Supplemental Engineering Report for Case No. 21CW3008(B)
AngelView, LLC, Application for Storage, and Plan for Augmentation including Exchange Issues Dealing with the Course of the Natural Stream known as Bartlett Gulch

Bartlett Gulch Upper Split May 17, 2019

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Prepared For:

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May 27, 2022

Project No. 904.2

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CERTIFICATION

This engineering report titled the "Supplemental Engineering Report for Case No. 21CW3008(B) AngelView, LLC, Application for Storage, and Plan for Augmentation including Exchange, Issues Dealing with the Course of the Natural Stream known as Bartlett Gulch," dated May 27, 2022, was authored under the direction and supervision of the undersigned.

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The following members of the staff of Martin and Wood Water Consultants, Inc. contributed to the preparation of this report.

Chase Van Alstine, P.G. — Staff II Hydrogeologist

On behalf of AngelView, LLC, this letter report supplements the opinions and information provided in the March 7, 2022 expert disclosure report prepared by Martin and Wood Water Consultants, Inc. (M&W expert report) in support of Case No. 21CW3008(B). This report addresses the State Engineer and the Division Engineer for Water Division No. 2 (Engineers) concerns and questions raised at the first meeting of the experts held on April 26, 2022, the site visit held on May 6, 2022, and additional internal discussions after the first meeting of the experts.

SECTION 1 – BARTLETT GULCH

This section provides additional information, analysis and opinions regarding the natural channel of Bartlett Gulch. Subsequent to the filing of the March 7, 2022 disclosure, M&W participated in a site visit with the Engineers for the purpose of removing the Engineer's Upper and Lower Dams. M&W also found some additional photographs[1] of the site that it had taken, or were provided by client representative Mr. Alan Elias, and were inadvertently not included in previous disclosures, some of which illustrated the dam sites prior to installation of the dams, alterations to the Bartlett Gulch channel, and subsequent erosion.

[1] Some of these photographs are included herein. All are being provided as a supplement disclosure.

1.1 Bartlett Gulch Upper Split

The below photographs show the site prior to the Engineers damming the Eastern Channel, after the installation of the dam blocking the Eastern Channel, and after removal of the dam that was blocking the Eastern Channel.

The above photograph shows the Upper Split of Bartlett Gulch prior to the installation of the Engineer's Upper Dam. Note that the majority of the flow is in the Eastern Channel and that the Western Channel is obstructed by a berm, fluvial deposits, a fallen tree, and a few large rocks.

The above photograph shows the Upper Split of Bartlett Gulch after installation of the Engineer's Upper Dam. Note that the berm, fluvial deposits, fallen tree, and rocks that were previously present in the Western Channel have been removed, and that the rocks appear to have been placed along the eastern bank and now form a protective barrier hindering erosion of the eastern bank and flow to the Eastern Channel. The Western Channel appears to have been widened when compared to the pre-dam installation conditions.

The above photograph shows the Upper Split of Bartlett Gulch after removal of the Engineer's Upper Dam. Note that neither the berm and rocks that were in the Western Channel prior to the installation of the dam, nor the tree over the opening to the Western Channel were reinstalled, though the rocks placed along the eastern bank were removed. The majority of the streamflow is now in the Western Channel rather that the Eastern Channel, which is opposite to the pre-dam installation conditions. The Western Channel remains widened when compared to the pre-dam installation conditions. An excellent visualization of the post dam removal flow is also shown in the video MVI_8402.

1.2 Bartlett Gulch Upper Breach

The below photographs show the site of the Engineer's Lower Dam prior to installation of the dam, after the installation of the dam, and after removal of the dam.

The above photograph shows the Upper Breach on the Eastern Branch of Bartlett Gulch prior to the installation of the Engineer's Lower Dam. The Upper Breach is approximately 80 feet downstream of the Upper Split of Bartlett Gulch. It is useful to use the branch visible on the left side of the photograph as a reference point in the following photographs.

The above photograph shows the previous location of the Upper Breach on the Eastern Branch of Bartlett Gulch after installation of the Engineer's Lower Dam. The Upper Breach has been removed to redirect any flow that was in the Eastern Channel to the Western Channel. This flow may include flow leaking through the Engineer's Upper Dam as well as subsurface flow. Using the branch visible on the left side of the previous photograph, make note of the level of the bottom of the channel that was created through the removal of the Upper Breach.

