Black Canyon Hydroelectric Project
FERC Project No. P-14110
Groundwater Study Report
March 2014

Prepared for
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1.0 EXECUTIVE SUMMARY

Black Canyon Hydro, LLC (BCH) plans to file an application with the Federal Energy Regulatory Commission (FERC) for an original license for the Black Canyon Hydroelectric Project (Project), FERC Project Number P-14110, and associated facilities on the North Fork Snoqualmie River approximately 4 miles northeast of North Bend, King County, Washington. As required by the Integrated Licensing Project of FERC, BCH filed Proposed Study Plans to evaluate a wide range of potential impacts associated with the Project.

Confluence Environmental Company (Confluence) conducted a study of groundwater within a segment of the North Fork Snoqualmie River that would be affected by the proposed Project. This portion of the river, which extends from approximately river mile [RM] 5.3 to RM 2.6), is referred to as the Project Reach. This document presents the study results as part of the overall program of studies evaluating how flow-dependent resources may be affected by the BCH Project operations and informing how Project goals can be achieved.

The groundwater analysis evaluates the potential impacts of partial river diversion on the recharge to groundwater and on natural springs or shallow water table areas. The analysis also considers potential effects on existing water rights.

Black Canyon Hydro conducted a review of water rights that may be potentially affected by the proposed partial river diversion. This review identified one water right held by the City of Snoqualmie that may be affected by the proposed partial river diversion. The potential for effects is based on its location and geological configuration with respect to the location of the Project Reach within the North Fork Snoqualmie River. The City of Snoqualmie maintains a well field for drinking water supply at a location commonly referred to as Canyon Springs.

Two potential effects on groundwater resources were evaluated in this analysis. The first potential effect relates to the potential for water diversion from the North Fork Snoqualmie River to alter recharge of the aquifer that supplies the City of Snoqualmie water right exercised at Canyon Springs. The second potential effect relates to the potential for the proposed deep tunnel tailrace to affect the same aquifer.

Geological conditions in the study area are documented in greater detail within the Preliminary Geotechnical Findings Report (BCH 2014). The aquifer that supplies water to the Canyon Springs well field is composed of recessional outwash deposited on top of bedrock. Rainfall is the primary recharge source for the aquifer (Grey & Osborne, 2013). The North Fork Snoqualmie River flows along the contact between the outwash and the underlying bedrock up gradient from the well field. In this configuration, there is potential for water from the river to recharge the aquifer.

Aquifer recharge from the river is possible as long as water is in contact with the aquifer and there is a head gradient that would direct flow into the river bed or river bank. Conversely, if groundwater saturates the soil on the river bank at an elevation higher than the river water surface elevation, water will flow from the bank into the river. At the time of this study, sufficient data do not exist to determine whether the river is gaining or losing from groundwater within the project reach. The river is incised, and topographic conditions suggest that the river would be receiving flow from groundwater within the project reach. Numerous springs were observed during the site reconnaissance conducted in August and September 2013 indicating groundwater flow into the river. The proposed partial water diversion would not affect the aquifer if the head gradient drives flow from the aquifer into the river. Neither would it affect the aquifer if the river is a source of recharge. Recharge will occur as long as water is present in the river bed in contact with the outwash that composes the aquifer.

The proposed deep tunnel tail race would be located within bedrock approximately 200 feet below the contact with the overlying aquifer for the majority of its length. In that configuration relative to the aquifer, the tunnel would not be in contact with the aquifer and would not create an opportunity for water loss from the aquifer.

2.0 INTRODUCTION

2.1 OVERVIEW

Black Canyon Hydro, LLC (BCH), ultimately plans to file an application for an original license for the Black Canyon Hydroelectric Project (Project), FERC Project Number P-14110, and associated facilities on the North Fork Snoqualmie River (North Fork) approximately 4 miles northeast of North Bend, King County, Washington. The Project has a proposed generating capacity of 25 megawatts (MW) and would be located predominantly on private lands. The combined maximum hydraulic capacity of the four project turbines would be 900 cubic feet per second (cfs). The minimum hydraulic capacity at which power can be generated is 40 cfs. The run-of-river project (i.e., no water impoundment) would divert water from an approximately 2.7-mile section of the river between river mile (RM) 5.3 and 2.6. This reach is referred to as the Project Reach.

