Geologic Survey of the

Panoramic View Subdivision Property

near Berthoud, Colorado

South-Eastern Larimer County

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prepared by

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The People's Lab

INDEX

1 BASIC INFORMATION

1.1 PROJECT DESCRIPTION

The Panoramic View Subdivision is comprised of approximately 21 rural acres to be subdivided into two equal parcels of 10.5 acres. Current zoning is FA-1 (agricultural). Grass hay farming was limited to the Northern 1/3 of the property. Except for an old silo in the Northeastern part of the property no other structures are currently present. After the subdivision one new single family dwelling per parcel is anticipated without changing the current zoning.

The Panoramic View acres are among other FA-1 zoned 62 to 8 acre farm-ranch parcels, most with single family dwellings. Exception is a large 140+ acre area directly to the Southwest belonging to Boulder county as an open space conservatory. To the West and North of the area are 20 to 30 acres of producing grass hay/ alfalfa fields. The closest occupied structure is an extended family dwelling modular home approximately 300 feet to the East on a 19 acre parcel with some organic farming and small livestock. Directly to the South is Boulder county with two more rural single family dwellings on estimated 35 acre parcels.

1.2 LOCATION OF PROPERTY

The proposed Panoramic View Subdivision is located in the Southeastern part of Colorado's Larimer County, specifically in the SE 1/4 of the SE 1/4 of Section 32, T4N, R69W (see figure 1). The project lies about 2 miles East of the nearest Rocky Mountain foothills within the Little Thompson River drainage system.

1.3 PURPOSE OF STUDY

This report was prepared in accordance with the Larimer County requirements for new subdivisions. Of interest is the geologic suitability of the proposed subdivision for the purposes indicated by the landowner. Conclusions concerning geologic compatibility of said property for residential / farm structures and subsequent design of roads and septic systems are of general nature. Specific engineering tests might be necessary to address project particularities prior to construction.

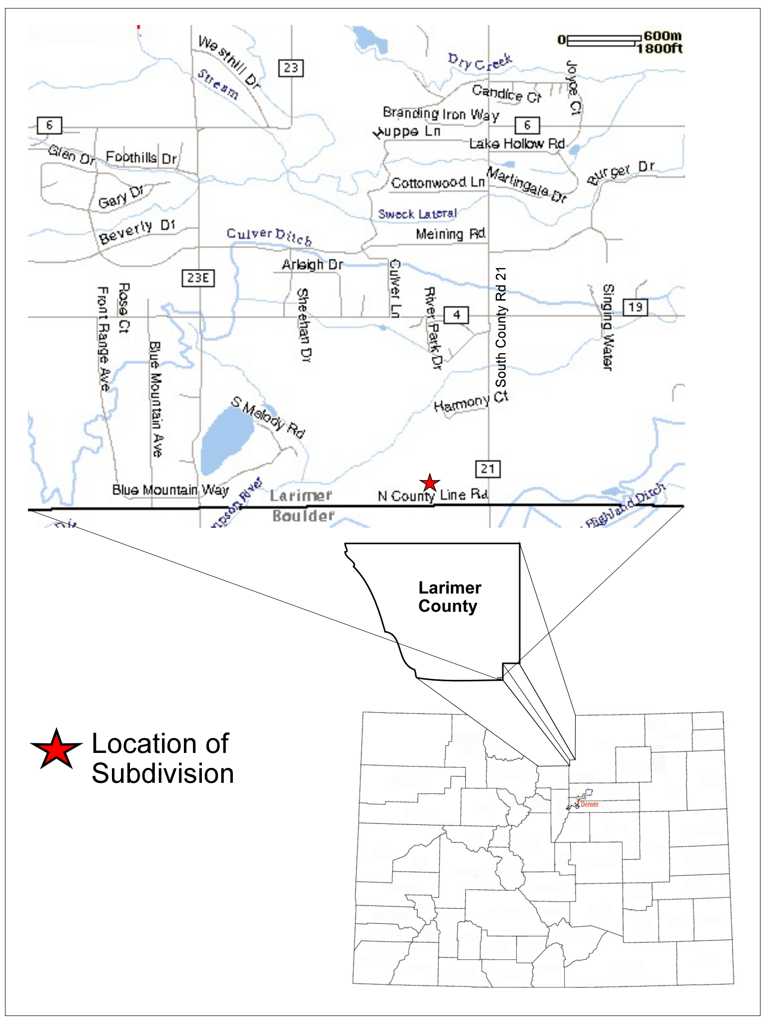

Figure 1 - Geographic Location of Subdivision in Larimer County and the State of Colorado.

The report was commissioned by the landowners, Paul and Sarah Smith, applicants for the Panoramic View Subdivision, in order to fulfill said Larimer County requirements.

1.4 SCOPE OF INVESTIGATION

The main scope of the study is the evaluation of geologic / hydrogeologic features of said property for the proposed residential / agricultural applications with the following objectives:

1. Show the distribution and quality of surface soils for proposed applications.
2. Investigate groundwater systems and quality.
3. Identify surface water run-off and impact on the topographic surfaces, especially in light of 100 year precipitation events.
4. Indicate the presence or absence of any possible natural mineral resources.

Certain geologic features did not pertain to the geographic area of investigation. Therefore, the ground instabilities or geologic hazards listed below were excluded from the scope of the study:

1. Any type of mass wasting, such as landslides, earthflows, debris flows, mudflows, rockfalls, debris avalanches, fault scarps, soil creep, erosion scarps, avalanche paths, and subsidence phenomenon.
2. Structural features, including joints, faults, shear zones, folds, schistocity, and foliation.
3. Seismic hazards.

No previous published or unpublished geologic report in the subject area for this particular geographic location exists to our knowledge. However, congruent with this investigation a report with the title “Geologic Survey of the Crystal Meadow Subdivision Property near Berthoud, Colorado, South-Eastern Larimer County”, a study immediately adjacent to the East of the current project was also prepared.

Data for this report was obtained from various sources listed under references as well as on-site and laboratory investigations summarized as follows:

1. Literature, map, and drill record research and compilation of reference materials useful for geologic interpretations, such as survey, topographic, geologic, and soil maps, airphotos and oil and gas drill data.
2. Field investigation:

Task and Purpose	Time	completed by:
Perimeter and field walk to identify soils and any pertinent geologic and geomorphic features	approx. 40 minutes	The People’s Lab LLC U.R. Kackstaetter, Ph.D. Geol.
Representative soil sampling for laboratory analysis	approx. 15 minutes	The People’s Lab LLC U.R. Kackstaetter, Ph.D. Geol.
Water measurements of pH, temperature, and conductivity, as well as sampling for laboratory analysis	approx. 20 minutes	The People’s Lab LLC U.R. Kackstaetter, Ph.D. Geol.

3. Laboratory investigations:

Task:	completed by:
Water analysis for nitrates, chlorides, sulfates, ammonia by VIS spectrophotometer.	The People's Lab LLC Sample, CO
Water analysis for 73 elements by ICP-MS	Acme Analytical Laboratories Ltd. Vancouver, BC
Soil analysis for rock forming oxides and elements by ICP-ES and Leco	Acme Analytical Laboratories Ltd. Vancouver, BC

2 BASIC DATA

2.1 REGIONAL SETTING

The property lies in a gently rolling topography within the Little Thompson River drainage basin about 3.5 miles due East from the first noticeable foothills features (Upper Cretaceous Niobrara limestone hogback) of the Rocky Mountains. The project lies approximately 40 to 80 feet elevated and 1800 feet Southeast from the river channel. The maximum elevation difference inside the Panoramic View Subdivision is 40 feet with the highest elevation of 5104 feet in the Southeastern corner of the property and it's low point of 5068 feet to the North. The total average downward slope of the project trends NNW with the steepest slope of 4.6% and overall average of 4%. For topographic detail see figure 2. A wet area of estimated 2 to 3 acres due to elevated groundwater exists in the Western area of the property. No surface water is present other than small artificial seasonal irrigation water storage reservoirs approximately 500 ft and Southwest of the premises. The historic Blower irrigation ditch crosses from the Southwestern part to the Central Eastern property boundary. Since irrigation water supply was switched roughly two decades ago to underground pipes, no water was since delivered on the surface through the historic ditch.

The whole property is underlain by the gray concretionary silty Upper Member shale of the Upper Cretaceous Pierre Formation. The Pierre Shale Bedrock is well weathered and not exposed. The present surface geology consists mainly of soil differentiated Upper Holocene to Pleistocene colluvium represented by bouldery to pebbly sandy silt and clay deposited by gravity and sheet wash on slopes (see also Colton, 1978). The closest tectonic features are faults within the Rocky Mountain Foothills vicinity of Rabbit Mountain, Dow Pass, and Meadow Hollow, about 4 miles due West. To the East of the project the horizontal geology of the Great Plains is evident.

General mineral resources in the area include sand deposits about 1800 feet Northwest situated in the Upper Holocene Post-Piney Creek Alluvium underlying the immediate flood plains of the Little Thompson River. Nevertheless, no sand or gravel is present on the property. Other mineral deposits include possible hydrocarbons as indicated by producing wells about 3 miles to the Northeast. Nonetheless, three dry oil wells within a ½ mile radius of the project negate any valuable petroleum deposits on the premises.

