Technical Memorandum DRAFT
WRE Committees Technical Support

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From:	Dan Graves, HDR
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Date:	September 18, 2019
Subject:	Consumptive Use Analytical Methods Technical Memorandum (Work Assignment 2, Task 2)

1.0 Introduction

HDR is providing technical support to the Washington State Department of Ecology (Ecology) and the Watershed Restoration and Enhancement (WRE) committees for Water Resource Inventory Areas (WRIAs) 10, 12, 13, 14, and 15. This memorandum provides a summary of the analytical methods proposed for Work Assignment 2 Task 2: Consumptive Use Estimates.

Under RCW 90.94 consumptive water use by permit-exempt (PE) domestic wells must be estimated to establish the water use that watershed restoration plans and plan updates are required to address and offset. Consumptive use is water that evaporates, transpires, is consumed by humans, or otherwise removed from an immediate water environment. Consumptive use estimates have two components, the indoor and outdoor portions of use. The use patterns and consumptive portions of indoor versus outdoor use associated with PE wells are different; therefore, separate approaches are used to estimate these two components of consumptive use.

Ecology has provided recommended guidance for estimating consumptive water use (Ecology 2018).This memorandum outlines the method recommended by Ecology (Section 2.0) and a second method using Water System data to estimate indoor and outdoor consumptive use by permit-exempt well connection (Section 3.0). WRE Committees may select additional methods for estimating consumptive use.

2.0 Department of Ecology Guidance Method

Consumptive use may be calculated by following Ecology's recommended method (Ecology 2018).

2.1 Indoor Consumptive Use – Ecology Method

Ecology Publication 18-11-007 recommends the following assumptions for estimating indoor consumptive water use:

- 60 gallons per day per person within a household
- 2.5 persons per household (or as otherwise defined by the Counties)
- 10 percent of indoor use is consumptively used

- Most homes served by a PE well use septic systems for wastewater. This method assumes 10 percent of water entering the septic system will evaporate out of the septic drain field and the rest will be returned to the groundwater system.

The above assumptions are used to estimate consumptive water use by occupants of a single dwelling unit. Assuming that there is one PE well connection per dwelling unit, a "per PE well connection" consumptive use factor will be applied to the growth projections forecast in each subbasin to determine total indoor consumptive use per subbasin.

2.2 Outdoor Consumptive Use – Ecology Method

The Ecology method of estimating future outdoor water use is based on an estimate of the average outdoor watering area for existing homes served by PE domestic wells. To calculate the consumptive portion of total outdoor water required per parcel/connection over a single growing season, Ecology recommends:

- estimating the average irrigated lawn area (pasture/turf grass) per parcel in each WRIA;
- applying crop irrigation requirements;
- correcting for application efficiency (75 percent efficiency recommended by Ecology guidance) to determine the total outdoor water required over a single growing season; and
- applying a percentage of outdoor water that is assumed to be consumptive (i.e., 80 percent outdoor consumptive use recommended).

Variables used in this analysis can be adjusted based on WRE Committee input.

2.2.2 Estimation of Average Irrigated Area per Connection

HDR will conduct an average irrigable area analysis for each WRIA to account for the variability in average size of irrigated area among parcels in each WRIA. The analysis will include 80 parcels identified as containing a dwelling unit served by a PE well per WRIA. To select the 80 parcels in each WRIA, a "selection pool" of all candidate parcels will be developed. The final 80 will be determined from the selection pool as described below.

2.2.3 Parcel Selection Pool

HDR will populate the selection pool using two methods, depending on available data indicating whether a dwelling unit on a parcel is served with a PE well: direct selection and indirect selection.

Direct Selection: Pierce, Thurston, and King Counties provided geospatial datasets containing individual domestic well locations. These points will be joined to their respective County parcel dataset to isolate the parcels known to be served by a PE well.

Indirect Selection: For Counties that do not have an adequate individual well database, parcels containing a single family domestic dwelling unit, located outside of water system service areas, are assumed to be served by a PE well and added to the selection pool.