As required by the Integrated Licensing Project of FERC, BCH filed Proposed Study Plans to evaluate a wide range of potential impacts associated with the project. Confluence Environmental Company (Confluence) conducted a study of groundwater within a segment of the North Fork that would be affected by the proposed Project. This portion of the river, which extends from approximately river mile [RM] 5.3 to RM 2.6), is referred to as the Project Reach. This document presents the study results as part of the overall program of studies evaluating how flow-dependent resources may be affected by the BCH Project operations and informing how Project goals can be achieved.

The location of the project is illustrated on Figure 1, and the Study Reach is identified in Figure 2.

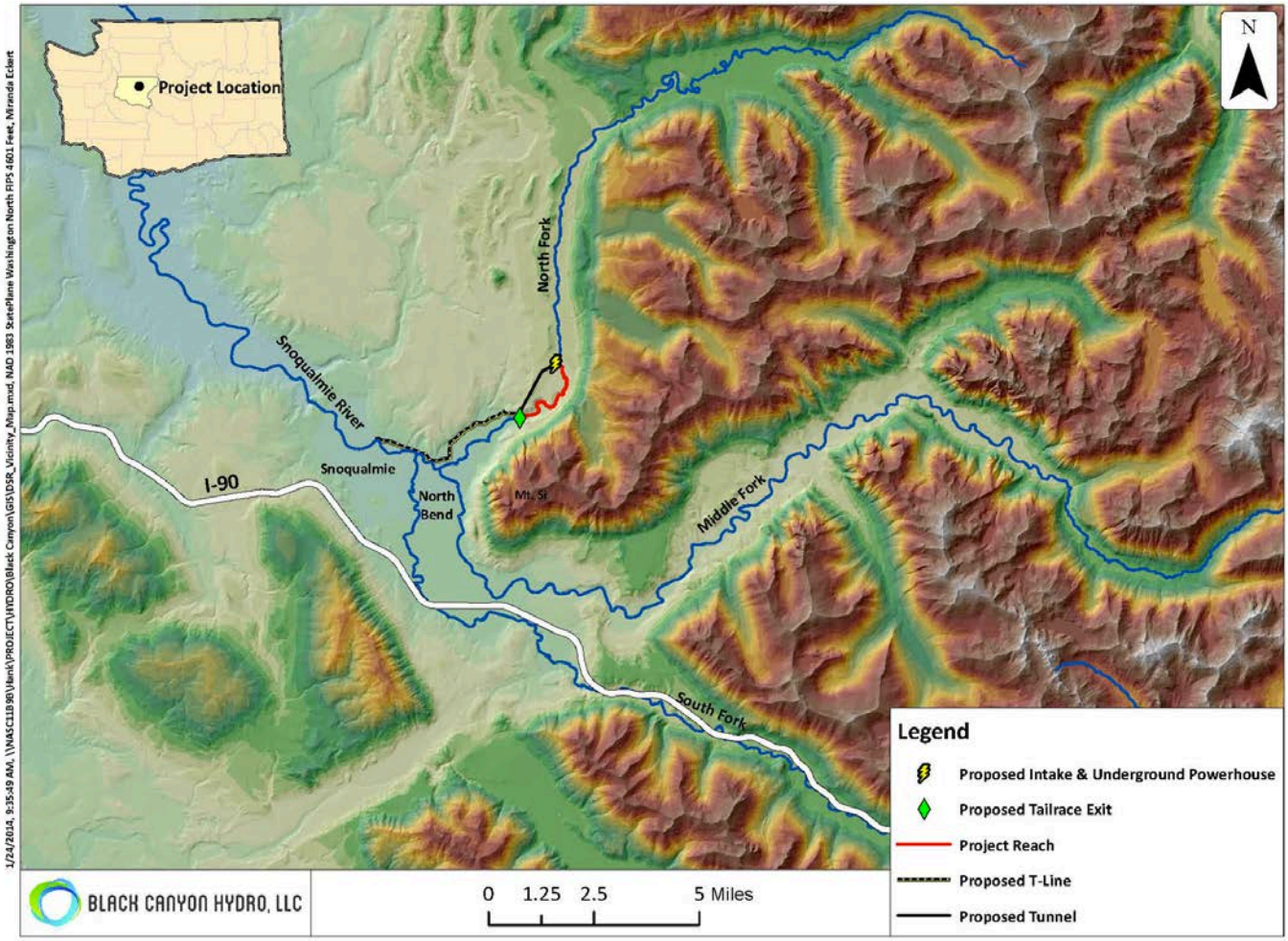