The above photograph shows the previous location of the Upper Breach on the Eastern Branch of Bartlett Gulch just prior to removal of the Engineer's Lower Dam. It appears that the stream channel has eroded to some extent (visible behind and below the branch), lowering the level of the return from the Eastern Channel to the Western Channel.

The above photograph shows the previous location of the Upper Breach on the Eastern Branch of Bartlett Gulch after removal of the Engineer's Lower Dam. Note that no flow is in the Eastern Channel, and that the base of the Eastern Channel is too high to accommodate any flow where the channel makes an approximately ninety degree turn towards the Western Channel. It is our opinion that an approximately ninety degree turn through a berm is not something a natural stream channel would do. The dashed blue line represents a breach in the western berm of the Eastern Channel, which based on the elevation of the top of the berm and the presence of what appears to be natural boulders and mature vegetation appears to have been breached by humans and is described further below. Again note that the breach is essentially at a right angle (approximately ninety degrees) to the flow direction in the Eastern Channel.

The adjacent photograph illustrates what appears to be a continuous natural berm on the west side of the Eastern Channel. The former location of the Upper Breach represents a breach in the berm. This is the location of the dashed blue line in the previous photograph.

The adjacent photograph also illustrates what appears to be a continuous natural berm on the west side of the Eastern Channel before the location of the Engineer's Lower Dam and breached berm. The former location of the Upper Breach represents a breach in the berm. This is the location of the dashed blue line in the previous photograph.

The above photograph illustrates the flow in the breach of the berm on the western bank of the Eastern Channel (the log spanning the breach, underneath the dashed blue line, was placed to represent the potential previous extent of a continuous berm). Note that the flow direction is essentially perpendicular to the Eastern Channel and takes another right-angle (approximately ninety degree) turn shortly after existing the channel to follow the slope of the terrain. It is our opinion that right angle or approximately ninety degree turns in a stream channel are not natural. The break in the berm may be manmade, as were the repairs in the berm consisting of the Upper Breach illustrated in the April 29, 2019 photograph earlier in this section. An excellent visualization of the berm/breach is also shown in the videos MVI_8411, MVI_8414, MVI_8421, and 67512668287__570EBEA5-DF60-43CF-A549-CB0950AD25B6.MOV
.

SECTION 2 - FEN DRY-UP AS A RESULT OF TERMINATION OF SURFACE FLOW TO THE EAST BRANCH OF BARTLETT GULCH

Per Alan Elias, the AngelView Manager, the surface water flow from Bartlett Gulch to the Eastern Channel was temporarily terminated through the construction of a temporary dam by the Colorado Department of Water Resources Division 2 personnel (DWR) on or about September 22, 2021. At the time that the Eastern Channel surface water flow was temporarily terminated, Fen A on the AngelView property (Figure 2.7 from our March 7, 2022 disclosure) was fully saturated and had standing water. On April 10, 2022, Alan Elias sent to Martin and Wood the two photographs included below showing the drying up of Fen A, with the water level decline in Fen A estimated at approximately 3 feet.

A site visit was conducted on May 6, 2022, for the removal of the temporary dam that was placed by DWR on or about September 22, 2021. During the May 6, 2022 site visit, Division 2 Engineer Bill Tyner expressed doubt that the termination of surface water flow in the Eastern Channel would impact Fen A in the approximately 8 months since surface water flow was terminated. Martin and Wood researched published hydrogeologic properties of glacial deposits to show that the termination of surface water flow could impact Fen A within an eight-month period.

Figure 2.7 from our March 7, 2022 Expert Report (attached) illustrates our opinion regarding the mapped Easterly Channel. Between the Lower Flow Split and the Beaver Ponds Location identified on Figure 2.7, the Eastern Channel splits into a northern subsurface channel (Northern Eastern Channel) that leads to Fen A and AngelView Pond, and a southern channel (Southern Eastern Channel) that travels through the Beaver Ponds Location and the U-Shaped Valley before reaching Twin Lakes. The Southern Eastern Channel to our knowledge has always had surface water flow when flow to the Eastern Channel has not been terminated. It is our opinion that surface water flow to the Northern Eastern Channel becomes groundwater flow where the Southern Eastern Channel and the Northern Eastern Channel split. This opinion is based on the bedrock trough that is evident below the Esker that is labeled in Figure 2.7, along with the small surface water drainage basin described in Section 3, which in our opinion is not a large enough surface water drainage basin to provide sufficient continuous water to Fen A.