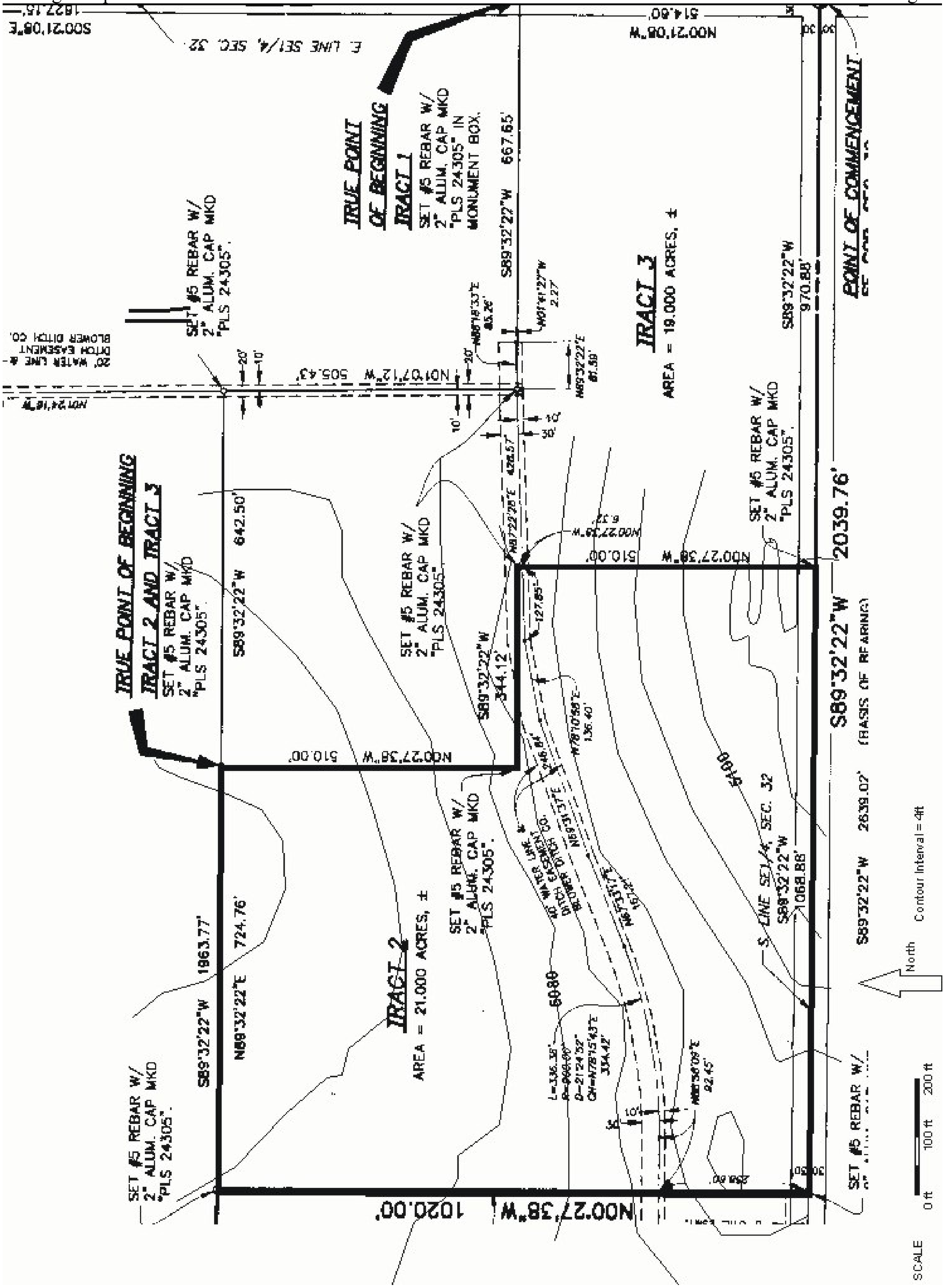

Figure 2 - Topographic map of the Panoramic View Subdivision area. Base Map from ADP (2001).Contour lines compiled from Bell Mapping (1985).

2.2 SITE EVALUATION

Site surface evaluation was predominantly restricted to soil surveys because of the small extent of the project and the uniform underlying geology of a single stratigraphic unit, the Upper Pierre Shale member. Surface mapping was completed by cross checking soils in the field with well mapped and published soil data for Larimer County, Colorado (see Moreland, 1980; USDA-NRCS, 2002;). Field observations validated the published materials. Only slight corrections of 10 to 20 feet southward was needed with soil unit 63 in the center of the project.

Subsurface geologic investigation was very limited in scope. The geologic map by Colton (1978) confirmed the anticipated uniformity and extent of the underlying stratigraphy. Decade old drainage trench excavations at the Western vicinity of the project allowed limited estimation of soil thickness and underlying geology (see figure 3 below for location). Additional, but meager subgeological information was secured from dry oil/gas wells records. Well Pope #1 is the closest to the project (see figure 3), but no formation data is given.

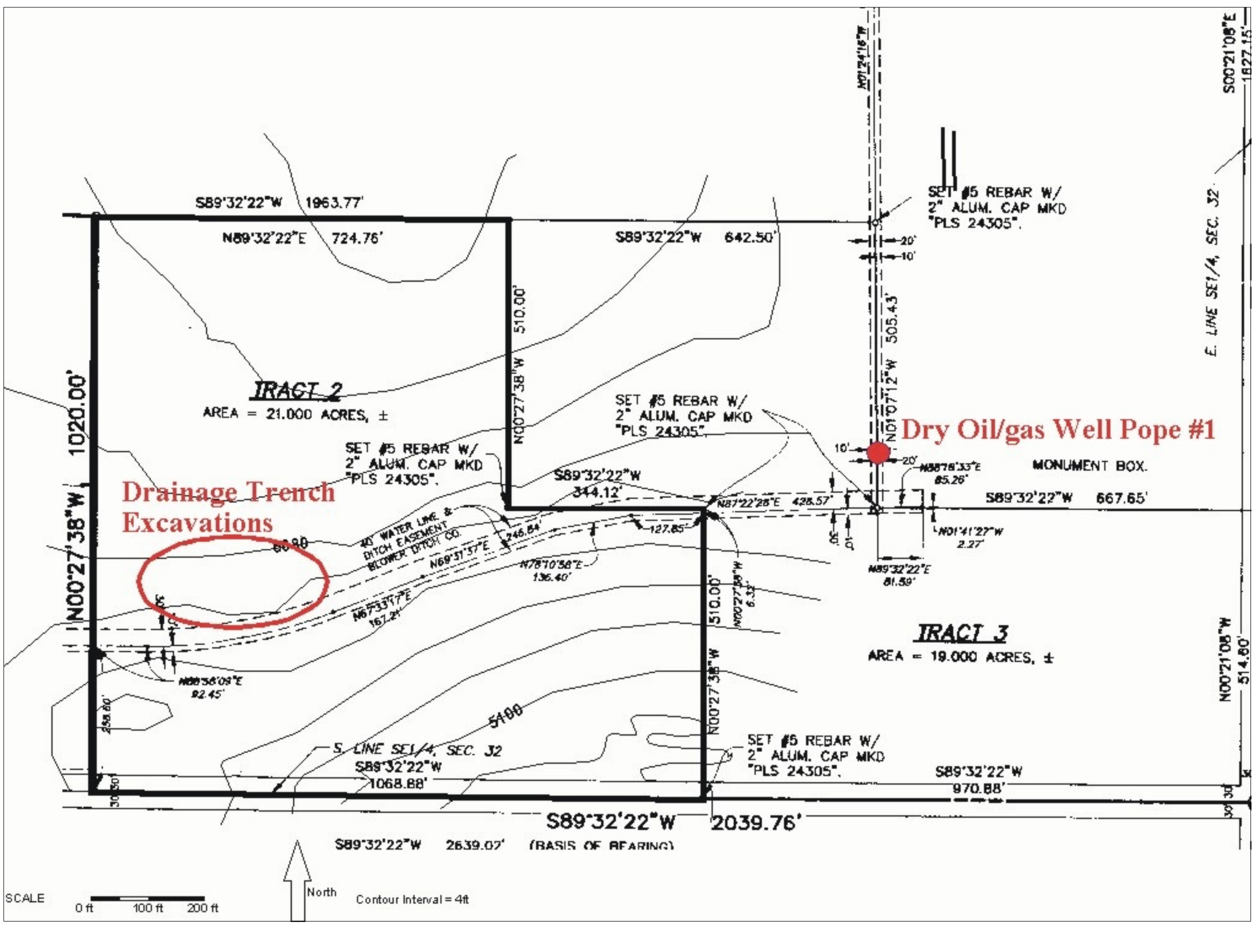

Figure 3 - Location of drainage trenches and closest dry oil/gas used in subsurface geological investigation for Panoramic View Subdivision.

2.2.1 Geologic / Soil Map

The geologic / soil map (figure 5) was created using a composite of a topographic map, a color ariel photograph, and a previous soil survey map taken from the following sources:

The topographic base map with a 4 foot contour interval was created by Bell Mapping Inc., Denver, Colorado (Bell Mapping, 1985?). Base for this unpublished map was a flood plain ariel photo survey of the Little Thompson River flown on April 16, 1975.

The color ariel photographs used are high resolution digital images ordered from GlobeXplorer Inc., San Francisco, California (GlobeXplorer, 2001), one of the largest providers of professional satellite and air photo images in the world. Changes in vegetation, color and ground texture were helpful in identifying drainage and soil extent.

