STATE OF WASHINGTON
FINAL
REPORT OF EXAMINATION
FOR WATER RIGHT APPLICATION

PRIORITY DATE	WATER RIGHT APPLICATION NUMBER
September 25, 2017	G1-28848

NAME AND MAILING ADDRESS	SITE ADDRESS (IF DIFFERENT)
Harborsmith Properties, LLC c/o Colin Smith 41 NE Midway Blvd Oak Harbor, WA 98277	Balda's Brier Water System 1471 Balda Road Oak Harbor, WA 98277

Total Rate and Quantity Authorized for Withdrawal

WITHDRAWAL RATE (gpm)	ANNUAL QUANTITY (ac-ft/yr)
30	7.8

gpm = Gallons per Minute; ac-ft/yr = Acre-feet per Year

Purpose

PURPOSE	WITHDRAWAL RATE (gpm)	ANNUAL QUANTITY (ac-ft/yr)	PERIOD OF USE
Municipal	30	7.8	Year-round

IRRIGATED ACRES	PUBLIC WATER SYSTEM INFORMATION	
NA	WATER SYSTEM NAME and ID	CONNECTIONS
	Balda's Brier Water System DOH Water System ID – AD788H	30

SPECIAL REMARKS:
Balda's Brier Water System is a proposed new Group A (municipal) water system that has requested a total of 30 connections. As of the date of this draft Report of Examination, the Washington State Department of Health (DOH) has not provided a number of total approved connections for Balda's Brier.

Source Location

COUNTY	WATERBODY	TRIBUTARY TO	WATER RESOURCE INVENTORY AREA
Island	Groundwater		6 – Island County

SOURCE NAME	PARCEL	WELL TAG	TOWNSHIP	RANGE	SECTION	QQ Q	LATITUDE	LONGITUDE
Well 1	R13215-330-3290	BJI 853	32N	01E	15	SW NE	48.2616	-122.6646

QQ Q = Quarter Quarter

Datum: NAD83/WGS84

Place of Use

PARCEL(S)
Island County Parcels: R13215-425-3310 and R13215-330-3290

LEGAL DESCRIPTION OF THE AUTHORIZED PLACE OF USE
See Island County Parcels above and Attachment 1

Proposed Works

Well 1 (BJI 853) is six inches in diameter and was drilled to a total depth of approximately 296 feet below ground surface (bgs). The well screen was constructed between approximately 284.5 and 294.5 feet bgs. A future well pump and source meter; water main and service lines; above-ground reservoir storage; and service meters associated with the proposed Balda's Brier municipal water system have yet to be installed.

Development Schedule

BEGIN PROJECT BY THIS DATE	COMPLETE PROJECT BY THIS DATE	PUT WATER TO FULL USE BY THIS DATE
Begun	June 1, 2031	June 1, 2036

Attention: These dates represent deadlines that must be met or risk cancellation of this authorization. Submittal of formal documentation for each stage is required. Extensions may be requested.

Measurement of Water Use

HOW OFTEN MUST WATER USE BE MEASURED AND RECORDED?	Bi-weekly
HOW OFTEN MUST WATER USE DATA BE REPORTED TO ECOLOGY?	Annually by January 31
WHAT QUANTITY SHOULD BE REPORTED?	Total annual quantity in acre-feet
WHAT RATE SHOULD BE REPORTED?	Annual peak rate of withdrawal in gpm

Provisions

Measurements, Monitoring, Metering, and Reporting

An approved measuring device must be installed and maintained for each of the sources identified by this water right in accordance with the rule "Requirements for Measuring and Reporting Water Use", chapter 173-173 WAC, which describes the requirements for data accuracy, device installation and operation, and information reporting. It also allows a water user to petition the Department of Ecology (Ecology) for modifications to some of the requirements.

Recorded water use data shall be submitted electronically by January 31 each year. To set up an Internet reporting account, contact the Regional Office. If you do not have Internet access, you can still submit hard copies by contacting the Regional Office for forms to submit your water use data.

Proof of Appropriation

Consistent with the development schedule given in this report (unless extended by Ecology), the water right holder must file a Notice of Proof of Appropriation (PA) of Water with Ecology. The PA documents the project is complete and all the water needed has been put to full beneficial use (perfected). In order to verify the extent of water use under this permit, an inspection of water use is typically required, known as a "proof exam". After filing the PA, the water right holder's next step is to hire a Certified Water Rights Examiner (CWRE) to conduct this proof exam. A list of CWREs is provided to the water right holder upon filing the PA with Ecology. The final water right document, a water right certificate, then may issue based upon the findings of the CWRE. Statutory county and state filing fees may apply prior to certificate issuance.

Schedule and Inspections
Department of Ecology personnel, upon presentation of proper credentials, shall have access at reasonable times, to the project location, and to inspect at reasonable times, records of water use, wells, diversions, measuring devices and associated distribution systems for compliance with water law.

Findings of Fact and Order

Upon reviewing the investigator's report, I find all facts, relevant and material to the subject application, have been thoroughly investigated.

Therefore, I ORDER **APPROVAL** of Application No. G1-28848, subject to existing rights and the provisions specified above.

Your Right To Appeal

You have a right to appeal this Order to the Pollution Control Hearings Board (PCHB) within 30 days of the date of receipt of this Order. The appeal process is governed by chapter 43.21B RCW and chapter 371-08 WAC. "Date of receipt" is defined in RCW 43.21B.001(2).

To appeal, you must do the following within 30 days of the date of receipt of the Order:

- File your appeal and a copy of this Order with the PCHB (see addresses below). Filing means actual receipt by the PCHB during regular business hours.
- Serve a copy of your appeal and this Order to Ecology in paper form - by mail or in person (see addresses below). E-mail is not accepted.

You must also comply with other applicable requirements in chapter 43.21B RCW and chapter 371-08 WAC.

Street Addresses	Mailing Addresses
Department of Ecology Attn: Appeals Processing Desk 300 Desmond Drive SE Lacey, WA 98503	**Department of Ecology** Attn: Appeals Processing Desk PO Box 47608 Olympia, WA 98504-7608
Pollution Control Hearings Board 1111 Israel RD SW, Ste 301 Tumwater, WA 98501	**Pollution Control Hearings Board** PO Box 40903 Olympia, WA 98504-0903

For additional information, visit the Environmental Hearings Office Website: http://www.eho.wa.gov. To find laws and agency rules, visit the Washington State Legislature Website: http://www1.leg.wa.gov/CodeReviser.

Authorizing Signature

Signed at Shoreline, Washington, this 16th day of June, 2022.

Kasey Cykler, Section Manager
Water Resources Program/Northwest Regional Office
Department of Ecology

INVESTIGATOR'S REPORT

Water Right Application No.: G1-28848 (Harborsmith Properties, LLC)
Investigator: Chelsea Jefferson, LHG

BACKGROUND

This report serves as the written findings of fact concerning Water Right Application No. G1-28848, submitted September 25, 2017, by Harborsmith Properties, LLC (Applicant). The proposed place of use is the Balda's Brier Water System, a proposed Group A (municipal) water system identified by the Washington State Department of Health (DOH) as Water System ID AD788H.

The Applicant originally applied for a maximum withdrawal rate (Qi) of 20 gallons per minute (gpm) from Well 1 to serve an estimated 25 connections. No annual quantity was specified on Application No. G1-28848. Following communication with Island County and the Washington State Department of Health (DOH), the Applicant amended Application No. G1-28848 to serve a proposed 30 connections with a maximum withdrawal rate of 30 gpm.

The Washington State Department of Ecology (Ecology) understands that the Applicant proposes to subdivide the existing site parcels and provide municipal water service to 23 Island County parcels, one of which will contain the existing on-Site single-family residence. The 30 proposed connections account for possible detached accessory dwelling units (ADUs) future parcel owners served by Balda's Brier may wish to construct following initial development by the Applicant.

Table 1. Summary of Requested Water Right

Applicant Name	Harborsmith Properties, LLC
Priority Date	September 25, 2017
County	Island County
WRIA	6 – Island County
Water Source	Groundwater
Place of Use	Island County Parcels: R13215-425-3310 and R13215-330-3290

Purpose	Instantaneous Rate (gpm)	Annual Quantity (ac-ft/yr)	Begin Season	End Season
Municipal	30	Not Specified	Year-round	

Source Name	Parcel	Well Tag	Township	Range	Section	QQ Q	Latitude	Longitude
Well 1	R13215-330-3290	BJI 853	32N	01E	15	SW NE	48.2616	-122.6646

WRIA = Water Resource Inventory Area; gpm = Gallons per Minute; ac-ft/yr = Acre-feet per Year; QQ Q = Quarter Quarter   Datum: NAD83/WGS84

INVESTIGATION

On March 9, 2021, Ecology Investigator, Chelsea Jefferson, LHG, conducted a Site visit at Balda's Brier Water System (Site). During the Site visit, developer and Applicant, Colin Smith of Harborsmith Properties, LLC, accompanied Chelsea Jefferson to all areas of the Site. During the Site visit, photos depicting the Site (generally) as well as existing Site features were collected. A photo log from the Site visit is included here as Appendix A. A general site map of the Site has been included as Attachment 1.

Ecology's Site visit and interview supplemented desktop research performed to investigate Water Right Application Number G1-28848. Desktop research conducted in advance of the Site visit included, but was not necessarily limited to, the following resources:

- Materials submitted by the Applicant in support of Water Right Application No. G1-28848
- Applicable laws (i.e. State Water Code), rules, policy, and case law
- Communication with Island County Public Health
- Published studies and professional reports of Island County and Whidbey Island

Investigative tasks performed are summarized below.

Proposed Use and Basis of Water Demand

Site Description

The Site currently contains Island County parcels R13215-425-3310 and R13215-330-3290, located southwest of the intersection of West Miller Road and Balda Road in Oak Harbor, WA. The Site is accessible by Balda Road at the current, on-site single-family residence, addressed at 1471 Balda Road, Oak Harbor, WA 98277. The single-family residence as well as sheds associated with a former chicken farm; enclosures for livestock (currently cattle); a permit exempt groundwater well; and Well 1 (BJI 853), corresponding to the proposed point of withdrawal under Application No. G1-28848, are located on the Site's southern parcel (R13215-330-3290). The northern parcel (R13215-425-3310) is currently vacant, undeveloped land.

Water System Description

The Applicant proposes to use Well 1 to provide service to 22 new residential units, in addition to the existing single-family residence, for 23 initial service connections. Ecology understands that the 30 connections requested under Application No. G1-28848 accounts for possible development of ADUs by future Site residents following initial development by the Applicant and that Island County considers water service to an ADU as a separate service connection.

Future Site infrastructure associated with municipal water supply by the Balda's Brier Water System to the initial 23 service connections includes: a well pump and source meter; water main and service lines; above-ground reservoir storage; and service meters. See **Figure 1** below for the configuration of the 23 residential parcels, ranging from one-half acre to one-acre, and the location of Well 1 and the permit exempt well.

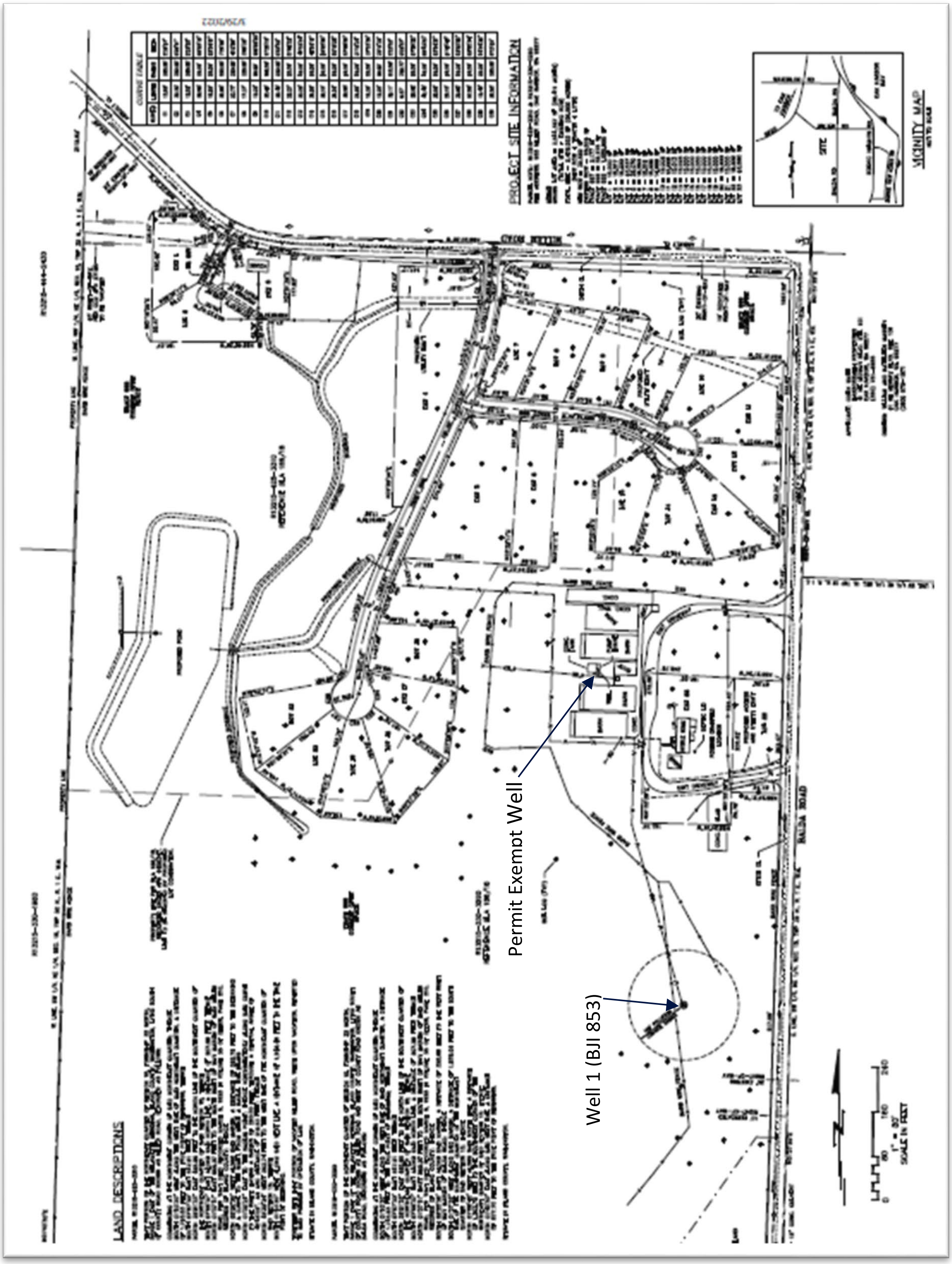


Figure 1. Conceptual layout of Balda's Brier Water System
Map adapted by Ecology, May 2022

History of Water Use

Water use at the Site has historically been limited to the permit-exempt well, which provides water for domestic use to the on-Site single-family residence addressed at 1471 Balda Road and stockwatering of approximately 40 cattle. The permit-exempt well is believed to be associated with Claim No. G1-019717CL (Appendix B) that describes the location of the existing permit-exempt well and a place of use within the Site boundaries. Claimed quantities under G1-019717CL are 25 gpm and two acre-feet per year used continuously for the purpose of stock watering. The claimant, Ed R. Adamson, estimated that these quantities were applied for beneficial use on the Site since before 1940. Current quantities from the permit-exempt well are not available as the well is not equipped with a meter.

Proposed Use

Ecology understands that the Applicant proposes to subdivide the existing site parcels and provide municipal water service to 23 Island County parcels, one of which will contain the existing on-Site single-family residence. The Applicant anticipates accessory dwelling units (ADUs) may be constructed by future parcel owners following initial development of the Site. Therefore, the Applicant requested 30 connections under Application No. G1-28848. The maximum instantaneous capacity (Qi) requested under Application No. G1-28848 is 30 gpm from Well 1, which corresponds to the rate at which a 24-hour constant rate aquifer test was conducted at the Site during May 2018 (Appendix C).

Estimated Use

No annual quantity was specified on Application No. G1-28848. Ecology calculated a maximum annual quantity based on 230 gallons per day per connection, which corresponds to the average water use on Island County (Island County, 2005a). Based on 230 gallons per day per connection, equivalent to 0.26 acre-feet per year per connection, and an estimated 30 connections, the total maximum annual quantity (Qa) used for this Report of Examination is 7.8 acre-feet per year.

Other Rights Associated with Project or Place of Use

Based on Ecology's review of mapped water rights, including water right claims, within the Site boundaries, Claim No. G1-019717CL (described above) was the only water right file identified. Information provided on Claim No. G1-019717CL describe the location of the permit-exempt well and a place of use within the Site boundaries. The claimed quantities of 25 gpm and two acre-feet per year used continuously for stock watering are within the limits of the groundwater permit exemption.

Once the current on-Site residence is connected to municipal water service, the existing permit-exempt well is expected to be used for limited agricultural irrigation and/or for stockwatering under the limits of the groundwater permit exemption (RCW 90.44.050).

Hydrogeologic Evaluation

Island County, Washington includes Whidbey and Camano Island, as well as several smaller islands. Island County is located northwest of Seattle, Washington, within the protected waters of the Puget Sound. North and central Whidbey Island are located within the rain shadow of the Olympic Mountains to the west and receive an average annual precipitation of 21 inches, compared to approximately 37 inches for Seattle.

Geologic Setting

Island County lies within the Puget Lowland, an elongated structural depression bounded by the Cascade Mountains to the east and the Olympic Mountains to the west. During the Quaternary Period, the Puget Lowland was at times overlain by 3,000 to 5,000 feet of ice as the Puget Lobe of the Cordilleran ice sheet cycled through phases of advancement and retreat. Consequently, the region is generally characterized by rolling topography and underlain by complex sequences of glacial and interglacial sediments. Whidbey and Camano Islands consist mostly of Pleistocene glacial and interglacial deposits (Easterbrook, 1968). The very northern portion of Whidbey Island consists of Tertiary-age (now the Paleocene to Neogene Period) and older volcanic and sedimentary bedrock (Jones, 1998).

According to Pleistocene Stratigraphy of Island County (Easterbrook, 1968), record of at least three glaciations separated by interglacial periods are observed on Island County. The Double Bluff is the oldest glacial deposit on Whidbey Island. The Double Bluff Glaciation is assumed to be about 185 to 125 ka based on marine oxygen isotope stage and stratigraphic position (Polenz, 2005). Double Bluff deposits consist of sand with some cross-bedding overlain by gravel and cobbles with cut and fill structure. This is followed by a deposit of silt, clay, and fine sand with horizontal bedding. All overlain by a deposit of gravelly silt, believed to be till, that includes some shell fragments. With the exception of possible till, Double Bluff deposits are believed to be proglacial outwash.

Deposits from the Double Bluff Glaciation are overlain by the Whidbey Formation, deposited during the Whidbey Interglaciation. The Whidbey Interglaciation is believed to be between 125 to 80 ka based on both the stratigraphic position and carbon dating (Polenz, 2005). The Whidbey Formation is characterized by silt, clay, and sand interbedded with peat and gravel lenses. The silt and clay is mostly horizontally stratified, whereas the sand displays cross-bedding. The Whidbey Formation sediments appear to have been deposited in a floodplain with aggrading, meandering streams surrounded by small lakes and swamp area (Easterbrook, 1968).

The Possession Glaciation follows the Whidbey Interglaciation. The Possession Glaciation is believed to be 80 to 60 ka (Polenz, 2005). Deposits from the Possession Glaciation consist of compact till, sand and gravel, and gravelly clay with shell fragments. These deposits are very discontinuous. According to Pleistocene Stratigraphy of Island County (Easterbrook, 1968), there are only six exposures that have been positively identified. The Possession Glaciation is followed by the Olympia Interglaciation, known as the Olympia Formation, believed to be between 60 to 20 ka. Only one outcrop of the Olympia Formation has been identified. Possession Glaciation deposits are commonly (unconformably) overlain by deposits from the Fraser Glaciation.

Ice from the Fraser Glaciation covered Whidbey Island approximately 18 ka (Polenz, 2005). Members of the Fraser Glaciation represent deposits from glacial advance and retreat of the last glaciation of Island County. Fraser Glaciation Members include (from oldest to youngest) Esperance Sand, Vashon Till, Patridge Gravel, and Everson Glaciomarine Drift. The Esperance Sand consists of proglacial outwash deposits of cross-bedded sand and gravel. The Vashon Till typically consists of compacted deposits of poorly sorted silt, clay, sand, gravel, and cobbles. The Patridge Gravel and the massive to rhythmic deposits of silt and clay associated with Everson Glaciomarine Drift (Polenz, 2005) represent a time of deglaciation (Easterbrook, 1968).

Hydrogeologic Setting

Early investigation of Island County identified a productive groundwater source from near sea level elevation (Easterbrook, 1968 and Cline et al., 1982). In 1985, the USGS presented a conceptual framework for Island County hydrogeology with five unique, laterally extensive aquifers that were believed to have common hydraulic properties and water quality. The report identified Aquifers C and D, occurring near and below sea level, as possibly being affected by seawater intrusion (Jones, 1985).

The only published numerical groundwater flow model for Island County was prepared in 1988 by Sapik et al. and used the Jones (1985) conceptual model of unique aquifers. Interspaced confining units between aquifers were used in the groundwater flow model likely to minimize the model's complexity given the limited computing power at the time.

Ecology believes the complex geologic setting of glacial and interglacial deposits described above is not likely to result in unique, laterally extensive aquifers with interspaced confining layers. It is more likely that the general hydrogeologic setting of Island County is characterized by productive water-bearing zones, including the "sea-level aquifer," that are highly variable in thickness and extent. Ecology believes these productive water-bearing zones are generally hydraulically connected and rely on recharge from precipitation and surface water infiltration.