In order to supply water to Fen A, the groundwater flow from the Southern Eastern Channel and the Northern Eastern Channel split would have to travel a distance of approximately 2,380 feet as groundwater flow. The attached Table 1 presents the results of our research results on representative hydraulic conductivities of deposits in glacial environments and associated travel times for the 2,380-foot distance from the Southern Eastern Channel and the Northern Eastern Channel split to Fen A. The travel times are calculated from the hydraulic conductivity values, which are in feet per day (ft/day) applied to the distance from for the 2,380-foot distance from the Southern Eastern Channel and the Northern Eastern Channel split to Fen A of 2,380 feet. We used an average days per month value of 30 days per month. As presented in Table 1, the unconsolidated deposits that are not cemented together, such as ferricrete, have travel times that are well within the 8-month period between when surface water to the Eastern Channel was terminated to the site visit conducted on May 6, 2022.

The Kahn et. al., 2017 publication (Kahn publication) is particularly relevant as the location and elevations are similar to the AngelView location and elevation. The Kahn publication is from a test site in Park County, which is in a tributary of the North Fork of the South Platte River at elevations of 11,000 feet to over 12,000 feet.

The Kahn publication test site includes single well pumping test and double ring infiltrometer infiltration test results from deposits mapped as landslide deposits, which is the same geologic deposit (Ql, which is identified in Figure 2.6 from our March 7, 2022 Disclosure) along Bartlett Gulch west of, and including, the southwest half of the AngelView Property. The hydraulic conductivity test results and associated travel times for the 2,380-foot distance from the Southern Eastern Channel and the Northern Eastern Channel split to Fen A are presented in Table 2. As with Table 1, the travel times for unconsolidated deposits that are not cemented together, such as ferricrete, are well within the 8-month period between when surface water to the Eastern Channel was terminated to the site visit conducted on May 6, 2022.

SECTION 3 - FEN DRAINAGE BASIN

StreamStats was used to generate monthly and annual average runoff to ascertain whether or not precipitation would be sufficient to sustain the development of Fen A. The StreamStats report (attached as Appendix A) calculated a drainage area of 0.0541 square miles and estimated an average annual runoff flow rate of 0.0274 cfs using an average annual precipitation of 12.27 inches. The stated precipitation would generate a total of 35.40 acre-feet on an annual basis. The average annual volume of runoff calculated from the average annual runoff flow rate is 19.85 acre-feet, which leaves 15.55 acre-feet for use by native vegetation and deep percolation. Applying the SEO default native vegetation credit of 70% to the total precipitation volume of 35.40 acre-feet results in native vegetation consumption of 24.78 acre-feet, which exceeds the 15.55 acre-feet available. While the consumptive use of native vegetation is likely lower than the SEO default value of 70%, it is our opinion that this analysis demonstrates that on an average annual basis the drainage basin above the fen cannot generate sufficient surface water and groundwater to sustain Fen A.

SECTION 4 - LIST OF ITEMS REVIEWED IN PREPARATION OF REPORT

The following additional documents were reviewed and considered in the preparation of this report.

1. Hayashi, M., Alpine Hydrogeology: *The Critical Role of Groundwater in Sourcing the Headwaters of the World*, Groundwater, Vol. 58, No. 4, July -August 2020, pages 498-510.
2. Kahn, et. al., *Characterization of the shallow groundwater system in an alpine watershed: Handcart Gulch, Colorado, USA*, Hydrology Journal, February 2008.
3. Somers and McKenzie, *A review of groundwater in high mountain environments*, Wiley, WIREs Water, 2020;7:e1475.
4. The report lists other references and items reviewed that may not be in this list.
5. Various photographs and videos disclosed herein by Angel View.

SECTION 5 – COMPUTATIONAL MODELS USED IN THE PREPARATION OF THIS REPORT

1. Spreadsheets were used to develop tables included in the text of the report.
2. The USGS StreamStats model was run to develop the Fen A drainage basin. The model may be accessed at https://streamstats.usgs.gov/ss/.

SECTION 6 – ERRATA

Please note the following errata for the March 7, 2022 Engineering Report for Case No. 21CW3008(B)

The date on the cover of the Engineering Report should be "March 7, 2022" rather than "March 7, 20022".