Once specific parcels in each County are added to the selection pool, a new parcel dataset for each WRIA will be developed to represent the selection pool in the WRIA frame of reference.

2.2.4 Parcel Selection

Differing socioeconomic landscapes within and between the WRIAs is a key factor influencing variance in the average irrigable area per dwelling unit. HDR will analyze the range and distribution

of property values throughout each WRIA and randomly select 80 parcels representative of the distribution pattern of property values.

2.2.5 Parcel Analysis

A maximum of two technician(s) will conduct the irrigated area analysis to minimize bias. The technician(s) will delineate irrigated lawn areas on each selected parcel using GoogleEarth aerial imagery taken during drier summer months (i.e., July and August). Unirrigated lawns (pasture/turf) go dormant in the dry summer months and turn brown. Areas that remain green in the summer imagery will be considered irrigated. To aid in this determination, aerial imagery from winter months will be reviewed alongside summer imagery to reveal which lawn areas change from green to brown. Those areas that do not change color, or moderately change color but remain green, will be considered irrigated. Additionally, the technician(s) will review imagery across multiple years (where available) to further corroborate the irrigated area delineation.

Yard areas may be obscured in aerial imagery by tree canopies or shadows; the technician will use their best professional judgment to interpolate the irrigated area under a tree canopy or across a shadow.

Septic drain fields are a potential non-irrigation source of water that turf may use to grow and remain green during summer months. Therefore, the technician will consider additional indicators of intentional lawn irrigation such as artificially precise boundaries between green and brown grass, and shapes of green grass indicative of an irrigation system. Irregular shapes and mottled grass will be included or excluded at the discretion of the technician based on nearness to a visible septic system and similarity to other, more pronounced irrigation signatures. Analyses conducted by other WRE planning groups included areas that appear to be “minimally irrigated,” and therefore will be included in this analysis. See Appendix A for additional details concerning the proposed irrigated area delineation analysis.

Upon completion of analysis for 80 parcels, irrigated area will be averaged per subbasin to determine the average irrigated area that will be used in the outdoor consumptive use analysis.

2.2.6 Method Confirmation

HDR will conduct the lawn area irrigation method on all parcels containing single family households within one metered group B water system in each WRIA. This will be performed to compare to results using the methodology described above to estimate outdoor water use.

2.2.7 Irrigation Requirements and Application Efficiency

Once average irrigable acreage per connection is determined for a WRIA, water use will be calculated based on irrigation requirements and application efficiency. Crop irrigation requirements will be estimated for pasture/turf grass from nearby stations as provided in the Washington Irrigation Guide (NRCS-USDA, 1997). An irrigation application efficiency will be applied to account for water that does not reach the turf. Ecology (2018) recommends using a 75 percent application efficiency factor. The consumptive portion of total amount of water used for outdoor use will then assumed to be 80 percent of the total.

3.0 Water System Consumption Data Method

Consumptive use by PE wells and connections may also be estimated using metered connections from water systems. Water systems required to plan per WAC 246-290 must install meters on all customer connections. Smaller water systems that do not have state planning requirements may choose to meter their customer connections if the system bills on a tiered rate structure (i.e., increasing costs per unit of water consumed coincident with higher total use in the billing period).

Some systems bill customers a flat rate (i.e., same bill every month regardless of consumption). The lack of a tiered rate structure reduces the financial incentive to conserve water, which may result in consumption patterns more similar to those observed on a PE well. These systems may or may not choose to meter their customers if meters are not required by law.

