MEMORANDUM

Project No. 180249

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To: Mike Hermanson, Spokane County Environmental Services

From:

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Re: **Preliminary Managed Aquifer Recharge Project Design**
Bear Creek & Dry Creek
WRIA 55 ESSB 6091/RCW 90.94 Watershed Plan Update

Introduction

The passage of Engrossed Substitute Senate Bill (ESSB) 6091, as codified by RCW 90.94, requires that an update to the existing Watershed Plan for Water Resource Inventory Area (WRIA) 55, the Little Spokane Watershed, be approved by the Washington Department of Ecology (Ecology) by February 1, 2021. Spokane County Environmental Services is serving as the lead agency for this process. The WRIA 55 Initiating Governments for the watershed planning process are Spokane County, Stevens County, Pend Oreille County, the City of Spokane, and Whitworth Water District. The process is supported by convening the WRIA 55 Planning Unit to review technical tasks and memorandums, policy decisions, and the pending Watershed Plan update. Aspect Consulting, LLC (Aspect) has been contracted by Spokane County to facilitate planning unit meetings, conduct supporting technical tasks, and prepare the Watershed Plan update.

As part of technical tasks associated with the WRIA 55 Watershed Plan update, Aspect assisted with development of water offset projects, including managed aquifer recharge (MAR) projects. An MAR site optimization and selection process was previously conducted in WRIA 55 by Aspect and EarthFX (a consulting group specializing in groundwater modeling). Details of the screening and selection analysis were documented in a December 2019 memorandum that was distributed to the WRIA 55 Planning Unit (Aspect, 2019). Based on the screening criteria discussed in that memorandum, 18 sites were targeted for further evaluation, with three sites ultimately selected for the field investigations. The field investigations concluded that two of the sites, Bear Creek and Dry Creek (Attachment 1), appear viable for design and implementation of MAR facilities (Aspect, 2020).

Aspect and the County recently completed the following work at each MAR site:

- Field investigations and analysis including test pit investigations, infiltration testing to evaluate infiltration rates, monitoring well installation and testing, surface water flow rates, assessment of source water availability, and source water quality sampling.

The purpose of this memorandum is to present the preliminary MAR project designs for the selected sites at Bear Creek and Dry Creek along with determination of project construction and O&M costs and permitting requirements. The following preliminary MAR design elements are presented:

- Methods to limit diversions to periods of high-water availability
- Surface water collection and conveyance structures
- Available infiltration capacity and geotechnical conditions
- Subsurface infiltration galleries
- Electrical power access
- Monitoring requirements
- Operation and maintenance
- Permitting requirements
- Cost estimates for project design, permitting, construction, and implementation

Preliminary Site Assessment and Site Access

A description of the hydrogeologic conceptual model, evaluation of the expected timing and quantity of instream flow benefits, and site access considerations are presented below:

Hydrogeologic Conceptual Model

Aspect completed a field investigation at the Bear Creek and Dry Creek sites in October and December of 2019. The purpose of the field investigation was to evaluate infiltration rates, subsurface conditions at the infiltration sites, water quality, and aquifer characteristics. Results from the field investigation, Ecology's well log database, Washington Department of Natural Resources (DNR) geologic portal, U.S. Geological Society (USGS) reports (Kahle et al., 2013), and the Little Spokane River Watershed Integrated Model Development (West and Earthfx, 2018) were used to develop a hydrogeologic conceptual model of the two sites.

The Bear Creek site is located within the Little Spokane/Deer Creek subbasin. Bear Creek is a tributary located in the western portion of the subbasin that originates from a shallow pass south of Eloika Lake which separates the West Branch of the Little Spokane River from Bear Creek. The Bear Creek valley is relatively flat terrain compared to the eastern portion of the subwatershed, and surrounding subwatersheds (Figure 1). The creek flows in a south-southeasterly direction along a relatively flat stream elevation profile. Bear Creek appears as an underfit stream that occupies a larger valley potentially carved by interglacial streams and/or outburst flooding and filled by glacial outwash deposits. Figure 2 shows the regional surficial geology and the location and orientation of cross-section A-A'.

The paleochannel is bounded by granitic bedrock and filled with primarily fine-grained glacial deposits overlain by a coarse-grained glacial deposit and thin alluvium. Figure 3 shows the cross-sectional view of the Bear Creek site between the infiltration area and Bear Creek. The groundwater flow direction is expected to be predominately southwest from the proposed infiltration gallery toward Bear Creek, with water reaching the creek downstream of the diversion point. The total thickness of the unconsolidated units varies from 85 to 20 feet from east to west with an unsaturated thickness thinning from approximately 70 feet to effectively 0 feet from the infiltration gallery to the stream.

The Dry Creek site is located within the Otter Creek subbasin. Dry Creek is a tributary located in the southeastern portion of the subbasin and originates in the Blanchard Pass area northeast of Mount Spokane. The Dry Creek site is located in an area of relatively steep terrain as the creek flows from east to west from Blanchard Pass to the Little Spokane River as shown on Figure 4. Figure 5 shows the regional surficial geology and the location and orientation of cross-section B-B'.

The creek currently occupies a channel of recent alluvial sediments that overly glacial outburst flood deposits. Figure 6 shows the cross-sectional view of the Dry Creek site between the infiltration area and Dry Creek. No groundwater was intercepted during drilling of the 85 feet deep monitoring well shown on Figure 6. During drilling the unconsolidated material transitioned from fine-grained glacial deposit to gruss of the similar grain size distribution to hard competent granitic rock. It is expected that infiltrated water will accumulate on top of the low hydraulic conductivity granitic bedrock and flow down the steep topographic gradient toward the stream. The unsaturated thickness varies from greater than 85 feet to effectively 0 feet from the infiltration gallery to the stream.

Expected Timing and Quantities of Instream Flow Benefits

GSFLOW (USGS) modeling investigations were completed for Bear Creek and Dry Creek. Initial modeling was conducted with the following parameters and assumptions:

- One (1) cubic foot per second (cfs) can be recharged (when available in the water source) at the modeled MAR site over the period March, April, and May.
- Streamflow was calculated at the nearest surface water discharge point from the proposed recharge site.
- Modeling was done over a multi-year period (15 years) to provide an indication of longer-term response of groundwater discharge to the recharge process over various hydrologic conditions (wet, dry, drought).

MAR modelling results for Bear Creek and Dry Creek indicate that the sites respond well to MAR modelling simulations. Suitable March to May streamflow was generally available for infiltration, and associated increases in nearby streamflows of up to 0.2+ cfs were apparent in the 8- or 9-month period following the recharge time, including during critical low streamflow periods. Further details on the MAR modelling is presented in the *Managed Aquifer Recharge Site Optimization and Selection WRIA 55 ESSB 6091/RCW 90.94 Watershed Plan Update Memorandum* (Aspect, 2019).

Site Access Considerations

Spokane County owns the land associated with both the Bear Creek and Dry Creek MAR project sites. In addition, Spokane County owns the road right-of-way and diversion (or withdrawal)

location at the Bear Creek site. Access agreements and easements will need to be secured between Spokane County Environmental Services and other County departments, but County discussions indicate that no issue with access is anticipated.

The use of County-owned parcels for a MAR facility requires compensation to the specific department that owns the parcel, whether it be compensation for an easement or an outright purchase of the property. The Bear Creek site is owned by Spokane County Public Works. Public Works has agreed to grant an easement to Environmental Services for the MAR facility at an approximate cost of $20,000. The Dry Creek site is owned by the Spokane County General Fund. It has not been determined whether an easement or purchase would be pursued. The current assessed value of the parcel is $47,840. For all project components that will be located in the road right-of-way a Franchise Agreement in accordance with Spokane County Code Title 9 Chapter 55 will be required.

The diversion (or withdrawal) site and a portion of the proposed pipeline alignment at Dry Creek is on private land. An easement will be required for the Dry Creek MAR site for the system components located on private property. The County has had preliminary discussions that indicate potential landowner interest in granting an easement or property purchase to the County. The Dry Creek diversion structure, wet well structure, and approximately 525 linear feet (LF) of forcemain are located on private property. The remaining system components are located on County-owned parcels. The anticipated easement area is approximately 0.27 acres (625 sq-ft per structure and 20-foot wide along forcemain).

Source Water Availability for MAR

This section discusses considerations for source water availability for the Bear Creek and Dry Creek MAR projects.

Background on Little Spokane Rule Closure

Water availability for permitted water uses in WRIA 55, including diversion or withdrawal of source water for MAR projects, is directly affected by limitations in available water supply relative to instream flows adopted by WAC 173-555, the Little Spokane Instream Flow Rule ("the Rule"). The Rule was established with a priority date of January 6, 1976, the proposed beneficial use of source water for MAR purposes, are subject to the rule. Both Bear and Dry Creek are closed to further appropriations from June 1 to October 31 and use of source water for MAR would be prohibited during that period each year. In addition, use of source water for MAR may be subject to curtailment by Ecology outside of the tributary closure period when instream flows are not met in the mainstem of the Little Spokane River. Depending on streamflow and weather conditions, diversion or withdrawal of water for infiltration may also begin in February, but must cease by June 1 when the closure goes into effect each year.

Existing Streamflow Measurements

Available stream discharge data for the proposed MAR sites is limited. Spokane County staff collected monthly stream discharge data from July through February 2020 at Bear Creek and only November through January at Dry Creek (see Table 1). Based on the available data, both Bear Creek and Dry Creek are expected to have sufficient flow to support source water diversions or withdrawals during the typical

project infiltration period of March through May. The County will continue to collect monthly or more frequent flow data with emphasis on the spring runoff season. In addition, the County would install and operate remote sensing equipment to monitor stream flows to help inform the County as to when the pump stations should be operated if the project is constructed.

Table 1. Measured Stream Discharge at Proposed MAR Sites

Date	Bear Creek	Dry Creek
7/25/19	2.44	NM
8/20/19	2.11	NM
9/9/19	2.70	NM
9/17/19	2.88	NM
10/15/19	3.52	NM
11/21/19	3.99	NM
11/26/19	NM	0.48
12/10/19	3.92	0.69
1/23/20	4.42	NM
1/29/20	NM	14.07
2/25/20	5.00	3.74
4/1/20	5.20	6.59
5/20/20	3.62	6.66

Field Investigation Results

Field investigations of the Bear Creek, Dry Creek, and Deadman Creek sites were conducted to evaluate site conditions (infiltration rates, water quality, and aquifer transmissivity) to inform preliminary design and permitting for potential construction of MAR facilities.

Field investigations occurred over three weeks between October and December 2019. The following observations and conclusions were made during the field investigation:

- Infiltration rates of the receptor unit(s) at:
    - The Deadman Creek site are too low (0.01 inches per hour [in/hr]) to feasibly implement surface infiltration; therefore, the alternative Dry Creek site was evaluated.
    - Dry Creek and the Bear Creek site have suitable subsurface conditions for surface infiltration.
- Surface water and groundwater quality and aquifer characteristics at Deadman Creek were not evaluated further due to limited feasibility for surface infiltration.
- Dry Creek was evaluated for surface water parameters only due to unsaturated conditions above a confining unit (competent bedrock). No surface water quality criteria were

exceeded. The thickness of the overlying unconsolidated sand unit (coarse-grained outburst flood deposit) is 52 feet.

- Bear Creek was evaluated for surface water and groundwater quality. No surface water quality criteria were exceeded; however, groundwater quality criteria were exceeded for total dissolved solids (TDS), chloride, and total iron. Groundwater quality has likely been affected by storage of a sand and road salt mixture that is stored on the ground without cover at the County gravel pit.
- The depth to the water table aquifer at Bear Creek is 71 feet below ground surface (bgs). The aquifer transmissivity is estimated at 2,300 square feet per day (feet2/day) based on the aquifer testing conducted in this study. The aquifer thickness is approximately 12 feet resulting in a horizontal hydraulic conductivity of 194 feet/day.

The Bear and Dry Creek sites appear suitable for surficial infiltration of diverted surface water based on the raw infiltration rates and depth to water table or confining units. The groundwater quality at the Bear Creek site is expected to have groundwater quality improvement due to infiltration of surface water combined with implementation of best management practices (BMPs) to prevent further infiltration of road salts.

Aspect recommends that the County continuously monitor groundwater levels in monitoring well MB1 at the Bear Creek site to better understand seasonal changes to the water table aquifer. In addition, surface water quality monitoring at Bear and Dry Creek during peak runoff is recommended to provide additional characterization of the water source for MAR infiltration. Lastly, additional investigation at the Bear Creek site should occur as part of final design work to determine if diversion of surface water with large capacity wells adjacent to the creek is feasible. This would lower project costs by simplifying permitting through elimination of a surface diversion structure, and reduce other infrastructure costs, such as for settling solids from the source water in a tank prior to infiltration.

