of the data used to arrive at any stated conclusions.

e. Exemptions. An SSI shall not be required for the following;

i. Any buildings or structures proposed on property zoned residential before August 7, 2012. If a property receives approval of a zoning district amendment to a non-residential zone, the property will not be exempt by this paragraph;

ii. Any buildings or structures proposed in a subdivision with a subdivision permit approved prior to August 7, 2012. If a property receives approval of a zoning district amendment to a non-residential zone, the property will not be exempt by this paragraph; or

iii. Any accessory buildings/structures or additions to existing buildings/structures that are within and consistent with the zoning of the property.

f. Modifications. Application for modifications to any APOZ development shall be submitted on a form supplied by the Albany County Planning Department. The application must address how the modification meets the recommendations of the SSI and technical review prepared for the original development. The Board of County Commissioners shall vote on any proposed modification.

10. Design Standards for on-site wastewater treatment systems.

a. The installation, design, repair, and removal of septic systems located within the APOZ must be in accordance with plans and specifications certified by a registered profession engineer or geologist licensed to practice in the State of Wyoming.

b. Septic systems must be pumped and maintained on a regular schedule by a County licensed septage pumper/hauler. Pumping and a visual inspection of the installed septic systems shall be conducted when the ownership of the property is transferred and reported to the Albany County Wastewater Engineer on a form supplied by that office.

c. When a septic tank is pumped, the pumper/hauler shall visually inspect the septic system, including its various components, for signs of failure or impending failure.

d. Any incidence of a septic system or any of its components exhibiting signs of failure or impending failure shall be reported by the septage pumper/hauler to the Albany County Wastewater Engineer on a form provided by that office and copied to the Albany County Planning Department. The form shall include the anticipated resolution of all noted issues and a schedule for resolution, to be enforced by the Albany County Planning Department.

No form or report is required for a properly function septic system.

e. All new and replacement septic systems and leach fields within the APOZ shall be inspected by the Albany County Wastewater Engineer before backfilling in accordance with Albany County Small Wastewater Regulations.

f. If a septage pumper/hauler finds that a septic system is not adequately designed or constructed to serve the use to which is intended, it shall not be used for the disposal of wastewater until it is cleaned, repaired, or otherwise made to operate adequately as determined by the Albany County Wastewater Engineer.

11. Nonconforming uses. If the nonconforming use is damaged due to conditions beyond the control of the owner or operator, it may be repaired and resumed at the same location, size, and scope.

    a. The owner or operator shall submit a report to the Albany County Planning Department. The report shall include;

        1) A description of the damage;

        2) A description of the planned repairs and how these will maintain the same location, size or volume, and scope of the operation prior to the damage;

        3) Documentation demonstrating how the planned repairs incorporate best available control technology to prevent hazardous materials from entering the Casper Aquifer; and

        4) Documentation demonstrating compliance with all county, state, and federal rules and regulations.

    b. Notwithstanding (a) above, repairs shall not be allowed to extend, enlarge, or expand the use, as prohibited by Section 6 of this Chapter

12. Proper abandonment of unused wells. All wells, including but not limited to groundwater pumping wells and monitoring wells, which are no longer in use by the owner must be properly abandoned by a well driller licensed in the State of Wyoming in accordance with Chapter 11, Section 70 of the Wyoming Department of Environmental Quality Rules and Regulations.

13. Existing law on aquifer contamination unaffected. The establishment of the APOZ and the use of properties in the APOZ in accordance with these regulations do not relieve any person from liability provided by law for contamination of the aquifer. These APOZ regulations do not supersede or modify the requirements of any federal, state or local law imposing stricter requirements regarding aquifer protection and/or contamination.

14. Severability. The provisions of these APOZ regulations are severable. If any provision is declared to be invalid or unenforceable by any court of competent jurisdiction, those provisions not so declared shall remain in effect.

Section 4. Official Zoning Maps. The boundaries of the zoning districts and their associated development constraints shall be determined and defined by the boundaries of the individual parcels which comprise each zoning district, as depicted on the Official Albany County Zoning Maps. Maps, representing the zoning districts at an appropriate scale and displaying the date prepared shall be maintained and made publicly available through the Planning Department. The Official Zoning Maps shall be updated to reflect amendments to zoning district boundaries within thirty (30) days of such amendments taking effect.

Section 5. Zoning District Amendment.

A. Purpose. The purpose of a zoning district amendment is to promote the public health, safety, morals, and general welfare of Albany County. Pursuant to W.S. § 9-8-301, amendments to this resolution's official zoning maps are to be guided by and further the policies, visions, goals, and objectives of the local land use plans of Albany County.

B. Initiation of a Zoning District Amendment: A zoning district amendment may be initiated at the request of the Board of County Commissioners, the Planning and Zoning Commission, planning staff, or a private entity (individual or business).

C. Application Submission: Applicant(s) must complete, sign, and submit to the Planning Department an application on a form prescribed by the Planning Director for a zoning district amendment.

D. Notification Requirements:

1. Contents of Notice: All mailed and publication notices shall include a brief description of the zoning district amendment; contact information for the Planning Department; and the location, date and time, and reviewing body for the public meeting or hearing.
2. Mail: Applicant shall be responsible for mailing notice, by certified mail, to surrounding, contiguous property owners of the proposed zoning district amendment. If the applicant is not the property owner of the parcel for which a zoning district amendment is requested, notice shall be sent in the described manner to the property owner(s). Notice of pending proposals for the Planning and Zoning Commission and the Board of County Commissioners at least fourteen (14) days prior to consideration. Names and addresses for the surrounding property owners shall be obtained from the real estate records filed with the Albany County Clerk's Office or the assessment records on file with the

AQUIFER PROTECTION OVERLAY ZONE
Federal/State Highway
Major City St/County Road
Minor City St/Private Road
City of Laramie Boundary
APOZ
Township/Range
Section
ALBANY COUNTY WYOMING Planning
Date: 11/29/2022
This map was created by the Albany County Planning Department for reference purposes only.
User Name: junverzagt
17N 72W
16N 73W
16N 72W
15N 73W
15N 72W
14N 73W
14N 72W
US HWY 30 287
INTERSTATE 80
GRAND AVE
SKYLINE DR
ROGER CANYON RD
SOLDIER SPRINGS RD
FORT SANDERS RD
STATE HWY 210
OLD US HWY 30 EAST
US HWY 287
0 0.75 1.5 3 4.5 Miles
University of Wyoming, Bureau of Land Management, Esri, HERE, Garmin, GeoTechnologies, Inc., USGS, METI/NASA, EPA, USDA

ORIGINAL ORDINANCE NO. 1748A INTRODUCED BY:____________

ENROLLED ORDINANCE NO.

AN ORDINANCE TO REPLACE LARAMIE MUNICIPAL CODE CHAPTER 17.82 THE AQUIFER PROTECTION OVERLAY ZONE IN ITS ENTIRETY FOR THE LONG TERM PROTECTION OF THE CITY OF LARAMIE'S MUNICIPAL WATER SUPPLY.

Whereas, the Council for the City of Laramie (City) has reaffirmed that safeguarding the City's drinking water provided by the Casper Aquifer is critical to the protection of public health, safety and welfare within the City;

Whereas, the Casper Aquifer supplies more than sixty percent (60%) of the City's fresh drinking water and one hundred percent (100%) of the fresh drinking water to the rural homeowners that fall within the Casper Aquifer Recharge Area;

Whereas, the delineated recharge area of the Casper Aquifer encompasses approximately seventy-two (72) square miles that lie east of the City and extends to the crest of the Laramie Range. The northern boundary is five (5) miles north of the City limits and the southern boundary is approximately six (6) miles south of the City limits. The City's four (4) municipal wellfields are included in the area. Exposure of the Casper Formation in the delineated area results in increased vulnerability to contamination from land uses;

Whereas, inappropriate development on the Aquifer Protection Overlay Zone can adversely affect the quality of the City's drinking water through the intentional or unintentional release of contaminants which is harmful to the health, safety and welfare of City residents;

Whereas, pursuant to Wyo. Stat. § 15-1-601 the City has the authority to adopt zoning and zoning districts to regulate development;

Whereas, the City has the authority pursuant to W.S. § 15-7-101 (a) (ii) and (iii) to regulate water systems supplying water to its inhabitants;

Whereas, pursuant to W.S. § 15-1-103 (a) (xli), the City further has the authority to adopt an ordinance which is necessary for the health, safety and welfare of the City, and necessary to give effect to the powers authorized by the State;

Whereas, the City, in Resolution 2002-02, charged the Environmental Advisory Committee (EAC) to study and monitor the groundwater quality and formulate an aquifer protection plan;

Whereas, in 2002, the City adopted the Casper Aquifer Protection Plan that provides scientific analysis, conclusions and policies for the protection of the Casper Aquifer;

Whereas, in 2002, the City adopted Ordinance No. 1404, establishing the Aquifer Protection Overlay Zone providing development standards for properties within the boundaries of the Casper Aquifer Protection Area;

Whereas, on August 21, 2007, the City Council adopted the Laramie Comprehensive Plan which states that protection of the Casper Aquifer is of high priority, listed as a vulnerable feature and is the primary water supply for City residents.

Whereas, on September 30, 2006 due to growing concerns on the quality of the Casper Aquifer, members of the public petitioned the Laramie Planning Commission to amend the Land Use Element to protect the Casper Aquifer from land uses that are incompatible with vulnerable areas and the water quality of the Casper Aquifer;

Whereas, on September 13, 2006, the Laramie Planning Commission acknowledged the petition, took public comments and forwarded the petition to the City Council for acknowledgment and direction;

Whereas, the City has the authority to implement a temporary moratorium under Wyo. Stat. § 15-1-103 (a) (xxxi), to take any action to regulate as deemed necessary any public water sources or supplies within the City;

Whereas, on October 3, 2006, the City Council acknowledged the petition, took public comments and remanded the petition back to the Laramie Planning Commission for further review, analysis and its recommendation on possible amendments to the Aquifer Protection Overlay Zone. It was also determined that a temporary moratorium suspend new building permits for development and subdivisions in the Aquifer Protection Overlay Zone. The moratorium is necessary until an updated Plan may be completed and recommendations implemented and/or adoption of an ordinance to amend chapter 17.82 of the Laramie Municipal Code to require an environmental report on all development within the Aquifer Protection Overlay Zone;

Whereas, on October 25, 2006, the City Planning Commission held a public hearing, which notice was given at least fifteen (15) days prior to hearing, and determined that a temporary moratorium suspending new building permits for development and subdivisions in the Aquifer Protection Overlay Zone. The moratorium is necessary until an updated Plan is completed and recommendations implemented and/or adoption of an ordinance to amend Chapter 17.82 of the Laramie Municipal Code to require an environmental report on all development within the Aquifer Protection Overlay Zone;

Whereas, on November 8, 2006, the City Council enacted Enrolled Ordinance No. 1500, placing a temporary moratorium on new building permits and subdivisions within the Aquifer Protection Overlay Zone, for a period not to exceed ninety (90) days, or until the effective date of the ordinance amending the Aquifer Protection Overlay Zone, or until the adoption of an updated Casper Aquifer Protection Plan by the City Council;

Whereas, on February 6, 2007, the City Council enacted Enrolled Ordinance No. 1506 extending Enrolled Ordinance No. 1500, to March 12, 2008 to insure there is sufficient amount of time for the adoption of an ordinance amending the Aquifer Protection Overlay Zone and publication of said ordinance;

Whereas, City Resolution 2006-78 authorized the update of the Casper Aquifer Protection Plan;

Whereas, on February 7, 2008 notice of the joint Laramie Planning Commission and Albany County Planning and Zoning Commission meeting to be held on February 11, 2008 was mailed to all City property owners within the proposed Aquifer Protection Overlay Zone and within 300 feet of the proposed Aquifer Protection Overlay Zone;

Whereas, on February 11, 2008 the City of Laramie Planning Commission and the Albany County Planning and Zoning Commission held a joint meeting to discuss updates to the Casper Aquifer Protection Plan, Aquifer Protection Ordinance and Resolution and took public comment;

Whereas, on February 25, 2008 the City of Laramie Planning Commission recommended approval of the Casper Aquifer Protection Plan and Aquifer Protection Ordinance to the City Council;

Whereas, on February 26, 2008 the Laramie City Council held a work session related to updates to the Casper Aquifer Protection Plan and Aquifer Protection Ordinance and took public comment;

Whereas, on March 4, 2008 the Laramie City Council held 1st reading of the Aquifer Protection Ordinance and took public comment;

Whereas, on March 5, 2008 notice of the March 25, 2008 public hearing was mailed to all City property owners within the proposed Aquifer Protection Overlay Zone and within 300 feet of the proposed Aquifer Protection Overlay Zone;

Whereas, on March 9, 2008 and March 23, 2008 a notice of public hearing was published in the Laramie Boomerang;

Whereas, on March 25, 2008 the Laramie City Council held a public hearing on the Aquifer Protection Ordinance;

Whereas, on May 6 and May 20, 2008 the Laramie City Council held 2nd reading on the Aquifer Protection Ordinance and took additional public comments.

BE IT ORDAINED BY THE CITY COUNCIL OF THE CITY OF LARAMIE:

Section 1.
17.82.010 - Legislative Findings.

More than half of the City of Laramie's municipal water supply and all of the drinking water supplied to Albany County rural residences comes from wells and springs in the Casper Aquifer. The delineated recharge area of the Casper Aquifer Protection Area (CAPA) encompasses approximately seventy-two (72) square miles that lie east of the City of Laramie and extends to the crest of the Laramie Range. The north and south boundaries are approximately five (5) and six (6) miles north and south, respectively of Laramie's city limits. Approximately 450 Albany County residents and four (4) City of Laramie municipal wellfields draw water from the Casper Aquifer in this area. The vast majority of the CAPA is the recharge area for the Casper Aquifer, and consequently, the Casper Aquifer is vulnerable to contamination from land uses in the CAPA. Exposure of the Casper Aquifer in the delineated area results in increased vulnerability to contamination from land uses. In addition to the general vulnerability of the Casper Aquifer in the area where aquifer materials are exposed at the surface, there are specific features that enhance the vulnerability of the aquifer to contamination.

A. Recharge into the Casper Aquifer system occurs rapidly as snowmelt and runoff infiltrates into porous sandstones and fractures that occur in drainages and on the land surface.

B. There is continuous residential and commercial development pressure east of Laramie where the Casper Aquifer is recharged. Development in this area increases the risk of contamination in two ways:

    1. New contamination sources – Homes and businesses are new sources of potential contamination to the aquifer (volatile organic compounds from fuels and solvents, nutrient fertilizers and pesticides from lawn care, nitrates and pathogens from septic leachate).

    2. New contamination pathways – New wells and excavations which weaken the integrity of the confining layer may provide a direct conduit to the Casper Aquifer or reduce the hydraulic barrier provided by the Satanka Shale that overlies the Casper Aquifer.

C. An unknown quantity of hazardous substances is transported along Interstate 80 (I-80) and I-80 transects the Casper Aquifer recharge area.

D. There is the potential for the rapid transport of contaminants in the saturated zone due to a steep hydraulic gradient and enhanced aquifer permeability from fractures, joints, and dissolution features.

E. The recharge area of the Casper Aquifer is in close physical proximity to withdrawal points for Albany County and City of Laramie residents.

The Laramie City Council adopts this ordinance because the Casper Aquifer provides a critical component of the existing and future drinking water supply for City residents – especially in drought conditions. The importance of the groundwater supply component was demonstrated in the summer of 2002 when the Laramie River supply was reduced significantly due to drought and the City had to rely almost exclusively on groundwater.

Section 2.
17.82.020 – Purpose and Intent

Inappropriate development over the Casper Aquifer can deteriorate the quality of the drinking water through the intentional or unintentional release of contaminants which is harmful to the health, safety, and welfare of residents. Therefore, the purpose and intent of this ordinance is to protect the high quality source water in the Casper Aquifer and to decrease the risk of contamination to the Casper Aquifer.

Section 3.
17.82.030 - Definitions

For the purpose of this Aquifer Protection Overlay Zone ordinance, the following words and terms shall have the meanings specified herein.

A. "Aquifer" means a formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield sufficient, economical quantities of water to wells, springs, and drain tunnels.

B. "City" means City of Laramie, Wyoming.

C. "City Council" means the City Council of the City of Laramie, Wyoming.

D. "Commercial" means an activity involving the sale of goods or services.

E. "Commission" means the Planning Commission of the City of Laramie, Wyoming.

F. "County" means Albany County, Wyoming.

G. "Development" means the preliminary and final platting of land, construction, reconstruction, conversion, structural alteration, relocation, or enlargement of any structure; any mine, excavation, landfill; and/or any change in use, or alteration or extension of the use of land**;** excluded from this definition are additions to single-family residences that do not increase the amount of wastewater effluent, above the capacity of the permitted small wastewater system (effluent amount determined by number of bedrooms), residential accessory buildings, construction of a single-family home on an existing lot that will be attached to a municipal or centralized sewer collection line, or construction that does not require a building permit.

H. "Development Department" means the Community Development Department of the City of Laramie, Wyoming.

I. “Hazardous Material” means any: chemical; combustible liquid; compressed gas; explosive; flammable aerosol, gas, liquid or solid; hazardous chemical; health hazard; mixture; organic peroxide, oxidizer; physical hazard; pyrophoric; unstable (reactive) or water reactive, as defined in 40 CFR 302.4 and listed therein Table 302.4 and any other chemical, material or substance identified by the State or the Commission as hazardous based on available scientific evidence but does not include natural gas or propane used to heat homes and businesses or the associated transmission lines. Hazardous materials include, but are not limited to, petroleum products, solvents, oil-based paint, and pesticides.

J. “Home occupation” means a business, profession, occupation or trade conducted for personal gain or support of the residential occupation and conducted within a residential building or accessory structure to a residential use.

K. “Overlay District” means a district that is superimposed over one or more zoning districts or parts of districts and imposes specified requirements that are in addition to those otherwise applicable for the underlying zone.

L. “Person” means and includes any individual, entity or association of individuals or entities of any kind, and includes without limitation, any developer, homeowner's association, group, partnership, limited partnership, corporation, joint venture, joint enterprise, trade association, regulatory government body including the City or any other legal entity.

M. “Potential contaminant” means any substance which may enter the Casper Aquifer and decrease water quality due to its introduction into the Casper Aquifer. Some examples include storm water, petroleum products, medical wastes, pesticides, and sewage effluent.

N. “Vulnerable feature” means any fault, fracture, fold, evidence of conduit flow, perennial drainage, intermittent drainage or ephemeral drainage.

Words that are not defined in this section shall be defined by the Laramie Municipal Code and then the common usage of the word.

Section 4.
17.82.040 - Aquifer Protection Overlay Zone Established and Applicability.

A. An aquifer protection overlay zone (APO zone) has been established within the incorporated City of Laramie, Wyoming and unincorporated area of Albany County. The APO zone is effective inside the City of Laramie corporate limits, as well as the unincorporated area of Albany County, and as delineated in the Casper Aquifer Protection Plan (CAPP) and in the attached map.

B. Delineation of the APO zone shall be as described by the CAPP approved by the City Council on June 3, 2008 and a map of the area has been included as Attachment A. Copies of the illustrations that accompany the CAPP shall be kept in appropriate City offices. All property within Zones 1, 2, and 3 are zoned APO by default.

C. Where the boundary line of the APO zone divides a lot or other parcel of land, the requirements established by this ordinance shall apply only to the portion of the lot or parcel that is located within the APO zone.

D. The establishment of the APO zone and the use of the APO zoned properties in accordance with this ordinance do not relieve any Person from liability provided by law for contamination of the Casper Aquifer. This ordinance does not supersede or modify the requirements of any federal law, state law, or local regulation that has more stringent requirements.

E. Where the bounds of the identified CAPA, as delineated, are in doubt or in dispute, any landowner aggrieved by such delineation may appeal the boundary location to the City Planning Commission. Upon receipt of a written appeal, the City Planning Commission shall suspend further action on development plans related to the area under appeal and shall engage, at the landowner's expense, a qualified hydrogeologist to prepare a report determining the proper location and extent of the Casper Aquifer and recharge area relative to the property in question.

F. Pursuant to W.S. § 15-1-609, the decision of the Planning Commission may be reviewed by the district court in the same manner as provided in Rule 12 of the Wyoming Rules of Appellate Procedure, for review of decisions of boards of adjustment.

G. Applications filed and accepted after the effective date of this ordinance shall meet the requirements of this ordinance.

H. Where this ordinance is less strict or where this ordinance is silent as to a particular issue, developments shall conform to the requirements of the underlying zoning district(s) in which the developments are located.

Section 5.
17.82.050 - Groundwater Monitoring Program Implementation.

The City of Laramie, in cooperation with Albany County, shall implement the groundwater monitoring program as described in the Casper Aquifer Protection Plan and Groundwater Monitoring Program.

Section 6.
17.82.060 - Prohibited Activity.

A. Within the APO zone, the underlying zoning classification shall control all aspects of the property's zoning except that no property may be used for any activities prohibited in sections 17.82.060.B and 17.82.060.C below or otherwise prohibited or limited by operation of this ordinance.

B. No activities are approved in Zone 1 of the APO except natural and undeveloped open space. Zone 1 is delineated as a 100-foot radius from the municipal wells and any historic springs which are associated with the municipal wells and shall include any expansion of Zone 1 hereafter. The existing wellfields include Spur, Turner, Pope, and Soldier. The historic springs protected in Zone 1 are City Springs, Pope Springs, and Soldier Springs. Any future municipal wells shall be included under this section.

C. Each prohibited activity listed in the left column of the Table of Prohibited Activities below is prohibited in the APO Zones 2 and 3. The Table of Prohibited Activities can not and does not include all possible proposed land uses in the APO. Therefore, the City may review all developments for compliance with this ordinance.

Table of Prohibited Activities

Prohibited Activity **The following activities are prohibited in the APO zone:**	**Examples of Prohibited Activities** **The following are examples of businesses or activities which may conduct the prohibited activity.**
1. Activities involving any equipment for the storage or transmission of any hazardous material to the extent that it is not pre-empted by federal law.	Petroleum pipelines or gasoline stations.
2. The discharge to groundwater of any waste product.	Any business or facility.
3. Commercial car or truck washes, unless all waste waters from the activity are lawfully disposed of through a connection to a Publicly Owned Treatment Works or centralized wastewater treatment system.	Car or truck washes, detail shops or car dealership.
4. Commercial and home occupation production or refining of chemicals, including without limitation, hazardous materials or asphalt.	Chemical, petroleum, asphalt or pesticide manufacturer.
5. Commercial and home occupation clothes or cloth cleaning service which involves the use, storage, or disposal of hazardous materials, including without limitation, dry-cleaning solvents.	Dry cleaner.
6. Commercial and home occupation generation of electrical power by means of fossil fuels except generation by means of natural gas or propane.	Fossil-fueled electric power producer.
7. Commercial and home occupation production or fabrication of metal products, electronic boards, electrical components, or other electrical equipment involving the use, storage or disposal of any hazardous material or involving metal plating, metal cleaning or degreasing of parts or equipment with industrial solvents, or etching operations.	Metal foundry, metal finisher, metal machinist metal fabricator, metal plating, electronic circuit board, electrical components or other electrical equipment manufacturer.
8. Commercial and home occupation on-site storage of oil, petroleum or gasoline for the purpose of wholesale or retail sale.	Bulk plant, gasoline station or oil and lube shop.
9. Commercial and home occupation embalming or crematory services which involve the use, storage or disposal of hazardous material, unless all waste waters from the activity are lawfully disposed of through a connection to a Publicly Owned Treatment Works or centralized wastewater treatment system.	Funeral home or crematory.
10. Commercial and home occupation furniture stripping operations which involve the use, storage or disposal of hazardous materials.	Furniture stripper.
11. Commercial and home occupation furniture finishing operations which involve the use, storage or disposal of hazardous materials.	Furniture repair.
12. Storage, treatment, or disposal of hazardous waste.	Hazardous waste treatment, storage or disposal facility.