A digital soil survey map from COGCC GIS Online (2002), depicting the surface extent of various soils in the area of the project, was transferred onto the topographic and ariel photo composite base map. Accuracy was checked in the field and soil units were adjusted accordingly. Additional information was also found in Moreland (1980).

A map composite was created by finding common points in each digitized map version and adjusting the maps until points were aligned. The final product including results of the field investigation is displayed in figure 5.

2.2.2 Subsurface drill hole data

Information for wells was obtained from COGIS-WELL Information (2002). A dry oil/gas well, Pope #1, was drilled in 1965 and is only 500 feat East of the project. While induction , caliper and

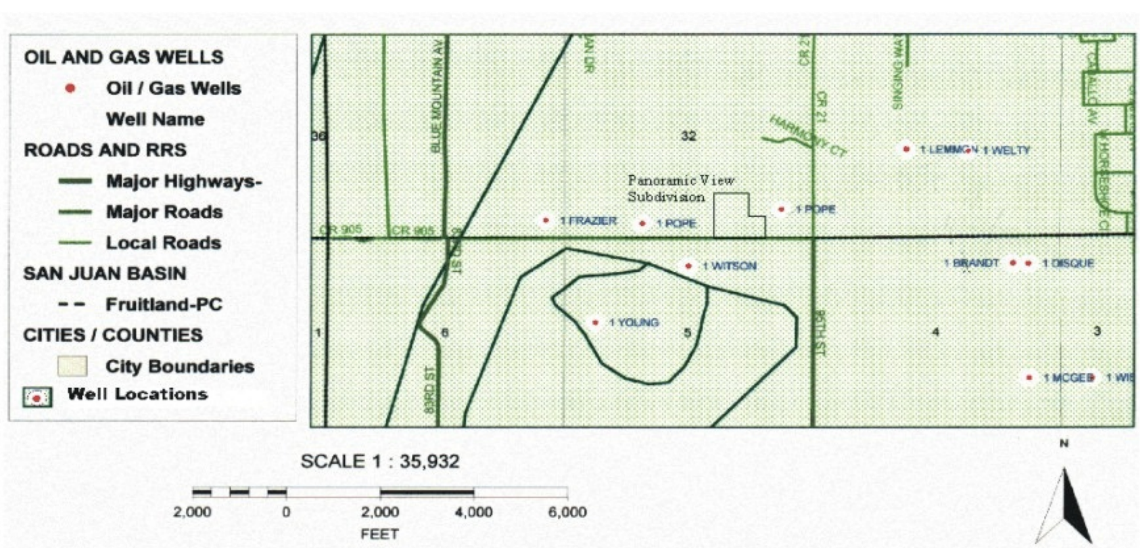

Figure 4 - Location of oil/gas wells with respect to project area. Data from COGCC GIS Online (2002)

acoustic logs are available for Pope #1, no formation logs are given, limiting the use for this report severely. Well Welty #1, completed in 1960 by Arrowhead Energy Corporation, located 4180 feet NE of Pope #1, is the only well within a 1 mile radius from the project with available geologic formation data. The subsurface geology is therefore estimated from data listed for Welty #1. Figure 4 displays oil wells in the area with respect to project location.

2.2.3 Field and Laboratory Tests

Field tests were mainly limited to on-site groundwater analysis of temperature, electric conductivity, pH, depth to water and collection of water and soil samples for laboratory analysis. Water samples were taken in clear 1 liter polypropylene bottles and transported to a refrigerated storage facility within 30 minutes. Representative soil samples were taken close to the center of mapped soil units. The first inch of top soil layer including organics and plant debris was removed within a 2 foot radius. This cleared area was mixed to a depth of 6 inches and approximately 2 kg of blended soil material was removed into clear plastic bags. Sample locations for water and representative soil samples are marked on the geologic map (figure 5).

Laboratory analysis was performed on water and soil samples. A 25ml water sample was removed into a smaller shipping container from the 1 liter storage bottles and acidified with 1 drop 0.1 M HNO_3. Samples were then mailed to *ACME Analytical Laboratories Ltd., Vancouver, BC, Canada* and analyzed by ICP-MS for Ag, Al, As (total), Au, B, Ba, Be, Bi, Br, Ca, Cd, Ce, Cl, Co, Cr, Cs, Cu, Dy, Er, Eu, Fe (total), Ga, Gd, Ge, Hf, Hg, Ho, I, In, Ir, K, La, Li, Lu, Mg, Mn, Mo, Na, Nb, Nd, Ni, Os, P, Pb, Pd, Pr, Pt, Rb, Re, Rh, Ru, S, Sb, Sc, Se, Si, Sm, Sn, Sr, Ta, Tb, Te, Th, Ti, Tl, Tm U, V, W, Y, Yb, Zn, and Zr. Because of high electric conductivity and therefore inferred high TDS (total dissolved solids), samples were diluted to below 0.1% TDS before analysis. Detection limits are accordingly elevated. Additional analysis for major anions was performed by *The People Lab LLC, Sample, CO, USA*. Using a visual light photospectrometer, water samples were analyzed with the appropriate Hach method for SO_4, Cl, NO_3, and NH_4. Results are summarized in Appendix 8.2, 8.3, 8.4. The completed water analysis indicates unsuitability of groundwater present in the vicinity of the project for agricultural and/or human use. However, the analysis can be used as a guide to soil geology and presence of pollutants as well as mineral deposits.

A 100 gram soil sample was mailed to *ACME Analytical Laboratories Ltd., Vancouver, BC, Canada* for analysis of rock forming oxides. The sample was first air dried, then pulverized to -100 Mesh size (ASTM). A 0.200 g sample split was fused with $LiBO_2$ and afterwards analyzed by ICP-ES for SiO_2, Al_2O_3, Fe_2O_3, MgO, Na_2O, K_2O, TiO_2, P_2O_5, MnO, Cr_2O_3, Ba, Ni, Sr, Zr, Y, Nb, and Sc. LOI was measured by Loss-on-ignition. Total Carbon and Sulfur were measured by LECO. Geochemical data aids in establishing soil mineralogy and physical soil parameters.

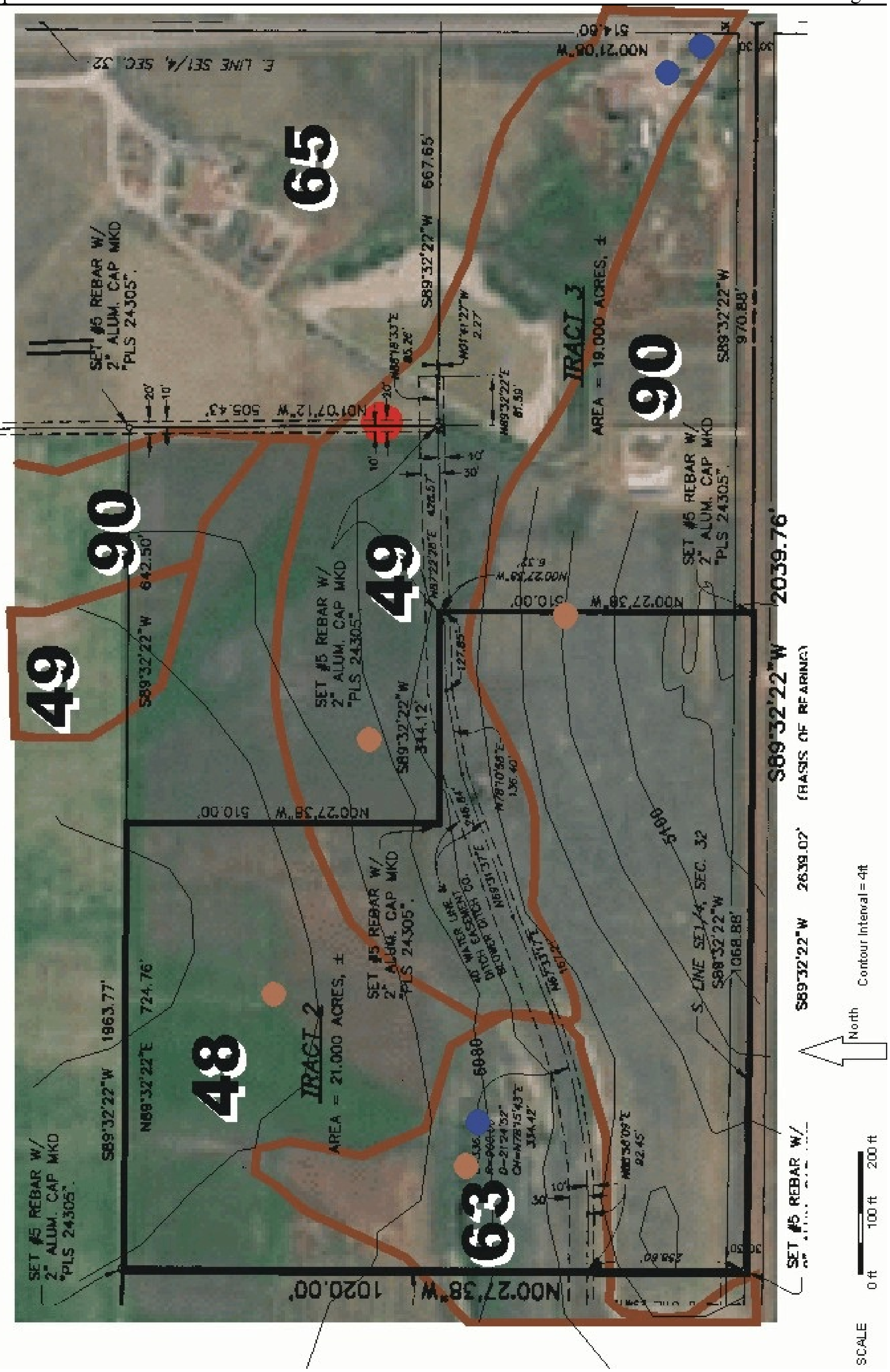

Figure 5 - Geologic Map for Panoramic View Subdivision. Composite base map from Topographic Map (Bell Mapping, 1985 (?)), Air Photo (GlobeXplorer, 2001), Initial Soil Map (COGCC, 2002).

