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Guidance for Aquifer Storage and Recovery AKART Analysis and Overriding Consideration of the Public Interest Demonstration

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Table of Contents

List of Tables

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Abstract/Executive Summary

The purpose of this document is twofold:

1. Provide guidance to Reservoir Permit applicants of Aquifer Storage and Recovery (ASR) projects on the analysis of All Known, Available and Reasonable methods of prevention, control and Treatment (AKART) and when an Overriding Consideration of the Public Interest (OCPI) benefits analysis is considered to meet the Water Quality Standards for Ground Waters of the State of Washington, Chapter 173-200 WAC.

2. Assist Water Quality Program reviewers in the AKART and OCPI determination approval process.

Because a guidance document cannot define AKART, three examples of past decisions on ASR AKART and OCPI determinations are provided with the pertinent information to either complete or review an analysis.

Introduction

Aquifer storage and recovery (ASR) projects increase existing water supplies by artificially recharging groundwater. Typically, some portion of the recharged water is eventually recovered for beneficial use. ASR can be an effective tool to help increase the availability of water during the summer months by capturing surface water and storing the water during times of the year when stream flows are higher and water demands are less.

This guidance covers ASR projects that recharge directly into an aquifer by way of a well. ASR projects that store water in an aquifer for later recovery require a Reservoir Permit issued by Ecology's Water Resource Program. A review by the Water Quality Program (WQP) is required when the concentration of contaminants in the recharge water exceed the Water Quality Standards for Ground Waters of the State of Washington, Chapter 173-200 WAC (GWQS) at some point during the recharge cycle. Groundwater samples are collected at the recharge point, in the aquifer (storage), during recovery; and or at down-gradient wells. Overriding consideration of public interest (OCPI) is a part of the antidegradation policy of WAC 173-200 that allows GWQS exceedances when site specific conditions are met. ASR proponents can submit an all known, available, and reasonable methods of prevention, control, and treatment (AKART) analysis in addition to the project benefits analysis in support of a determination of whether a project is in the OCPI.

The reservoir permit examples discussed in this document were issued to municipalities to store water in an aquifer. The municipalities use their existing drinking water infrastructure to pump the source water (recharge water) to the ASR recharge well(s). The water for recharge is surface water treated and disinfected to drinking water quality standards. Three municipal ASR project examples are provided, the City of Yakima, Kennewick and Walla Walla and include the elements considered for their AKART and OCPI determinations.

Common contaminants of concern with ASR projects are Disinfection ByProducts (DBPs). If the recharge water contains organic matter, DBPs can form during the disinfection process by a reaction between organic matter (and bromide) and the disinfectant. A disinfectant residual is required in the drinking water distribution lines which can also affect the concentration of DBPs in the water. Once recharged in the aquifer, if chlorine is used as the disinfectant, DBP concentrations may also increase if chlorine is present in the recharge water.

The term overriding consideration of the public interest and overriding public interest are used in many Ecology regulations. For example RCW 90.54 uses the term overriding consideration of the public interest. The GWQS uses both of the terms, overriding consideration of the public interest and the term overriding public interest, however, the term overriding considerations of the public interest is used in this document based on RCW 90.54 and the GWQS.

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Purpose and Scope

The purpose of this document is to provide information to both ASR proponents to complete an ASR AKART and benefits analysis when an OCPI is considered to meet the Water Quality Standards for Ground Waters of the State of Washington, Chapter 173-200 WAC and to Water Quality Program reviewers to assist in the approval process. The source of the recharge water is municipal drinking water.

The scope of this guidance is to provide information to complete an ASR AKART analysis and an OCPI determination for projects not in compliance with the Ground Water Quality Standards, and to assist water quality reviewers in the approval process.

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Regulatory Overview for ASR projects

Law and Regulations Governing ASR Projects

Federal Statues

- Safe Drinking Water Act. https://www.epa.gov/sdwa.

State Statues

- RCW 90.03.370, Reservoir Permits Underground artificial storage and recovery Project standards and rules. http://app.leg.wa.gov/RCW/default.aspx?cite=90.03.370
- RCW 90.48, Water Pollution Control State Regulations, http://app.leg.wa.gov/RCW/default.aspx?cite=90.48
- RCW 90.54, Water Resources Act of 1971, http://app.leg.wa.gov/RCW/default.aspx?cite=90.54
- Underground Artificial Storage and Recovery, chapter 173-157 WAC, https://fortress.wa.gov/ecy/publications/SummaryPages/173157.html
- Water Quality Standards for Ground Waters of the State of Washington, Chapter 173-200 WAC (GWQS), https://fortress.wa.gov/ecy/publications/SummaryPages/173200.html
- Underground Injection Control (UIC) wells, through Chapter 173-218 WAC, https://fortress.wa.gov/ecy/publications/SummaryPages/173218.html

The federal Safe Drinking Water Act (SDWA) protects drinking water and public drinking water sources. Requirements in the SDWA are intended to prevent contamination of underground sources of drinking water from injection wells.

RCW 90.03.370's definition of "reservoir" includes "any naturally occurring underground geological formation where water is collected and stored for subsequent use as part of an underground artificial storage and recovery project". This allows Ecology to issue reservoir permits to authorize ASR projects. Before a reservoir permit can be issued, this law requires any adverse impacts in an underground reservoir be addressed, such as chemical compatibility of surface waters and groundwater and environmental impacts.

RCW 90.48 requires all known available and reasonable methods to prevent and control pollution to discharges to waters of the state, including groundwater.

The Underground Artificial Storage and Recovery rule, Chapter 173-157 WAC outlines the standards for review of ASR proposals, and sets standards for mitigation of any adverse impacts. The rule requires the following information for the reservoir permit:

- A pilot study
- Hydrogeologic system conceptual model
- Project operation plan
- Legal framework
- Environmental assessment and analysis
- A project mitigation plan (if required)
- Project monitoring plan.

See Appendix A for a description of the required information for each of the items submitted with a reservoir permit application.

WAC 173-157 -200 How will the department issue reservoir permits and/or secondary permits for ASR projects?

> (1) The department will process applications for permits for ASR projects in accordance with the provisions of RCW 90.03.250 through 90.03.320, RCW 90.03.370, chapter 173-152 WAC and this chapter.
>
> (2) The department shall give strong consideration to the overriding public interest in its evaluation of compliance with ground water quality protection standards.

The Water Quality Standards for Ground Waters of the State of Washington, Chapter 173-200 WAC (GWQS), establish the standards for ASR projects when groundwater quality exceedances will occur in the ASR cycle. Sections Chapter 173-200-030 and 050-(3)(b)(vi) are the pertinent references. Water Resource and Water Quality Program memo, see Appendix B, outlines the approach the Water Quality Program will use to approve an ASR project through OCPI.

WAC 173-200-030(2) Antidegradation policy.

> (c) Whenever ground waters are of a higher quality than the criteria assigned for said waters, the existing water quality shall be protected, and contaminants that will reduce the existing quality thereof shall not be allowed to enter such waters, except in those instances where it can be demonstrated to the department's satisfaction that:
>
> (i) An overriding consideration of the public interest will be served; and
>
> (ii) All contaminants proposed for entry into said ground waters shall be provided with all known, available, and reasonable methods of prevention, control, and treatment prior to entry.

Antidegradation is implemented by establishing enforcement limits within a permit to account for site specific conditions, including back ground groundwater quality. An enforcement limit is assigned to any contaminant to regulate and to protect existing groundwater quality and prevent groundwater pollution, WAC 173-200-050(1). The GWQS include six exceptions which allow an enforcement limit to exceed the criterion. The sixth exception, WAC 173-200-050(3) (b) (vi), has applied to ASR projects.

WAC 173-200-050(3) (b) (vi) may allow enforcement limits to exceed a criterion for an activity up to five years with reconsideration of the following occurring every five years:

A. The activity provides a greater benefit to the environment as a whole and to protect other media such as air, surface water, soil, or sediments;
B. The activity has been demonstrated to be in the overriding public interest of human health and the environment;
C. The department selects, from a variety of control technologies available that minimize impacts to all affected media;
D. The action has been approved by the director of the department or his/her designee.

Along with the rule requirements presented here, if OCPI is recommended, the Water Quality Program regional section supervisor prepares a memo for the Water Quality Program Manager's signature comparing the issues and the benefits and includes any required conditions or control technologies. The signed memo is then sent to the Water Resource Program's Manager.

Washington has primacy to regulate discharges into Underground Injection Control (UIC) wells, through Chapter 173-218 WAC. An ASR well is considered a UIC well. To use a UIC well in Washington, registration is required and the discharge must be rule authorized as described in 173-218 WAC or a discharge permit is required. The discharge permit requirements will be captured in the reservoir Permit.

ASR Projects Inject Water Treated to the Drinking Water Quality Standards but the Water Must Meet the Ground Water Quality Standards in the Recharge Cycle(s)

Municipal ASR projects may utilize their drinking water infrastructure to deliver water to the recharge well(s). In at least two of the existing ASR programs the recharge well is also a municipal drinking water supply well. In those instances the source of the recharge water is surface water, treated at the drinking water treatment plant, and then pumped through the water distribution system to the water supply well/recharge well. That water is treated to the Safe Drinking Water Act standards by complying with Washington's Drinking Water Quality Standards, chapter 246-290 (DWQS) in the system; however, based on WAC 173-157 ASR, WAC 173-200 GWQS, and WAC 173-218 UIC Program, reservoir permits require the water quality to meet the GWQS not the DWQS.

The DWQS differ from the GWQS when regulating disinfection by products (DBPs). The DWQS regulate DBPs as total concentrations; trihalomethanes (THMs) and haloacetic acids (HAAs), while the GWQS established criterion for only some of the individual DBPs, see Table 1.

Table 1. Comparison of Disinfection Byproduct Criterion in the DWQS and the GWQS.

Regulated Contaminant	Department of Health Maximum Contaminant Level (MCL)	GWQS
Haloacetic acids (HAAs)	60 ug/l	-
Monochloroacetic acid		-
Dichloroacetic acid		-
Trichloroacetic		-
Bromoacetic acid		-
Dibromoacetic acid		-
B Bromate (plants that use ozone)	0.010 mg/l	-
Chlorite (plants that use chlorine dioxide)	1.0 mg/l	-
Total trihalomethanes (TTHM)	80 ug/l	-
Chloroform		7.0 ug/l
Bromodichloromethane		0.3 ug/l
Dibromochloromethane		-
Bromoform		5 ug/l
Regulated Disinfectants		-
Chlorine as Cl_2	4.0 mg/l as Cl_2	-
Chloramines as Cl_2	4.0 mg/l as Cl_2	-
Chlorine dioxide	0.8 mg/l	-

During the ASR review it is common for the question to come up that if the recharge water meets the DWQS, and the water is good enough for human consumption, why does it have to meet the GWQS? The answer stems from the different purposes of the two regulations (see Appendix C for more information):

- DWQS are used to ensure that the public water supply is acceptable for drinking and other consumptive uses at the point of use.
- GWQS are discharge standards and protect existing ambient groundwater conditions and support all beneficial uses.

The criteria for the two different regulations were also determined differently:

- The DWQS maximum contaminant levels (MCL) are the highest level of a contaminant allowed in drinking water. These enforceable standards are set as close as possible to the MCL goal, the maximum level of a contaminant in drinking water where no known or anticipated adverse effect on the health of an individual occur. MCL goals are non-enforceable public health goals and the limits of detection and treatment technology effectiveness were not factors considered when the goals were set. However, when MCLs are decided, the best available treatment technology and costs are factors taken into consideration (EPA 2012).
- The GWQS standards criteria were chosen as the most conservative of the following three criteria: the DWQS MCL, the DWQS MCL goal, and the concentration anticipated to result in a one in a million cancer risk. Treatment technology and cost were not factors considered when determining the GWQS criteria.

Contaminants of Concern

The predominant contaminants of concern for ASR projects are DBPs; however, inorganic parameters, such as arsenic, can differ between surface and groundwater quality. Chlorine too can be a contaminant of concern.