Page 13, Section 2.9.1 Upper Bartlett Gulch

The first sentence of this section is amended to read as follows:

> There were several notable observations concerning upper Bartlett Gulch, which for the purposes herein is defined as a section of Bartlett Gulch beginning a few hundred feet above the Engineer's Upper Dam (this is the dam placed in the Bartlett Gulch channel at what is known as the Upper Split by the Engineers to redirect all of the Bartlett Gulch flow to the Village of Twin Lakes via the Western Channel) and ending downstream at the Engineer's Lower Dam (this in the dam placed in the Bartlett Gulch channel <u>approximately 80 feet downstream of the Upper Flow Split</u> by the Engineers to redirect all of the Bartlett Gulch flow to the Village of Twin Lakes).

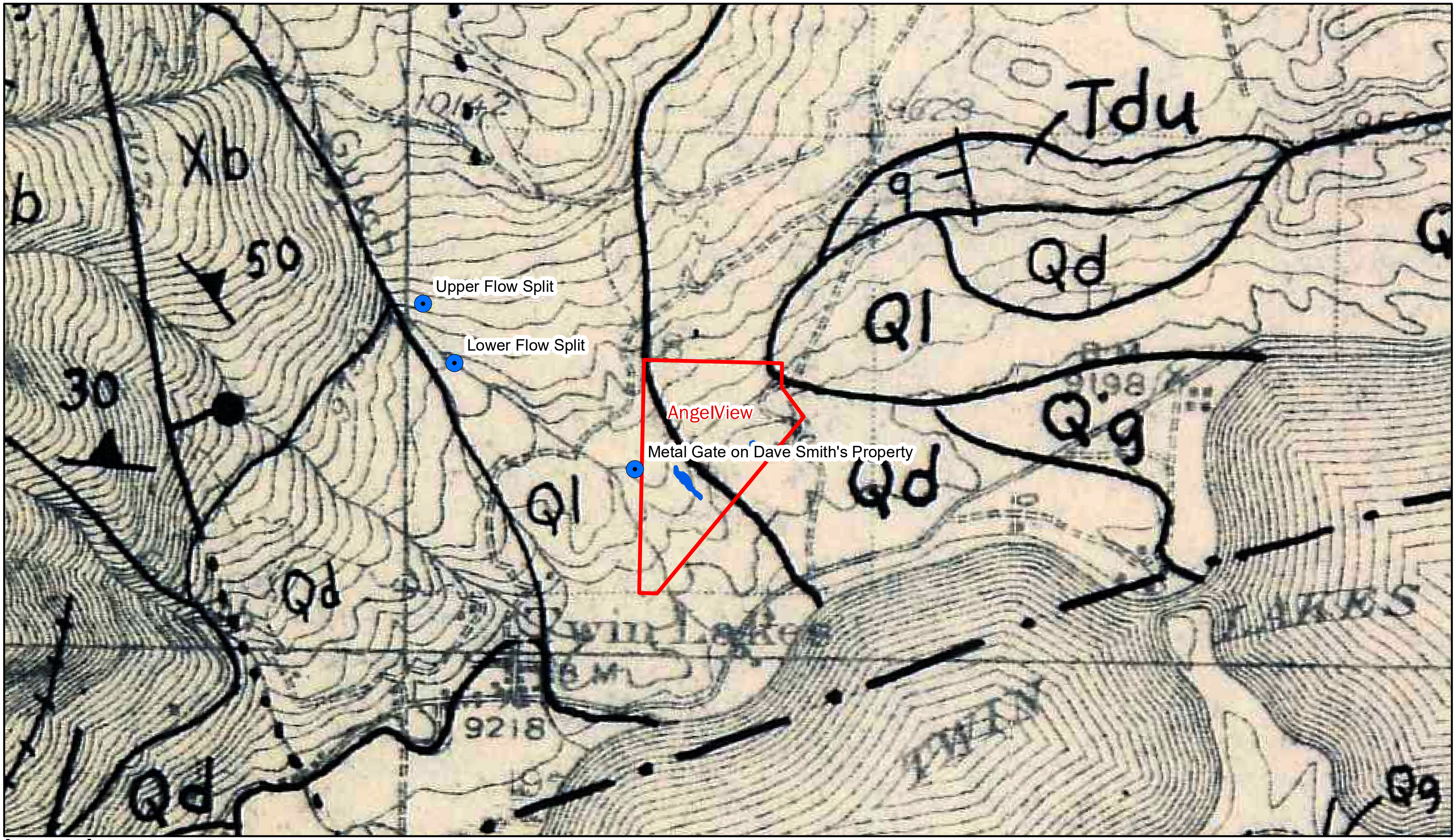
Page 16 & 17, Section 2.9.2 Mapped Channel of Bartlett Gulch Downstream of Lower Split/Engineer's Lower Dam

