Application: 41H 30127867 **T01S, R05E, Section 26**

Applicant: FLIR Systems Inc. **Gallatin County**

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Depletion Report

Application Background

The applicant requests three points of diversion (extraction wells), a flow rate of 700 gallons per minute (gpm) and a volume of 831 acre-feet (AF) per year for an open loop geothermal system that will discharge back into the aquifer via four injection wells returning the water back to the same source aquifer. Submersible pumps within the wells will be interfaced with variable-frequency controllers that will receive a flow-demand signal from the heat-exchange system in the building. The submersible pumps' flow rates will be variable throughout the year and will provide a combined flow up to a peak of 700 gpm for a new building to be built in Bozeman, Gallatin County. The three extraction wells and four injection wells are completed in the Tertiary aged deposits of the Gallatin Valley (English, 2018). Two of the extraction wells are 181 below ground surface (bgs), while the third extraction well is 206 feet bgs. The injection wells have total depths of 120 feet bgs. All wells in this application are in Township 1 South, Range 5 East, Section 26 in Bozeman City limits.

Hydrogeologic Setting

The hydrogeology of the alluvial aquifers in the Gallatin Valley is described in publications by Hackett et al. (1960), Custer et al. (1991), Slagle (1995), Custer and Dixon (2002), Kaczmarek (2003 and 2008), Sutherland et al. (2014), Michalek et al. (2017, in preparation), and Sutherland et al. (2017, in preparation). Additional information on the alluvial aquifers is available in a geologic map by Vuke et al. (2014).

The surficial geology is mapped as Quaternary braid plain alluvium by Vuke et al. (2014) at the point of use (POU). Aquifer thickness increases northward into a trough identified by Hackett et al. (1960) who described it as the down dropped side of the Central Park Fault. The thickness of the alluvium decreases abruptly to the north of the fault resulting in groundwater discharge north of the fault.

Tertiary sediments underlying alluvium are composed of cobbles, sand, and fine sediment and is estimated to be as much as 4,000 feet thick in the Gallatin Valley (Hackett et al. 1960). Hydrogeologic information collected by United States Geologic Survey (USGS), Montana Bureau of Mines and Geology (MBMG), and DNRC have shown that clay layers are discontinuous and, therefore, that the Quaternary and Tertiary sediments act as one aquifer system on a basin scale.

Groundwater in the Gallatin Valley is recharged primarily by seepage from streams and irrigation canals and ditches, and infiltration of applied irrigation water. Groundwater discharges to springs and the Gallatin River and its tributaries as well as to evapotranspiration where groundwater levels are shallow north of Central Park (Hackett et al. 1960; Sutherland et al. 2014). Discharge from the source aquifer near the POU is through upward flow to springs and seeps along stream channels.

Methodology

The following analysis of net depletion will be used in subsequent evaluations of legal availability and adverse effects to surface water required under §85-2-311, MCA. Net depletion is the calculated volume, rate, timing, and location of reductions to surface water resulting from a groundwater appropriation that is not offset by the corresponding accretions to surface water by water that is not consumed and subsequently returns to the surface water. Net depletion is evaluated in three steps: identification of potentially affected surface waters, calculation of consumption, and calculation of the rate and timing of depletions to the identified affected surface waters.

The locations of potentially affected surface waters depend on propagation of drawdown to locations where surface water is hydraulically connected to groundwater. Propagation of drawdown and depletion of surface water depends on the hydraulic properties of an aquifer and is not a function of groundwater flow rate or direction (Theis, 1938; Leake, 2011). Furthermore, drawdown can propagate through the entire thickness of the confining layer (Konikow and Neuzil, 2007). Hydraulic connection depends on the depth to groundwater beneath the beds of surface waters and can vary along a reach and with time of year.

Consumption depends on the percentage of water that returns to the source under the proposed use. Depletion is assumed to be equivalent to consumption on an annual basis unless return flows do not accrete to the potentially affected surface water.