The Safe Drinking Water Act requires the Environmental Protection Agency (EPA) to establish minimum standards to protect human health by setting limits of contaminants in drinking water provided by public systems. Currently the EPA Disinfectants and Disinfection Byproduct Rules (DBPR) regulate haloacetic acids (HAAs), trihalomethanes (THMs), and disinfectants. Disinfectant concentrations are regulated to protect human health and to maintain a disinfectant residual in the water system to meet compliance with maximum contaminant levels (MCLs) (EPA 2006). HAAs and THMs are classified by the EPA as potentially carcinogenic (Thomas 2000).

DBPs are formed during the disinfection process when a disinfectant, such as chlorine, chloramines, chlorine dioxide, or oxone, reacts with natural organic matter [measured as total organic carbon (TOC)] and or inorganic matter, such as bromide. The DBPs that can form are THMs, HAAs, chlorite and bromate (Wu 2010). One THM, chloroform, can also form from the degradation of the HAA, trichloroacetic acid (Windholz (ed) 1976). THMs are the most common DBP.

DBP formation can occur at a treatment plant, in a drinking water distribution system, as well as, in an aquifer. Drinking water distribution systems are required to maintain a chlorine residual in their systems. For example, during two of the City of Yakima's recharge cycles, the chlorine residual was detected in the aquifer for approximately one month after recharge. Once the residual chlorine was depleted DBP formation ceased (Golder 2015).

The reduction-oxidation conditions of water can affect the stability of DBPs. THM degradation occurs in anaerobic conditions or by biologic degradation due to cometabolism. Cometabolism is dependent on the reduction-oxidation conditions and the microbes present in an aquifer (Bertrand, 2010). Brominated THMs degrade in anoxic environments and haloacetic acids degrade in aerobic conditions by hydrolysis while THMs are usually stable and persistent (Fram, 2003).

Recharge can also affect the reduction-oxidation conditions of an aquifer which can lead to mobilization of metals.

Dispersion, dilution, and mixing in the aquifer were considered the main factors for the decline of THM concentrations in the Yakima aquifer during storage (Golder 2015).

All Known, Available, and Reasonable Methods of Prevention, Control, and Treatment (AKART)

The Administrative Procedures Act at Chapter 34.05.010 (16) states, establishing requirements for an industry, such as defining AKART, is considered a "rule," (personal communication, B. Moore). Therefore, this guidance document cannot define AKART but lists the required information for an AKART analysis and describes the information considered for past water quality approvals for OCPI. Three ASR project examples are provided in this document and they describe the factors that were considered to meet AKART and OCPI determination.

AKART must be determined on a facility-by-facility basis to determine whether the "reasonable" part of AKART has been met through an economic analysis.

AKART can be met even when an enforcement limit is exceeded [Ecology 2016(a)]. If a preliminary reservoir permit is issued and includes enforcement limits, and exceedances occur, a compliance schedule (or the components of one) can be added to the final reservoir permit.

The AKART analysis is a separate document from the reservoir permit application documents. Although an ASR proponent's permit application may include some of the information, it should be restated in the AKART analysis or include a complete reference.

AKART analysis examines the current treatment processes and compares alternative treatment methods, benefits, costs and associated risks in regard to reducing contaminant concentrations in the recharge water.

Additional information on AKART can be found in Ecology's Water Quality Program Permit Writer's Manual, Chapter 4, at https://fortress.wa.gov/ecy/publications/SummaryPages/92109.html.

The following are factors to consider for an AKART analysis for an ASR project injecting water treated to drinking water standards and when the formation of DBPs are a concern. Several factors can affect the formation of DBPs (WU 2010; Drinking Water Research 2010):

- Type of disinfectant: chlorine, monochloramine, chlorine dioxide, ozone and UV irradiation. Ozone and UV radiation have high efficacy rates but do not provide a disinfectant residual in the distribution system (Westerhoff 2006).
- Residence time in the distribution system. Older/stagnant water is associated with higher DBP concentrations (loss of chlorine residual to DBP production). Flushing of systems removes organics and sediments as well.
- Disinfectant dosage and contact time. The longer the disinfectant is in contact with TOC or bromide the higher the rate of DBP formation (Westerhoff 2006)
- Type and concentration of DBP precursors/natural organic matter (NOM).

- The lower the NOM concentration the lower the rate of DBP formation. Greater than 5 mg/l of TOC is considered a high level of TOC for ASR projects (Singer, 2006). Many water treatment plants control DBP formation by reducing DBP precursors by coagulation or filtration.
- There are two types of NOM, hydrophobic (water repelling) and hydrophilic fractions. The hydrophobic are composed of primarily humic material that is reactive to oxidants/chlorine. The hydrophobic humic material tend to form higher THM levels. The hydrophilic (water absorbing) fraction of organic matter is a relatively poor THM precursor (E. U. EPA). Several parameters, including total and dissolved organic carbon and UV absorbance at a 254 nm wavelength, can be used to assess the concentration and NOM types in water. The City of Walla Walla measured UV_{254} to characterize their TTHM formation (HDR 2011).

- Disinfection point in distribution system. It is advantageous to chlorinate water later in the treatment process.
- pH and water temperature. THM formation decreases and HAAs increase with a lower pH.

Required Elements for an AKART and the overriding consideration of the public interest determination analysis

An analysis to determine if the GWQS are met will identify and evaluate water treatment and infrastructure alternatives available to reduce the environmental risks of the project. The analysis must be based on existing and available treatability data and the provisions within WAC 173-200 such as overriding public interest, establishing appropriate enforcement limits, and point of compliance. The elements are organized into three categories: Water Quality Evaluation, AKART Determination Analysis and an OCPI determination evaluation:

Water Quality Evaluation

This evaluation should provide:

- Background groundwater water quality at the test well based upon;
  - Recharge water quality data, obtained from the Washington State Department of Health's drinking water System database, Sentry Internet, http://www.doh.wa.gov/DataandStatisticalReports/EnvironmentalHealth/DrinkingWaterSystemData, which contains summary information on public drinking water systems including water quality data.
  - Results from a minimum of eight representative samples to determine background conditions, see GWQS Implementation Guidance, https://fortress.wa.gov/ecy/publications/SummaryPages/9602.html

Evaluate Water Quality to:

- Compare project source water quality to ground water standards (WAC 173-200-040);
- Identify any data gaps;
- Evaluate the comparability of water treatment plant samples to distal distribution system water quality samples.
- Evaluate existing water quality information from City records and assess whether seasonal variability (during the anticipated recharge season) will require additional source water characterization, and;
- Identify any constituents that exceed background groundwater water quality.

Evaluate Geochemical Compatibility to:

- Evaluate the potential for water-water and rock-water interactions; Assess potential of metal leaching in the aquifer.
- Estimate recovered water quality and compare that to drinking water standards;
- Assess the potential for down gradient changes in water quality by:
  - Utilizing the conceptual model (see Appendix A) to determine changes in the aquifer system with supporting data. Estimate the potential area impacted by the ASR cycles. A key question will be whether the recharge water migrate from the storage zone prior to recovery or captured during recovery?
  - Predicting the rate at which the recharge water could reach any down-gradient water supply wells. [City of Yakima's draft reservoir permit included a 90% annual recovery of recharge volume leaving 10% of recharged water in the aquifer (quantity could change if permit is amended)] [Ecology 2016(b)].
- Identify any changes in background or groundwater criteria exceedances, including those caused by the introduction of oxygenated water in the aquifer.
- Assess the time-dependency/persistence of contaminants introduced and water quality changes in the aquifer. Reservoir permits do not allow the removal of the total volume of recharged water from the aquifer; 10% on a year by year basis, must be left in the aquifer.

AKART

This evaluation should:

Evaluate Treatment Methods/Technologies

- Identify and evaluate treatment methods/technologies capable of removing constituents that exceed background groundwater quality prior to recharge. This evaluation will be based on treatment methods/technologies that will be identified as viable options for the City's ASR project.
- Estimate the degree of contaminant reduction provided by each viable treatment method/technology option, and;
- Identify the viable options that could effectively reduce contaminant levels to acceptable levels.

Prepare Cost Estimates

- To evaluate viable option(s) for wellhead treatment based on treatment methods/technologies identified as described above. Cost estimates will include the following:
  - Capital costs
  - Operation and maintenance
  - Observation wells and monitoring/sampling program.

OCPI Determination

This evaluation should:

Identify Potential Receptors

- Review well logs to identify wells completed at depths/elevations similar to the injection zones, and to determine the ground water gradient and flow direction in the target storage zone near the test well site. A brief analytical evaluation of mixing through dispersion, vertical continuity, and the potential for attenuation in the subsurface will be completed to assess whether down gradient wells are likely to experience analyte concentration increases above background because of ASR operations.

Compare Alternative Strategies to Treatment Methods/Technologies

- Evaluate other strategies/approaches for meeting water quality criteria and the State's antidegradation policy. Compare these alternatives to the treatment methods/technologies identified previously. This section will include a comparison of the following alternatives:
  - Pre-recharge treatment.
  - Overriding public interest.
  - Alternative point of compliance and monitoring.

When a water quality enforcement limit is allowed to exceed a criterion, then WAC 173-200-050(3)(b)(vi) must be addressed if not already captured in the previously listed elements:

Include a recommendation to meet compliance with the GWQS:

- Develop a recommendation that identifies the preferred alternative from those identified and compared above. The recommendation should be based on a discussion of the balance of costs and risks to protecting background water quality.

Overriding Consideration of the Public Interest Determinations

The GWQS provide mechanisms, on a case by case basis, that allow a discharge to occur even with concentrations that exceed criteria. As previously stated, the antidegradation policy allows for "contaminants that will reduce the existing quality" to be discharged only when overriding consideration of the public interest will be served and AKART will be applied to the water prior to entry into groundwater.

To meet the overriding public interest threshold, a project proponent must minimize the risk by meeting AKART. Ecology can make a determination of overriding public interest only when AKART is met, the project benefits exceed the potential risks, and the remaining risks are identified as part of an analysis.

The Implementation Guidance for the Ground Water Quality Standards, Publication # 96-02, https://fortress.wa.gov/ecy/publications/SummaryPages/9602.html, states if high quality ground water cannot be maintained and a discharge will also cause a violation of any of the GWQS, then overriding consideration of public interest must be demonstrated through one of the following:

- An alleviation of a public health concern,
- A net improvement to the environment, or
- Socioeconomic benefits to the community.

Detailed justifications, and not generalizations, are required for a recommendation of overriding public interest.

Three examples of overriding consideration of the public interest determination

Three municipalities have prepared an AKART and benefits analysis for overriding consideration of public interest review: city of Yakima, city of Walla Walla, and the city of Kennewick. The elements considered for the Water Quality Program approval of these are listed below. Appendix E includes copies of the memos from Ecology's Water Quality Program to the Water Resources Program to recommend overriding consideration of public interest for the three cities.

City of Yakima [Ecology 2016(a)]

- THMs were likely to be present in the recharge water and could accumulate in the aquifer if the recharge water was not withdrawn from the aquifer. Dilution and or groundwater migration were the leading factors for THM reduction in the aquifer.
- The project met AKART but did not meet the enforcements limits of the temporary reservoir permit.