Seawater Intrusion and Regional Water Quality

Seawater intrusion is the most common source of groundwater contamination in coastal aquifers (Fetter, 2001). The extent of seawater intrusion is generally defined by either the position of the freshwater/seawater interface (at depth), or by the inland extent of a saltwater wedge. Seawater intrusion is the result of hydraulic properties and hydrogeologic processes, including hydraulic conductivity and freshwater discharge to the sea. Reduced aquifer recharge and withdrawal of freshwater from an aquifer has the potential to result in seawater intrusion in Island County.

The first analysis of groundwater quality on central Whidbey Island was prepared by Ecology in 1993 (Culhane, 1993). To distinguish groundwater impacted by seawater intrusion to that more closely resembling very hard water, Culhane used Stiff Diagrams to demonstrate an empirical relationship between chloride/hardness and conductivity that is characteristic of dilute seawater. Culhane's work supported Island County's Saltwater Intrusion Policy by identifying "risk zones" based on chloride concentrations expected to be the result of seawater intrusion.

Island County's Seawater Intrusion Topic Paper (2005b) argued that to provide a more accurate resource management tool, use of water level elevations in conjunction with chloride concentrations should be used by Island County. The groundwater level elevation expected to be indicative of increased risk of seawater intrusion identified during this study was 8.4 feet above mean sea level. The result of this work was a revised map of seawater intrusion vulnerability that Island County Public Health uses to evaluate proposed new groundwater sources for public water supply.

Site Evaluation

The Site is located on North Whidbey Island, south of the City of Oak Harbor and north of Penn Cove, located within the NE ¼ of Section 15, Township 32 North, Range 01 East, W.M., in Island County, Washington. This area of Island County is mainly rural with single-family residences and some agricultural properties. The Site elevation ranges from approximately 160 feet above mean sea level (amsl) on the western portion of the Site to 200 feet amsl on the east-central portion of the Site.

Geologic units inferred at the Site by Dragovich et al. (2005) represent deposits from the advance and retreat of the Fraser Glaciation in a glaciomarine to deltaic and/or terrestrial environment. Glaciomarine deposits, referred to as Everson Glaciomarine Drift, mainly consist of clay and were inferred on the western portion of the Site, corresponding to lower Site elevations. Deltaic and/or terrestrial gravels, referred to as Patridge Gravel, may represent a late-Pleistocene terrace and were inferred on the east-central portion of the Site, corresponding the Site's topographic high. Vashon till appears to unconformably mantle the Site's topographic high and was inferred on the central portion of the Site.

The proposed point of withdrawal (Well 1) was constructed during April 2018 to an approximate depth of 296 feet below ground surface (bgs). The well screen was constructed between approximately 284.5 and 294.5 feet bgs. At the time of well construction, Well 1 had a static water level of approximately 183 feet below the top of well casing, corresponding approximately to sea-level elevation. Based on the cross-section near the Site produced by Dragovich et al. (2005), the well was likely completed in the Whidbey Formation, which is believed to consist of an ancient Skagit River fluvial-deltaic system.

In May 2018, a 24-hour constant-rate aquifer test was conducted at Well 1 to determine groundwater availability. The aquifer test was conducted at a sustained rate of 30 gpm. The maximum drawdown during testing was 13 feet, which occurred at the beginning of testing and was therefore assumed to represent mostly wellbore storage (Pacific Groundwater Group, 2018). Following testing, a simplified numerical groundwater model was constructed using estimated aquifer parameters and an average constant pumping rate of 12.4 gpm. The numerical model predicted possible well interference to nearby groundwater withdrawals on the order of hundredths of a foot.

During testing, water quality samples collected from Well 1 had chloride concentrations between 40.1 and 41.3 milligrams per liter (mg/L). These concentrations are below DOH guidelines and the U.S. Environmental Protection Agency secondary maximum contamination limit for chloride of 250 mg/L. Additionally, the chloride concentrations are below Island County's initial risk threshold of 100 mg/L. Well 1 is therefore considered "low risk" according to Island County's risk zones, which consider both water level elevation and chloride concentrations. The aquifer test report, which includes a description of water quality samples collected, is provided here as Appendix C.

Potential for Stream Impacts and Impairment
Island County, corresponding to Water Resources Inventory Area (WRIA) 6, does not have an instream flow rule. There are two known surface water source limitations on Island County associated with Washington Department of Fish and Wildlife (WDFW) recommendations received by Ecology. These recommendations act as regulatory protections from future impairment by new appropriative water rights. Surface water source limitations documented by Ecology include:

- An unnamed stream located within Section 22, Township 33 North, Range 02 East, W.M., which empties into Skagit Bay. According to the WDFW letter received, one-half flow is to remain in the unnamed stream.
- An unnamed stream – that may be referred to as Maxwelton Creek – located within Section 28, Township 29 North, Range 03 East, W.M., which empties into Useless Bay. For this source, WDFW has recommended that Ecology not approve any future water rights in the surface water source.

The first unnamed stream is located on North Whidbey Island, approximately 7.5 miles north-northeast from Well 1, and is believed to have intermittent (as opposed to year-round) flows. The second unnamed stream described above, which may be referred to as Maxwelton Creek, is located on south Whidbey Island. Maxwelton Creek is a perennial stream with year-round flow to Useless Bay and is located approximately 20 miles from Well 1. No gaging stations are known to exist on either stream.

Area topography and the location of the unnamed stream on north Whidbey Island suggest that intermittent streamflow may rely on a spring source from the hillside where the stream appears to begin. The unnamed stream may also rely on runoff and shallow groundwater. Based on area topography, Ecology expects that shallow groundwater flow toward Skagit Bay to the northeast may contribute to seasonal flows in the unnamed stream. Groundwater flow at the Site and Well 1 is expected to flow generally northeast to Oak Harbor, located one-half mile away, under a hydraulic gradient from the local topographic high to the west.

Potential for Impairment of Other Water Rights

In Island County, the potential exists for impairment of senior appropriative groundwater rights, including those established under the groundwater permit exemption (RCW 90.44.050) and water right claims, from new or exacerbated seawater intrusion. Well 1 is in the vicinity of senior water rights that either operate under the groundwater permit exemption or a groundwater permit or certificate issued by Ecology to (mostly) multiple domestic water systems. Based on available chloride concentrations at Well 1 and Island County's estimated "low risk" of seawater intrusion at the Site and vicinity, Ecology considers it unlikely for seawater intrusion to impact proximal groundwater wells.

Additionally, impairment of senior appropriative water rights may be caused by the excessive drawdown of a shared source of supply. Impairment of a senior groundwater right can happen when a well that fully penetrates an aquifer is no longer usable because a junior groundwater right has caused significant aquifer declines. This is very uncommon in Western Washington because the heterogeneous and discontinuous aquifers formed by glacial and interglacial deposits, like what is observed at the Site, are in hydraulic connectivity with other unconfined or leaky unconfined aquifers. Additionally, unconfined and leaky unconfined aquifers do not typically experience significant drawdown from well interference like a confined aquifer of limited extent.

ANALYSIS

Under Washington State law (RCW 90.03.290), each of the following four criteria must be met for an application for a new water right permit to be approved:

- Water must be available for appropriation.
- Water withdrawal and use must not cause impairment of existing water rights.
- The proposed water use must be beneficial.
- Water use must not be detrimental to the public interest (public welfare).

Water Availability

For any new appropriation, water must be both physically and legally available.

Physical Availability

For water to be physically available for appropriation, water must be present in quantities and quality and on a sufficiently frequent basis to provide a reasonably reliable source for the requested beneficial use or uses. An analysis of physical availability is required for both surface water and groundwater applications.

Physical availability of the requested maximum withdrawal rate of 30 gpm was demonstrated during the 24-hour drawdown test at Well 1 conducted during May 2018.

Legal Availability

To meet the legal availability test, the proposed appropriation may not withdraw and use water that is already "spoken for", such as water from sources that are protected by administrative rule or court order.

Island County, corresponding to Water Resources Inventory Area (WRIA) 6, does not have an instream flow rule. There are two known surface water source limitations on Island County associated with Washington Department of Fish and Wildlife (WDFW) recommendations received by Ecology. Well 1, corresponding to the proposed point of withdrawal, is not located within the sub-basins of either of the surface water source limitations and is not expected to impact either stream.

Impairment

In analyzing impairment, Ecology must make a determination as to whether existing water rights, including adopted instream flows, may be impaired by the withdrawal and proposed use.

Based on the hydrogeology of the site, interpreted groundwater flow direction, and expected low risk of seawater intrusion (see Site Evaluation above), Ecology does not expect there will be impairment of regulated streams and/or senior water rights as a result of Ecology's approval of the requested quantities under Application G1-28848.

Beneficial Use

The proposed appropriation must be for a beneficial use of water.

Municipal water supply is considered a beneficial use of water under RCW 90.54.020(1).

Public Interest

The withdrawal and associated use must not be detrimental to the public interest. At a minimum, the following are considered when making this assessment.

Notification to the Washington Department of Fish and Wildlife
Per RCW 90.03.280 and 77.57.020, Ecology must give notice to the Washington Department of Fish and Wildlife (WDFW) of applications to divert, withdraw, use, or store water.

WDFW was provided notice of Application No. G1-28848 on February 4, 2021. As of the date of this Report of Examination, no comment from WDFW has been received.

State Environmental Policy Act (SEPA)
Under chapter 197-11 WAC, a water right application is subject to a SEPA threshold determination (i.e., an evaluation of whether there will be significant adverse environmental impacts) if any of the following conditions are met:

- It is a surface water right application for more than 1 cfs, unless that project is for agricultural irrigation, in which case the threshold is increased to 50 cfs, so long as that irrigation project will not receive public subsidies;
- It is a groundwater right application for more than 2,250 gpm;
- It is an application that, in combination with other water right applications for the same project, collectively exceed the amounts above;
- It is a part of a larger proposal that is subject to SEPA for other reasons (e.g., the need to obtain other permits that are not exempt from SEPA);
- It is part of a series of exempt actions that, together, trigger the need to do a threshold determination, as defined under WAC 197-11-305.

Considering that none of the above conditions are met, the application under review is categorically exempt from a SEPA threshold determination.

Public Notice

RCW 90.03.280 requires that notice of a water right application be published once a week, for two consecutive weeks, in a newspaper of general circulation in the county or counties where the water is to be stored, diverted, and used. Notice of this application was published in the Whidbey News Times on May 9 and May 16, 2018.

No protests to this water right application were received.

Conclusions

I find that:

- Water is physically and legally available.
- The appropriation will not impair existing rights.
- The proposed municipal water supply is a beneficial use.
- Approval of this application will not be detrimental to the public interest.

RECOMMENDATIONS

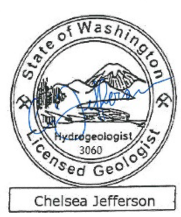
Based on the above investigation and conclusions, I recommend this request for a water right be **APPROVED** in the amounts and within the limitations listed below and subject to the provisions listed above.

Recommended Quantities, Purpose of Use, and Project Location

The rate and quantity of water recommended are maximum limits. The permit holder may only withdraw water at a rate and quantity within the specified limits that are reasonable and beneficial:

Table 2. Recommended Limits and Location

Maximum Instantaneous Rate (gpm)	30
Maximum Annual Quantity (ac-ft/yr)	7.8
Purpose(s) of Use	Municipal water supply
Point of Withdrawal	SW ¼ of the NE ¼ of Section 15, Township 32 North, Range 01 East, W.M.
Place of Use	See Attachment 1



5/27/22

Chelsea Jefferson, LHG *Date*

To request ADA accommodation including materials in a format for the visually impaired, call Ecology Water Resources Program at 360-407-6872. Persons with impaired hearing may call Washington Relay Service at 711. Persons with speech disability may call TTY at 877-833-6341.

References

Cline, D.R., M.A. Jones, N.P. Dion, K.J. Whiteman, and D.B. Sapik (1982). Preliminary survey of groundwater resources for Island County, Washington, Water Resources Investigations Open-File Report 82-561, U.S. Geological Survey.

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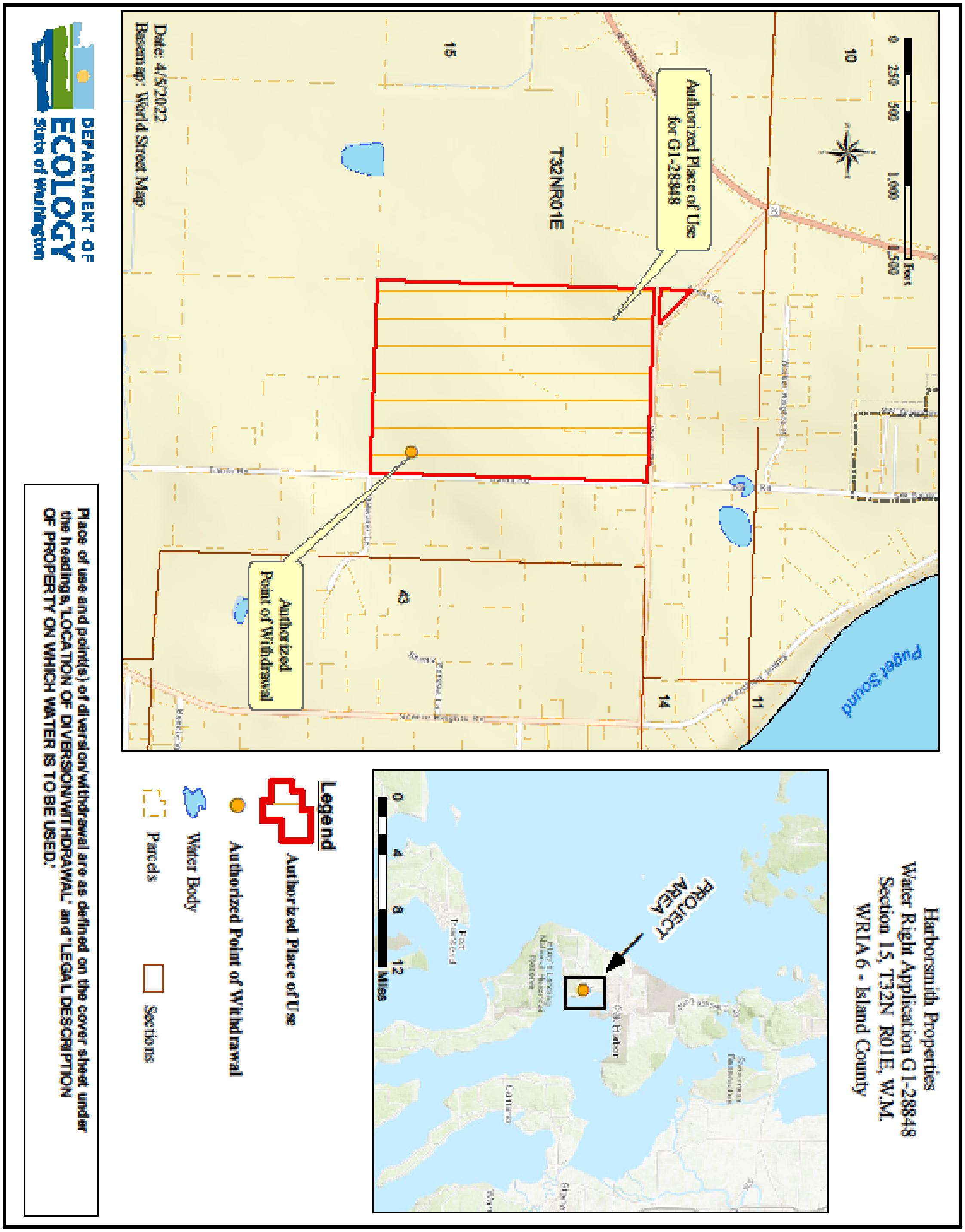


ATTACHMENT 1

Photograph 1 View of the site well, located on the southeastern portion of the property

Photograph 2 View of the on-site well's Ecology Well Tag ID # BJI 853

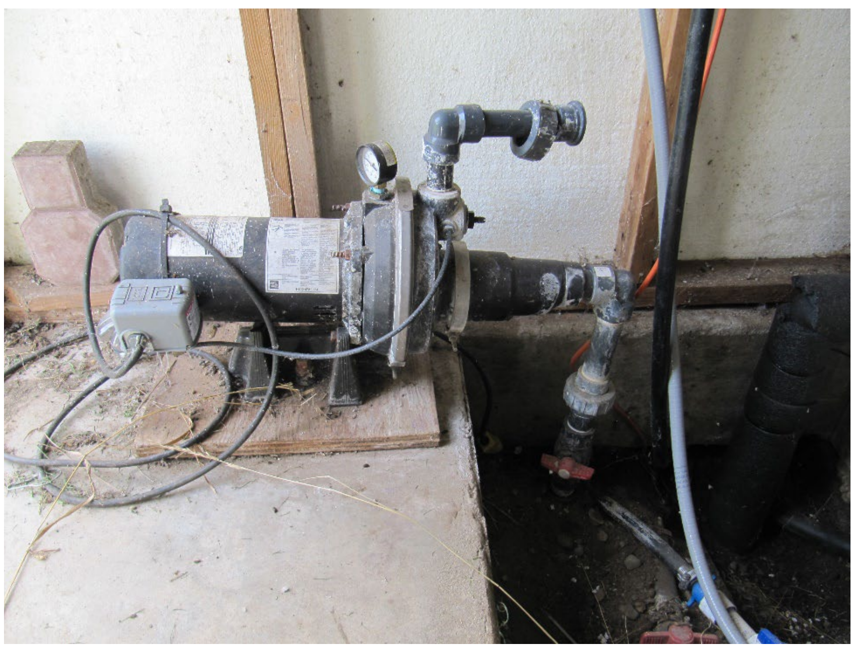
Photograph 3 View of the site from the center of the property, looking to the southeast

Photograph 4 View of on-site sheds used at the former chicken farm, located on the east-central portion of the property

Photograph 5 View from the east-central portion of the site, looking generally north

Photograph 6 View from the central portion of the site, looking generally northwest

Photograph 7 View of access to a septic system associated with the former chicken farm, located on the central portion of the site and west of the existing sheds formerly used for chicken farming



Photograph 8 View inside well house (of pump) associated with existing permit exempt well, located on the central portion of the property

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
WATER RIGHT CLAIMS REGISTRATION

WATER RIGHT CLAIM

72028008

1. NAME Ed R. Adamson

ADDRESS Rt 1 Box 682

Oak Harbor Washington ZIP CODE 98277

2. SOURCE FROM WHICH THE RIGHT TO TAKE AND MAKE USE OF WATER IS CLAIMED: Ground (SURFACE OR GROUND WATER)

W.R.I.A. 06 (LEAVE BLANK)

A. IF GROUND WATER, THE SOURCE IS Drilled Well

B. IF SURFACE WATER, THE SOURCE IS

3. THE QUANTITIES OF WATER AND TIMES OF USE CLAIMED:

A. QUANTITY OF WATER CLAIMED 25 g.p.m. PRESENTLY USED 25 g.p.m. (CUBIC FEET PER SECOND OR GALLONS PER MINUTE)

B. ANNUAL QUANTITY CLAIMED 2 PRESENTLY USED 1 (ACRE FEET PER YEAR)

C. IF FOR IRRIGATION, ACRES CLAIMED PRESENTLY IRRIGATED

D. TIME(S) DURING EACH YEAR WHEN WATER IS USED: 12 months

4. DATE OF FIRST PUTTING WATER TO USE: Before the YEAR 1910

5. LOCATION OF THE POINT(S) OF DIVERSION/WITHDRAWAL: 1600 FEET West AND 1500 FEET South FROM THE North [redacted] East CORNER OF SECTION 15

BEING WITHIN boundaries OF SECTION 15 T. 32 N. N., R. 1 E. (E.OR W.) W.M.

IF THIS IS WITHIN THE LIMITS OF A RECORDED PLATTED PROPERTY, LOT BLOCK OF

(GIVE NAME OF PLAT OR ADDITION)

6. LEGAL DESCRIPTION OF LANDS ON WHICH THE WATER IS USED:

The Southwest quarter of the Northeast Quarter of Section 15, Township 32 North, Range 1, East of the Willamette Meridian; EXCEPT County road along the East line, thereof.

COUNTY Island

7. PURPOSE(S) FOR WHICH WATER IS USED: Domestic - Live stock

8. THE LEGAL DOCTRINE(S) UPON WHICH THE RIGHT OF CLAIM IS BASED: Appropriation

DO NOT USE THIS SPACE

THE FILING OF A STATEMENT OF CLAIM DOES NOT CONSTITUTE AN ADJUDICATION OF ANY CLAIM TO THE RIGHT TO USE OF WATERS AS BETWEEN THE WATER USE CLAIMANT AND THE STATE OR AS BETWEEN ONE OR MORE WATER USE CLAIMANTS AND ANOTHER OR OTHERS. THIS ACKNOWLEDGEMENT CONSTITUTES RECEIPT FOR THE FILING FEE.

DATE RETURNED THIS HAS BEEN ASSIGNED WATER RIGHT CLAIM REGISTRY NO.

NOV 21 72 019717

John Biggs

DIRECTOR - DEPARTMENT OF ECOLOGY

I HEREBY SWEAR THAT THE ABOVE INFORMATION IS TRUE AND ACCURATE TO THE BEST OF MY KNOWLEDGE AND BELIEF.

X Ed R. Adamson

DATE 11-20-72

IF CLAIM FILED BY DESIGNATED REPRESENTATIVE, PRINT OR TYPE FULL NAME AND MAILING ADDRESS OF AGENT BELOW.

☐ ADDITIONAL INFORMATION RELATING TO WATER QUALITY AND/OR WELL CONSTRUCTION IS AVAILABLE

A FEE OF $2.00 MUST ACCOMPANY THIS WATER RIGHT CLAIM.

