DISCUSSION PAPER

Arrowsmith Water Service
Englishman River Water Intake Study
Phase 1 - Conceptual Planning

Discussion Paper 8-1 – Comparison of Intake and Water Treatment Plant Siting Options

Prepared by: Keith Kohut and Matt Henney

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1 Introduction

The purpose of this discussion paper is to review in greater detail the characteristics of the top-listed sites for the proposed Englishman River intake and water treatment plant. Geological conditions, environmental sensitivity, and hydrological impacts were identified for each site. Conceptual level layouts were developed for the intake and water treatment facilities and, based on these layouts, Class 'D' cost estimates were developed. Significant upgrades to the supporting water distribution system were also identified and priced.

2 Development of Short-List of Siting Options

2.1 Constraint Mapping

As detailed in Discussion Paper (DP) 6-2, a 10 km stretch of the Englishman River was examined for its suitability of supporting an intake and treatment plant. The 10 km stretch extends from upstream of the Morrison Creek confluence to just upstream of the estuary area at the river mouth. The 10 km stretch was divided into 19 reaches based on significant bends in the river, tributary confluences, and the location of significant rights-of-way (ROWs). The reach boundaries conformed to legal property lines where possible. The 19 reaches were then subdivided into a left and right bank of the river, for a total of 38 reaches to evaluate.

To create a site short-list, an evaluation matrix was developed that awarded each reach a suitability score. The score was based on the equal weighting of the following criteria:

- Land use compatibility;
- Heritage/archaeology concerns;
- Ecological impacts;
- Geotechnical conditions; and
- Water system considerations.

A higher score indicated that a given reach was more favourable along these criteria. The results of the scoring process are detailed in DP 6-2. The evaluation indicated that the preferable sites for the proposed intake and water treatment plant would be in the lower reaches of the English River, from Highway 19 northward. **Figure 2-1** shows the overall scoring of each reach.

2.2 Site Short-List

Based on the conclusions of the constraint mapping, five sites north of Highway 19 were identified as potential locations for the proposed intake and water treatment plant:

- Site 1 in Reach 12E
- Site 2 in Reach 14W
- Site 3 in Reach 17W
- Site 4 in Reach 18W
- Site 5 in Reach 19W

Upon closer examination, Sites 2 and 4 were rejected based on a number of issues. Site 2 lies well within the 200-year flood plain and is also downstream of where several river channels diverge from the Englishman River and flood areas along the western bank. Site 4 is also predominantly in the flood plain and is located immediately downstream of Highway 19A at a shallow point in the river. In addition, Site 4 is heavily used by the public.

The assessment therefore omitted these two sites to focus on Sites 1, 3, and 5.

2.3 Detailed Site Evaluation

The three remaining top-listed sites were examined in greater detail. Site visits were conducted by the team to assess and identify geological, hydrological and environmental issues, and to identify site features that could be advantageous to site layouts. River crossings at each site were surveyed to develop accurate riverbed and riverbank profiles. The team's findings are detailed in the appendices as follows:

- **Appendix B** – Koers memorandum: distribution main tie-ins and upgrades depending on which site option is used
- **Appendix C** – EBA memorandum: geological site assessments
- **Appendix D** – Hayco memorandum: hydrological site assessments
- **Appendix E** – LGL memorandum: environmental site assessments

This level of site assessment sites was used to develop conceptual level layouts of the three sites. A fourth layout was developed that links two of the top-listed sites together. The layout options were, therefore, labelled as Site 1A, Site 3, Site 5 and Site 1B. These layouts are discussed in Section 4.0.