Figure 1. Project Vicinity and Project Reach
King County, Washington

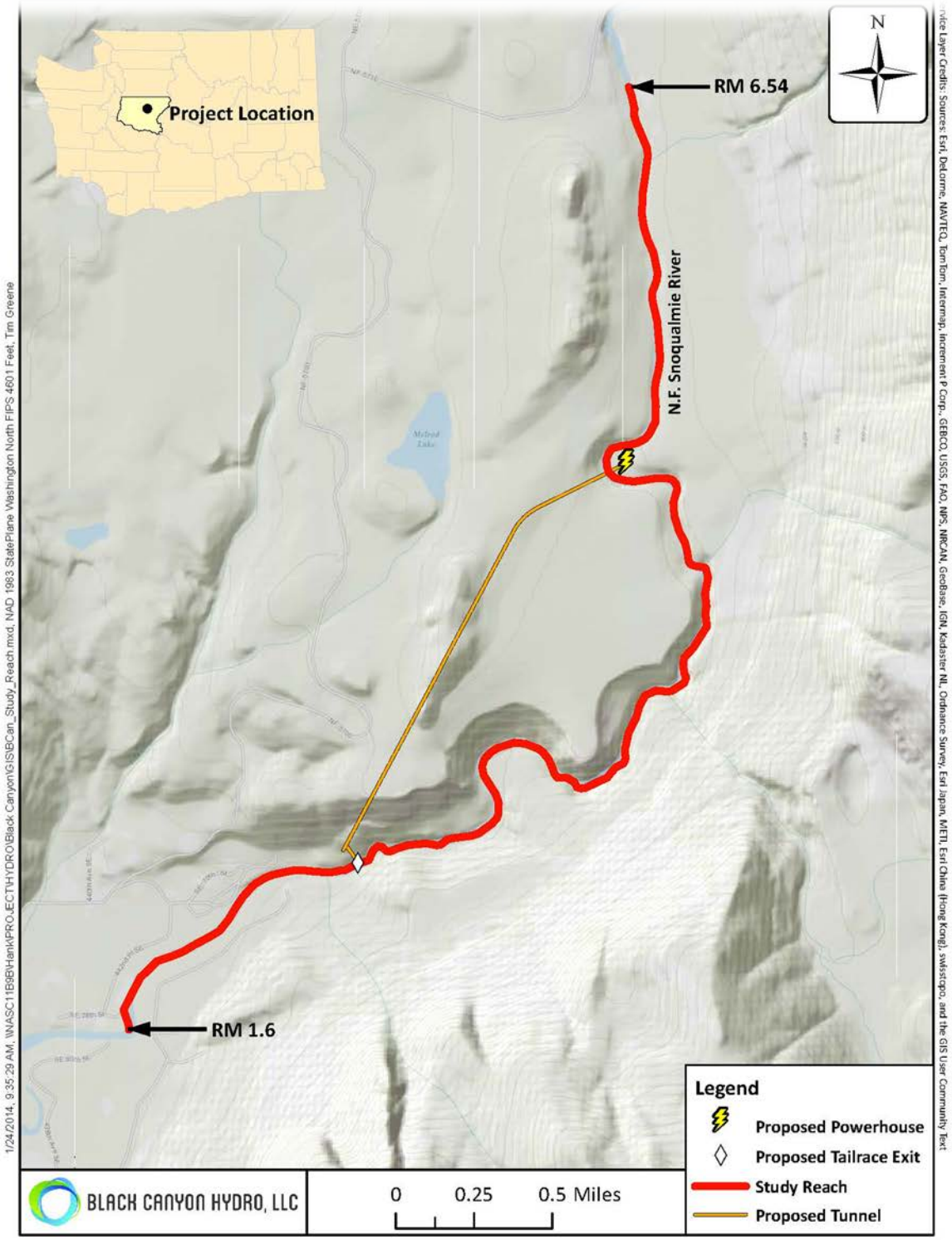

Figure 2. Study Reach, FERC No. P-14110
King County, WA

2.2 PROJECT DESIGN

2.2.1 Intake

The following description of intake features reflects an evolution in Project design since the filing of the Pre-Application Document (PAD) (BCH 2012) through scoping, stakeholder comment, and study results. As a result of completing relevant studies, two possible design alternatives have been developed for the intake. These alternatives are called Alternatives C and D. Both alternatives involve bulk water screening located at approximately RM 5.3, on the same river bend and point-bar as Alternative A. Alternative C uses a vertical plate screening system, and Alternative D uses a horizontal plate screening system.