RETURN ALL THREE COPIES WITH CARBONS INTACT, ALONG WITH YOUR FEE TO:
DEPARTMENT OF ECOLOGY
WATER RIGHT CLAIMS REGISTRATION
P.O. BOX 829 OLYMPIA, WASHINGTON 98501

ORIGINAL DWR

PACIFIC groundwater GROUP

HYDROGEOLOGIC REPORT & PUMPING IMPACT ANALYSIS MILLER-BALDA WELL

July, 2018

Hydrogeologic Report & Pumping Impact Analysis Miller-Balda Well

Prepared for:

Harborsmith Properties
41 NE Midway Blvd Ste. 101
Oak Harbor, WA 98277

Prepared by:

Pacific Groundwater Group
2377 Eastlake Avenue East, Suite 200
Seattle, Washington 98102
206.329.0141
www.pgwg.com

July 18, 2018
JZ1802

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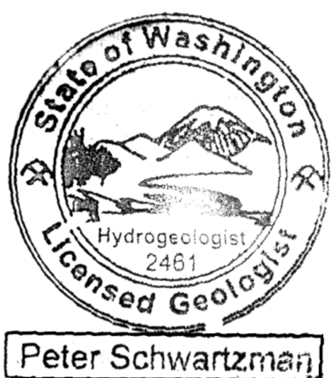
FIGURES

APPENDICES

SIGNATURE

This report, and Pacific Groundwater Group's work contributing to this report, were reviewed by the undersigned and approved for release.



Peter Schwartzman
Principal Hydrogeologist
Washington State Hydrogeologist No. 2461

1.0 INTRODUCTION

Pacific Groundwater Group (PGG) was retained by Harborsmith Properties to prepare a Hydrogeologic Report for a new water-supply well installed to serve new development, including a 30 residence 20 acre manufactured housing community located on the north adjacent parcel, application currently being reviewed by the Island County. The Miller-Balda Well is located about a half mile southwest of Oak Harbor, about halfway between the towns of Coupeville and Oak Harbor WA (**Figure 1**). The analyses contained herein address: the hydrogeologic framework and the completion aquifer of the Miller-Balda Well; its static groundwater elevation and tidal response; aquifer properties based on a 24-hour pumping test; recommended well operation and well yield; and potential for pumping impacts at expected rates of withdrawal. PGG's services included the following tasks:

Data Review: PGG reviewed documentation on file with Island County (County) related to the Miller-Balda Well and to neighboring wells within a 5000-foot radius to assess local hydrogeologic conditions and groundwater quality.

Drilling Advice: PGG provided input to the well driller regarding drilling strategy, well completion and well development during drilling of the Miller-Balda Well.

Water-Level Monitoring & Aquifer Test: PGG designed, instrumented and supervised a 24-hour aquifer test on the Miller-Balda Well. We analyzed the aquifer test data to estimate aquifer hydraulic properties and whether pumping affected chloride concentrations in the well. Our analysis was also used to recommend well pumping operations.

Pumping Impact Analysis: PGG developed a groundwater flow model that represents estimated aquifer properties, groundwater recharge, hydraulic connection between the aquifer and marine water, and the proposed pumping withdrawal to evaluate impacts from pumping (i.e. drawdown and seawater intrusion potential).

This work was performed and this report was prepared in accordance with generally accepted hydrogeologic practices at this time and in this area for the exclusive use of Harborsmith Properties. Use of this report and any information or analyses contained herein for any purpose beyond that of understanding local hydrogeologic conditions and potential seawater intrusion associated with pumping the Miller-Balda Well is at the sole risk of the person, persons, or organization using the information or analyses. Pacific Groundwater Group is not responsible for, and makes no warranty for, any other use of the information and analyses presented herein. No other warranty, expressed or implied, is made.

2.0 SUMMARY OF FINDINGS

1. The Miller-Balda Well is completed in Aquifer C, which occurs below -60 feet mean sea level (MSL) and is hydraulically connected to adjacent marine water bodies (Strait of Juan de Fuca, Saratoga Passage and Penn Cove). Aquifer thickness is estimated to be around 40 feet, but is not well documented in the site vicinity. The aquifer is overlain by a confining bed (aquitard), which in turn is overlain by Aquifer D. Aquifer D generally occurs below sea level and is also hydraulically connected to adjacent marine bodies. During testing of the Miller-Balda Well, Washington Department of Ecology (Ecology) required monitoring of the Bonnie View Well, which is completed in Aquifer D.
2. Based on almost 6-days of water-level monitoring and survey of the wellhead elevation, PGG measured static water level elevations ranging from 6.5 to 9 feet MSL in the Miller-Balda Well and 1.5 to

2.3 feet MSL in the Bonnie View Well. Both wells clearly exhibited tidal response, with calculated tidal efficiencies of 4.7% (Miller-Balda Well) and 0.8% (Bonnie View Well). Based on these static water-level elevations, PGG estimated that the saltwater interface beneath the Miller-Balda Well would be far below the well screen (and likely locally non-existent in Aquifer C), but that the zone of diffusion associated with the saltwater interface in Aquifer D may occur at depth below the Bonnie View well screen.

3. The Miller-Balda Well has chloride concentrations on the order of 41 mg/L, significantly below the threshold of 100 mg/l that triggers risk concerns by Island County. The static water-level in the Miller-Balda well is also classified as "low risk". The Bonnie View Well has a maximum measured chloride concentration of 87 mg/l (classified by the County as "low risk"). Maximum measured chloride concentrations within a 5000-foot radius of the Miller Balda Well appear to be slightly elevated relative to the county-wide distribution of chloride occurrence. This may be attributed to relic chloride in the aquifer and/or the influence of brackish water associated with the zone of diffusion (a transition zone that comprises the saltwater interface). Rising chloride trends in the Bonnie View Well suggest influence of the saltwater interface in response to pumping ("lateral intrusion" and/or "upconing").

4. PGG performed a 24-hour constant-rate aquifer test on the Miller-Balda Well at a pumping rate of 30 gallons per minute (gpm). We estimated aquifer transmissivity between 2,600-8,100 $feet^2$/day, and chloride concentrations stayed stable of the course of the test.

5. The Miller-Balda Well is estimated to be about 10% to 33% efficient (well efficiency after pumping at 30 gpm for 24 hours), with a specific capacity of 2.4 gpm per foot of drawdown. These values are consistent with small diameter wells with relatively narrow screen slots completed in moderately transmissive aquifers. Assessment of pump capacity, maximum instantaneous well yield, and potential for seawater intrusion via "upconing" led to the conclusion that pump capacity (30 gpm) is the factor that most limits recommended well yield. This capacity will easily serve the maximum daily demand of 19 gpm estimated for the project.

6. PGG developed a simple groundwater model to estimate the drawdown associated with pumping the Miller-Balda Well at an annual average rate of 8.3 gpm and a seasonal maximum monthly rate of 12.4 gpm. The model used the U.S. Geological Survey software "MODFLOW" and represented both Aquifers C and D with aquifer properties derived from the constant-rate test. The model also simulates natural recharge to the aquifers and their connection with marine water bodies.

7. The model predicted that drawdowns associated with proposed groundwater withdrawals are on the order of hundredths of a foot (with larger drawdowns in the immediate vicinity of the well). Predicted drawdowns are not expected to impair customary uses of neighboring wells both from the standpoint of well yield and associated water quality (i.e. seawater intrusion impacts). PGG's analysis indicates that the proposed groundwater withdrawal from the Miller-Balda Well meets those elements of Ecology's "Four-Part Test" addressed in this report, as required for issuance of a new water right.

3.0 HYDROGEOLOGIC CONDITIONS

The following sections describe the stratigraphy of the groundwater flow system, completion aquifers for local wells, static groundwater elevations, and ambient chloride concentrations in local groundwater.

3.1 HYDROSTRATIGRAPHIC FRAMEWORK & WELL COMPLETIONS

The USGS (Jones, 1985 and Sapik et al, 1988) studied the hydrogeology of Whidbey Island and described a layered (stratified) system of aquifers and intervening aquitards. It should be noted that the aquifer top-elevations and thicknesses interpreted by the USGS are approximate because contour intervals on the USGS maps employ coarse resolution. In the vicinity of the Miller-Balda Well, the uppermost aquifer ("Aquifer E") is interpreted to occur at an elevation of about 100 feet above mean sea level (MSL) with a thickness of less than 30 feet. Below an intervening aquitard, the top of "Aquifer D" is interpreted to occur near MSL with a thickness between 0 and 75 feet. The USGS interpret Aquifer D underlain by aquitard materials followed by "Aquifer C", with a top elevation of around -50 feet MSL. USGS estimates of the thickness of Aquifer C were locally hampered by lack of wells fully penetrating the aquifer.

Because the USGS hydrostratigraphic framework was developed to characterize conditions on a regional scale, it does not always perfectly fit local conditions. This is true for the Miller-Balda Well, which did not encounter a sufficient water-bearing materials to complete the well in the elevation range interpreted for Aquifer D, but *did* encounter sufficient water-bearing materials in the elevation range interpreted for Aquifer C. The Miller-Balda well was constructed in April 2018 and the driller's log is presented in **Appendix A**. Relative to a ground-surface elevation of about 198 feet NAVD88 (194 feet MSL[1]), the driller's log shows:

1. Interlayered hardpan and gravelly clay to a depth of 64 feet below ground surface (bgs);
2. Interlayered sand and silty sand from 64 to 160 feet bgs (129 to 34 feet MSL);
3. Clay and sandy clay from 160 to 260 feet bgs (34 to -66 feet MSL), including a water-bearing sand zone from 186 to 189 feet bgs (8 to 5 feet MSL) and a water-bearing silty-sand zone from 193 to 201 feet bgs (1 to -7 feet MSL);
4. Water-bearing sand from 260 to 294.5 feet (-66 to -100.5 feet MSL), including silty sand from 260-286 feet bgs and sand from 286-294.5 feet bgs; and
5. Sandy clay from 294.5 to 296 feet (total depth of well).

The Miller-Balda Well was completed in the lower water-bearing sand using 10 feet of 10-slot well screen from 284.5 to 294.5 feet bgs (-90.5 to -100.5 feet MSL). Relative to the USGS regional interpretation, the sand layers observed by the driller between 34 to 129 feet MSL may contain Aquifer E; the thin sand and/or the silty sand observed near sea level likely correlates to Aquifer D, and the sand in which the well was completed likely correlates to Aquifer C. The driller chose not to complete the well in the materials interpreted as Aquifer D because they were either too thin or too silty to produce sufficient water.

PGG mapped the bottom elevation of well completions within a mile of the Miller-Balda Well (**Figure 2**), and found that most wells in the area have bottom completion elevations ranging from -10 to -50 feet MSL. PGG interprets these wells as completed in Aquifer D. However, several areas occur where below-sea-level wells are typically completed below -75 feet MSL, including a notable "swath" of wells occurs with bottom completion elevations from -75 to -105 feet MSL extending from the Miller-Balda Well southeast to the coastline. Within this "swath", it is possible that Aquifer D is either absent, too thin or too silty, thus forcing drillers to drill deeper to tap the next deeper aquifer (Aquifer C). The occurrence of Aquifer C is not documented in other locations because well owners did not have to drill below Aquifer D to obtain sufficient water supply. The well specified by Ecology for observation during aquifer testing ("Bonnie View Well" shown on **Figure 2**) is interpreted as completed in Aquifer D, with a bottom completion elevation of -34 feet MSL.

Both Aquifers D and C are expected to have hydraulic connections to marine water based on comparison of respective aquifer-top elevations (just below sea level and below -75 feet MSL respectively) with adja-

[1] In the vicinity of the Miller-Balda Well, mean sea level (MSL) is 4.41 feet NAVD88. The wellhead was surveyed at an elevation of 199.5 feet NAVD88 and is about 1.5 feet above the ground surface.

cent seafloor elevations. Review of bathymetry data from NOAA's GEODAS bathymetric database (Finlayson, 2005) shows that sea-floor elevations of -20 feet MSL (roughly representative of Aquifer D) occur close to the coastline except in Oak Harbor, where the seafloor is typically above -20 feet MSL. The bathymetric data also show that sea-floor elevations of -75 feet MSL (roughly representative of Aquifer C) occur several thousand feet offshore both in Saratoga Passage (east of the Miller-Balda Well) and the Strait of Juan de Fuca (west of the Miller-Balda Well). Assuming that both of these aquifers extend sufficiently offshore, the degree of hydraulic connection between the aquifer and marine water will depend both on aquifer properties and the texture/thickness of the seafloor substrate.

3.2 STATIC GROUNDWATER ELEVATION

Aquifers D and C are both considered "confined" because their top elevations (at or below mean sea level) occur below their static water levels (typically exceeding mean sea level). PGG monitored static groundwater elevations in the Miller-Balda and Bonnie View wells for 5 days following recovery from aquifer testing of the Miller-Balda Well. The data show that both wells are tidally influenced, as can be seen in **Figures 3** and **4**. Based on the surveyed elevation of the Miller-Balda wellhead, post-recovery static water levels in the well ranged from about 6.5 to 9 feet MSL (**Figure 3**). A declining water-level trend occurred between 6/1/18 and 6/3/18, which is unexplained but may be related to nearby irrigation pumping[2]. Studies by Island County have found wells with groundwater elevations below 4.0 feet MSL tend to have statistically higher risk of seawater intrusion (Island County, 2005), although water-level elevations are just one of several factors contributing to seawater intrusion vulnerability.

In coastal aquifers, saltwater can underlie fresh groundwater in a "wedge" where the interface between freshwater and saltwater is deeper with distance inland. Static groundwater elevation in the Miller-Balda Well can be used to estimate the elevation of the saltwater interface based on the principals of Ghyben (1888) and Herzberg (1901). The Ghyben-Herzberg relation assumes a sharp interface between fresh and saltwater; however, actual interfaces are diffuse (often characterized as a "zone of diffusion") due to tidal mixing and other factors[3]. Based on a seawater density of 1.022 g/ml for the Strait of Juan De Fuca (0.022 g/ml greater than "fresh" water), the saltwater interface (commonly interpreted as the middle of the zone of diffusion) is predicted to occur at a depth (below MSL) 45.5-times the height of the static groundwater elevation (above MSL). Based on static groundwater elevations of 6.5 and 9.0 feet MSL, the middle of the saltwater interface should occur at elevations of -296 feet and -410 feet MSL (respectively). Given that Aquifer C well completions generally range from -75 to -105 feet MSL, and that the USGS interpret the aquifer thickness to be less than 100 feet across most of Whidbey Island (Sapik et al, 1988), the aquifer bottom should be above -296 feet MSL. While the Gyhben-Herzberg calculation above suggests that the saltwater interface at the Miller-Balda Well is significantly deeper that the bottom of Aquifer C, the interface will rise in elevation closer to the coast as static groundwater elevations trend downwards towards the point of marine discharge.

The Bonnie View Well provides a surveyed static water-level elevation near the coast for Aquifer D. Based on a wellhead elevation of 152.7 feet MSL[4], observations of static water-level elevation in the Bonnie View Well ranged from about 1.5 to 2.3 feet MSL (**Figure 4**). The Ghyben-Herzberg relationship would estimate the saltwater interface at around -68 to -105 feet MSL, which is significantly closer to the expected bottom of Aquifer D (approximately -50 feet MSL). While Ghyben-Herzberg would predict that

[2] A water cannon was observed operating in a field immediately southwest of the Miller-Balda property, and other agricultural parcels surround the project site.
[3] For more information about saltwater intrusion, with an emphasis on Island County, see: https://www.islandcountywa.gov/Health/DNR/Documents/TopicPaper%20SWI.pdf
[4] Frazier Surveying, LLC measured the wellhead elevation as 156.8 feet NAVD88.

the interface is unlikely to directly underlie the Bonnie View Well completion (-34 feet MSL) during static conditions, the interface may occur not far coastward of the well, and the zone of diffusion may be still closer to the well intake.

3.3 AMBIENT CHLORIDE CONCENTRATIONS

The Miller-Balda Well was sampled for chloride during aquifer testing, and had a stable chloride concentration of 41 mg/l for 3 samples taken over the 24-hour test period. A sample from the Bonnie View Well at the beginning of the aquifer test showed 83 mg/l chloride, and the Island County database shows a rising trend in the Bonnie View Well between 1980 through present with concentrations increasing from around 60 mg/l to a recent maximum value of 87 mg/l.

PGG reviewed data from the Island County database to assess chloride concentrations in wells located within a 5000-foot search radius of the Miller-Balda Well. Maximum measured chloride data were available for 49 wells in the search radius with values ranging from 5 to 120 mg/L. **Figure 5** provides a map of maximum observed chloride concentrations, with wells segregated by completion elevation (below -60 feet MSL loosely interpreted as Aquifer C, above -60 feet MSL loosely interpreted as Aquifer D). While there is no notable pattern to the geographic distribution of maximum chloride concentrations, several of the higher chloride value (>80 mg/l) wells are located closer to the coast. Island County identifies chloride concentrations above 100 mg/l as an indicator of risk for seawater intrusion. Such an exceedance is only observed in one well, located about 5,000 feet southwest of Miller-Balda with a chloride value of 120 mg/l.

Figure 6 presents a histogram of maximum chloride concentrations both within the 5000-foot search radius and for Island County overall. Typical chloride values in the Miller-Balda vicinity are clearly higher than the distribution of values across Island County. Within the 5000-foot search radius, 22% of sampled wells have maximum chloride concentrations below 40 mg/l, 49% have values between 40-60 mg/l, and 18% have values between 60-80 mg/l. In contrast, county-wide, 72% of sampled wells have maximum chloride concentrations below 40 mg/l, 8% have values between 40-60 mg/l, and 6% have values between 60-80 mg/l. The apparent difference in maximum chloride distributions may be attributed to a variety of factors typical of Island County, including: “connate” chloride (residual from sediment deposition or prior relatively higher sea level) or vertical proximity of well completions to the “zone of diffusion” (the transition between fresh and saline groundwater around the saltwater interface). Thus, the slightly-elevated chloride concentrations in the Miller-Balda vicinity may be associated with natural causes, but could also be affected by groundwater withdrawals. Few local wells have time-series chloride data; however, the increasing trend in the Bonnie View Well suggests a possible response to groundwater withdrawals.

4.0 AQUIFER TEST & WELL YIELD ASSESSMENT

4.1 PROCEDURES

PGG supervised a 24-hour constant-rate test on the Miller-Balda Well to document aquifer response and estimate aquifer transmissivity. The 295-foot well was fitted with a Walling 4F27A30 3-horsepower submersible pump set at a depth of 240 feet, with a maximum pumping capacity of approximately 30 gallons per minute (gpm). The test began at 12:55 PM on May 29, 2018 and maintained an average pumping rate of approximately 30 gpm for a total duration of 1,440 minutes (one day). Water pumped from the Miller-Balda well was discharged about 50 feet away to an immediately adjacent field where it infiltrated surficial soils. Given the reported occurrence of interlayered hardpan and gravelly clay from the ground surface to a depth of 64 feet (Section 3.1), infiltration of discharge was not expected to influence the aquifer test.

Water-levels were monitored in both the pumping well (Miller-Balda) and a nearby observation well (Bonnie View). The Bonnie View observation well is located about 2,300 feet from the pumping well (**Figure 1**). Water levels in both wells were measured manually (using a graduated electrical sounding tape) and with unvented datalogging pressure transducers ("dataloggers") set at 1-minute recording intervals. Manual water-level data for the Miller-Balda well were collected intensively during the first several hours of pumping by PGG, which then gradually transitioned to manual measurements on a roughly half-hour basis by Colin Smith of Harborview Properties (except between 11pm and 4am when no manual measurements were collected). Manual water-level data for the Bonnie View well were also collected intensively during the first two hours of pumping by Colin Smith, and approximately every hour during the remainder of the pumping period (except between 11pm and 4am when no manual measurements were collected). Colin Smith recorded manual water-level measurements from both wells during the first 24 hours after pump shut-down ("recovery"). The datalogger in the Miller-Balda Well recorded recovery and post-recovery data (to measure static water level under tidal influence) until 9:20 AM on June 5, 2018 (approximately 5.9 days after shutting down the constant-rate test). The datalogger in the Bonnie View well also recorded recovery and post-recovery data for approximately 5.9 days after shutting down the test. Pump discharge volumes and rates were measured with a totalizing flow meter, and were periodically recorded manually from the totalizer during pumping.

Barometric data was collected with a barologger transducer set at 10-minute recording intervals. PGG used the software program "WTides"[5] to obtain estimates of tidal elevation at Coupeville, WA at 1-minute intervals. The tidal and barometric data were used to correct the pumping and recovery data based on the values of tidal efficiency, tidal time-lag, and barometric efficiency discussed below.

4.2 AQUIFER TESTING

4.2.1 Theory

Drawdown in a pumping well includes two components: aquifer loss and well (efficiency) loss. Aquifer loss is the drawdown that occurs within the aquifer as a result of the pumping stress. Well loss is the additional drawdown that occurs in the vicinity of the well screen as a result of convergent (turbulent) flow. Mathematically these two quantities are described as follows:

$$s = B*Q + C*Q^2 \qquad \text{(Equation 1)}$$

where,

s = the drawdown in the well,
Q = the pumping rate,
B = the aquifer loss coefficient,
C = the well loss coefficient,

The coefficient "B" indicates the linear component of drawdown, which is predominantly caused by aquifer loss but can also include some frictional head loss through the well screen and immediately adjacent sediments. Generally, most of the linear component of drawdown is time related, and increases over longer pumping periods as drawdown propagates through the aquifer. The coefficient "C" represents the non-linear component of drawdown, and is caused by turbulent effects associated with non-laminar flow.