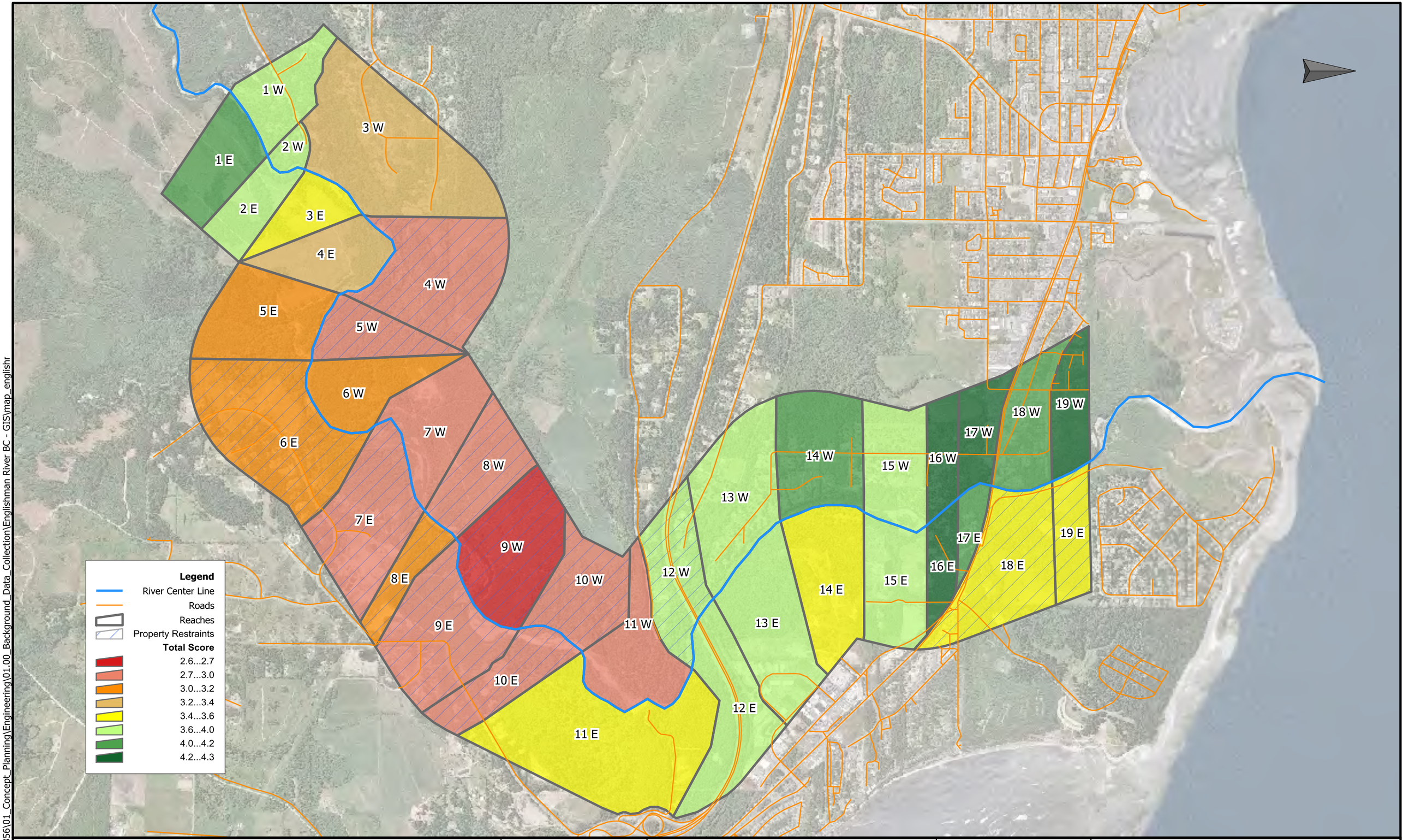

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Figure 2-1: Total Score Map

Projection: UTM Zone 10
Datum: NAD83

0 500 m

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Englishman River Water Intake Study
Phase 1 - Conceptual Planning
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3 Design Basis

3.1 Capacity Estimation

The treatment facilities were sized for the projected 2050 water demands. As detailed in DP 3-1 and DP 3-2, future community water demands were estimated based on projected population growth and on their historical water consumption rates. A low and high per capita demand were estimated that reflect the potential impact of implementing more stringent water conservation between now and 2050. The sustainable capacities of the Arrowsmith Water Services (AWS) groundwater supplies were incorporated to determine the amount of water needed specifically from the Englishman River. The ranges were calculated for two scenarios: one that included full participation by the Township of Qualicum Beach (TQB) and one without TQB's participation. Capacity requirements are listed in **Table 3-1**.

For daily operation requirements, it is also beneficial to estimate 2050 average day surface water capacity requirements. DP 3-2 assumed a 1.3 ratio of average day demands to maximum day demands. Using this ratio and assuming that the full capacity of the groundwater supplies would be available during an average day, the average surface water capacities were calculated and are also listed in Table 3-1.

Table 3-1
Surface Water Supply Capacity Requirements

TQB Participation	2050 Maximum Day Demand (m^3/day)	2050 Average Day Demand (m^3/day)	Groundwater Capacity (m^3/day)	2050 Maximum Day Surface Water Capacity Required (m^3/day)	2050 Average Day Surface Water Capacity Required (m^3/day)
Full Participation	52,318 – 87,320	40,245 – 67,169	39,000	13,318 – 48,329	1,245 – 28,169
No Participation	40,218 – 65,329	30,937 – 50,253	19,000	21,218 – 46,329	11,937 – 31,253

The average day estimates do not incorporate the impact of using treated surface water to supplement the groundwater supplies. This process, termed Aquifer Storage and Recovery (ASR) involves injecting treated surface water into an aquifer. This water is then drawn back into the distribution system during periods of low river flow to decrease demands on the surface water supply. ASR will be examined in DP 5-2.

Table 3-1 demonstrates that the extent of TQB's participation will affect the lower end of the supply requirement estimates, but does not have a significant impact on the upper end. At this stage it is prudent to size the water treatment plant for the worst case maximum day demands, therefore the AWS design capacity is assumed to be 48 ML/d.