Managed Aquifer Recharge Permitting Analysis

Several permits are likely to be required for the Bear Creek and Dry Creek MAR projects. These permits include, but may not be limited to, those listed below:

- Grading Permit – Projects that excavate more than 500 cubic yards require a grading permit and submittal of a State Environmental Policy Act (SEPA) checklist. Both the Bear Creek and Dry Creek MAR projects are anticipated to require grading permits as the anticipated excavation work is excess of 1,000 cubic yards. The time it takes to obtain a permit is approximately four to six weeks.
- SEPA – The State Environmental Policy Act process identifies and analyzes environmental impacts associated with projects. The SEPA process ensures that environmental values are considered during decision-making by state and local agencies.Time to complete the SEPA review and receive a determination can vary significantly depending on the project and is estimated at three months.
- Critical Areas / Shoreline Permits – Projects involving work within 250 feet of a shoreline, within 250 feet of a wetland, or within the 100-year flood plain will require a County

Critical Areas / Shoreline Permit. The time it takes to obtain a permit is approximately two to three months.

- Electrical – County electrical permits will be required for the MAR project pump stations and electrical service. These are typically over-the-counter permits that will be acquired by the Contractor during construction.
- Hydraulic Project Approval (HPA) – Work that crosses over a waterbody or includes in-water work may require coverage under an HPA Permit from the Washington Department of Fish and Wildlife (WDFW). An HPA ensures that construction is done in a manner that protects fish and their aquatic habitats. Time to obtain a permit is dependent on the project and type of HPA.
- WA State Underground Injection Control (UIC) Program (WAC 173-218) – Ecology administers the statewide UIC program to protect groundwater by regulating the discharge of fluids from UIC injection wells (drywells, infiltration galleries with perforated pipe, etc.) The proposed infiltration galleries (with perforated pipe) at Bear Creek and Dry Creek will require registration with Ecology's Water Quality Program. Registration is typically done at the final design stage (prior to construction) and then modified as needed after construction to reflect the as-built condition. Time to complete the registration is approximately one week.
- Cultural Resources Review – Projects involving excavation activities are required to perform a cultural resource review within the project area. Executive Order 05-05 Section 106 of the National Historic Preservation Act requires all state agencies implementing or assisting capital projects using funds appropriated in the State's biennial Capital Budget to consider how future proposed projects may impact significant cultural and historic places. To do so, agencies are required to notify the Department of Archaeology and Historic Preservation (DAHP), the Governor's Office of Indian Affairs (GOIA), and concerned tribes. and afford them an opportunity to review and provide comments about potential project impacts. A project review form and inadvertent discovery plan will be required to be submitted to Ecology per Executive Order 05-05 Section 106 of the National Historic Preservation Act. Typical review time is 30 days minimum.
- Construction Stormwater General Permit – Projects that disturb 1-acre or more of land and discharge stormwater to surface waters of the State are required to obtain a Construction Stormwater General Permit from the Ecology. A Notice of Intent must be submitted at least 60 days before discharging stormwater from construction activities. Permittees are required to develop and implement a Stormwater Pollution Prevention Plan (SWPPP) through final site stabilization.
- Water Rights Permits – Diversion of water or withdrawal from wells adjacent to the creeks to provide source water for infiltration will require a new water right at each MAR location. In order to be approved by Ecology, the water rights will need to be interruptible, allowing diversion/withdrawal only when instream flows are met. Applications for new water rights will need to be submitted to Ecology, followed by processing of the applications through preparation of Reports of Examination.
- Dredge / Fill Permit (Section 404) – In-water work that will involve dredging or filling in the waterway will require a Section 404 permit from the U.S. Army Corps of Engineers. Time to obtain a permit can be up to one year.

- Endangered Species Act (ESA) Compliance – Section 7 of the ESA requires all Federal agencies to use their authorities to conserve endangered and threatened species in consultation with the U.S. Fish and Wildlife Service (USFWS), the National Oceanic and Atmospheric Administration (NOAA), and the National Marine Fisheries Service (NOAA Fisheries). Projects are required to address direct and indirect impacts to species, as well as direct and indirect impacts to their critical habitat.

Preliminary Managed Aquifer Recharge Project Design

A description of the project operational elements is presented below.

Project Operational Elements (i.e., System Description)

System components associated with the proposed MAR projects at Bear Creek and Dry Creek are described in the sections below. Preliminary MAR project designs are presented in Attachment 2.

Surface Water Collection and Conveyance Structures

Diversion / Fish Screen Structure

Any instream diversion of stream flows will require fish screening. Per the WDFW SalmonScape application, Eastern Brook Trout are present in Bear Creek and Rainbow Trout are present in Dry Creek. Fish screening options considered are shown in Attachment 3 and include:

- Instream pump intake screen
- Paddle wheel driven or solar powered rotary drum screen or rotary wiper screen
- Traveling belt screen
- Vertical plate screen
- Horizontal screen

During the final design phase, it is recommended that an alternatives analysis be completed to identify and select the most appropriate diversion/fish screen structure for each MAR site. The analysis will need to consider the stream characteristics (channel cross-section, gradient, and wetted area for a range of hydrologic conditions), likelihood of success, operation and maintenance requirements, etc. Channel cross sections should be evaluated to determine if water levels will be of sufficient height to divert up to 1 cfs into the diversion structure. If water levels will not be of sufficient height, an in-channel check structure may be needed to raise the water level in the vicinity of the diversion structure.

For the purposes of preliminary design, the proposed diversion structure would consist of an instream structure located on the streambank with vertical plate screen and built-in slide/canal gate to limit diversion to periods of high-water availability (see Figure 7). An instream structure with vertical plate screen was selected based on its ease of maintenance (passive self-cleaning), reliability, and ability to site within space constrained locations. The structure can be easily modified to incorporate a presettling sump to trap/retain larger sediments and a wet well for placement of one or more pumps. In a future design stage, screen material and mesh size will be selected based on current WDFW screening criteria. In addition, approach velocity, sweeping velocity, and minimum screen area will be determined to verify compliance.

Figure 7. Example Vertical Plate Screen Diversion Structure (Image Source: WDFW, 2009)

During the final design phase, it is recommended that shallow wells adjacent to the creek diversion sites be explored as an alternative source of water for the MAR project. If streambank soil conditions are favorable, a series of shallow wells could be located along the streambank to intercept and reliably supply up to 1 cfs of water to the MAR sites. It is recommended, as a part of the final design phase, that additional site hydrogeologic investigations be performed at each MAR diversion site (e.g., test pits or borings) to evaluate if shallow wells would serve as a viable alternative to instream diversion structures. Utilizing shallow wells would avoid in-water work and project permitting associated with an instream diversion structure. Further, the quality of water from shallow wells will be improved over an instream diversion structure, which would eliminate the need for a pre-settling structure to protect the infiltration system and will therefore reduce project capital and annual operation and maintenance costs.

Pump Station

The preliminary design for the pump stations include the following components:

- Wet well integrated into diversion structure or separate concrete wet well adjacent to diversion structure.
- The Bear Creek pump should be sized for a minimum capacity of 449 gpm (1 cfs) with a total dynamic head (TDH) of approximately 135 feet. The Dry Creek pump should be sized for minimum capacity of 449 gpm (1 cfs) with approximately 175 feet TDH. Pump selection will be performed during the final design phase; however, preliminary pump cost estimates are provided with the project cost estimate. Preliminary total dynamic head calculations for pump sizing are included in Attachment 4.
- Pump motor controls will be provided near each pump station housed in watertight enclosures.

- Electrical service will be provided at each pump station. The preliminary Bear Creek pump station is within 200 feet of an existing overhead power line, while the preliminary Dry Creek pump station is 2,000 feet from the nearest existing overhead power line.
- Water measurement equipment (flow meters) installed on the discharge side of the pump to monitor the flow rate and cumulative volume delivered to each infiltration gallery, as well as limit the flow rate to 449 gpm (1 cfs).

Forcemain

The forcemain at each site was sized to handle 449 gpm (1 cfs) at velocities ≤ 5 ft/s. Eight-inch PVC was selected for preliminary design. Preliminary forcemain velocity and friction loss calculations are included in Attachment 4.

Pretreatment – Sedimentation Tank

Springtime flows in Bear Creek and Dry Creek may have the potential to be turbid and protection of the infiltration system from plugging due to siltation will be important to extend the life of the infiltration facilities. In addition to the settling of larger sediment at the proposed diversion structure, an 8-foot wide by 40-foot long by 8-foot deep above-ground sedimentation tank (approx. 19,000 gallons) has been incorporated into the design for additional settling capacity. A sedimentation tank will be situated immediately upstream of each proposed infiltration facility allowing for gravity flow from the sedimentation tank into the infiltration facility. Preliminary sedimentation analysis was completed for the proposed tank size and is included in Attachment 5. The results of the sedimentation analysis indicate that the proposed tank will remove particle sizes 0.028 mm (silt range) and larger.

Additional sedimentation tank design details will be developed during the final design phase. Further, it is recommended that water samples be collected during the spring runoff period and analyzed for Total Suspended Solids (TSS). Based on TSS results, the sedimentation tank size can be revised to settle out the desired particle size.

Infiltration System

Based on recent field investigation and analysis work completed by Aspect, both sites are well suited for infiltration systems (Aspect, 2020). The receptor soil geology at the Bear Creek site consists of gravel with cobbles and boulders, while the Dry Creek MAR site consists of a well graded sand. Infiltration testing was completed at Bear Creek and Dry Creek with long-term design infiltration rates estimated to be 25 in/hr and 15 in/hr, respectively.

The preliminary design for the infiltration systems includes the following components:

- The infiltration system for each MAR site will be a subsurface infiltration gallery consisting of perforated piping encased in washed gravel (similar to an infiltration trench or drain field). To infiltrate 1 cfs at a 25 in/hr infiltration rate, the preliminary Bear Creek infiltration gallery will need to be 30-feet wide by 60-feet long. To infiltrate 1 cfs at a 15 in/hr infiltration rate, the preliminary Dry Creek infiltration gallery will need to be 40-feet wide by 75-feet long.

  Preliminary infiltration gallery sizing calculations are provided in Attachment 6.
- The washed rock should be separated from the native soil by a suitable woven geotextile.

- Observation wells (or inspection ports) will be provided at the lower end of each infiltration gallery to monitor water levels, drawdown time, sediment accumulation, and conduct water quality monitoring.
- Given the uncertainty in suspended sediment concentrations during spring runoff and potential loading to the infiltration system over the long-term, capacity for a secondary infiltration system should be considered during the final design phase. Stub outs should be provided to allow for a future connection to a secondary infiltration system in the event that the primary system becomes plugged. In the final design phase, it is recommended that water samples be collected during the spring runoff period and analyzed for Total Suspended Solids (TSS). If the range of sediment concentrations are found to be within the removal capabilities of the pre-treatment system, then the secondary system can be omitted from the final design.

Water Quality Considerations

MAR projects do not require National Pollutant Discharge Elimination System or State Waste Discharge permits; however, water quality anti-degradation rules still apply, and waters of the state must be protected. Surface water quality of Bear and Dry Creek were evaluated during the field investigation. In addition, Ecology and other entities have collected water quality data on the streams. This information is described below to characterize the source water that is infiltrated into the ground. Groundwater at Bear Creek is also evaluated from the perspective as a receiving water to address protection of groundwater quality.

Surface (Source) Water Characterization

Bear Creek has the following current water quality listings:

- Category 5 303d list for dissolved oxygen (Listing ID 47074)
- Category 4a listing for bacteria (Listing ID 45524) and temperature (Listing ID 48337)
- Category 2 listing for dissolved oxygen (Listing ID 77655) for the reach where the point of diversion, or withdrawal, would occur

Dry Creek has the follow current water quality listings:

- Category 5 (303d) list for pH (Listing ID 50373)
- Category 4a for bacteria (Listing ID 45511) and temperature (Listing ID 48329)
- Category 2 listing for dissolved oxygen (Listing ID 47067)

None of the Dry Creek listings occur along the reach where the point of diversion would occur.