Both alternatives would have: (1) a control sill to control the normal water surface elevation and maintain a consistent river bed elevation for a side channel bulk-water intake. The control sill would consist of a concrete weir with boulders inset on the surface over top of a sheet pile cutoff wall to capture hyporheic flow. The sill would be at the newly established grade of the river bed and would allow uninterrupted flow through a re-profiled river as a roughened channel series of step pools, riffles, and boulder weirs. (2) An intake structure with a coarse trashrack, jib crane, sluiceway, and radial gate with sluiceway located on the east bank of the river. Diverted water would be conveyed through (3) an open channel to a (4) head gate control structure and into a (5) fish and debris screening structure. (6) Fish and debris would be screened and bypassed back into the river. Screened water would then flow through a power conduit to the underground powerhouse. (7) Access to the intake site would use an existing logging road and approximately 400 feet of new roadway extending to the intake site.

2.2.2 Powerhouse

The powerhouse would be located underground beneath the selected intake site. This would include a (1) 450-foot-tall, 30-foot-diameter vertical shaft to allow space for the power conduit(s), elevator, stairs, ducting, mechanical, and electrical chases. Screened water from the intake screen system would be delivered down a (2) vertical power conduit(s) to the powerhouse. The powerhouse would (3) use four Pelton Turbines each rated at 6.25-MW, as well as appurtenant facilities. The (4) substation and (5) elevator building would be located near the intake structure.

2.2.3 Tailrace

The tailrace will be an approximately (1) 8,600-foot-long 10-foot-diameter tunnel, and is anticipated to be constructed primarily in bedrock. The tailrace water return to the North Fork would be located at approximately the same location as proposed in the PAD, at approximately RM 2.6. Access to the tunnel start, end, and shaft access points is planned to use existing logging roads, new roads, and temporary construction roads.

2.2.4 Transmission

Transmission would consist of a 115-kilovolt overhead transmission line and underground transmission that transmits Project power to the regional grid. The transmission line would be sited predominantly on an existing power line corridor. The transmission line would originate at the powerhouse substation located at the intake site at RM 5.3. Subsurface transmission would follow the vertical shaft to the underground powerhouse, and down the 1.6-mile-long tunnel. After exiting the tunnel the transmission would travel 4.2 miles as 115- kilovolt overhead transmission line predominantly following an existing power line corridor to the point of interconnection. The point of interconnection is located at an existing overhead transmission line near the intersection of 396th Drive SE and SE Reinig Road approximately 0.4 miles from the City of Snoqualmie. Alternatively, the Project could possibly connect to the existing 34-kilovolt transmission line running from the existing Black Creek Hydroelectric Project (FERC No. P-6221) to the point of interconnection at the existing overhead transmission line located near the intersection of Highway 202 and Tokul Road.

3.0 DESCRIPTION OF STUDY

In accordance with 18 CFR §5.11(d)(1), this section describes the goals and objectives of the study and the information that was obtained. The goal of this study is to evaluate existing groundwater supplies, particularly the City of Snoqualmie's water supply source (termed "Canyon Springs") that may be affected by construction and operation of the proposed project, and to assess the potential effects of the project on groundwater supply in the study area. If potential adverse impacts to water supply sources are identified, with a focus on the City of Snoqualmie's water supply source, the study will outline steps to monitor the groundwater system to identify impacts as early as possible and propose mitigation options to reduce any significant adverse impacts when identified.

The study was carried out to achieve the following general goals:

Evaluate the impacts of partial river diversion on the recharge to groundwater at different times of the year. Evaluate the potential of partial river diversion to affect natural springs or shallow water table areas.

More specific objectives for the study are:

- Objective 1: Identify water rights holders, in addition to the City of Snoqualmie, that have groundwater or spring use rights in the study area that could be affected by the proposed project.
- Objective 2: Obtain records from the City of Snoqualmie regarding their use of the water source, including daily, monthly, and annual volumes of water removed; percent of the City's requirements, additional water sources for the City, water

quality information, and projected use of the water source for the duration of the proposed project life.

- Objective 3: Estimate the storage capacity of the gravel aquifer at Canyon Springs by estimating the areal extent and depth of the aquifer, the porosity, the recharge from rainfall, and the seasonal fluctuation. Estimate the hydraulic conductivity and transmissivity of the aquifer.
- Objective 4: Conduct a preliminary geophysical survey in the area of the proposed intake**,** penstock, and powerhouse to estimate the depths to bedrock.