3.1 System Selection

Use of data from water systems that measure consumption but bill on a flat rate are preferable for estimating the water use of a PE well. HDR requested water system recommendations from WRE Workgroups and contacted multiple water systems to acquire data. Water system names or data that were provided by WRIA workgroup members include:

WRIA 10: Kapowsin (Pierce County, managed by Valley Water District)

WRIA 12: Spanaway Water District

WRIA 13: Prairie Ridge (Thurston PUD)

WRIA 14: All Mason PUD data

WRIA 15: All Kitsap PUD data combined into a single analysis

3.2 Methodology – Water System Data

3.2.1 Indoor Use

Average daily use in December, January, and February is representative of year-round daily indoor use. Average daily system-wide use is divided by the number of connections (assuming all connections are residential), to determine average daily indoor use per connection. A 10 percent consumptive use factor (or as otherwise decided upon by the WRE Committee) will be applied to the average daily use in the winter months to determine the consumptive portion of indoor water use per connection.

3.2.2 Annual Outdoor Water Use

Average daily indoor use will be multiplied by the number of days in a year to estimate total annual indoor use. Total annual indoor use will be subtracted from total annual use by a water system to estimate total annual outdoor use. An 80 percent consumptive factor (or as otherwise decided upon by the WRE Committee) will be applied to determine the consumptive portion of outdoor use.

3.2.3 Seasonal Outdoor Water Use

Additionally, outdoor consumptive use was estimated on a seasonal basis. The Washington Irrigation Guide reports irrigation requirements between the months of April and September for all weather stations representative of WRIAs 10, 12, 13, 14 and 15, therefore the seasonal outdoor water use was assumed to occur over a period of six months. Average daily indoor use is multiplied by the number of days in the irrigation season to calculate total indoor use for the irrigation season.

Total irrigation season indoor use is subtracted from total season use to determine total outdoor use for the irrigation season. An 80 percent consumptive factor (or as otherwise decided upon by the WRE Committee) will be applied to determine the consumptive portion of outdoor use.

3.3 Additional Data

Kitsap PUD noted a 2014 USGS study by Welch, Frans, and Olsen titled *Hydrogeologic Framework, Groundwater Movement and Water Budget of the Kitsap Peninsula, West-Central Washington*. This study included a survey of consumption from select water utilities, and differentiated between the indoor and outdoor portions of use. Kitsap PUD used these estimates of indoor and outdoor use to develop an additional estimate of consumptive use per PE well connection in WRIA 15.

Ecology contracted with a consultant to conduct an exempt well metering program in 2012–2013 (Einberger et al 2014). The study provides information about the parcels included in the study, including summaries of average annual indoor and outdoor daily use per property. The results of this study can be compared to the results of the various water system analyses to determine if rate structures have a significant impact on water use, and if a correction factor is needed for systems that bill on a tiered rate.

4.0 Sources

DeOreo, W., Mayer, P., Dziegielewski, B., Kiefer, J. 2016. *Residential End Uses of Water, Version 2*. Water Research Foundation, Report #4309b.

Dunn, A. B. and A. Neff., 2018. *Potential Consumptive Use Impacts of Domestic Groundwater Permit-Exempt Wells Over the Next 20 Years in WRIA 1 – Version 2 Technical Memorandum*. RH2 Engineering.

Ecology. 2018. *Recommendations for Water Use Estimates*. Washington State Department of Ecology, Publication 18-11-007.

Einberger, C., C. Pitre, and D. Banton, D. 2014. *Skagit County Exempt Well Metering Program – 2012-2013 Technical Memorandum*. Washington State Department of Ecology.

Natural Resource Conservation Service, 1997. Washington Irrigation Guide (WAIG). U.S. Department of Agriculture.

Welch, W.B, L.M. Frans, and T.D. Olsen. 2014. *Hydrogeologic Framework, Groundwater Movement and Water Budget of the Kitsap Peninsula, West-Central Washington*, Scientific Investigation Report 2014-5106.