The field investigation sampling on December 18, 2019, did not find any excursions of surface water quality criteria for total suspended solids, total nitrogen, total phosphorus, dissolved and total metals (arsenic, cadmium, chromium, zinc, and lead), fecal coliform, and E. coli bacteria, as well as any parameters identified in the 303(d) listing for either Bear Creek nor Dry Creek. Tables 2 and 3 show the results for detected analytes in surface water. Historical data collected by others at the same sampling station show similar general water quality. An apparent exceedance of the fecal coliform criteria occurred in the historical record during the fall. This may be associated with first

rain. Water quality data downloaded from the Environmental Information Management system (EIM) is provided in Table 4.

Two additional sampling events are planned to occur during the proposed period Spokane County would divert surface water to the infiltration gallery.

Groundwater (Receiving Water) Characterization

The surficial aquifer at the Bear Creek site was sampled once for analysis of the:

- Minimum required analytes (total suspended solids, total nitrogen, total phosphorus, dissolved and total metals (arsenic, cadmium, chromium, zinc, and lead) and fecal coliform and E. coli bacteria)
- Major cations (calcium, magnesium, potassium, and sodium) and anions (chloride and sulfate)
- Priority pollutant list metals
- Alkalinity
- Field parameters (temperature, specific conductance, dissolved oxygen, pH, and oxidation-reduction potential)

The groundwater had exceedances of groundwater quality criteria for chloride, total dissolved solids, and total iron. Tables 2 and 3 show the results for detected analytes in groundwater. The high total dissolved solids and chloride appear associated with storage of road deicing sand and salt deicing mixture stored on the ground at the Spokane County gravel pit. Infiltration of source water may improve groundwater quality through dilution of high total dissolved solids concentrations in the surficial aquifer, combined with implementation of best management practices (BMPs) to prevent further infiltration of road salts.

Additional Water Quality Considerations

The MAR projects are designed to operate only during ambient high-water flows. Diversions will not occur during flooding events where the streams are exceeding their banks and picking up additional pollutants from the surrounding land areas. Similarly, stormwater will be excluded from running onto the infiltration galleries or into the conveyances. As mentioned above, sedimentation tanks will be employed in advance of the infiltration galleries.

At the Bear Creek site residential dumping was documented on the property 1,000 feet cross gradient of the proposed infiltration gallery. An expanded groundwater analyte suite was used to determine if the residential dumping has impacted groundwater. Groundwater sample results did not indicate groundwater contamination has occurred from the residential dumping.

Operation & Maintenance

Recommended operation and maintenance for each system component is provided below.

Diversion Structure & Pump Station

Prior to system start-up each year, perform the following inspection and maintenance activities:

- Close pump wet well structure drain valve, conveyance line drain valve, and drain valves on pump(s) and associated appurtenances.
- Inspect for damaged or cracked pipes, valves, and fittings from over-winter storage; repair or replace as needed.
- Open slide/canal gate; exercise gate as needed to ensure proper operation over the full range.
- Maintain records of all inspections, maintenance, and repairs performed.

During system operation, perform the following inspection and maintenance activities:

- Visually inspect fish screen (weekly or more frequently) for accumulation of debris and fine materials; remove debris and clean screen as needed.
- Visually inspect diversion structure and slide/canal gate (weekly or more frequently) for signs of erosion, structural damage, settling, etc. Complete maintenance and repairs as needed.
- Visually inspect pump station (weekly or more frequently) for the following:
  - Check and clean the pump screen.
  - Verify the low-water shutoff/alarm is working.
  - If the pump control panel has an elapsed time meter or a cycle counter, read and record those values. Elapsed time and cycle counts are valuable troubleshooting data if problems occur in the system.
  - Verify flow meter and restriction valving is set such that only 449 gpm (1 cfs) is directed to the infiltration gallery (when available in the creek). Read and record flow meter totalizer for total cumulative volume of water delivered to the infiltration system.

At system shut-down each year, perform the following inspection and maintenance activities:

- Fully close slide/canal gate during non-operational periods (generally June through February).
- Open pump wet well structure drain valve and conveyance line drain valve; fully drain conveyance line, pump(s), and associated appurtenances.
- Access diversion structure pre-settling sump and measure depth of accumulated sediment; remove and properly dispose of accumulated sediment as needed.
- Visually inspect diversion structure for signs of erosion, structural damage, settling, etc. Complete maintenance and repairs as needed.
- Visually inspect the fish screen for: (a) holes or dents in the screen surface or frame that would allow small fish to pass through the screen or be injured by contact with the surface; (b) screen mesh openings that exceed the maximum allowable opening diameter for the type of screen material used; and (c) gaps or spaces between the screen, structural frame, and/or concrete structure. Complete maintenance or repairs as needed following WDFW criteria (WDFW, 2009).

- Contract with qualified service provider to complete full electrical and mechanical inspection of pump controls and electrical system. Complete maintenance or repairs as needed.
- Maintain records of all inspections, maintenance, and repairs performed.

Sedimentation Tank

- Inspect weekly to measure depth of accumulated sediment; remove and properly dispose of accumulated sediment when depth reaches 6 inches.

Infiltration Gallery

- Inspect weekly during periods of system operation when pump station is off for ponded water in the observation wells. Temporary ponding may occur at the end of a pump cycle but should dissipate before the next pump cycle begins. If ponded water resides in an observation well prior to the next pump cycle beginning the infiltration gallery may need to be cleaned. The infiltration gallery can be cleaned by injecting high pressure water into each cleanout port sequentially with other infiltration gallery pipe valves closed. Reinspect after next pump cycle to verify draw down performance.

Operation and Maintenance Funding Approaches

Spokane County acknowledges there will be an ongoing need to fund operation and maintenance of these facilities. The Board of County Commissioners has directed staff to develop funding mechanism proposals for their consideration, but as a first step, has agreed to fund the operation and maintenance of the Bear Creek MAR project[1] from the County General Fund until a funding mechanism is in place.

Preliminary Cost Estimate

The preliminary cost to design, permit, and construct the Bear Creek MAR is estimated to be $594K, including a 15 percent contingency. The estimated annual operation & maintenance cost is approximately $22.5K, including a $5K annual set-aside for future equipment repair and replacement (R&R). Detailed preliminary design cost estimates are provided in Attachment 7.

The preliminary cost to design, permit, and construct the Dry Creek MAR is estimated to be $616K, including a 15 percent contingency. The estimated annual operation & maintenance cost is approximately $22.5K, including a $5K annual set-aside for future equipment R&R. Detailed preliminary design cost estimates are provided in Attachment 7.

Design effort for each MAR site will generally include topographic site survey; geotechnical explorations and construction recommendations related to proposed infrastructure; 60%, 90%, and Final design plans, details, specifications and engineer's estimate of probable cost. The design cost is estimated to be $100,000 for each MAR site and has been included in the total preliminary cost estimate presented above.

[1] Spokane County is filing a Streamflow Restoration Grant application with Ecology to obtain capital funding to complete design and build the Bear Creek MAR facility. The Board of County Commissioners agreement to fund operation and maintenance for this project is contingent on Ecology capital funding for the project.

As noted previously, at both locations, the design preference is to use shallow wells rather than diversion structures as an alternative source of water for the MAR project. As part of the final design phase of this work, additional site hydrogeologic investigations have been included in the cost estimates for each project to evaluate if shallow wells would serve as a viable alternative to instream diversion structures. Utilizing shallow wells would avoid in-water work and project permitting associated with an instream diversion structure. Further, the quality of water from shallow wells will be improved over an instream diversion structure, which would eliminate the need for a presettling structure to protect the infiltration system and will therefore reduce project capital and annual operation and maintenance costs. As a preliminary estimate, this may result in a cost savings of approximately 10 percent for both capital costs and operation and maintenance costs at each location, should source wells rather than a diversion structure prove feasible.

References

Aspect, 2019. Memorandum: Managed Aquifer Recharge Site Optimization and Selection WRIA 55 ESSB 6091/RCW 90.94 Watershed Plan Update, December 2, 2019.

Aspect, 2020. Draft Memorandum: Managed Aquifer Recharge Field Investigation, WRIA 55 ESSB 6091/RCW 90.94 Watershed Plan Update, February 13, 2020.

Kahle, S.C., Olsen, T.D., and Fasser, E.T., 2013, Hydrogeology of the Little Spokane River Basin, Spokane, Stevens, and Pend Oreille Counties, Washington: U.S. Geological Survey Scientific Investigations Report 2013–5124, 52 p.

Washington Department of Fish and Wildlife (WDFW), 2009. Fish Passage Barrier and Surface Water Diversion Screening Assessment and Prioritization Manual.

Washington State Department of Natural Resources, 2020, Geologic Information Portal, Washington Interactive Geologic Map. http://www.dnr.wa.gov/programs-and-services/geology/publications-and-data/geologic-information-portal.

West Consultants, Inc (West) and Earthfx Incorporated (Earthfx), 2018, Integrated Groundwater/Surface Water Model for the Little Spokane Watershed – Water Bank Modeling and Decision Support Tool: Model Development and Application Report, December 2018.

Limitations

Work for this project was performed for Spokane County (Client), and this memorandum was prepared in accordance with generally accepted professional practices for the nature and conditions of work completed in the same or similar localities, at the time the work was performed. This memorandum does not represent a legal opinion. No other warranty, expressed or implied, is made.

All reports prepared by Aspect Consulting for the Client apply only to the services described in the Agreement(s) with the Client. Any use or reuse by any party other than the Client is at the sole risk of that party, and without liability to Aspect Consulting. Aspect Consulting's original files/reports shall govern in the event of any dispute regarding the content of electronic documents furnished to others.

Tables:
Table 1 - Measured Stream Discharge at Proposed MAR Sites *(in-text)*
Table 2 - Surface Water and Groundwater Laboratory Results for Detects
Table 3 - Surface Water and Groundwater Field Parameters
Table 4 – Bear Creek EIM Water Quality Data

Figures:
Figure 1 – Bear Creek Topography and Groundwater Flow Direction
Figure 2 – Bear Creek Surficial Geology
Figure 3 – Bear Creek Cross Section A-A'
Figure 4 – Dry Creek Topography and Groundwater Flow Direction
Figure 5 – Dry Creek Surficial Geology
Figure 6 – Dry Creek Cross Section B-B'
Figure 7 - Example Vertical Plate Screen Diversion Structure *(in-text)*

Attachments:
Attachment 1 – MAR Project Location
Attachment 2 – Preliminary MAR Project Designs
Attachment 3 – Small Fish Screening Options
Attachment 4 – Preliminary Hydraulic Calculations
Attachment 5 – Preliminary Sedimentation Analysis
Attachment 6 – Preliminary Infiltration Gallery Sizing
Attachment 7 – Preliminary Cost Estimates

V:\180249 WRIA 55 Watershed Plan Update\Deliverables\MAR PrelimDesign\PreliminaryDesignMemo 6_18_20.docx

TABLES

Table 2. Surface Water and Groundwater Laboratory Results for Detects

Project No. 180249, Spokane, Washington

						Location	**MB1-GW**	**MB-SW**	**ND-SW**
						Date	**12/18/2019**	**12/18/2019**	**12/18/2019**
						Sample	**MB1-GW-191218**	**MB-SW-191218**	**ND-SW-191218**
				Surface Water WAC 173-201A-200 & 240		Groundwater			
Analyte	CAS_RN	Fraction	Unit	Acute	Chronic	WAC 173-200-040			
Bacteria									
E.Coli	68583-22-2	N	MPN/100mL	100			< 1.8 U	**2**	**79**
Total Coliform	ColiTot	N	MPN/100mL			1	< 1.8 U	**350**	**170**
Conventionals									
Alkalinity, Total	ALKT	T	mg/L as CaCO3				**78.4**	**149**	**42.6**
Chloride	16887-00-6	T	mg/L			250	**2140**	**3.91**	**3.34**
Nitrate as Nitrogen	14797-55-8	T	mg/L			10	**1.69**	**1.47**	**0.102**
Nitrate-Nitrite	NO3NO2N	T	mg/L				**1.69**	**1.48**	**0.102**
Nitrogen	7727-37-9	T	mg/L				**1.69**	**1.48**	< 0.600 U
Orthophosphate	14265-44-2	T	mg/L				**0.016**	**0.016**	**0.039**
Phosphorus	7723-14-0	T	mg/L				**0.018**	< 0.010 U	**0.046**
Sulfate	14808-79-8	T	mg/L			250	**23.7**	**6.46**	**4.6**
Total Dissolved Solids	TDS	T	mg/L	10000	10000	500	**3900**	**172**	**125**
Total Suspended Solids	TSS	T	mg/L				**11**	< 5.0 U	< 5.0 U
Destination									
Hardness (destination)	Hard_MixZone	N	mg/L				**1940**	**147**	**33.7**
Field Parameters									
Temperature	Temp	N	deg C	17.5			**11.4**	**1**	**1.6**
Specific Conductance	Cond	N	uS/cm			700	**5866**	**289.8**	**96.2**
Dissolved Oxygen	DO	N	mg/L	8.5			**9.87**	**10.64**	**12.54**
pH	pH	N	pH units	6.5-8.5		6.5-8.5	**7.65**	**7.85**	**7.84**
Oxidation Reduction Potential	ORP	N	mV				**140.4**	**234.7**	**206.1**
Turbidity	Turb	N	NTU				**10**	--	--
Metals									
Calcium	7440-70-2	T	mg/L				**517**	**44.7**	**9.84**
Chromium	7440-47-3	T	mg/L	ND = 0.225; MB = 0.752	ND = 0.073; MB = 0.244	0.05	**0.0068**	< 0.0060 U	< 0.0060 U
Iron	7439-89-6	D	mg/L				< 0.100 U	< 0.100 U	**0.164**
Iron	7439-89-6	T	mg/L			0.3	**0.936**	< 0.100 U	**0.464**
Magnesium	7439-95-4	T	mg/L				**157**	**8.71**	**2.23**
Potassium	7440-09-7	T	mg/L				**10**	**2.29**	**1.48**
Sodium	7440-23-5	T	mg/L				**504**	**4.85**	**7.64**
Zinc	7440-66-6	D	mg/L	ND = 0.045; MB = 0.159	ND = 0.042; MB = 0.145		**0.04**	< 0.010 U	< 0.010 U
Zinc	7440-66-6	T	mg/L			5	**0.054**	< 0.010 U	< 0.010 U