- The risk of introducing DBPs into the aquifer and to the down-gradient water well users were minimized because of:
  - Multiple water rights associated with water wells constructed in the storage zone and or areas with hydraulic connectivity could remove or hydraulically control the movement of the recharge water from leaving the city property boundaries.
  - The draft reservoir permit included suspending recharge if the enforcement limits were exceeded two consecutive times at the point of compliance, at the recharge well head prior to recharge, until more protective methods were in place to bring contaminant concentrations into compliance. If DBP concentrations exceeded enforcements limits in down-gradient wells, then recharge would have been discontinued.
  - A minimal number of water supply wells were constructed in the down-gradient portions of the storage aquifer and all wells were municipally owned or used for irrigation. Drinking water treatment, if needed, would have occurred at the drinking water wells prior to use.
  - The Yakima River is the eastern boundary of the recharge basin. USGS studies determined shallow groundwater provided the majority of the baseflow to the river and not the deeper aquifer used for ASR storage (Vaccaro 2011).
- The temporary permit enforcement limits were exceeded in the recharge storage and recovery periods during 3 recharge events. Components of a compliance schedule were added to the draft reservoir permit to address reduction of DBP concentrations to meet the enforcement limits and to determine the effects of the multiple water rights utilization on the recharged water.
- GWQS require permit review every five years, 173-200 050 (3)(b)(v)
- The compliance point was at the recharge well head prior to recharge;
- Detailed environmental benefits were included in the final AKART analysis, see Appendix E Aerobic conditions were present in the storage aquifer. THM degradation conditions, anaerobic environment and or bacteria to enable cometabolic degradation, were not present.
- Washington State Department of Health commented and agreed upon allowance of DBP concentrations in the recharge water up to one half the DWQS totals.
- Monitoring wells were not in close proximity to the recharge wells. New wells were cost prohibitive to drill and construct.
- Limited impact to other media. Chloroform absorbs poorly to soil, especially one with low organic carbon content. If chloroform reaches the Yakima River, the volatilization half-life is 3.5 hours.

City of Walla Walla [Ecology 2014(a)]

- THMs and arsenic were likely to be present in the recharge water and could accumulate in the aquifer. Dilution and or groundwater migration were the leading factors for THM reduction in the aquifer.
- Environmental risk was minimized due to improvements proposed to their municipal water treatment system (from draft reservoir permit):
  - Installation of a slow sand filter for biofiltration (reduce THM precursors prior to treatment).

  - Reducing the use of ozone for disinfection (to adjust pH, and decrease availability of chlorine for THMs production).
  - Changing disinfection method from injection of chlorine gas to liquid hypochlorite addition.
- The recharge would be suspended if the THM concentration in water withdrawn from the recharge wells exceeded 40 ug/l.
- Quarterly monitoring was required for chloroform, anions, and cations in the distribution system and down gradient water wells.
- Initial two year review of the project performance and water quality outcomes.
- Monitoring wells were not in close proximity to the recharge wells. New well construction was cost prohibitive.

City of Kennewick (Ecology 2012)

- DBPs and arsenic were likely to exceed the GWQS and the background groundwater levels of the storage aquifer.
- AKART was met by reducing arsenic and DBP concentrations to the maximum extent feasible by following WA DOH and US EPA’s guidance requirements for drinking water protection. Filtration was used to remove organic carbon precursors prior to disinfection and the chlorine level was carefully managed to minimize the chlorine residual in the system.
- No drinking water wells were completed in the target ASR aquifer impacted by the project.

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Appendices

Appendix A. Reservoir Permit Application Required Documents

The majority of the Reservoir Permit application documents are needed to complete an AKART analysis. A description summary is listed below, for more detail see WAC 173-157, https://fortress.wa.gov/ecy/publications/SummaryPages/173157.html.

Table A-1. WAC 173-157-120 through 173-157-170 Reservoir Permit application required documents: Pilot Study Findings.

Hydrogeologic system (conceptual model)	(1)	Properties of aquifer targeted for storage
	(2)	Estimated groundwater flow direction and rate of movement
	(3)	Anticipated changes to groundwater system due to ASR activities
	(4)	Area impacted by project
	(5)	General geologic conditions including stratigraphy and structure
	(6)	Existing natural hazards
	(7)	Surface water conditions
	(8)	Locations of all wells or other sources of groundwater in the affected area
	(9)	Source water and receiving aquifer quality and water compatibility
Project Operation Plan	(1)	Recharge water availability, quantity and times of year
	(2)	Recharge and recovery rates and durations
	(3)	Storage period
	(4)	Proposed recharge and recovery facilities; location, number, and capacity
	(5)	Variability in source water quality and reliability
	(6)	Water treatment methods to meet GWQS
	(7)	Plan if discharge is to surface water
	(8)	Operation and maintenance plans to manage suspended sediment from ASR well
	(9)	Discharge permitting and destination for flushing water
Legal Framework	(1)	Project water rights documentation
	(2)	Other water rights in ASR project area
	(3)	Instream flows or stream closures within ASR project area
	(4)	Ownership and control of project facilities
Environmental Assessment and Analysis	(1)	Environmental aspects of ASR project area; contaminated areas, land uses, wetland habitat, flood plains, surface water bodies or springs
	(2)	Adverse impacts to slope stability, wetlands, flood plains, ground deformation, surface water bodies or springs
	(3)	If past environmental assessment completed, reference the document.
Mitigation Plan	(1)	Mitigation plan actions to be taken to prevent adverse impacts to the environment
Project Monitoring Plan (for pilot and operation phases)	(1)	Time intervals for sampling and subsequent reporting
	(2)	Measurement methods, threshold values and evaluation techniques to determine water quality of source and receiving waters, quantity injected, aquifer elevation changes, recoverable water available over time, to evaluate effectiveness of mitigation, and other necessary monitoring data. Source and recharge water testing MDL should be at or below the GWQS criteria
	(3)	Monitoring report

Appendix B. WQ and WR Programs Program Management Team Agreement on implementing Overriding Public Interest within the ASR Reservoir Permit process

Aquifer Storage and Recovery (ASR) Projects and Overriding Public Interest (OCPI)

ISSUE: Water Resources Program (WRP) put the following language in their ASR Rule. They approached Water Quality Program (WQP) to figure out how to implement this section in a way that is consistent with how WQ would make a similar decision. It is likely that the only viable option on some ASR projects would include an OCPI determination and injection of water that exceeds groundwater quality standards. So WRP wants to know more about how WQP would approve such project (if you would/could at all), and how/what we (or the applicant) should do to get there.

> WAC 173-157-200 How will the department issue reservoir permits and/or secondary permits for ASR projects?
>
> (1) The department will process applications for permits for ASR projects in accordance with the provisions of RCW 90.03.250 through 90.03.320, RCW 90.03.370, chapter 173-152 WAC and this chapter.
>
> (2) The department shall give strong consideration to the overriding public interest in its evaluation of compliance with ground water quality protection standards.

ASR projects are permitted by the WRP. A waste discharge permit is not usually issued. It is extremely important that Water Quality and Water Resources Programs work closely at all stages of a demonstration of overriding public interest for an ASR project.

Projects that require or use chlorine disinfection of the source water prior to discharging into the groundwater will produce disinfection byproducts that will most likely violate the ground water standards. The following ASR projects in Walla Walla, Kennewick, and White Salmon may require Ecology/WQP approval of OCPI because of disinfection byproducts. The Groundwater guidance states the Director or their designee can approve OCPI.

The Hydrogeologist work group met with WRP and came up with the following recommendations that need WQP approval:

At the regional staff level, WQP and WRP staff work with project proponent to address water quality issues.

- Project proponent completes AKART analysis for any identified issues: Likely examine water treatment process to determine best way to meet all applicable requirements, (likely to include WDOH drinking water MCLs which include a minimum chlorine residual). If after AKART analysis, it is not possible to meet GWQC, must ensure that contaminants are minimized to the maximum extent reasonable.

- Identify any potential receptors.
- Identify project benefits.
- Identify all other important factors for consideration
- WAC 173-200-050(3)(b)(vi) allows enforcement limits exceeding the GWQC where
  - (A): Greater benefit to the environment as a whole and to protect other media such as air, surface water, soil, or sediment,
  - (B): Activity is in the overriding consideration of the public interest of human health and the environment, and
  - (C): Department selects from a variety of control technologies that minimize impacts to all media.

If overriding public interest is recommended, the WQP regional section supervisor prepares a memo for the WQP Manager's signature comparing the issues and the benefits; include any required conditions or control technologies. Memo concludes that project will meet standards for overriding consideration of public interest, if conditions and control technologies are met. The signed memo is then sent to the WRP Manager.

Appendix C. Comparison of the Drinking Water Quality Standards (DWQS) WAC 246-290 and the Ground Water Quality Standards (GWQS) WAC 173-200 [Ecology. 2014(b)]

The DWQS and the GWQS have different goals:

- DWQS are used to ensure that the public water supply is acceptable for drinking and other consumptive uses at the point of use.
- GWQS are discharge standards and protect existing ambient groundwater conditions and support all beneficial uses.

The criteria were determined differently too:

- The DWQS maximum contaminant levels (MCL) (highest level of a contaminant allowed in drinking water) were set as close as possible to the MCL goal (where no known or anticipated adverse effect on the health of an individual occur) as feasible using the best available treatment technology and taking cost into the consideration (EPA 2012).
- The GWQS standards criteria was chosen as the most conservative of the 3 criteria; MCL, MCLG, and the concentration anticipated to result in a 1 in a million cancer risk. Treatment technology and cost were not factors considered when determining the criteria.

Antidegradation within the GWQS but not the DWQS:

- The GWQS include an antidegradation policy which is mandated by RCW 90.48.10 and RCW 90.54.020(3).
- The antidegradation policy is designed to ensure the protection of the state’s groundwater and the natural environment. Background ground water quality is protected and considered when discharge enforcement limits are determined. In most cases the enforcement limit would be less than the GWQS criteria except when background is greater than the criteria.
- If drinking water concentrations reach the DWQS criteria this would allow degradation of groundwater quality. The current groundwater standards goal is to maintain levels at or below the standards and not allow degradation up to the standard.

Antidegradation and overriding public interest

- Current state water law asserts that “Wastes shall not be allowed to enter state waters which will reduce the quality thereof, except in those situations where it is clear the overriding considerations of the public interest will be served (RCW 90.54.020).
- The groundwater standards include an antidegradation policy which is mandated by RCW 90.48.10 and RCW 90.54.020(3)

- Overriding consideration of the public interest (OCPI) is a part of the antidegradation policy that allows exceedances of the groundwater standards under certain site specific situations.

- Potential for degradation of groundwater up to the standard if DWQS applied.
    - A potential for degradation of ambient groundwater quality up to the standard exists if the drinking water standards are substituted for the groundwater standards and antidegradation is assumed to be met regardless of which standard is used, antidegradation is critical to protecting ambient conditions. A statistical evaluation (GAO, 1988) of nationwide data indicated:
        - The beneficial use of drinking water protects other uses such as
            - Irrigation of crops
            - Livestock watering
        - Aquatic life is not protected
            - GWQS MCLs for 17 of the substances are more stringent than the DWQS (true in Washington)
            - Groundwater often provides recharge to surface water.

Table C-1. Statistical Evaluation of Different Standards

Standard	Quality better than the drinking water standard	Percent of groundwater that could be degraded if antidegradation did not protect ambient conditions and drinking water standards were only used
MCL	92%	92%
MCLG	71%	71%
$1X10^{-6}$ cancer risk	43%	43%
Aquatic life	67%	67%

Narrative Standards

- GWQS include a narrative standard for any contaminant. The GWQS's narrative standard addresses any contaminant which would affect a beneficial use, not just those specifically listed as criteria in the WAC.

- The DWQS only regulate those contaminants with an MCL (maximum contaminant level). Contaminants with no MCL would be allowed to be injected using the drinking water standards (for example, the DBPs: Bromodichloromethane, bromoform, dibromochloromethane, chloroform)

Table C-2. Differences between the DWQS and the GWQS.