3.2 Phased Construction and Plant Expansion

The water treatment processes were laid out in a modular design, with several identically-sized tanks and treatment equipment running in parallel trains. This allows for flexibility in plant operation, in case one treatment train must be temporarily off-line and for straight-forward expansion of the plant. To increase the plant capacity, replicates of the existing tanks would be added to the side of the parallel tanks. Staging the water treatment plant will cost more to reach the ultimate 2050 design capacity, but will allow some costs to be deferred.

For the purposes of site comparison, it was assumed that the intake and treatment plant were constructed in a single stage. However the plant layouts were designed such that a portion of the process trains could be added at a later date without affecting existing infrastructure or the operation of the plant.

3.3 Intake and Treatment Process Selection

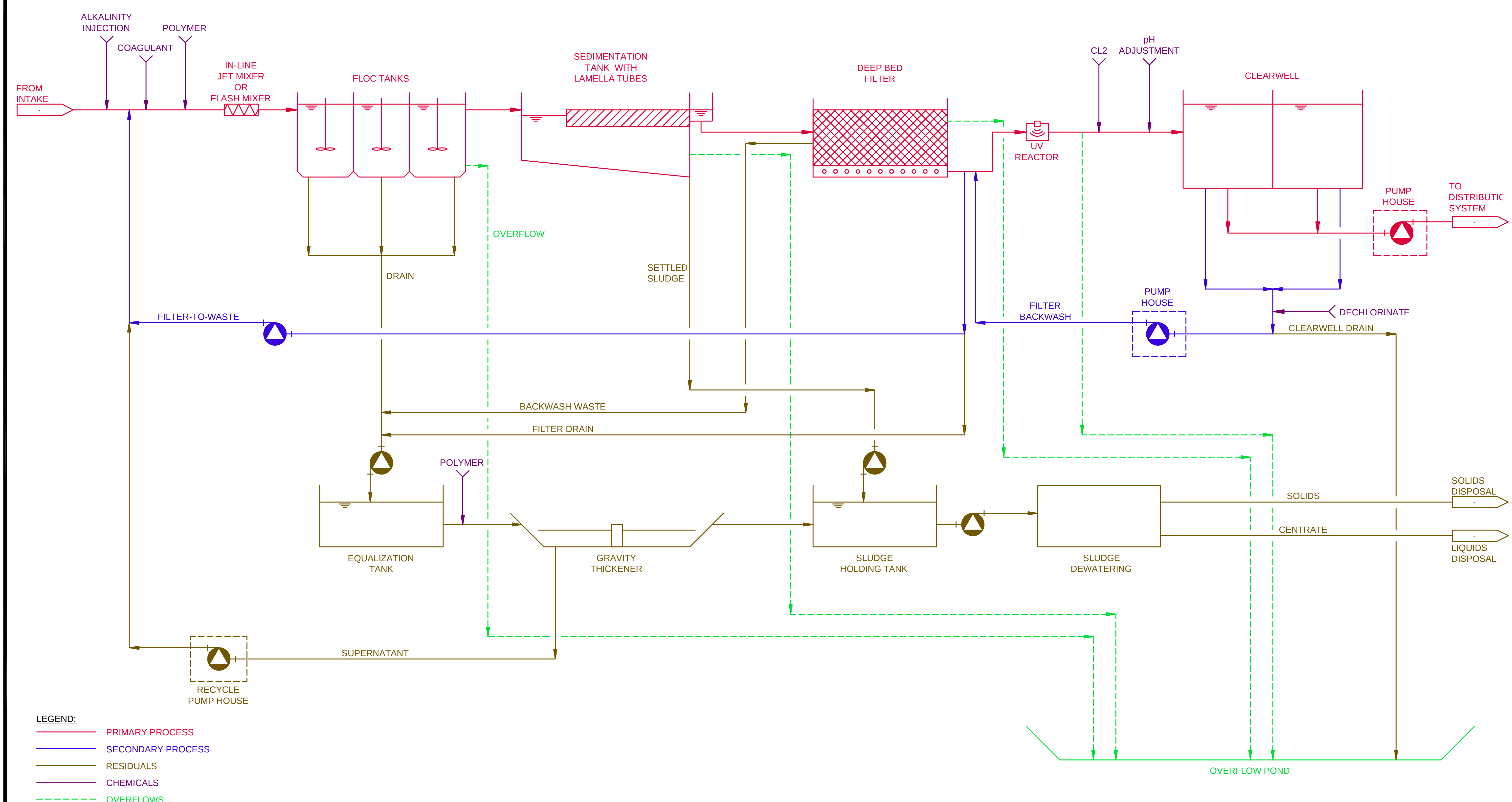
DP 4-3 identified the different combinations of treatment processes that would be suitable for treating Englishman River water. DP 4-4 recommended that the plant siting layouts use the treatment combination with the largest footprint in order to provide flexibility to the ultimate process selection, as it is better to have extra space on the construction site than to find late in design that insufficient space is available. Therefore the plant was sized for a conventional treatment system using sedimentation and media filtration. Even when conservatively sizing the treatment plant, the processes were kept as compact as the technology would allow by including space-saving features such as inclined plate settlers and deep bed media filters. The treatment plant process flow diagram is shown in **Figure 3-1**.