All occurrences of "Lower Split/Engineer's Lower Dam," "Lower Flow Split/Engineer's Lower Dam," and "Lower Split" should read as "Engineer's Lower Dam."

Page 18, Section 2.9.3 Twin Lakes Ditch

In the first sentence of this section, "Lower Split" should read "Lower Flow Split."

FIGURES



Legend

- Diversion Structures
- Angel View Pond
- Angel View Property

Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

N W E S

0 1,300 2,600 5,200 Feet

Coordinate System: NAD 1983 UTM Zone 13N
Projection: Transverse Mercator
Datum: North American 1983
Scale: 1:20,000

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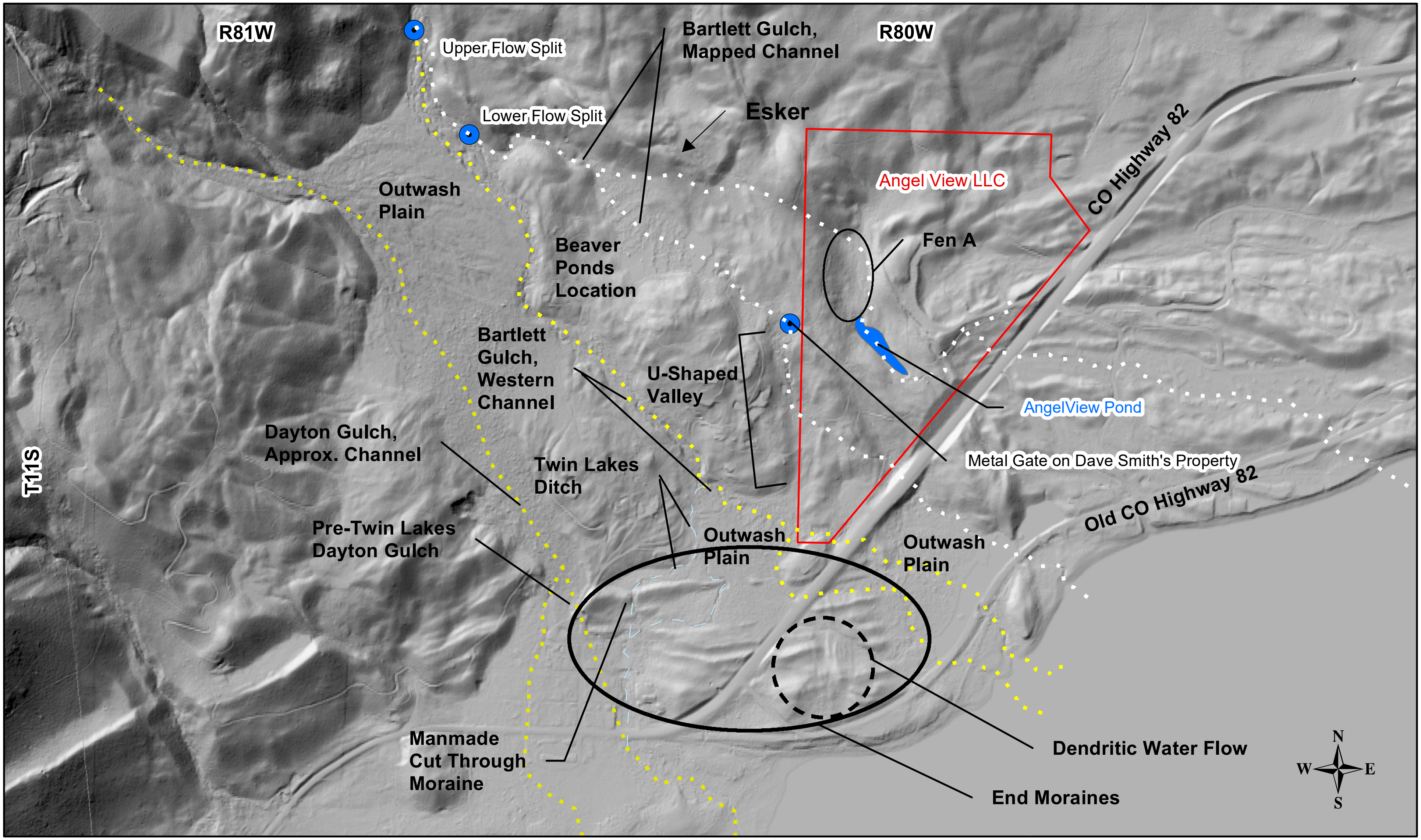
Figure 2.6
Angel View LLC
U.S. Geological Survey
Leadville Quadrangle Geologic Map