Element	Definition	Groundwater Quality Standards	Drinking Water Standards
		Chapter 173-200 WAC	Chapter 246-290 WAC
Goal		Protect existing groundwater quality	Ensure public water is safe to drink
Level of protection		• All beneficial uses • Human health • Protect the natural environment	Human health
Basis	MCL takes into account health effects, treatment technologies and cost of treatment. MCLGs are no observable health effects.	• Numeric criteria (MCLs, MCLGs, 1 in a million cancer risk, whichever is most stringent) • Antidegradation • AKART	MCLs
Regulated contaminants		More extensive list of criteria than drinking water. MCLs, MCLGs, carcinogens, any contaminant that would degrade a beneficial use.	MCLs
Narrative standards	Includes any contaminant besides those specifically listed	Yes	No
Antidegradation	Protect existing groundwater, prevent degradation up to the standard	Yes	No
Beneficial Uses		Drinking water Irrigated crops Livestock watering Aquatic life	Drinking water (stringent enough to also protect irrigation and livestock, but not aquatic life)

Appendix D. City of Yakima ASR Sampling Regime

Table D-1. Water Quality Analytical Requirements.
(from Yakima Record of Examination for ASR, R4-34552)

Analyte Group/Analyte	Units	MCL	Analytical Method
Alkalinity	mg CaCO3/L		SM2320B
Ammonia	mg/L as N		SM4500NH3G
Bicarbonate	mg/L as CaCO3		SM2320B
Carbonate	mg/L as CaCO3		SM2320B
Chloride	mg/L	250	EPA 300.0
Fluoride	mg/L	1	EPA 300.0
Hardness	mg CaCO3/L		EPA 200.8
Nitrate+Nitrite (total N)	mg/L as N	10	EPA 300.0
Nitrate-N	mg/L as N	10	EPA 300.0
Nitrite-N	mg/L as N	1	EPA 300.0
Orthophosphate as P	mg/L		EPA 300.0
Silica (as SiO2)	mg/L		EPA 200.8
Sulfate	mg/L	250 (SMCL)	EPA 300.0
Sulfide	mg/L		SM4500S2F
Total Metals			
Arsenic	mg/L	0.01	EPA 200.8
Calcium	mg/L		EPA 200.8
Iron	mg/L	0.3 (SMCL)	EPA 200.8
Magnesium	mg/L		EPA 200.8
Manganese	mg/L	0.05 (SMCL)	EPA 200.8
Potassium	mg/L		EPA 200.8
Disinfection BY Products (DBPs) & Residual Disinfectants			
Bromate	mg/L	0.01	EPA 300.1
Chlorite	mg/L	1	EPA 300.1
Residual Chlorine	mg/L	4	SM 4500CL-G
Bromodichloromethane	µg/L		EPA 524.2
Bromoform	µg/L		EPA 524.2
Chloroform	µg/L	70	EPA 524.2
Dibromochloromethane	µg/L		EPA 524.2
Total Trihalomethane (TTHM)	µg/L	80	EPA 524.2
Dibromoacetic Acid	µg/L		SM6251B
Dichloroacetic Acid	µg/L		SM6251B
Monobromoacetic Acid	µg/L		SM6251B
Monochloroacetic Acid	µg/L		SM6251B
Trichloroacetic Acid	µg/L		SM6251B
Total Haloacetic Acids	µg/L	60	SM6251B
General Chemistry			
Chemical Oxygen Demand	mg/L		EPA 410.4
Color	Color units	15	SM 2120B
Corrosivity (S.U.)	Standard units		Langelier Index
Dissolved Organic Carbon	mg/L		SM 5310C
Total Dissolved Solids	mg/L	500 (SMCL)	SM 2540C

Analyte Group/Analyte	Units	MCL	Analytical Method
Total Organic Carbon	mg/L		SM5310C
Total Suspended Solids	mg/L		SM 2540D
Turbidity	NTU	1/5	EPA 180.1
pH	pH units	6.5 to 8.5	EPA 150.1
Specific Conductance	µS/cm	700 (SMCL)	EPA 120.1
Oxidation-Reduction Potential	millivolts		SM 2580B

Example of Water Quality Monitoring Framework

Water Quality Monitoring at ASR Wells (Table 4 of City of Yakima Report of Examinations for ASR)			
Period	**Location**	**Frequency**	**Analyte List**
Pre Recharge	All ASR wells	Prior to Injection.	GC[1], FP[2]
Recharge[3]	Source water at recharge wells	0-2%, 40-60%, 80-100%[4] Of recharged volume	GC[5],DBPs[6], FP
Storage[7]	Each well used for recharge in last period	Mid-storage, end of storage.[8]	DBPs, FP
Recovery[9]	Each well used for recharge in current year	1-2%, 40-60%, 90-100%, 150-250% Withdrawal of recharge volume.	GC, FP

GC = Geochemical suite, including inorganics, selected total metals, disinfection by-products, and general chemistry listed in Table 5.

[2] FC = Field parameters, includes temperature, pH, DO, specific conductance, and ORP.

[3] The recharge period is defined as the time the City is injecting water into the aquifer, including intermittent shutdowns. The period ends when the City stops injecting water for the recharge season.

[4] 40-60% sample only required if recharge period is anticipated to go beyond 30 days.

[5] GC sample only required on 0-2% sample.

[6] DPBs are listed in Table 5.

[7] The storage period is defined as the time after recharge ends and before recovery begins within an annual cycle.

[8] A minimum of 1 sample shall be collected at end of storage period if storage is less than 30 days and additional 1 per month for storage periods greater than 30 days.

[9] The recovery period begins when an ASR well is used regularly following an annual storage period, including intermittent shutdowns.

Appendix E. Ecology’s Water Quality Program Memos, Overriding Public Interest Determination, to the Water Resource Program for the City of Yakima, City of Walla Walla, and the City of Kennewick

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
PO Box 47600 • Olympia, WA 98504-7600 • 360-407-6000
711 for Washington Relay Service • Persons with a speech disability can call 877-833-6341

March 7, 2016

TO:	Tom Tebb Director of the Office of Columbia River
FROM:	Heather Bartlett Water Quality Program Manager
RE:	Overriding Public Interest Determination for the City of Yakima's Aquifer Storage and Recovery Project

Attached to this cover sheet is a memo from the Water Quality Program (WQP) supporting an overriding public interest (OPI) determination for the City of Yakima's Aquifer Storage and Recovery (ASR) Project, Reservoir Permit R4-34552. This OPI determination was prepared in coordination with the Water Resources Program and was based on the July 27, 2010 WQP document, *Aquifer Storage and Recovery (ASR) Projects and Overriding Public Interest,* see attached. Meeting the enforcement limits of the Temporary Reservoir Permit R4-34552 for disinfection byproducts in the recharged water, one-half of the Drinking Water Quality standards, was a condition in the OPI determination process. The enforcement limits were exceeded; therefore, a compliance schedule is warranted, and is a condition of this recommendation, to be included in the reservoir permit. The City of Yakima's ASR project will meet standards for overriding consideration of public interest, if the conditions of the permit are met.

The analysis completed for this determination included data collected from three recharge cycles, water quality and source control data from the City of Yakima's municipal water supply systems, hydrogeologic reports, chlorine disinfection related research reports, consultations with the Water Quality Program hydrogeologists and permit managers, and the Department of Health Office of Drinking Water.

The OPI determination process considers the environmental, and health risks, and the benefits of the ASR project, and compliance with regulatory requirements. The environmental benefits outweigh the risks as long as the conditions of the permit are implemented.

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
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March 7, 2016

TO: Heather Bartlett
Water Quality Program, Manager

THROUGH: Don Seeberger,
Water Quality Program, Deputy Manager

FROM: Mary Shaleen Hansen
UIC Coordinator
Watershed Management Section

RE: Recommendations for overriding public interest determination for the City of Yakima's Aquifer Storage and Recovery Reservoir Permit R4-34552

Summary:

The City of Yakima (City) has applied for a reservoir permit to construct a reservoir for underground aquifer storage and recovery (ASR) of water for beneficial uses. The reservoir is located in the Upper Ellensburg formation aquifer within the Ahtanum-Moxee Sub-basin of the Yakima River Basin. The source water for recharge (source water) is surface water diverted from the Naches River during low demand periods and treated to drinking water standards. Disinfection byproducts (DBPs) are formed during the water treatment process.

As part of the permit process, the Washington State Department of Ecology's Water Quality Program (Ecology) reviewed the ASR documents for compliance with the Water Quality Standards for Ground Waters of the State of Washington, Chapter 173-200 WAC (GWQS). Our review indicates that the project is likely to exceed the GWQS for disinfection byproducts (DBPs).

The GWQS allow criteria exceedences when 173-200-50 (3) (b) (vi) can be met. The City's ASR documents demonstrate that 173-200-050-(3) (b) (vi) have been met, however a compliance schedule is warranted because the enforcement limits of the Temporary Reservoir Permit R4-34552 (Temporary Permit) were exceeded (Golder 2015d). Also, if the enforcement limits of Temporary Permit were applied to the two pilot studies, exceedences would have occurred during one of the two studies.

This document demonstrates the findings to recommend the authorization of Reservoir Permit R4-34552 for ASR under the conditions set forth in this memo and Reservoir Permit R4-34552.

City of Yakima,
ASR reservoir permit application
Ahtanum Valley of the Yakima River Basin
March 7, 2016

Regulatory framework

The Underground Artificial Storage and Recovery, chapter 173-157 WAC, and the Water Quality Standards for Ground Waters of the State of Washington, Chapter 173-200 WAC (GWQS), establish the standards for ASR projects when groundwater quality impact mitigation options are needed:

WAC 173-157-200. How will the department issue reservoir permits and/or secondary permits for ASR projects?

> *(1) The department will process applications for permits for ASR projects in accordance with the provisions of RCW 90.03.250 through 90.03.320, RCW 90.03.370, chapter 173-152 WAC and this chapter.*
> *(2) The department shall give strong consideration to the overriding public interest in its evaluation of compliance with ground water quality protection standards.*

WAC173-200-050(3) (b) (vi) may allow enforcement limits to exceed a criterion when:

> *(A) The activity provides a greater benefit to the environment as a whole and to protect other media such as air, surface water, soil, or sediments;*
> *(B) The activity has been demonstrated to be in the overriding public interest of human health and the environment;*
> *(C) The department selects, from a variety of control technologies available that minimize impacts to all affected media;*

The City's ASR project recharges drinking water quality water into a groundwater aquifer. Drinking water providers must meet the requirements of the Safe Drinking Water Act by complying with Washington's Drinking Water Quality Standards, chapter 246-290 (DWQS) which differ from the GWQS that regulate discharges to groundwater. For this recommendation, DBPs, are the concerns. The DWQS regulate DBPs as totals; total trihalomethanes (THMs) and total haloacetic acids (HAAs), while the GWQS established criterion for only some of the individual DBPs. However, when a criterion is not established in the GWQS, the practical quantification limit can be used as the enforcement limit in groundwater.

Washington has primacy to regulate discharges into Underground Injection Control (UIC) wells, through Chapter 173-218 WAC. An ASR well is considered a UIC well. UIC wells must be registered, and the discharge must meet the non-endangerment standard as described in 173-218WAC or a discharge permit is required to use the well. The City of Yakima's Gardner and Kissel wells are registered with Ecology. The discharge permit requirements will be captured in Reservoir Permit R4-34552.

Background

Surface waters in the Yakima River Basin are currently under adjudication and new water rights are not available. The 1905 Reclamation Enabling Act authorized construction of the six major federal reservoirs in the basin and included withdrawal of all forms of further appropriation of unappropriated surface water in the Yakima River Basin. Legal actions in 1945 established the framework of how water demands are managed - nonproratable and proratable water rights (Vaccaro 2009). During drought years the junior water right holders (post 1905) will have their water rights prorated.

Rivers in the Yakima River Basin depend on groundwater for baseflow during summer months. Permits for groundwater uses were put on hold, and indicate that future groundwater water rights may be limited, or not available (Ecology 2014a). Recurring drought and potential climate change affects have increased awareness of the risk of not maintaining a reliable water supply source. The Yakima Basin Integrated Water Resource Management Plan was developed to address the current and future water supply issues. The City's ASR project is one element of this plan.

The City operates two water systems: a municipal drinking water, and a raw water irrigation system. Both systems divert water from the Naches River. The Naches River is the primary source of drinking water for the City: up to 25 million gallons per day are diverted for drinking water use (Golder 2014b). Once diverted, the water is treated at the Naches River Water Treatment Plant. The City also has four groundwater wells as a backup source to the surface water system.

The City depends on groundwater for their drinking water supply when the Naches River's diversion from the river is compromised due to unfavorable water quality (turbidity), low instream conditions requiring prorationing of water rights are in place, or winter conditions prevent water intake.