Bold - detected
Blue Shaded - Detected result exceeded Acute Aquatic Life level (if WS) or WAC-173-200 (if WG)
Red Text - Detected result exceeded Chronic Aquatic Life Level
U - Analyte not detected at or above Reporting Limit (RL) shown
D - Dissolved Fraction (filtered) sample result
T - Total Fraction (unfiltered) sample result
N - Fraction Not Applicable

Table 3. Surface Water and Groundwater Field Parameters

Project No. 180249, Spokane, Washington

			Location	MB1-GW	MB-SW	ND-SW
			Date	12/18/2019	12/18/2019	12/18/2019
			Sample	MB1-GW-191218	MB-SW-191218	ND-SW-191218
Analyte	CAS_RN	Fraction	Unit			
Field Parameters						
Temperature	Temp	N	deg C	**11.4**	**1**	**1.6**
Specific Conductance	Cond	N	uS/cm	**5866**	**289.8**	**96.2**
Dissolved Oxygen	DO	N	mg/L	**9.87**	**10.64**	**12.54**
pH	pH	N	pH units	**7.65**	**7.85**	**7.84**
Oxidation Reduction Potential	ORP	N	mV	**140.4**	**234.7**	**206.1**
Turbidity	Turb	N	NTU	**10**	--	--

Bold - detected

Table 4. Bear Creek EIM Water Quality Data

Project No. 180249, Spokane, Washington

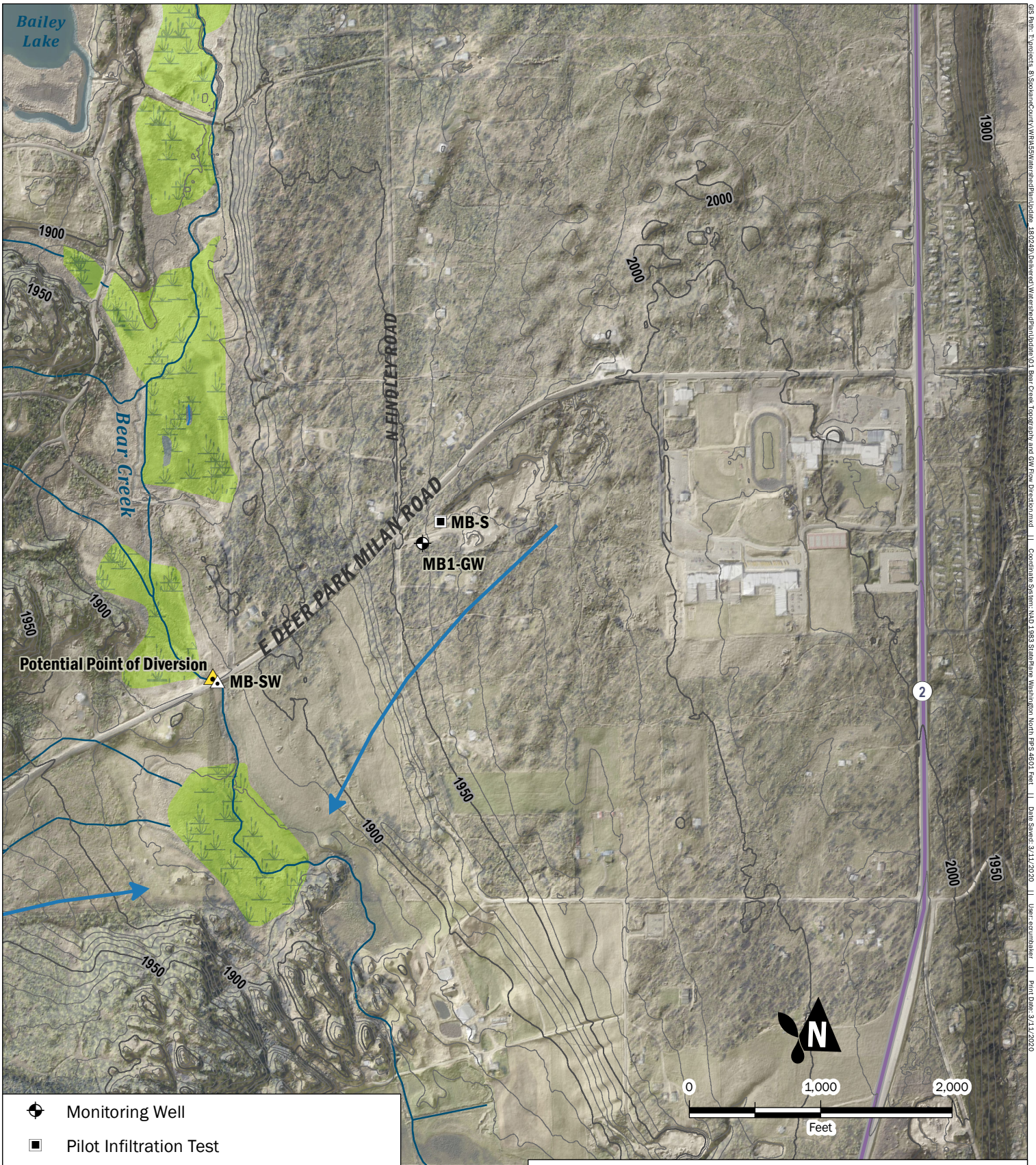
Date	Alkalinity, Total as CaCO3	Ammonia	Chloride	Conductivity	Dissolved Organic Carbon	Dissolved Oxygen	Fecal Coliform	Flow	Nitrate + Nitrite as N	Ortho-Phosphate
	mg/L	mg/L	mg/L	uS/cm	mg/L	mg/L	/100mL	cfs	mg/L	mg/L
10/28/08	150	0.01	3.15	300	1.6	11		3.2	1.3	0.0037
11/18/08	150	0.01	3.85	306	3.2	11		3.3	1.29	0.0065
01/20/09	168	0.03	4.45	326	7.6	1		5.8	0.584	0.0089
10/01/14	--	--	--	318	--	8	30	--	--	--
11/26/14	--	--	--	302	--	12	152	--	--	--
12/17/14	--	--	--	296	--	15	1	--	--	--
01/13/15	--	--	--	--	--	--	4	--	--	--
02/12/15	--	--	--	271	--	9	1	--	--	--
03/10/15	--	--	--	305	--	12	15	--	--	--
04/14/15	--	--	--	289	--	11	1	--	--	--
05/14/15	--	--	--	298	--	9	27	--	--	--
06/11/15	--	--	--	305	--	8	82	--	--	--
07/29/15	--	--	--	302	--	8	97	--	--	--
10/01/15	--	--	--	302	--	7	130	--	--	--
10/18/15	--	--	--		--	--	--	2.2	--	--
10/27/15	--	--	--	304	--	11	9	--	--	--
12/02/15	--	--	--	307	--	8	3	--	--	--
04/06/16	--	--	--	--	--	--	--	4.7	--	--

Table 4. Bear Creek EIM Water Quality Data

Project No. 180249, Spokane, Washington

Date	pH	Temperature, water	Total Organic Carbon	Total Persulfate Nitrogen	Total Phosphorus	Total Suspended Solids
	SU	deg C	mg/L	mg/L	mg/L	mg/L
10/28/08	7.6	4.7	1.8	1.47	0.0078	2
11/18/08	7.6	3.8	3.6	1.55	0.0072	2
01/20/09	7.0	0.0	8.6	1.08	0.0253	2
10/01/14	8.5	10.9	--	--	--	--
11/26/14	7.7	0.0	--	--	--	--
12/17/14	10.3	1.4	--	--	--	--
01/13/15	--	--	--	--	--	--
02/12/15	7.7	4.2	--	--	--	--
03/10/15	7.6	3.6	--	--	--	--
04/14/15	7.8	8.5	--	--	--	--
05/14/15	8.0	11.5	--	--	--	--
06/11/15	7.7	17.4	--	--	--	--
07/29/15	7.9	14.9	--	--	--	--
10/01/15	7.5	10.1	--	--	--	--
10/18/15	--	--	--	--	--	--
10/27/15	7.9	8.1	--	--	--	--
12/02/15	7.9	0.0	--	--	--	--
04/06/16	--	--	--	--	--	--

FIGURES



- Monitoring Well
- Pilot Infiltration Test
- Surface Water Gaging/Sampling Location
- Potential Point of Diversion
- Groundwater Flow Direction
- 50-ft Contour (LiDAR, 2019)
- 10-ft Contour (LiDAR, 2019)
- Marsh

Bear Creek Topography and Groundwater Flow Direction

Preliminary Managed Aquifer Recharge Project Design
Bear Creek & Dry Creek WRIA 55 ESSB 6091/RCW 90.94
Watershed Plan Update
Spokane County, Washington

Aspect Consulting	MAR-2020	BY: JS / EAC	FIGURE NO. 1
	PROJECT NO. 180249-06	REVISED BY: ---	

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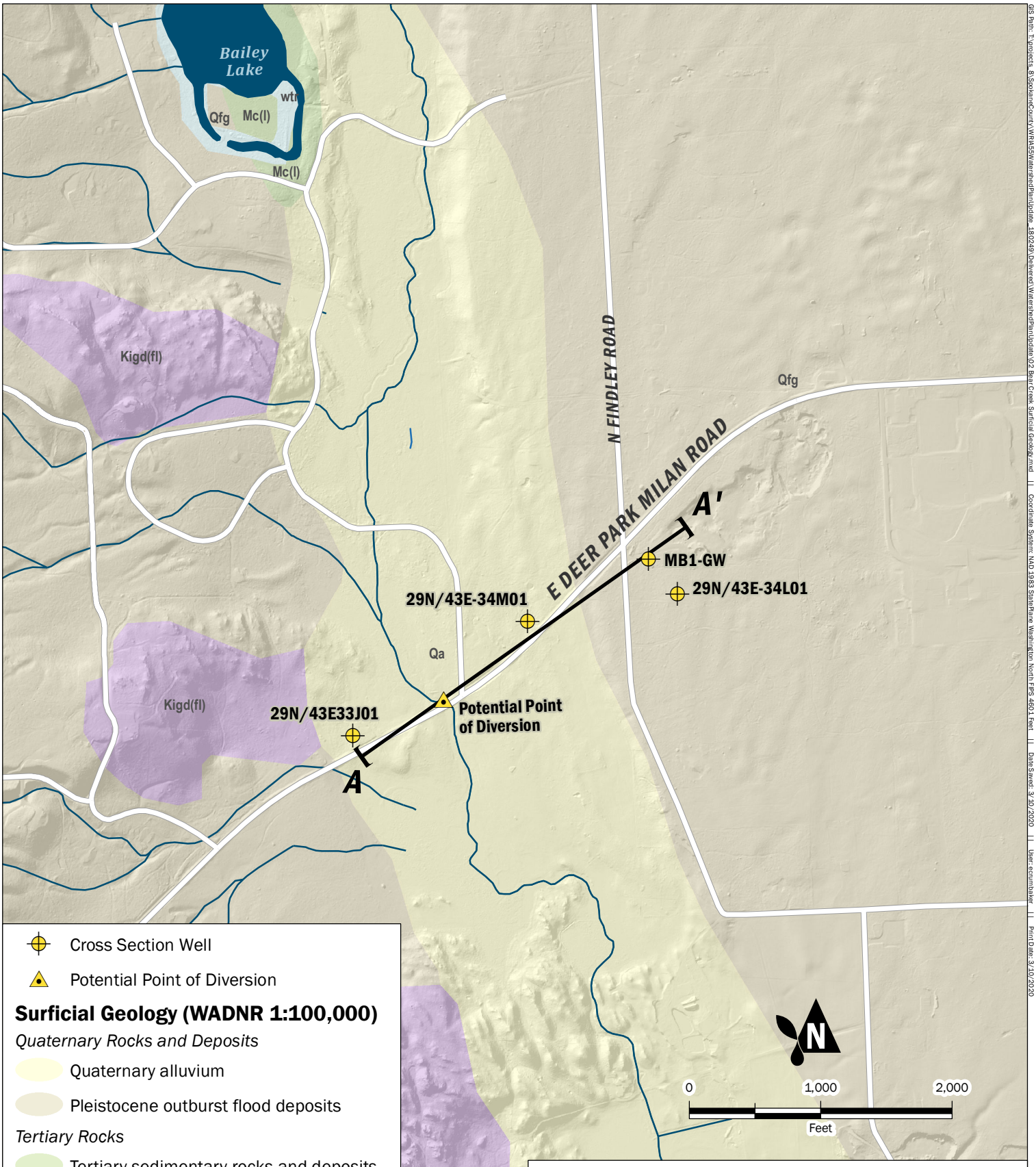