[5] https://www.wtides.com/

Non-linear well losses are commonly considered a result of turbulence in the well screen and sand pack, although non-linear losses in the aquifer immediately adjacent to the well can occur. The non-linear component of drawdown is independent of time. Linear losses are typically referred to as “aquifer loss,” whereas non-linear losses are referred to as “well loss.”

It should be noted that aquifer loss (drawdown in the aquifer) is directly proportional to the pumping rate (Q), whereas well loss is proportional to the pumping rate squared. Thus, at relatively low pumping rates, drawdown in a production well is largely influenced by the drawdown in the aquifer, whereas at higher pumping rates, particularly where well efficiencies are low (i.e. high C values), a significant portion of the drawdown may be related to well loss. Well efficiency is often expressed as a percentage of the aquifer loss to the total observed drawdown. A well that is 100 percent efficient will have a well loss coefficient (C) of zero and all drawdown is associated with the aquifer loss. A well that is 50 percent efficient will have 50 percent of the drawdown associated with well loss and the other 50 percent associated with aquifer loss.

The aquifer loss coefficient (B) is a function of pumping period and aquifer characteristics such as transmissivity (T) and storativity (S). Analysis of the time-drawdown and time-recovery data obtained from pumping tests provides estimates of aquifer characteristics and well efficiency. Methods of analyzing the constant-rate test data are applied in Section 4.2.4.

4.2.2 General Water-Level Trends

Prior to evaluating water-level trends and aquifer-test responses, all data from the unvented dataloggers were compensated for barometric influence. **Figures 3** and **4** show the full, barometrically-compensated datalogger record as well as manual water-level measurements for both the Miller-Balda and Bonnie View wells (respectively). General observations for the Miller-Balda Well, shown on **Figure 3**, include:

- The static water level elevation before the pumping test was about 8.5 feet MSL.
- The pumping water level at the end of the 24-hour pumping test was about -4 feet MSL, indicating about 12.5 feet of pumping drawdown.
- Abrupt shifts (depth displacements) of the datalogger occurred on 5/30 20:50 and 5/31 13:28, and were corrected on the plot. Slight deviations between manual measurements and datalogger near these times may be due to the displacement correction.
- Water-level variations unrelated to pumping include daily tidal variations of about 0.3 feet, a decreasing trend of about 3 feet between 6/1 and 6/3, an increasing trend of about 0.7 feet between 5/30 and 6/1, and responses to barometric pressure changes (barometric efficiency). Causes for the decreasing and increasing background trends are unknown.

General observations for the Bonnie View Well (**Figure 4**) are:

- Static water level elevation before the pumping test was about 1.6 feet MSL and increased to about 2.3 feet MSL when the datalogger was removed 5.9 days after pumping ended.
- During the pumping test, static water-level rose by around 0.1 feet, suggesting little or no impact from the pumping well.
- The well had been shut down 2 days before the pumping test. Well operation was reinitiated about 24 hours after the end of the pumping test with about 3.5 to 4 feet of drawdown during each pumping cycle.

4.2.3 Corrections for Background, Tidal and Barometric Trends

Before correcting the water-level data for tidal and barometric effects, the decreasing and increasing background trends were removed from the Miller-Balda Well (**Figure 7**). Removal of the 3-day decline was limited to the 3-day period, leaving a gentle remaining increasing trend up to June 3rd, which was removed from the data record up to that date.

With background trends removed, data from the Miller-Balda Well over the post-recovery period (5/31 to 6/5) were used to formulate corrections for tidal and barometric effects (applied to the *entire* data record). **Figure 8** shows post-recovery groundwater elevations (without correction for tidal and barometric effects), the barometric trend measured over the same time period, and two corrections developed by PGG (one that only corrects for tidal influence, the second that corrects for both tidal and barometric influence).

The computed tidal data from Coupeville were related to tidal response observed in the Miller-Balda Well by visual curve fitting and the following transformation:

$TR_t = TH_{t-n*}TE+dH$ (Equation 2)

where:

TR_t = Tidal groundwater response in feet at time "t"
TH_{t-n} = Coupeville tide height in feet at an earlier time ("t-n")
n = Tidal time lag in days
TE = Tidal efficiency in percent (%)
dH = Head offset in feet

Estimated barometric response was added to estimated tidal response to develop a *combined* tidal and barometric response for fitting to the observed groundwater level trend using:

$HC_t = TR_t – BD_t*BE$ (Equation 3)

where:

HC_t = combined tidal response and barometric correction in feet at time "t"
BD_t = Barometric departure (change from beginning of time period) in feet at time "t"
BE = Barometric efficiency in percent (%)

The tidal efficiency (TE), head offset (dH), tidal time lag (n) and barometric efficiency (BE) were adjusted manually until a best match was achieved between HC_t and the groundwater elevation. A reasonably good match was achieved at the beginning part of the post recovery (5/31 through 6/1) using the following parameters for the Miller-Balda Well (**Figure 7**):

- TE = 4.7%
- dH = 8.2 feet
- n = 0 days
- BE = 66%

After 6/1, the match between HC_t (gray dashed line) and groundwater elevation (blue line) is not as consistent. There are periods when HC_t closely parallels groundwater elevations and periods where they diverge. The reasons for periods of dissimilarity between the two trends are not fully understood but may relate to: 1) differences between calculated vs. *actual* tidal variations, 2) aquifer heterogeneity, and 3) unaccounted influences of adjacent pumping (e.g. water-cannon irrigation to the southwest). Nevertheless, these periodic dissimilarities mean that correction of measured water-level trends for outside tidal and barometric trends will be imperfect.

A similar approach was used to assess combined tidal and barometric response in the Bonnie View Well during periods when the well was not pumping (5/29-5/31). Self-pumping and apparent background trends influence the well after 5/31 (outside the period for which responses were correlated). The graphical fitting procedure yielded the following parameters for the Bonnie View Well (**Figure 9**):

- TE = 0.8%
- dH = 1.51 feet
- n = 0.15 days
- BE = 40%

It is interesting to note that despite the fact that the Bonnie View Well is located closer to the shore than the Miller Balda Well (700 vs. 2,700 feet), the Miller-Balda Well appears to be more responsive to tidal influence (i.e. higher tidal efficiency and shorter time lag). While this is unexpected, the two wells are interpreted as completed in different aquifers (Section 3.1), which apparently exhibit different tidal connectivity. As discussed in Section 3.1, tidal connectivity between Aquifer D and Oak Harbor appears to be limited by the fact that Oak Harbor is relatively shallow, with a seafloor that may predominantly occur above the top of the aquifer.

4.2.4 Aquifer Property Estimation

Prior to using the water-level data to estimate aquifer properties, both background trends and combined tidal/barometric responses were subtracted from the data. The fully corrected data were then used to generate semi-log plots of drawdown and recovery for the Miller-Balda Well (**Figures 10** and **11**) and an arithmetic water-level plot for the Bonnie View Well (**Figure 12**). For the Miller-Balda Well, the method of Cooper-Jacob (1946) was used to estimate aquifer transmissivity based on:

$T = 264Q/\Delta s$ (Equation 4)

where:

T = transmissivity of aquifer, in gallons per day per foot (gpd/ft)
Q = pumping rate, in gallons per minute (gpm)
Δs = drawdown over one log cycle on the straight-line part of the drawdown

The time-drawdown data between 5 and 300 minutes plot on a straight line on **Figure 10** with a fitted curve resulting in a transmissivity of 19,800 gpd/ft (2,647 ft^2/day). After 300 minutes the rate of drawdown appears to increase suggestive of a hydraulic boundary; however, we interpret the later time part of the drawdown curve to reflect residual tidal noise. As described above, groundwater elevations were not perfectly matched during the tidal correction. On a semi-log plot, the later-time data (300-1,440 minutes) are compressed on the graph such that accumulated imperfections in tidal correction become more graphically prominent.

While the drawdown data are plotted as drawdown vs. time, the recovery data are plotted as drawdown vs. “dimensionless time” (t/t’)[6], which is also plotted on a logarithmic scale (**Figure 11**). Early recovery

[6] Dimensionless time is the total time since pumping started divided by the time since pumping ended.

time occurs on the right side of the graph (large values of t/t'), and late recovery time occurs on the left. Early time recovery plot on a straight line with a fitted curve resulting in a somewhat higher transmissivity of 60,923 gpd/ft (8,144 ft^2/day). Later time recovery data is also affected by residual tidal noise making it difficult to interpret the later time recovery period.

Assuming an aquifer thickness (b) of 35 feet (based on the thickness of the water bearing zone identified on the well log), the range in aquifer hydraulic conductivity (K) is estimated to be:

- Drawdown: K = T/b ≈ 2,600/35 ≈ 75 ft/day
- Recovery: K = T/b ≈ 8,100/35 ≈ 230 ft/day

Figure 12 shows barometrically and tidally corrected depth to water in the Bonnie View observation well. The corrected water-level data show no notable response to pumping at the Miller-Balda Well, which can be attributed to completion of the two wells in different aquifers and the horizontal distance between the wells.

4.2.5 Chloride Monitoring During Testing

Three water samples were taken during the pumping phase of the constant-rate test to evaluate changes in chloride, electrical conductance (EC) and hardness over time. The samples were taken 5 minutes, 6 hours and 23 hours into the pumping test. The samples were sent to Edge Analytical Labs in Burlington, WA. No significant change in chloride was noted over the 24-hour pumping period. All chloride concentrations were 41 mg/L.

Well ID	Date-Time	Chloride (mg/l)	EC (umhos/cm)	Hardness (mg/l)	Comment
Balda	5/29/18 13:00	41.2	470	160	One hour into drawdown phase
Balda	5/29/18 19:03	41.1	478	164	Midway in test, near high tide
Balda	5/30/18 11:55	41.3	478	185	Near end of test
Bonnie View	5/29/18 12:00	83.1	768	267	No test-end sample taken

Because pumping the Bonnie View Well would interfere with its role as an observation well, samples could not be obtained from the well during the 24-hour aquifer test. Immediately prior to testing, a sample was taken from a spigot at the well house (sourced by gravity flow from the above-ground storage reservoir filled 48 hours prior to pumping the Miller-Balda Well), which showed a chloride concentration of 83 mg/l. The Bonnie View Well was pumped heavily after the recovery period (to refill storage in the reservoir), and further sampling was not performed as it would likely reflect the effects of this heavy pumping.

4.3 WELL YIELD ASSESSMENT

On an average daily basis, Washington Department of Health (WDOH) typically assumes that each single residence will use 400 gallons per day (gpd). For the proposed 30-residence project, this equates to an average annual withdrawal 13.5 acre-feet, or an average pumping rate (*average daily demand*, or "ADD") of 8.3 gpm. However, *instantaneous* water demands exceed average rates of withdrawal, and wells are seldom pumped at the average rate. The recommended instantaneous pumping rate for a well depends on a variety of factors, including: 1) pump capacity and required lift, 2) well performance and available drawdown, and 3) seawater intrusion concerns.

Maximum pump capacity is based on the installed pump (Walling 3-horsepower submersible) and the required lift. B&W Pumps estimates the installed pump should be able to provide 30 gpm into the proposed project distribution system. While instantaneous pumping (i.e. to fill the storage reservoir) may occur at a rate of 30 gpm, it should be noted that maximum daily demand (“MDD”) is typically about 2.3 times ADD, and is therefore expected to be around 19 gpm.

Well performance is typically expressed as measures of “well efficiency” and “specific capacity”:

1. Well efficiency is commonly defined as the portion of total observed drawdown associated with aquifer losses. PGG used the aquifer test analysis AqteSolve™ to estimate a reasonable range of drawdown expected for a 6-inch diameter well pumped for 24 hours at 30 gpm from a confined aquifer with transmissivity ranging from 2,600 to 8,100 ft^2/d and reasonable estimates of confined storage coefficient (0.0001 to 0.00001). Estimated 24-hour drawdown due solely to aquifer losses ranged from 1.3 to 4.1 feet. Relative to the drawdown trend shown on **Figure 10** (projecting 12.5 feet of drawdown at 24 hours), well efficiency is estimated to range from 10% to 33%. While these efficiency values are relatively low, they are generally consistent with the small diameter of the well and the small slot-size of the screen.
2. Specific capacity (SC) is defined as the pumping rate (Q) divided by associated drawdown, and also varies with Q. At the end of the 24-hour pumping test, the drawdown of 12.5 feet associated with a pumping rate of 30 gpm provides a SC of 2.4 gpm per foot of drawdown (gpm/ft). This is considered to be a low-to-moderate value typical of wells of similar construction. SC will decrease with longer pumping durations (due to continued drawdown over time) and at higher pumping rates, while SC will increase with shorter durations and lower pumping rates.

Available drawdown (AD) is defined as the difference between the static water-level elevation (6.5-9 feet MSL) and the top of the well screen elevation (-90.5 feet MSL). AD for the Miller-Balda Well is about 98 feet. In assessing maximum instantaneous well yield, AD is typically reduced by a “buffer” quantity to adjust for pump placement, water-level variations (seasonal, tidal, etc.), interference drawdowns from neighboring wells, and potential long-term water-level declines. In this case, the pump placement at 240 feet bgs (-42 feet MSL) provides nearly 50 feet of buffer, which is considered to be more than sufficient. With this buffer, available drawdown is effectively reduced to around 48 feet. Given that 24-hours of continuous pumping at 30 gpm resulted in 12.5 feet of drawdown, and that maximum daily demand is expected to average about 19 gpm, 48 feet of AD is considered to be sufficient for obtaining the well yields associated with the proposed project.

Seawater intrusion concerns apply to both “lateral intrusion” (where the saltwater “wedge” moves inland) and “upconing” (where the saltwater interface beneath the bottom of the pumping well is drawn up towards the well intake due to depressed groundwater levels local to the pumping well). The potential for lateral intrusion to the pumping well is assessed with a groundwater flow model in Section 5.5 and estimated to be insignificant. In areas vulnerable to intrusion, the potential for upconing can limit the recommended maximum instantaneous pumping rate. Despite the possibility that the saltwater interface may not be locally present beneath the well (Section 3.2), PGG assumed that the interface may be present and used the method of Todd (1980) to estimate the maximum pumping rate (Q_{max}) that would *not* cause upconing at the Miller-Balda Well based on the following equation:

$$Q_{max} = \pi d^2 K \Delta r \qquad \text{(Equation 5)}$$

d = distance between well bottom and interface
K = hydraulic conductivity of the aquifer
Δr = density difference between fresh and salt water.

Seawater density and elevations for the well bottom and saltwater interface are discussed in Sections 3.1 and 3.2, and the minimum value of K estimated in Section 4.2.4 was 75 ft/d. Based on these values, the maximum rate of pumping for the Miller-Balda Well that would not cause upconing is estimated to be

1,010 gpm. No evidence of upconing was noted during the 30-gpm constant-rate test based on three chloride measurements taken over the 24-hour pumping period.

Among the three factors that limit well yield discussed above, the limiting factor for the Miller-Balda Well appears to be installed pump capacity. Although the well could potentially pump at a higher rate, longer-duration withdrawals at lower rates are generally recommended both because they tend to cause less deterioration of the well screen and because they cause less interference drawdown to adjacent well owners.

5.0 GROUNDWATER MODEL & ESTIMATION OF PUMPING IMPACTS

Pumping a well causes adjacent water-level decline in the groundwater flow system (drawdown), which typically stabilizes after the groundwater system achieves a new equilibrium. In order to approve a new water right, Ecology must determine that the drawdown associated with proposed pumping will not significantly interfere with the ability of senior water-right holders to obtain customary groundwater withdrawals. Pumping-induced groundwater level declines can also shift the location of the saltwater interface within the groundwater flow system. The potential for seawater reaching the Miller-Balda Well via upconing was addressed in Section 4.3. Whereas upconing occurs in the immediate vicinity of the pumped well, pumping-induced drawdown also has the potential to cause inland migration of the saltwater wedge ("lateral intrusion").

PGG developed a simple groundwater flow model using the aquifer-property estimates above to estimate how groundwater withdrawals from the Miller-Balda Well will affect surrounding groundwater levels and the associated position of the saltwater interface. The computer model was developed using the USGS finite difference code "MODFLOW-2000" (Merritt & Konikow, 2000) and the graphical user interface Groundwater Vistas 6.0 (ESI, 2011).

5.1 MODELING APPROACH

The computer model represents the two confined aquifers in which most wells are completed (Aquifer D and Aquifer C) separated by a lower-permeability confining unit. This aquifer system is recharged from overlying hydrostratigraphic units and is hydraulically connected to marine water of sufficient depth along the eastern and western coastlines. The model was first run without representation of groundwater withdrawals, and then run with pumping from the Miller-Balda Well to estimate associated drawdown. Model estimates of drawdown were used to assess the potential for lateral seawater intrusion.

5.2 MODEL DOMAIN, GRID DISCRETIZATION AND TIME DISCRETIZATION

The model domain occupies an east-west swath extending from the Strait of Juan de Fuca (west) to Penn Cove (east) (**Figure 1**). The domain occupies about 60 square miles, is about 9.25 miles long and 6.5 miles high, and is roughly centered in the north-south dimension on the Miller-Balda Well (**Figure 13**). The model consists of three layers of 83 rows and 115 columns each, with model cell dimensions of 500x500 feet over most of the domain reducing to 125x125 feet in the immediate vicinity of the Miller-Balda well. Starting from a top elevation of 0 feet MSL, uniform layer thicknesses include 40 feet (Aquifer D), 30 feet (intervening aquitard) and 40 feet (Aquifer C). The bottom of the model domain occurs at -110 feet MSL. The model was run in steady-state mode. This means that recharge and pumping are simulated at average rates (no variation over time), and that estimates of aquifer storage coefficient are not needed.

5.3 MODEL BOUNDARY CONDITIONS

Boundary conditions are user specified hydrogeologic conditions within the numerical model. Boundary conditions used in this model include: no-flow, constant-head, recharge and pumping (well) boundaries. Boundary conditions specified for model layers 1 and 3 (Aquifer D and Aquifer C) are shown on **Figure 13**.

5.3.1 No-Flow Boundaries

No-flow boundaries form the north and south sides of the model domain, and were selected to be far enough from the Miller-Balda Well so as not to significantly impact predictions of groundwater elevation at the Miller-Balda Well or associated pumping drawdown. It is worth noting that where no-flow boundaries do effect model predictions, their use is conservative as it causes overestimation of response to pumping.

No-flow boundaries are also represented seaward of the constant-head boundaries used to represent the submarine interfaces between Aquifers D and C and the seafloor (discussed below). These no-flow boundaries are coincident with "inactive" portions of the model domain (10,151 of 28,635 model cells are inactive). These inactive areas have no effect on model predictions because they occur beyond the constant-head cells that represent the submarine interfaces.

5.3.2 Constant-Head Boundaries

Constant-head boundaries hold the groundwater elevation of associated model cells at a user-specified value. Constant-head cells were specified where Aquifers D and C are expected to sub-crop against the seafloor of Penn Cove and the Strait of Juan de Fuca. PGG defined the sub-crops using LiDAR bathymetric elevation data as coincident with seafloor elevation contours of -20 feet MSL (Aquifer D)[7] and -75 feet MSL (Aquifer C). Groundwater Vistas was used to calculate the equivalent freshwater head at the depth of these sub-crops based on the middle elevation of the model layers and a seawater density of 1.022 g/ml.

As can be seen on **Figure 13**, a constant-head boundary in model layer 1 was not specified within Oak Harbor. Oak Harbor is a relatively shallow feature, with most of its seafloor elevation above -20 feet MSL. It is also a relatively low energy feature, sheltered from currents in adjacent deeper channels. As such, Oak Harbor is expected to be underlain by finer-textured, lower-permeability sediments. During initial model simulations, representing a high-level of groundwater/marine-water connection in Oak Harbor using constant-head cells caused a mismatch between simulated and observed groundwater levels in the Miller-Balda and Bonnie View wells. Based on seafloor elevation, expected sedimentary texture, and model response – the connection between Aquifer D and marine water in Oak Harbor was interpreted to relatively minor and was not included in the model.

5.3.3 Recharge

Groundwater recharge was applied uniformly to the active area of the model domain. The recharge rate was specified at 4 inches/year based on local USGS recharge estimates. **Figure 14** presents recharge estimated by the USGS for the model vicinity (Sumioka & Bauer, 2003), and shows that most of the model vicinity has recharge estimated from either 0-4 in/yr or 4-8 in/yr. Recharge is applied to the top of layer 1 (Aquifer D), a portion of which continues to infiltrate downward to Aquifer C.

[7] Although some Aquifer D wells have completion elevations of -10 feet MSL, PGG's interpretation of limited connectivity between Aquifer D and Oak Harbor (described above) led to the assumption that the top of Aquifer D near the coastline occurs around -20 feet MSL (i.e. beneath the Oak Harbor seafloor).

5.3.4 Pumping

Based on the discussion in Section 4.3, pumping from the Miller-Balda Well was simulated using MODFLOW's "well" boundary condition at a steady-state (annual average) rate of 13.5 acre-feet/year (8.3 gpm), based on 30 residences each using 400 gallons per day. This value is consistent with typical water-use numbers developed by WDOH, but likely over-estimates the actual *net* withdrawal from the groundwater system because 90% of inside use is expected to discharge to the septic system and recharge groundwater. In order to represent drawdown during periods of seasonally higher water demand (summer), the model was also run with the Miller-Balda Well pumping at 12.4 gpm based on an assumed 1.5 multiplier between maximum monthly demand (MMD) and average daily demand (ADD). Simulating MMD in steady-state model mode is also conservative because such higher pumping only occurs over several months rather than year-round in perpetuity. Both of these assumptions are conservative in that they lead to over-estimation of expected drawdown for the given model configuration.