Treated surface water will be the source water for the City's ASR project. The ASR operation will transmit the treated source water through their water supply distribution lines to city-owned drinking water supply well(s) to recharge into the Upper Ellensburg formation aquifer.

The City's ASR Program will include using the Kissel and Gardner wells, both owned by the City, and installing a third well in the southeast area of the City for recharge of 3,000 gallons per minute (gpm), per well (up to 6 months of the year during low demand conditions), for a total of 9,600 acre feet per year. The intent is to recover water from the aquifer during drought, or pro-rationing years, to alleviate diversions from the river. Between 2000 and 2013 pro-rationing occurred on the average of once every 3 years. Using this as a basis, the recharged water would be pumped from the aquifer every 3 years to augment the City's drinking water supply (Golder 2014c).

To date, three recharge events were completed; two as pilot studies, and the third was authorized under the Temporary Permit.

The Hydrogeologic Setting

The ASR project is located west of the Yakima River (Ahtanum Valley) in the Ahtanum-Moxee sub-basin within the Yakima River Basin. The Yakima River Basin was formed when area wide folding and faulting of the rock and sediments created anticlinal and synclinal structures (Yakima Fold Belt), forming the ridge and valley features of the basin (Jones 2006).

The Ahtanum Valley is an east-west trending valley bounded by the Yakima Ridge to the north, the Ahtanum Ridge and Rattlesnake Hills to the south, and the Yakima River to the east.

The Ahtanum Valley hydrogeology includes a surficial aquifer consisting of alluvial sediments, underlain by the Upper Ellensburg Formation, including the Thorpe Gravel, which lies on top of the Saddle Mountain Basalt formation of the Columbia River Basalt Group.

The recharge reservoir is predominantly within the lower unit of Upper Ellensburg Formation (Golder 2014c). The Upper Ellensburg Formation is a semi-consolidated sandstone that fills most of the basin and is described as three stratigraphic units: the upper member consists of hundreds of feet of gravels and clays. The intermediate zone is considered a confining layer comprised of clays and silts, and is considered continuous across the basin (Golder 2000). The lower unit includes sandstone, shale, or conglomerate and unconsolidated sediments.

The three Upper Ellensburg Formation units and the Saddle Mountain Basalt are all important groundwater producing units. The lower portion of the Upper Ellensburg Formation is presumed to have semi-connected water producing zones with different confining pressures, (Golder 2001). The Saddle Mountain Basalt aquifer discharges to the overlying Ellensburg formation in some areas of the basin. The Upper Ellensburg formation thickness ranges from 400 to 1,000 feet thick between the Gardner and Kissel recharge wells, and the Yakima River.

Groundwater recharge is derived from rainfall, snowmelt, and irrigation. The water sources for river water aquifer exchanges are primarily very recent water, and young shallow groundwater. Shallow groundwater and surface water have a different isotopic composition than deep well water. The isotopic composition of surface and ground water indicate the river receives only a small amount of water from the deep flow system (Vaccaro 2011).

The groundwater flow system in the Ellensburg Formation is compartmentalized due to topography and geologic structure (Vaccaro 2009).

The general groundwater flow direction is from the ridge crests towards the center of the valley, and then eastward toward the Yakima River (Golder 2000) to discharge at Union Gap. The lateral groundwater movement is generally greater within the shallower depths then the deeper flow zone (Vaccaro 2009). The addition of irrigation water in the basin affects water levels and flow direction in the surficial hydrogeologic units (Vaccaro 2009).

Groundwater conditions have changed in some of the confined flowing artesian wells in the consolidated hydrogeologic units (lower unit of the Upper Ellensburg formation) within the Ahtanum-Moxee sub-basin (USGS, 2009, page 48). One example is the Kissel well, where pressure was 72 feet above ground surface (artesian) in 1961, and declined to 60 feet below ground surface in 2014 (Golder 2014c).

Groundwater Use

The majority of the USGS hydrogeologic research for this area reports on the Yakima River Basin as a whole, and the following will help describe groundwater use in the Ahtanum Valley. In 2001, there were approximately 2,800 groundwater rights in the Yakima River Basin associated with wells that could withdraw an annual total of 530,000 acre-feet of water. Approximately 60 percent of total pumpage was used for irrigation supply (Vaccaro 2006), and 20 percent for public water and domestic supply (Vaccaro, Jones, 2009). More than 20,000 water wells are recorded within the six basins of the Yakima River Basin. Seventy percent are shallower then 250 feet (Vaccaro 2011). The ASR reservoir is located at a greater depth than the majority of the water supply wells in the sub-basin. The cost of constructing deeper wells has prevented many from being drilled.

Water supply wells constructed in the lower member of the Upper Ellensburg Formation, the recharge area of the aquifer, are few, with the majority being municipally owned. Only 10 wells have been recorded that were drilled through the intermediate zone into the lower member of the Upper Ellensburg Formation (Golder 2014c).

ASR activities are expected to change the regional groundwater level by less than 10 feet (Golder 2014c).

Groundwater and Recharge Water Quality

Source water and groundwater quality are similar and geochemically compatible for recharge and storage (Golder 2014d). GWQS considers the background groundwater quality and the contaminant criteria when protecting groundwater quality. Six inorganic contaminants in the source water exceeded background groundwater quality but did not exceed the GWQS criteria. Of the six, total organic carbon (TOC) is a concern because it reacts with chlorine creating DBPs. The DWQS require a chlorine residual in the City's drinking water system. DBPs exceed the GWQS and are contaminants of concern in the source water.

The DBPs that exceed background groundwater quality and the GWQS criteria are the THMs; chloroform, bromodichloromethane, and dibromochloromethane, and the HAAs, dichloacetic and trichloroacetic acids. HAAs, specifically, trichloroacetic acid, can degrade to chloroform (Golder 2001and J. Maroncelli). Trichloroacetic acid should be considered a contaminant of concern.

AKART

The all known, available and reasonable methods of prevention, control and treatment (AKART) analysis examined the current water treatment processes and compared them to alternative treatment methods, benefits, costs, and associated risks in regard to reducing DBPs. The Naches River drinking water treatment plant uses coagulation and flocculation through the addition of aluminum chlorohydrate, filtration, and disinfection with sodium hypochlorite, to meet the DWQS. The DWQS treatment requirements that protect human health are considered AKART in this document.

For DBP reduction the following are considered:

- Reduction of organic carbon in the source water;
- Minimizing chlorine residuals in the treatment and distribution system; and
- Operation and source control of the water treatment system.

The TOC content of the source water is low (TOC's running annual average must be less than 4.0 mg/L to reduce monitoring requirements); the City uses filtration and coagulation to further remove organic carbon prior to disinfection. The monthly TOC average for the treated source water is 0.8 mg/l (Golder 2015a).

The City has maintained a low concentration of chlorine in their drinking water compared to the DWQS maximum residual limit. The DWQS maximum residual disinfectant limit for chlorine is 4 mg/l. The City's monthly chlorine average between October 2012 and September 2013 was 1.04 mg/l (Golder 2015a).

The AKART analysis considered aeration as an alternative treatment choice to reduce DBPs in the source water, but was discarded because it is not effective at reducing HAAs, plus, the other contaminants, TOC, chlorine, and inorganic constituents (Golder 2015a); however, THMs are the prominent contaminants of concern. The City may wish to reconsider aeration as a treatment choice since THM formation from the reaction of chlorine and TOC would decrease, the degradation of HAAs to chloroform would be the predominant reaction contributing to the THM totals, which may help prevent exceedences of the enforcement limit.

The Water Research Foundation suggests an increase in residence time within the distribution system, the location where the chlorine is added in the distribution system, and the carbon type can affect the formation of DBPs in drinking water (Water Research Foundation 2010 and Liang 2003).

The City has reasonably demonstrated that AKART has been met. However, exceedences of the enforcement limits require implementation of the tasks in the compliance schedule to reduce the DBP concentrations in the source water and bring the ASR Program into compliance with the GWQS.

Risks

The environmental risks associated with the City's ASR program is the introduction of DBPs into the aquifer and to the users of groundwater from wells installed downgradient of the recharge zones. The DBPs, HAAs and THMs, are formed in the disinfection process when chlorine reacts with organic carbon. THMs can also form from the degradation of the HAA trichloroacetic acid. The THMs, chloroform, bromodichloromethane, and dibromochloromethane, and the HAAs, dichloroacetic and trichloroacetic acids have exceeded the GWQS criteria at the well head during recharge and in the aquifer during the storage and recovery periods of the ASR cycles (Golder 2015a). Chloroform accounts for the overwhelming majority of the three THMs and is the main THM contaminant of concern. THMs could build up in the aquifer.

The information provided by Golder establishes the Upper Ellensburg Formation aquifer as aerobic. HAAs degrade by hydrolysis in aerobic conditions. Chloroform degrades in anaerobic conditions and can degrade cometabolically under aerobic conditions (US EPA). Neither cometabolic degradation (bacteria growing on other chemicals and then the bacteria cometabolizes chloroform [Wahman 2005]), nor anaerobic conditions are present in the lower member of the Upper Ellensburg Formation aquifer. Monitoring results from two recharge events show chloroform increasing during storage, probably due to the reaction of residual chlorine with organic carbon and the degradation of HAAs to THMs, then stabilizing and decreasing to background levels during the recovery phase (pumping of aquifer) due to dissolution, dispersion, and mixing (Golder 2015a).

The proposed ASR program includes leaving the source water in the aquifer until the water is needed due to drought conditions, or issues at the water treatment plant to prevent surface water usage. In addition, the total recharge water volume is not available for recovery under the ASR permit: 90 percent of the recharge water is available for recovery within the first year of recharge, and the amount decreases by an additional 10 percent for each subsequent year, with no recovery of water after 10 years of storage (Golder 2014c).

The City has multiple water rights, other than the ASR related water rights, associated with the Gardner and Kissel wells. Potential control of the DBPs in the aquifer could occur through the use of the City's non-ASR water rights. The annual quantities of non-ASR permit water rights for the Kissel and Gardner wells total 6,098 acre feet (AF) per year, (see table below), which is slightly less than the approximately 6,400 AF of recharge water permitted per year for both wells. One other City owned water supply well, the Airport well, located in close proximity to the Kissel and Gardner wells, completed in the Upper Ellensburg formation, responds to recharge activities (Golder 2015c), and has non-ASR permit water rights totaling 3,200 AF per year. The Kissel, Gardner, and Airport, non-ASR water rights total 9,298 AF per year, which is 130 percent of the proposed ASR Reservoir Permit R4-34552 water rights of 6,400 AF per year. If the City fully utilized their non-ASR water rights, the recharge volume may be removed annually from the aquifer, or hydraulically controlled.

City of Yakima Groundwater Rights Qa(annual) at the Kissel, Gardner, and Airport Wells (NON ASR related rights) (Nazy 2015)		
Water Right	**Well**	**Qa**
190-A(A) Certificate and (B) Permit	Kissel Well	(A) 958 AF (B) 490 AF
GWC 2851-A	Kissel Well	4,650 AF
	Gardner Well	
5318-A	Airport Well	3,200 AF
Total		9,298 AF

The average groundwater velocity estimates, calculated from the Kissel and Gardner aquifer test analysis, range from 0.2-0.6 feet per day (73-219 feet/year) (Golder 2014c). Determining the potential effects of the City's cumulative water rights on the control and movement of the recharge water is included in the compliance schedule, and could better define the long term risk of DBPs in the aquifer.

The reported receptor wells located downgradient from the City's recharge wells, and completed in the Upper Ellensburg Formation, are municipally owned wells, and are considered a low risk to exposure of DBPs when the groundwater is pumped for use. If water is pumped from the downgradient wells and used for drinking water, the municipal water will be tested, and treated if necessary, prior to use. An irrigation well completed at a shallower depth, within the upper member of the Upper Ellensburg Formation, responds to recharge at the Kissel well, but is not considered downgradient of the recharge wells (Golder 2015b). Downgradient groundwater monitoring is required, and will provide information on the fate and transport of DBPs in the aquifer.