Cross Section Well

Potential Point of Diversion

Surficial Geology (WADNR 1:100,000)

Quaternary Rocks and Deposits

Quaternary alluvium

Pleistocene outburst flood deposits

Tertiary Rocks

Tertiary sedimentary rocks and deposits

Mesozoic Rocks

Mesozoic intrusive rocks

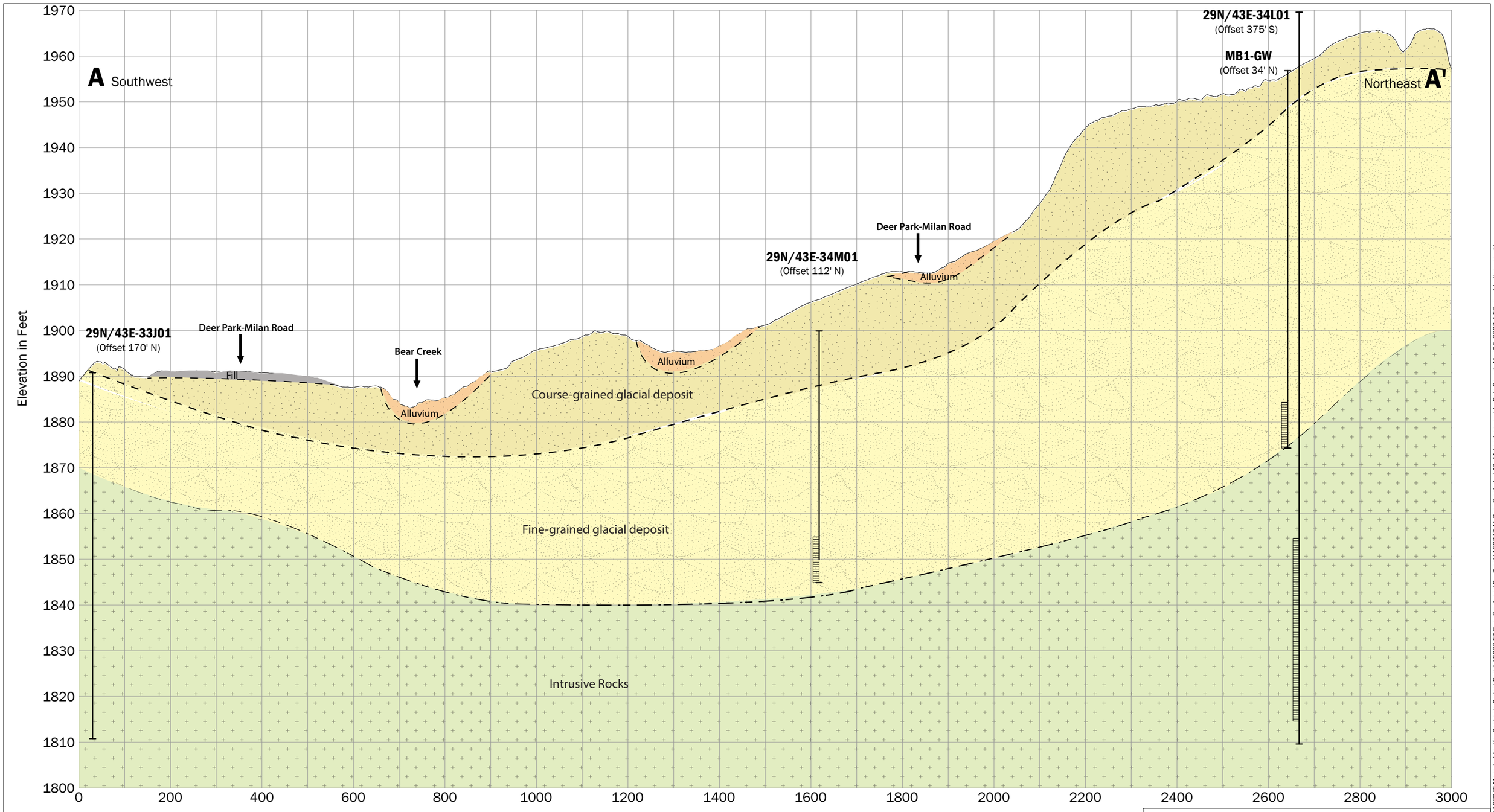
Water

Water

Bear Creek Surficial Geology

Preliminary Managed Aquifer Recharge Project Design
Bear Creek & Dry Creek WRIA 55 ESSB 6091/RCW 90.94
Watershed Plan Update
Spokane County, Washington

Aspect Consulting	MAR-2020	BY: JS / EAC	FIGURE NO. 2
	PROJECT NO. 180249-06	REVISED BY: ---	



MW-2 ← Monitoring Well ID

← Well Screen Interval

Horizontal Scale: 1" = 200'
Vertical Scale: 1" = 20'
Vertical Exaggeration 10x

0 200 400 Feet

Bear Creek Cross Section A-A'

Preliminary Managed Aquifer Recharge Project Design
Bear Creek & Dry Creek WRIA 55 ESSB 6091/RCW 90.94
Watershed Plan Update
Location, Washington

Aspect Consulting	Mar-2020	BY: JMS/SCC	FIGURE NO. 3
	PROJECT NO. 180249	REVISED BY: -	

CAD Path: Q:\Little Spokane Watershed Planning\180249 Managed Aquifer Recharge Project Design\2020-03 Bear Creek and Dry Creek\180249-AA Bear Creek.dwg 17x11 Landscape || Date Saved: Mar 05, 2020 4:07pm || User: scudd

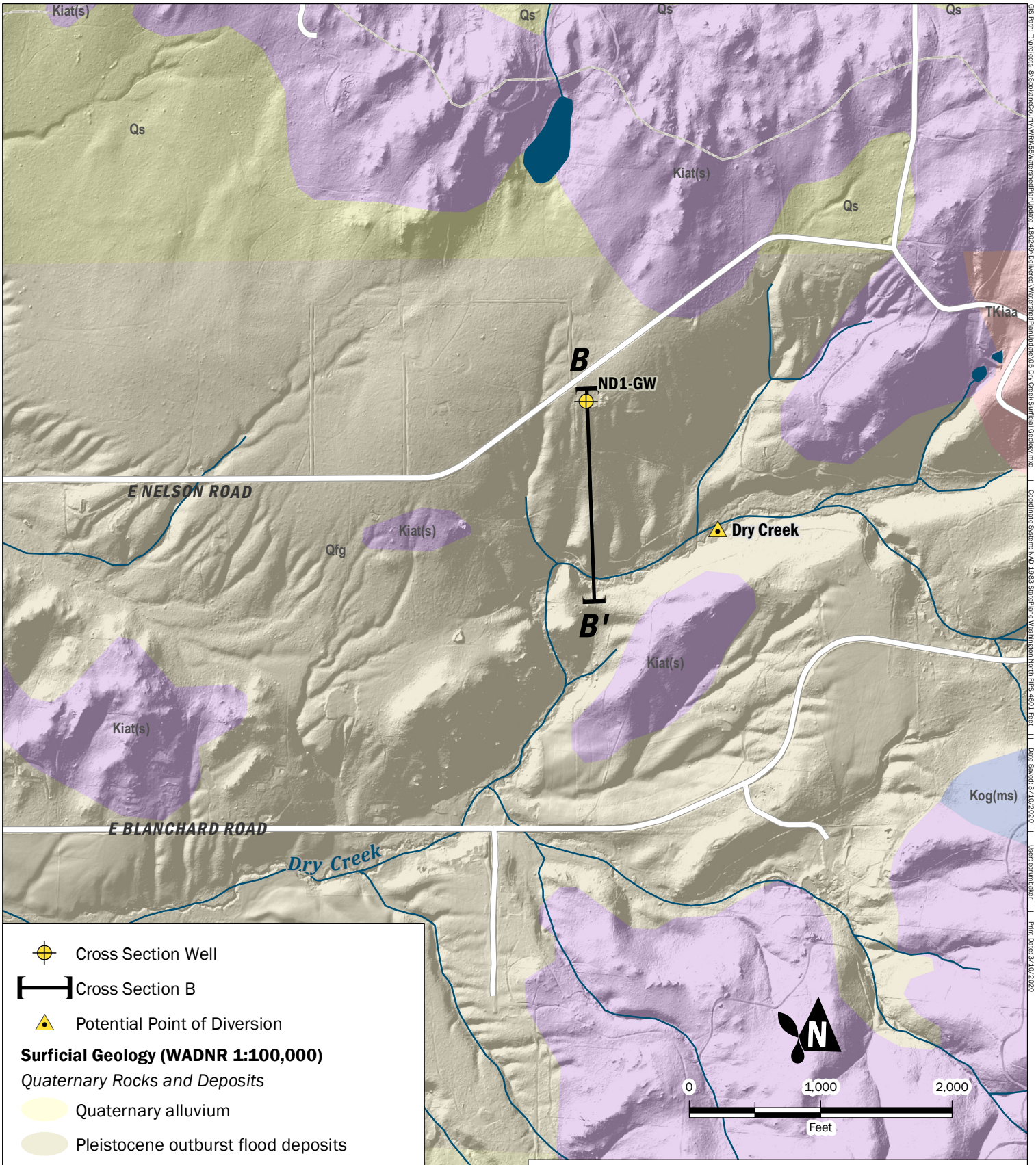
- Monitoring Well
- Pilot Infiltration Test
- Surface Water Gaging/Sampling Location
- Potential Diversion Site Location
- Groundwater Flow Direction
- 50-ft Contour (LiDAR, 2016)
- 10-ft Contour (LiDAR, 2016)

Dry Creek Topography and Groundwater Flow Direction

Preliminary Managed Aquifer Recharge Project Design
Bear Creek & Dry Creek WRIA 55 ESSB 6091/RCW 90.94
Watershed Plan Update
Spokane County, Washington

Aspect Consulting	MAR-2020	BY: JS / EAC	FIGURE NO. 4
	PROJECT NO. 180249-06	REVISED BY: ---	

Basemap Layer Credits || Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community



Cross Section Well

Cross Section B

Potential Point of Diversion

Surficial Geology (WADNR 1:100,000)