For the intention of site comparison, the plant layouts were kept as consistent as available space would allow. At this stage, it was assumed that the treatment plant would be a single-story building with masonry walls and slanted steel roof. The residual management infrastructure, pump stations, and clearwells were assumed to be concrete structures.

Different intake designs were discussed in DP 4-4. Riverbank intakes were recommended if river conditions would permit. For shallower reaches of the Englishman River, riverbank filtration systems or infiltration galleries were recommended.

3.4 Residual Management

To reduce the amount of waste requiring disposal, residual management infrastructure was included to recycle and dewater waste generated from the treatment processes. As shown in **Figure 3-1**, the wastes generated for off-site disposal are dewatered sludge, dewatering centrate, and plant sanitary waste. The 2050 waste production rate for the treatment processes was calculated as follows:



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DESIGNED	K. KOHUT
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APPROVED	
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ARROWSMITH WATER SERVICES

ENLISHMAN RIVER INTAKE AND TREATMENT FACILITIES

PROCESS MECHANICAL
PROCESS FLOW DIAGRAM

DRAWING NUMBER	REV. NO.	SHEET
FIGURE 3-1	A	

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- 8 m^3/day (1700 kg/day) of dewatered sludge
- 138 m^3/day (200 kg/day) of dewatering centrate with 1500 mg/L total suspended solids
- >1 m^3/day of plant sanitary waste

It is assumed that the dewatered sludge will be trucked offsite for landfill disposal. It is assumed that the centrate could be sent via the sanitary sewer to the French Creek wastewater treatment plant. The Regional District of Nanaimo (RDN) Sewer Use Bylaw states that wastes containing greater than 350 mg/L of total suspended solids is considered "Restricted Waste", which can only be discharged to the sewer if a Waste Discharge Permit or Authorization is obtained. At this stage it is assumed that a permit or authorization will be granted. It should be noted that the volume of generated waste can be reduced further, but at a greater cost.

4 Option Descriptions

The four siting options are described below. The infrastructure sizing criteria is provided in DP 4-4. Appendix B details recommended upgrades for the distribution system for each option, while geological, hydrological, and environmental characteristics are detailed in Appendices C, D, and E, respectively.

Site 1A – Intake and Water Treatment Plant at Site 1

Description

This layout involves drawing water from an intake near the Highway 19 and railway crossing of the Englishman River, to the water treatment plant located in an abandoned gravel pit behind the City of Parksville (COP) Public Works Yard. **Figure 4-1** shows the overall site plan. The river is deep enough in this reach to allow a riverbank intake. For favourable hydraulics, the intake should be placed on the outside edge of a river bend, along the stretch of bedrock that extends from just upstream of the Highway 19 crossing, to just slightly downstream of the railway river crossing.

The conceptual layout of the intake consists of water passing through trash screens into the intake substructure. Water would then pass through travelling screens to the intake wet well. Fish would be diverted from the travelling screens to side channels and returned to the river through a fish return pump. The configuration of the travelling screen and fish return pump would be developed with the intention to minimize any impact on fish that have entered the structure. While travelling screens have been assumed at this stage, alternatively static screens can also be used. Screen selection will be reviewed in a later stage of design. Water in the wet well downstream of the screens would travel through vertical turbine pumps to the intake upper floor and to a 600 mm diameter raw water main.

An access road to the intake is required for regular maintenance duties. The west bank of the river is relatively steep and it would be difficult to construct an access road from the highway. Instead the access road would come off of Martindale Road and run south beneath the railway crossing to reach the intake. Access would be through a residential property.

Site 1A – Intake and Water Treatment Plant at Site 1

To reach the water treatment plant the pipe will need to cross the river. While the west bank is steep, there is a flat section of ground that follows along the east bank and the pipe should cross to the east bank as soon as possible to take advantage of its gentler slope. It is assumed that the water main crossing will be an open cut trench, installed during a window in the season that has a minimal impact on fish in the river.

The raw water main would travel approximately 600 m through heavy foliage to reach the water treatment plant. The water main may need to travel through a section of Lot 1465, a privately-owned property which is being held for future residential building development. Development of this property is planned by the owners to occur in the next five to ten years.