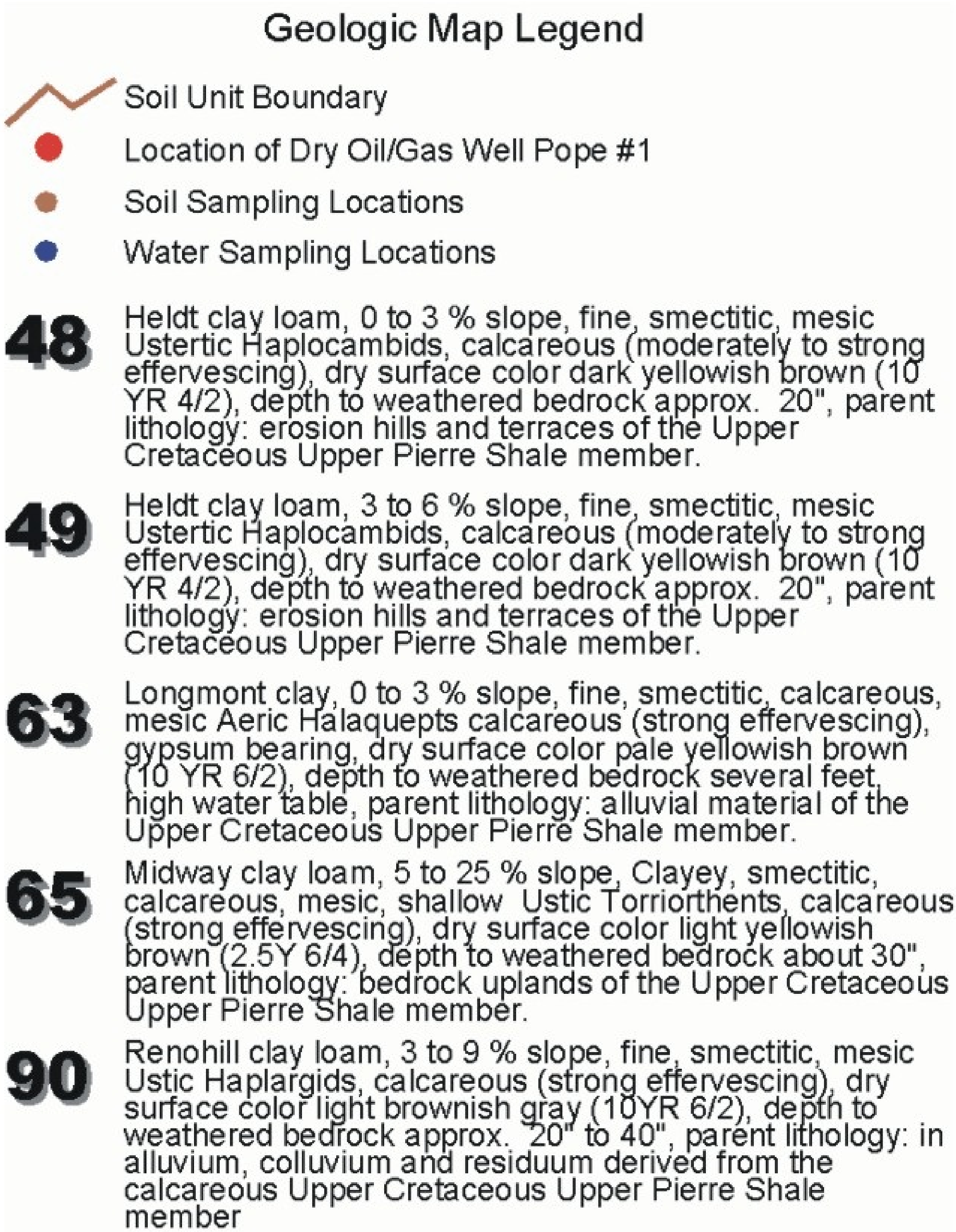

Figure 5 (continued) - Map Legend for Geologic Map of Panoramic View Subdivision

3 GEOLOGIC DESCRIPTION

3.1 BEDROCK UNITS

The geologic bedrock unit is the Upper Cretaceous Upper Pierre Shale member. While the overlying soils indicate their source as a typical shale or claystone sedimentary rock unit, weathering of the massive Pierre shale may reach downward 20 feet below the surface. This is also indicate by drilling records from the Welty #1 dry Oil/gas well (COGIS-WELL Information, 2002), located 4180 feet NE of well Pope #1 shown on the geologic map (figure 5). Assuming only minimal changes in stratigraphy over said distance, the following subsurface lithologies were estimated (figure 6):

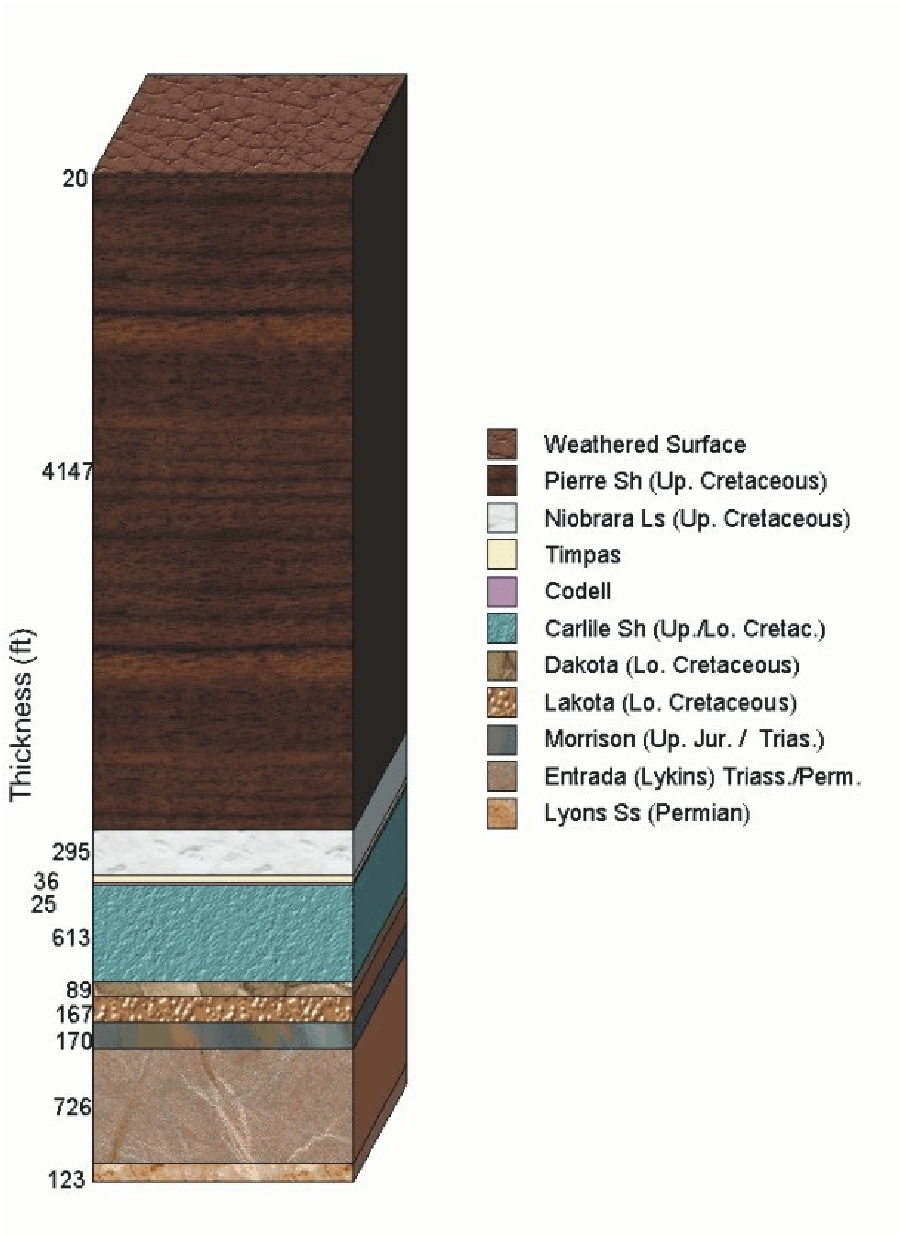

Figure 6 - Subsurface Stratigraphy according to Welty #1 drillhole data (COGIS-WELL Information, 2002)

3.2 SURFICIAL DEPOSITS

The colluvial overburden can be more precisely distinguished into three predominant soils in the vicinity of the project:

1. Heldt Clay Series, marked on the geologic map as unit 48 and 49. Heldt Clay units are only differentiated by slope.
2. Longmont Clay, mapped as soil unit 63 on the map.
3. Renohill Clay Loam, identified as soil unit 90.