Quaternary Rocks and Deposits

Quaternary alluvium

Pleistocene outburst flood deposits

Quaternary sedimentary rocks and deposits

Tertiary-Cretaceous Rocks

Tertiary-Cretaceous intrusive rocks

Mesozoic Rocks

Mesozoic heterogeneous metamorphic rocks

Mesozoic intrusive rocks

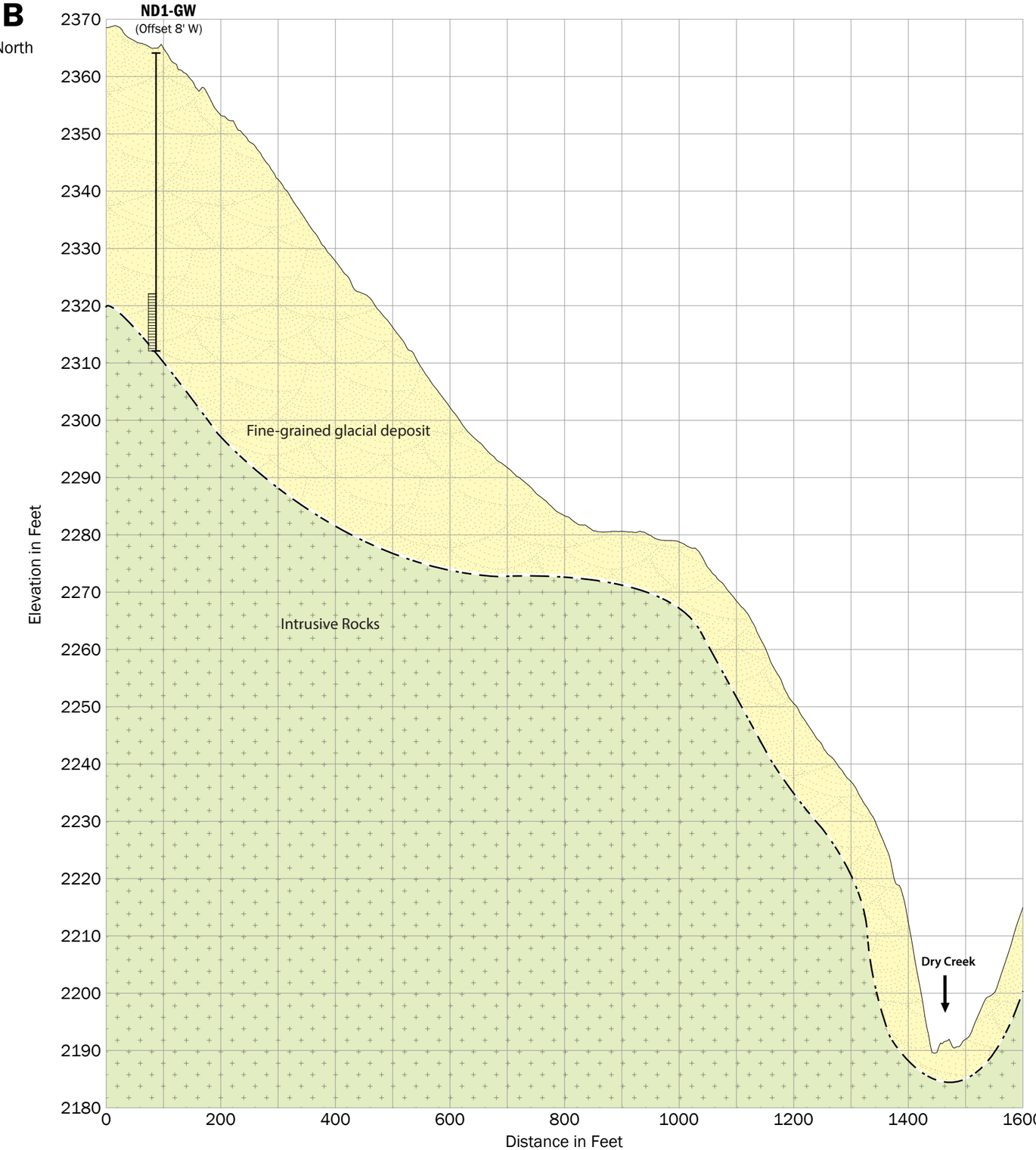
Dry Creek Surficial Geology

Preliminary Managed Aquifer Recharge Project Design
Bear Creek & Dry Creek WRIA 55 ESSB 6091/RCW 90.94
Watershed Plan Update
Spokane County, Washington

Aspect Consulting	MAR-2020	BY: JS / EAC	FIGURE NO. 5
	PROJECT NO. 180249-06	REVISED BY: ---	

B
North

B'
South



MW-2 ← Monitoring Well ID

Well Screen Interval

Horizontal Scale: 1" = 200'
Vertical Scale: 1" = 20'
Vertical Exaggeration 10x

0 200 400 Feet

Dry Creek Cross Section B-B'

Preliminary Managed Aquifer Recharge Project Design
Bear Creek & Dry Creek WRIA 55 ESSB 6091/RCW 90.94
Watershed Plan Update
Location, Washington

Aspect Consulting	Mar-2020	BY: JMS/SCC	FIGURE NO. 6
	PROJECT NO. 180249	REVISED BY: -	

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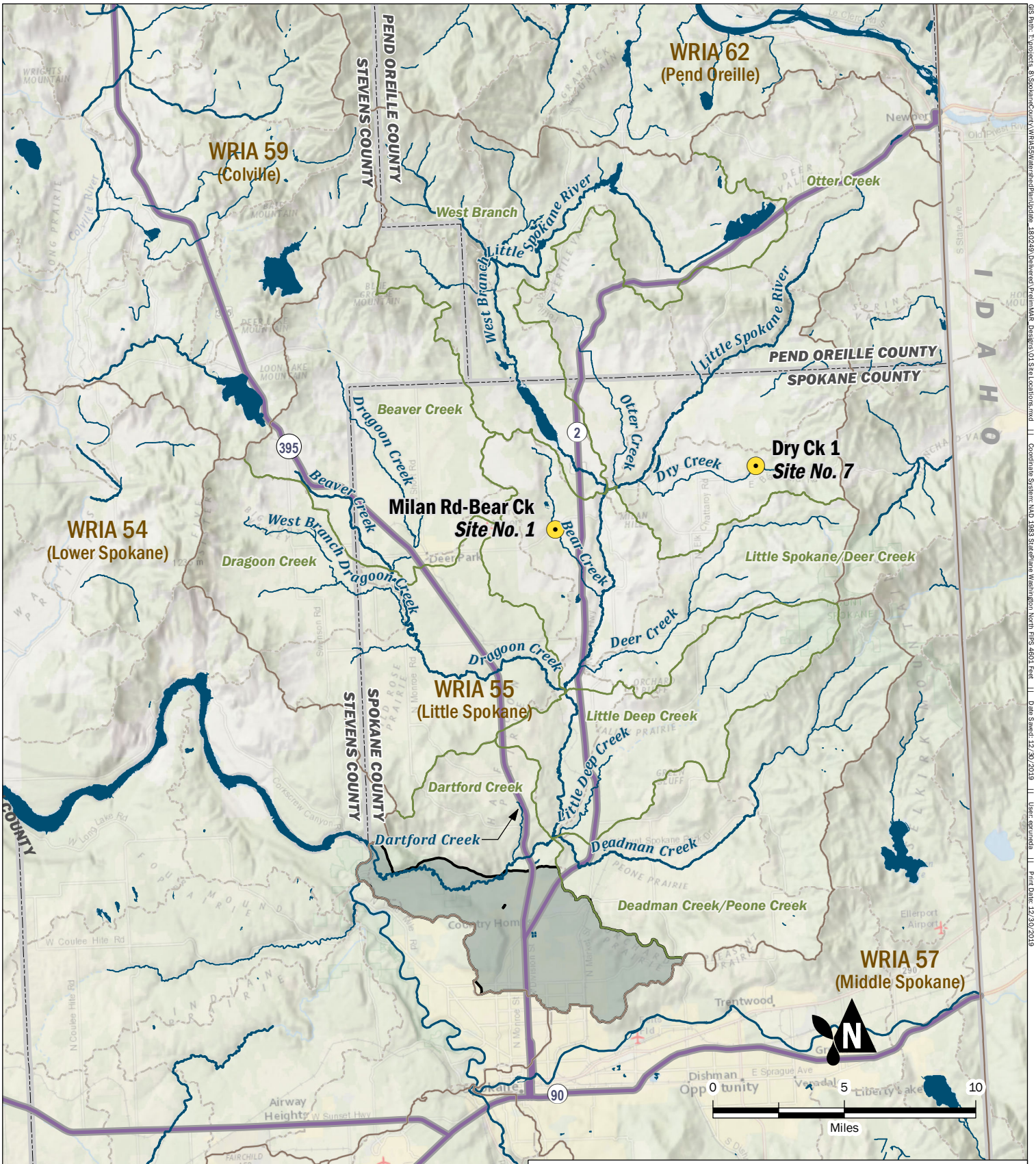
ATTACHMENT 1

MAR Project Location



MAR Project Location

WRIA 55 Subbasins

MAR Project Locations

Managed Aquifer Recharge
Preliminary Design Tech Memo
WRIA 55, Washington

Aspect Consulting	DEC-2019	BY: CME / EAC	ATTACHMENT NO. 1
	PROJECT NO. 180249	REVISED BY: ---	

ATTACHMENT 2

Preliminary MAR Project Designs

Fish Screen/Diversion
Pump Station
Sedimentation Tank
PVC Pipe (Gravity)
PVC Pipe (Forcemain)
5-ft Contour (NED)
Subsurface Infiltration Gallery
Spokane County Parcel

Note: Available Bear Creek centerline does not match well with available aerial imagery.

0 200 400
Feet

Preliminary MAR Project Design
Bear Creek

Managed Aquifer Recharge
Preliminary Design Tech Memo
WRIA 55, Washington

Aspect Consulting	JAN-2020	BY: EP / EAC	ATTACHMENT NO. 2A
	PROJECT NO. 180249	REVISED BY: ---	

Basemap Layer Credits || Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

GIS Path: T:\projects_8\SpokaneCounty\WRIA55WatershedPlnUpdate_180249\Deliverech\PrelimMAR_Design\s\02 Site Map - Bear Creek Site.mxd || Coordinate System: NAD 1983 StatePlane Washington North FIPS 4601 Feet || Date Saved: 1/21/2020 || User: eprunneta || Print Date: 1/21/2020

SPOKANE COUNTY
Elk, WA 99009
PARCEL # 49231.9056

SPOKANE COUNTY
Elk, WA 99009
PARCEL # 49231.9057

SPOKANE COUNTY
Elk, WA 99009
PARCEL # 49231.9057

SPOKANE COUNTY
Elk, WA 99009
PARCEL # 49231.9058

E NELSON RD

MALY, BURR & JAIME
Elk, WA 99009
PARCEL # 49232.9065

Sedimentation Tank

40' x 75' Infiltration Gallery

1,770 LF 8" Solid Wall PVC Forcemain

KING, MARK
14301 E NELSON RD
PARCEL # 49232.9062

SPOKANE COUNTY
Elk, WA 99009
PARCEL # 49231.9056

KIEHN, ELSIE L
Elk, WA 99009
PARCEL # 49235.9053

LEIGH, DOUGLAS G & DEANNA
Elk, WA 99009
PARCEL # 49234.9060

Pump Wet Well Structure

Diversion Structure

Dry Creek

2435 2430 2425 2420 2415 2410 2405 2400 2395 2390 2385 2380 2375 2370 2365 2360 2350 2345 2340 2335 2330 2325 2320 2315 2310 2305 2300 2295 2290 2285 2280 2275 2270 2265 2260 2255 2250 2245 2240 2235 2230 2225 2220 2215 2210 2205

Fish Screen/Diversion
Pump Station
Sedimentation Tank
PVC Pipe (Gravity)
PVC Pipe (Forcemain)
5-ft Contour (NED)
Subsurface Infiltration Gallery
Spokane County Parcel

N

0 75 150
Feet

Preliminary MAR Project Design
Dry Creek

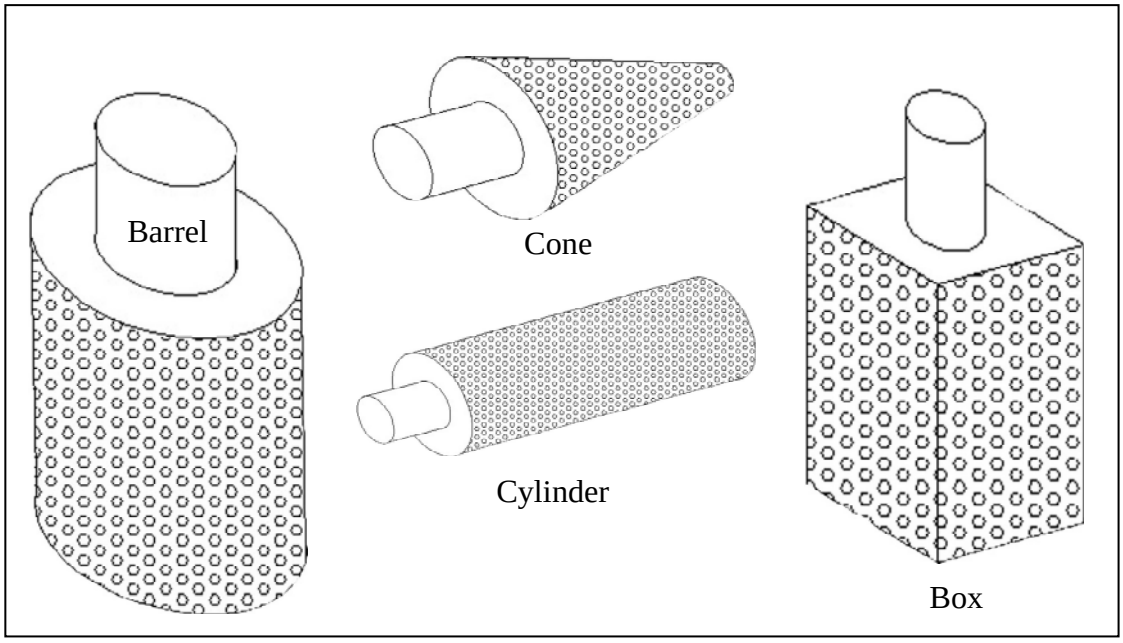
Managed Aquifer Recharge
Preliminary Design Tech Memo
WRIA 55, Washington