5.4 AQUIFER PROPERTIES

For confined aquifers represented in a steady-state model, the only effective aquifer property is transmissivity (T). PGG modeled Aquifer C with a T of 3,000 ft^2/d, using a hydraulic conductivity (K) value of 75 ft/day (derived from the drawdown portion of the aquifer test discussed in Section 4.2.4) and an estimated thickness of 40 feet. Aquifer D was assumed to have the same T and K as Aquifer C. As shown on **Figure 13**, these aquifer-property values provided a reasonable match to static water levels observed at the Miller-Balda Well (approximately 7 feet MSL) and the Bonnie View Well (approximately 2 feet MSL). Model simulations at the higher end of the transmissivity range estimated in Section 4.2.4 resulted in groundwater levels that were too low in the two monitored wells.

For the aquitard materials between Aquifer D and Aquifer C, the controlling property is vertical hydraulic conductivity (Kv). For a silty aquitard, Kv values are typically expected to range from about 0.3 to 0.03 ft/d ($1x10^{-4}$ to $1x10^{-5}$ cm/sec) per values published in Freeze & Cherry (1979). Initial model simulations showed that predicted groundwater levels were not very sensitive to aquitard Kv, therefore a midpoint value of 0.1 ft/d was selected.

5.5 MODEL PREDICTIONS

PGG added average-annual pumping from the Miller-Balda Well (8.3 gpm) to the steady-state model to estimate associated average-annual drawdown. Model estimates of average-annual drawdown in Aquifers C and D are presented on **Figures 15a** and **15b** (respectively). Predicted drawdown in the pumping aquifer (Aquifer C) in the immediate vicinity of the well (averaged within a 125-foot model cell) was on the order of 0.4 feet. With increasing distance, the model predicted a drawdown of 0.13 feet at a distance of approximately 600 feet and a drawdown of 0.07 at a distance of approximately 1500 feet. Drawdown in Aquifer D is predicted to be less than Aquifer C due to the influence of the intervening aquitard. Drawdown in Aquifer C at the Bonnie View Well, located 2,300 feet from the Miller-Balda well, is predicted to be around 0.04 feet (**Figure 15b**).

Model estimates of steady-state drawdown associated with MMD are presented on **Figures 16a** and **16b** (Aquifers C and D respectively). Predicted drawdown in the pumping aquifer (Aquifer C) in the immediate vicinity of the well (averaged within a 125-foot model cell) was on the order of 0.59 feet. With increasing distance, the model predicted a drawdown of 0.2 feet at a distance of approximately 600 feet and a drawdown of 0.11 at a distance of approximately 1500 feet. Drawdown in Aquifer D at the Bonnie View Well is predicted to be around 0.06 feet (**Figure 16b**).

It should be noted that model predictions are considered to be conservative because:

1) The model does not represent increased local recharge due to infiltration of water from the project large onsite septic system (LOSS). About 90% of water used for inside use is routed to the LOSS.
2) Steady-state prediction of drawdown associated with seasonal pumping at MMD tends to overestimate associated drawdown, since the cone of depression associated with pumping may not reach its maximum equilibrium dimension over this limited time period.

5.6 WATER RIGHTS IMPACT ANALYSIS

Ecology addresses the following four-part test when assessing a water-right application:

A. Water must be available (both physically and legally);
B. Water must be used beneficially;
C. Water use must not impair another existing use; and,
D. Water use must be in the public's interest.

The physical availability of water in the Miller-Balda Well is established through the yield analysis in Section 4.3 and the fact that the model predicts only minimal long-term drawdown in response to the proposed pumping withdrawal. Issuance of new water rights on Island County is not legally restricted, as long as they pass the four-part test above. Regarding beneficial use, Ecology includes the proposed purpose of water use ("domestic multiple") in their characterization of "beneficial".

The question of impairment addresses whether the new pumping withdrawal would interfere with existing (senior) water users to obtain customary yields from their wells. Model prediction of groundwater declines (<0.2 feet at the nearest well and <0.1 feet at most wells) should not interfere with customary rates of production from surrounding wells.

The question of "public interest" can be multi-faceted depending on the nature of the water-right application. For coastal environments with potential for saltwater intrusion, one applicable public-interest facet is whether new pumping would cause significant water-quality changes associated with seawater intrusion, where "significant" is defined as degrading the quality of a freshwater aquifer or reducing the usability of water pumped from existing neighboring wells. In the paragraphs below, PGG addresses whether movement of the saltwater interface associated with pumping the Miller-Balda Well would cause significant degradation of groundwater quality in Aquifers C and D, and whether pumping the well is expected to degrade water quality in the Bonnie View Well (for which Ecology has expressed specific interest) or Well B8G (the only well with a chloride concentration that currently exceeds 100 mg/l). As explained below, significant impacts to water quality (and usability) of the aquifers and the referenced wells are not expected.

Regarding the question of regional water-quality impacts to Aquifers C and D, it should first be noted that existing chloride concentrations are not associated with a classification of "intruded" by Island County. Most wells in the 5000-foot search radius have chloride concentrations significantly below the 100 mg/l value that Island County uses as a criteria to classify wells with potential intrusion. Based on chloride values and static water level in the Miller-Balda Well, Island County has determined that the Miller-Balda Well is at low risk for causing seawater intrusion and has approved the proposed groundwater withdrawal (Kelley, 2018). Nevertheless, Section 3.3 notes that the distribution of chloride concentrations in the Miller-Balda vicinity is higher than the county-wide distribution, and suggests that elevated values in some wells may be related to proximity between the well completion and the zone of diffusion associated with the freshwater/saltwater interface.

The vulnerability of an aquifer to inland migration of the saltwater wedge ("lateral intrusion") depends on whether groundwater levels are sufficiently high to preclude the saltwater wedge from moving inland. The water-level elevation needed to preclude inland migration of the wedge is called the "critical head" (H_c) and is equivalent to the Ghyben-Herzberg estimate of the water level that would place the estimated saltwater interface at the bottom of the aquifer. For instance, assuming bottom elevations of -45 feet and -113 feet MSL for Aquifers D and C, the Ghyben-Herzberg equation would estimate H_c values of 1 and 2.5 feet MSL (respectively). Due to the expected offshore locations of groundwater/marine-water sub-crops (based on seafloor bathymetry and the assumption that the aquifer extends beyond the shoreline towards its marine outcrop) and the equivalent freshwater head expected at these sub-crops (based on seawater density and depth of aquifer occurrence within the marine water column), predicted groundwater elevations on **Figures 13a** and **13b** suggest that H_c values are generally expected to occur offshore[8]. Furthermore, average-annual drawdowns predicted where water-level elevations equal H_c are on the order of hundredths of a foot (**Figures 15a** and **15b**). Given groundwater gradients estimated by the model in these areas, drawdowns of this magnitude are expected to cause insignificant inland migration of the toe of the saltwater wedge.

Ecology has expressed particular interest in the Bonnie View Well, which has exhibited increasing chloride over time and a maximum measured concentration of 87 mg/l. For this reason, model predictions of drawdown at the Bonnie View Well were applied to assess the potential for increasing chloride due to lateral intrusion resulting from pumping drawdown. With a representative static water-level elevation of 2.0 feet MSL, the Ghyben-Herzberg equation predicts that the middle of the saltwater interface would occur at -91 feet MSL. This interface elevation is below the interpreted bottom elevation of Aquifer D; however, the increasing trend of chloride concentration in the Bonnie-View Well suggests some proximity to the saltwater interface. The calculated elevation of the saltwater interface is often interpreted as corresponding to the middle of a zone of diffusion, which is a diffuse transition between saline water (below) to freshwater (above) composed of brackish water. Although Ghyben-Herzberg estimates that the saltwater interface does not occur in Aquifer D beneath the Bonnie View Well during static conditions, the interface occurs further seaward and drawdown caused by pumping the well could draw the associated zone of diffusion back towards the well completion. Even if the bottom of Aquifer D were sufficiently deep that the saltwater wedge occurred beneath the Bonnie View Well, water-quality impacts associated with pumping the Miller-Balda Well are expected to be minor based on the following observations:

- With the bottom of the well completion at -34 feet MSL, the static saltwater interface (-91 feet MSL) would be 57 feet below the well bottom, with brackish conditions extending upward (i.e. closer to the well bottom).
- Average-annual drawdown predicted at the Bonnie View Well (0.04 feet) would be expected to raise the saltwater interface by 1.8 feet (2%) to -89.2 feet MSL. This would cause a minor reduction in the distance between the well bottom and the center of the interface from 57 feet to 55.2 feet.
- While prolonged drawdown at the higher seasonal pumping rate would cause a 2.7-foot (3%) rise in the saltwater interface, it should be noted that intrusion can be a relatively slow process, and 3 months of higher pumping is unlikely to lead to the full predicted response.

[8] The model tends to over-estimate groundwater elevations in Aquifer D close to the shoreline. Note the difference between the observed static water-level elevation in the Bonnie View Well (2 feet MSL) and the model predicted value (4 feet MSL) on **Figure 13a**. Nevertheless, given that the Bonnie View Well is only 550 feet from the shoreline, a groundwater elevation of 1 feet MSL close to the shoreline is highly likely.

While evaluating means of addressing the increasing chloride trend in the Bonnie View Well is beyond the scope of this investigation, we suggest that (given its relatively low static water level elevation) pumping the well may be drawing the zone of diffusion towards the well screen. Pumping the well at a lower rate for more hours during the day could potentially reduce observed chloride concentrations.

Well B8G is located about 5,000 feet southeast of the Miller-Balda Well (**Figure 5**). It exhibits a maximum chloride concentration of 120 mg/l and is 277 feet deep with a bottom completion elevation of -83 feet MSL (interpreted as completed in Aquifer C). This domestic well is located only 400 feet from the shore, and does not have a surveyed water-level elevation. Given its distance from the Miller-Balda Well, seasonal variations in drawdown are expected to be minor. The predicted average annual drawdown at this well location (0.003 feet) would result in an upward shift of the saltwater interface of 0.14 feet (1.7 inches). PGG considers this displacement to be relatively insignificant.

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Model Domain

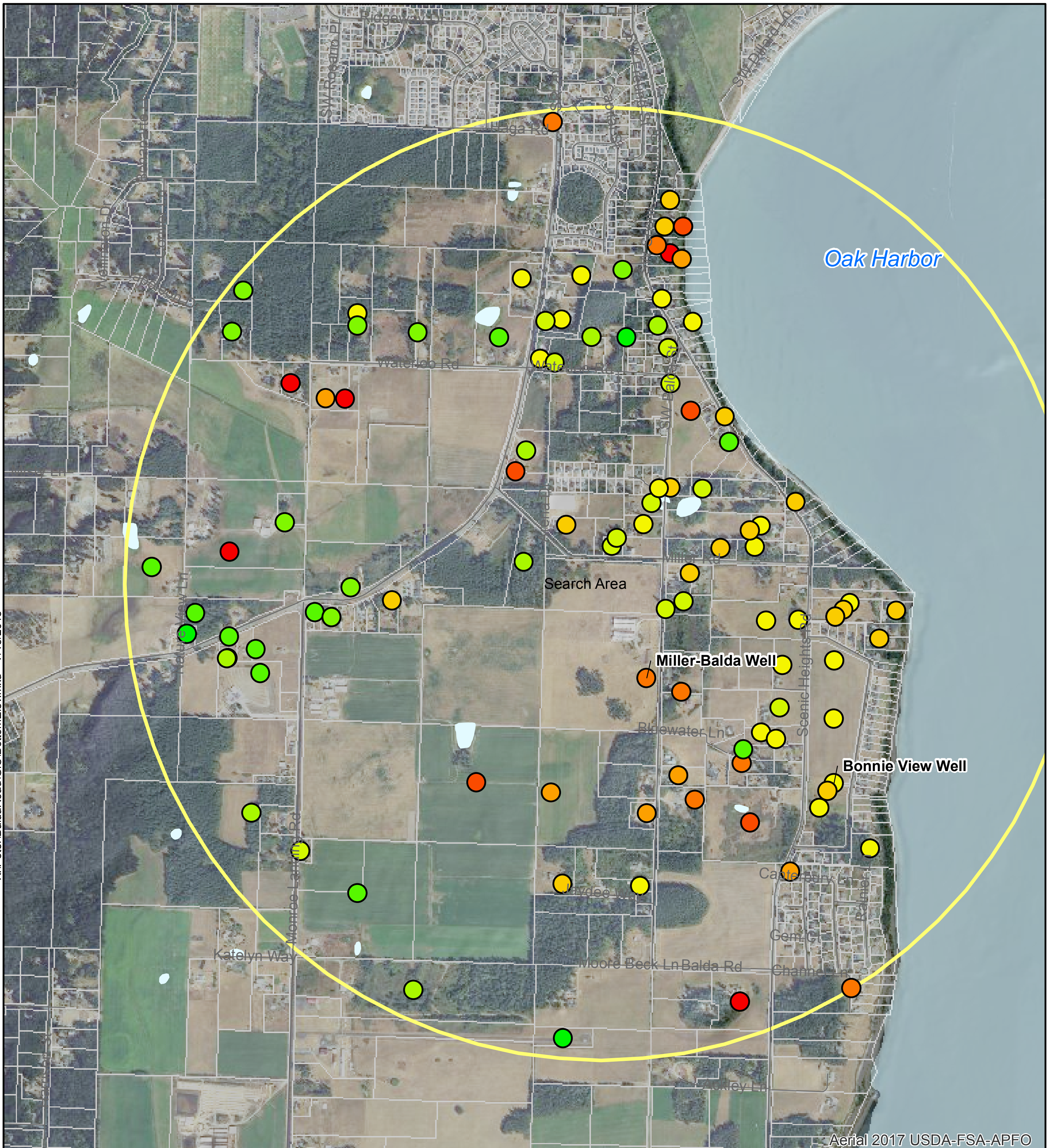
N

0 Miles 1

Figure 1

Vicinity Map

Miller-Balda Water Supply



Well Completion Bottom Elevation (feet MSL)

- -184 to -150
- -149 to -100
- -99 to -80
- -79 to -60
- -59 to -40
- -39 to -20
- -19 to 0
- 1 to 20
- 21 to 50
- 51 to 100
- 101 to 166
- Island County Search Area