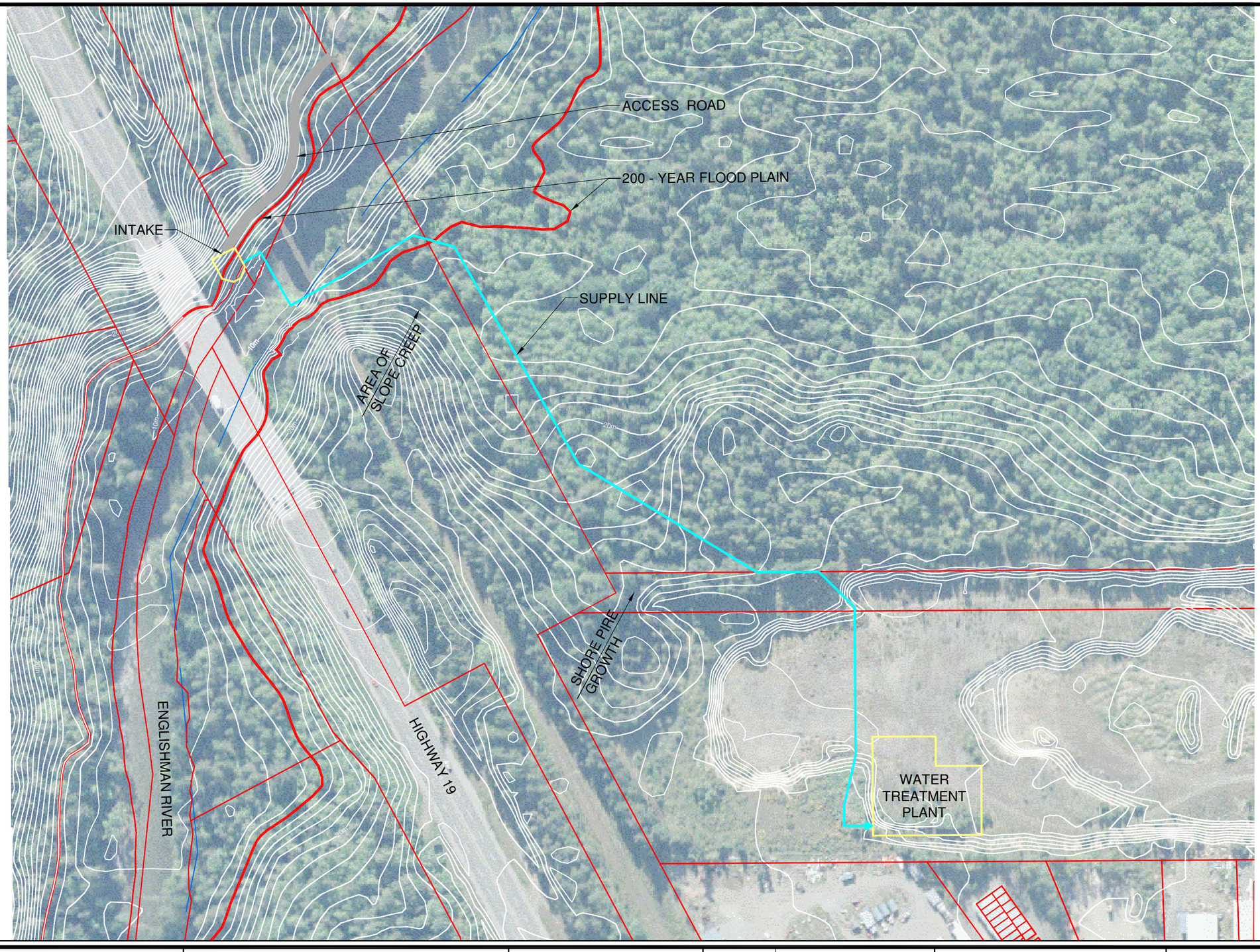
Midway through the evaluation, an alternative location for the intake was identified. While this alternative location was not used in the comparison of sites, it is of interest and is shown in **Figure 4-2**.

The water treatment plant site is an abandoned gravel pit. The property is separated from Lot 1465 by a road ROW reserved to access the future residential development. The treatment plant site consists of several benches, dropping in elevation when moving north. The site will generally be graded for a continuous, gradual slope across the site but the benches can also be used to take advantage of gravity flow through the plant processes. For example, in the site layout developed the clearwell was placed as an above-ground structure on a lower bench to allow gravity flow from the plant to the clearwell while saving costs on not having to bury the structure. **Figure 4-3** shows a more detailed layout of the water treatment plant site and **Figure 4-4** shows the corresponding hydraulic profile.

The water treatment processes, administration facilities and chemical rooms are all located in a single building, on the south side of the site. The clearwell, residual management infrastructure, and pump stations are individual structures but placed in groups to allow easy access throughout the site to each component. The site is not readily visible to the public so the aesthetic appearance of the site is not as crucial as when the plant is in an open, public place. However, the AWS will likely want to host tours of the plant, therefore some level of effort would be invested in the site's appearance.

The main access point to the site will be through the Public Works Yard, but provisions will be made to allow a secondary access point from the ROW to the west when a road is constructed there. Parking is provided near the administration building and the roads allow access to the chemical loading bay and the dewatered solids pick-up area.

Treated water from the plant would flow to the clearwell and be pumped off site through a transmission main that splits into two sections. One section would connect to an existing 250 mm diameter water main on Franklin Gully Way and travels eastward. The other section would parallel the raw water supply main in a shared trench, crossing the Englishman River and travelling north up Martindale Road. Waste streams from the treatment plant and from the dewatering facility would connect to a sanitary sewer main located on Herring Gull Way. Power for the intake is available from the power lines alongside Highway 19. Power for the treatment plant would come from the power lines on Herring Gull Way.