4.0 METHODS

In accordance with 18 CFR §5.11(d)(1) and §5.11(d)(5), this section provides a detailed description of the study methodology, including data collection and analysis techniques, or objectively quantified information. Work was conducted in late 2013 and early 2014. This section lays out specific methods to address the study objectives identified above. The methodology for each of the study objectives are discussed below.

4.1 IDENTIFY WATER RIGHT HOLDERS

In addition to the City of Snoqualmie, BCH researched public records from the Washington State Department of Ecology to identify other water rights holders that have groundwater or spring use rights in the study area that could be affected by the proposed project.

4.2 RECORDS REQUEST TO CITY OF SNOQUALMIE

BCH requested records from the City of Snoqualmie of their use of the Canyon Springs water source, including daily, monthly and annual volumes of water removed; the percentage of the City's requirements that Canyon Springs represents, what the additional water sources for the City are, and projected use of the water source for the duration of the proposed project life. Water quality information was requested for use in the water quality study, including any information on current treatment of the water prior to use as a municipal water supply.

4.3 ESTIMATE AQUIFER CONDITIONS

BCH used available information to estimate aquifer conditions. Boring logs from two deep borings in the study area provided information on the soil gradation and stratigraphy. From this information, and surficial geologic mapping from earlier studies, BCH made preliminary estimates of the aquifer parameters, including areal extent and depth of the aquifer, the porosity, hydraulic conductivity, transmissivity, storage capacity, recharge from rainfall, and how the groundwater supply fluctuates seasonally.

4.4 GEOPHYSICAL SURVEY TO ESTIMATE DEPTH TO BEDROCK

BCH conducted a geophysical survey in the area to estimate the depths to bedrock. Geophysical surveys were conducted up slope from Canyon Springs, at the proposed intake and powerhouse sites, and along the water conveyance tunnel alignment, to further evaluate variations in the depth to the top of the bedrock across the site. The geophysical methods used were a combination of seismic refraction, electrical resistivity tomography, and multi-channel analysis of surface waves.

5.0 RESULTS

The results of the study are presented using the same study elements as those defined in the previous methods discussion.

5.1 IDENTIFY WATER RIGHT HOLDERS

BCH researched public records from the Washington State Department of Ecology to identify other water rights holders that have groundwater or spring use rights in the study area that could be affected by the proposed project. The only potentially affected water rights holder identified within the study area is the City of Snoqualmie.

The City of Snoqualmie owns a municipal drinking water source located in the southeast quarter section of section 24 located on the west bank of the North Fork Snoqualmie River. The drinking water source is commonly referred to as “Canyon Springs”. Details about the Canyon Springs water source including its configuration, location, and wellhead protection area are included in the Preliminary Geotechnical Findings Report (BCH, 2014), and in the City of Snoqualmie Water System Plan (Gray & Osborne, 2013).

5.2 RECORDS REQUEST TO CITY OF SNOQUALMIE

BCH requested records from the City of Snoqualmie of their use of the Canyon Springs water source. Records provided by the City include the City of Snoqualmie Water System Plan (Grey & Osborne, 2013) as well as raw data pertaining to use of the water source. That information is applied and cited throughout this report.

5.3 ESTIMATE AQUIFER CONDITIONS

BCH used available information to estimate aquifer conditions. Boring logs from two deep borings in the study area provided information on the soil gradation and stratigraphy. From this information, and surficial geologic mapping from earlier studies, BCH made preliminary estimates of the aquifer parameters, including areal extent and depth of the aquifer, the porosity, hydraulic conductivity, transmissivity, storage capacity, recharge from rainfall, and how the groundwater supply fluctuates seasonally. These estimates are documented in the Preliminary Geotechnical Findings Report (BCH 2014).

Estimated aquifer conditions are described in the City of Snoqualmie Water System Plan (Gray & Osborne, 2013). The following information relevant to the current study is excerpted from that plan for reference:

"The zone of contribution is an approximation of the area that would intercept rainfall. Since the area is flat, it is assumed that any precipitation that is not lost through evapotranspiration recharges the aquifer that feeds the spring. There is no information about the depth of the aquifer, its grade, or its transmissivity. Consequently, an understanding of the travel time through the aquifer and development of 6-month, 1-year, 5-year, and 10-year zones of contribution are not possible. A cursory analysis of total precipitation over the area indicates that the rainfall contribution is only slightly higher than the expected yield. The average precipitation for the area is approximately 90 inches and 36 to 48 inches of evapotranspiration are assumed as average for second-growth conifer forest in western Washington. A net recharge of 40 to 50 inches of precipitation over the 10,000,000 square feet of the zone of contribution would yield approximately 300 million gallons per year, approximately the estimated yield of Canyon Springs.