Island County Search Area

0 Feet 2,000

Figure 2

Well Completion Bottom Elevations

Miller-Balda Water Supply

PGG

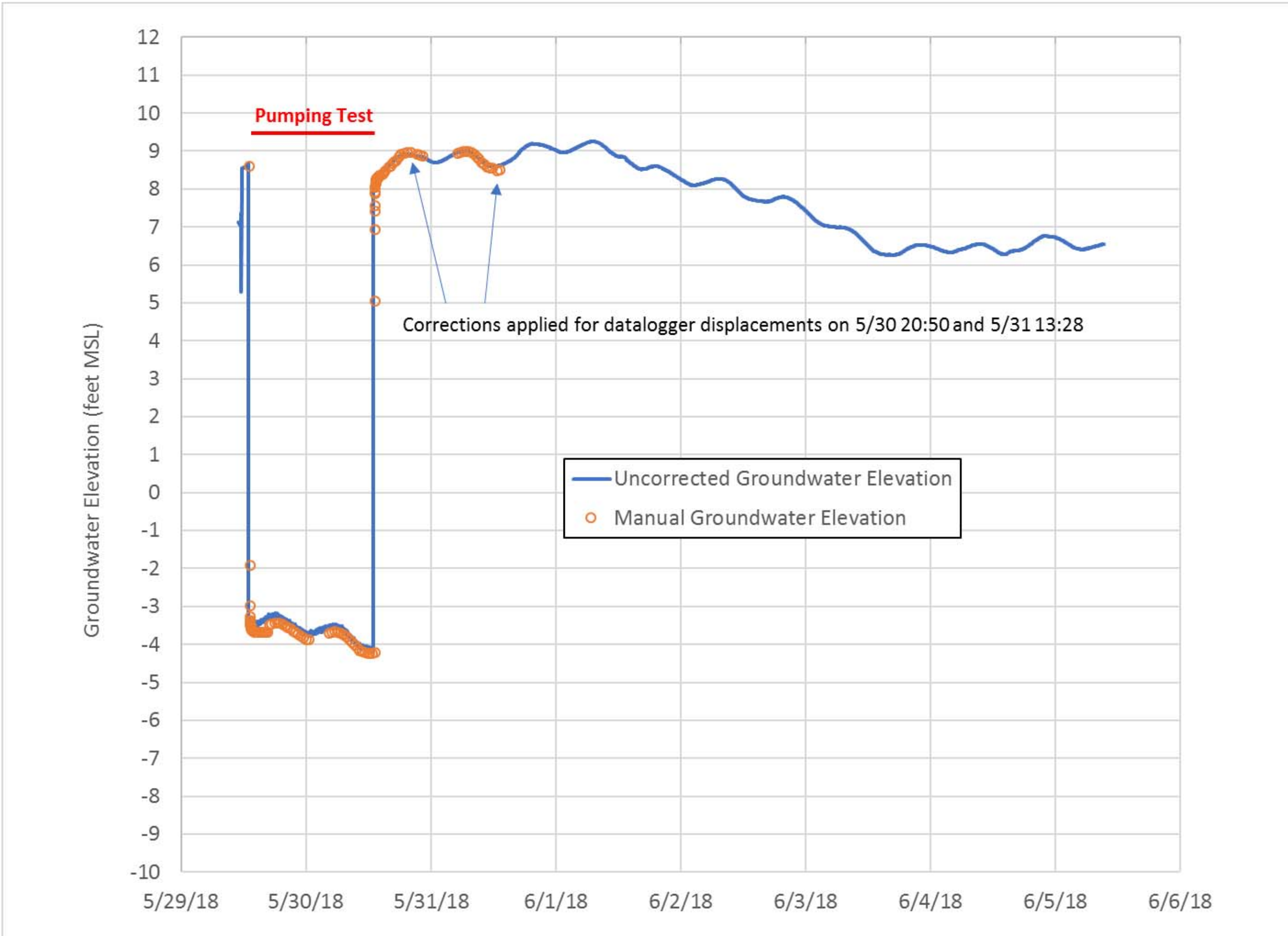


Figure 3
Groundwater Level Elevations in Miller-Balda Well

Miller-Balda Water Supply
Hydrogeologic Report

PGG

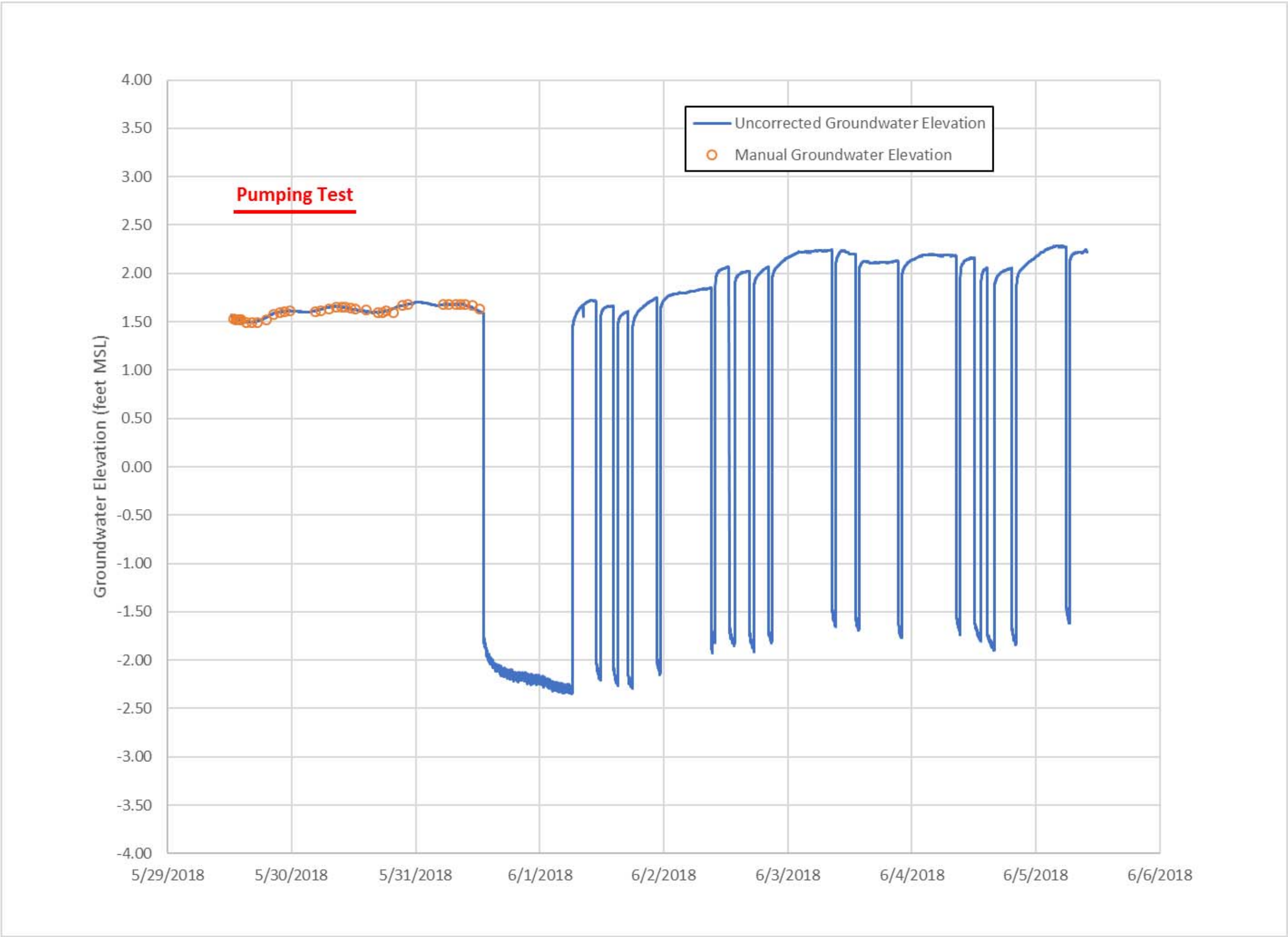
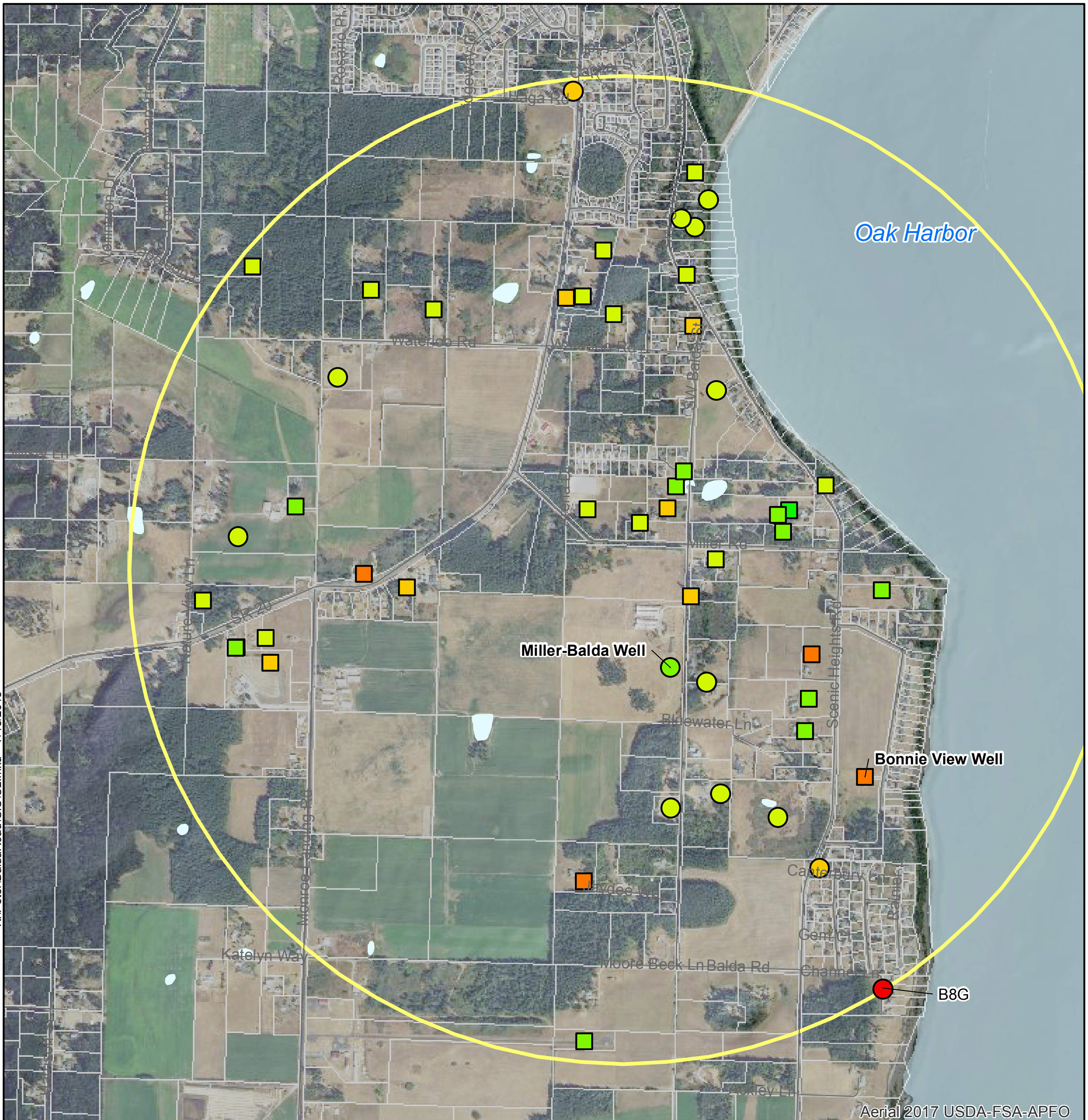


Figure 4
Groundwater Level Elevations in Bonnie View Well

Miller-Balda Water Supply
Hydrogeologic Report

PGG



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Maximum Reported Chloride Concentration (mg/l)

Aquifer D (> 60 feet MSL)	**Aquifer C (< 60 Feet MSL)**
5.0 - 20.0	5.0 - 20.0
20.1 - 40.0	20.1 - 40.0
40.1 - 60.0	40.1 - 60.0
60.1 - 80.0	60.1 - 80.0
80.1 - 100.0	80.1 - 100.0
100.1 - 130.0	100.1 - 130.0

Island County Search Area

N

0 Feet 2,000

Figure 5

Maximum
Chloride Concentrations

Miller-Balda Water Supply

PGG

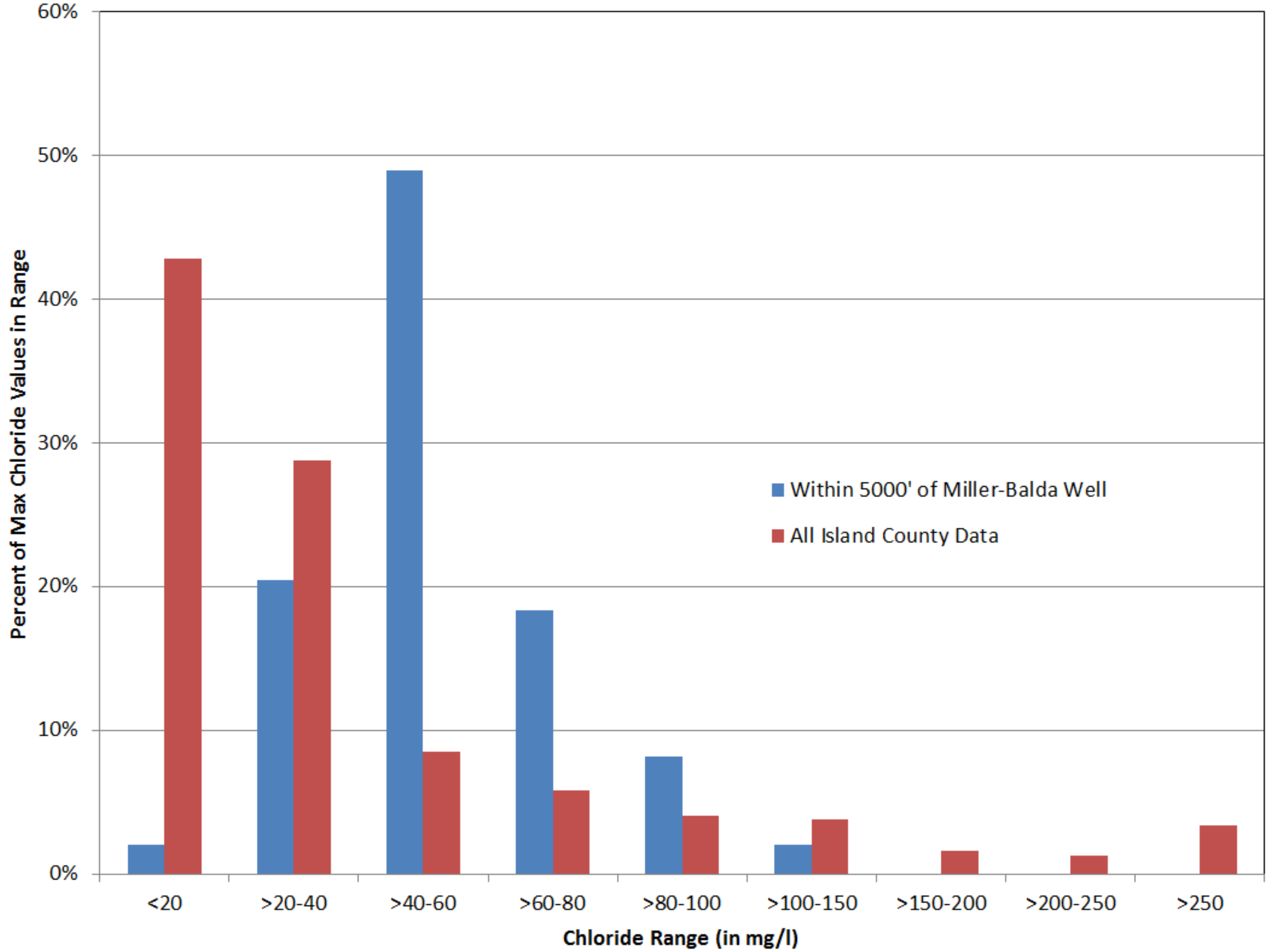

Figure 6
Comparative Histogram of Maximum Measured Chloride

Miller-Balda Water Supply
Hydrogeologic Report

PgG

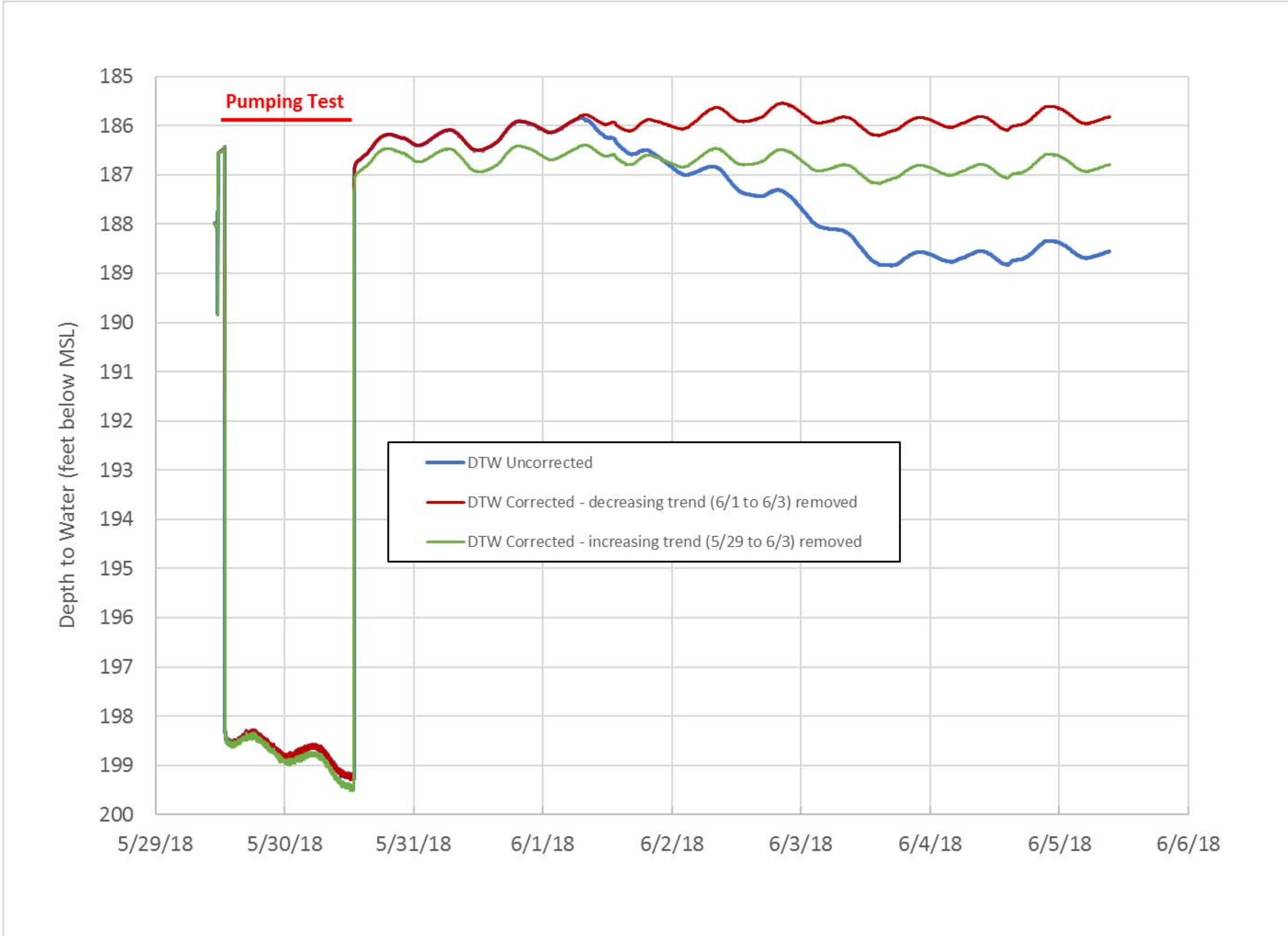

Figure 7
Depth to Water in Miller-Balda Well with Background Trends Removed

Miller-Balda Water Supply
Hydrogeologic Report

PGG

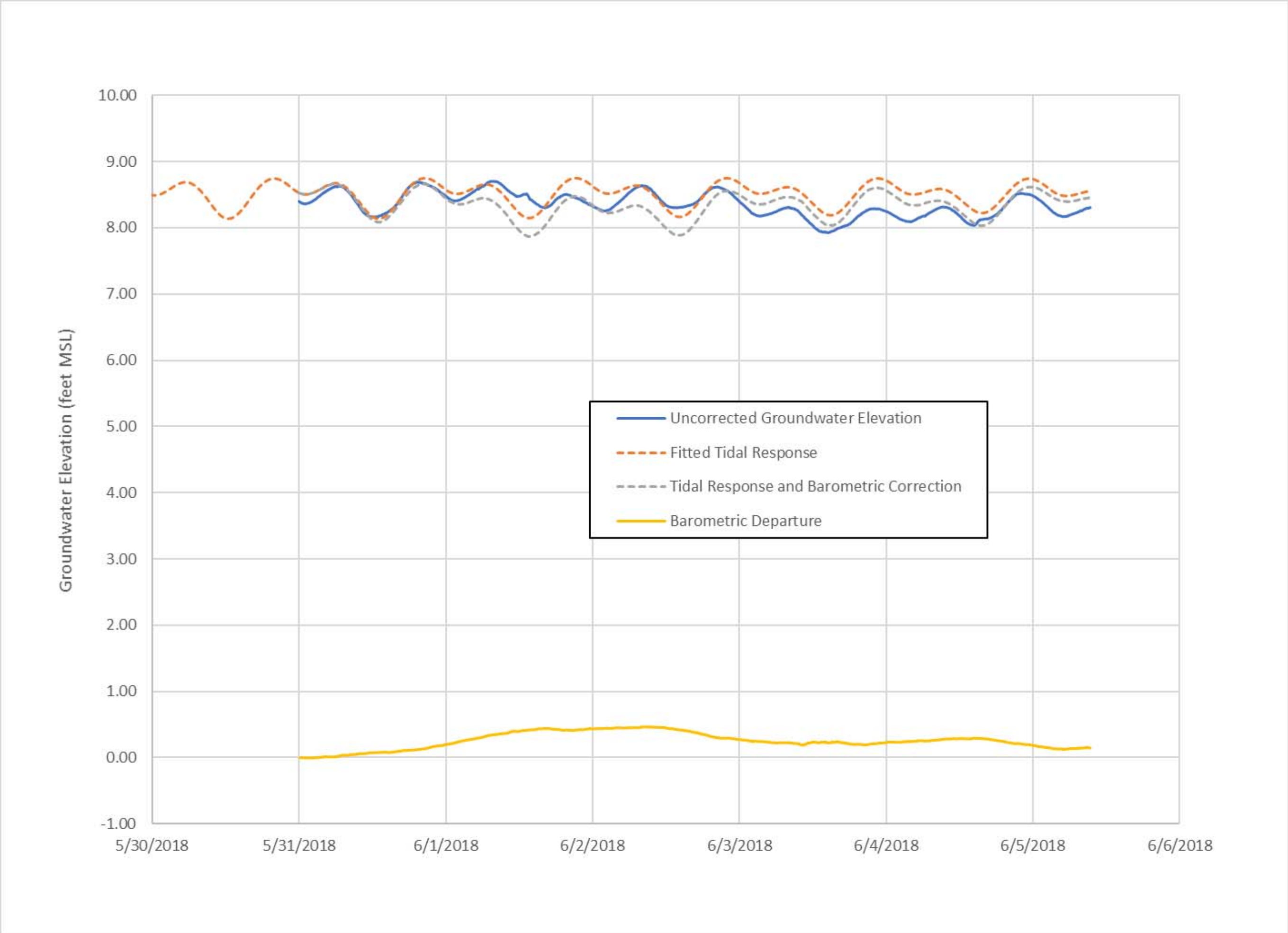

Figure 8
Correlation of Groundwater-Level Trends to Tidal and Barometric Trends in Miller-Balda Well

Miller-Balda Water Supply
Hydrogeologic Report

PGG

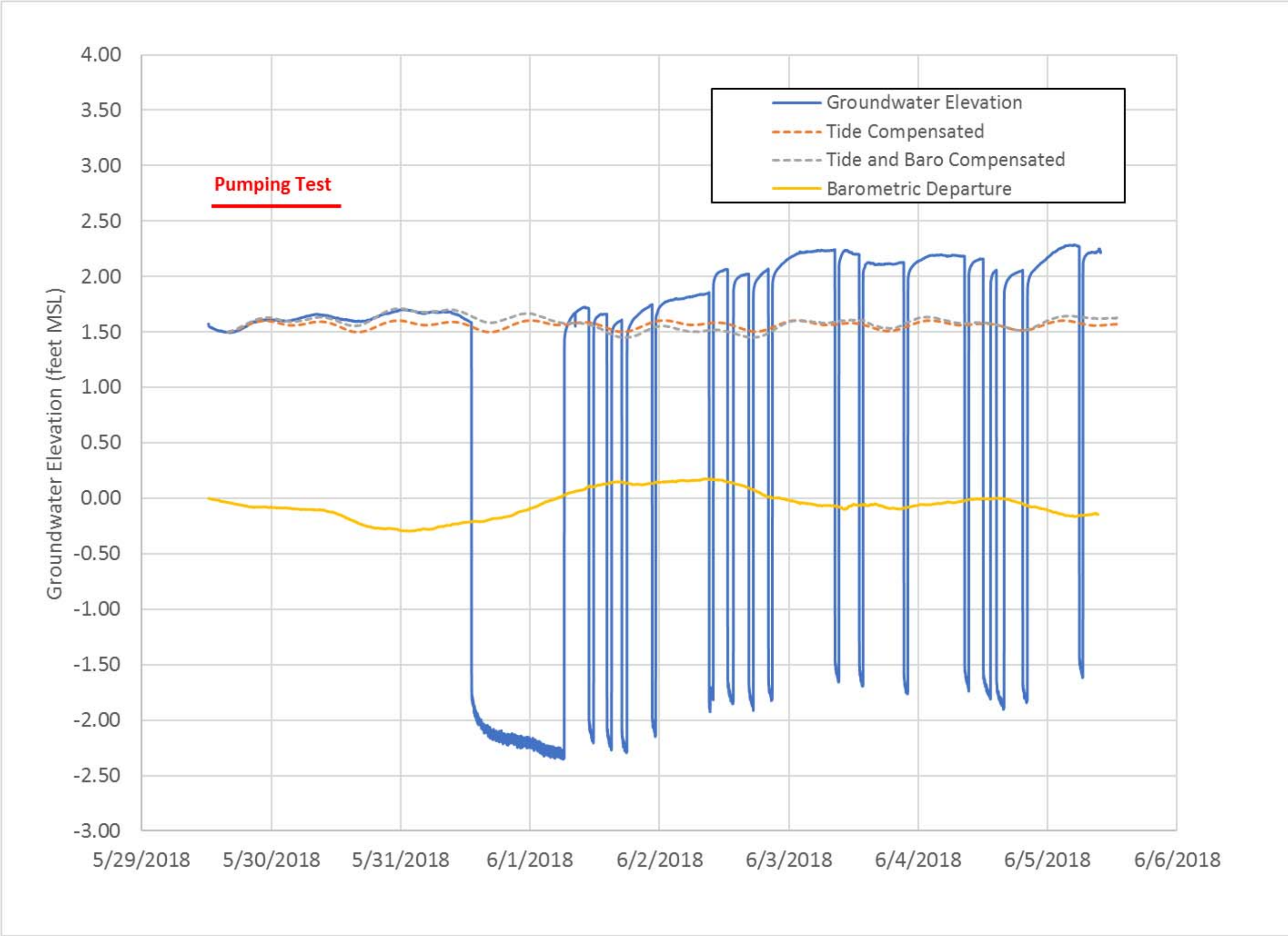

Figure 9
Correlation of Groundwater-Level Trends to Tidal and Barometric Trends in Bonnie View Well