The introduction of DBPs in the aquifer will be a minimal impact to other media. Shallow groundwater is in hydraulic continuity with the Yakima River. USGS research suggests the deeper groundwater exits the basin at the sub-basin outlet by Union Gap. If groundwater containing chloroform, reach the Yakima River, the impact to the river would be minimal because chloroform will evaporate primarily into the atmosphere. Modeling studies predict chloroform's volatilization half-life of 3.5 hours in a river. Chloroforms degrades slower in the atmosphere at an approximate half-life of 80 days (US EPA). Chloroform absorbs poorly to sediment, especially if the organic carbon content is low. The aquifer matrix of the lower portion of the Upper Ellensburg Formation tends to be sandstone, shale, or conglomerate, and absorption should be minimal.

Along with completing the tasks in the compliance schedule, the GWQS require discharges that exceed the criteria to be reevaluated every 5 years, WAC 173-200-050(3) (b).

Benefits

The potential benefits of the project must outweigh the potential risks or adverse impacts, as outlined above, to be in the overriding public interest of the GWQS. The major benefits of City's ASR program as listed in the project documents are:

- Recharging water will increase groundwater storage in the aquifer. Pressure in some artesian wells, Kissel, and Gardner, have declined over time. Approximately 2,000 AF per year, on average, would be added to groundwater storage (Golder 2014c).

- Changing the Yakima River's surface water diversion during low instream flow conditions in the summer, to the winter months when withdrawals are at their lowest and stream flow is highest, would protect in-stream flows for the Naches and Yakima Rivers. By eliminating summer diversions, in stream flow could increase up to 20 cubic feet per second (Golder 2015a).

- Base flow to the Yakima River should increase in proximity to the sub-basin outlet (Union Gap), north of the Parker Gage.

- Ground water temperatures are cooler compared to the Yakima River water temperatures. Increase in base flow of colder groundwater could benefit aquatic and salmonid habitat. Furthermore, the Kissel well pilot test recorded the recharge water temperatures were even cooler than the groundwater, 5.5° Celsius compared to 23° Celsius (Golder 2001).

- Stored groundwater could be pumped from the reservoir aquifer to augment the Yakima River during low instream flow conditions; approximately 6 cubic feet second (2,800 gpm recovery rate).

- Using water captured during winter stream flow in the summer, will help off-set potential hydrologic changes resulting from climate change. Future spring runoff may occur earlier in the year, and a recharge event could capture a portion of it.

- The ASR program will provide a redundant and reliable water supply for the City. 9,600 acre feet per year of water can be recharged into the aquifer. This total includes the proposed well to be drilled in the southeast area of the City.

- Over time, the storage of water in the aquifer reservoir versus an equivalent surface water storage facility will be more cost effective. Costs per acre foot, per year of recharge capacity, was estimated to be approximately $920, which includes maintenance and operation, where a surface storage facility is estimated at $1,232 per AF per year (Ecology 2014c).

Recommendation to Authorize

Data collected during the two pilot recharge events, and the recharge cycle permitted under the 2014-2015 Temporary Permit, show DBP exceedences of the GWQS criteria, and also the Temporary Permit enforcement limit of 0.040 mg/l for total THMs, and 0.030 mg/l for total HAAs in the recharge cycle periods. THMs are persistent and may build up in the aquifer over time. However, cumulated water rights associated with the ASR recharge wells, plus the Airport well, if fully used, may remove or provide hydraulic control of the recharged water. Furthermore, recharge activities are a low risk to owners of water supply wells located downgradient from the ASR wells, because either the wells are City owned and used for drinking water, or used for irrigation. The City will test and treat all water used for drinking water.

The City reasonably addressed AKART, and met the requirements to justify exceedences of the GWQS criteria in 173-200-050-3) (b) (vi). The potential benefits of the ASR program outweigh the environmental risks when the DBP enforcement limits of the Temporary Permit are met. However, since the Temporary Permit enforcement limits were exceeded, a compliance schedule is a condition of the recommendation to authorize Reservoir Permit R4-34552.

Washington State Department of Health, Office of Drinking Water, members of the Water Quality Hydrogeologist Work Group, and Water Quality permit managers, were consulted and concur with this recommendation.

Permit Conditions

The point of compliance is at the recharge well prior to recharge.

Concentrations of DBPs must not exceed 0.040 mg/l for total THMs and 0.030 mg/l for HAAs, or one-half the current DWQS for contaminants at the point of compliance, and/or in groundwater downgradient of the recharge locations.

The proposed Reservoir Permit R4-34552 requires the City to sample and submit water quality information from all ASR wells and downgradient monitoring wells, including Airport and Union Gap #5. Raw water sample results from DOH Sentry database for DBPs, chlorine, TOC, all ASR, and downgradient monitoring wells must be included in the annual report. A downgradient sampling location must be established when the third well is installed.

Water quality sampling during the storage and recovery periods is required for all wells that have received recharge water, regardless of the water right used.

A groundwater quality violation occurs when two consecutive samples from the same well and the same parameter occurs. If a violation occurs in any of the recharge or downgradient monitoring wells, notify Ecology's Central Regional Office, Water Resource Program immediately (within 48 hours). Collect another sample within 48 hours of the first, from the same well where the violation occurred and for the same parameter. Recharge cannot proceed till the DBP concentrations are less than the enforcement limits.

Water Quality Monitoring at ASR Wells			
Period	**Location**	**Frequency**	**Analyte List**
Pre Recharge	All ASR wells, including downgradient monitoring wells	Prior to Injection.	GC[1], FP[2]
Recharge[3]	Source water at recharge wells	0-2%, 40-60%, 80-100% of recharge volume.[4]	GC[5],DBPs[6], FP
Storage[7]	Each well used for recharge in last period	Mid-storage, end of storage.[8]	DBPs, FP
Recovery[9]	Each well used for recharge in current year	1-2%, 40-60%, 90-100%, 150-250% withdrawal of recharge volume.	GC, FP

[1] GC = Geochemical suite, including inorganics, selected total metals, disinfection by-products, and general chemistry listed in Table 5.
[2] FP = Field parameters, includes temperature, pH, DO, specific conductance, and ORP.

[3] The recharge period is defined as the time City is injecting water into the aquifer, including intermittent shutdowns. The period ends when the City stops injecting water for the recharge season.
[4] 40-60% sample only required if recharge period is anticipated to go beyond 30 days.
[5] GC sample only required on 0-2% sample.
[6] DPBs are listed in Table 5 of the Draft Report of Examination for Reservoir Permit R4-34552.
[7] The storage period is defined as the time after recharge ends, and before recovery begins, within an annual cycle.
[8] A minimum of 1 sample shall be collected at end of storage period if storage is less than 30 days; and additional 1 per month for storage periods greater than 30 days.
[9] The recovery period begins when an ASR well is used regularly following an annual storage period, including intermittent shutdowns.

Compliance Schedule

By the dates listed below, the City must complete the following tasks, and submit with their annual report to Ecology describing, at a minimum:

- Whether the task was completed and, if not, the date on which it expects to complete the task.
- The reasons for delay, and the steps it is taking to return the project to the established schedule and or the completed reports.

	Tasks	Date Due
1.	Submit to Ecology for review and approval, an engineering report addressing reduction of disinfection byproduct concentrations to meet the permit enforcement limits. Source control, and treatment options as described in the AKART review, and comments should be included.	1 year after the permit issuance date
2.	Submit to Ecology for review and approval an analysis on the potential effects of the City's cumulative water rights on the hydraulic control of the recharge water in the aquifer to better define the long term risk of DBPs and submit to Ecology.	18 months after the permit issuance date
3.	Develop, and submit to Ecology for review, a Quality Assurance Project Plan for monitoring, data quality objectives, sampling, and reporting.	1 year after the permit issuance date
4.	Complete the installation of treatment, and/or implementation of the methods to reduce DBP concentrations, in the recharge water cycles.	Source control 3 years, if treatment is needed, 5 years from the permit issuance date

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City of Walla Walla Water Quality Program recommendation for overriding public interest for the Walla Walla Aquifer Storage and recovery Reservoir Permit

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February 12, 2014

TO: Tom Loranger, Water Resources Program Manager

FROM: Don Seeberger, Acting Water Quality Program Manager

SUBJECT: Overriding Public Interest Determination for the Walla Walla Aquifer Storage and Recovery Project

Attached to this cover sheet is a memo from the Water Quality Program (WQP) supporting an overriding public interest (OPI) determination for the Walla Walla Aquifer Storage and Recovery (ASR) Project. This OPI determination was prepared in coordination with the Water Resources Program and was based on a July 27, 2010 WQP guidance document entitled: *Aquifer Storage and Recovery Projects and Overriding Public Interest.*

The analysis in this memo includes water quality data from City of Walla Walla's municipal water supply system, hydrogeology and geology reports by various authors and agencies and in consultation with members of the WQP Hydrogeology Work Group, the Water Resources Program, the Department of Health Office of Drinking Water, the City of Walla Walla, and the National Marine Fisheries Service. A tribal water rights specialist, Mr. Chris Marks, was contacted and is aware of this proposal. In addition, I would recommend the Water Resources Program initiate a government to government consultation with the Confederated Tribes of the Umatilla Indian Reservation.

This OPI determination considers the health and environmental risks and benefits of the ASR project proposal and compliance with regulatory requirements. Overall, the benefits of this ASR project outweigh the risks in terms of increased instream summer flows, improved stream habitat to protect ESA-listed fish, water supply security and hydroelectric power.

These benefits are balanced against the potential to increase the concentration of trihalomethanes (THMs) in the ground water and the aquifer. THMs measured in groundwater occasionally exceed groundwater quality criteria, but are well below the drinking water standards. Measures planned to protect water quality include: installation of a slow sand filter to remove precursors to THM formation; a robust two year and five year adaptive management review of the system performance and groundwater quality; and a threshold concentration limit of 40 ug/l for THMs if ASR operations need to be suspended.

This project had good coordination between the Water Quality and the Water Resources Programs and is a good example of "Delivering Integrated Water Solutions" as identified in the Ecology Strategic Plan. Please let me know if you have any questions or concerns.

cc: Jim Bellatty, ERO Water Quality Section Manager
Keith Stoffel, ERO Water Resources Section Manager
Victoria Leuba, ERO Water Resources Permit Supervisor
John Covert, ERO Water Resources Hydrogeologist
John Stormon, SWRO Water Quality Hydrogeologist
Diana Washington, ERO Water Quality Permit Unit Supervisor
Llyn Doremus, ERO Water Quality Hydrogeologist
Grant Pfeifer, ERO Regional Director

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DEPARTMENT OF ECOLOGY
4601 N Monroe Street • Spokane, Washington 99205-1295 • (509)329-3400

February 11, 2014

TO: Don Seeberger, Water Quality Program Manager

FROM: Llyn Doremus, ERO Hydrogeologist

SUBJECT: Overriding Public Interest recommendation for the Walla Walla Aquifer Storage and Recovery Reservoir Permit

---

Ecology is considering an application from the City of Walla Walla for a reservoir permit that would authorize diversion of flows from Mill Creek for storage through injection into the basalt aquifer and subsequent recovery used for municipal supply (WR file NR R3-30526). The water quality implications of the proposed aquifer storage and recovery project (ASR), criteria used to recommend authorization for this project based on an overriding consideration of public interest, and the conditions and control technologies that will be implemented for protection of water quality justifying that recommendation, are described herein.

Summary

The potential for the Walla Walla Aquifer Storage and Recovery (ASR) project to impact the water users and suppliers nearby and downgradient of the ASR operations by increasing trihalomethanes (THM) concentrations in groundwater can likely be avoided with the proposed changes to the water treatment system, quarterly chloroform monitoring and reporting, and the 40 ug/L total THM concentration limit set as a condition for continued project operation.