Prohibited Activity **The following activities are prohibited in the APO zone:**	**Examples of Prohibited Activities** **The following are examples of businesses or activities which may conduct the prohibited activity.**
13. Commercial and home occupation clothes or cloth cleaning service for any industrial activity that involves the cleaning of clothes or cloth contaminated by hazardous material, unless all waste waters from the activity are lawfully disposed of through a connection to a Publicly Owned Treatment Works or centralized wastewater treatment system.	Industrial laundry.
14. Commercial and home occupation of any biological or chemical testing, analysis or research which involves the use, storage or disposal of hazardous material.	Laboratory: biological, chemical, clinical, educational, product testing or research.
15. Commercial and home occupation pest control businesses which involve storage, mixing or loading of pesticides or other hazardous materials.	Lawn care or pest control business.
16. Commercial and home occupation salvage operations of metal or vehicle parts.	Metal salvage yards, vehicle parts, salvage yards or junk yards.
17. Commercial and home occupation photographic finishing which involves the use, storage, or disposal of hazardous materials.	Photographic finishing laboratory.
18. Commercial and home occupation printing, plate making, lithography, photoengraving or gravure, which involves the use, storage or disposal of hazardous materials.	Printer or publisher.
19. Commercial and home occupation pulp production, which involves the use, storage or disposal of any hazardous materials.	Pulp, paper or cardboard manufacturer.
20. Accumulation or storage of waste oil, anti-freeze or spent lead-acid batteries.	Recycling facility which accepts waste oil, spent anti-freeze or spent lead-acid batteries.
21. Commercial and home occupation production or processing of rubber, resin cements, elastomers or plastic, which involves the use, storage or disposal of hazardous materials.	Rubber, plastic, fabric coating, elastomer or resin cement manufacturer.
22. Storage of pavement de-icing chemicals unless storage takes place within a weather-tight waterproof structure.	Salt or de-icing storage facilities.
23. Commercial and home occupation accumulation, storage, handling, recycling, disposal, reduction, processing, burning, transfer or composting of solid waste.	Solid waste facility or intermediate processing center. Landfill or dumps on residential or commercial property (such as cars, appliances, lawn mowers).
24. Commercial and home occupation finishing or etching of stone, clay, concrete or glass products or painting of clay products which involves the use, storage, or disposal of hazardous materials.	Stone, clay or glass products manufacturer.
25. Commercial and home occupation dying, coating or printing of textiles, or tanning or finishing of leather, which involves the use, storage, or disposal of hazardous materials.	Textile mill, tannery.

Prohibited Activity **The following activities are prohibited in the APO zone:**	**Examples of Prohibited Activities** **The following are examples of businesses or activities which may conduct the prohibited activity.**
26. Commercial and home occupations involving the repair or maintenance of automotive or marine vehicles or internal combustion engines of vehicles, involving the use, storage or disposal of hazardous materials, including solvents, lubricants, paints, brake or transmission fluids or the generation of hazardous wastes.	Vehicle service facilities which may include: new or used car dealership, automobile body repair or paint shop, aircraft repair shop, automobile radiator, or transmission repair; small-engine repair; boat dealer; recreational vehicle dealer; motorcycle dealer; truck dealer; truck stop; diesel service station; automotive service station, municipal garage, employee fleet maintenance garage or construction equipment repair or rental.
27. Commercial and home occupation of on-site storage of hazardous materials for the purpose of wholesale or retail sale.	Wholesale trade, storage or warehousing of hazardous substances, hazardous wastes, pesticides, oil or petroleum.
28. Commercial and home occupation production or treatment of wood, veneer, plywood, or reconstituted wood, which involves the use, storage or disposal of any hazardous material.	Manufacturer of wood veneer, plywood or reconstituted wood products.
29. All Underground Injection Control (UIC) wells except Class V subclasses 5B2, 5B3, 5B4, 5B5, 5B6, 5B7, 5E3, 5E4, and 5E5 and Class V subclasses 5A1 and 5A2 , if 5A1 and 5A2 facilities do not use any additives, as defined in WDEQ Chapter 16.	Underground injection control facilities.
30. Water wells which are not capped. Water wells which are not cased at least to the top of the production zone with the annular space sealed from the top of the production zone to the surface, or in accordance with the state engineer's requirements or recommendations, whichever is stricter.	Residential, commercial, or agricultural uses.
31. Application of pesticides and herbicides which do not become non-hazardous within 48 hours of application or which are not applied according to the manufacturer's instructions.	Residential, commercial or agricultural uses.
32. Application of fertilizer at greater than the agronomic uptake rate of the vegetation fertilized.	Residential, commercial or agricultural uses.
33. Commercial and home occupation quarrying and sand and gravel mining unless the operations are conducted pursuant to valid permits issued by the Wyoming Department of Environmental Quality, Bureau of Land Management or other federal or state regulatory agency.	
34. Above ground storage of any hazardous material, including oil and petroleum, unless enclosed in secondary containment as described in Section 17.82.120.D of this ordinance.	Agricultural gasoline storage.
35. Installation and use of on-site wastewater treatment systems or septic-systems.	Residential lots with septic systems or on-site wastewater treatment systems.

Prohibited Activity **The following activities are prohibited in the APO zone:**	**Examples of Prohibited Activities** **The following are examples of businesses or activities which may conduct the prohibited activity.**
36. Commercial and home occupation animal feeding operations where a) animals have been, are, or will be stabled or confined and fed or maintained for a total of 45 days or more in any 12-month period, and b) crops, vegetation, forage growth, or post-harvest residues are not sustained in the normal growing season over any portion of the lot or facility.	Feedlot, concentrated animal feeding operation, stockyards or boarding stable.
37. Commercial and home occupation golf courses or intensely managed turf.	Golf course or driving range.
38. Commercial and home occupation cemeteries.	Commercial cemeteries of all types.

Section 7.
17.82.070 - Vulnerable Features that require a Setback.

A. *Vulnerable features* that require a setback in the Casper Aquifer are:

1. Folds, faults, fractures or other evidence of conduit flow that extend to the ground surface.

2. Perennial, intermittent, and ephemeral drainages.

B. No development shall be approved within the APO until the applicant demonstrates to the City that there is no portion of a vulnerable feature within 100 feet of any point of the proposed development. At a minimum, the certification must include a signed and stamped site-specific investigation, as described in Section 17.82.080 of this ordinance, by a Wyoming licensed professional engineer, geologist, hydrologist or other qualified professional who, by experience and/or by training has the required skills in the areas of groundwater evaluation, geologic formation analysis, and the science of contaminant transport.
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Section 8.
17.82.080 - Site-specific Investigation for All Proposed Developments.

A. A site-specific investigation shall be performed for all developments proposed within the APO Zones 2 and 3. The investigation shall be conducted by a professional engineer or professional geologist who, by experience and/or by training has the required skills in the areas of groundwater evaluation, geologic formation analysis, and the science of contaminant transport.

B. The purpose of the site-specific investigation is to identify, as a minimum, the impacts, if any, of the proposed development(s) on the Casper Aquifer.

C. The site-specific investigation shall describe, to the extent possible given the existing data and site-plan information, the existing conditions, all proposed activities, and all proposed management techniques, including any measures necessary to mitigate risks.

D. The site-specific investigation shall consist of:

1. A literature search to determine the presence of mapped faults, folds, fractures, and other evidence of conduit flow on the subject property.

2. A site narrative that includes historical information on previous land use, contaminant releases, abandoned wells, underground storage tanks, and septic systems as well as any other information relevant to the site.

3. A site plan showing the proposed use and zoning of the property including existing and proposed ground contours accurate to a two-foot interval as referenced to the USGS contour map for the area or other specified elevation standard as required by the City, and for a distance of at least five hundred feet beyond any proposed development activity, existing and proposed structures, parking areas, driveways, landscaping areas, setbacks, surface and subsurface drainage facilities, potential contaminant storage locations and methods of storage, above ground storage tanks, best management practices, utilities, roads, stormwater management, and a vicinity map. Where necessary, specific construction details shall be provided to assure adequacy to accepted design standards.

4. Identification of potential contaminants and amounts stored, generated or handled on the subject property.

5. A field inspection shall be conducted to verify the presence or absence of vulnerable features as defined in Section 7.82.070.A. A summary of the field inspection shall include a written report, maps identifying the vulnerable features, and the distance and direction of the nearest well and vulnerable feature. Where subsurface wastewater disposal is proposed, the investigator shall conduct deep pit soil analysis to a depth at least five feet below the proposed bottom of the leaching system to establish that there are no obstructions such as bedrock, water table or other forms of refusal that could interfere with the proper functioning of the wastewater disposal system.

6. A map showing the area and types of exposed bedrock, marshes, perennial drainages, intermittent drainages, ephemeral drainages, creeks, and other bodies of water on the subject property.

7. Where the 100-year flood plain mapping is unavailable, the professional geologist and/or engineer will calculate the 100-year flood plain for the drainage. The flood plain mapping will be provided on a site map with a scale not to exceed 1 inch equals 200 feet.

8. An evaluation of the water supply and sewage system that includes the potential effects or risks of the systems to the Casper Aquifer and its recharge area and the adequacy and safety of the systems. Items such as floor drains and plumbing schematics and the locations of potential contaminants, waste storage, and liquid transfer area locations shall be provided.

9. A map(s) depicting the potentiometric surface of the Casper Aquifer at the subject property using data from historical water level measurements and published potentiometric surface maps. No new wells shall be drilled for the purpose of determining the potentiometric surface.

10. A surface water risk assessment and mitigation plan for any impacts caused by storm water runoff, retention and/or detention basins on the City water supply and the Casper Aquifer.

11. A maintenance plan and agreement for any retention and/or detention basins and associated improvements will be required. Such plan and agreements shall be recorded in the Albany County Clerk's Office.

12. A groundwater risk assessment and mitigation plan to respond to any evidence of contamination or vulnerability which is the result of the development. Such plan shall not limit the liability of any Person for impacts to the Casper Aquifer.

13. Demonstration of compliance with all applicable City Standards.

Section 9.
17.82.090 - Conditions of Approval for Development in the Aquifer Protection Overlay Zone.

A. No development shall be permitted in the APO zone unless the effects of such development meet the following criteria.

1. The proposed type of development and area in which the development is proposed meets the standards of this ordinance.

2. No vulnerable feature, as defined in Section 17.82.070.A exists within 100 feet of the proposed development.

3. A site-specific investigation, as defined in Section 17.82.080 has been performed for the property and a written report, including maps, of the site-specific investigation has been submitted to the City.

4. A professional engineer (the City Engineer or other licensed professional engineer), geologist, hydrologist, or other qualified designee who, by experience and/or by training has the required skills in the areas of groundwater evaluation, geologic formation analysis, and the science of contaminant transport, other than the professional that performed the site-specific investigation, must review the site-specific investigation and verify that the proposed development meets the requirements of this ordinance. If review of the site-specific investigation is conducted by anyone other than the City Engineer, the City may be reimbursed for the cost of the review.

   In review of the site-specific investigation, the qualified professional will assess and determine whether the site and development plans meet the overall objectives of the Casper Aquifer Protection Plan and this ordinance.

B. The City may attach conditions of approval to ensure the protection of the groundwater quality, including, but not limited to, further evaluation, reasonable technical improvements, monitoring or other mitigation measures. All conditions of approval shall be reviewed and evaluated by the professional engineer, geologist, hydrologist, or other qualified designee who reviews the site-specific investigation to ensure that the condition(s) of approval are of sound scientific and technical reasoning.

Section 10.
17.82.100 - Design Standards for On-Site Wastewater Treatment System/Septic Systems.

A. No new septic systems shall be permitted within the APO zone.

B. Installation, design, repair, and removal of septic systems located within the APO zone must be in accordance with plans and specifications prepared by and certified by a professional engineer skilled in the science of wastewater disposal and licensed to practice in the State of Wyoming. This ordinance does not grant the right to install a septic system or on-site wastewater treatment system otherwise forbidden by City regulations.

C. Each existing septic system shall be pumped to prevent solids, oils, and grease from building up to a level in the tank where these materials will begin washing out to the leach field and clogging the field lines. Pumping shall occur not less than every five years or on a schedule as otherwise recommended by a City licensed wastewater system pumper/hauler. A database regarding the septic systems and their pumping and inspection schedules will be maintained and updated by the City GIS to maintain records and track schedules, which information shall be made available to the County.

D. Each existing septic system and leach field within the APO shall be inspected by the City Engineer or other City qualified designee skilled in the science of wastewater disposal.

1. During installation of replacement system, before backfilling; and

2. At least once every three years.

E. If upon inspection a septic system is found to be inadequately designed or constructed to serve the use for which it is intended, without undue risk to the Casper Aquifer, it shall not be used for the disposal of wastewater until it is cleaned, repaired or otherwise made to operate properly or replaced.

Section 11.
17.82.110 - Connection to Municipal or District Sewage Collection Lines.

A. For properties within the APO zone no private on-site wastewater treatment system may be used after the earlier of:

1. One year after installation of a municipal sewer collection line in a right of way or easement that is contiguous to the property on which the system is location; or

2. One year after the inclusion of the property containing the on-site system in a district connected to the City of Laramie's wastewater treatment system or another wastewater treatment facility and if the sewage collection line is in a right of way or easement that is contiguous to the property.

B. This section shall be consistent with the provisions within the existing City of Laramie - Albany County 201 Wastewater Agreement. If there is a disagreement between this ordinance and the 201 Wastewater Agreement, the stricter of the two shall apply.

Section 12.
17.82.120 - Pre-Existing Nonconforming Uses.

Pre-existing nonconforming uses within the APO zone are subject to the terms of this ordinance and to other general ordinance provisions on pre-existing nonconforming uses.

A. A pre-existing nonconforming use is a use prohibited by this regulation but which is in place upon property included in the APO zone as of the date the property was included in the APO zone. That date may be the effective date of this ordinance or the date a use becomes nonconforming because of an amendment to this ordinance. Septic systems and other on-site wastewater treatment systems are controlled by this ordinance and are not subject to these provisions on pre-existing nonconforming uses.

B. Pre-existing nonconforming uses may continue in the same location they were in when they became nonconforming uses, but shall not be expanded in size or scope. Pre-existing nonconforming uses which are damaged may be repaired and resumed at the same location, size, and scope, provided that after repairs are complete, the best available control technology shall be in place to prevent contact between hazardous materials and the surface of the ground or groundwater.

C. A pre-existing nonconforming use may be expanded under these conditions.

1. All provisions in Section 17.82.080 and Section 17.82.090 are met.

2. The expansion does not increase the risk of contamination of the Casper Aquifer.

3. Control technology built in to the expansion will prevent any increased risk to the Casper Aquifer because:

   a. Substitution is made of one hazardous material for another provided the substituted material is used for the same function and in equal or lesser amounts as the original material;

   b. Substitution of equipment or process for equipment or process provided that the substituted equipment or process performs the same function as the original equipment or process, without increasing the storage volume of hazardous materials stored at the subject business or facility;

   c. Expansion of wholesale or retail sales volume which increases the use of hazardous materials but which does not increase the storage capacity for hazardous material; and

   d. Initiation at the subject facility or business of an activity that is not a prohibited activity.

D. Every pre-existing nonconforming use shall:

1. Store hazardous material in an enclosed structure or under a roof which eliminates storm water entry to the containment area;

2. Provide floors within a structure where hazardous material is stored, coated to protect the surface of the floor from deterioration due to spillage of any such material. A structure which may be used for storage or transfer of hazardous material shall be protected from storm water run-on and ground water intrusion;

3. Store hazardous material within an enclosed impermeable containment area which is capable of containing at least the volume of the largest container of such hazardous material present in the area or 110% of the total volume of all such containers in the area, whichever is larger, without overflow of released hazardous material from the containment area;

4. Store hazardous material in a manner that will prevent the contact of chemicals with any materials so as to create a hazard of fire, explosion or generation of toxic substances;

5. Store hazardous materials only in containers that have been certified by a state or federal agency or the American Society of Testing Materials as suitable for the transport or storage of the material;

6. Store all hazardous material in an area secured against entry by the public, except items offered for retail sale in their original unopened containers;

7. Not use, maintain or install floor drains, dry wells or other infiltration devices or appurtenances which allow the release of wastewater to the ground water; and

8. Not discharge any substance or material to the ground in the APO zone unless the discharge is permitted by law.

E. These requirements are intended to supplement, and not to supersede, any other applicable requirements of federal, state or local law.

Section 13.
17.82.130 - Proper Plugging and Abandonment of Unused Wells.

All wells, including but not limited to groundwater pumping wells and monitoring wells, that are no longer in use by the owner must be properly plugged and abandoned in accordance with Chapter 11, Section 70, Part G of the Wyoming Department of Environmental Quality Rules and Regulations.

Section 14.
17.82.140 - Exception From 100-feet Setback from Vulnerable Features for Infrastructure.

The construction of sewer and water lines that are attached to either a centralized wastewater or water system or the City of Laramie's Wastewater or Water system, may be installed within the APO in order to protect water quality. Sewer lines shall be engineered in such a way as to limit the possibility of an undetected leak; this may include double walled pipes and regular pressure testing or other engineering techniques and leak detection systems that reduce the possibility of undetected leaks. Exceptions also include other general utilities used specifically to serve local developments such as electric lines, gas lines for heating, cable television, and telephone lines. Roads may also be excepted if appropriate stormwater drainage and management is included.

Section 15.
17.82.150 - Existing Law on Aquifer Contamination Unaffected.

The establishment of the APO zone, and the use of APO-zoned properties in accord with this ordinance, does not relieve any Person from liability provided by law for contamination of the Casper Aquifer. This ordinance does not supersede or modify the requirements of any federal, state or local law which makes stricter requirements.

Section 16.

17.82.160 - Severability.

The provisions of this ordinance are severable. If any provision is declared to be invalid or unenforceable by any court of competent jurisdiction, those provisions not so declared shall remain in effect.

Section 17.
17.82.170 - This ordinance is effective immediately upon publication.

PASSED AND APPROVED this ________ day of __________, 2008.

____
Klaus Hanson,
Mayor and President
Laramie City Council, Laramie, Wyoming

ATTEST:

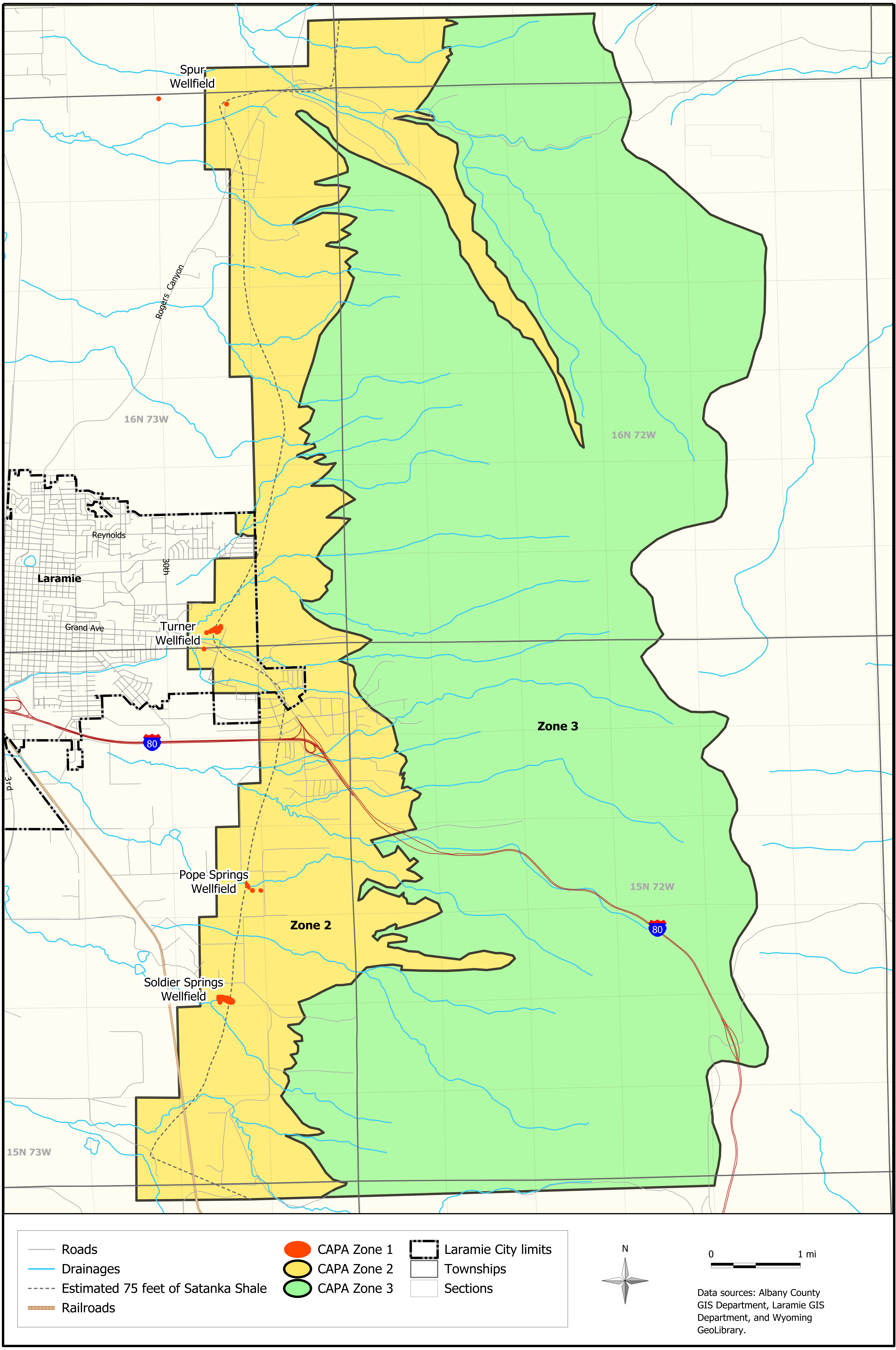
____
Sue Morris-Jones, CMC
City Clerk

Work Session:	February 25, 2008
1st reading:	March 4, 2008
Public hearing:	March 25, 2008
2nd reading:	May 20, 2008
3rd reading:	June 3, 2008

Duly published in the Laramie Daily Boomerang this ________day of _________, 2008

ATTACHMENT A

Map of the Casper Aquifer Protection Area



Attachment A. Casper Aquifer Protection Area (CAPA) boundaries and zones.

APPENDIX I

Septic System Treatment Documentation

SepticSmart Dos and Don’ts for an Advanced Treatment Unit (ATU)

septicsmart
U.S. Environmental Protection Agency

What is an ATU?

Advanced Treatment Units (ATUs), referred here to as an individual residential system, are small biological treatment systems used to treat wastewater to a higher degree than a traditional septic system.

Why would I need or want an ATU versus a traditional septic system?

ATUs are used in many states to achieve a higher-quality wastewater than what exits traditional septic tanks. In fact, they are necessary in some areas — either because of the sensitivity of the environment, or because of site conditions. ATUs are also designed to reduce nutrient loadings, whereas traditional septic systems are not.

What is the required maintenance?

As with all septic systems, an ATU’s proper functioning relies on regular maintenance. Due to its advanced components, an ATU needs more maintenance than a traditional septic system.

To ensure proper functioning, most states require annual operation, maintenance, monitoring and reporting as a requirement of the homeowner’s septic permit. A maintenance provider should perform these services. Contact the ATU manufacturer for information on maintenance providers. The ATU manufacturer trains maintenance providers to assure they are familiar with the manufacturer’s treatment system.

In addition to the *Dos and Don’ts of Septic Systems*, ATUs have some additional dos and don’ts because of their advanced parts.

Follow Septic Sam’s ATU dos and don’ts:

Don’t:

- Turn off any air supply device, alarm or electrical component of the system.
- Bypass the system.
- Modify, cover or move any system components without prior approval from the service provider.
- Pump the ATU without service provider approval or supervision.

Do:

- Use soaps and detergents that are low-suds, biodegradable, and low- or phosphate-free.
- Fix leaky fixtures.
- Use low-flow fixtures.
- Dispose of unused medications in the garbage.
- Substitute liquid fabric softener with dryer sheets.

For more SepticSmart tips, visit **www.epa.gov/septic**

EPA EPA-832-F-14-008 • September 2014

BAY RESTORATION FUND RANKING DOCUMENTATION December 1, 2021

VENDOR IN ASCENDING ORDER	COST OF PURCHASE, INSTALLATION AND 2 YEAR OPERATION MAINTENANCE	VERIFIED BY
Fuji Clean CEN5	$12,244	Vendor
Singulair TNT	$13,383	Vendor
Singulair Green	$13,542	Vendor
AquaKlear AK6S245	$13,592	Vendor
BioMicrobics RetroFast**	$14,109	Vendor
Hydro Action AN series	$15,104	Vendor
Fuji Clean CEN 7	$16,140	Vendor
Hoot BNR	$17,426	Vendor
SeptiTech M400D	$17,794	Vendor
AdvanTex AX20	$18,560	Vendor
Advantex AX20RT	$21,130	Vendor

All prices are Estimate Averages across Maryland and subject to change per county, contact Manufacturer.

The BRF Program no longer funds the non field verified systems for installation.

Price does not include electrical costs per year.

** RetroFast unit limited to households of 1-4 occupants with 3 bedrooms or less. Price includes use of new tank. For use of existing tank, manufacturer must certify tank suitable and watertight.