Miller-Balda Water Supply
Hydrogeologic Report

PGG

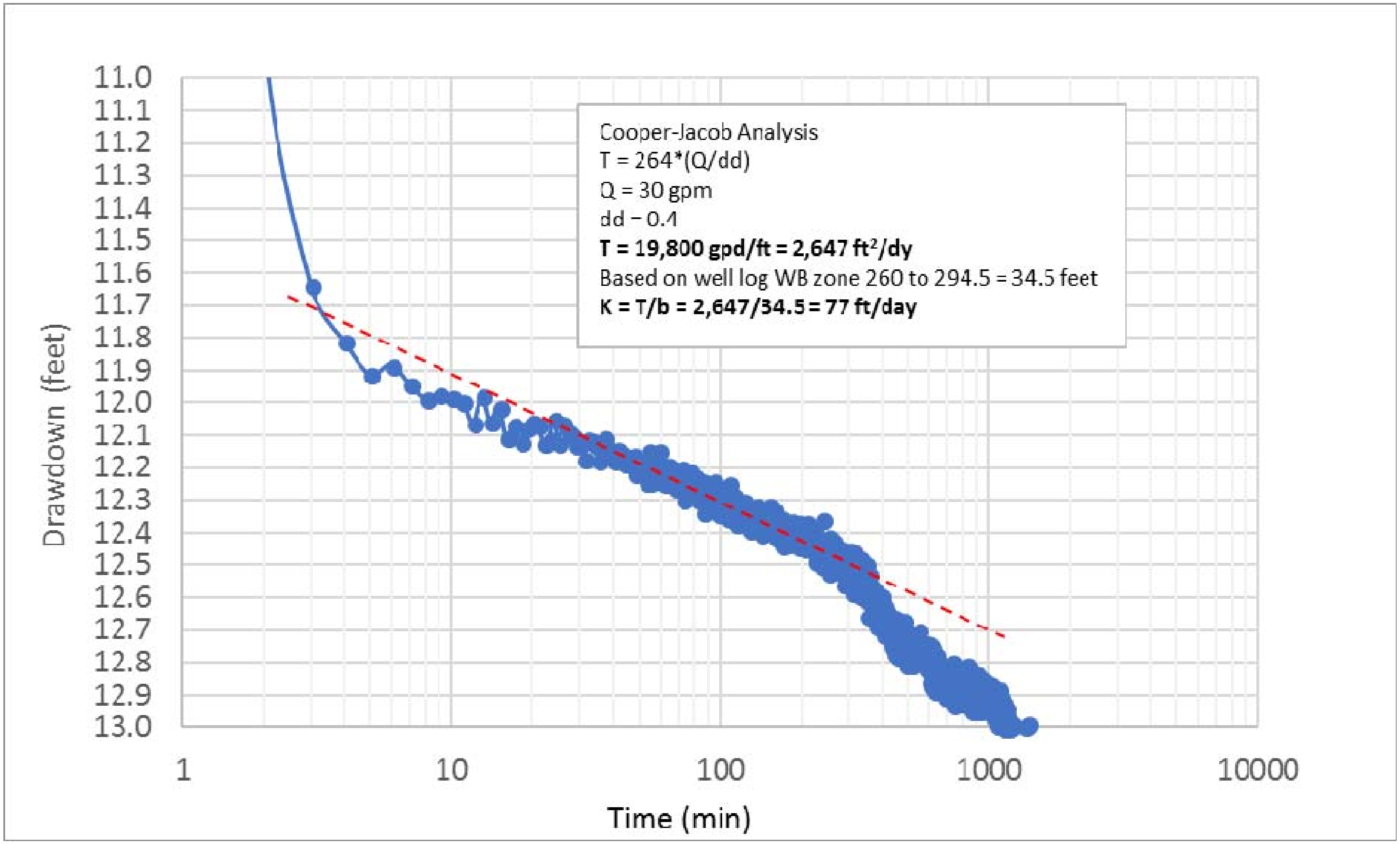

Figure 10
Cooper-Jacob Analysis of Drawdown in Miller-Balda Well

Miller-Balda Water Supply
Hydrogeologic Report

PgG

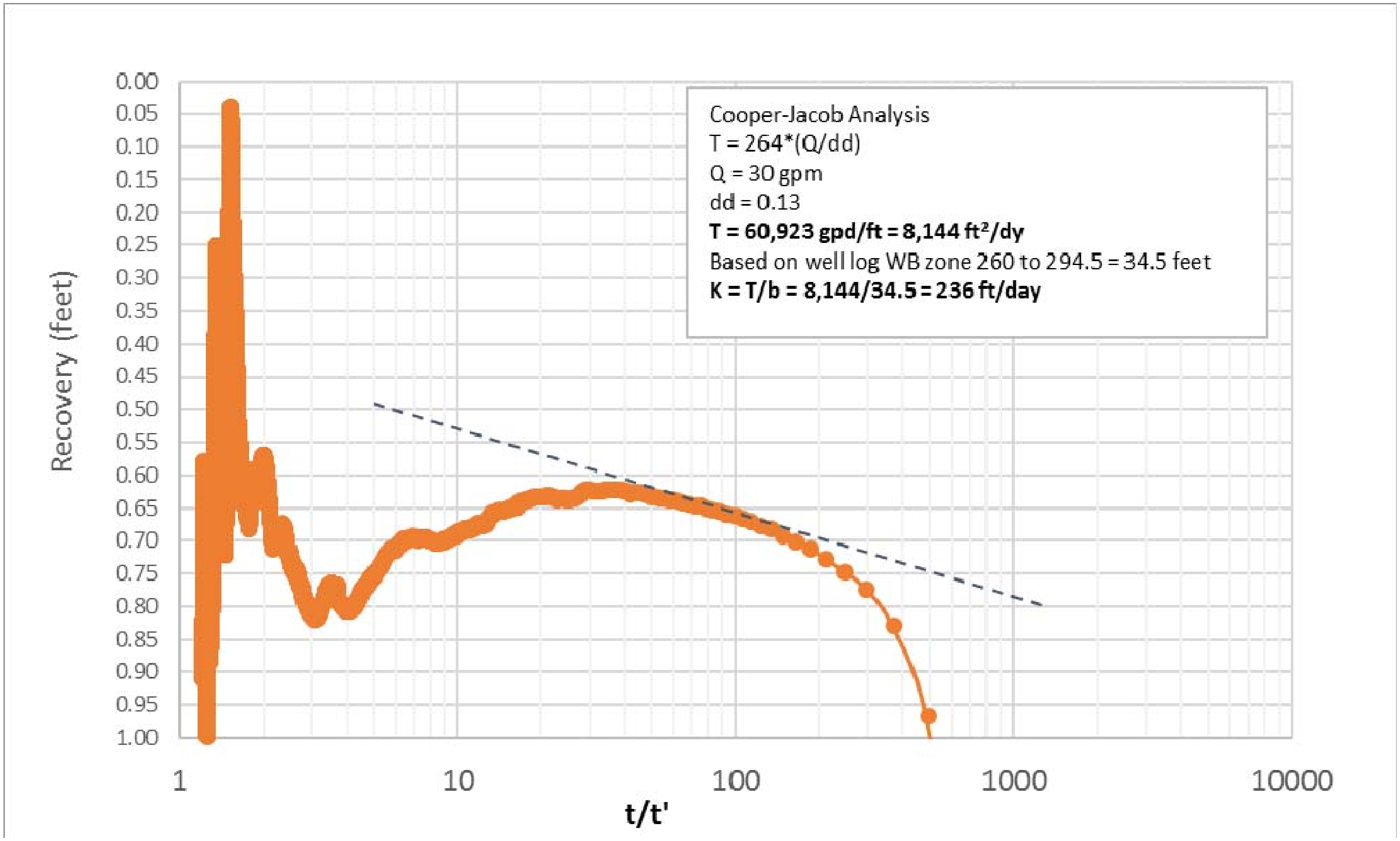

Figure 11
Cooper-Jacob Analysis of Recovery in Miller-Balda Well

Miller-Balda Water Supply
Hydrogeologic Report

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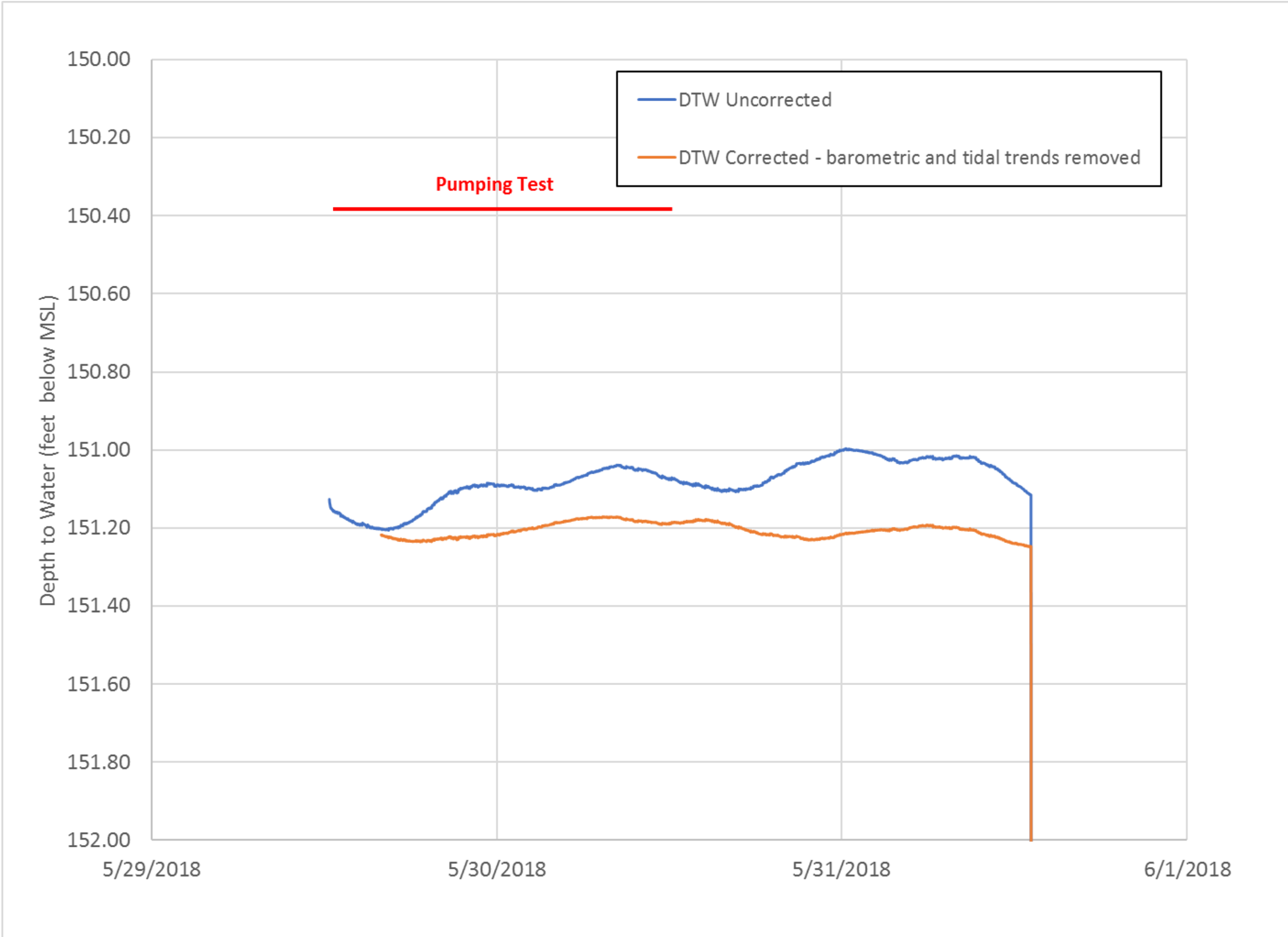


Figure 12
Barometric and Tidal Corrected Depth to Water in Bonnie View Well

Miller-Balda Water Supply
Hydrogeologic Report

PgG

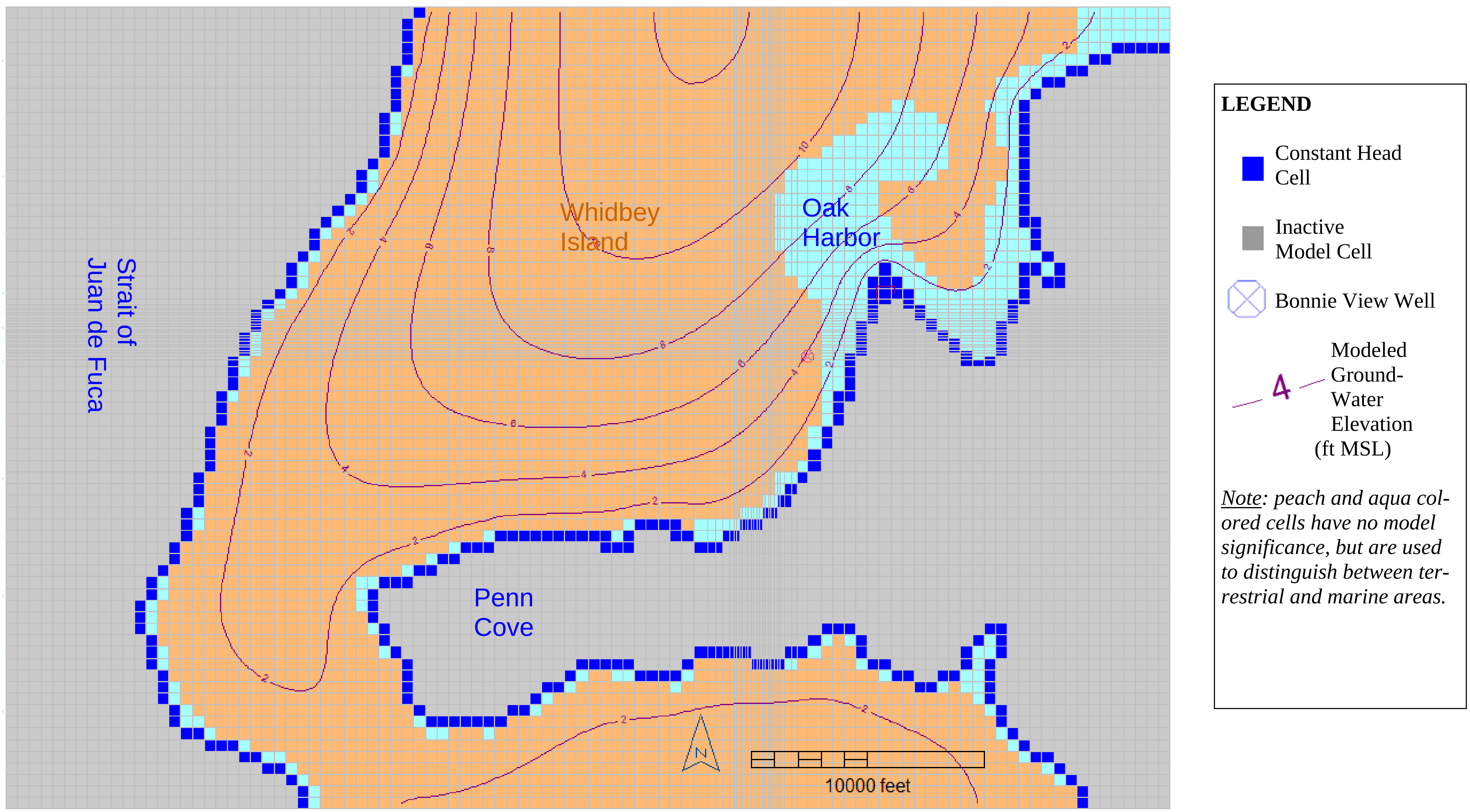


Figure 13a
Model Domain and Pre-Pumping Groundwater Elevations in Model Layer 1 (Aquifer D)

Miller-Balda Water Supply
Hydrogeologic Report

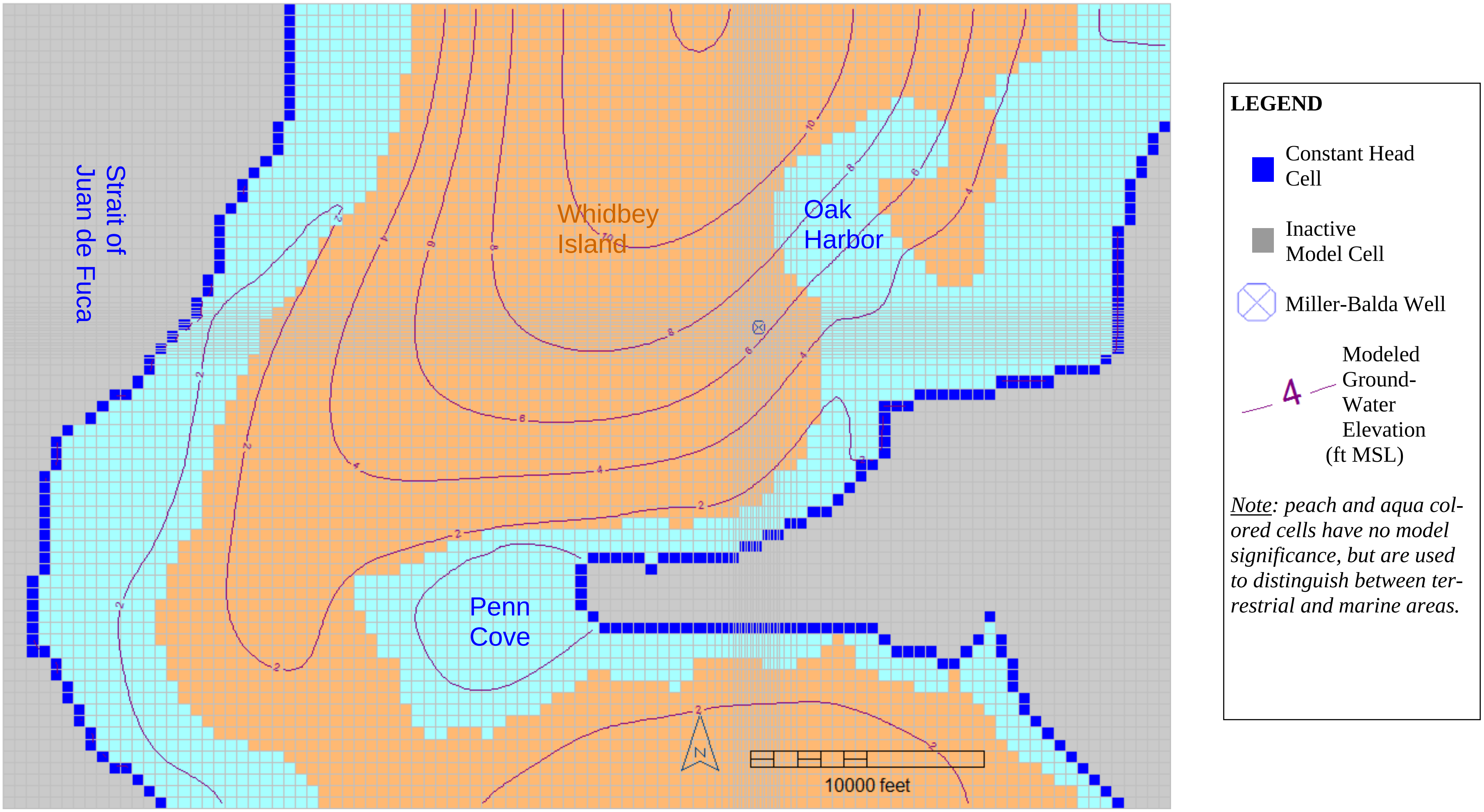


Figure 13b
Model Domain and Pre-Pumping Groundwater Elevations in Model Layer 3 (Aquifer C)