Appendix A

Proposed Irrigated Area Estimation Method

Preliminary Analysis - Methodology and Results (9/18/2019)

1. The GIS technician selected four sample parcels from the WRIA 13 parcel selection pool to draft preliminary delineations. Parcels that displayed a range of potential irrigation situations (e.g., unirrigated lawns, lawns requiring tree/shadow interpolations, minimally irrigated area) were selected for the preliminary analysis.
2. Polygons were created in Google Earth representing the irrigated area within a given tax parcel. The GIS technician made several judgments and assumptions:
    a. Landscaped shrub/flower bed areas within a larger irrigated footprint were included. Shrub and flower bed areas outside of the irrigated footprint were excluded.
    b. If the irrigated area extends beyond the parcel boundary, those areas will be included.
    c. Parcels with no visible signs of irrigation were tracked as zero irrigated footprint.
    d. Areas that appeared to be native forest or unmaintained grass were not included in the irrigated footprint.
    e. Parcels with homes under construction in the most recent Google Earth imagery were excluded from the analysis.
    f. New construction due to additional dwelling units (ADUs) will not be counted.

    The following examples illustrate example delineations.

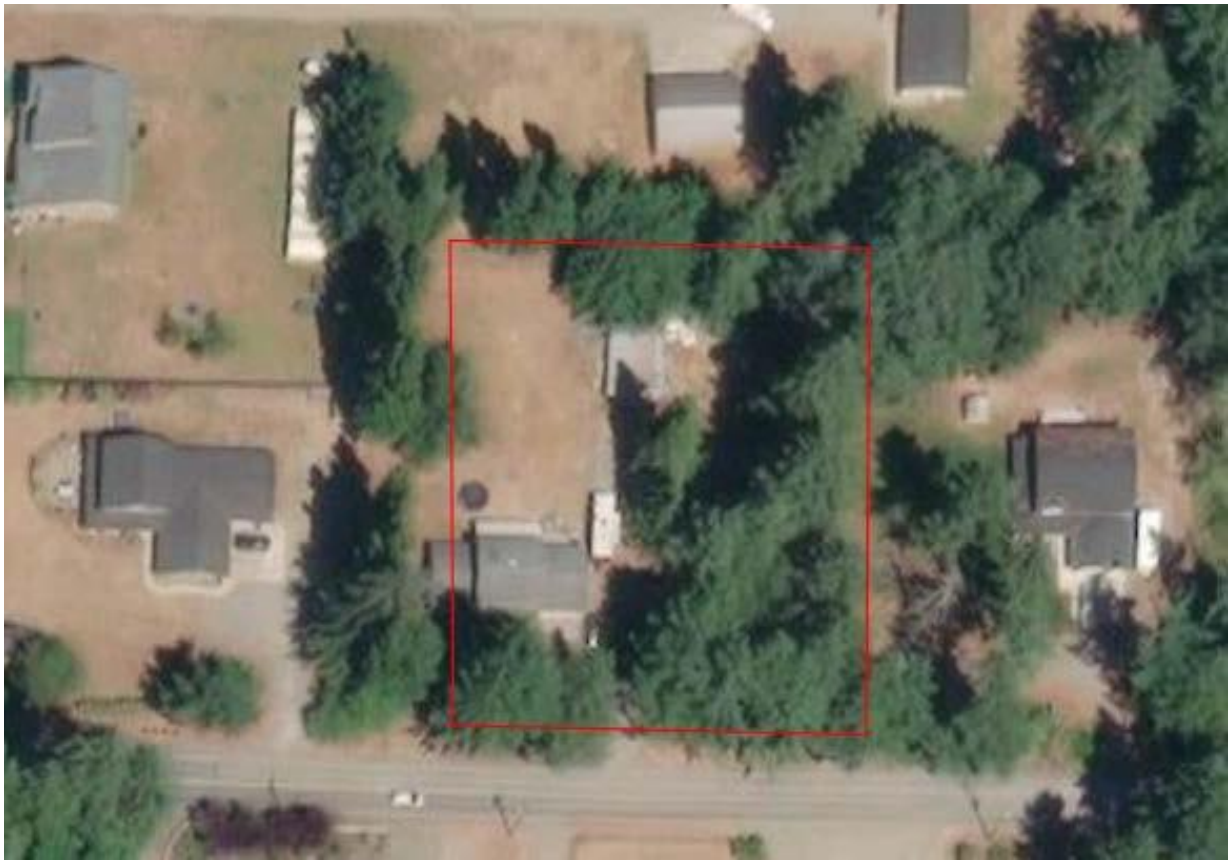

Figure 1. No irrigated areas visible in most recent google earth aerial imagery.