Evaluations of the rate and timing of depletions caused by pumping are based on the basic concept that groundwater pumping eventually is offset by an equivalent increase in recharge or decrease in discharge (Theis, 1940; Leake et al., 2008), a process defined as capture by Lohman (1972). Capture occurs as drawdown propagates to surface water and areas of phreatophyte vegetation that takes water directly from groundwater. In the absence of credible evidence to the contrary, capture of ET by phreatophytes is neglected and net depletion is assumed to equal total capture. This assumption is justified because published estimates for conditions common in Montana alluvial valleys indicate capture of ET generally is less than 10 percent of total capture (Xunhong, 2006). Capture of ET in ephemeral drainages may be significant and will be evaluated on an application by application basis.

The rate and timing of net depletion caused by pumping may be modeled using a variety of analytical and numerical models selected to fit site-specific conditions and needs. Simple models including the Alluvial Water Accounting System (AWAS) and the Well Pumping Depletion Model (WPDM) typically are used to model depletions to one source with simple aquifer boundaries. Adjustments may be made for more complex conditions or multiple sources using methods like those described by Contor (2011)**,** analytical models by Hunt (2003) and Butler et al. (2001) or a superposition numerical groundwater flow model. Modeling is not necessary in some situations such as where a proposed use is constant year-round, where depletion is expected to be limited to a single stream reach, or where confined conditions dampen variations in depletion.

The net depletion will be apportioned between each potentially affected stream using an inverse distance squared weighting procedure described in DNRC (2018). Conclusions presented in this report are based on review of available evidence on hydraulic connection of the source aquifer to surface water.

Potentially Affected Surface Waters

The closest perennial surface water body to the project site, the East Gallatin River, is approximately 3,100 feet from the three extraction wells (GWIC #s – 304056, 304057, and 303698) and the four injection wells (GWIC #s 305205, 305206, 305207, 305208). Other nearby surface water bodies include a intermittent drainage ditch locally known as Catron Creek approximately 500 feet from the extraction and injection wells. The seven, either extraction or injection wells have an average static water level 6.5 feet bgs, indicating a connection to groundwater.

Well logs and mapping done by Vuke et al. (2014) and Hackett et al. (1960) suggest strong surface and groundwater interactions through the region and connections between shallow tertiary and alluvial sediments with nearby streams. Injection and extraction well locations are surrounded by layers of clay most likely causing perched groundwater tables and semi-confined layers (English, 2018). Due to the lack of extent of some of these semi-impervious layers, the alluvial aquifer and tertiary sediments readily receive groundwater recharge through irrigation, conveyance losses and stream seepage leading to a groundwater discharge to the East Gallatin River (Hackett et al. 1960). Based on this information, Catron Creek and East Gallatin are the potentially affected surface water bodies.

Consumption

This application is for a non-consumptive water right for geothermal based heating and cooling. The Department typically assumes that pumping and injection at the same location and bases modeling on the net consumption.

In this case, pumping and injection rates were modeled separately in the Aquifer Test Report for the proposed wells. The distance and direction of the paired injection wells with respect to the extraction wells is approximately 250 feet to the northwest and 350 feet to the northeast.

However, the extraction rate and injection rates over the pumping schedule are equal making the use a net non-consumptive use closed system. This assumes that depletions and accretions will cancel and result in no net affect to surface water flows to Catron Creek and the East Gallatin River.

Rate and Timing of Depletions

Since the applicant requests a non-consumptive water right for geothermal based heating and cooling; there will be no increase in surface water depletion to Catron Creek and the East Gallatin River on an annual basis (**Table 1**). In addition, the timing and location of depletion from pumping and accretion resulting from injection should be the same because the distance between the extraction and injection wells is relatively small compared to the distance to the potentially affected surface waters.

Table 1: Consumption and net depletion to Catron Creek and the East Gallatin River for the FLIR application # 41H 30127867.

Month	New Consumption (AF)	Net Depletion (AF)	Net Depletion (GPM)
January	0	0	0
February	0	0	0
March	0	0	0
April	0	0	0
May	0	0	0
June	0	0	0
July	0	0	0
August	0	0	0
September	0	0	0
October	0	0	0
November	0	0	0
December	0	0	0
	0	0	

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