The following is a more concise description of these units. See also Moreland (1980) for detailed information.

3.2.1 Heldt Clay (Map Unit 48 & 49)

The Heldt series are very deep, moderately well drained, moderately slow to slowly permeable soils. In the vicinity of the project, these soils formed in fine textured alluvium on fan remnants or terraces of the underlying Pierre Shale. Slopes do not exceed are 4.6 percent.

TAXONOMIC CLASS: Fine, smectitic, mesic Ustertic Haplocambids

TYPICAL PEDON according to Moreland (1980): Heldt silty clay loam-on a nearly level alluvial terrace under native vegetation.
A- Horizon: 0 to 6 inches; light brownish gray (2.5Y 6/2) silty clay loam, grayish brown (2.5Y 5/2) moist; strong very fine granular structure; soft, very friable, sticky and plastic; slightly effervescent, calcium carbonate disseminated; moderately alkaline (pH 8.2); clear smooth boundary. (5 to 10 inches thick). Organic content of the A1 horizon averages .6 to 2 percent and decreases uniformly with depth. The A horizon has hue of 5Y through 7.5YR, value of 5 through 7 dry, 3 through 6 moist, and chroma of 1 through 4. Surface horizons having value as dark as 5 dry and 3 moist are too thin or contain too little organic matter to be mollic epipedons. Reaction is mildly alkaline through strongly alkaline.
Bw- Horizon: 6 to 40 inches; light brownish gray (2.5Y 6/2) silty clay, grayish brown (2.5Y 5/2) moist; moderate coarse prismatic structure parting to moderate coarse angular blocky; extremely hard, friable, very sticky and very plastic; common distinct slickensides; slightly effervescent, calcium carbonate occurs as few prominent seams; strongly alkaline (pH 8.5); gradual wavy boundary. (15 to 40 inches thick). Conductivity typically ranges from 0 to about 12 millimhos in the upper 40 inches. The Bw horizon has hue of 5Y through 7.5YR, value of 5 through 7 dry, 4 through 6 moist, and chroma of 2 through 5. It is usually clay or silty clay but is silty clay loam in some pedons. Reaction is moderately alkaline or strongly alkaline.
Bk- Horizon: 40 to 60 inches; light gray (2.5Y 7/2) silty clay, grayish brown (2.5Y 5/2) moist; few distinct reddish brown (5YR 5/4) redox concentrations; massive, extremely hard, firm, very sticky and very plastic; strongly effervescent, calcium carbonate occurs as common prominent soft masses and seams; few distinct gypsum crystals; moderately alkaline (pH 8.3); gradual smooth boundary. (6 to 12 inches thick). The Bk or C horizon has hue of 5Y through 7.5YR, value of 5 through 7 dry, 4 through 6 moist, and chroma of 2 through 5. Reaction is moderately or strongly alkaline. It has 3 to 10 percent calcium carbonate equivalent.
Horizon Summary Characteristics: The soils are usually calcareous throughout, but depth to calcareous material ranges from 0 to 15 inches. Exchangeable sodium percentage usually ranges from less than 1 to 5 percent in the upper part of the control section but commonly increases with

increasing depth. The particle size control section is usually clay or silty clay but ranges in clay from 35 to 50 percent, in silt from 10 to 50 percent, and in sand from 10 to 45 percent. Coarse fragments are typically less than 5 percent but range from 0 to 15 percent. Cracks more than .4 inch wide and 12 inches long occur in the upper 20 inches when the soils are dry.

GEOGRAPHIC SETTING: In the vicinity of the project the Heldt soils are on fan remnants terraces and hillslopes of the Upper Cretaceous Upper Pierre Shale member with maximum slopes of 4.6 percent. The soils formed in fine textured alluvial sediments derived primarily from the underlying shale.

DRAINAGE AND PERMEABILITY according to Moreland (1980): Well or moderately well drained; slow or very slow runoff; slow to moderately slow permeability.

CORROSION OF CONCRETE AND STEEL according to Moreland (1980): The interpretation rating of the susceptibility of concrete to corrosion when in contact with the soil is weak to medium weak. The susceptibility of uncoated steel to corrosion when in contact with the soil is none.

LIMITATIONS FOR BUILDINGS according to Moreland (1980): Limitations for buildings without basements are indicated as severe because of shrink-swell characteristics. However, properly constructed basements should control the problem. Septic design in soil 48 show only slight limitations. Soil 49 indicates moderate limitations because of increased slope.

USE AND VEGETATION: Soils in the project area can be classified as native pastureland, although in the last decade the Northern 3/4 of Heldt Clay 48 and Northern 1/4 of Heldt Clay 49 were used as irrigated crop land for grass hay. Present native vegetation is primarily western wheatgrass, green needlegrass, blue grama, basin wildrye and some introduced alfalfa and brome grasses.

DISTRIBUTION AND EXTENT: Central and northern Wyoming, southern Montana, and northern Colorado. The Heldt Clay Series is of moderate extent.

GEOCHEMISTRY: The complete geochemical analysis of the upper soil horizons is listed under appendix 8.1. The high Al_2O_3 content of 13.25 to 13.51% and the LOI of 12.0 to 12.2 indicates a high amount of clay in the sample. Total C of 1.85 to 2.02 % points to $CaCO_3$, indicated also by effervescing of the sample. Low total S of .02 to .04 % agrees with findings of little or no $CaSO_4$ in the sample. Clay mineralogy was estimated by using the Rational Analysis Spreadsheet calculations from the Tennessee-Kentucky Clay Company (1997):

	RATIONAL ANALYSIS		
Sample: SD 48	Feldspar	Mica	Average
Calculated Kaolin	21.25	-28.89	-3.82
Calculated Montmorillonite	0.00	48.33	24.17
Calculated Total Clay	21.25	19.44	20.35
Calculated Silica	42.74	25.95	34.34
Calculated Organics	7.12	14.45	10.79
Calculated K.Na.Ca FELDSPAR	24.87	0.00	12.44
Calculated K.Na MICA	0.00	34.47	17.24

		RATIONAL ANALYSIS	
Sample: SD 49	Feldspar	Mica	Average
Calculated Kaolin	21.52	-31.36	-4.92
Calculated Montmorillonite	0.00	53.33	26.67
Calculated Total Clay	21.52	21.97	21.74
Calculated Silica	41.13	21.93	31.53
Calculated Organics	7.09	14.98	11.04
Calculated K.Na.Ca FELDSPAR	25.42	0.00	12.71
Calculated K.Na MICA	0.00	34.72	17.36

Both calculations show the absence of Kaolinite or simple clay and the presence of Montmorillonite, a related Smectite or swelling clay thus conforming the shrink swell potential of the soil.

3.2.2 Longmont Clay (Map Unit 63)

Longmont clay soil has a light brownish gray very friable A horizon. In the excavated drainage ditches of the project area a massive light olive brown and pale olive mottled clay C horizons was observed.

TAXONOMIC CLASS: Fine, smectitic, calcareous, mesic Aeric Halaquepts

TYPICAL PEDON according to Moreland (1980): Longmont clay - grassland. High Groundwater.
A11- Horizon: 0 to 5 inches; light brownish gray (2.5Y 6/2) clay, dark grayish brown (2.5Y 4/2) moist; weak fine subangular blocky structure that parts to moderate fine granules; hard, firm, very sticky, very plastic; calcareous; strongly alkaline (pH 9.0); clear smooth boundary. (4 to 8 inches thick).Organic carbon in the surface horizon ranges from .7 to 2 percent and decreases uniformly with increasing depth.
A12- Horizon: 5 to 21 inches; light olive brown (2.5Y 5/3) clay, olive brown (2.5Y 4/3) moist; weak coarse subangular blocky structure; extremely hard, very firm, very sticky, very plastic; calcareous; very strongly alkaline (pH 9.2); gradual wavy boundary. (10 to 20 inches thick). The A1 horizon has hue of 5Y through 10YR, value of 5 or 6 dry, 3 through 5 moist, and chroma of 1 through 3. It has weak subangular blocky or fine granular structure depending on concentration of soluble salts. This horizon is soft or slightly hard. It is strongly or very strongly alkaline (pH 8.6 to 9.5) and has more than 15 percent exchangeable sodium in some part.
C1cscag-Horizon: 21 to 31 inches; light olive brown (2.5Y 5/3) clay, olive brown (2.5Y 4/3) moist; massive; extremely hard, very firm, very sticky, very plastic; many medium distinct mottles of yellowish brown (10YR 5/4) moist; some accumulation of calcium sulfate as crystals and calcium carbonate as concretions; calcareous; strongly alkaline (pH 8.6); gradual wavy boundary. (8 to 32 inches thick). Accumulation of salt more soluble than gypsum is common in the surface horizons but does not exceed 4 percent in any horizon as much as 6 inches thick above a depth of 40 inches. Exchangeable sodium percentage exceeds 15 percent in 1/2 or more of the upper 20 inches and decreases with increasing depth below 20 inches. Weighted average clay content of the upper 40 inches is 35 to 60 percent. Rock fragments range from 0 to 15 percent but are typically less than 5 percent. The Ccscag horizon has hue of 5Y through 10YR and chroma greater than 2. It is moderately or strongly alkaline (pH 8.0 to 8.8) and becomes less alkaline with increasing depth. It

typically has less than 10 percent exchangeable sodium throughout most of the horizon and the percentage decreases with increasing depth. This horizon has 4 to 12 percent calcium carbonate equivalent and common calcium sulfate crystals.