VENDOR IN DESCENDING ORDER	MEAN % REDUCTION TN (Using 60mg/L influent)	MEAN EFFLUENT CONCENTRATION	VERIFIED BY
Fuji Clean CEN 5	77%	14.1 mg/L	MDE
Fuji Clean CEN 7	77%	14.1 mg/L	MDE
Advantex AX20RT	76%	14.5 mg/L	MDE
AdvanTex AX20	71%	17 mg/L	MDE
SeptiTech M400D	67%	20 mg/L	MDE
Hydro Action AN series	66%	20.3 mg/L	MDE
Hoot BNR	64%	21 mg/L	MDE
BioMicrobics RetroFast**	58%	25.4 mg/L	MDE
Singulair Green	55%	27 mg/L	MDE
Singulair TNT	55%	27 mg/L	MDE
AquaKlear AK6S245	54%	27.5 mg/L	MDE

As the data for non-field verified systems is incomplete, MDE has classified the % reduction of TN and the Price per Pound of N Reduced for non-field verified systems as Deliberative Data.

** RetroFast unit limited to households of 1-4 occupants with 3 bedrooms or less.

VENDOR IN ASCENDING ORDER	PRICE PER POUND OF N REDUCED	VERIFIED BY
Fuji Clean CEN 5	$79.41	MDE
Fuji Clean CEN 7	$91.03	MDE
Hydro Action AN series	$100.50	MDE
AquaKlear AK6S245	$106.68	MDE
AdvanTex AX20	$109.19	MDE
Singulair TNT	$110.31	MDE
Singulair Green	$111.49	MDE
BioMicrobics RetroFast**	$113.94	MDE
Advantex AX20RT	$115.91	MDE
Hoot BNR	$118.84	MDE
SeptiTech M400D	$124.16	MDE

Price per pound of N reduced equals [((Price of technology plus (increased electrical costs multiplied by Ten))divided by Ten] divided by (24.32 lbs of N per year multiplied by percent reduction of N by system)

As the data for non field verified systems is incomplete, MDE has classified the % reduction of TN and the Price per Pound of N Reduced fornon field verified systems as Deliberative Data.

** RetroFast unit limited to households of 1-4 occupants with 3 bedrooms or less.

VENDOR IN ASCENDING ORDER	OPERATION AND MAINTENANCE PER YEAR AFTER THE 2 YEAR CONTRACT	MINIMUM NUMBER OF SITE VISITS PER YEAR*	VERIFIED BY
AdvanTex AX20	$225.00	1	Vendor
Advantex AX20RT	$225.00	2	Vendor
Fuji Clean CEN 5	$225.00	2	Vendor
Fuji Clean CEN 7	$225.00	2	Vendor
AquaKlear AK6S245	$250.00	1	Vendor
BioMicrobics RetroFast**	$275.00	1	Vendor
SeptiTech M400D	$275.00	1	Vendor
Hoot BNR	$325.00	1	Vendor
Singulair TNT	$325.00	2	Vendor
Singulair Green	$325.00	2	Vendor
Hydro Action AN series	$300.00	2	Vendor

All prices are estimates and based on the 2-yr O&M BAT bid submitted to the State. Some prices have been rounded.

Prices are subject to change and may vary based on location. Contact manufacturer for O&M price details.

* Based off manufacturer-required service visits per year

Additional Charges may apply with certain manufacturers. It is the responsibility of the homeowner to contact the manufacturer for precise details of contract.

VENDOR IN ASCENDING ORDER	1 YEAR ELECTRICAL CONSUMPTION (represented as kWh/year)	INCREASED ELECTRICAL COSTS PER YEAR ASSUMING $0.14 PER kWh	VERIFIED BY
Advantex AX20RT	210.2 kWh/year	$29.43	OSET NTP
AdvanTex AX20	210.2 kWh/year	$29.43	OSET NTP
AquaKlear AK6S245	298.7 kWh/ year	$41.82	Vendor
Fuji Clean CEN 5	446.7 kWh/year	$62.54	Manufacturer
Fuji Clean CEN 7	648.2 kWh/year	$90.75	Manufacturer
Hydro Action AN series	734.26 kWh/year	$102.80	Pump Manufacturer
Hoot BNR	765.77 kWh/ year	$107.21	NSF International
Singulair TNT	979.66 kWh/ year	$137.15	NAT Testing Lab
Singulair Green	979.66 kWh/year	$137.15	NAT Testing Lab
BioMicrobics RetroFast**	1401.6 kWh/year	$196.22	Pump Manufacturer
SeptiTech M400D	1741.05 kWh/year	$243.75	Vendor

$0.14 is an assumed average kW/h rate for Maryland 2021.

** RetroFast unit limited to households of 1-4 occupants with 3 bedrooms or less.

HydroAction utilizes a mixer pump during start up. Pump use is discontinued after start up. Usage data will vary after start-up period.

For a list of vendors visit: https://mde.maryland.gov/programs/Water/BayRestorationFund/OnsiteDisposalSystems/Documents/BAT_CLASS_I.pdf

Before selecting a technology for use on the property in question, please contact each vendor to verify the information is current and accurate. MDE is only a facilitator in presenting this information in accordance with HB347. MDE strongly advises that the applicant contact the vendor directly for more information.

Please contact the county Environmental Health Division for specific process on submitting an application

For a list of county contact information, 410-537-3599

Please contact the Maryland Department of the Environment for specific questions regarding becoming a Best Available Technology in Maryland.

For MDE contact information, 410-537-3599

RED Font = Technologies that have successfully completed Maryland's Bay Restoration Fund Field Verification process.

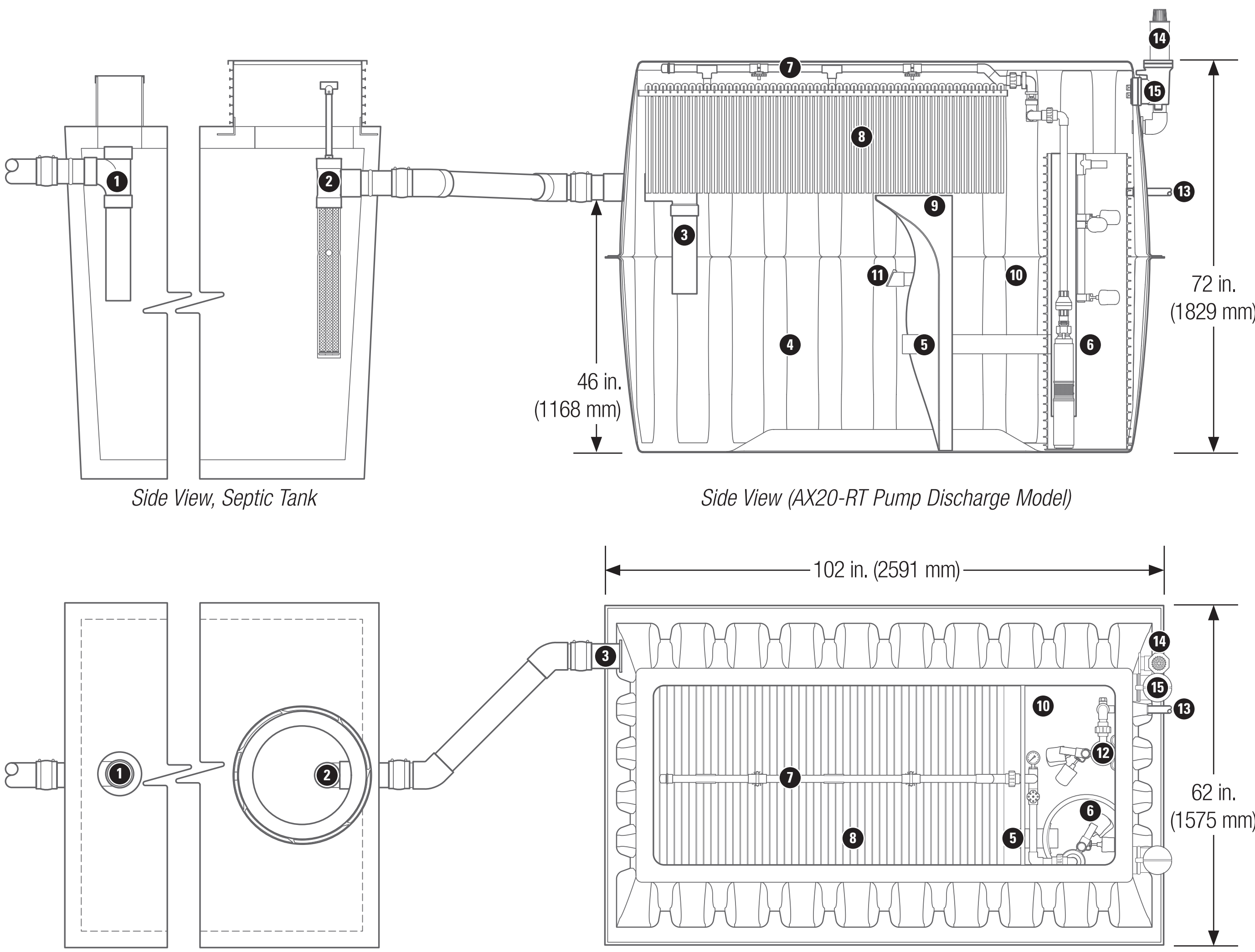
AdvanTex® AX-RT Treatment Systems

For Single-Family Home Applications

System Description

The AdvanTex® Treatment System is a multiple-pass, packed-bed aerobic wastewater treatment system specifically designed and engineered for long-term processing of residential strength wastewater. The treatment media is an engineered textile, which has an extremely high void capacity, moisture-holding capacity, and surface area per unit volume. Consequently, AdvanTex Treatment Systems are capable of processing residential strength wastewater to better than "secondary standards." Figure 1 shows a basic overview of the AX-RT Treatment System.

Figure 1. AdvanTex® AX-RT Functional Areas, Components, and Selected Dimensions (AX20-RT Shown)



1. Septic Tank Inlet Tee
2. Biotube® Effluent Filter
3. AX-RT Inlet and Tee
4. Treatment Tank (Recirc/Blend Chamber)
5. Recirc-Transfer Line
6. Recirc Pumping System
7. Manifold and Spin Nozzles
8. Textile Media
9. Tank Baffle
10. Treatment Tank (Recirc/Filtrate Chamber)
11. Recirc-Return Valve
12. Discharge Pumping System
13. AX-RT Outlet
14. Passive Air Vent
15. Splice Box
16. Control Panel (Not Shown)

Treatment Process

AdvanTex AX-RT Treatment Systems use the same recirculating textile filter technology as Orenco's AdvanTex AX20 textile filter, but they combine the textile filter media, recirculation tank and discharge pump system into a single, shallowly buried unit. The AX20-RT is designed to provide treatment for homes with 1-4 bedrooms and the AX25-RT is designed to provide treatment for homes with 5-6 bedrooms. Figure 2 shows a standard flow path for the AX-RT.

Here's how it works: raw sewage enters the septic tank through its inlet tee. In the septic tank, the raw sewage separates into three distinct zones — a scum layer, a sludge layer, and a clear zone. Effluent from the clear layer passes through a Biotube® effluent filter and is discharged by gravity to the recirc/blend chamber of the AX-RT unit. The effluent then flows through the recirc transfer line to the recirc pumping system.

The recirculation pump is timer-controlled to ensure that small, intermittent doses (micro-doses) of effluent are applied to the textile sheets throughout the day. This ensures an aerobic, unsaturated environment for optimal treatment to occur. A manifold with distribution nozzles distribute the effluent evenly over the textile.

The effluent then percolates down through the textile sheets and is distributed between the recirc/blend and recirc/filtrate chambers by means of a tank baffle that separates the unit into different sections. The textile material is suspended from the top of the treatment unit, with a portion of the media positioned over the recirc/blend chamber. The remainder of the media is positioned over a recirc/filtrate chamber that is separated from the recirc/blend chamber by a baffle, and from which filtrate (treated effluent) is discharged.

The baffle is fitted with a recirc-return valve for equalization during low-flow periods. Under low daily flow conditions, the valve allows 100% of the filtrate to be returned to the recirc/blend chamber for continued recirculation. The recirc-return valve is similar to a check valve in that it allows preferential flow in one direction only — in this case, from the recirc/filtrate chamber to the recirc/blend chamber.

The recirc-return valve closes when the liquid head on the recirc/blend side is equal to or greater than the liquid head on the recirc/filtrate side. When the liquid head on the recirc/filtrate side is higher, the pressure differential pushes the recirc return valve open for filtrate to pass back to the recirc/blend side of the baffle, thus providing for continued recirculation during periods of low or no inflow. Flow from the recirc/blend chamber can pass to the recirc/filtrate chamber only through the treatment media.

System Requirements

Residential Strength Wastewater

Residential wastewater must meet the criteria listed in Table 1. Consult Orenco or your AdvanTex Dealer for larger treatment system designs or for designs with higher-strength influent.

Table 1. Residential Strength Wastewater (Septic Tank Effluent Characteristics)[1]

Characteristic	Average (mg/L)	Weekly Peak (mg/L)	Rarely Exceed (mg/L)
$CBOD_5$	130	200	300
TSS	40	60	150
TKN	65	75	150
G&O	20	25	25

[1] Maximum allowable wastewater strength into AdvanTex Treatment System is "Residential Strength Wastewater." Residential strength wastewater is defined as primary sewage effluent from a septic tank that does not exceed the above parameters.

1. Filtered effluent from the septic tank flows into the recirc/blend chamber of the AX-RT Treatment Unit.
2. Effluent from the recirc/blend chamber flows through the recirc transfer line into the recirc pump vault.
3. The recirc pumping system pumps effluent into the manifold and out through the spin nozzles where it is applied to the textile media.
4. Effluent percolates through the textile media and is split by the tank baffle between the recirc/blend chamber and the recirc/filtrate chamber.
5. The recirc-return valve allows one-way flow from the recirc/filtrate chamber to the recirc/blend chamber during low-use periods.
6. Treated effluent is discharged via gravity or discharge pumping system from the recirc/filtrate chamber.

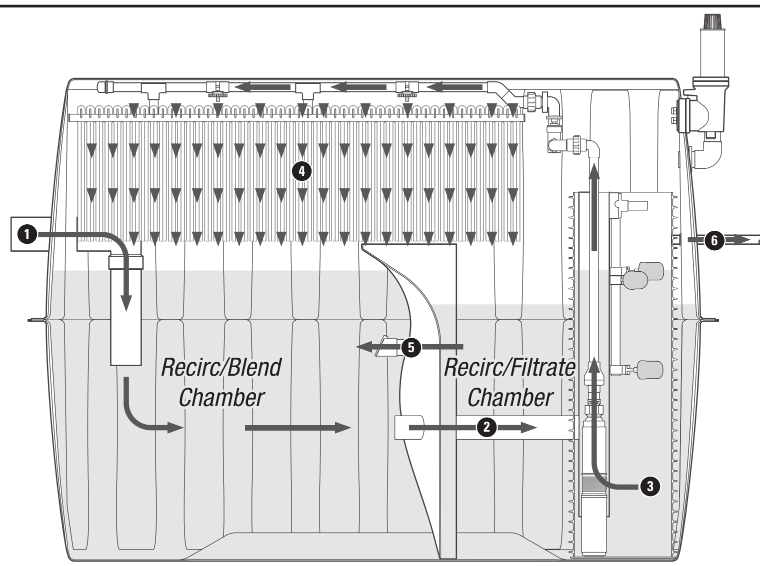


Figure 2. AdvanTex AX-RT Treatment Path and Process (AX20-RT Pump Discharge Model Shown)

Septic Tank

The septic tank preceding an AX-RT unit requires a minimum usable volume of 1000 gallons (3800 liters) for the AX20-RT and 1250 gallons (4732 liters) for the AX25-RT; it must also incorporate an effluent filter at its outlet. All septic tanks must meet Orenco's minimum structural requirements, be completely watertight, and pass a watertight test including the riser/tank connection. The septic tank should include an at-grade access, with a securable and removable lid to allow access to the effluent filter and inlet tee of the tank. For detailed specifications, see structural and watertightness criteria in Orenco's *General Specifications*, NSP-EFS-SPEC-1; *Acknowledgment of Minimum Tank Requirements — AX-RT*, SLD-TNK-SPEC-2; and the tank specifications checklist in Orenco's *Concrete Tank Questionnaire*, NCL-TNK-TNK-1.

The invert of the inlet on the AX-RT is 26 inches (660 millimeters) below the top of the unit and 46 inches (1168 millimeters) above the bottom of the unit. The top of the AX-RT unit should be 2 inches above final grade. A minimum slope of 1⁄8 inch per foot (10 millimeters per meter or 1%) from the outlet of the septic tank to the inlet of the AX-RT is required for all septic tanks that will flow via gravity to an AX-RT unit.

For existing tanks that are buried too deep to provide sufficient fall to the AX-RT, a grade ring can be installed on the AX-RT unit to allow for deeper burials. In extreme cases, a pumping system may need to be installed in the septic tank to move the filtered effluent to the AX-RT unit. (Contact Orenco for design assistance.)

Water softener backwash from a salt-type water softener must not be plumbed into the septic tank or AX-RT unit, as this will void the system's warranty. See the Orenco white paper, *Water Softeners and Wastewater Treatment Systems*, CWP-SOFT-1, for more information.

Biotube Effluent Filter

An Orenco Biotube® effluent filter is required to be installed on the septic tank outlet preceding an AX-RT Treatment System. The effluent filter should have a minimum surface area of 5 ft^2 (0.46 m^2). Any of the following Orenco effluent filters can be used: FT0822-14B, FTW0444-36V, or FTS0444-36V.

Recirc Pumping Equipment

The AX-RT Treatment Unit includes an Orenco recirculation pumping system, consisting of an Orenco multi-stage effluent pump and a float switch assembly, housed in an integral pump vault.

Design Loading Rates

Orenco's suggested design loading rates are based upon the average influent strength characteristics shown in Table 1 and occupancy or typical per capita flow rates (50-60 gpd/person or 189-227 L/day/person) as shown in Table 2.

The information in Table 2 is based on a mean hydraulic loading rate of 29.1 gpd/ft^2 (1184 L/m^2/day) for all residential AX-RT units. The nominal hydraulic loading rate is 25 gpd/ft^2 (1019 L/m^2/day).

Table 2. Treatment Unit Recommendations

Number of Bedrooms	Number of Occupants	Septic Tank Size, gal. (L)	AX-RT Model
1-4	8	1000 (3800)	AX20-RT
5	10	1250 (4732)	AX25-RT
6	12	1500 (5678)	AX25-RT

In jurisdictions where the nominal hydraulic loading rate does not exceed 500 gpd (2000 L/day), a single AX20-RT unit may be used as long as the system's anticipated treatment levels (see Figure 3) meet local requirements. For homes with more than 6 bedrooms or homes that are larger than 5000 ft^2 (465 m^2), contact Orenco.

Peak hydraulic loading rates may reach 1000 gpd (3785 L). Hydraulic loading rates may need to be adjusted to compensate for high organic or nitrogen influent concentrations.

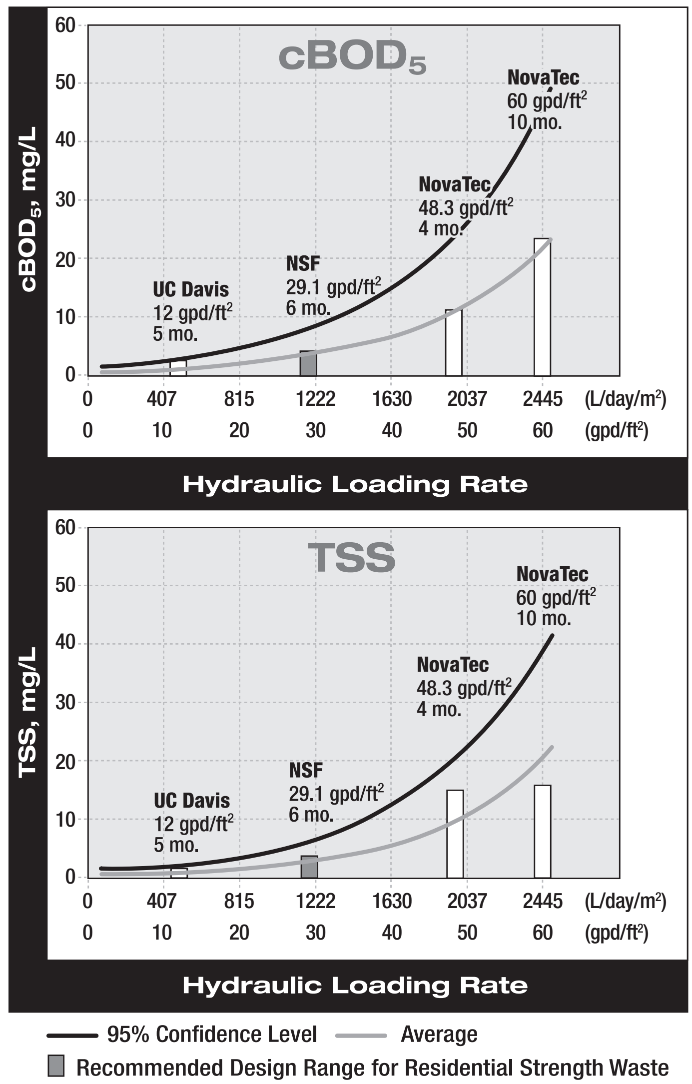


Figure 3. Effluent Quality vs. Hydraulic Loading Rates Third Party, NSF/ANSI Standard 40 Testing Results

Performance is a function of the expected typical loads with periodic weekly highs. Typically, the daily mass loading is based on the expected daily flows and actual strength. Orenco's AX-RT units are listed as NSF/ANSI Standard 40 Class I Treatment Units and are suitable for residences with up to 6 bedrooms. For applications with more than 6 bedrooms, contact Orenco.

Manifold Pressures

A manifold pressure of 3 to 3.5 psi (20.7 to 24.1 kPa) is used to determine the initial timer settings. Orenco Spin Nozzles typically operate at a flow rate of about 6 gpm (0.38 L/sec.) The AX20-RT and AX20-RTUV Treatment Units have two nozzles on the manifold; AX25-RT Treatment Units have three nozzles on the manifold.

Table 3. Recommended Timer Settings for New Systems

Models AX20-RT, AX20-RTUV	Number of Residents	Time On Setting Min (Sec)	Avg Daily Flow gpd (L/day)	Time Off Setting Min
	2	0.8 (45)	100 (379)	30
	3	0.8 (45)	150 (568)	20
	4	0.8 (45)	200 (757)	15
	5	0.8 (45)	250 (946)	15
	6	0.8 (45)	300 (1136)	10
	7	0.8 (45)	350 (1325)	10
	8	0.8 (45)	400 (1514)	8
Model AX25-RT	**Number of Residents**	**Time On Setting Min (Sec)**	**Avg Daily Flow gpd (L/day)**	**Time Off Setting Min**
	2	1.0 (60)	100 (379)	40
	3	1.0 (60)	150 (568)	30
	4	1.0 (60)	200 (757)	20
	5	1.0 (60)	250 (946)	15
	6	1.0 (60)	300 (1136)	15
	7	1.0 (60)	350 (1325)	10
	8	1.0 (60)	400 (1514)	10
	9	1.0 (60)	450 (1703)	8
	10	1.0 (60)	500 (1893)	8
	11	1.0 (60)	550 (2082)	7
	12	1.0 (60)	600 (2271)	7

• *Assumes water usage of 50 gal. (190 L) per person per day and a return recirculation ratio of 3:1. (Filter recirculation ratio of 4:1.)*

• *Override OFF cycle time is set at one-half of the OFF cycle time. Override ON cycle time is set the same as the ON cycle time.*

Recirculation Ratios and Timer Settings

Initial timer settings for an AX-RT should be established based upon expected average daily flows and a recirculation ratio of 4:1 (filter recirculation ratio). Table 3 provides recommended timer settings. If flows vary significantly from expected flows, timer settings should be adjusted accordingly. Contact Orenco for more information.

AdvanTex Control System

Critical to the success of the AdvanTex Treatment System is the method by which the effluent is loaded onto the textile sheets. Over the past three decades, timer-controlled applications have played an essential role in optimizing the performance of both fixed and suspended-growth biological systems. A timer-controlled pump in the treatment tank periodically doses effluent to the distribution manifold over the textile sheets. The effluent then percolates through the textile media and is treated by naturally occurring microorganisms that populate the filter. During periods of high flow, a timer override float will temporarily modify the timer settings to process the additional flow. Conversely, during periods of low flow, the timer settings can be modified to reduce loading onto the filter.

AdvanTex Treatment Systems are paired with Orenco's VeriComm® control panels. (MVP control panel option available.) VeriComm is a Web-based monitoring system that monitors the AdvanTex system 24 hours per day, seven days per week. It provides an automatic alarm communication, an escalating alarm response process, and a secure, password-protected Web site.