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ARROWSMITH WATER SERVICES

CIVIL
OVERALL SITE PLAN
SITE #1A

ARROWSMITH WATER SERVICES
ENLISHMAN RIVER INTAKE
STUDY

DRAWING NUMBER	REV. NO.	SHEET
FIGURE 4-1		

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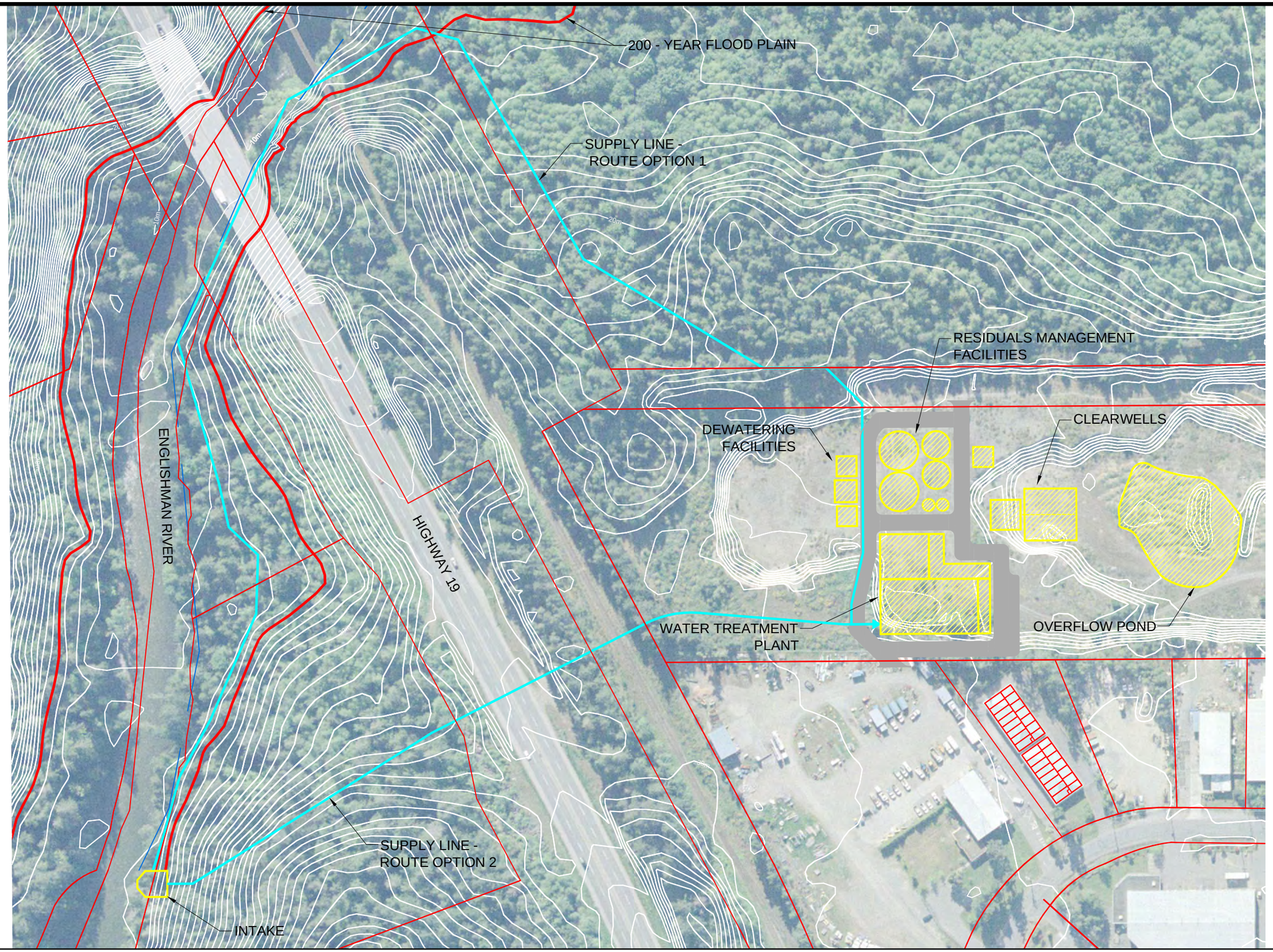