C2cscag-Horizon: 31 to 60 inches; pale olive (5Y 6/3) clay, olive (5Y 5/3) moist; massive; extremely hard, very firm, very sticky, very plastic; common medium distinct mottles of olive (5Y 4/3) moist; some accumulation of calcium sulfate and calcium carbonate occurring as crystals and small concretions; calcareous; moderately alkaline (pH 8.4).

Horizon Summary Characteristics: These soils are usually moist due to fluctuating water tables and are saturated in some season of most every year.

GEOGRAPHIC SETTING: In the project area the Longmont soil is nearly level to slightly concave or depressed indicating very gently sloping alluvial fans and terraces of the underlying Pierre Shale lithologies. Slope gradients are less than 4 percent. The soil formed in fine textured calcareous alluvial parent materials derived principally from the eroding sedimentary Pierre Shale. The soils has a fluctuating water that has been controlled by drainage channels dug in the project vicinity. Otherwise soil is usually moist or seasonally saturated.

DRAINAGE AND PERMEABILITY according to Moreland (1980): Poor to somewhat poorly drained; slow runoff; slow permeability.

CORROSION OF CONCRETE AND STEEL according to Moreland (1980): There is a strong to potentially strong rating of the susceptibility of concrete to corrosion when in contact with the soil. The susceptibility of uncoated steel to corrosion when in contact with the soil is none.

LIMITATIONS FOR BUILDINGS according to Moreland (1980): Limitations for buildings without basements are indicated as severe because of shrink-swell characteristics. Even buildings with properly constructed basements are susceptible to occasional flooding unless the building site is properly drained. Aggressiveness of the moist soil to concrete might be another limiting factor. Septic design in soil 63 is severely limited because of the high water table and flooding potential.

USE AND VEGETATION: Can be used as native pastureland or native hay meadow. Because of high salt content in the moist soil the principal native vegetation is alkali sacation and saltgrass.

DISTRIBUTION AND EXTENT: Central Colorado. The series has moderate extent.

GEOCHEMISTRY: The complete geochemistry of the upper soil horizons is summarized in appendix 8.1. The high Al_2O_3 content of 13.55% but with a moderate LOI of 10.9%, the lowest in all the samples, is indicative of a fair amount of clay in the sample. Total C of 1.19 % shows moderate $CaCO_3$ content, indicated also by some effervescing of the sample. A total S of .24% is indicative of the presence of $CaSO_4$. Clay mineralogy was calculated by using the Rational Analysis Spreadsheet computations from the Tennessee-Kentucky Clay Company (1997):

		RATIONAL ANALYSIS	
Sample: SD 63	Feldspar	Mica	Average
Calculated Kaolin	20.81	-36.91	-8.05
Calculated Montmorillonite	0.00	58.06	29.03
Calculated Total Clay	20.81	21.15	20.98
Calculated Silica	42.37	22.13	32.25
Calculated Organics	5.70	14.32	10.01
Calculated K.Na.Ca FELDSPAR	27.20	0.00	13.60
Calculated K.Na MICA	0.00	37.56	18.78

The calculations show the absence of Kaolinite or simple clay and the presence of Montmorillonite, a related Smectite or swelling clay thus confirming the shrink swell potential of the soil. A higher amount of calculated silica may also point to the abundance of silt in the material. Computed organics might be misleading because of the definite presence of Calcite and Gypsum in the sample.

3.2.3 Renohill Clay Loam (Map Unit 90)

The Renohill series consists of well drained soils that are moderately deep to soft bedrock. Soils in the project area formed in alluvium, colluvium, and residuum of the Pierre Shale. Renohill soils are on bedrock controlled plateaus, hills and ridges. Slopes of approximately 4% are encountered.

TAXONOMIC CLASS: Fine, smectitic, mesic Ustic Haplargids

TYPICAL PEDON according to Moreland (1980): Renohill clay loam-rangeland and dry pasture grass.
A-Horizon: 0 to 4 inches; light brownish gray (10YR 6/2) clay loam, dark grayish brown (10YR 4/2) moist; strong fine granular structure; soft, very friable, slightly sticky and slightly plastic; common medium and fine roots; neutral (pH 7.2); clear smooth boundary. (1 to 6 inches thick)
BA- Horizon: 4 to 7 inches; grayish brown (10YR 5/2) heavy clay loam, dark grayish brown (10YR 4/2) moist; moderate medium subangular blocky structure parting to moderate medium granular; slightly hard, friable, sticky and plastic; common fine and medium roots; slightly alkaline (pH 7.6); clear smooth boundary. (0 to 4 inches thick). The A horizon has hue of 2.5Y or 10YR, value of 4 to 6 dry and 3 to 5 moist, and chroma of 2 or 3. It is clay loam or loam. Reaction is neutral or slightly alkaline.
Bt- Horizon: 7 to 14 inches; light olive brown (2.5Y 5/4) clay, olive brown (2.5Y 4/4) moist; moderate medium prismatic parting to moderate medium angular blocky; very hard, firm, very sticky and very plastic; common fine and medium roots; many prominent clay films on faces of peds and lining root channels and pores; slightly alkaline (pH 7.4); clear smooth boundary. (5 to 16 inches thick). The Bt horizon has hue of 2.5Y or 10YR, value of 4 to 6 dry and 4 or 5 moist, and chroma of 2 to 5. Texture is clay or heavy clay loam with 35 to 50 percent clay. EC is less than 2 mmhos. Reaction is neutral to moderately alkaline. This horizon is typically noncalcareous throughout but may be effervescent immediately above the Btk horizon.

Btk- Horizon: 14 to 20 inches; light yellowish brown (2.5Y 6/4) clay loam, light olive brown (2.5Y 5/4) moist; weak coarse angular and subangular blocky structure; very hard, firm, sticky and plastic;

few faint clay films on faces of peds; strongly effervescent, calcium carbonate occurs in common soft masses and filaments; moderately alkaline (pH 8.2); gradual smooth boundary. (4 to 16 inches thick). The Btk horizon has hue of 2.5Y or 10YR, value of 5 to 7 dry and 4 to 6 moist, and chroma of 2 to 4. Texture is clay, clay loam, silty clay loam or silty clay with 35 to 50 percent clay. Secondary carbonates range from 3 to 12 percent. EC ranges up to 4 mmhos/cm. Reaction is moderately alkaline or strongly alkaline.
Bk- Horizon: 20 to 30 inches; light brownish gray (2.5Y 6/2) clay loam, grayish brown (2.5Y 5/2) moist; massive; very hard, firm, sticky and plastic; strongly effervescent, calcium carbonate occurs as common soft masses and threads; about 5 percent soft shale chips; moderately alkaline (pH 8.4); clear smooth boundary. (5 to 20 inches thick). The Bk horizon has hue of 2.5Y or 10YR, value of 5 to 7 dry and 4 to 6 moist, and chroma of 2 to 6. Texture is clay loam, clay, silty clay loam or silty clay with 28 to 42 percent clay. Secondary carbonates range from 5 to 15 percent. EC ranges up to 4 mmhos/cm. Reaction is moderately alkaline or strongly alkaline.
Cr- Horizon: 30 to 60 inches; soft, calcareous shale with thin lenses of sandstone at 40 and 50 inches. The Cr horizon consists of soft, effervescent shale interbedded with thin lenses of sandstone or siltstone. In some pedons the bedrock is noneffervescent.
Horizon Summary Characteristics: Depth to bedrock and the paralithic contact ranges from 20 to 40 inches. Depth to the base of the argillic horizon ranges from 12 to 28 inches. Depth to carbonates ranges from 10 to 20 inches. Rock fragments are typically less than 5 percent but may range from 0 to 15 percent. The majority of the rock fragments are soft and break down upon pretreatment.

GEOGRAPHIC SETTING: The Renohill soil is on bedrock controlled hill in the vicinity of the Panoramic View subdivision.. Soil 90 formed in alluvium, colluvium and residuum derived from calcareous Pierre Shale residues. Slopes are 3 to 4.6 percent.

DRAINAGE AND PERMEABILITY according to Moreland (1980): Well drained; low to high runoff; slow permeability.

CORROSION OF CONCRETE AND STEEL according to Moreland (1980): The susceptibility of concrete to corrosion when in contact with the soil is none. Uncoated steel has a low susceptibility to corrosion when in contact with the soil.

LIMITATIONS FOR BUILDINGS according to Moreland (1980): Limitations for buildings without basements are only moderate with some shrink-swell potential. Septic design problems are indicated as severe because of the depth to bedrock. However, septic systems exist successfully in soil 90 and in close proximity to the Panoramic View Subdivision project. Percolation rate average just 150 feet to the East of the project, measured for the septic design of Kackstaetter's Extended Family Dwelling are given as 1.58"/hr or 47 min./ in more than suitable for a liquid waste disposal system. For details see appendix 8.5 and Pond (1983). Indvidual site testing for percolation rates is highly encouraged.