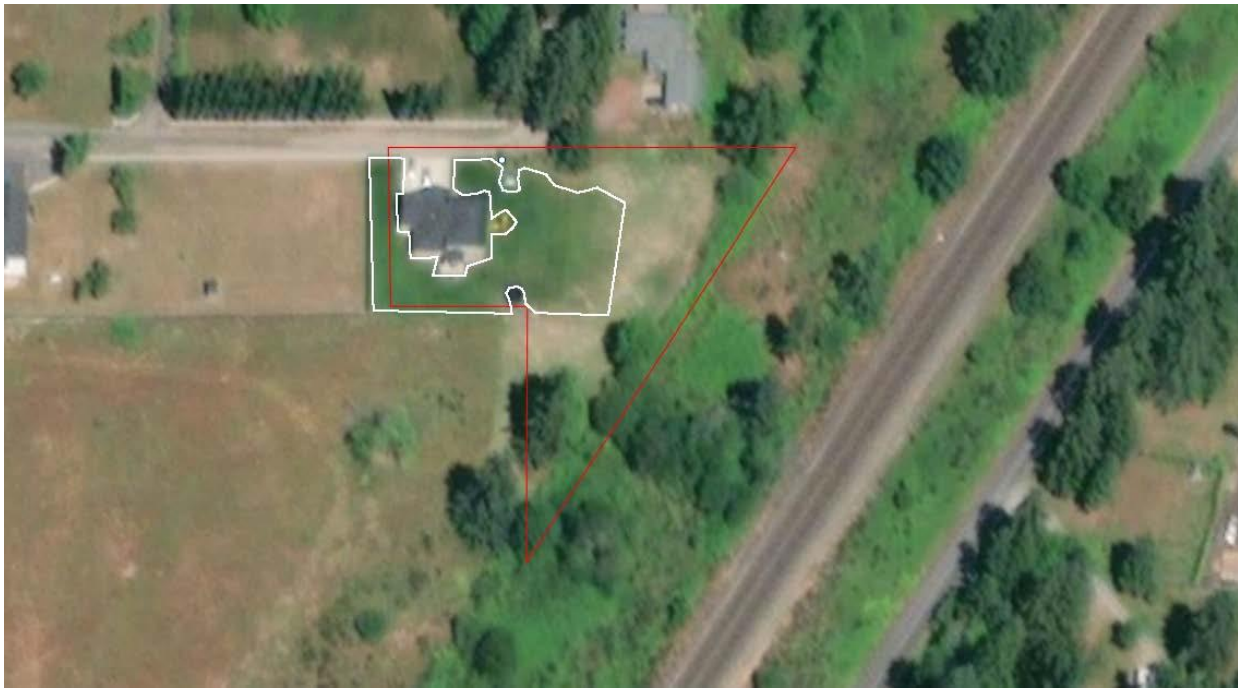

Figure 2. Area in white includes maintained grass. Residence constructed between June 2017 and July 2018. Therefore, historical irrigation of property is unavailable in GoogleEarth imagery.