The benefits of increasing the basalt aquifer groundwater storage and availability, increases in stream flow and improving water quality in Mill Creek and other downgradient creeks and rivers, are significant, long term environmental benefits of the ASR project. Improved water security for the City of Walla Walla is a significant human health benefit of the ASR project proposed.

Together these findings demonstrate an overriding public interest for the ASR project implementation, and provide the basis to recommend the authorization of reservoir permit R3-30526. Re-evaluation of the permit conditions in two years, and again in five years as required by Ch 173-200-050(3)(b) vi WAC will allow the findings used in determining that ASR project operation is an overriding public interest to be reevaluated with actual project performance information.

Background

Walla Walla initiated pilot testing of aquifer injection through their municipal supply wells by refitting wells no 1 and 6, and testing no. 6 in 1999, and no. 1 in 2003. All six of Walla Walla's municipal supply wells and the Walla Walla Community College water supply well are proposed for injection use under the reservoir permit application submitted in 2009. The seven wells are to be authorized for cumulative annual injection of 1,399 acre feet into block one, and 1,178 acre feet into block two of the basalt aquifer. Drinking water quality analyses provided by Frank Nicholson, Walla Walla Public Works Director, in November 2013; ASR project test results reported by Golder Associates Inc (GAI) in 2009 and 2011; and AKART analysis data submitted by HDR (2011 and 2012) are used in making the determination that aquifer storage and recovery project implementation constitutes an overriding public interest. Other documents reviewed in making this determination are listed at the end of this memo.

Regulatory and Policy Framework

Ecology's criteria to establish an overriding public interest for Aquifer Storage and Recovery projects is specified in the regulations and policy summarized below.

Groundwater quality standards are listed in Chapter 173-200 WAC and drinking water quality standards listed in Chapter 246-290-310. In particular the limits for arsenic and trihalomethanes (THMs) are considered in this recommendation memo. For arsenic the groundwater quality standard is 0.05 micrograms per liter (ug/L). THMs, a byproduct of water treatment with chlorine, consist of: chloroform, bromodichloromethane, chlorodibromomethane, and bromoform. Chloroform and bromodichloromethane have been detected in the Walla Walla water system, and are considered further in this memo.

Trihalomethanes concentrations are regulated differently under the groundwater quality standards than under regulations for drinking water. Drinking water regulations establish a limit for the total amount present of all trihalomethanes of 80 ug/L. For protection of groundwater quality, a limit for each THM constituent is established. The limit for chloroform content is 7 ug/L, and the bromodichloromethane limit is 0.3 ug/L. The groundwater standards do not define a limit for the total combined THM content. The groundwater quality limits established for arsenic and THMs are calculated to reduce the human health risk for contracting cancer from exposure to the particular constituent to 1 in 1,000,000 (or 10^{-6}).

The groundwater quality standards [WAC 173-200-050(3)(b)(vi)] list criteria for aquifer storage and recovery project evaluations where enforcement limits exceed the groundwater quality criteria. Those provisions are:

(A) Greater benefit to the environment as a whole and to protect other media such as air, surface water, soil, or sediment,

(B) Activity is in the overriding public interest of human health and the environment, and

(C) Department selects from a variety of control technologies that minimize impacts to all media.

Washington prescribes regulations for Underground Artificial Storage and Recovery in Chapter 173-157 WAC, which lists other regulations applicable to ASR permitting. Specifically, it directs that Ch 90.03.370 applies (which pertains to the permitting of reservoirs for Underground Artificial Storage and Recovery Projects standards), that states as some of the criteria for project approval: chemical compatibility of surface and groundwater; and environmental impacts.

Public interest considerations for aquifer storage and recover projects with water quality implications are listed in Ecology's *Groundwater Implementation Guidance for Ground Water Quality Standards* (Section 3.2) which states:

> For situations where existing high quality groundwater cannot be maintained and the discharge causes a violation of any of the criteria, the following requirements must be achieved:
>
> 1. AKART must be applied to the wastewater prior to being released to the environment, and
> 2. Overriding public interest must be demonstrated through one of the following:
>   i. An alleviation of a public health concern
>   ii. A net improvement to the environment, or
>   iii. Socioeconomic benefits to the community.

Washington oversees water that is injected directly into groundwater under the underground injection control regulations, Chapter 173-218 WAC. These regulations require that injection wells be registered, and that they comply with the non-endangerment standard. Walla Walla has registered only well no. 6, leaving the other wells used for injection to be registered. The non-endangerment standard is met for well no. 6 by the procedures described in the AKART analyses (HDR 2012).

Walla Walla Hydrogeology

The Walla Walla vicinity is underlain by coarse glacial and alluvial deposits of sand and gravel that extend to a maximum depth of 200 feet. Shallow unconfined groundwater movement in the gravel deposits is in hydraulic continuity with the streams traversing the Walla Walla Basin. Beneath the gravel is an extensive clay layer (also up to 200 feet in thickness) that rests on the Columbia River Basalts. Successive basalt extrusion events over 5 to 17 million years ago deposited multiple basalt layers and sedimentary interlayers between the basalt flows. The basalts have been classified into three units, listed here in order of oldest to youngest: Grande Ronde, Wanapum and Saddle Mountains. The clay unit is deposited directly on the Saddle

Mountains Basalt. Groundwater aquifers formed in the permeable interbeds and flow layers of the basalt units are tapped for municipal water supply and irrigation use.

Movement of groundwater within the basalt units and in the overlying gravel deposits is influenced by the structural folding of the basalt. The axis of the Walla Walla Syncline trends from east to west, dipping downward to the west. Along the northern margin of the Walla Walla Valley the syncline limb tilts down from north to south directing groundwater toward the syncline axis. The south to north dipping limb of the syncline overlies the southern portion of the Walla Walla Valley in Oregon. Groundwater flow is directed downward between the limbs of the syncline to the center of the Walla Walla Valley, and from east to west along the plunging syncline axis that parallels the flow direction of the Walla Walla River. A northeast to southwest trending monocline located just to east of the City of Walla Walla slopes downward to the west, from the Blue Mountains. Groundwater movement in the area east of Walla Walla is directed westward along the west dipping monocline into the Walla Walla Valley.

Ecology recognizes that subsurface faulting influences groundwater movement in basalts underlying the Walla Walla Valley, dividing the basalt aquifer into blocks of hydraulically semi-isolated aquifers. Golder Assoc. Inc. (2009) identified four fault blocks; the proposed reservoir permit authorizes blocks one and two for aquifer storage and recovery, with the potential to add another block and associated wells.

To the west, the Walla Walla watershed narrows, as the Walla Walla River flows downstream to the Columbia River. In the lower Walla Walla River reaches (river mile 0 to 10) basalt outcrops along the north and south slopes along the river. Groundwater movement westward out of the Walla Walla Valley is likely restricted by the narrow channel between the basalt outcrops. As a result, groundwater likely accumulates in the basalt depression underlying the Valley, making it readily available for withdrawal for water supply and irrigation purposes.

Groundwater use

Groundwater is drawn from both the shallow gravel aquifer and from the deeper Columbia River Basalt aquifers for municipal and irrigation purposes. About equal amounts are withdrawn from each aquifer, estimates average 25,000 acre feet annually extracted from each source. Water level elevations in the unconfined gravel aquifer are relatively stable. An average five foot drop in elevation was recorded in four wells in Oregon between 1960 and 1985, with a rate of decline of 0.2 foot per year. Groundwater elevations in the basalt aquifer(s) have drawn down more rapidly. In the 1960s and 1970s rates of decline approached 5 feet/year. In the recent past, declines have decreased and water levels have stabilized.

Walla Walla's municipal supply is drawn from seven wells that access the basalt aquifer(s), at depths of 790 to 1410 feet below ground surface. All well boreholes recover water from a significant aquifer thickness. Screened or open borehole intervals range from 350 to 1,000 feet.

Groundwater in the Walla Walla watershed is allocated in the Mill Creek, Walla Walla and College Place vicinities through 603 water rights that authorize a total of 77,800 acre feet annual withdrawals. Lower in the Walla Walla watershed, an additional 83,000 acre feet is allocated through 256 existing water rights. Of the 859 existing water rights, sixty are used to supply water for domestic and municipal uses.

Groundwater Quality

Water quality is monitored in groundwater treated for municipal supply purposes for a wide variety of constituents, including: cations and anions (inorganic constituents), nitrate, volatile organic compounds, herbicides and water treatment by-products. Constituent concentrations are regulated in municipal supply water and in groundwater in order to preserve a water quality level sufficient to preserve the beneficial uses of that water. Golder Associates Inc. reported water quality measurements from aquifer water recovered during ASR project testing and from Mill Creek (2009 and 2011). In general water quality was high in the aquifer before and after ASR testing, with two exceptions. Arsenic concentrations have not been measured to the level of accuracy required to determine if the groundwater quality standard (0.05 micrograms/liter or ug/L) is actually being achieved. The practical quantitation limit (PQL) for arsenic analyses conducted by Walla Walla's contracted analytical laboratory, Edge Analytical, is 1 ug/L. If future analyses results are of insufficient accuracy to demonstrate compliance with the water quality limit, both the method detection limit (MDL) and the PQL should be reported with arsenic test results. Chloroform and bromodichloromethane (by-products of water treatment) concentrations exceed the groundwater quality standard (7 ug/L and 0.3 ug/L respectively) in samples from wells no. 1 and 6 (used for aquifer injection and storage).

Treatment By-Products

Water treated with chlorine for municipal supply purposes reacts with organic matter and bromide present in the raw water to generate trihalomethanes (which include chloroform and bromodichloromethane). Water quality analyses completed during pilot testing of ASR wells no. 1 and 6 detected chloroform at over 20 ug/L in well no. 1, and 8 ug/L in well no. 6. Bromodichloromethane was detected at concentrations just over 1 ug/L in well no. 1, and was not detected in well no. 6.

Walla Walla's source water testing (required for municipal supplied water) shows concentrations of chloroform in water supply (and injection) wells no. 1 and 6 to be increasing. Between 2001 and 2009 concentrations of chloroform in well no. 1 progressively increased from 7.5 to 11.1 ug/L; for well no. 6 chloroform increased from non-detection in 2001 to 6 ug/L in 2006. The data is sparse, so more comprehensive evaluation for all seven Walla Walla water supply wells was not possible with existing data.

AKART

Walla Walla submitted analyses of All Known and Reasonable Technologies for reducing the content of chloroform and bromodichloromethane generated during the treatment processes, in order to reduce their concentration and accumulation in groundwater. The specific objectives used in evaluating treatment technologies were:

- reduce chlorine usage,
- remove natural organic material from raw water, and
- remove bromate from raw water
- increase operational safety and reliability.

The technologies evaluated were: UV disinfection, coagulation and filtration, activated carbon adsorption, high pressure membrane filtration, aeration, biofiltration (slow sand filtration), and chlorination using chloramination or chlorine dioxide. The AKART analyses yielded a recommendation to remove natural organic matter and bromate via biofiltration (installation of slow sand filtration), and to disinfect with hypochlorite addition.

Water used for Walla Walla's municipal supply is currently treated using sedimentation, ozonation and chlorination. To implement the AKART analyses findings Walla Walla is proposing to modify the treatment processes by:

- Replacing sedimentation basins with a slow sand filter (biofiltration)
- Ozonation use will be restricted to a backup treatment method
- Chlorination with hypochlorite (chlorine gas) will be replaced with liquid hypochlorite addition.

Slow sand filter pilot testing results reported by HDR (2011) show removal of 14% and 28% of the precursors for THMs formation (organic matter and bromate) through biological adsorption and degradation processes. The existing gas chlorination method will be replaced with liquid hypochlorite to improve the safety and reliability of the water treatment operations. Use of hypochlorite will increase the pH of water, thereby increasing the propensity for THMs formation. Walla Walla's priorities for its water system and complexity of system operations will require meticulous management and monitoring to accomplish the objectives that the ASR system is intended to achieve, and avoid THM production.