Aspect Consulting	JAN-2020	BY: EP / EAC	ATTACHMENT NO. 2B
	PROJECT NO. 180249	REVISED BY: ---	

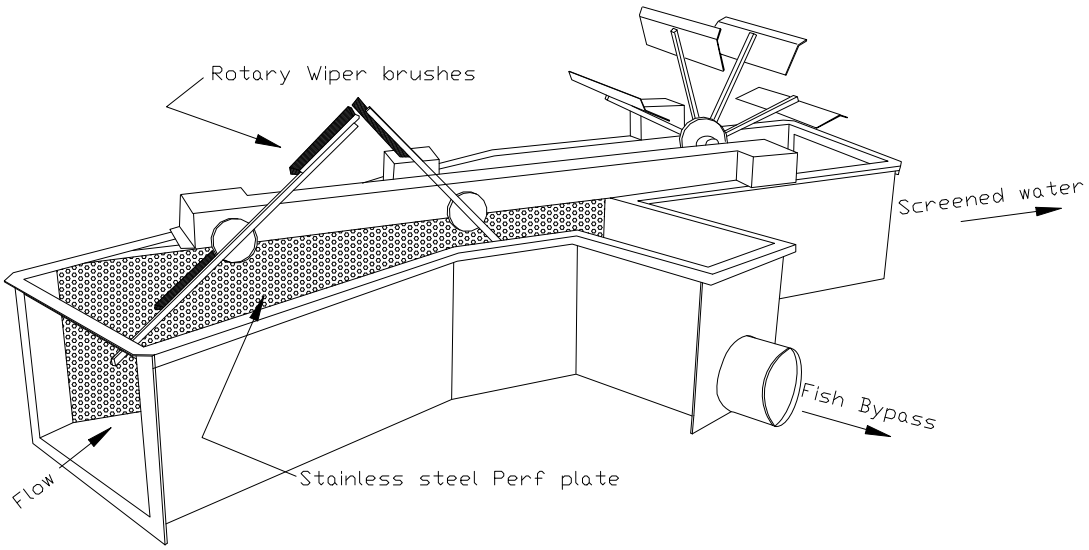
ATTACHMENT 3

Small Fish
Screening Options

Screened Pump Intake (WDFW, 2009)



Rotary Wiper Screen (WDFW, 2009)

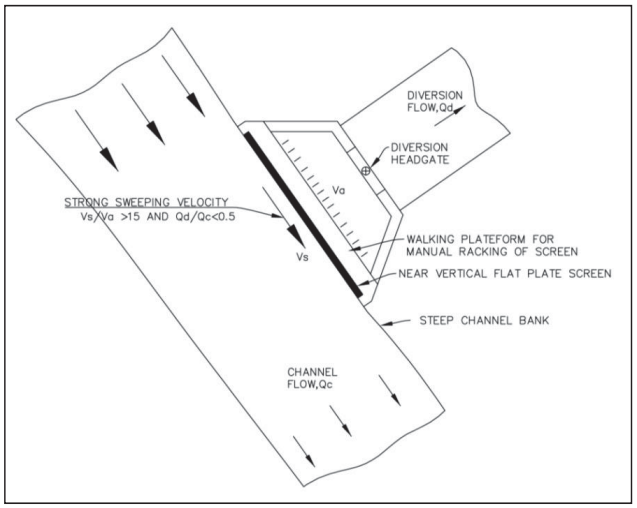


Traveling Belt Screen (USBR, 2014)

Source: Wyoming Game and Fish

Standard Application	In-stream or in-ditch bank mounted applications.
Strong Points	Belt movement assists in moving debris downstream with bypass flow. Operates well over a wide range of sweeping velocity.
Issues	Relatively new design with short history of operation.
Standard Mounting	Stand alone screen set in vertical guides.
Cleaning	Horizontally rotating screen with scraper bar.
Screen Material	Articulated slotted panels
Power Requirements	Yes, may be run off solar power
Water Surface Drop across the Screen (Head Requirements	~0.2 ft to 0.5 ft
Fish Bypass Structure	Not required for in-stream installations
Commercially Available	Yes
Search Key Words	Horizontal belt screen, Hydrolox Screens

Fixed Flat Plate Bank Screen (USBR, 2014)



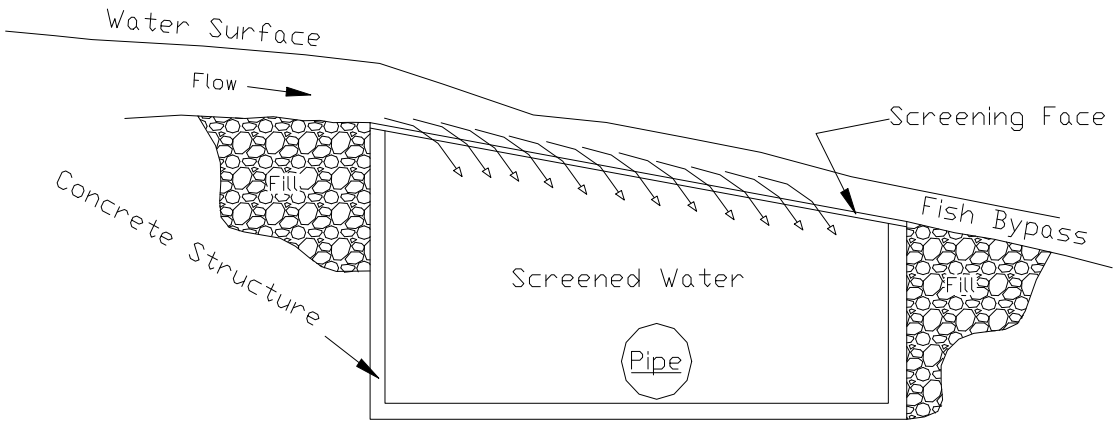
Standard Application	In-stream screen used for gravity diversion or pump sump
Strong Points	Good cleaning characteristics when located on a straight bankline mounted flush with the bank.
Issues	Generally designed as a high Vs/Va screen. Site requires strong sweeping flow adjacent to bankline. Cleaning effectiveness can be impacted by changes in stream conditions that effect sweeping flow alignment .. A mechanical cleaner is recommended if diversion flow is > 0.5 times the upstream channel flow.
Standard Mounting	Best on straight stream reaches. Screen mounted parallel to stream flow, generally flush with stream bank.
Cleaning	Passive, requires Vs/Va ratios > ~15 with occasional manual cleaning (see similar screens in air- and water-burst cleaning section
Screen Material	Wedge-wire, perforated plate
Flow Capacity	0 to >25 ft^3/s
Power Requirements	None
Water Surface Drop across the Screen (Head Requirements	~>0.3ft across screen structure
Fish Bypass	None
Commercially Available	Screen fabric only
Search Key Words	Wedge-wire screen, Hendrick Screens, Johnson Screens, Norris Screens, Corrugated Water Screens

Horizontal Flat Plate Down Ramp (USBR, 2014)

Source: USBR

Standard Application	Flow diversion at an elevation drop.
Strong Points	Passive screen with high diversion capacity. Can be designed using USBR Coanda screen design program. Simpler to construct than a curved Coanda screen.
Issues	Difficult to control bypass flow. Possible dewatering of the screen toe and loss of bypass flow during low flows. Generally not approach velocity NOAA compliant.
Standard Mounting	In line with stream or ditch
Cleaning	Passive
Screen Material	Tilted wire wedge-wire, flat wedge wire or perforated plate
Flow Capacity	Generally < $1ft^3/s/ft^2$. Best when constructed using tilted wedge wire screen and an upstream acceleration ramp (see figure 9) as specified by the USBR Coanda design guidance program, reference 15.
Power Requirements	None
Water Surface Drop across the Screen (Head Requirements)	Generally >1 ft
Fish Bypass	Fish and debris are transported by additional flow passing over screen.
Commercially Available	Yes
Search Key Words	Corrugated Water Screens, Watson Irrigation

Horizontal Flat Plate Screen (WDFW, 2009)



Downward Sloping

ATTACHMENT 4

Preliminary Hydraulic Calculations

Attachment 4 - Preliminary Pump Station and Force Main Calculations

Project No. 180249, Bear Creek Dry Creek MAR, Spokane County, WA

Pump Station	Flow Rate (cfs)	Flow Rate (gpm)	Flows To	Pipe Diameter (in)	Pipe Length (ft)	Roughness Coefficient (Hazen-Williams)	Pipeline Friction Head Loss (ft of water)	Minor Head Loss (ft of water)	Pumping Lift (ft)	Total Dynamic Head (ft of water)	Velocity (ft/s)
Bear Creek	1.0	449	Infiltration Gallery	8	2,050	140	7.61	2.12	100	109.73	2.86
Dry Creek	1.0	449	Infiltration Gallery	8	1,850	140	6.87	2.12	140	148.99	2.86

Notes:

1. Pipe lengths, pumping lifts, and minor head losses are based on conceptual design and will be revised during the design process

Attachment 4 - Preliminary Minor Head Loss Calculations

Project No. 180249, Bear Creek Dry Creek MAR, Spokane County, WA

Pump Station	Flow Rate (cfs)	Flow Rate (gpm)	Flows To	Pipe Diameter (in)	Component	Equivalent Pipe Length (ft)	Number of Components	Total Equivalent Pipe Length (ft)	Roughness Coefficient (Hazen-Williams)	Minor Head Loss (ft of water)
Bear Creek	1.0	449	Infiltration Gallery	8	45 Elbow	20	10	200	140	0.74
					90 Elbow	20	10	200	140	0.74
					Tee (Branch Flow)	40	2	80	140	0.30
					Tee (Pass-Through)	13.3	2	27	140	0.10
					Coupler	0	0	0	140	0.00
					Check Valve	33.3	1	33	140	0.12
					Butterfly Valve	30	1	30	140	0.11
					Flow Meter	0	1	0	140	0.00
									Total	**2.12**
Dry Creek	1.0	449	Infiltration Gallery	8	45 Elbow	20	10	200	140	0.74
					90 Elbow	20	10	200	140	0.74
					Tee (Branch Flow)	40	2	80	140	0.30
					Tee (Pass-Through)	13.3	2	27	140	0.10
					Coupler	0	0	0	140	0.00
					Check Valve	33.3	1	33	140	0.12
					Butterfly Valve	30	1	30	140	0.11
					Flow Meter	0	1	0	140	0.00
									Total	**2.12**

Notes:

1. Minor head losses based on equivalent pipe length method.
2. Type and quantity of fittings are based on conceptual design and will be revised during the design process.