Job No.: 904.2
Date: 3/7/2022
Drawn: CRV

S:\904 - AngelView, LLC\904.2 - Lily Pond Ditch\GIS\Figure 6 - USGS Geological Map.mxd



Angel View Property

Angel View Pond

Diversion Structures

Bartlett Gulch, Easterly Channel

Bartlett Gulch, Westerly Channel

Dayton Gulch, Approx. Channel

Twin Lakes Ditch

Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
USGS National Map 3D Elevation Program (3DEP)

0 550 1,100 2,200 Feet

Coordinate System: NAD 1983 UTM Zone 13N
Projection: Transverse Mercator
Datum: North American 1983
Scale: 1:11,000

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Figure 2.7
Angel View LLC
North Arkansas River Valley LiDAR

Job No.: 904.2
Date: 3/7/2022
Drawn: CRV

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TABLES

Table 1
AngelView Ponds 21CW3008
Hydraulic Conductivity and Infiltration Rates for High Alpine Deposits in Glacial Environments

Aquifer Type	Low Hydraulic Conductivity (feet/day)	High Hydraulic Conductivity (feet/day)	Number of Data Points Evaluated	Low Infiltration Rates (feet/day)	High Infiltration Rates (feet/day)	Low Hydraulic Conductivity Travel Time (months)[1]	High Hydraulic Conductivity Travel Time (months)[1]	Source	Comment
Talus deposits	2,000.00	9,000.00	Not Defined	Not Defined	Not Defined	0.04	0.01	Hayashi, 2020	From Clow et. al. (2003) and Muir et. al. (2011).
Moraine deposits, coarse-textures	1,200.00	1,800.00	Not Defined	Not Defined	Not Defined	0.07	0.05	Hayashi, 2020	From Langston et. al. (2013).
Moraine deposits, fine-textures	30.00	300.00	Not Defined	Not Defined	Not Defined	2.65	0.27	Hayashi, 2020	From Magnusson et. al. (2014); Rogger et. al. (2017); Vincet et. al.
Rock glacier deposits	20.00	14,000.00	Not Defined	Not Defined	Not Defined	3.97	0.01	Hayashi, 2020	From Winkler et. al. (2016).
Rock glacier deposits	5.00	20.00	3 layers, 1 well	Not Defined	Not Defined	15.87	3.97	Kahn et. al., 2008	Pumping/injection tests in a similar setting to the AngelView Project in Colorado.
Progalcial moraine and talus deposits in the Canadian Rockies[2]	Not Defined	950.00	Not Defined	Not Defined	Not Defined	Not Defined	0.09	Somers and McKenzie, 2020	Langston, Hyashi and Roy (2013) used salt tracers to develop hydraulic conductivity.
Quaternary alluvium deposits[3]	Not Defined	Not Defined	2 sites	Not Defined	411.05	Not Defined	0.20	Kahn et. al., 2008	Infiltration rate obtained from double-ring infiltrometer tests.
Quaternary rock glacier deposits[3]	Not Defined	Not Defined	3 sites	986.51	29,481.76	0.09	<0.01	Kahn et. al., 2008	Infiltration rate obtained from double-ring infiltrometer tests.

Notes
[1]: Assumes that hydraulic conductivity is approximately analogous to groundwater velocity through the aquifer.
[2]: Only one value was given in two sources with the hydraulic conductivity values.
[3]: Infiltration tests are performed on the surface material at each site where the test was performed, which is not necessarily the same location of the aquifer tests.