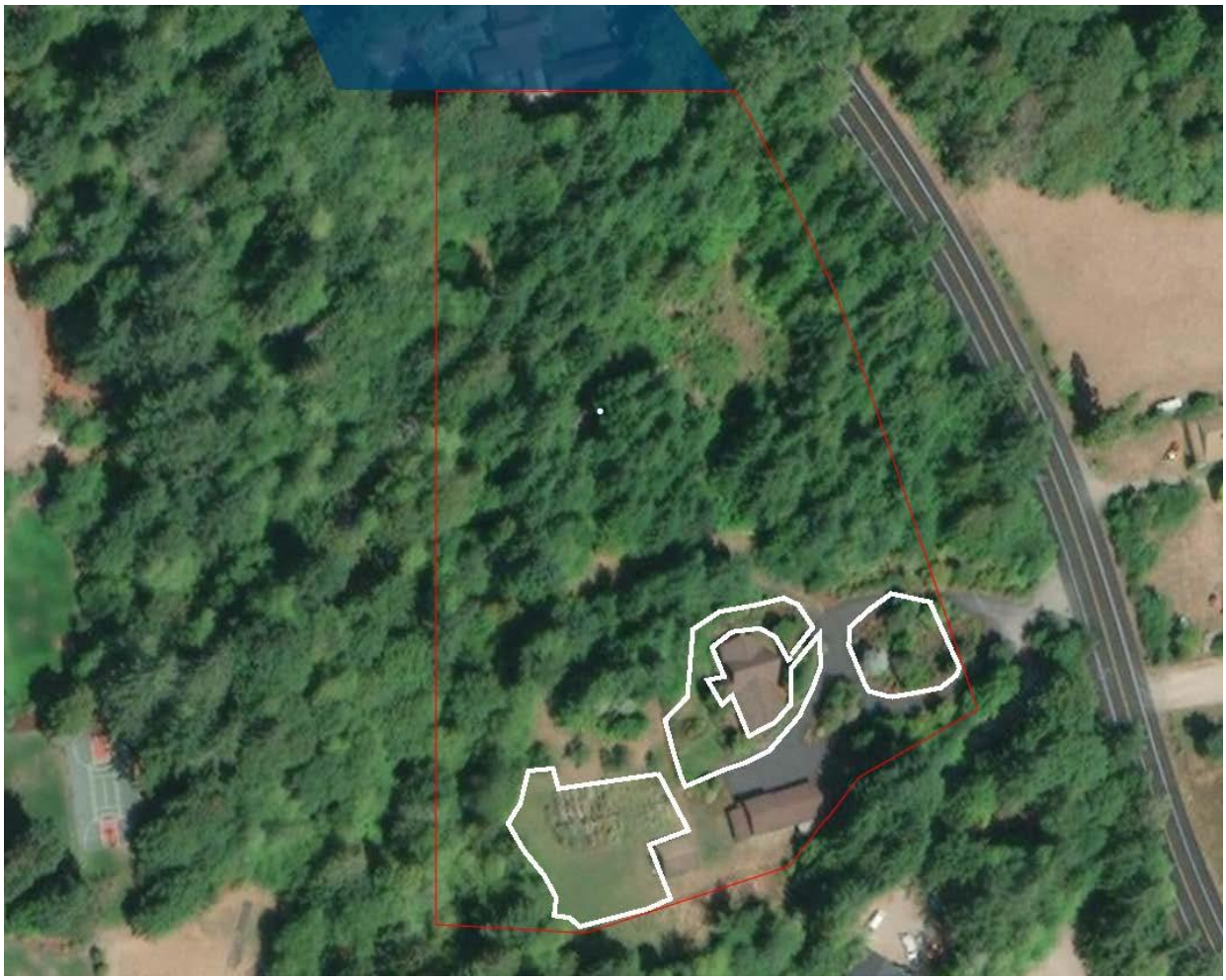

Figure 3. Irrigated area includes landscaped area in driveway, maintained yard around residence, garden area, and maintained grass near garden area.