ATTACHMENT 5

Preliminary
Sedimentation Analysis

Attachment 5 - Preliminary Sedimentation Analysis

Project No. 180249, Bear Creek and Dry Creek MAR, Spokane County, WA

Storm Inflow (cfs)	Settling Time (s)	Settling Time (hr)	Particle Diameter (mm)
0.10	25,600	7.11	0.00891
0.15	17,067	4.74	0.01091
0.20	12,800	3.56	0.01260
0.25	10,240	2.84	0.01409
0.30	8,533	2.37	0.01543
0.35	7,314	2.03	0.01667
0.40	6,400	1.78	0.01782
0.45	5,689	1.58	0.01890
0.50	5,120	1.42	0.01992
0.55	4,655	1.29	0.02089
0.60	4,267	1.19	0.02182
0.65	3,938	1.09	0.02271
0.70	3,657	1.02	0.02357
0.75	3,413	0.95	0.02440
0.80	3,200	0.89	0.02520
0.85	3,012	0.84	0.02597
0.90	2,844	0.79	0.02673
0.95	2,695	0.75	0.02746
1.00	2,560	0.71	0.02817
1.05	2,438	0.68	0.02887
1.10	2,327	0.65	0.02955
1.15	2,226	0.62	0.03021
1.20	2,133	0.59	0.03086
1.25	2,048	0.57	0.03150
1.30	1,969	0.55	0.03212
1.35	1,896	0.53	0.03273
1.40	1,829	0.51	0.03334
1.45	1,766	0.49	0.03393
1.50	1,707	0.47	0.03451
1.55	1,652	0.46	0.03508
1.60	1,600	0.44	0.03564
1.65	1,552	0.43	0.03619
1.70	1,506	0.42	0.03673
1.75	1,463	0.41	0.03727
1.80	1,422	0.40	0.03780
1.85	1,384	0.38	0.03832
1.90	1,347	0.37	0.03883
1.95	1,313	0.36	0.03934
2.00	1,280	0.36	0.03984

Assumptions:

Vault Volume (cf) = 2,560 *(8' wide x 40' long x 8' deep)*

Settling Time (s) = Pond Volume / Storm Inflow

Particle Settling Time = Particle Settling Distance / k * (Particle Diameter)^{2}

Particle Diameter = (Particle Settling Distance / k * Settling Time)$^{0.5}$

Settling Distance (m) = 1.8288

k (m^{-1} s^{-1}) = 900,000

Descriptive Term	Size Range and Sieve Number
Boulders	Larger than 12"
Cobbles	3" to 12"
Gravel	3" to No. 4 (4.75 mm)
Coarse Gravel	3" to 3/4"
Fine Gravel	3/4" to No. 4 (4.75 mm)
Sand	No. 4 (4.75 mm) to No. 200 (0.075 mm)
Coarse Sand	No. 4 (4.75 mm) to No. 10 (2.00 mm)
Medium Sand	No. 10 (2.00 mm) to No. 40 (0.425 mm)
Fine Sand	No. 40 (0.425 mm) to No. 200 (0.075 mm)
Silt and Clay	Smaller than No. 200 (0.075 mm)

ATTACHMENT 6

Preliminary Infiltration Gallery Sizing

Attachment 6 - Preliminary Infiltration Gallery Sizing

Project No. 180249, Bear Creek Dry Creek MAR, Spokane County, WA

Infiltration Gallery	Inflow Rate (ft^3/s)	Inflow Rate (ft^3/hr)	Length (ft)	Width (ft)	Long-Term Design Infiltration Rate (in/hr)	Long-Term Design Infiltration Rate (ft/hr)	Facilty Infiltration Rate (ft^3/hr)	Facilty Infiltration Rate (ft^3/s)
Bear Creek	1.00	3,600	60	30	25	2.08	3,750	1.04
Dry Creek	1.00	3,600	75	40	15	1.25	3,750	1.04

ATTACHMENT 7

Preliminary Cost Estimates

Bear Creek MAR			Preliminary Capital Cost Estimate	
DESCRIPTION OF ITEM	**UNIT**	**ESTIMATED QUANTITY**	**UNIT PRICE**	**EXTENDED AMOUNT**
General Construction				
Mobilization	LS	1	$ 30,000.00	$ 30,000.00
SPCC Plan	LS	1	$ 1,000.00	$ 1,000.00
Project Temporary Traffic Control / Signage	LS	1	$ 20,000.00	$ 20,000.00
Erosion / Water Pollution Control	FA	EST	$ 5,000.00	$ 5,000.00
In-Water Work Preparations	FA	EST	$ 10,000.00	$ 10,000.00
			Subtotal	*$ 66,000.00*
In-Water Diversion Structure				
Diversion Structure with Fish Screen	EA	1	$ 15,000.00	$ 15,000.00
Slide/Canal Gate Valve	EA	1	$ 3,000.00	$ 3,000.00
Structure Excavation Class B	CY	33	$ 20.00	$ 660.00
Remote Monitoring Equipment	LS	1	$ 5,000.00	$ 5,000.00
			Subtotal	*$ 23,660.00*
Electrical				
Power Service Extension	LF	200	$ 15.00	$ 3,000.00
			Subtotal	*$ 3,000.00*
Pump Station				
Structure Excavation Class B	CY	54	$ 20.00	$ 1,080.00
Solid Wall PVC Pipe 12 In. Diam.	LF	40	$ 25.00	$ 1,000.00
Pump Wet Well Structure	EA	1	$ 5,000.00	$ 5,000.00
8 In. Drain Valve	EA	1	$ 1,500.00	$ 1,500.00
Power and Pump Control Enclosure	EA	1	$ 5,000.00	$ 5,000.00
Pump Panel, Floats	EA	1	$ 2,500.00	$ 2,500.00
Pump and Motor	EA	1	$ 35,000.00	$ 35,000.00
Flow Meter Vault	EA	1	$ 2,500.00	$ 2,500.00
Flow Meter	EA	1	$ 5,000.00	$ 5,000.00
Flow Control Valve	EA	1	$ 1,000.00	$ 1,000.00
Air Release Valve	EA	1	$ 5,000.00	$ 5,000.00
			Subtotal	*$ 64,580.00*
Force Main				
Structure Excavation Class B	CY	912	$ 20.00	$ 18,240.00
Solid Wall PVC 8 In. Diam.	LF	2,050	$ 28.00	$ 57,400.00
			Subtotal	*$ 75,640.00*
Pre-Treatment & Infiltration Gallery				
Structure Excavation Class B	CY	267	$ 20.00	$ 5,340.00
Sedimentation Tank	EA	1	$ 25,000.00	$ 25,000.00
Perforated PVC Pipe 4 In. Diam.	LF	120	$ 18.00	$ 2,160.00
Cleanout Ports	EA	4	$ 500.00	$ 2,000.00
Monitoring Ports	EA	2	$ 500.00	$ 1,000.00
4 In. Infiltration Gallery Pipe Valves	EA	2	$ 500.00	$ 1,000.00
Infiltration Gallery Rock	CY	140	$ 50.00	$ 7,000.00
Woven Geotextile for Underground Drainage	SY	440	$ 5.00	$ 2,200.00
Gravel Backfill for Pipe Zone Bedding	CY	371	$ 40.00	$ 14,840.00
			Subtotal	*$ 60,540.00*
			SUBTOTAL	**$ 293,420.00**
			Construction Management (10%)	$ 29,342.00
			WA State Sales Tax (8.1%)	$ 23,767.02
			CONSTRUCTION TOTAL	**$ 346,529.02**
			Easement	$ 20,000.00
			Engineering Design and Supporting Field Investigations (Survey, Geotech/Hydrogeo, Civil)	$ 120,000.00
			Permitting (Water Rights, In-Water Work, Other)	$ 30,000.00
			PROJECT SUBTOTAL	**$ 516,529.02**
			Contingency (15%)	$ 77,479.35
			PROJECT TOTAL	**$ 594,008.37**

Bear Creek MAR			Preliminary Annual O&M Cost Estimate	
DESCRIPTION OF ITEM	**UNIT**	**ESTIMATED QUANTITY**	**UNIT PRICE**	**EXTENDED AMOUNT**
Pump Station Annual Power (3 Months per Year)	HR	2,160	$ 2	$ 4,320
MAR System Operation & Maintenance	HR	60	$ 50	$ 3,000
Ground & Surface Water Sampling, Stream Gaging	HR	60	$ 50	$ 3,000
Data Analysis & Reporting	HR	40	$ 50	$ 2,000
Analytical	EA	7	$ 300	$ 2,100
Pump Contractor	HR	15	$ 200	$ 3,000
Equipment Repair & Replacement Reserve	LS	1	$ 5,000	$ 5,000
			ANNUAL O&M TOTAL	**$ 22,420**

Dry Creek MAR			Preliminary Capital Cost Estimate	
DESCRIPTION OF ITEM	**UNIT**	**ESTIMATED QUANTITY**	**UNIT PRICE**	**EXTENDED AMOUNT**
General Construction				
Mobilization	LS	1	$ 30,000.00	$ 30,000.00
SPCC Plan	LS	1	$ 1,000.00	$ 1,000.00
Project Temporary Traffic Control / Signage	LS	1	$ 2,500.00	$ 2,500.00
Erosion / Water Pollution Control	FA	EST	$ 5,000.00	$ 5,000.00
In-Water Work Preparations	FA	EST	$ 10,000.00	$ 10,000.00
			Subtotal	*$ 48,500.00*
In-Water Diversion Structure				
Diversion Structure with Fish Screen	EA	1	$ 15,000.00	$ 15,000.00
Slide/Canal Gate Valve	EA	1	$ 3,000.00	$ 3,000.00
Structure Excavation Class B	CY	33	$ 20.00	$ 660.00
Remote Monitoring Equipment	LS	1	$ 5,000.00	$ 5,000.00
			Subtotal	*$ 23,660.00*
Electrical				
Power Service Extension	LF	2,000	$ 15.00	$ 30,000.00
			Subtotal	*$ 30,000.00*
Pump Station				
Structure Excavation Class B	CY	54	$ 20.00	$ 1,080.00
Solid Wall PVC Pipe 12 In. Diam.	LF	40	$ 25.00	$ 1,000.00
Pump Wet Well Structure	EA	1	$ 5,000.00	$ 5,000.00
8 In. Drain Valve	EA	1	$ 1,500.00	$ 1,500.00
Power and Pump Control Enclosure	EA	1	$ 5,000.00	$ 5,000.00
Pump Panel, Floats	EA	1	$ 2,500.00	$ 2,500.00
Pump and Motor	EA	1	$ 37,000.00	$ 37,000.00
Flow Meter Vault	EA	1	$ 2,500.00	$ 2,500.00
Flow Meter	EA	1	$ 5,000.00	$ 5,000.00
Flow Control Valve	EA	1	$ 1,000.00	$ 1,000.00
Air Release Valve	EA	1	$ 5,000.00	$ 5,000.00
			Subtotal	*$ 66,580.00*
Force Main				
Structure Excavation Class B	CY	823	$ 20.00	$ 16,460.00
Solid Wall PVC 8 In. Diam.	LF	1,850	$ 28.00	$ 51,800.00
			Subtotal	*$ 68,260.00*
Pre-Treatment & Infiltration Gallery				
Structure Excavation Class B	CY	445	$ 20.00	$ 8,900.00
Sedimentation Tank	EA	1	$ 25,000.00	$ 25,000.00
Perforated PVC Pipe 4 In. Diam.	LF	225	$ 18.00	$ 4,050.00
Cleanout Ports	EA	6	$ 500.00	$ 3,000.00
Monitoring Ports	EA	3	$ 500.00	$ 1,500.00
4 In. Infiltration Gallery Pipe Valves	EA	3	$ 500.00	$ 1,500.00
Infiltration Gallery Rock	CY	230	$ 50.00	$ 11,500.00
Woven Geotextile for Underground Drainage	SY	720	$ 5.00	$ 3,600.00
Gravel Backfill for Pipe Zone Bedding	CY	339	$ 40.00	$ 13,560.00
			Subtotal	*$ 72,610.00*
			SUBTOTAL	**$ 309,610.00**
			Construction Management (10%)	$ 30,961.00
			WA State Sales Tax (8.1%)	$ 25,078.41
			CONSTRUCTION TOTAL	**$ 365,649.41**
			Easement	$ 20,000.00
			Engineering Design and Supporting Field Investigations (Survey, Geotech/Hydrogeo, Civil)	$ 120,000.00
			Permitting (Water Rights, In-Water Work, Other)	$ 30,000.00
			PROJECT SUBTOTAL	**$ 535,649.41**
			Contingency (15%)	$ 80,347.41
			PROJECT TOTAL	**$ 615,996.82**

Dry Creek MAR			Preliminary Annual O&M Cost Estimate	
DESCRIPTION OF ITEM	**UNIT**	**ESTIMATED QUANTITY**	**UNIT PRICE**	**EXTENDED AMOUNT**
Pump Station Annual Power (3 Months per Year)	HR	2,160	$ 2	$ 4,320
MAR System Operation & Maintenance	HR	60	$ 50	$ 3,000
Ground & Surface Water Sampling, Stream Gaging	HR	60	$ 50	$ 3,000
Data Analysis & Reporting	HR	40	$ 50	$ 2,000
Analytical	EA	7	$ 300	$ 2,100
Pump Contractor	HR	15	$ 200	$ 3,000
Equipment Repair & Replacement Reserve	LS	1	$ 5,000	$ 5,000
			ANNUAL O&M TOTAL	**$ 22,420.00**