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ARROWSMITH WATER SERVICES

CIVIL
ALTERNATIVE SITE 1A PLAN

ARROWSMITH WATER SERVICES
ENGLISHMAN RIVER INTAKE
STUDY

DRAWING NUMBER	REV. NO.	SHEET
FIGURE 4-2		

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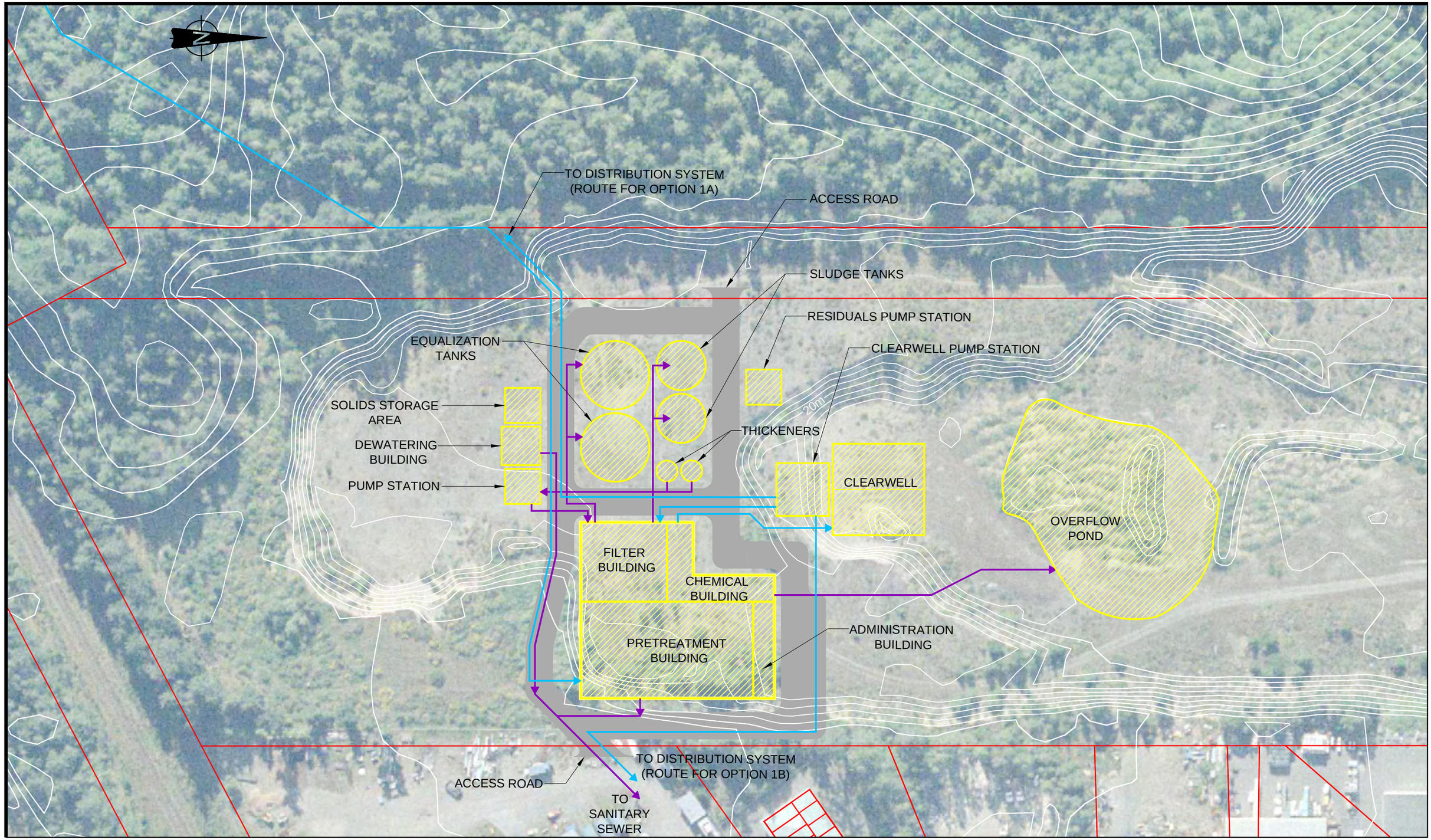
DATE: 2011-05-11, Keith Kohut



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ARROWSMITH WATER SERVICES

CIVIL
TREATMENT PLANT SITE PLAN
SITE #1

ARROWSMITH WATER SERVICES
ENGLISHMAN RIVER INTAKE
STUDY

DRAWING NUMBER	REV. NO.	SHEET
FIGURE 4-3		

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DATE: 2011-05-17, Keith Kohut