Key functions of the VeriComm Monitoring System include:

- Automatic notification of alert and alarm conditions for service providers
- Self-adjustment based on trend data of system use, compensating for greater-than-average and less-than average flows
- Remote adjustment of settings
- Standard monthly call-in to Web site under normal operation

Typical Effluent Quality

Effluent quality is dependent on several factors, including influent characteristics and loading rates. Figure 3 shows third party, NSF/ANSI Standard 40 testing results. The results demonstrate that moderate loading rates typically produce $CBOD_5$ and TSS of about 5 mg/L average, while higher loading rates produce $CBOD_5$ and TSS in the range of 15-25 mg/L.

Field testing of systems in real-world conditions shows similar results, with $CBOD_5$ and TSS of <10 mg/L. (See *AX Performance Summary*, AHO-ATX-PERF-1.)

Nitrogen reduction in standard AX-RT systems will typically exceed 60%, with total nitrogen (TN) in the filtrate ranging between 20-35 mg/L. Nitrogen reduction in AX-RT systems configured for enhanced nitrogen reduction can reach 70% or better (TN 20 ±), depending on wastewater strength and other characteristics such as grease and oils, pH, and alkalinity concentrations.

Nitrification can be inhibited if the buffering capacity (alkalinity) of the wastewater is too low. Theoretically, 7.14 mg/L of alkalinity as $CaCO_3$ is needed to nitrify 1 mg/L of NH_4^+. (See *AX Performance Summary - Nutrient Reduction*, AHO-ATX-PERF-TN-1.) Where nitrogen limits are more restrictive than 20 ppm TN, a lower loading rate has to be used.

Discharge Equipment

Treated effluent can be discharged to the drainfield by means of a discharge pump system or by gravity discharge.

Gravity Discharge to Final Dispersal

AX-RT units with a gravity outlet simply discharge when the level of treated effluent in the recirc/filtrate chamber is at the level of the outlet.

The invert of the outlet at the wall penetration is located 40½ inches (1013 mm) below the top of the unit and 31½ inches (800 mm) above the bottom of the unit. The invert of the outlet inside of the unit is 37 inches (940 mm) below the top of the unit and 35 inches (889 mm) above the bottom of the unit.

Pump Discharge to Final Dispersal

For sites where gravity discharge is not an option, an Orenco pumping system is incorporated into the recirc/filtrate chamber of the AX-RT unit. The "High Level Alarm" and "ON" floats for the discharge pump are factory-set and are non-adjustable. Discharge dose volume is determined by adjustments to the "OFF" float.

Tables 4a and 4b show discharge dose volumes for AX-RT Treatment Systems.

Table 4a. Discharge Dose Volumes: AX20-RT & AX25-RT

Pump Model gpm (L/sec)	Factory Float Setting in. (mm)	Lowest "Off" Setting in. (mm)	Maximum Dose Volume gal. (L)
PF1005, 10 (0.6)	31 (787)	16 (406)	156 (591)
PF2005, 20 (1.3)	31 (787)	18 (457)	139 (526)
PF3005, 30 (1.9)	31 (787)	20 (508)	123 (466)
PF5005, 50 (3.2)	31 (787)	24 (610)	90 (341)

Table 4b. Discharge Dose Volume: AX20-RTUV

Pump Model, gpm (L/sec)	Factory Float Setting in. (mm)	Lowest "Off" Setting in. (mm)	Maximum Dose Volume gal. (L)
PF1005, 10 (0.6)	31 (787)	16 (406)	78.0 (295)
PF2005, 20 (1.3)	31 (787)	18 (457)	69.5 (263)
PF3005, 30 (1.9)	31 (787)	20 (508)	61.0 (231)
PF5005, 50 (3.2)	31 (787)	24 (610)	45.0 (170)

For units equipped with UV disinfection, the effluent passes through the UV treatment unit before being pumped or flowing by gravity to final dispersal.

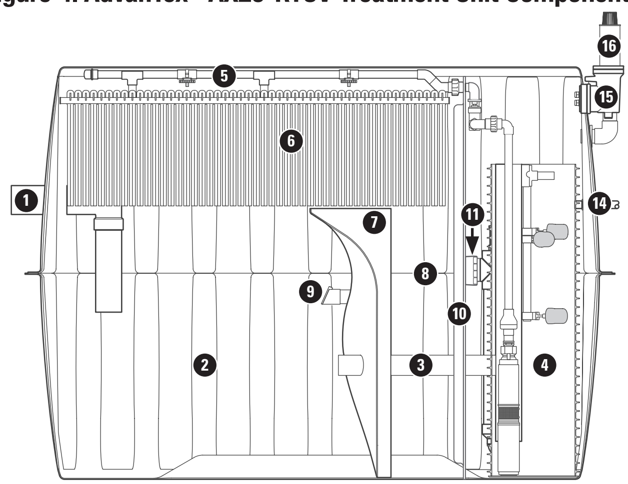
UV Disinfection

In areas that require disinfection before dispersal, an AX20-RT unit is available with integral UV treatment provided by an Orenco AXUV disinfection unit. (See Figure 4.)

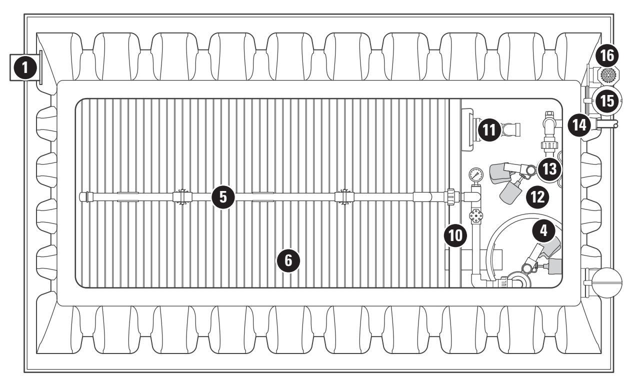
Treated effluent flows by gravity through the contact chamber and around the UV lamp where it is disinfected in a 360-degree contact zone. The unit uses no chemicals and has no moving parts. It requires cleaning yearly and a lamp replacement every two years.

The AXUV Disinfection Unit comes with a power ballast and a lamp current sensor, housed in either an MVP™ digital programmable control panel or VeriComm™ remote telemetry control panel, manufactured by Orenco.

Figure 4. AdvanTex® AX20-RTUV Treatment Unit Components



Side View (Pump Discharge Model Shown)



Top View (Pump Discharge Model Shown)

1. AX-RT Inlet and Tee
2. Treatment Tank (Recirc/Blend Chamber)
3. Recirc Transfer Line
4. Recirc Pumping System
5. Manifold and Spin Nozzles
6. Textile Media
7. Tank Baffle
8. Treatment Tank (Recirc/Filtrate Chamber)
9. Recirc-Return Valve
10. Divider Wall
11. Orenco UV Disinfection Unit
12. Treatment Tank (Disinfection/Discharge Chamber)
13. Discharge Pumping System
14. AX-RT Outlet
15. External Splice Box
16. Passive Air Vent
17. Control Panel (Not Shown)

These panels prevent discharge of non-disinfected effluent due to lamp failure or control panel failure. The current sensor monitors lamp function. In the event of lamp failure, the discharge pump is automatically disabled until the lamp is replaced. With MVP-equipped systems, an audible and visual alarm is activated. With VeriComm-equipped systems, an e-mail alert is sent to the Service Provider.

The lamp used in the disinfection unit is rated at 125 $\mu W/cm^2$ intensity at one meter. In a 2011 NSF® comparative test procedure, the AXUV reduced bacteria by 99.999% (5 logs), meeting or exceeding the performance of other residential UV disinfection units.

The AXUV Disinfection Unit provides the following contact chamber doses at 65% transmittance and 20% lamp degradation:

- 270,000 $\mu W \cdot s/cm^2$ at 1 gpm (0.06 L/sec)
- 55,000 $\mu W \cdot s/cm^2$ at 5 gpm (0.32 L/sec)
- 28,000 $\mu W \cdot s/cm^2$ at 10 gpm (0.63 L/sec)

Surge Volume/ Emergency Reserve Volume

The surge volume in an AX-RT is the volume between the low liquid level and the override timer float. For residential applications, AX20-RT and AX25-RT units have 135 gallons (511 liters) of surge volume, with an additional 75 gallons (284 liters) of surge volume above the override activation point.

AdvanTex AX-RT systems have designed-in emergency storage to account for power outages and mechanical malfunctions. In the US, power outages occur infrequently and typically last from a few hours to 1-2 days. Downtime associated with mechanical malfunctions is limited due the robustness of the mechanical components of the AX-RT.

The total emergency storage capacity of an AX-RT, measured from the recirculating high water alarm up to the inside top of the unit, is approximately 500 gallons (1893 liters). On units configured for gravity discharge, wastewater will discharge as designed during a power outage or mechanical component failure and no back-ups will occur.

A minimum 1000-gallon (3785-liter) septic tank is required to precede the AX20-RT unit and a minimum 1250-gallon (4732-liter) septic tank is required to precede the AX25-RT. As water rises above the invert of the inlet in the AX-RT unit, the water will back up into the septic tank. Consequently, the liquid capacity available in the septic tank can also provide storage during emergencies. The available capacity will vary depending upon the tank design but typically 1000-gallon tanks hold about 200 gallons (760 liters) and 1500-gallon tanks hold about 300 gallons (1140 liters) between the invert of the outlet and the inside top of the tank.

Most 3- or 4-bedroom homes produce about 150-200 gallons (570-760 liters) of wastewater each day (3-4 occupants at 50-60 gallons or 190-230 liters per occupant per day) as a conservative estimate. Between the septic tank and the AX-RT unit, there is approximately 700-800 gallons (2650-3028 liters) of emergency storage capacity, which equates to more than 4 days' emergency reserve.

Power Outage

During a power outage, water usage is significantly reduced because water heaters, dishwashers, and laundry equipment aren't used. Under these conditions, it is realistic to estimate that water usage will be reduced by 50 percent to around 100 gpd (473 L/d) and the emergency storage capacity available in the system will increase to approximately 8 days. Since power outages typically last less than 2 days, the emergency storage capacity of the system is more than adequate.

Mechanical Malfunction

Failure of a pump or electrical component may cause the system to stop operating, requiring some amount of emergency storage volume. If the system is equipped with a VeriComm® Monitoring System, the Service Provider is immediately notified of the alarm condition and the potential cause of the alarm. This allows the Service Provider to respond very quickly with the correct replacement components necessary to fix the problem. In most cases, no more than one day (250 gallons or 950 liters) would be needed for the Service Provider to respond and get the system running again. Therefore, the emergency storage capacity available in the AX-RT System during a mechanical malfunction, more than 4 days' worth, is quite adequate.

Cold Weather Considerations

AX-RT units can be manufactured with an insulated-core lid. Installing insulation around the sides of the filter pod is optional and is done on-site as needed. Other cold weather considerations include allowing all lines to drain between doses, backfilling the risers with pea gravel if frost heave is a concern, and extending the passive vent filter above the highest level of snow pack during winter months to ensure adequate airflow.

Additionally, the discharge line to final dispersal can be configured with an outlet below the frost line, for extreme cold conditions. Contact Orenco for more information on cold weather options.

SEPTIC SYSTEM ENFORCEMENT IN IDAHO

Appendix A

Nutrient-Pathogen Evaluation Technical Guide for On-Site Wastewater Treatment Systems In Teton County, Idaho

Introduction

The Idaho Department of Environmental Quality (DEQ) and the Eastern Idaho Public Health District (EIPHD) require property developers to investigate potential impacts to ground water and surface water from on-site wastewater treatment systems. The primary source of these requirements can be found in Idaho Ground Water Quality Rule, Idaho Water Quality Standards (IDAPA 58.01.02) and Individual Subsurface Disposal Rules (IDAPA 58.01.03) for surface water, and *Technical Guidance Manual for Individual and Subsurface Sewage Disposal Systems* (http://www2.state.id.us/deq/waste/tgm_sewage.htm), hereinafter called "Guidelines".

In addition to State requirements, Teton County requires property developers in Teton County to investigate potential impacts to waters of the state when one or more of the criteria in Title 9, Section 9-3-2-C-3-B-i (and Applicability section below) apply to the proposed development. These criteria are detailed below in the "Applicability" section below.

The investigations must include a comprehensive, scientifically based evaluation of soils, geologic conditions, and water resources in and around the area of the proposed development. For approval of the on-site wastewater treatment systems, the site investigation (termed nutrient-pathogen (NP) evaluation) shall conclude that the effluent from the treatment systems will not adversely impact the waters of the state.

This document is intended to provide guidance to those required to perform NP evaluations under Teton County's oversight of proposed developments utilizing on-site wastewater treatment systems in sensitive water quality areas of the county.

Applicability

NP evaluations are designed to locate an appropriate number of on-site wastewater treatment systems on a given parcel of land, and to direct the placement of the individual on-site wastewater treatment systems and level of treatment in a way that will not significantly degrade the quality of Teton County's water resources.

NP evaluations are required for all proposed developments utilizing on-site wastewater treatment systems when:

1. Any portion of a proposed development is within the county's Wetland and Waterways Overlay area; or

2. There is evidence that groundwater comes within ten feet of the ground surface on the proposed development parcel some time of the year; or

3. There is evidence that soil depth to fractured bedrock is ten feet or less anywhere on the

proposed development parcel; or

4. The proposed development includes a food service, commercial, or industrial facility generating 600 gallons per day or more wastewater; or

5. The proposed development is within an area where the concentration of nitrate-nitrogen in groundwater is five mg/l or higher.

Following the completion of a Level 1 NP evaluation, Teton County may allow suitable alternative on-site wastewater treatment system designs to better protect water quality in lieu of performing a Level 2 NP evaluation, provided it meets the Level 1 requirements.

Qualifications
NP evaluations must be performed by a qualified professional with experience in subsurface resource evaluation practices. The work is typically performed by environmental consultants with backgrounds in geology, hydrogeology, soil science, geochemistry, or related engineering disciplines. The evaluation relates the predicted nutrient and pathogen movement in the subsurface to the type of on-site wastewater treatment system proposed, and the soil, geologic, and hydrologic conditions existing at the site. The qualified professional must be a Professional Geologist or Professional Engineer who is registered in the State of Idaho and has experience conducting studies similar to NP evaluations. To conduct a Level II NP evaluation, the qualified professional must have experience in groundwater modeling. The professional performing the evaluation must certify that the results and any recommendations on design or placement of on-site wastewater treatment systems satisfy the approval criteria, below.

Approval Criteria
In order to be approved NP evaluation must demonstrate that the proposed on-site wastewater treatment system(s) will not significantly degrade ground water or surface water quality beyond an increase of 1.0 mg/l nitrate, or less above existing "background levels" for example the development cannot cause concentrations of nutrients or pathogens in ground water or surface water to exceed those concentrations that exist at the site prior to the development). An increase of 1.0 mg/l nitrate, or less, predicted to occur at the compliance boundary is considered a negligible (not significant) impact.

Nitrate is used as the substance to measure in the application of these guidelines; i.e. the fate of nitrate discharged to the subsurface. Nitrate is often the limiting factor in determining appropriate lot sizes and on-site wastewater treatment system design and placement because it is the most mobile constituent of concern in domestic wastewater and has an impact on public health when a maximum contaminant level (MCL) is exceeded (Subsurface Water Rules (IDAPA 58.01.11). Note that all references to nitrate concentration infers nitrate measured as nitrogen (NO_3 as N).

The evaluation of pathogens is performed by characterizing soil and geologic conditions to a level that enables the NP professional to verify that pathogens will be attenuated in the subsurface before impacting surface or ground water. At the present time (July 2009), pathogen transport modeling cannot be done with enough certainty to be useful.

The compliance boundary is defined as one, or any combination of, the following:

- Individual lot boundaries - when non-centralized water supply wells are used (e.g. a single on-site wastewater treatment system cannot cause nitrate concentrations to increase more than 1.0 mg/l above pre-development levels as measured at the downgradient lot boundary when neighboring lots contain individual water supply wells).

- Downgradient boundary of the overall subdivision or development - when a centralized, or community, water system is used (e.g., nitrate concentrations cannot increase more than 1.0 mg/l above pre-development levels as a result of the combined effect of all on-site wastewater treatment systems as measured at the outermost boundary of the development when the development is served by a centralized water system).

- Surface water bodies - when subsurface conditions result in a hydraulic connection between impacted ground water and a surface water body within the boundary of the development. Phosphorus is usually the chemical of concern with respect to surface water quality. Direct coordination with EIPHD, DEQ, and the County's technical NP representative (see Title 9, Section 9-3-2-C-3-B-iii) is necessary to design an appropriate NP evaluation when surface water impacts are a concern.

Cumulative Impacts
The County may require an additional level of study when the existing nitrate concentrations are above 5 mg/l or where the proposed development in combination with existing or other pending developments could increase the existing concentration of nitrate in the groundwater to above 5 mg/l have a significant cumulative impact on water quality.

Nutrient-Pathogen Evaluation Process
Prior to performing an NP evaluation, the "property developer and/or his/her NP professional" (hereinafter "Applicant") shall meet with the DEQ, EIPHD, and the County's technical representative to discuss the elements and objectives of the NP evaluation. Teton County requires the Applicant to submit a work plan (a scope of work) to the County's technical representative for approval. The purpose of a meeting or work plan submittal is to ensure that unnecessary or inappropriate activities are not completed. Submittal of a work plan should expedite the NP evaluation approval process.

The general term "nutrient-pathogen evaluation" refers to a set of activities that includes the compilation of existing information, collection of site-specific information, and the completion of predictive contaminant fate and transport modeling for ground water.

A nitrogen mass-balance spreadsheet is a simplified screening tool, available from DEQ, to help the NP professional assess the expected nitrogen load from the proposed development. This spreadsheet is required for a Level 1 County NP evaluation and will determine whether a more detailed Level 2 NP evaluation is needed. The mass-balance spreadsheet allows the Applicant to adjust lot sizes, orientation with respect to ground water flow, and wastewater treatment options to minimize ground water impacts.

The minimum required elements for a County NP evaluation follows:

- Well driller reports for wells within ½ mile radius of the project site.
- Map showing the project with proposed lot configuration, property lines, on-site wastewater treatment systems, water supply wells, surface water features, and location of surrounding wells within 500 feet of the property boundaries.
- Information on the depth to ground water and ground water flow direction.
- Information on soil and surface geologic conditions at the site for evaluation of pathogen fate and nutrient migration.
- Soil descriptions from test pits excavated at a minimum depth of ten feet at the site.
- Ground water quality data and surface water nitrate data in the vicinity of the project.
- Nitrogen mass-balance spreadsheet to estimate impacts from the development.

The applicant's experience and judgment are necessary to determine if other types of information are warranted due to the unique characteristics of a project.

Upon review of the Level 1 NP evaluation described above, the County may determine that further study is needed. In such case, the Level 2 NP evaluation shall follow the DEQ requirements for Level 2 NP evaluations, found at http://www.deq.state.id.us/WATER/assist_business/septic/nutrient_pathogen_eval_guide.pdf or a suitable alternative on-site wastewater treatment system design may be allowed by the County (see Applicability section above).

Procedure for Determining Groundwater Elevation

Peak groundwater table elevation can be assessed by a qualified professional observing redoximorphic features (soil mottling) in excavated test holes, or by a–qualified professional installing ground water piezometers (observation wells) and measuring depth to groundwater at weekly intervals over the period of known or suspected high ground water (spring runoff or irrigation induced high ground water).

Procedure for Determining Nutrient-Pathogen Contamination

Determining the level of existing nutrient and/or pathogen contamination can be made by reviewing existing ground and surface water quality data. Data sources include the Idaho Department of Water Resources Statewide Ground Water Monitoring Network; the Eastern Idaho Public Health District the Idaho Department of Agriculture ground water monitoring data; and the Idaho Department of Environmental Quality ground and surface water monitoring results, sub-basin assessments, and Total Maximum Daily Load (TMDL) documentation.

Analysis Techniques

Analysis for the County NP evaluation should include: the use of an appropriate mixing zone;

the comprehensiveness of the evaluation of soils, geologic conditions, and water resources; the assessment of pathogen and phosphate attenuation; the justification and validity of assumptions utilized during analysis; the use of appropriate dispersivity values; the use of appropriate nutrient concentration in wastewater and the use of appropriate wastewater flow volume per drain field, and; the adequate assessment and discussion of model accuracy (including the flow component and other sensitive parameters.

Predictive Modeling
Ground water flow and contaminant transport modeling is used in NP evaluations as a tool to predict the impact of the proposed development on ground water quality. Surface water quality may also need to be considered if ground water discharges to nearby drains or creeks.

In most cases nitrate is the contaminant that dictates the necessary lot configuration, lot size, and on-site wastewater treatment system placement. Nitrate is used as a surrogate for other constituents in the modeling effort. Other elements of the NP evaluation (e.g. soil analyses) need to address the adequacy of pathogen and phosphorus attenuation.

It is imperative that the modeler develop a realistic site conceptual model by: (1) collecting adequate information on the subsurface geologic structure and aquifer properties and (2) considering factors such as the influence of nearby surface water bodies or pumping wells. When assumptions and professional judgment are used, provide clear, written justification for any assumptions used.

Nutrient Modeling
The model must simulate all sources of contaminant input simultaneously. Consult the DEQ Guidelines, Nutrient Modeling Parameters, for more detail on modeling requirements.

Below are some basic modeling requirements:

1. Model non-reactive chemical transport to conservatively simulate nitrate migration. Contaminant transport simulations should project plume migration at time periods of 5, 10, and 20 years after on-site wastewater treatment system use begin.

2. If the Applicant wants to consider the effects of recharge from precipitation or irrigation, the nutrient load associated with the recharge must also be investigated and included in the model.

3. Ground water flow direction: determined at the site by the installation of at least three monitoring wells constructed in the uppermost aquifer. An accurate elevation survey must be performed to establish the relative elevation of the monitoring wells.

4. Hydraulic conductivity, determined at the site by aquifer pumping tests, slug tests, or by use of an empirical formula based on grain-size distribution analysis. Samples should be collected from the uppermost aquifer at multiple well locations.

5. Aquifer thickness: determined by an analysis of on-site boring logs and well driller reports for nearby wells.

6. Background concentrations of nitrate determined by sampling on-site monitoring wells and by considering existing regional nitrate data.

7. Contaminant source introduction. The conservative approach calls for introduction of the total volume of septic tank effluent within the upper 15 feet of the aquifer. One hundred percent conversion of all nitrogen forms to nitrate at the water table is assumed. Adjustments to nitrate input concentrations may be considered for systems utilizing enhanced nutrient treatment, or where other site-specific factors (e.g., geochemical conditions resulting in de-nitrification) warrant adjustment.

Nitrate source locations may be modeled as injection wells placed in the locations of the proposed drainfields or as area recharge over zones sized to represent the drainfield footprint. For grid-based models, the grid must be sized to represent the size of the individual nutrient sources (both for wells and areal distributed nitrate introduction).

8. Aquifer porosity, determined by a laboratory analysis of soil bulk density (to calculate porosity) from samples collected at the property, or from text book values for typical aquifer materials.

9. Dispersivity. For purposes of NP evaluations, the default value shall be 20 feet for longitudinal dispersivity and 0.8 feet for transverse (horizontal) and 0.08 feet for transverse (vertical) dispersivity. Table 3 in the DEQ Guidelines provides a summary of default modeling parameters. Alternative values may be warranted in some cases, but must be supported by site-specific data.

Nutrient Modeling Parameter Variances

Consideration of more realistic nutrient fate and transport phenomena may be used, however, the Applicant must justify that performing more complex modeling or using parameters that deviate from the default values or requirements is necessary. These project specific variances shall be discussed with the County's technical representative and with DEQ or EIPHD prior to utilization.

Model Boundary Conditions

It is generally desirable to confine the model domain with real physical boundaries, such as impermeable geologic contacts or hydraulically connected surface water features, however the distance to such permanent features may prohibit the use of physical boundaries as external model boundaries. Hydraulic boundaries shall be set far enough from the area of interest (i.e. the drainfield locations) so that they do not influence the flow pattern resulting from the introduction of wastewater from the drainfields.

Surface water features found in the model domain, such as agricultural drains, canals, springs, streams, rivers, lakes and reservoirs must be considered. Surface water features hydraulically connected to an underlying aquifer can be represented as a constant head, constant flux, or variable flux boundary.

In all cases, it is necessary to base boundary condition selections on the physical and hydraulic characteristics of the project location, and to document why the boundary conditions were chosen. Flux boundaries must be as realistic as possible even if they are adjusted during model calibration. Data from regional or local water budget assessments are often necessary to assign reasonable flux boundaries.

Assessing the Model

The output from the flow component of the model (i.e. modeled heads) must be compared with on-site and regional ground water elevations to assess the accuracy of the model.