Miller-Balda Water Supply
Hydrogeologic Report

PGG

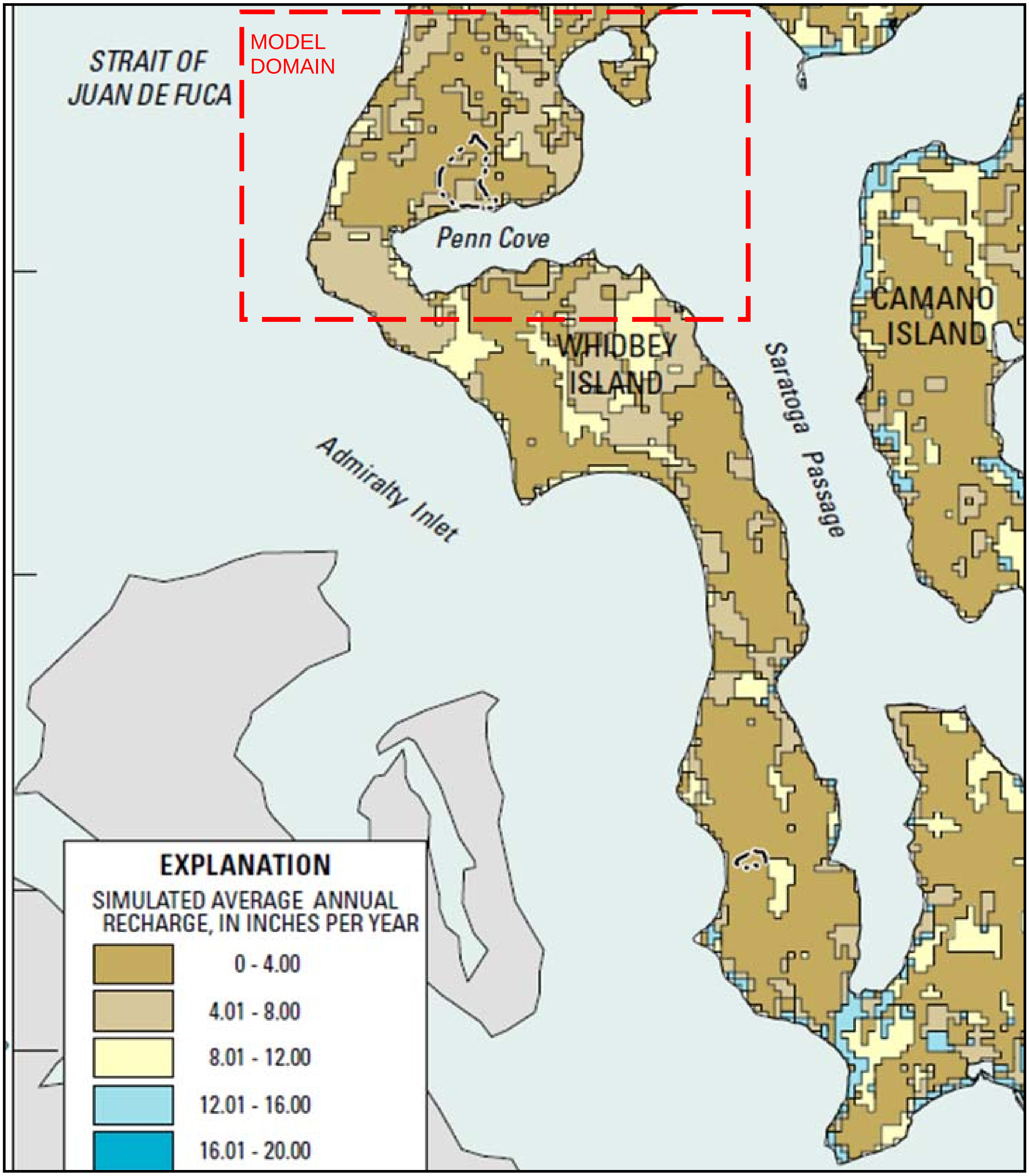


Figure 14
USGS Recharge Estimates

Miller-Balda Water Supply
Hydrogeologic Report

PGG

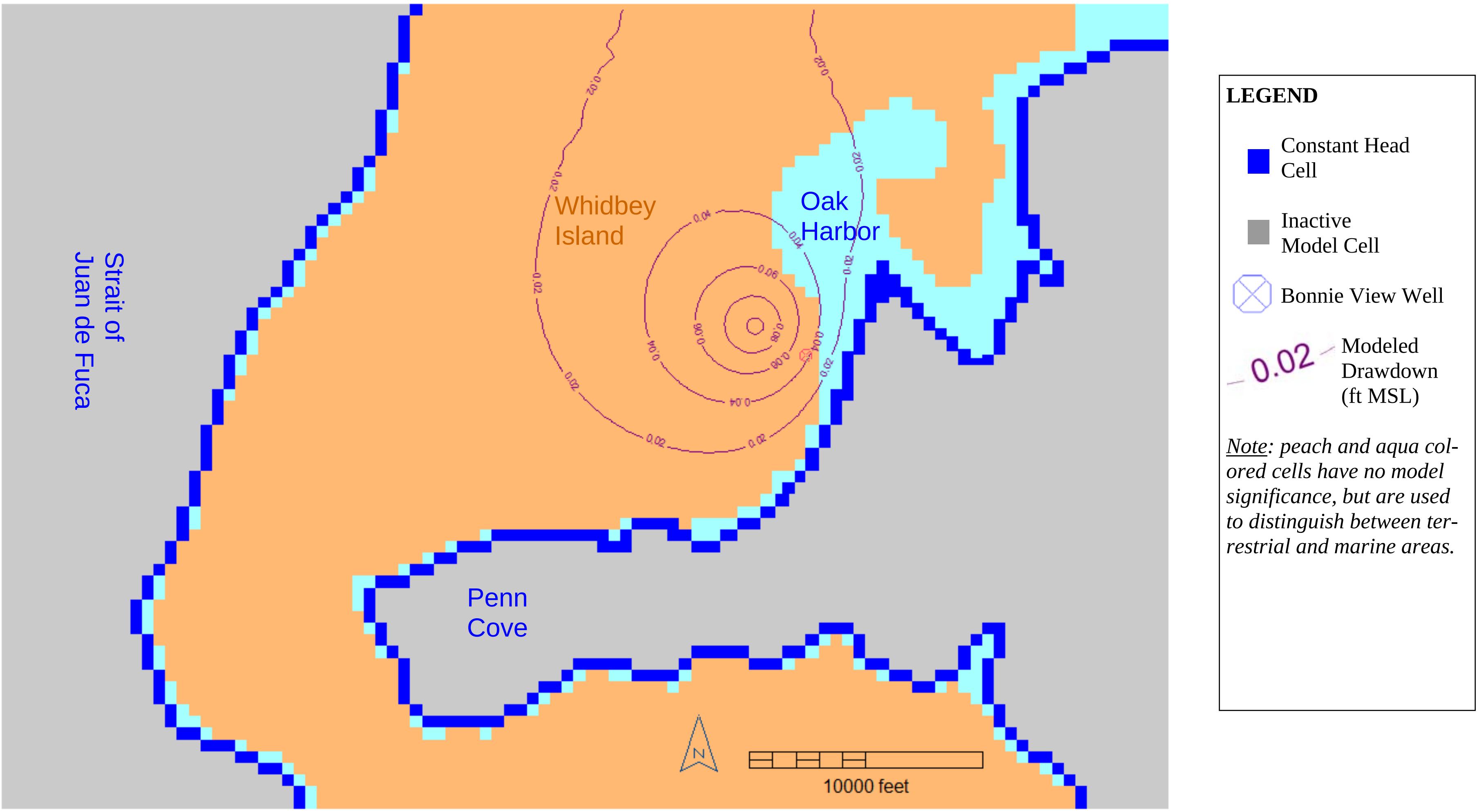


Figure 15a
Model Predicted Drawdown at Average Annual Withdrawal in Model Layer 1 (Aquifer D)

Miller-Balda Water Supply
Hydrogeologic Report

PgG

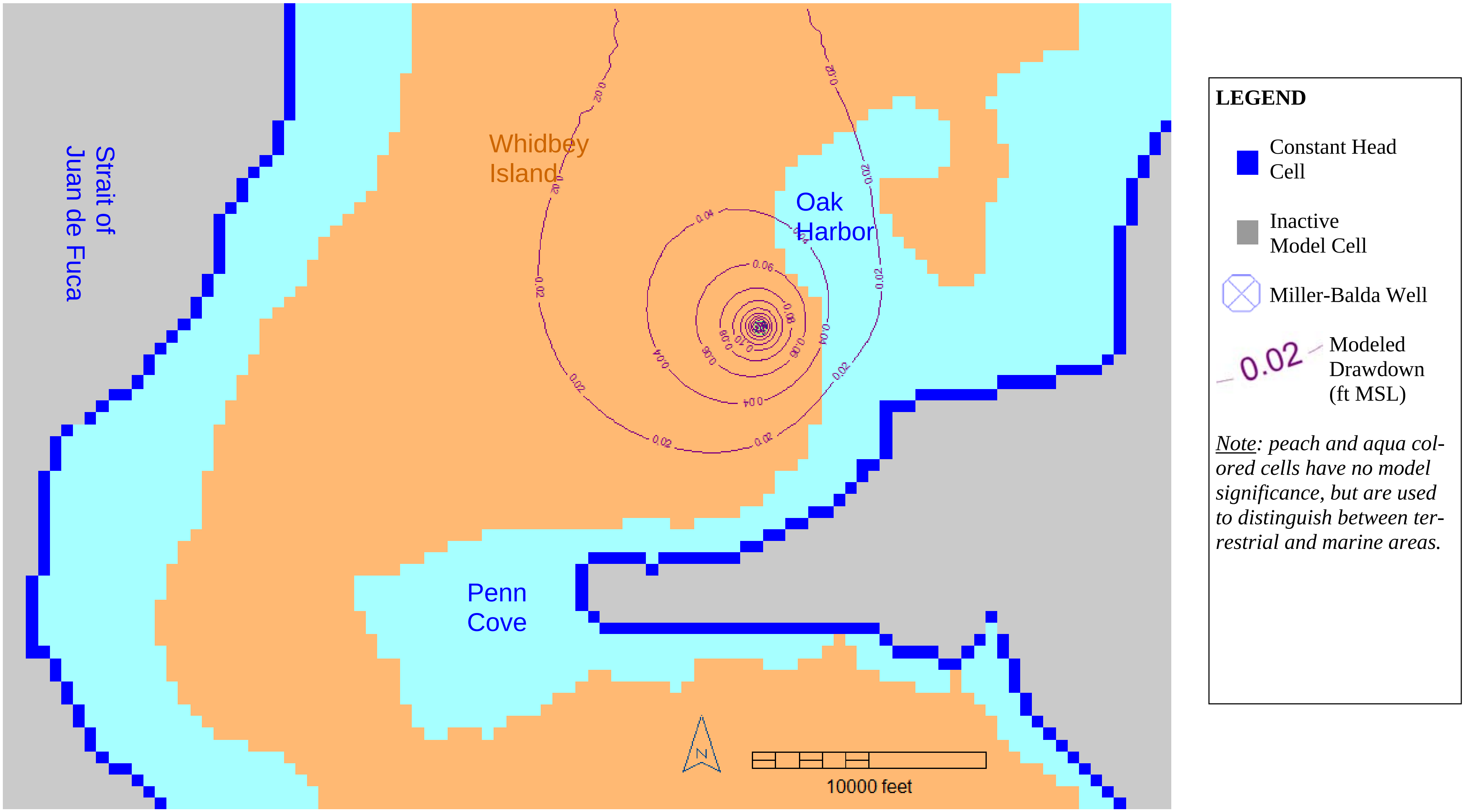
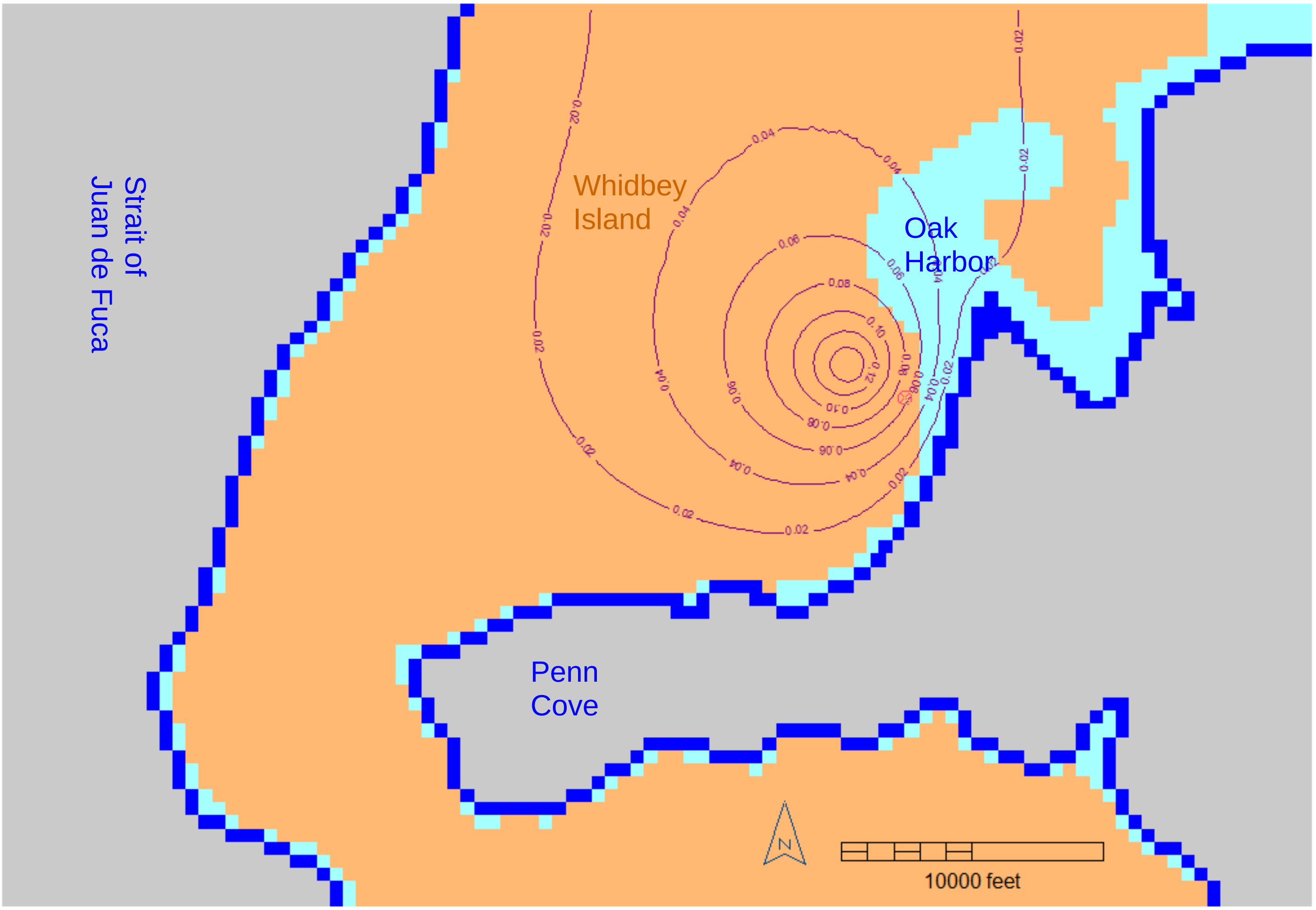


Figure 15b
Model Predicted Drawdown at Average Annual Withdrawal in Model Layer 3 (Aquifer C)

Miller-Balda Water Supply
Hydrogeologic Report

PgG



LEGEND

Constant Head Cell

Inactive Model Cell

Bonnie View Well

0.02 Modeled Drawdown (ft MSL)

Note: peach and aqua colored cells have no model significance, but are used to distinguish between terrestrial and marine areas.

Figure 16a
Model Predicted Drawdown at Maximum Monthly Withdrawal in Model Layer 1 (Aquifer D)

Miller-Balda Water Supply
Hydrogeologic Report

PgG

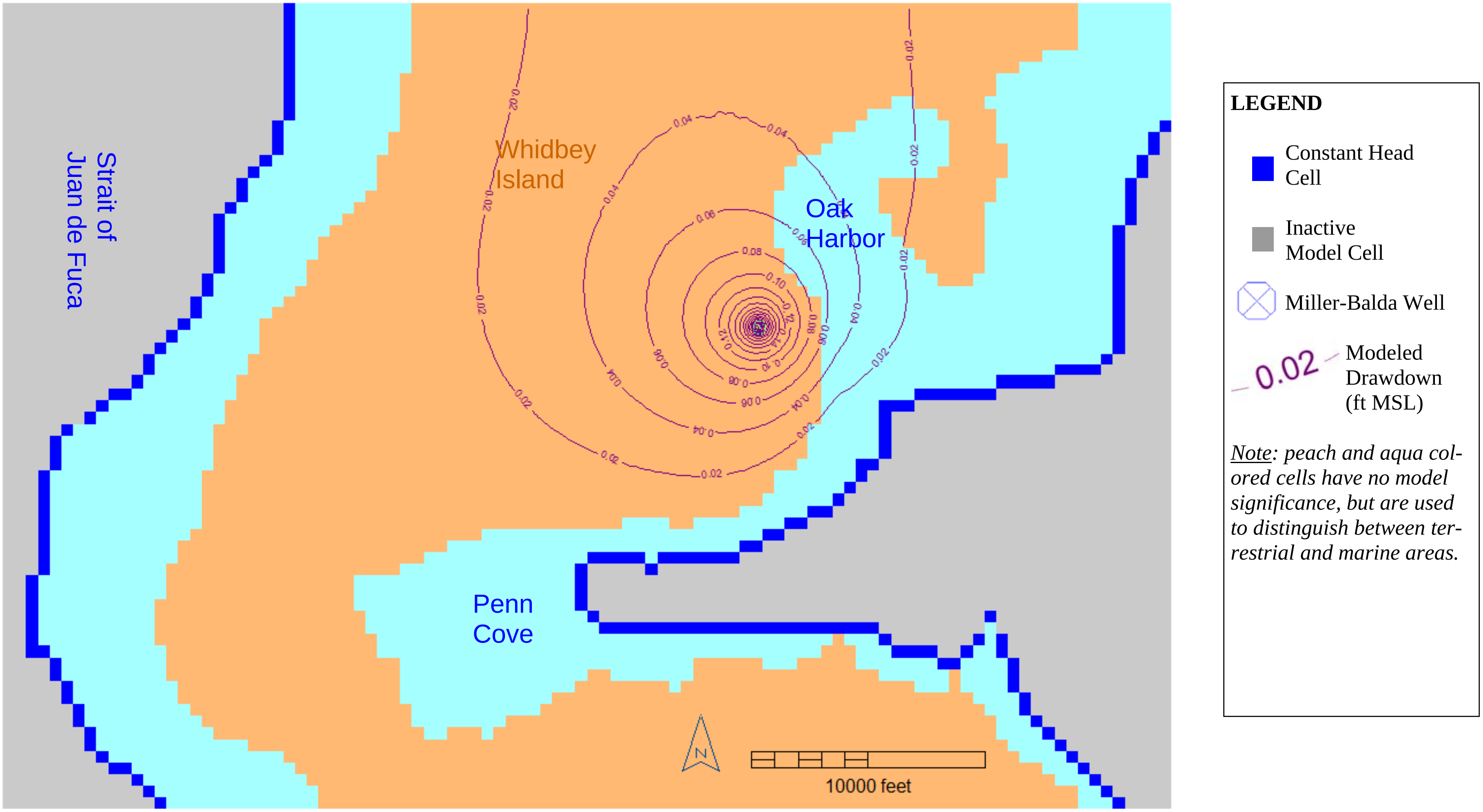


Figure 16b
Model Predicted Drawdown at Maximum Monthly Withdrawal in Model Layer 3 (Aquifer C)

Miller-Balda Water Supply
Hydrogeologic Report

PgG

Appendix A

Miller-Balda Well Log

WATER WELL REPORT

Original & 1st copy – Ecology, 2nd copy – owner, 3rd copy – driller

DEPARTMENT OF ECOLOGY State of Washington

Construction/Decommission *("x" in circle)*

☒ Construction
☐ Decommission *ORIGINAL INSTALLATION*
Notice of Intent Number ____

CURRENT

Notice of Intent No. WE 30431

Unique Ecology Well ID Tag No. BJI 853

Water Right Permit No. ____

Property Owner Name COLIN SMITH BILL MASSEY

Well Street Address 1471 BALDA RD

City OAK HARBOR County Island

Location SW1/4-1/4 NE1/4 Sec 15 Twn 32N R 1 EWM ☒ Or WWM ☐
(s, t, r Still REQUIRED)

Lat/Long
Lat Deg ____ Lat Min/Sec ____
Long Deg ____ Long Min/Sec ____

Tax parcel No. (Required) R13215-330-3290

PROPOSED USE: ☐ Domestic ☐ Industrial ☒ Municipal ☐ DeWater ☐ Irrigation ☐ Test Well ☐ Other ____

TYPE OF WORK: Owner's number of well (if more than one) ____
☒ New well ☐ Reconditioned *Method:* ☐ Dug ☐ Bored ☐ Driven
☐ Deepened ☒ Cable ☐ Rotary ☐ Jetted

DIMENSIONS: Diameter of well 6 inches, drilled 296 ft.
Depth of completed well 296 ft.

CONSTRUCTION DETAILS

Casing Installed: ☒ Welded 6" Diam. from +1.5 ft. to 285 ft.
☐ Liner installed ____" Diam. from ____ ft. to ____ ft.
☐ Threaded ____" Diam. From ____ ft. to ____ ft.

Perforations: ☐ Yes ☒ No
Type of perforator used ____
SIZE of perfs ____ in. by ____ in. and no. of perfs ____ from ____ ft. to ____ ft.

Screens: ☒ Yes ☐ No ☒ K-Pac Location 284
Manufacturer's Name alloy
Type Stainless Model No. ____
Diam. 6 Slot size 10 from 284.5 ft. to 294.5 ft.
Diam. ____ Slot size ____ from ____ ft. to ____ ft.

Gravel/Filter packed: ☐ Yes ☒ No Size of gravel/sand ____
Materials placed from ____ ft. to ____ ft.

Surface Seal: ☒ Yes ☐ No To what depth? 18ft.
Material used in seal Bentonite 3/8 chips
Did any strata contain unusable water? ☐ Yes ☐ No
Type of water? ____ Depth of strata ____
Method of sealing strata off ____

PUMP: Manufacturer's Name ____
Type: ____ H.P. ____

WATER LEVELS: Land-surface elevation above mean sea level 200 ft.
Static level 183 ft. below top of well Date 4/14/18
Artesian pressure ____ lbs. per square inch Date ____
Artesian water is controlled by ____ (cap, valve, etc.)

WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? ☐ Yes ☐ No If yes, by whom? ____
Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.
Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.
Yield: ____ gal./min. with ____ ft. drawdown after ____ hrs.

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ____

Bailer test 10 gal./min. with 5 ft. drawdown after 4 hrs.

Airtest ____ gal./min. with stem set at ____ ft. for ____ hrs.

Artesian flow ____ g.p.m. Date ____

Temperature of water ____ Was a chemical analysis made? ☐ Yes ☒ No

CONSTRUCTION OR DECOMMISSION PROCEDURE

Formation: Describe by color, character, size of material and structure, and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information. (USE ADDITIONAL SHEETS IF NECESSARY.)

MATERIAL	FROM	TO
Top soil	0	2
Brown gravel	2	4
Hardpan	4	30
Gravely clay	30	32
Hardpan	32	56
Clay	56	64
Silty sand	64	87
Sand	87	157
Silty sand	157	160
Clay Grey	160-	182
Sandy clay	182	186
Sand with some water (SL 169)	186	189
Clay	189	193
Silty wet sand	193	201
Clay	201	242
Sandy clay	242	260
Silty sand with water	260	286
Sand	286	294.5
Sandy clay	294.5	296
Wellsite approved by Island County		
Well needs to be test pumped to determen		
total GPM		
1.5 Ft 5" Pipe welded to bottom of screen		
Total lengt of screen 12ft 8"		

Start Date 4/3/18 Completed Date 4/14/2018

WELL CONSTRUCTION CERTIFICATION: I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

☐ Driller ☐ Engineer ☐ Trainee Name (Print) Gerlof Boonstra
Driller/Engineer/Trainee Signature [signature]
Driller or trainee License No. 0038
IF TRAINEE: Driller's License No:
Driller's Signature:

Drilling Company WHIDBEY WELL DRILLERS
Address 716 Holbrook Rd
City, State, Zip Coupeville, WA, 98239
Contractor's Registration No. WHIDBW921RS Date 4/15/2018

ECY 050-1-20 (Rev 02-2010) To request ADA accommodation including materials in a format for the visually impaired, call Ecology Water Resources Program at 360-407-6872. Persons with impaired hearing may call Washington Relay Service at 711. Persons with speech disability may call TTY at 877-833-6341.