Walla Walla's AKART analyses and proposed improvements to its municipal water treatment system reasonably demonstrate conformance with US EPA and Washington Department of Health guidance to reduce disinfection byproducts to the maximum extent feasible. However, even with the improvements planned, formation and buildup of THMs in the treated water may plausibly be expected to generate concentrations of chloroform and bromodichloromethane that exceed the groundwater quality standards in the aquifer, but comply with the drinking water quality standards.

Overriding Public Interest Considerations

Aquifer Storage and Recovery Operations Benefits

Environmental benefits

- Reductions in surface water diverted from Mill Creek will allow more water to remain instream, and increase flows in Mill Creek, Yellowhawk Creek and Garrison Creek during summer months (with the use of groundwater during summer low-flow months that was injected during higher winter flow months, replacing water that would otherwise be diverted from Mill Creek). Increased flows will improve instream habitat conditions for fish in Yellowhawk Creek, which supports endangered species of steelhead and bull trout, and to recently re-introduced spring Chinook (of cultural significance to the Confederated Tribes of the Umatilla Reservation). The National Marine Fisheries Service considers the project to provide a net benefit to fish in the Walla Walla watershed.

- Restoration of declining groundwater levels in basalt aquifer(s).

- Increase groundwater discharge to streams downgradient of the aquifer injection wells, contributing to improvements in water quality and increasing instream flows in streams downgradient of the aquifer injection sites, which include: Mill Creek and the Walla Walla River.

Public health benefits

- Reduced potential pathogenic exposure with water supplied from groundwater instead of surface water (minimizing the use of surface water potentially exposed to surface contamination processes)

- Increased security of municipal water supply for City of Walla Walla. Backup water source is available from the aquifer reservoir if the surface water supply from Mill Creek is impacted by fire or landslide.

Energy production benefits

- Source water will be available for hydropower generation that is not withdrawn from Mill Creek for water supply purposes.

Risks Associated with Aquifer Injection Operations

Receptors

Over time repeated injection of treated water into groundwater may result in accumulation and concentration of treatment byproducts in the aquifer. The ASR system thereby poses a risk of building up water treatment byproducts (particularly chloroform and bromodichloromethane) in the aquifer, and those constituents migrating downgradient in groundwater. Water rights holders that use groundwater for domestic supply from the basalt aquifer downgradient of the injection wells are potential receptors of groundwater impacted by ASR operations. Sixty domestic water rights holders in the injection well vicinities (Walla Walla, College Place and Mill Creek) are permitted to use groundwater for domestic supply purposes. The basalt aquifer(s) in the Walla Walla vicinity are separated by faults into isolated aquifers (termed blocks). Four aquifer blocks are postulated to be present in the Walla Walla Valley. Block two (as illustrated in the Golder Assoc. Inc. 2009 reservoir application) receives injection from Walla Walla wells no. 4 and 6. HDR (2012) identified injection operations from wells no. 4 and 6 as potentially impacting 17 water rights holders. More specific delineation of impacts to water rights holders that withdraw groundwater from the other basalt aquifer blocks has not been completed.

Overriding Public Interest Recommendation

Water quality analyses completed during pilot project testing of the aquifer storage and recovery project indicate that trihalomethanes (THMs) are present in the water being injected into the basalt aquifer(s) from which Walla Walla withdraws its municipal supply water. The hydrogeology of the vicinity and the water quality data indicate that accumulation and increase of THMs in the aquifer is likely. Chloroform does not degrade under anaerobic or aerobic aquifer conditions (Landmeyer et al., 2000), and concentrations of chloroform in the aquifer would be expected to stabilize or decrease only through the processes of dilution or groundwater migration.

Existing water users and water suppliers in the vicinity and downgradient of the aquifer injection and storage operations will potentially be impacted by degradation of the quality of their water supply.

Walla Walla has reasonably addressed the potential for THMs build up in the basalt aquifer(s) in their evaluation of All Known and Reasonable Technologies to reduce THMs in treated water. The improvements proposed to their municipal water treatment system are as follows.

- Installation of a slow sand filter for biofiltration (to remove THM precursors prior to treatment)
- Reducing the use of ozone for disinfection (to adjust pH , and reduce availability of chlorine for THMs production)
- Changing disinfection method from injection of chlorine gas to liquid hypochlorite addition.

The proposed reservoir permit (R3-30526) is conditioned to require that Walla Walla submit information with which to assess water quality degradation as the project proceeds. Quarterly monitoring of the treatment byproduct chloroform, and anions and cations, in the distribution system and from wells accessing aquifers receiving injected water will support regular assessment of groundwater quality. Additionally, if total THM concentrations are found to exceed 40 ug/L (half the drinking water standard of 80 ug/L) injection to the aquifer will be suspended until more protective measures can be identified to reverse the buildup of THMs in groundwater.

Ecology Water Resources Program staff (Victoria Leuba and John Covert), members of the Water Quality Hydrogeologist Work Group, the Washington Department of Health Office of Drinking Water, and NOAA National Marine Fisheries Service were consulted in making this recommendation, and concur with these findings.

A two year review of the ASR project will be conducted to revisit the permit conditions and operations, project performance and water quality outcomes. The requisite five year review (as specified in Ch. 173-200-050 (3)(b) vi WAC) and reevaluation of the project consistency with overriding public interests also facilitates scrutiny of project performance with respect to protection of ground water quality.

An underground injection control registration should be completed for Walla Walla's municipal supply well no. 1 and any other wells used for injection to the aquifer.

Recommendation Based on Best Professional Judgment

The findings documented herein demonstrate an overriding public interest for the ASR project implementation, and provide the basis to recommend the authorization of reservoir permit R3-30526. In my best professional judgment the Overriding Public Interest is met with the operation of the Walla Walla Aquifer Storage and Recovery Project.

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exp. 8/11/2014

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City of Kennewick Water Quality Program recommendation for overriding public interest for the Walla Walla Aquifer Storage and recovery Reservoir Permit

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December 12, 2012

TO: Maia Bellon, Water Resources Program Manager

FROM: Kelly Susewind, Water Quality Program Manager KS

SUBJECT: Water Quality Program Review of Phase 2 Kennewick ASR Feasibility Study Report, September 21, 2012 and Recommendation for Overriding Public Interest Determination.

Summary:
The Washington State Department of Ecology's (Ecology) Water Quality Program has reviewed project documents provided for the Kennewick Aquifer Storage and Recovery (ASR) Project. Our review confirms that this project is likely to exceed the Ground Water Quality Criteria of Chapter 173-200 WAC for Disinfection Byproducts and Arsenic. The project documents indicate that the project will meet AKART (all known, available and reasonable methods of prevention, control and treatment) for these contaminants. The potential risks of negative impacts from the project are low because they identified no users that would be affected. The potential benefits of the project to both the Columbia River and the City of Kennewick are predicted to be significant. We suggest that to meet AKART, Kennewick be required to reduce Arsenic and Disinfection Byproduct concentrations to the maximum extent feasible by continuing to follow Washington State Department of Health and United States Environmental Protection Agency (U.S. EPA) guidance and requirements currently in place and as they are updated. As long as Kennewick continues to reduce contaminants to the maximum extent reasonable, Ecology's Water Quality Program supports Kennewick's compliance with the ground water quality standards using Overriding Public Interest, as recommended in WAC 173-157-200(2) and WAC 173-200-050(3)(b)(vi).

Discussion:
The Kennewick ASR feasibility study indicates that levels for Arsenic and Disinfection Byproducts in source water are likely to exceed the Ground Water Quality Criteria (GWQC) of Ch 173-200 WAC and also exceed the background ground water levels in the ASR target aquifer.

The Aquifer Storage and Recovery (ASR) Rules provide clear guidance on how the Department of Ecology will assess ground water quality protection standards.

WAC 173-157-200 How will the department issue reservoir permits and/or secondary permits for ASR projects?

(1) The department will process applications for permits for ASR projects in accordance with the provisions of RCW 90.03.250 through 90.03.320, RCW 90.03.370, chapter 173-152 WAC and this chapter.

(2) The department shall give strong consideration to the overriding public interest in its evaluation of compliance with ground water quality protection standards.

The Water Quality Standards for Ground Waters of the State of Washington, WAC 173-200-050(3) require all enforcement limits to be based on all known, available and reasonable methods of prevention, control and treatment.

WAC 173-200-050(3)(b)(vi) allows enforcement limits exceeding the GWQC where:

(A) Greater benefit to the environment as a whole is provided and to protect other media such as air, surface water, soil, or sediment,

(B) Activity is in the overriding public interest of human health and the environment, and

(C) Department selects from a variety of control technologies that minimize impacts to all media.

AKART:
Kennewick uses filtration to remove organic carbon precursors prior to disinfection and carefully manages chlorine levels to meet drinking water minimum chlorine residual requirements. Kennewick does not allow chlorine levels to climb above the required drinking water minimum, which could result in high levels of Disinfection Byproduct formation. Kennewick has successfully demonstrated that they meet AKART for the ASR proposed injections by employing all reasonable means for reducing contaminants to the maximum extent feasible.

Project Risks:
The report indicates that there are no drinking water wells completed in the target ASR aquifer within the area estimated to be impacted by this project and the sole irrigation well is upgradient; therefore, the risk is low that adverse impacts associated with the project could affect the public or the environment.

Project Benefits:
The project documents list the following benefits of the project both to the citizens of Kennewick and the Columbia River:

"Specific public, environmental and economic benefits associated with this ASR project include:

- The ASR program would withdraw water from the Columbia River using the City's existing infrastructure and treatment facilities during the winter months, store it in a deep basalt aquifer at the ASR-1 test well location, and recover the water to supplement peak demands during the summer months. This would allow the City to supplement summer municipal demand without increasing permitted withdrawals from the Columbia River during the low-flow summer months allowing more efficient use of existing water rights.
- Shifting water withdrawals from the Columbia River from the summer months when flows in the river are at their lowest and withdrawals are at their highest, to the winter months when withdrawals are at their lowest and streamflow highest. This would help protect both in-stream and out-of-stream water uses utilizing the Columbia River during peak demand, low-flow periods;
- The net return flow to the Columbia River will increase during the ASR recovery/low streamflow period. When the ASR program is in operation, the withdrawal during the peak summer months from existing supply sources would decrease, but the return flow from the City's waste water treatment plant (WWTP) would stay the same, thus improving the withdrawal-to-return ratio during the ASR recovery periods; and

- The ASR system represents a cost-effective means to optimize the City's water supply infrastructure. It would provide a redundant drinking water source to address increasing water demand without having to make costly modifications to the City's existing drinking water supply sources (water filtration plant or the Ranney collector wells)."

Overriding Public Interest:
Kennewick's ASR Feasibility Report provides the needed information to determine that this project would be in the overriding public interest. The information in the ASR Feasibility Report supports a determination that the potential benefits of the project outweigh any potential risks of adverse impacts. As long as Kennewick continues to reduce contaminants to the maximum extent reasonable by following Washington Department of Health and U.S. EPA drinking water guidance and requirements, Ecology's Water Quality Program supports Kennewick's compliance with the ground water quality standards using Overriding Public Interest, as recommended in WAC 173-157-200(2) and WAC 173-200-050(3)(b)(vi).

cc: Mark Kemner, Water Resources, CRO
John Stormon, Water Quality, SWRO
Sanjay Barik, Water Quality, CRO
Charlie McKinney, Water Quality, CRO

Appendix F. Acronyms

AKART	All known, available and reasonable methods of prevention, control and treatment
ASR	Aquifer storage and recovery
DBPs	Disinfection byproducts
DWQS	Drinking Water Quality Standards
EPA	Environmental Protection Agency
GWQS	Ground Water Quality Standards
HAAs	Haloacetic acids
MCL	Maximum contaminant level
MCLG	Maximum contaminant level goal
NOM	Natural organic matter
OCPI	Overriding consideration of public interest
RCW	Revised Code of Washington
SDWA	Safe Drinking Water Act
THMs	Trihalomethanes
TOC	Total organic carbon
UIC	Underground Injection Control
WAC	Washington Administrative Code
WDOH	Washington State Department of Health
WQP	Water Quality Program, WA State Department of Ecology