The NP evaluation report must include a discussion about the accuracy of the flow component and about any other parameters (flow or contaminant transport) that are particularly sensitive. Several model runs that include a range of input parameters may be warranted when the uncertainty about the value of key parameters is high.

Reporting

A thorough presentation of compiled historical data and the data collected from the project site shall be submitted in a written report along with a completed NP evaluation to the County's technical representative, DEQ, and EIPHD. The report shall include a qualified NP professional's interpretation and certification of the findings as well as recommendations for design or the need for further site evaluation. All interpretations need to be well supported by the NP evaluation data. A suggested outline for an NP evaluation report follows:

0.0 Identify: as Level 1 or Level 2.

1.0 Introduction: Evaluation is required by Teton County or by DEQ or both; list the name of the project, project location, legal description and current land uses; also discuss the intended site use and development design; anticipated wastewater characteristics; geographic, geologic, and hydrologic setting and water well inventory.

2.0 Field Investigation: describe the installation of borings, soil test pits, and monitoring wells; discuss the protocol used in sampling (all media involved), aquifer hydraulic conductivity testing, pathogen fate assessment, and contaminant fate and transport modeling for ground water; include documentation supporting assumptions made during model development.

3.0 Results: Discuss soil conditions; ground water elevation and flow characteristics; background water quality; hydraulic conductivity; nutrient- pathogen fate issues; model results; model uncertainty.

4.0 Conclusions: summarize the key elements of the evaluation.

5.0 Recommendations: provide recommendations for development layout; on- site wastewater treatment system design; water supply and well construction; and the need for further evaluation activities.

The presentation of recommendations on the part of the qualified NP professional constitutes certification that: (1) the data adequately support the recommendations and, (2) that interpretations based on the data are accurate and represent sound, unbiased professional judgment.

The Applicant is responsible for submitting the NP evaluation to the County. Upon receipt the County will request DEQ review, comments, and provide recommendations on the NP evaluation. DEQ will provide its feedback to the Planning & Zoning Commission as agreed in the MOA. The County's technical representative will review the NP evaluation, including assessment of data collection, analysis techniques, and presented conclusions in the context of specific site characteristics, and will transmit written comments to the planning & zoning commission to become part of the public hearing document.

Conclusions

Teton County believes that these guidelines provide a reasonable approach to typical NP evaluation scenarios found in Teton County. They should be used in conjunction with sound scientific reasoning and judgment. Projects presenting unusual problems or issues should be discussed ahead of time with DEQ, EIPHD, and the County's technical representative.

5.13 Proprietary Wastewater Treatment Products

Revision: September 24, 2020

Table 5-17 lists proprietary wastewater treatment product approved by DEQ. Proprietary wastewater treatment products shall be installed by a permitted complex installer.

Table 5-17. Proprietary wastewater treatment products.

Proprietary Wastewater Treatment Product Manufacturer and Model	Treatment Limits (GPD) [a]	Designer Requirements	Operation, Maintenance, and Monitoring Requirements	Drainfield Sizing and Size Limits	Vertical Separation Distances	Approval Date	Comments
Eljen Corporation Eljen GSF	None	Idaho licensed professional engineer required for the design of a mound system or if effluent is pressure distributed	Homeowner managed O&M	Table 4-22 for application rates Drainfield may exceed 1,500 ft² when pressurized	Table 4-21	1/22/2018 Updated: 3/18/2019	Residential: See sections 2.17 and 2.18 of the product manual. Commercial: Contact Eljen for design information. Eljen GSF Idaho Design & Installation Manual
Geomatrix Systems, LLC GeoMat Leaching Systems GeoMat 1200 GeoMat 3900	1,500	Idaho licensed professional engineer required for a mound system or if effluent is pressure distributed	Homeowner managed O&M	Table 4-22 for application rates Drainfield may exceed 1,500 ft² when pressurized	Table 4-21	9/24/2020	Residential: 78 LF/bedroom (GeoMat 1200) or 24 LF/bedroom (GeoMat 3900) Idaho GeoMat Leaching Systems Design Manual for Pressure and Gravity Applications – August 2020
Infiltrator Water Technologies, LLC Advanced Treatment Leachfield (ATL)	1,500	Idaho licensed professional engineer required if effluent is pressure distributed	Homeowner managed O&M	Table 4-22 for application rates Drainfield may exceed 1,500 ft² when pressurized	Table 4-21	4/2/2018 Updated: 9/03/2020	Residential application: 70 LF/bedroom, Nonresidential application: 2.14 GPD/LF. Design and Installation Manual for the Infiltrator ATL System in Idaho – JUNE 2020

Proprietary Wastewater Treatment Product Manufacturer and Model	Treatment Limits (GPD) [a]	Designer Requirements	Operation, Maintenance, and Monitoring Requirements	Drainfield Sizing and Size Limits	Vertical Separation Distances	Approval Date	Comments
Lowridge Onsite Technologies Onsite Sand Coil Recharge (OSCAR-II): OS-50 OS-100	500 [b]	Idaho-licensed professional engineer required for applications >350 GPD, or if effluent is pressure distributed	Homeowner managed O&M	Table 4-22 for application rates	Table 4-21	3/12/2019 Updated: 10/2/2019	Residential/nonresidential: Number of coils required for the design flow depends on whether OS-50 (50 GPD) or OS-100 (100 GPD) coils are used. Lowridge Oscar- II Design Manual September 2019
Presby Environmental, Inc. Advanced Enviro-Septic (AES)	1,500	Idaho licensed professional engineer required if effluent is pressure distributed	Homeowner managed O&M	Table 4-22 for application rates Drainfield may not exceed 1,500 ft^2	Table 4-21	08/16/2016 Updated: 9/04/2020	Residential application: 70 LF/bedroom. Nonresidential application 2.14 GPD/LF. Presby AES Idaho Design & Installation Manual JUNE 2020

a. Treatment limit for normal domestic-strength wastewater. Treatment limits for non-domestic wastewater must be determined by the manufacturer on a property-specific basis and shall not exceed the domestic treatment limit.
b. System designs with flows above 500 GPD must be proportionally upsized, contact Lowridge Onsite Technologies.
Notes: linear feet (LF); gallons per day (GPD); square feet (ft^2); milligrams per liter (mg/L)

SEPTIC SYSTEM ENFORCEMENT IN MONTANA

September 12, 2019
Local Government Interim Committee
Toni Henneman

ON-SITE WASTEWATER TREATMENT SYSTEMS – STATE REGULATIONS

PURPOSE OF REGULATIONS

The Montana Department of Environmental Quality (DEQ) develops rules and regulations regarding the permitting, design, and installation of on-site waste treatment systems. These systems are used by landowners who do not have reasonable access to a municipal sewer system. To promote and protect the public and environmental health of the state, the DEQ establishes rules for acceptable systems that adequately treat waste while also maintaining healthy water quality and soil composition.

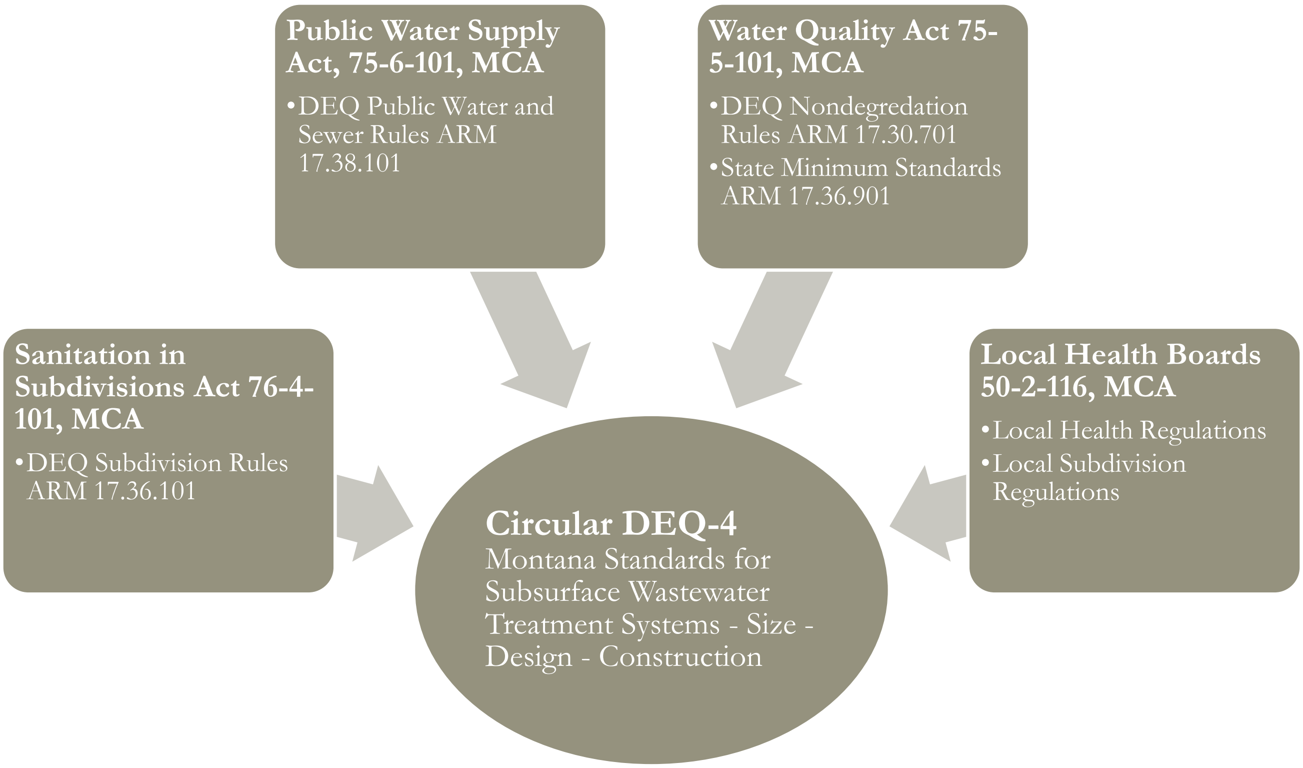
MINIMUM STANDARDS

> The minimum standards for on-site wastewater treatment systems are found in Circular DEQ-4.

The minimum standards for on-site subsurface wastewater treatment and disposal systems are found in CIRCULAR DEQ-4, which is updated approximately every five years. Circular 4 lists and describes various types of systems currently permitted in Montana, including but not limited to septic tanks, absorption trenches, sand filters, aerobic wastewater treatment units, and holding tanks. Circular 4 also details the process to request a deviation from the minimum standards for existing system components or for new, experimental systems that may not have been thoroughly researched by the department.[1]

[1] The process for requesting a deviation is detailed on page 9 of this document.

The department develops the Circular 4 in compliance with various state statutes, administrative rule, and local regulations. The following chart illustrates the sources of authority that dictate many of the components of the Circular 4:



TYPES OF SYSTEMS

Wastewater can be treated and dispersed back into the environment using a variety of technologies that employ biological, physical, and chemical processes to digest, neutralize, or otherwise remove pollutants. Many types of on-site wastewater treatment systems exist, but, generally, a successful system consists of an apparatus to trap solids and begin nitrification and an absorption field to disperse and filter wastewater through the soil.

The most common form of on-site wastewater treatment system is a septic system that utilizes a septic tank and a subsurface soil absorption field (drain field). Buried in the ground, septic tanks are essentially watertight single or multiple chamber sedimentation and anaerobic digestion tanks. They are designed to receive and pretreat domestic wastewater, mediate peak flows, and keep settleable solids, oils, scum, and other floatable material out of the absorption field. Wastewater effluent is discharged from the tank and passes to the soil via a series of underground perforated pipes, perforated pipe wrapped in permeable synthetic materials, leaching chambers, pressure drip irrigation pipes or tubing, or other distribution system. From there, the partially treated effluent flows onto and through the developing biomat located at the soil infiltrative surface, and finally into the soil itself. Treatment occurs in the septic tank, on and within the biomat that forms at the soil infiltrative surface, in the soil, and continues as the effluent moves through the underlying soil toward groundwater or nearby surface waters.

The department maintains a list of approved types of systems to not only meet the needs of landowners but also to address the wide variety of environmental factors present in land parcels across the state. Not all systems may work in all areas, and thus many options exist to offer solutions for landowners who install and maintain their own system.

The following tables outline the most common types of on-site wastewater treatment system components permitted by DEQ; however, local health requirements may be more stringent than DEQ's requirements. Keep in mind that a successful system needs to address both solid waste and wastewater (gray water), thus a complete system utilizes multiple components. Additionally, some sites may require an advanced treatment system described in Table 3 to successfully treat wastewater.

TABLE 1: OPTIONS FOR SOLID WASTE SEGREGATION

Type of System	Description
Septic Tank *Chap. 5.1, Circular DEQ-4* (Appendix: Figure 1)	• All solids and wastewater are collected in tank • Effluent filter traps solids and allows wastewater to pass to absorption field (see Table 2 for options) • Solids must be pumped on regular schedule • May use a distribution box, drop box, or manifold to further aid in separating solids from wastewater Construction material options: concrete (precast or cast-in-place concrete), thermoplastic, or fiberglass
Holding Tank *Chap. 8.1, Circular DEQ-4*	• Holds all effluent (solids and wastewater) with no outlet • Used only for storage, not for treatment of any type of waste • Must be pumped regularly • May not be used for new systems unless the facility is licensed by DPHHS or operated by a government agency and a waiver is granted[2]
Sealed Pit (Vault) Privy *Chap. 8.2, Circular DEQ-4*	• Similar to holding tank – holds all waste without an outlet or treatment method • Must be pumped regularly • May not be used for new systems

[2] Holding tanks are prohibited for new systems under ARM 17.36.321 except for systems that qualify for a waiver. Holding tanks are also prohibited under ARM 17.36.916 except for seasonal use (120 days of the year). Some counties, like Flathead County, do not allow holding tanks in any capacity, so even if DEQ granted a waiver, a holding tank could not be installed in a county that does not allow holding tanks.

Unsealed Pit Privy *Chap. 8.3, Circular DEQ-4*	• May only be used with structures with no pumping fixtures or running water • Must be pumped regularly • May not be used for new systems
Seepage Pits (Cesspool) *Chap. 8.4, Circular DEQ-4*	• Perforated concrete rings are placed in drain rock and effluent is released over drain rock covered with appropriate geotextile fabric, untreated building paper, or straw • Very limited types of soil allow for a seepage pit (soil must have percolation rate greater than 60 mpi) and the seepage pit must be installed at least 25 feet above groundwater[3] • May not be used for new systems[4]
Composting Toilet *Chap. 8.5.3.1, Circular DEQ-4*	• Waste is broken down through aeration and microbial colonization • Must include continuous forced ventilation to the outside of storage or treatment chamber • Must be able to sustain suitable temperatures for biological activity (average range of 68°-130° F) • Must be used in conjunction with an absorption field (Table 2) to treat wastewater • Unit must be able to meet testing criteria and performance requirements for NSF Standard 41
Incinerating Toilet *Chap. 8.5.3.2, Circular DEQ-4*	• Electric or gas-fired • Vapor and products of combustion must be adequately vented independent of other household venting systems • Must comply with local air pollution requirements • Contents of incinerating toilet must be removed and disposed of in compliance with 40 CFR Part 503 and Title 75, Chapter 10, part 2, MCA • Must be used in conjunction with an absorption field (Table 2) to treat wastewater[5] • Unit must be able to meet testing criteria and performance requirements for NSF Standard 41

[3] As required in ARM 17.36.916.
[4] Under ARM 17.36.916, seepage pits can only be used for replacement systems and when no other means of disposal is available.
[5] The department recently approved via waiver an incinerating toilet for total incineration, so no drain field was required. See page 9 of this document for more information on system waivers.

TABLE 2: OPTIONS FOR WASTEWATER TREATMENT

Type of System	Description
Regardless of type, a successful wastewater treatment system is largely dependent upon wastewater quality and proper site selection. Wastewater quality if often dependent upon the effectiveness of the effluent system in Table 1.	
Absorption Trenches *Chaps. 6.1 – 6.6 Circular DEQ-4* (Appendix: Figures 2-4)	• Trench dug below the surface and lined with drain rock • Distribution pipes are installed and may be either gravity-fed or pressure dosed • Wastewater is filtered through soil to remove impurities and reenters the water supply • Design and size determined by flow and soil type Options: shallow, deep, at-grade, sand-lined, gravel-less, leaching chamber
Elevated Sand Mounds *Chap. 6.7 Circular DEQ-4* (Appendix: Fig. 5)	• Sand mounds are built above natural soil and are used to separate the distance between the treatment system and a limiting layer • Pressure distribution must be provided • Must have a minimum of 21 in. of sand above at least 4 ft. of natural soil surface Options: may utilize equipment used in absorption trenches: distribution pipes, drain rock, geotextile fabric, building paper, straw, leaching chambers
Evapotranspiration Absorption (ETA) & Evapotranspiration (ET) System *Chap. 6.8 Circular DEQ-4* (Appendix: Figs. 6 & 7)	• An ETA is used in soils with slow percolation rates (clay) and an ET is used in areas where discharging waste into the soil is undesirable • System installed at least 30 in. below ground surface and filled with drain rock or coarse sand and covered with a suitable medium (sandy loam, silt loam) that provides drainage and aeration • Effluent then passed to secondary system (absorption trench, distribution pipes, etc.) • Should be used with wastewater flow reduction strategies
Subsurface Drip *Chap. 6.9 Circular DEQ-4* (Appendix: Fig. 8)	• Uniformly spaced drip emitters discharge small volumes of wastewater throughout the day • Drip line normally installed directly into the soil without other media • Must not be placed where vehicles will cross them, and potable water lines may not pass under or through any part of the dispersal system • Must be designed to remain free-flowing during freezing conditions

	• Must use a septic tank (Table 1), an advanced wastewater treatment system (Table 3), pressure dosing, and use an effective pump to regulate the volume and pressure of the discharge
Gray Water Irrigation *Chap. 6.10 Circular DEQ-4*	• If the location meets criteria for gray water reuse, gray water (water from bath tubs, showers, sinks, dish and clothes washers, etc.) may be collected and used in a subsurface dispersal system at least 6 in. below the surface • Kitchen water must be used in conjunction with another wastewater treatment method • Systems must utilize filters, surge tanks, and regulator pumps • Must either be designed for freezing conditions or provide a drainfield for use during freezing conditions
Absorption Beds *Chap. 6.11 Circular DEQ-4*	• May be used where standard absorption trenches are not possible • May not be used for new systems • Absorption beds must be at least 3 ft. wide and 2 ft. deep unless circumstances provide otherwise. • Pressure distribution and a minimum of 2 distribution pipes must be provided • Excavated beds must be backfilled with appropriate drain rock

TABLE 3: ADDITIONAL ADVANCED TREATMENT SYSTEMS IF NEEDED OR REQUESTED

Type of System	Description
Recirculating Media Trickling Filter *Chap. 7.1, Circular DEQ-4*	• Utilizes aerobic processes to biologically oxidize organic material and convert ammonia to nitrate and then some recirculates back to the tank for anoxic denitrification • A bio-film is adhered to a bed of highly permeable medium in an unsaturated environment • Wastewater trickles through the media and microorganisms in the bio-film degrade organic material • An under-drain system collects treated water and any solids and transports it to a settling tank where the waste is recirculated back through the media or the septic tank
Intermittent Sand Filter *Chap. 7.2, Circular DEQ-4*	• A watertight container is filled with drain rock, gravel, sand, or loamy sand • Waste water is passed through the sand filter before being released in to a wastewater treatment system (Table 2) • Flow must be pressure dosed • Acts as a contained, additional filtration system
Recirculating Sand Filter *Chap. 7.3, Circular DEQ-4*	• Similar to an intermittent sand filter, but effluent is recirculated back through the filter
Aerobic Wastewater Treatment Unit (ATU) *Chap. 7.4, Circular DEQ-4*	• A container provides aerobic biodegradation or decomposition of the wastewater components in a saturated environment • Wastewater is brought into contact with air by mechanical means • Must demonstrate compliance with testing criteria and performance requirements of NSF Standard No. 40 for Class 1 certification • Must include a sampling port to test the quality of the effluent
Chemical Nutrient Reduction System *Chap. 7.5. Circular DEQ-4*	• Treats effluent from septic tanks using chemical processes • The reviewing authority has wide discretion to determine the complexity and maintenance required of the system.
Alternative Advanced Treatment Systems *Chap. 7.6, Circular DEQ-4*	• The reviewing authority may evaluate alternative advanced treatment systems and allow systems that meet requirements found in NSF Standard No. 40 for Class 1 certification

HOW TYPES OF SYSTEMS ARE CHOSEN

In many instances, landowners may choose the type of system that works best for their needs. When deciding, owners often consider the projected volume of wastewater expected to be treated, the cost of installing a certain kind of system, and the amount of maintenance the system requires.

However, many factors outside of a landowner's control ultimately determine the type of system required. The type of soil present where the system is to be installed, the proximity of the system to surface water, the ability of the system to handle the actual volume of waste, and other environmental factors may rule out certain types of systems allowable in a landowner's area. Also, many systems require a substantial amount of space to operate effectively, so some parcels may not qualify for certain systems simply based on their size or geography.

Ultimately, the choice of system is decided using a combination of factors derived from state and local regulations in conjunction with a landowner's preference and budget when possible.

SYSTEM COSTS

The following table[6] provides estimated costs for various system components. Be aware that costs vary widely, and the table should be used as an estimate rather than a standard.

Type of Onsite System	Installation Cost	% Cost Increase from Conventional Treatment
Conventional Septic Tank	$2,000-$6,000 ($4,000 average)	--
Absorption Trenches	$4,000-$7,000	38%
Elevated/Mound Systems	$7,000-$12,000	138%
Intermittent sand/media filters	$5,000-$10,000	88%
Recirculating sand/media filters	$8,000-$11,000	138%
Aerobic Treatment Units	$3,000-$6,000	13%
Constructed Wetlands	$10,000-$20,000	275%

[6] "Appendix K: On-Site Domestic Wastewater Treatment in the Lake Helena Watershed," prepared for the Montana Department of Environmental Quality by the U.S. Environmental Protection Agency, Montana Operations Office, 2006. https://deq.mt.gov/Portals/112/Water/WQPB/TMDL/PDF/LakeHelena/VolII/M09-TMDL-02a_App_K.pdf

EXPERIMENTAL SYSTEMS & DEVIATION REQUESTS

When revising the Circular 4 approximately every five years, DEQ often adds additional types of systems that have proven popular and successful. In order for a type of system to be considered standard, adequate research must be compiled and tests completed that prove a system is able to perform successfully in Montana.

In addition, a person may submit a written request for a deviation for any system, either one described above or for a system that is not included in the current Circular.

A written deviation[7] shall be submitted to the reviewing authority having jurisdiction and shall:

1. identify the specific section of the Circular to be considered;
2. include adequate justification for the deviation;
    - "engineering judgment" or "professional opinion" without supporting data is considered inadequate justification
3. address how the system allowed by the deviation would be unlikely to cause pollution of state waters in violation of 75-5-605, MCA;
4. address that granting the deviation would protect the quality and potability of water for public water supplies and domestic uses and would protect the quality of water for other beneficial uses, including those specified in 76-4-101, MCA; and
5. address that granting the deviation would not adversely affect public health, safety and welfare.

The reviewing authority having jurisdiction will review the request and make final determination on whether a deviation may be granted.

Source:

Circular DEQ 4, *Montana Department of Environmental Quality,* 2013.

https://deq.mt.gov/Portals/112/Water/PWSUB/Documents/docs/engineers/2014/DEQ4-2013-Final.pdf.

[7] Deviation requirements are detailed in Chapter 1.1.4.2 Circular DEQ-4.