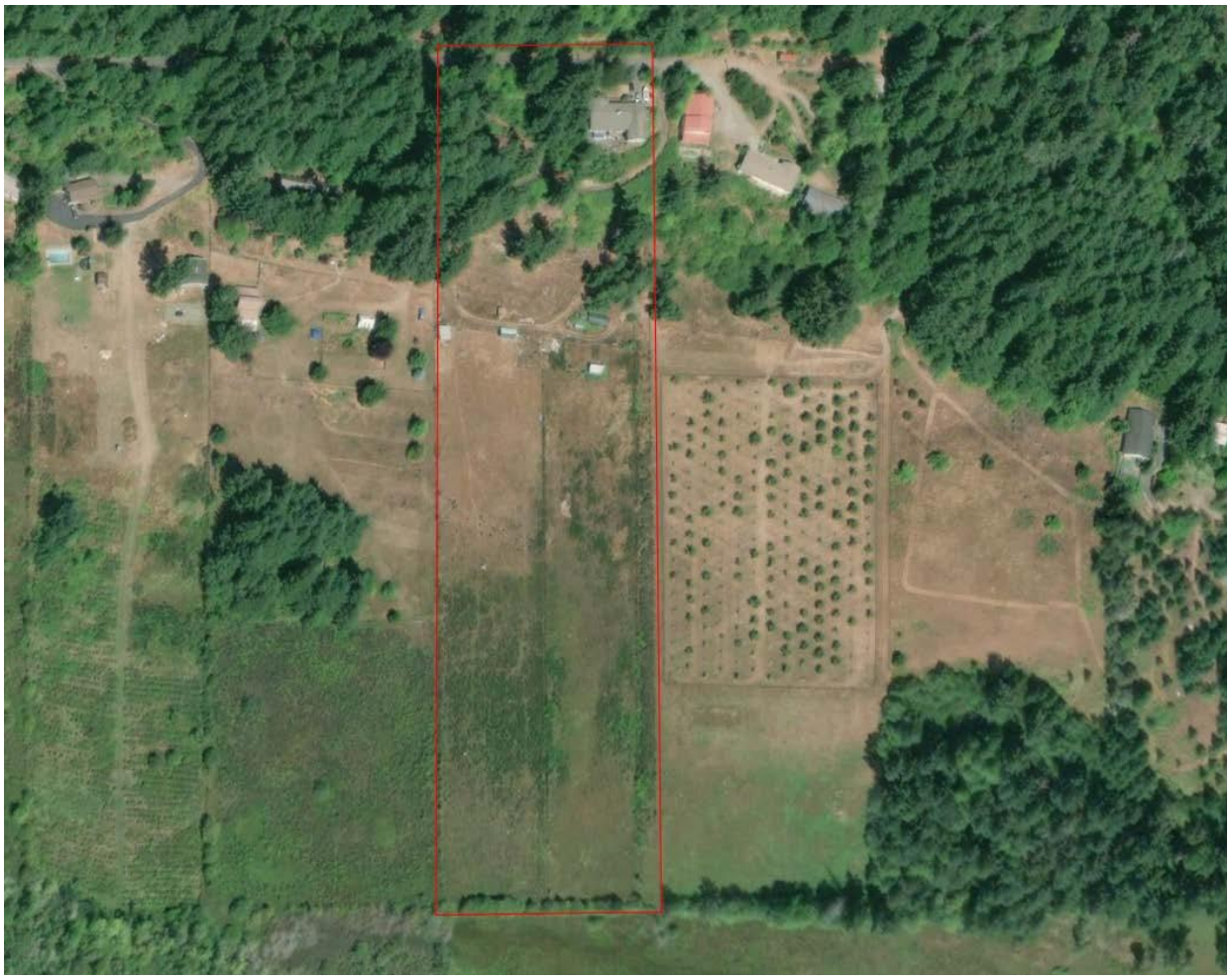

Figure 4. No irrigated area. Assumption that green vegeation on southern portion of parcel is due to proximity to Spurgeon Creek since clear delineation of irrigated area is not present on aerial. Green area near residence appears to be tree and shrubs, not maintained landscaping and is excluded.

Next Steps

1. Upon Ecology approval of methodology and delineation protocol, HDR will expand the parcel selection to the 80 proposed parcels for each WRIA, and conduct the full analysis, which will result in the final irrigated area estimation for each WRIA.
2. The Google Earth polygons will be imported (KMZ) into GIS, where acreages and summary statistics for the irrigated areas will be calculated.