Table 2
AngelView Ponds 21CW3008
Travel Times of Groundwater in High Alpine Glacial Deposits, Colorado
Determined by Hydraulic Conductivities from Pumping and Injection Tests

Aquifer Type and Data Point (Well, Modeled Depth Interval)	Hydraulic Conductivity (feet/day)	Groundwater Travel Time (months)[1]
Rock glacier deposits (HCFW3, 0 to 1 meters bgl)	20.00	3.97
Rock glacier deposits (HCFW3, 1 to 3 meters bgl)	11.40	6.96
Rock glacier deposits (HCFW3, 3 to 4.1 meters bgl)	5.00	15.87
Aquifer Type and Data Point (Infiltration Test Location)	**Infiltration Rate (feet/day)**	**Groundwater Travel Time (months)[1]**
Quaternary alluvium deposits (1)	411.04	0.19
Quaternary rock glacier deposits (5)	29,481.75	<0.01
Quaternary rock glacier deposits (6)	394.03	0.21
Quaternary rock glacier deposits (7)	986.50	0.09

Notes
All data is derived from well HCFW3 and infiltration tests from Kahn et. al., 2008
bgl: below ground level
[1]: Assumes that hydraulic conductivity is approximately analogous to groundwater velocity through the aquifer.

APPENDICES

APPENDIX A

StreamStats Report

StreamStats Report

Region ID: CO
Workspace ID: CO20220525002719597000
Clicked Point (Latitude, Longitude): 39.08925, -106.37581
Time: 2022-05-24 18:27:40 -0600

Collapse All

Basin Characteristics

Parameter Code	Parameter Description	Value	Unit
DRNAREA	Area that drains to a point on a stream	0.0541	square miles
PRECIP	Mean Annual Precipitation	12.27	inches

Annual Flow Statistics

Annual Flow Statistics Parameters [Mountain Region Mean Flow]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.0541	square miles	1	1060
PRECIP	Mean Annual Precipitation	12.27	inches	18	47

Annual Flow Statistics Disclaimers [Mountain Region Mean Flow]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors.

Annual Flow Statistics Flow Report [Mountain Region Mean Flow]

Statistic	Value	Unit
Mean Annual Flow	0.0274	ft^3/s

Annual Flow Statistics Citations

Capesius, J.P., and Stephens, V. C.,2009, Regional Regression Equations for Estimation of Natural Streamflow Statistics in Colorado: U. S. Geological Survey Scientific Investigations Report 2009-5136, 32 p. (http://pubs.usgs.gov/sir/2009/5136/http://pubs.usgs.gov/sir/2009/5136/)

Monthly Flow Statistics

Monthly Flow Statistics Parameters [Mountain Region Mean Flow]

Parameter Code	Parameter Name	Value	Units	Min Limit	Max Limit
DRNAREA	Drainage Area	0.0541	square miles	1	1060
PRECIP	Mean Annual Precipitation	12.27	inches	18	47

Monthly Flow Statistics Disclaimers [Mountain Region Mean Flow]

One or more of the parameters is outside the suggested range. Estimates were extrapolated with unknown errors.

Monthly Flow Statistics Flow Report [Mountain Region Mean Flow]

Statistic	Value	Unit
January Mean Flow	0.00242	ft^3/s
February Mean Flow	0.00239	ft^3/s
March Mean Flow	0.00215	ft^3/s
April Mean Flow	0.00246	ft^3/s
May Mean Flow	0.0599	ft^3/s
June Mean Flow	0.212	ft^3/s
July Mean Flow	0.0366	ft^3/s
August Mean Flow	0.0187	ft^3/s
September Mean Flow	0.00809	ft^3/s
October Mean Flow	0.00434	ft^3/s
November Mean Flow	0.0036	ft^3/s
December Mean Flow	0.00308	ft^3/s

Monthly Flow Statistics Citations

Capesius, J.P., and Stephens, V. C.,2009, Regional Regression Equations for Estimation of Natural Streamflow Statistics in Colorado: U. S. Geological Survey Scientific Investigations Report 2009-5136, 32 p. (http://pubs.usgs.gov/sir/2009/5136/http://pubs.usgs.gov/sir/2009/5136/)

Application Version: 4.9.0

StreamStats Services Version: 1.2.22

NSS Services Version: 2.2.0