APPENDIX 1: SYSTEM DIAGRAMS

FIGURE 1: STANDARD SEPTIC TANK

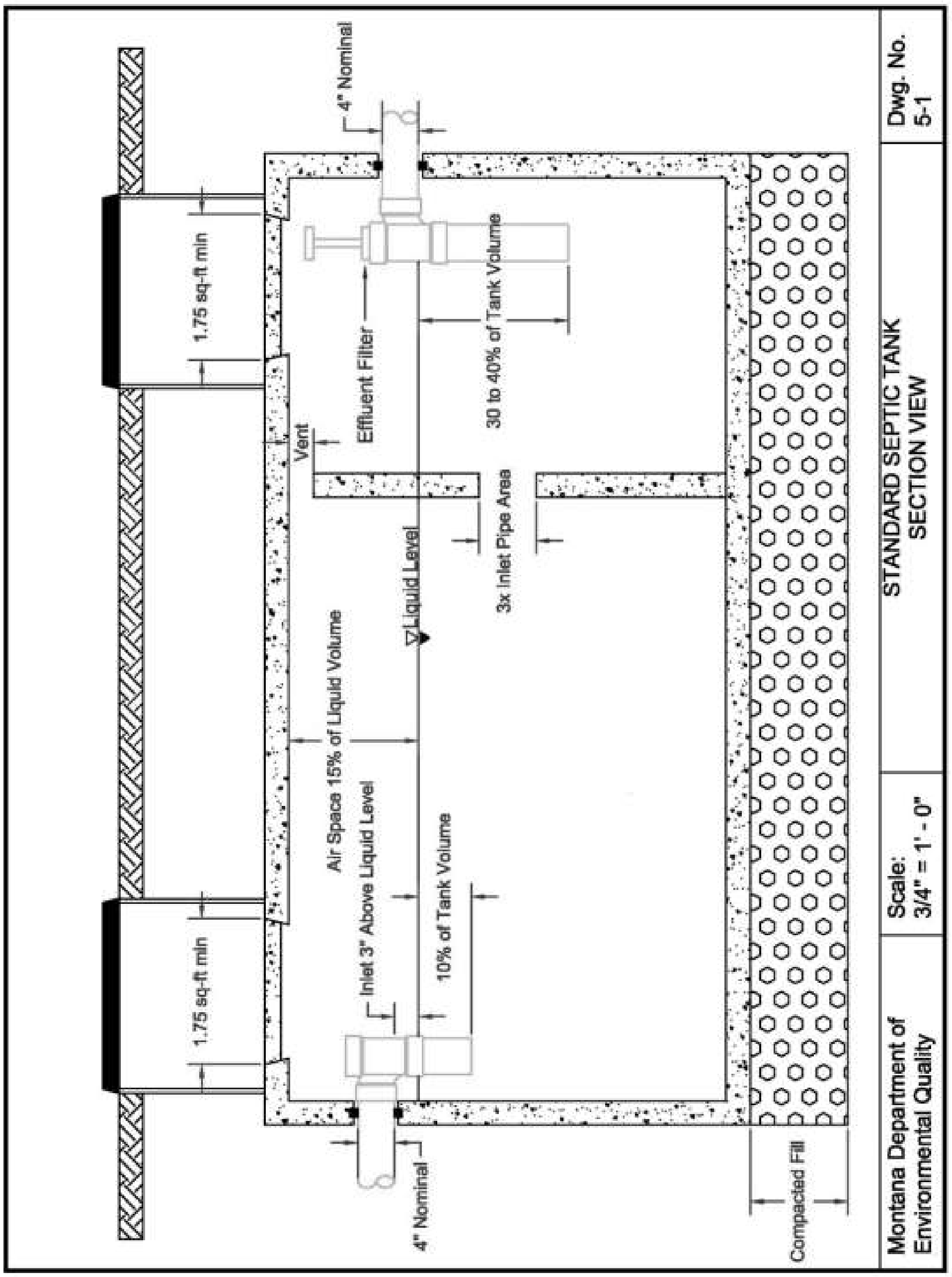


FIGURE 2: STANDARD ABSORPTION TRENCH – GRAVITY FED

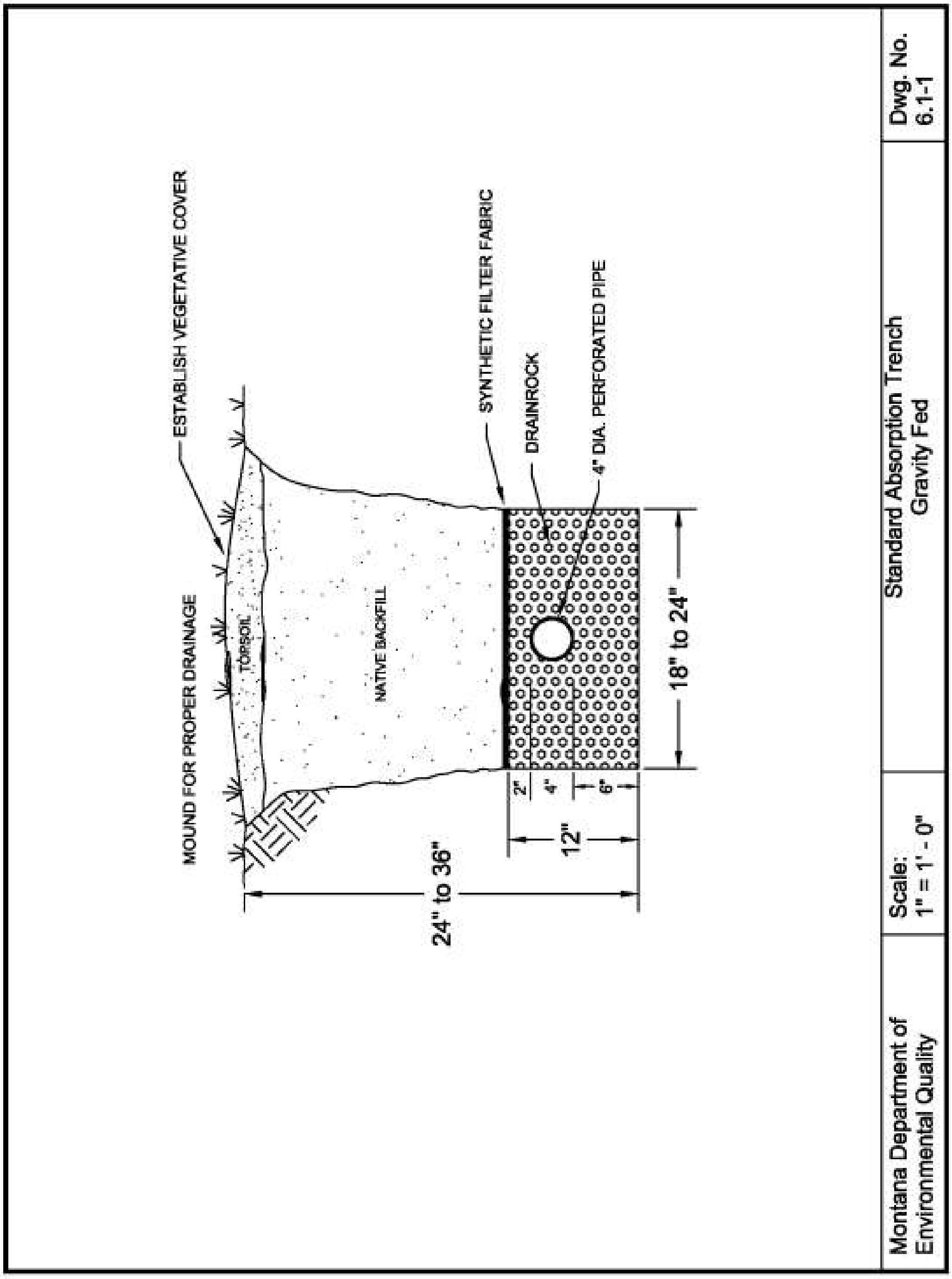


FIGURE 3: STANDARD ABSORPTION TRENCH – PRESSURE DOSED

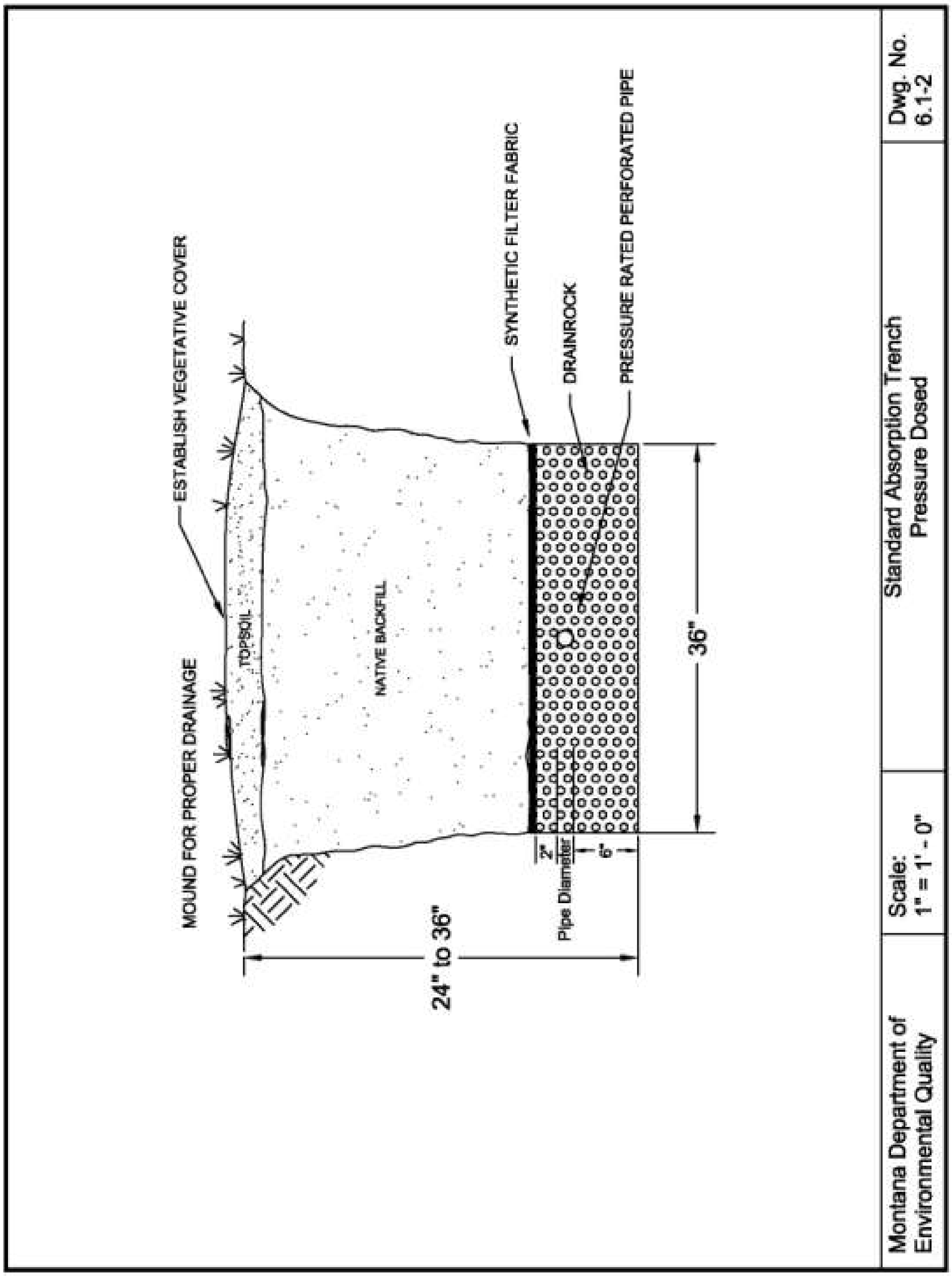


FIGURE 4: SHALLOW-CAPPED ABSORPTION TRENCH WITH LEECHING CHAMBERS

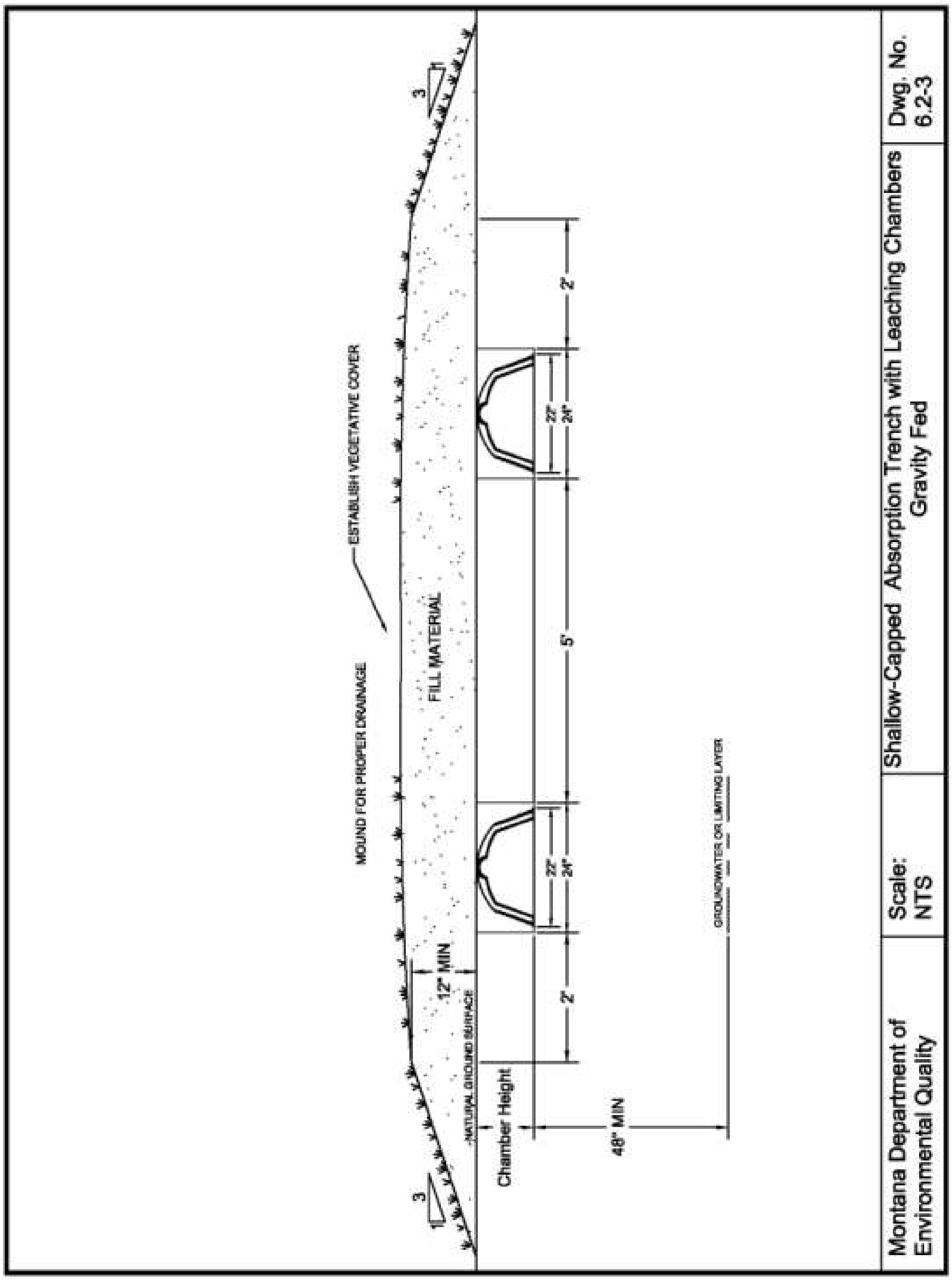


FIGURE 5: ELEVATED SAND MOUND

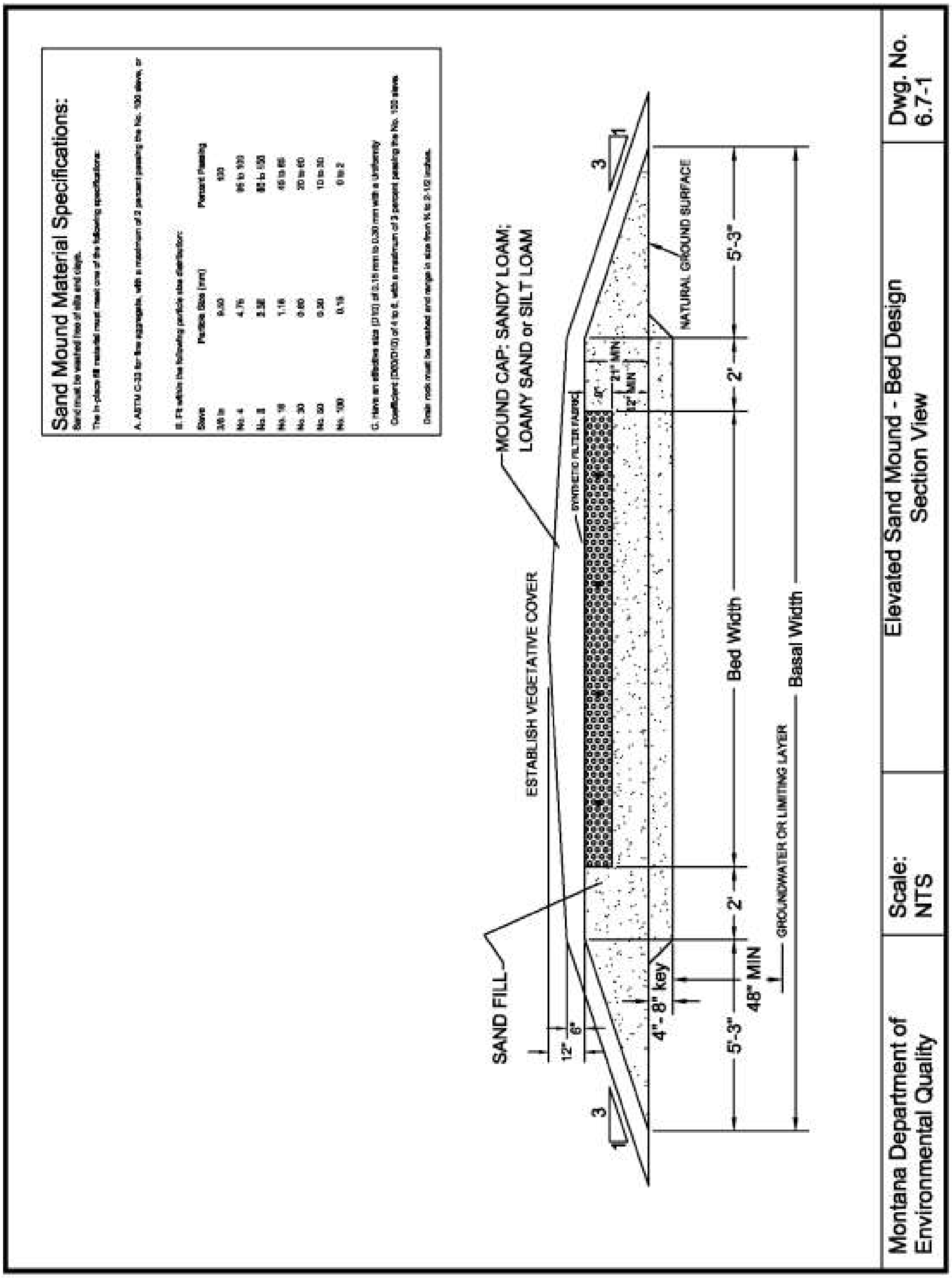


FIGURE 6: ELEVATED SAND MOUND WITH LEACHING CHAMBERS

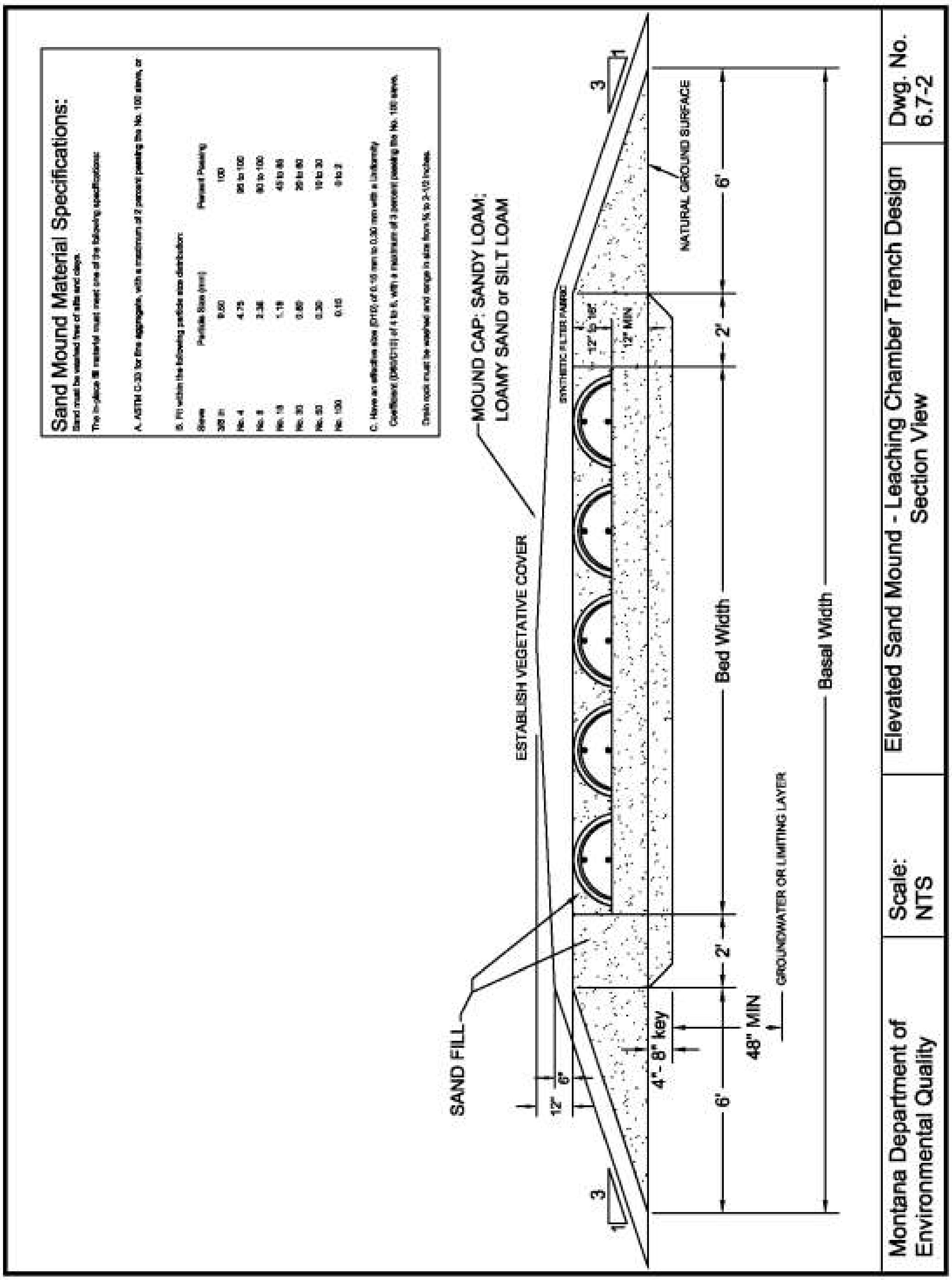
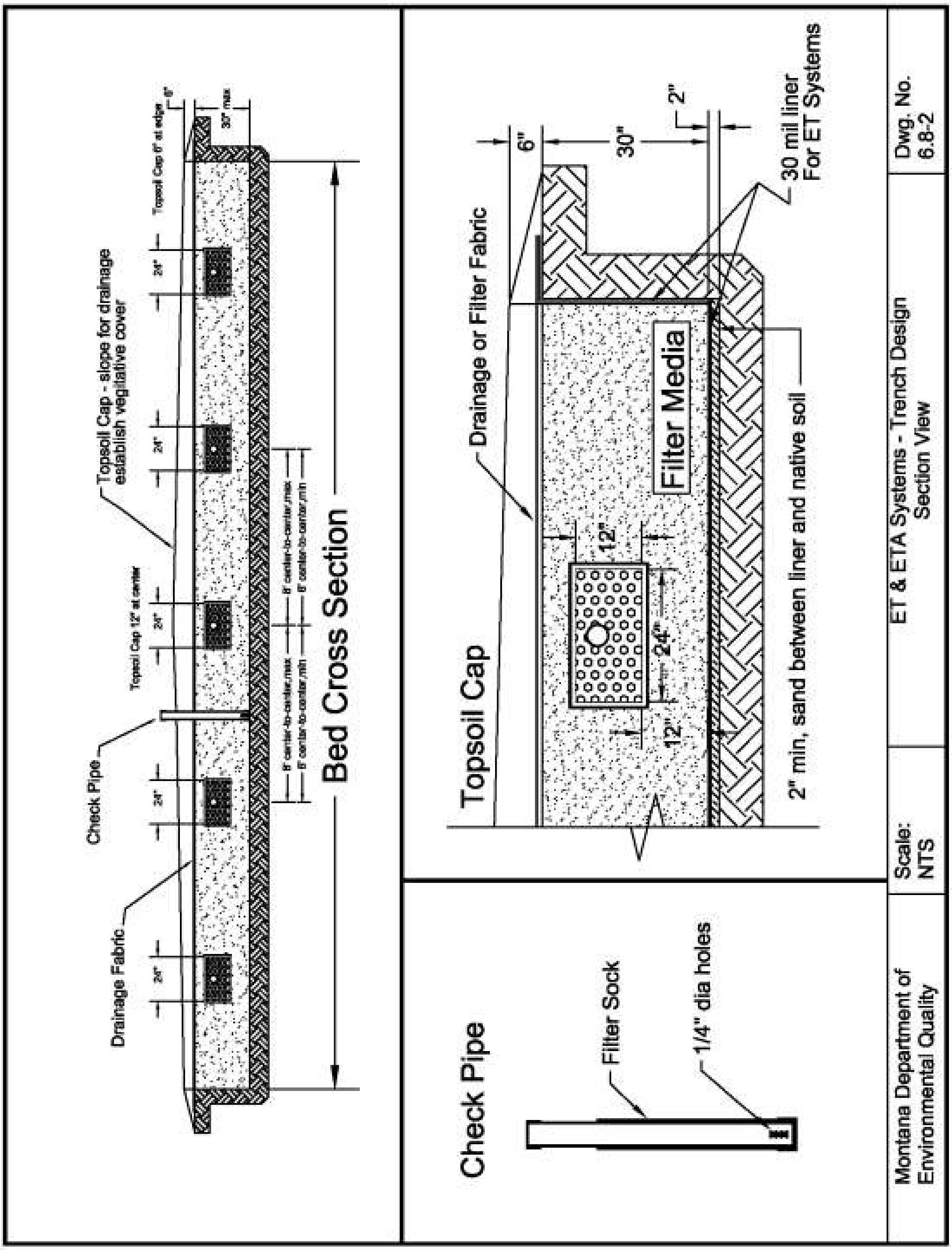
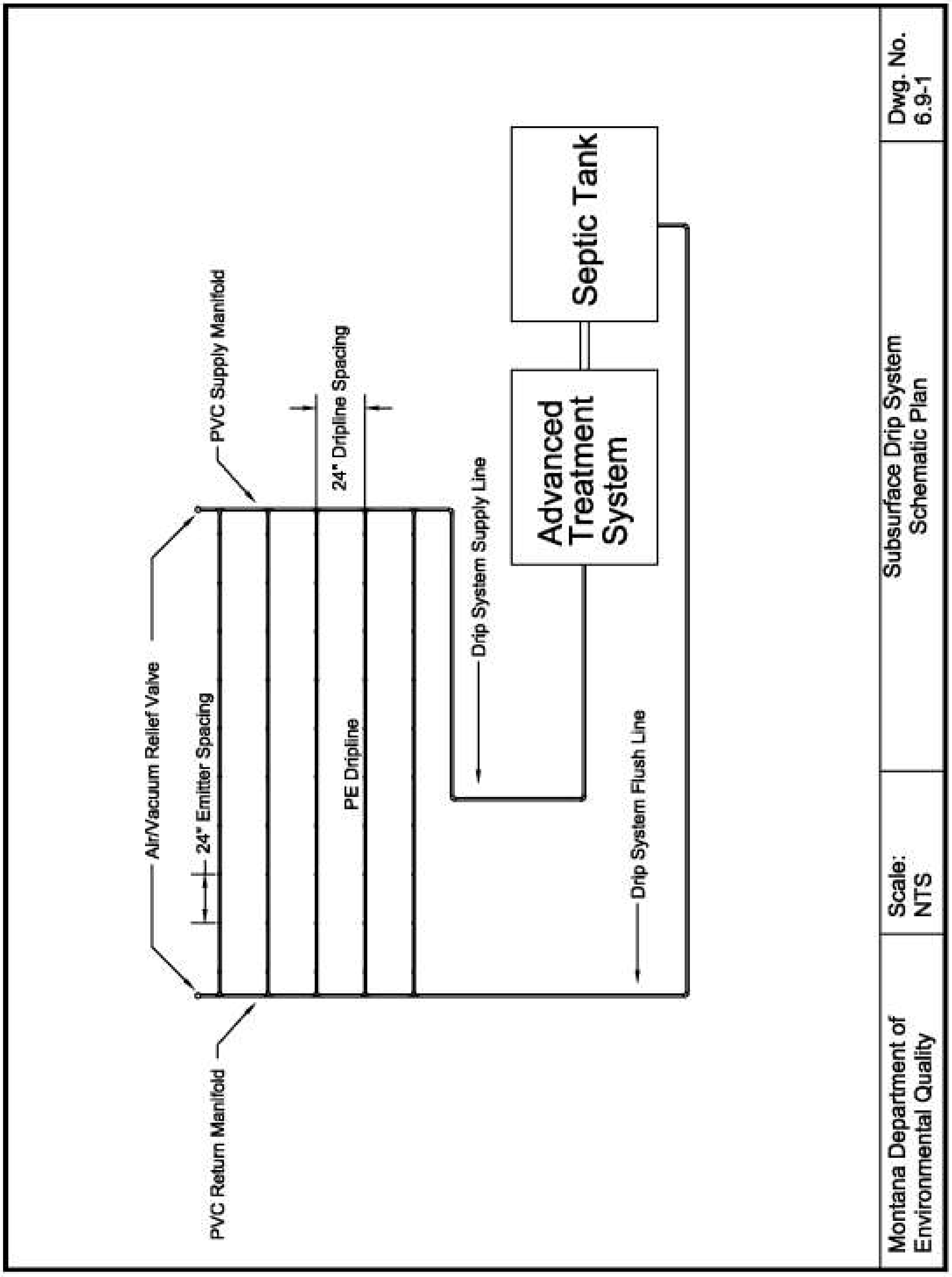