It is possible that the aquifer receives recharge from the North Fork of the Snoqualmie River in the northern portion of the zone of contribution. At that point, the river is flowing through the outwash gravels and is at a higher elevation than the springs. It is conceivable that some of the flow could, depending upon soil saturation and groundwater levels, flow from the river into the aquifer and emerge at Canyon Springs after passing through the outwash gravels."

Aquifer recharge from the river is possible as long as water is in contact with the aquifer and there is a head gradient that would direct flow into the river bed or river bank. Conversely, if groundwater saturates the soil above the river elevation, water will flow from the bank into the river. At the time of this study, sufficient data do not exist to determine whether the river is gaining or losing from groundwater. The river is incised, and topographic conditions suggest that the river would be receiving flow from groundwater within the project reach. Numerous springs were observed during the site reconnaissance conducted in August and September 2013 indicating groundwater flow into the river. The proposed partial water diversion would not affect the aquifer if the head gradient drives flow from the aquifer into the river. Neither would it affect the aquifer if the river is a source of recharge. Recharge will occur as long as water is present in the river bed in contact with the outwash that composes the aquifer. Potential head differences due to changes in river stage within the operational flow range would not significantly affect flow between the river and the aquifer.

5.4 GEOPHYSICAL SURVEY TO ESTIMATE DEPTH TO BEDROCK

BCH conducted a geophysical survey in the area to estimate the depths to bedrock. Those results are reported in the Preliminary Geotechnical Findings Report (BCH 2014; AMEC

2012). The Preliminary Geotechnical Findings Report (BCH 2014) concludes from multiple lines of evidence that the bedrock contact with overlying glacial outwash occurs at depth ranging from elevation 685 ft above mean sea level at Canyon Springs to elevation 783-859 ft above mean sea level within the wellhead protection area.

The tunnel tail race location and depth were notably revised since the time of initial project scoping. This revision was motivated in part by an effort to minimize the potential for the tunnel to affect the aquifer supplying the Canyon Springs water supply. The revised tunnel alignment moves the tunnel to a greater depth by locating the power house at the proposed water diversion/intake at depth. The proposed tunnel alignment also was relocated west to ensure the tunnel would be located within bedrock.

The proposed deep tunnel tail race would be located within bedrock approximately 200 feet below the contact with the overlying aquifer for the majority of its length. In that configuration relative to the aquifer, the tunnel would not be in contact with the aquifer and would not create an opportunity for water loss from the aquifer.

6.0 CONCLUSIONS

Preliminary analysis of potential effects on groundwater resources indicate that the proposed partial water withdrawal would not adversely affect groundwater resources in the project area. One water right held by the City of Snoqualmie and exercised at the Canyon Springs location was identified and included in this analysis. Two potential effects were evaluated including potential effects on aquifer recharge by the North Fork Snoqualmie River and potential groundwater effects of the deep tunnel tail race.

Aquifer recharge from the river is possible as long as water is in contact with the aquifer and there is a head gradient that would direct flow into the river bed or river bank. Conversely, if groundwater saturates the soil above the river elevation, water will flow from the bank into the river. At the time of this study, sufficient data do not exist to determine whether the river is gaining or losing from groundwater. The river is incised, and topographic conditions suggest that the river would be receiving flow from groundwater within the project reach. Numerous springs were observed during the site reconnaissance conducted in August and September 2013 indicating groundwater flow into the river. The proposed partial water diversion would not affect the aquifer if the head gradient drives flow from the aquifer into the river. Neither would it affect the aquifer if the river is a source of recharge. Recharge will occur as long as water is present in the river bed in contact with the outwash that composes the aquifer. Potential head differences due to changes in river stage within the operational flow range would not significantly affect flow between the river and the aquifer.

The proposed deep tunnel tail race would be located within bedrock approximately 200 feet below the contact with the overlying aquifer for the majority of its length. In that

configuration relative to the aquifer, the tunnel would not be in contact with the aquifer and would not create an opportunity for water loss from the aquifer.

7.0 REFERENCES

AMEC Environmental & Infrastructure, Inc. 2012. Preliminary Geophysical Study.

Black Canyon Hydro (BCH) 2012. Pre-Application Document.

Black Canyon Hydro (BCH), 2014. Preliminary Geotechnial Findings Report.

Gray & Osborne, Inc. 2013. City of Snoqualmie Water System Plan.