USE AND VEGETATION: Mostly rangeland. Very dry unless irrigated. Native vegetation consists of western wheatgrass, green needlegrass, blue grama and rarely scattered big sagebrush.

DISTRIBUTION AND EXTENT: Wyoming, Colorado and Montana. The series is of moderate extent.

GEOCHEMISTRY: The complete geochemistry of the upper soil horizons is summarized in appendix 8.1. The very high Al_2O_3 content of 14.03% with a high LOI of 12.5% is indicative of a high clay content. Total C of 1.58 % shows moderate $CaCO_3$ content, indicated also by effervescing of the sample. A total S of only .0.1% shows the absence of $CaSO_4$ or sulfides. The following clay mineralogy was calculated using the Rational Analysis Spreadsheet computations from the Tennessee-Kentucky Clay Company (1997):

		RATIONAL ANALYSIS	
Sample: SD 90	Feldspar	Mica	Average
Calculated Kaolin	23.20	-28.11	-2.46
Calculated Montmorillonite	0.00	53.06	26.53
Calculated Total Clay	23.20	24.95	24.07
Calculated Silica	38.90	19.84	29.37
Calculated Organics	7.17	14.91	11.04
Calculated K.Na.Ca FELDSPAR	24.40	0.00	12.20
Calculated K.Na MICA	0.00	32.91	16.45

Again, Kaolinite or simple clay is virtually absent and the presence of Montmorillonite, a related Smectite or swelling clay confirms the shrink swell potential of the soil. A higher amount of calculated silica may also point to the abundance of silt in the material, showing the loamy characteristic of the sample.

3.3 GEOMORPHIC FEATURES

No prominent geomorphic features are present, except a smooth rolling elevation to the South side of the project as previously indicated.

3.4 STRUCTURAL FEATURES

Structural geologic features were not observed on the premises.

3.5 SURFACE DRAINAGE

Because of the gentle topography, drainage in the area can be basically considered as sheet drainage. A broad drainage channel in excess of 200 feet width exists in the central part of the property, allowing run-off drainage to the North. Accumulation of significant amounts of run-off are not given because of the limited topography and a slope of less than 4%. Heavy rainfall accumulation may occur in the region of soil 63 with indicated flooding potential because of poor soil drainage.

3.6 GROUNDWATER

Presently the only accessible groundwater exists in the drainage ditches of soil area 63. The complete water analysis is summarized in appendix 8.2, 8.3, and 8.4. Figure 7 shows a Schoeller diagram of concentration of selected elements in the Panoramic View Swamp water compared to water systems in close vicinity or from the same lithologies. The high amount of total dissolved solids as well as SO_4, Na, and Ca is immediately apparent. Being in contact with and part of the weathering products of the Pierre Shale, this water has accumulated very high amounts of dissolved minerals. As indicated in appendix 8.4 the groundwater is unsuitable for human consumption and because of the high mineral content only of limited use for agricultural endeavors. The composition of dissolved rare earth elements and heavy metals indicates a typical shale or claystone water.

The drainage ditches have lowered the water table in the usually saturated area of soil 63 to below 7 feet.

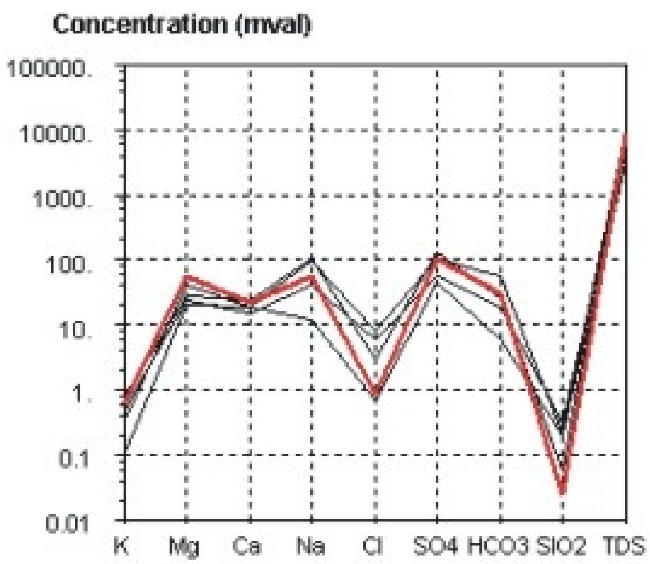

Figure 7 - Schoeller Diagram of concentrations in groundwater of selected ions and TDS in mval for Panoramic View Subdivision (red line) compared to groundwater samples from similar lithologies (gray lines).

4 GEOLOGIC INTERPRETATION

4.1 GEOLOGIC HAZARDS

The geologic investigation of the Panoramic View Subdivision indicates no geologic hazards in the vicinity or close proximity. No susceptibility for man induced hazards presently or for the future is indicated.

4.2 GEOLOGIC CONSTRAINTS

High shrink-swell parameters, especially in soils 48, 49, and especially 63 may limit foundation and building construction. Area of soil 63 is also constrained because of severe flooding potential and the aggressiveness of soil to concrete and steel, unless properly drained. A summary of geologic soil constraints are given in the table below. However, the table is only of general nature and independent testing may confirm or negate listed soil parameters as has been shown in this report with limitations for lagoons and the successful installed septic system in a soil with such limitations.

Soils of Larimer County

Map Unit Symbol	Map Unit Name	Limitations for Buildings[1]	Limitations for Lagoons[2]	Permeability[3]	Flooding Potential[4]	Depth to Water Table[5] (ft)
48	Heldt clay loam, 0 to 3 percent slopes	Severe shrink-swell	Slight	Slow	none	>6
49	Heldt clay loam, 3 to 6 percent slopes	Severe shrink-swell	Moderate slope	Slow	none	>6
63	Longmont clay, 0 to 3 percent slopes	Severe flooding, shrink-swell	Severe flooding	Slow	occasional	2 - 2.5
65	Midway clay loam, 5 to 25 percent slopes	Severe shrink-swell, slope	Severe depth to rock, slope	V. Slow	none	>6
73	Nunn clay loam, 0 to 1 percent slope	Severe shrink-swell	Slight	Slow	none	>6
84	Poudre fine sandy loam, 0 to 1 percent slope	Severe flooding, wetness	Severe seepage, flooding, wetness	Mod. Rapid	occasional	1.0 - 3.0
90	Renohill clay loam, 3 to 9 percent slopes	Moderate shrink-swell	Severe depth to rock	V. Slow	none	>6
113	Ulm clay loam, 0 to 3 percent slopes	Moderate shrink-swell	Moderate seepage	Slow	none	>6

1 - Limitations for Buildings (without basements) - Slight limitations indicate that soil properties are favorable. Moderately-limited soils have properties that are unfavorable, but can be overcome or minimized by special planning and design. Severely-limited soils have properties that are so unfavorable that a major increase in construction, special design, or intensive maintenance is required. For some soils, such costly measures may not be feasible.

2 - Limitations for Sewage Lagoons - Soils with slight limitations are favorable. Moderately-limited soils have properties that are unfavorable but can be overcome by special planning and design. Severely-limited soils have properties so unfavorable that major reclamation, special designs, or intensive maintenance are required.

3 - Permeability - The rate of water movement through the soil. This column uses the slowest rate determined for horizons within the top three feet. Soils with slower permeability rates within the top three feet have greater potential for surface water runoff.

4 - Flooding Potential - The frequency of flooding.

5. - Depth to Water Table - Depth to the highest level of a saturated zone more than 2 inches thick for continuous periods of more than 2 weeks during most years.

4.3 WATER RESOURCES

Groundwater is of poor quality and can not be used for human consumption or agricultural purposes. Flow rates of groundwater in the shale derived soils is estimated as extremely poor. Sewage disposal systems can not be constructed in the area of soil 63. Soil 90 restriction for septic fields must be investigated by site specific percolation tests because of the wide latitude of soil physical parameters. Indication for groundwater contamination is not given. The proposed project will have very little impact on groundwater recharge, if at all.

4.4 MINERAL RESOURCES

No mineral resources are indicated. Oil/gas exploration in the vicinity of the project has yielded dry wells. Other resources, such as sand or gravel deposits are not indicative of the area.

5 CONCLUSIONS

The proposed project is fully compatible with potential geologic hazards (non-existent), constraints (for limited area only), and mineral resources (non-existent) and no mitigation is necessary. Soil area 63 should be avoided for residential construction because of aggressive soils to concrete and metal, severe shrink-swell potentials, extreme flooding and low seepage. Soil area 90 is very favorable for building construction, since shrink-swell potential is low and soils are non aggressive to building materials. Septic system design is locally possible, but needs to be confirmed by site specific percolation tests.

6 RECOMMENDATIONS

Soil Area 63 is not recommended for building but would make a great location for a swimming hole or water storage reservoir. Building sites should be investigated by site specific percolation tests.