FIGURE 7: EVAPOTRANPIRATION/EVAPOTRANSPIRATION ABSORPTION SYSTEM



LEGISLATIVE SERVICES DIVISION

FIGURE 8: SUBSURFACE DRIP SYSTEM



List of Subsurface Wastewater Treatment Systems (SWTS) that are Approved as a Nitrogen-Reducing System

Updated December 2019

Pursuant to Administrative Rules of Montana (ARM) 17.30.702(9)(10) and (11), the Department defines three different types of nitrogen-reducing SWTS, level 1a, level 1b and level 2 systems. The definitions from the rule are as follows:

(9) "Level 1a treatment" means a subsurface wastewater treatment system (SWTS) that:
(a) removes at least 50%, but less than 60%, of total nitrogen as measured from the raw sewage load to the system; or
(b) discharges a total nitrogen effluent concentration of greater than 24 mg/L, but not greater than 30 mg/L. The term does not include treatment systems for industrial waste. A level 1a designation allows the use of 30 mg/L nitrate (as N) as the nitrate effluent concentration for mixing zone calculations.
(10) "Level 1b treatment" means a SWTS that:
(a) removes at least 34%, but less than 50%, of total nitrogen as measured from the raw sewage load to the system; or
(b) discharges a total nitrogen effluent concentration of greater than 30 mg/L, but not greater than 40 mg/L. The term does not include treatment systems for industrial waste. A level 1b designation allows the use of 40 mg/L nitrate (as N) as the nitrate effluent concentration for mixing zone calculations.
(11) "Level 2 treatment" means a SWTS that:
(a) removes at least 60% of total nitrogen as measured from the raw sewage load to the system; or
(b) discharges a total nitrogen effluent concentration of 24 mg/L or less. The term does not include treatment systems for industrial waste.

As of the date at the top of this document, the following list shows those SWTS that are designated as level 1a, level 1b or level 2 by the Department. Level 2 systems are approved for 24 mg/L unless otherwise noted in the table:

Level 2 (date approved)	**Level 1a**	**Level 1b**
Recirculating Sand Filter (~1993)		Intermittent Sand Filter (5/1/2005)
Orenco – AdvanTex (AX model - 8/4/2004) (AXRT model 4/11/2011)		
Fluidyne – Eliminite (8/5/2004)		
International Wastewater Systems (IWS) model 6000 sequencing batch reactor (7/28/2005)		
Santec – Extended Aeration (7/18/2006) *[approved for nitrogen reduction to 14 mg/L]*		
Bio-Microbics – Micro-FAST and Retro-FAST (11/9/2006)		
HDR Engineering Activated Sludge / Biological Nutrient Reduction Systems (1/24/2007) *[approved for nitrogen reduction to 10 mg/L]*		
HDR Engineering Activated Sludge / Biological Nutrient Reduction Systems/Membrane Filtration (6/16/2007) *[approved for nitrogen reduction to 7.5 mg/L]*		
International Wastewater Systems (IWS) model 6000 sequencing batch reactor with methanol addition, coagulation and filtration (5/21/2007) *[approved for nitrogen reduction to 7.5 mg/L]*		

Level 2	Level 1a	Level 1b
Norweco - Singulair Model TNT (12/10/2007)		
Norweco – Singulair Green TNT (04/29/2014)		
Norweco – Hydro-Kinetic Model 600 FEU (04/29/2014)		
Fluidyne - ISAM Sequencing Batch Reactor (12/23/2009)		
Quanics Bio-COIR and AeroCell (6/7/2010)		
SepticNET (2/16/2011) *[approved for nitrogen reduction to 7.5 mg/L]*		
Jet – J-500CF (3/25/2011)		
Northwest Water Systems (NWS) – model 2400 sequencing batch reactor (6/28/2011)		
Northwest Water Systems (NWS) model 7500 sequencing batch reactor with methanol addition, coagulation and filtration (6/28/2011) *[approved for nitrogen reduction to 7.5 mg/L]*		
SeptiTech - M400D through M3000D models (4/10/2012)		
E-Z Treat Models 600 and 1200 (10/3/2017)		
Bio-Barrie MBR 1.5, 1.0 and 1.5 (7/23/2019		
ECOPOD-N Series: E50-N, E60-N, E75-N, E100-N and E150-N (9/23/2019)		

** NOTE: As of May 1, 2005 elevated sand mounds (ESM) were removed from the level 2 list. They no longer qualify for any level of nitrogen reduction (the effluent concentration for an ESM in the nitrogen dilution calculations is the same as a septic tank/drainfield system, 50 mg/L).*

This list will be updated on a regular basis as it changes. Systems can be both added and removed from the list at any time, check back frequently to insure you are working off of the current list. If the designation of an SWTS on the above list is modified, the Department will provide advanced notification via the Department's subdivision mailing list and/or e-mail list of the intention to modify the designation (advanced notification will not be given for an SWTS that is being added to the list for the first time). If you wish to be added to the subdivision mailing list, contact the Department at 444-4400. Advanced notification will allow persons on the mailing list to plan accordingly, particularly with respect to submission of future applications.

If a subdivision application, ground water discharge permit application, or public water supply application with appropriate fees is received by the Department using a specific nitrogen-reducing SWTS, and the designation of that SWTS is changed to a less efficient nutrient reducing system (e.g. changing the designation from level 2 to level 1a) prior to final approval by the Department, the treatment designation of the SWTS will remain the same as it was on the day the application was received by the Department (e.g. the SWTS will be grandfathered under its previous designation for that application).

The rule requirements for classifying an SWTS as a nitrogen-reducing system are listed in ARM 17.30.718. For vendors or manufacturers who are interested in having a SWTS evaluated for nitrogen-reducing designation, the Department has developed a scoring sheet to facilitate the process. Vendors and manufacturers can use the scoring sheet as a preliminary guide to determine if they have sufficient information to submit a request to the Department. The scoring sheet is available on this web site. Please be aware that the scoring sheet is not part of the rule, and is only to be used as a guideline. The Department will make the final determination regarding the nitrogen-reducing classification in accordance with the rule (ARM 17.30.718).

APPENDIX J

Groundwater Monitoring Plan

1 EXPANDED GROUNDWATER MONITORING PROGRAM

The intent of the groundwater monitoring program is to establish baseline water-quality data, monitor water-quality changes in the Casper Aquifer, and develop a database that will allow assessment of the hydrologic condition of the Casper Aquifer. The program is designed to provide a long-term systematic approach to monitoring the Casper Aquifer. To date, the City and County have been monitoring water level and water quality conditions on an approximately quarterly basis in 10 wells. Stantec recommends the City and County expand this program to include a number of existing wells and to include several monitoring wells that have yet to be drilled.

Below is a proposed scope of work for this program. The City and County may hire a consultant to design the monitoring program or may use this document as guidance for creating a Monitoring and Sampling Plan. This is not intended to be a Monitoring and Sampling Plan, but it provides information on proposed monitoring locations. The recommendations include the key elements of a comprehensive monitoring plan and should be used to guide the development a formal Monitoring and Sampling Plan. The Plan should:

1. Establish a network of monitoring wells for assessment of water levels and water quality in the Casper Aquifer.
2. Specify details for monitoring well construction and identify final locations.
3. Establish a monitoring schedule.
4. Specify water-quality constituents to include in sampling.
5. Specify the analytical methodologies to be used in laboratory analyses.
6. Specify field protocols including procedures for purging, sampling, decontamination, and collection of field quality assurance samples.

1.1 SAMPLING LOCATIONS

To reduce costs, Stantec recommends the City and County use existing wells where possible. However, there are areas where additional monitoring wells are proposed and recommended to complete the network. The map (**Figure J-1**) illustrates the proposed locations of the monitoring wells, and indicates the locations of the 10 wells that are already in the monitoring network along with proposed monitoring locations for wells that exist (17) or have yet to be drilled (10). The exact locations for the wells yet to be drilled may need to be moved due to property ownership and/or access issues.

For the expanded monitoring well network, Stantec recommends the network include water level and water quality assessment in the following areas: between the Spur and Turner Wellfields, near or along I80, near residential development at the east end of Grand Avenue, and near the Mountain Cement Quarry. Table 1J presents the existing and proposed wells that would be included in these four areas. The monitoring wells that are downgradient of specific potential contaminant sources will allow long-term monitoring of these activities while the other wells will allow more general long-term monitoring of the aquifer. Additional locations should be added in the rural subdivisions if landowner consent can be obtained to sample domestic wells.

Following is a description of the existing monitoring wells and additional areas that are recommended to be monitored (**Table 1J**). In general, monitoring locations are placed along the one (1) year time-of-travel as modeled by Western Water Consultants (1993) or where monitoring wells already exist but are not already included in the current monitoring network. The following is a summary of ownership of the existing monitoring wells:

1. Existing City-owned monitoring wells.
    a. Soldier MW-5
    b. Spur MW-6
    c. 41T2
    d. 41T3
    e. LCCC
    f. EQ #1 (WYDOT Well)
    g. Triangle Well
    h. Imperial Heights North
    i. Imperial Heights South
    j. Simpson MW-1
2. Other existing monitoring wells.
    a. Huntoon #1, Wyoming State Engineer's Office
    b. Huntoon #2, Wyoming State Engineer's Office .
    c. Mountain Cement monitoring wells used for baseline monitoring including P72810W, P8769P, P94793W, P95938W, WAITKUS-R, MCMW#1, MCMW#2, MCMW#3, MCMW#4, MCMW#5, MCMW#7, MCMW#8, MCMW#9 and MCMW#10 (14 wells total).

d. WYDOT monitoring well EQ #2.

For general aquifer monitoring, particularly between the Spur and Turner Wellfields, Stantec recommends that several new wells be constructed. Proposed monitoring wells between the Spur and Turner Wellfields lie along the 1 year time-of-travel boundary and are identified in Table 1J as Turner MW-1, Turner MW-2, Turner MW-3, Turner MW-4, and Turner MW-5. These new wells would be used along with Soldier MW-5, Simpson MW-1, 41T3, LCCC, and 41T2 as sentinel wells which will be used to collect long-term data, provide an early warning if contamination occurred, and allow the City Utility to conduct additional sampling if water-quality was degraded compared to historical data.

For monitoring aquifer conditions along I80, Stantec recommends the construction of three additional wells, two east of the existing WYDOT wells and one east of the Pope Springs Wellfield. These wells are presented as I80 MW-1, I80 MW-2, and TCMW-2 in Table 1J. These three new monitoring wells along with the existing EQ #1, EQ #2, and Huntoon #2 wells could be used for both long-term monitoring and sampling if a hazardous material spill occurred on I-80. The City and County should work with WYDOT to see if funding is available for installing, maintaining, and monitoring these wells through WYDOT offices.

To monitor water quality conditions downgradient of existing residential development, Stantec recommends monitoring of several existing wells. Monitored wells would include Spur MW6, Huntoon #1, Triangle Well, and Imperial Heights North and South. While no new monitoring wells are proposed for this area, sampling additional domestic wells in this area would be helpful in monitoring local nitrate concentrations. The monitoring wells below residential development will allow long-term monitoring of the aquifer and data to help determine the impact of residential land use on the aquifer.

For the Mountain Cement Quarry, Stantec recommends the construction of two additional wells in this area, but more importantly, using the existing 14 Mountain Cement monitoring wells to evaluate aquifer conditions in this area of the CAPA. These existing wells provide a significant amount of data on the Casper Aquifer east of the Soldier Spring Wellfield and Simpson Springs. MC-3 and MC-4 would be completed east and upgradient of the Pope and Soldier Springs Wellfields. Together, these monitoring wells around the mining operation will allow determination of the impacts, if any, of limestone mining on the aquifer

Table 1J: Proposed Monitoring Wells for the Expanded Groundwater Monitoring Program.

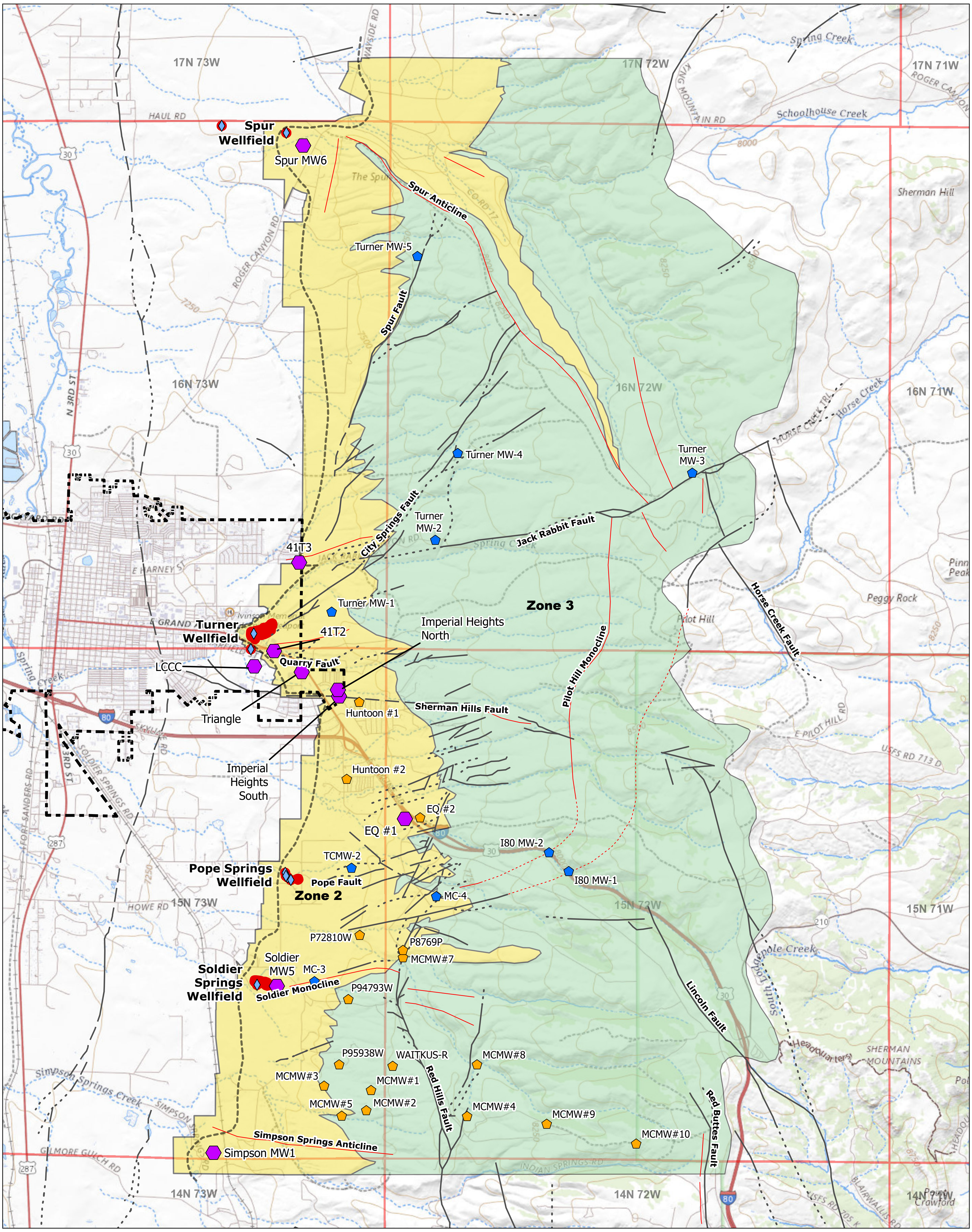
Purpose	Existing wells	Proposed wells
General monitoring	Soldier MW-5 Simpson MW-1 41T2 41T3 LCCC	Turner MW-1 Turner MW-2 Turner MW-3 Turner MW-4 Turner MW-5

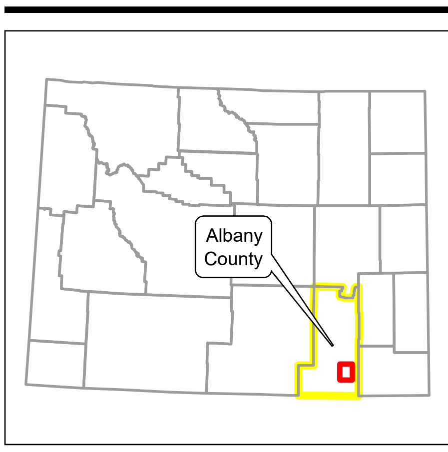
Purpose	Existing wells	Proposed wells
I-80 monitoring	EQ #1 EQ #2 Huntoon #2	I80 MW-1 I80 MW-2 TCMW-2
Residential development monitoring	Spur MW-6 Huntoon #1 Triangle Well Imperial Heights North Imperial Heights South	
Mountain Cement Quarry monitoring	P72810W, P8769P, P94793W, P95938W, WAITKUS-R, MCMW#1, MCMW#2, MCMW#3, MCMW#4, MCMW#5 , MCMW#7, MCMW#8, MCMW#9 and MCMW#10	MC-3 MC-4

1.2 SAMPLING PARAMETERS AND FREQUENCY

Stantec recommends a similar sampling frequency and water quality parameter list to that used by Mountain Cement. To achieve that, monitoring wells would be monitored quarterly and each monitoring event would include both water level measurements and water-quality samples. Monthly, semi-annual, or annual sampling could also be used, but quarterly sampling provides a reasonable picture of seasonality in water quality and water level conditions. Monitoring at regular intervals throughout the year and into the future is the key to understanding changes in water quality and water level conditions, and how those changes will affect groundwater availability and drinking water suitability.

With regard to groundwater sampling, Mountain Cement is sampling for a fairly extensive list of analytes, which is similar to what the City is sampling for at its municipal wells. To be consistent with Mountain Cement, Stantec would recommend the City and County sample the groundwater for the following analytes: total dissolved solids, electrical conductivity, total alkalinity, nitrate plus nitrite, major cations, major anions, dissolved metals, total metals, pH, fecal coliform, and total petroleum hydrocarbons (TPH). At a minimum, Stantec recommends the monitoring wells be sampled for total dissolved solids, dissolved oxygen, nitrate, chloride, pH, electrical conductivity, and fecal coliform. TPH should be sampled for once every two to three years. The petroleum hydrocarbons will be used as a surrogate for organic compounds. If a petroleum hydrocarbon is detected, the City and County should initiate additional organic parameter testing at the impacted well. For the existing Mountain Cement monitoring wells, the City and County will obtain the Annual Report from WDEQ/LQD that will provide the analytical results for the quarterly sampling events for the above described quarry monitoring wells.





Legend

- City of Laramie Municipal Wells

Monitoring Wells

- Proposed (To Be Built)
- Proposed (Existing)
- Existing
- Fold
- Fault
- Municipalities
- Protective Satanka Shale Thickness
- CAPA Zone 1
- CAPA Zone 2
- CAPA Zone 3

0 0.6 1.2 Miles

(At original document size of 11x17)
1:76,032

N

Notes
1. Coordinate System: NAD 1983 StatePlane Wyoming East FIPS 4901 Feet
2. Data Sources: USGS, Ver Ploeg and Boyd (2007), City of Laramie
3. Background: USGS 7.5 Minute Quadrangle

Stantec

Project Location
T16N, R73W
Laramie, Albany Co., WY

Prepared by KAB on 2023-02-15
TR by XXX on 2020-XX-XX
IR by XXX on 2020-XX-XX

Client/Project
227704690
City of Laramie/Albany County
Casper Aquifer Protection Plan Update

Figure No.
J-1

Title
Existing and Proposed Monitoring Well Locations

V:\2277\active\227704690\03_data\gis_cad\gis\pro\CAPP UPDATE 2022\CAPP UPDATE 2022.aprx Revised: 2023-02-15 By: kberglund

APPENDIX K

Comments and Responses

Comments Received before DRAFT CAPP was issued

Before this DRAFT document was released to the public, Stantec met with several groups from the local Laramie community to discuss potential updates and changes to the CAPP. These meetings were held with Albany County Clean Water Advocates on June 27, 2022, the Casper Aquifer Protection Network on July 11, 2022, and a technical group of local engineers and geologists on July 11, 2022. This table documents comments received by group.