7 APPENDICES

7.1 Soil Analysis

SOIL ANALYSIS

ELEMENT	SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	Na_2O	K_2O	TiO_2	P_2O_5	MnO	Cr_2O_3	Ba	Ni	Sr	Zr	Y	Nb	Sc	LOI	TOT/C	TOT/S	SUM
SAMPLES	%	%	%	%	%	%	%	%	%	%	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%	%	%	%
SD 48	60.15	13.25	5.59	1.74	2.69	1.06	2.53	0.54	0.22	0.05	0.009	792	24	173	210	31	< 10	11	12	2.02	0.04	99.98
SD 49	58.36	13.51	5.7	1.92	3.61	0.97	2.69	0.6	0.24	0.05	0.006	647	34	196	172	28	14	11	12.2	1.85	0.02	99.98
SD 63	60.43	13.55	5	2.09	3.21	1.18	2.72	0.53	0.19	0.04	0.007	652	42	256	196	29	12	11	10.9	1.19	0.24	99.99
SD 90	56.78	14.03	6.18	1.91	4.22	0.94	2.52	0.55	0.17	0.05	0.008	635	23	202	150	31	10	12	12.5	1.58	0.01	99.98

Analysis performed by ACME ANALYTICAL LABORATORIES, CANADA

0.200 g sample analyzed by $LiBO_2$ Fusion. Analysis by ICP-ES. LOI by Loss-On-Ignition. Total C & S by LECO (not included in SUM)

7.2 Water Analysis (Total)

WATER ANALYSIS

ELEMENT	Ag	Al	As	Au	B	Ba	Be	Bi	Br	Ca	Cd	Ce	Cl	Co	Cr	Cs	Cu
SAMPLES	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppm	ppb	ppb	ppb	ppb
PVS SW	0.07	< 1	2	0.33	559	11.04	0.21	< .05	118	446057	3.5	< .01	30	0.11	14.8	< .01	12.3
CMS CY	0.08	59	2	0.47	481	26.82	0.44	< .05	396	495006	2.45	0.24	104	0.29	2.5	0.13	24.7
CMS SP	0.07	< 1	4	1.37	1658	17.87	0.19	0.1	567	293206	1.01	< .01	203	0.23	28.1	< .01	20.3

ELEMENT	Dy	Er	Eu	Fe	Ga	Gd	Ge	Hf	Hg	Ho	I	In	Ir	K	La	Li	Lu
SAMPLES	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
PVS SW	< .01	< .01	< .01	401	< .05	< .01	0.14	< .02	< .1	< .01	< 1	< .01	< .05	24095	< .01	587	< .01
CMS CY	< .01	< .01	< .01	634	< .05	< .01	0.1	< .02	< .1	< .01	< 1	< .01	< .05	30301	< .01	530	< .01
CMS SP	< .01	< .01	< .01	257	< .05	< .01	0.1	< .02	< .1	< .01	< 1	< .01	< .05	19047	< .01	243	< .01

ELEMENT	Mg	Mn	Mo	Na	Nb	Nd	Ni	Os	P	Pb	Pd	Pr	Pt	Rb	Re	Rh	Ru
SAMPLES	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
PVS SW	667847	0.41	0.7	1261759	< .01	< .01	< .2	< .05	24	< .1	< .2	< .01	0.01	6.71	0.37	< .01	< .05
CMS CY	332918	6.21	18.4	2379403	< .01	0.04	< .2	< .05	73	3.2	< .2	< .01	< .01	40.68	0.7	< .01	< .05
CMS SP	294295	< .05	14.3	948228	< .01	< .01	< .2	< .05	174	< .1	< .2	< .01	< .01	2.41	0.43	< .01	< .05

ELEMENT	S	Sb	Sc	Se	Si	Sm	Sn	Sr	Ta	Tb	Te	Th	Ti	Tl	Tm	U	V
SAMPLES	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
PVS SW	1631	< .05	2.25	1	674	< .05	< .05	6520.94	< .05	< .01	< .05	< .05	< 10	< .01	< .01	5.54	< 1
CMS CY	2053	1.5	3.38	16.4	1671	< .05	< .05	7418.57	< .05	< .01	< .05	0.1	< 10	0.01	< .01	2.75	5
CMS SP	1006	0.35	8.1	10.9	8601	< .05	< .05	4771.42	< .05	< .01	< .05	0.12	< 10	< .01	< .01	47.8	3

ELEMENT	W	Y	Yb	Zn	Zr	NH_4	NO_3	SO_4
SAMPLES	ppb	ppb	ppb	ppb	ppb	ppm	ppm	ppm
PVS SW	< .1	< .01	< .01	15.6	< .5	5.22	3.66	4887
CMS CY	< .1	< .01	< .01	275	< .5	2.7	38.81	6151
CMS SP	< .1	< .01	< .01	172	0.5	0.77	24.79	2700

Analysis for all except NH_4, NO_3, SO_4 performed by ACME ANALYTICAL LABORATORIES, CANADA. NH_4, NO_3, SO_4 anlyzed by THE PEOPLE'S LAB, USA.

Samples analyzed by ICP-MS (except NH_4, NO_3, SO_4). Solution samples diluted to below 0.1% Total Dissolved Solids before analysis. Detection limits elevated accordingly. NH_4, NO_3, SO_4 analyzed by VIS Spectrophotometry.

SAMPLES: PVS SW = Panoramic View Subdivision - Swamp Area; CMS CY = Crystal Meadow Subdivision - Cystern; CMS SP = Crystal Meadow Subdivision - Sump Pump

7.3 Water Analysis (General for Panoramic View Subdivision)

Location	: Swamp
Site	: Panoramic View Subdivision
Sampling Date	: 09-02-02
Geology	: Pierre Shale, Soil 63
Watertype	: Mg-Na-SO4-HCO3

Sum of Anions (meq/l)	: 132.80
Sum of Cations (meq/l)	: 133.15
Balance:	: 0.1%

Total dissolved solids	: 265.9 meq/l	9169.4 mg/l	
Total hardness	: 38.6 mmol/l	386.01 °f	216.17 °g
Alkalinity	: 30.10 mmol/l	150.53 °f	84.30 °g

(1 °f = 10 mg/l CaCO3/ 1 °g = 10 mg/l CaO)

Major ion composition

	mg/l	mmol/l	meq/l	meq%
Na	1261.759	54.883	54.883	20.637
K	24.095	0.616	0.616	0.232
Ca	446.057	11.129	22.258	8.369
Mg	667.847	27.472	54.944	20.66
Cl	30.0	0.846	0.846	0.318
SO4	4887.0	50.877	101.753	38.26
HCO3	1836.488	30.102	30.102	11.319

Ratios			Seawater mg/l	mmol/l
Ca/Mg	0.668	0.405	0.319	0.194
Ca/SO4	0.091	0.219	0.152	0.364
Na/Cl	42.059	64.859	0.556	0.858
Cl/Br	254.237	573.0	287.5	648.1

Dissolved Minerals	:	mg/l	mmol/l
Halite (NaCl)	:	1.396	0.0239
Anhydrite (CaSO4)	:	6929.389	50.877
SiO2 as Quartz	:	1.44	0.024
or Feldspar (NaAlSi3O8)	:	6.287	0.024

Values calculated with Hydrowin V.3.0. (see Calmbach, 1995)

7.4 Water Analysis and International Drinking Water Regulations

Location : Swamp
Site : Panoramic View Subdivision
Sampling Date : 09-02-02

Drinking Water Quality Regulations:

Element		Recommended	Maximum
pH	8.3	6.5- 8.5	< 9.2
T(Wa)	23.6	8- 15	< 25
TDS	8543.4	100- 500	< 1500
Na	1261.759	< 20	< 150
K	24.095	0- 10	
Mg	667.847	5- 30	< 50
Ca	446.057	40- 100	
NH4	5.22	< .05	< .5
Cl	30	< 20	< 200
SO4	4887	10- 50	< 200
As	.002	< .002	< .05

Irrigation water:
Conductivity = 10950 uS
Sodium Adsorption Ratio (SAR) : 8.83
Adjusted SAR : 35.81

Values calculated with Hydrowin V.3.0. (see Calmbach, 1995)

7.5 Shortened Percolation Test in Renohill Clay Loam (Map Unit 90)

BACKGROUND

This report presents the results of percolation tests performed by me or under my supervision on 14 Mar. 1983 and provides septic system recomendations for a proposed single family residence located in the SE/4 of the SE/4 of Section 32, T4N, R69W, of the 6th P.M., Larimer County, Colorado (See Dwg. 1).

The proposed septic field site is located on a northeasterly sloping hillside as shown in the Plot Plan (See Dwg. 1). The three percolation test holes and 8' deep boring are located as shown on the plot plan. No groundwater was encountered in the 8' deep boring.

PERCOLATION TEST RESULTS

The test holes were initially filled on 12 Mar. 1983 and percolation tests run on 14 Mar. 1983 producing the following results :

Time (minutes)	PH1	PH2	PH3
0	All holes partially filled		
120	25"	21 1/2"	22 1/2"
150	26 1/4"	21 3/4"	23 1/2"
195	27 1/2"	22 1/2"	24"
225	28 1/4"	23"	24 3/4"
270	29 1/2"	23 3/4"	25 1/2"

Percolation rate = Average of 2, 1 1/4 & 1 1/2"/hour
= 1.58"/hr.
= 47min./in.

CALCULATIONS FOR ABSORPTION TRENCH SYSTEM

Perc. rate = 47 min./in.
Residence - 2 bedroom
Q = 2 X 100 gal./day = 200 gal./day

$$\text{Trench area} = \frac{Q}{t \div 42} = \frac{200}{47 \div 42}$$

= 1007 sq. ft.
Use 1000 sq. ft. trench

Shortened Percolation Test in Renohill Clay performed March 1983 by S. Pond, P.E. (1983)

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