Comment Source	Direct Comment Text	Comment Summary	How Comment was Addressed
CAP Network small group meeting	"Is the purpose to protect public water supplies or individual wells?"	What is the overall purpose of the plan – protection of public water supplies, or individual wells?	Added language stating that the purpose of the CAPP is to protect both public water supply wells and individual domestic wells from contamination by protecting the aquifer at large.
CAP Network small group meeting	"This is all just a solution looking for a problem"	What is the problem is that needs to be remedied?	Added language stating that there has been contamination of the aquifer locally due to nitrates.
CAP Network small group meeting	"Public water supplies have not been negatively affected according to the city's own data"		Added language on the dangers of nitrates in drinking water. These dangers apply equally to public and domestic water supplies.
CAP Network small group meeting	"We all have wells there, we don't want our water to be bad" (and it isn't – there's no evidence of a problem)"		
CAP Network small group meeting	"Why isn't there a map of all the wells you looked at?"	Make clear on map all the wells for which information was examined, particularly in delineation of the Western Boundary.	Present several maps of data sources, including well logs and SSIs, used during CAPP boundary delineation. Tables indicate Satanka Shale thicknesses derived from water well and SSIs. The maps also indicate Satanka Shale thickness relative to local geologic maps and property boundaries.
CAP Network small group meeting	"Make clear what SSIs have been drawn upon for W Boundary delineation"		

Comment Source	**Direct Comment Text**	**Comment Summary**	**How Comment was Addressed**
ACCWA small group meeting	"Describe the amount of data reviewed to arrive at the Satanka line"		
CAP Network small group meeting	"Satanka is impermeable unless fractured, according to Huntoon"	Why was the delineation changed and what evidence was used to support the increased Satanka thickness threshold? Clarify which versions of the CAPP made these changes	Added language stating that drilling evidence found locations where the existing 75 ft thickness line was inaccurate. The western boundary was revised on the basis of drilling data that provided improved definition of Satanka Shale thickness conditions in the area.
CAP Network small group meeting	"If you look at the original delineation, both CAPPs, recommended no wholesale change of boundary. We should only do so if underlying assumptions appear wrong""		Added language clarifying that Satanka thicknesses of less than 50 ft are not considered sufficient to protect the aquifer
ACCWA small group meeting	"Explain why 75 feet: re communication between Satanka and CA at certain depths?"		
CAP Network small group meeting	"Way too expensive and can take forever, have looked at AdvanTex etc. – all are expensive. And expenses include hauling away and disposing of old materials, including old leachfield.	Present in detail the possible financial support options for homeowners who may have to replace/update septic systems with enhanced septic.	Include research on enhanced septic tank feasibility, cost, and availability
			Recommend funding sources be communicated to homeowners as they become available.

<table>
<tr><th>Comment Source</th><th>Direct Comment Text</th><th>Comment Summary</th><th>How Comment was Addressed</th></tr>
<tr><td>CAP Network small group meeting</td><td>Hard to judge from coloring of maps what they show – please make color scheme consistent, between old and new maps, so that key aspects (75 ft line, Western Boundary etc.) stand out, and so that what is different between old and new stands out to viewer</td><td rowspan="4">Change figure clarity and legibility</td><td>Figures were updated based on review of previous City and County map versions.</td></tr>
<tr><td>ACCWA small group meeting</td><td>Map views: make map slightly wider to include Highway 287 So, etc., so people can orient themselves</td><td>Highway 287 is included on most figures for reference.</td></tr>
<tr><td>Technical, engineers and geologists CAPP small group meeting</td><td>Make clear the Western boundary details, provide close-ups</td><td rowspan="2">Close up figures added</td></tr>
<tr><td>ACCWA small group meeting</td><td>Make the Satanka line brighter on maps</td></tr>
<tr><td rowspan="2">CAP Network small group meeting</td><td rowspan="2">“DEQ doesn’t require enhanced septic systems and they must have a reason for that”</td><td rowspan="2">Why propose stricter requirements than DEQ does? How does the county have power to do that?</td><td>DEQ permitting delegated to the county or city if their standards are at least as stringent as the state's. County and City can develop more stringent standards with the goal of protecting the aquifer.</td></tr>
<tr><td>Added language describing evidence of contamination and threat to the aquifer to justify proposed use of Advanced Treatment Units on smaller lots</td></tr>
</table>

Comment Source	Direct Comment Text	Comment Summary	How Comment was Addressed
CAP Network small group meeting	“It is commonly repeated, and it is incorrect - people say septic systems don’t do the job”;	Provide info on septic system basics and what they really accomplish re nitrates or other contaminants	Evidence of existing contamination and prior studies or evidence that enhanced septic systems could work in this area
CAP Network small group meeting	"EPA would disagree that nitrogen gets through the septic system"		Add language describing past studies which found that a functioning conventional septic system within the CAPA does not sufficiently reduce the nitrogen load to protect the Casper Aquifer
CAP Network small group meeting	“standard conventional system will treat nitrates down to 14 ppm”		Added a discussion of where this recommendation falls in terms of stringency levels
			Added a table of costs compared to nitrate reduction for an example study
CAP Network small group meeting	"Expense is much greater than the manufacturer or distributor claims – expense includes, for instance, disposition disposal of earlier leachfield, with expensive restrictions on how that can be done"	Provide info on enhanced septic systems, why/how they are better, where nationally they are required and/or in use – costs as documented (if possible) by other communities, not by the manufacturer/distributor	Added a table of enhanced septic system costs and availability in Wyoming
ACCWA small group meeting	How accessible are enhanced septic systems in our region?		
ACCWA small group meeting	"What are the real costs of enhanced septic systems"		
ACCWA small group meeting	A PE should be required to sign off on “as built” for these systems		Added a discussions of DEQ's approval status for each of the septic system options

Comment Source	Direct Comment Text	Comment Summary	How Comment was Addressed
CAP Network small group meeting	"The potentiometric map presented in initial PowerPoint essentially discredits your approach and the test hole requirement"	Explain the potentiometric maps and what they mean for which areas can impact both City Springs and domestic wells	Added language emphasize that the issue is protection of entire aquifer, not just city springs.
CAP Network small group meeting	"The way it's put, you'll be making people prove the water isn't going towards the city wells"		Added language clarify that the potentiometric maps show general flow direction but do not represent all potential flow paths and contaminant transport mechanisms.
CAP Network small group meeting	"Explain how development in magenta-outlined areas (those requiring test holes for any development) could possibly affect city springs, given the potentiometric maps"		
CAP Network small group meeting	"All this is driven by politics."	Why does the consultant make policy recommendations, going beyond just presenting the latest scientific information?	Added language stating that the goal of this work is to protect public water supply wells and individual domestic wells from contamination .
ACCWA small group meeting	Explain the science, reasoning that backs up all these rules		Added language stating that changes to the CAPA delineation were made based on drilling data, and exiting SSIs
Technical, engineers and geologists CAPP small group meeting	Policy (and therefore the consultant's recommendations) needs to "balance" competing needs of the community		

Comment Source	Direct Comment Text	Comment Summary	How Comment was Addressed
CAP Network small group meeting	"Consultants should produce just the scientific information, just 'here is what we know'; the perception is that consultants have been advocates in the past 20 years"		
ACCWA small group meeting	Instead of commercial animal confinement, maybe "commercial animal husbandry" is better term for what is prohibited	Prohibition on "intensely managed turf" (and commercial confined animal sites) needs better definition, possibly stating what's NOT prohibited use	Changed language defining prohibited uses with regards to AFOs and included DEQ definition that applies only to operations with over 1000 animal units per facility or 10+ animals per acre on parcels smaller than 35 acres
CAP Network small group meeting	"Kids need their 4H projects, animals, for better mental health"		
Technical, engineers and geologists CAPP small group meeting	How many animals define a commercial feeding operation and how is that measured?		
Technical, engineers and geologists CAPP small group meeting	What does intensely managed turf means? Could you have a Pine-Bluffs type golf course?		Changed language defining prohibited uses with regards to intensely managed turf and included a definition that applies only to high water demand grasses and large quantities of pesticides/fertilizers/herbicides.
ACCWA small group meeting	Prohibiting commercial agriculture?		
CAP Network small group meeting	"A fault could have a smear that makes it impermeable at that spot"	Need better definition of vulnerable features and more specific recommendations	Added language clarifying that faults effect permeability in unpredictable ways and must be treated as vulnerable features

Comment Source	**Direct Comment Text**	**Comment Summary**	**How Comment was Addressed**
ACCWA small group meeting	Vulnerable feature setback: don't allow exceptions (as is the case now in city) for facilities that have "engineering controls."		Added language recommending a geologist or engineer's review of all new development or proposed uses near vulnerable features
ACCWA small group meeting	Relying on engineering controls to operate, be operated and understood, 25 years from now is misplaced reliance on institutions to remain attentive to issues involved in CAPP		
Technical, engineers and geologists CAPP small group meeting	What "contaminant sources" must have a setback of 100 ft from "vulnerable features", and why?		Addressed in the Potential Contaminant Sources and Setback from Vulnerable Features sections
Technical, engineers and geologists CAPP small group meeting	Define/quantify exactly what "wastewater facilities" have to be set back 100 feet from vulnerable features		Plan recommends setback for all development
CAP Network small group meeting	"CAP Network spent $180k on geologists who came to conclusions – they told the truth"	Look at data that CAP Network has gathered.	
CAP Network small group meeting	"People have had trouble getting qualified inspectors or installers"	What is the justification for requiring regular pumping and inspections of septic tanks, or requiring	Added language stating concerns about existing septic systems causing contamination of the aquifer

Comment Source	**Direct Comment Text**	**Comment Summary**	**How Comment was Addressed**
CAP Network small group meeting	"Property owner contacting septic tank pumper is better than requirements"	inspection when property changes hands?	Added language allowing County required inspections to be waived if homeowner can provide evidence of recent inspections and pumpage
CAP Network small group meeting	"Take water samples in densely populated areas (in APOZ) – maybe those owners would permit it"	Why haven't more wells been sampled for nitrate levels?	
CAP Network small group meeting	"No one is interested in letting the city or county have data; they will give it only to private people"		
CAP Network small group meeting	"If in this plan you move the Western boundary, you just create more non-conforming uses"	Explain and give more detail on how "expansions" of grandfathered use will be evaluated (to determine if prohibited use)	Added language recommending no expansion of nonconforming uses
CAP Network small group meeting	"Expansion as additional prohibited use is targeting people and preventing valuable improvements that would better take care of the property"		Makes recommendations regarding pre-existing nonconforming uses
ACCWA small group meeting	Expansion of existing non-conforming uses: define expansion		

Comment Source	Direct Comment Text	Comment Summary	How Comment was Addressed
ACCWA small group meeting	In general, give clear enough definitions and guidelines (re SSIs, test holes, additional prohibited uses, etc.) so that city and county staff are not left with amount of discretion that subjects them to pressure from development etc. interests to waive or err on side of less protection	Avoid placing too much responsibility on City and County staff when it comes to decisions regarding SSIs	Added language that County Engineers should not conduct SSI reviews
ACCWA small group meeting	Make it clear this proposes *rules* for development in APA, not *moratorium*		The CAPP Report only makes recommendations regarding proposed regulations for the city and county to implement
ACCWA small group meeting	"Could developer alternatively put in a monitoring or water well instead of a test hole?"	Purpose for recommending test wells in key areas where no SSI or drilling data is available	Language added that allows a groundwater well data to be used in lieu of a test hole. Amended language to allow hollow stem auger/air rotary drilling methods.
CAP Network small group meeting	Test hole drill costs high, who pays for that? Currently cost is $50/foot, with a 7 mo. backlog, to get drillers		
ACCWA small group meeting	Note in discussion of the future that the plan could be amended if data, from test holes or monitoring wells, etc., suggests some surprise information		

Comment Source	Direct Comment Text	Comment Summary	How Comment was Addressed
ACCWA small group meeting	In areas of data gaps (where test holes are currently proposed) – could we make that a proposed research program instead?		
ACCWA small group meeting	Other possible research program to propose: how to design study to determine travel time in certain faults		
Technical, engineers and geologists CAPP small group meeting	Test holes being proposed for areas where there is no data – in those areas, could CAPP maps mark locations where there is no data but it doesn't matter?		
ACCWA small group meeting	SSIs should not just be "windshield" reviews, especially in key areas.	Changes to SSI requirements	Made recommended SSI requirements more stringent
ACCWA small group meeting	Spell out the OWTS acronym on first use		Onsite Wastewater Treatment System (OWTS)
ACCWA small group meeting	Pay attention to effects of other human activities in residential areas, etc., not just nitrates		Expanded on other potential sources of contamination
ACCWA small group meeting	Distribute info through realtors? Banks? Title records? Other means?	Provide info to those moving into/considering purchasing property in CAPA	Added language recommending education regarding CAPP requirements in order to protect those seeking to develop or purchase property within the CAPP

Comment Source	Direct Comment Text	Comment Summary	How Comment was Addressed
ACCWA small group meeting	Provide educational flyers to banks and realtors that they could give people, even if you can't require them to do so		Recommend realtors or real estate groups provide potential homebuyers with a summary of requirements that could affect the property
ACCWA small group meeting	Possibly require xeriscape in subdivisions on in CAPA on lands within city limits		
Technical, engineers and geologists CAPP small group meeting	Use of property boundaries to draw boundary lines: why not do that between Z 2 and 3?	Clarify how the boundary between zones 2 and 3 was differentiated. Underline whether or not there any differences in implementation between these zones	Eliminated any differences in regulatory recommendations between Zones 2 and 3
			Included additional language describing the geologic boundary between Zones 2 and 3 and why it was chosen.
Technical, engineers and geologists CAPP small group meeting	Are enhanced septic system required in Z 2 but not in Z 3?		The two zones should be regulated the same
Technical, engineers and geologists CAPP small group meeting	Compare the value of these recommendations with the costs	For all recommendations – prioritize them, with some sense of cost vs. benefit	Added a table of costs and availability in Wyoming compared to nitrate reduction
			Not feasible to include a cost benefit analysis for every recommendation
Technical, engineers and geologists CAPP small group meeting	Why the 35 acre lot size? (other than that it's currently in county regs)	References to prior studies that establish the 35 acre lot size	Added language describing where the 35 acre lot size requirement came from

Small Group Meetings:

Technical, engineers and geologists CAPP small group meeting:	July 11, 2022	1-3:30 pm
Albany County Clean Water Advocates (ACCWA) small group meeting:	June 27, 2022	7-9 pm
CAP Network small group meeting:	July 11, 2022	7-10:30 pm

Comments Received on the DRAFT CAPP

After this DRAFT document was released to the public, Stantec received numerous comments in writing from individuals as well as verbal comments presented during three public meetings that were held on September 7 and 13, and October 5, 2022. This table generally documents comments received by source.

Comment Source	Direct Comment Text	Comment Summary	How Comment was Addressed
Chris Moody	"The preamble is intended to be an informal, somewhat philosophical/emotional appeal for aquifer protection."	This long dense document could use a summary to help local residents understand aquifer protection.	The preamble was added and slightly modified.
Chris Moody	"There is a lot going on within the community regarding aquifer protection that I think should be recognized in the CAPP."	The efforts of the local community to protect the aquifer need to be acknowledged.	Added in and slightly modified the summary provided.
Chris Moody	"Also included are jpeg images of the murals that would make beautiful graphic inserts in the document with some caption info."	The aquifer art created by Paul Taylor and Laramie High School students would be a nice addition to this document.	Three of the murals were added into the plan document along with descriptive captions.
Chris Moody	"My attached comments and suggestions re the ver. 3 draft CAPP are incomplete and spotty"	Many comments regarding the CAPP document text	Addressed as appropriate relative to comments provided.
Chris Moody	Comments regarding vulnerable features and SSIs	Suggested changes to improve vulnerable features section and SSIs.	Added language to support changes noted.

Comment Source	Direct Comment Text	Comment Summary	How Comment was Addressed
Bern Hinckley	“Split Chapter 3 (“Delineation”) into two pieces, Chapter 3 - “Hydrogeologic Setting” (possible title) and then Chapter 4 - “Delineation”.”	The hydrogeologic setting of the Casper Aquifer should be presented prior to the delineation of the aquifer protection area.	Sections 3.2 and 3.3 were pulled from the document and placed into their own chapter that precedes the aquifer protection area delineation. All remaining sections/chapters were renumbered accordingly.
Bern Hinckley	“The CAPP is fundamentally about groundwater quality. The new subsection of the hydrogeology discussion would be “Water Quality”.”	The groundwater quality data for the Casper Aquifer should be presented to characterize aquifer water quality.	Water quality data for the Casper Aquifer were assembled from various sources and added to the document.
Bern Hinckley	“It would be useful to review the authority and procedures under which this land use plan is being prepared.”	Need to clarify DEQ relationship to this document and rationale for its completion.	Language was added to clarify the basis for authority of this plan.
Bern Hinckley	“We need a careful assessment of the SSI requirements”	Revise SSI requirements so that they directly relate to development constraints	Added language as needed or moved items related to improving understanding of the aquifer.
Bern Hinckley	“Attached is a WORD document with my comments as I read through the August DRAFT.”	Many comments on the CAPP document text	Addressed as appropriate relative to comments provided.
Bern Hinckley	“Attached is a markup of the August DRAFT CAPP Executive Summary”	Suggested modifications to the executive summary	Added in some suggested changes.
Bern Hinckley	“Attached is a short set of comments addressing the August DRAFT's discussion of pre-existing, nonconforming uses”	Some requirements may not be allowable	Noted that the requirements be added to the extent statutory authority allows.

Comment Source	Direct Comment Text	Comment Summary	How Comment was Addressed
Maura Hanning	"Thank you for considering the following comments regarding the Draft Casper Aquifer Protection Plan (CAPP) Update, dated August 19, 2022. The document is a robust update and excellent resource"	Many comments on the CAPP document text	Addressed as appropriate relative to comments provided.
Rhiannon Jakopak	"As a Laramie resident for the past 12 years, I am writing in support of the Casper Aquifer Protection Plan. There has been considerable public involvement from numerous stakeholder groups throughout the entire process…"	Anticipates methods, recommendations, and requirements for septic systems will be laid out, and increased monitoring	Revised septic system presentation and management strategies accordingly.
Anonymous	"Now I understand that it isn't the septic systems that have failed. So, why did the soil around a correctly and accurately performing septic system fail and what needs to be done about it? Correcting the problem, as has been proposed, significantly impacts property owners in the county."	Who decides whether the septic system has failed? What options might there be for second opinions? What options exist for funding replacement septic systems?	Added details on advanced treatment units and approaches other states have taken to address septic systems
Albany County Clean Water Advocates	"pasted below and attached please find general comments on the draft CAPP update from Albany County Clean Water Advocates."	Many comments on the CAPP document text	Addressed as appropriate relative to comments provided.
Randy Tepler	"I am in favor of protecting the Casper Aquifer and having a plan to protect it. The plan should be based on science regarding threats to the aquifer, not bias or opinion."	Septic system regulations need to better align with state requirements. Soil science should be play in larger role in making decisions on septic systems.	Presented current regulations and their limitations along with how other jurisdictions have approached septic system regulation.

Comment Source	Direct Comment Text	Comment Summary	How Comment was Addressed
Murray Schroeder	"At this time I'm providing an opinion that estimating the 100 year flood and delineation caused by offsite and on-site storm water does not provide enough value in most cases. "	Delineating the 100 year flood plain does not add significant value to the SSI process	Modified floodplain mapping requirement so that it is pertinent to the proposed development at the subject property. Eliminated some requirements on hydrology, flood flows, etc.
Bill Voight	"Clean water is essential for the health and well being of Albany County's residents. The proposed CAPP is based on sound science and should be adopted by Albany County. "	Adopt the plan.	No additions made.
Bonnie Heidel	"I've been following the preparation and implementation of the CAPP for much of 20 years, and see this document as a major stride. It warrants treatment as a stand-alone document with addition of supporting data."	Add in supporting data, particularly water quality and 2009 nitrate sampling results	Added a water quality section to the document and included many water quality sample results.
Nancy Currah"	I believe the plan will be great if the City of Laramie and the Country of Albany adopt these simple rules:…"	Adopt the additional provisions included in the update.	No additions made.
Anne Guzzo	"Regarding protection of the Casper Aquifer, I ask that the city adopt the recommendations of the Draft Aquifer Protection Plan. It is a good plan and will protect our water. Thank you."	Adopt the recommendations provided in the update	No additions made.
Eric Quade	"I encourage the city and county to adopt the recommendations of the Draft Aquifer Protection Plan."	Adopt the recommendations provided in the update	No additions made.

Comment Source	**Direct Comment Text**	**Comment Summary**	**How Comment was Addressed**
Geri Doherty	"I have not read the plan, but most definitely agree with the 3 protections listed in your email. Glad that Laramie is actively protecting their groundwater!"	Agree with protections	No additions made.
Madeline Dalrymple	"We appreciate the plan. It looks like it will protect water."	Agree with protection	No additions made.
Sandra Frost	"I would like the city of Laramie and Albany County to adopt the draft recommendations for protection of the Casper Aquifer. Our leaders need to think 50 years ahead for survival."	Adopt the plan	No additions made.
Joy Handy	"I agree there needs to be a support for keeping animals, businesses, and golf courses physically out of the drinking water, to avoid contamination of people's health."	Maintain provisions to protect groundwater	No additions made.
Linda Johnson	"Advanced Septic Systems are expensive, parts are not available for maintenance; therefore, wait time would be a huge problem. What does "replacement" mean? At this time, I can get any part for my current septic system immediately, and my home returned to working order….At this point, septic systems seem to be doing a great job."	Septic systems are doing a great job, and advanced treatment units are too expensive to install or inconvenient to maintain	Addressed how conventional septic systems provide treatment and provided documentation supporting the use advanced treatment units to protect the aquifer.

Comment Source	**Direct Comment Text**	**Comment Summary**	**How Comment was Addressed**
Roberta & Danny Dunlavy	“How are "our" expansion plans contaminating the aquifer? We feel this is so invasive to our property rights, when there is NO proof of contamination. How can expanding or improving an operation contaminate the aquifer?”	The regulations are unnecessary and unreasonably expensive	Provided additional water quality and documented nitrate contamination. Clarified that expansion pertains to nonconforming uses or grandfathered prohibited activities that have the potential to contaminate the Casper Aquifer.
Shay Howlin	“I support the recommendations made in the document and would encourage the Council to adopt the recommendations of the Draft Aquifer Protection Plan. These protections are needed for all citizens of Laramie for today and the future.”	Adopt the updated plan	No additions made.
Jason Robison	“I encourage the City of Laramie and Albany County to adopt the recommendations of the Draft Aquifer Protection Plan. I particularly support the following recommendations:…”	Adopt the updated plan	No additions made
Conor Mullen	“…We urge you to support the recommended updates to the plan, which would strengthen protections for a resource that serves most of the residents of Albany County…	Adopt the updated plan	No additions made

Comment Source	Direct Comment Text	Comment Summary	How Comment was Addressed
Brandon Reynolds	The Wyoming Outdoor Council supports the inter-governmental effort to streamline the coordination and regulations between the City of Laramie and Albany County. WOC also supports the recommendations provided in the report that are most protective of groundwater, both private wells and the City wells and well fields within the Casper Aquifer…	Adopt the updated plan	No additions made
Matt Burkhart	"I am opposed to this update of the Casper Aquifer plan and continue to oppose the original plan. Clean water is important but it can be maintained without eliminating private property rights like this plan does. The Plan and Update eliminate private property rights and negatively impact private property values…"	The plan both protects the aquifer, but as constructed infringes on private property rights	Corrected maps showing potential sources of contamination and septic systems with revised county data, and addressed comments on inspections and advanced treatment units

Comments Received on the DRAFT CAPP

After this DRAFT document was released to the public, Stantec received additional comments from members of the City and County Planning Commissions and Environmental Advisory Committee as well as the technical subcommittee from these boards. These comments were generally received in December 2022. This table generally documents comments received by source, and notes document locations where those specific comments were addressed in this updated CAPP. Document locations noted in the table below relate to the DRAFT document released February 17, 2023.

Comment Source	**Direct Comment Text**	**Comment Summary**	**Document Location**	**How Comment was Addressed**
City and County Planning Boards Technical Subcommittee and Members	“Here's our end-of-year report to the contract managers (David and Darren)…”	CAPP needs to provide more support for 35 acre minimum lot size, clarify western boundary language, explain shallow groundwater, further discuss fractures, and provide context on septics	Throughout the document	Added in supplementary information or revised as necessary. Restructured document sections to increase readability.