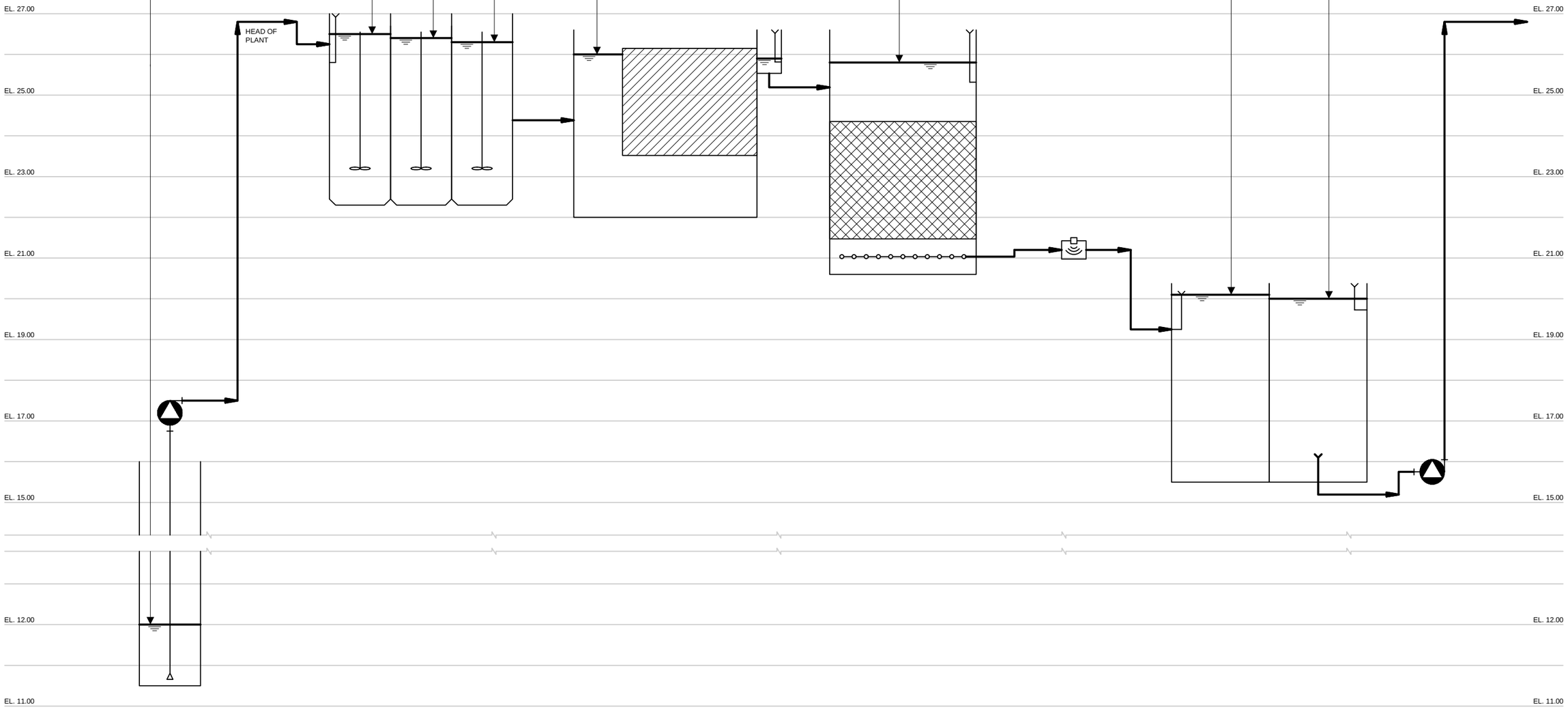
INTAKE WET WELL | FLOCCULATORS | SEDIMENTATION TANKS | FILTERS | UV REACTORS | CLEARWELLS

XXX	TANK HEIGHT
XXX	DESIGN FLOW 48 ML/d

16.0 / 12.0 | 27.0 / 26.5 | 27.0 / 26.4 | 27.0 / 26.3 | 26.5 / 26.0 | 26.3 / 25.8 | 20.6 / 20.1 | 20.6 / 20.0

200 YEAR FLOOD LEVEL: 15.5m

APPROX. LOW WATER LEVEL: 12.0m



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ARROWSMITH WATER SERVICES

PROCESS MECHANICAL
SITE 1 HYDRAULIC PROFILE

ENLISHMAN RIVER
INTAKE AND TREATMENT
FACILITIES

DRAWING NUMBER	REV. NO.	SHEET
FIGURE 4-4		

Site 1A – Intake and Water Treatment Plant at Site 1

Stormwater runoff and neutralized overflow from the plant would be sent to an overflow pond in the site's lower bench. It is assumed that water in the overflow pond, if it does not percolate through the porous soils will follow the elevation contours and gravity flow to the river north of the site.

Geotechnical Considerations

Beyond the bedrock, the west bank consists of sandy silt and gravel, which is not favourable for construction of a riverbank intake. The location of the intake is therefore limited to the stretch of bedrock near Highway 19 and the railway crossing.

The hill paralleling Highway 19 to the north showed evidence of a high rate of soil creep. The toe of this hill should be avoided for the raw water main supply route from the intake to the treatment plant.

The water treatment plant site consists of sand and gravel to a depth of at least 20 m. The site is well drained, and the seismic Site Class is likely C to D.

Hydrology Considerations

The intake should be designed so that the intake and wet well are low enough to allow sufficient water to enter the intake during low water level periods while the ceiling of the wet well should be above the 200-year flood level. An example profile of the intake is provided in **Figure 4-5**. The lower water levels at this site are currently unknown, and were estimated based on a water level monitoring station located near Highway 19A, labelled MOE1 in DP 4-1. A detailed water level assessment would be required if this site is selected for the intake.

There are several small rapids near this site, which could lead to the formation of frazil ice during the winter. Careful intake design would be required to prevent frazil ice from clogging the intake.

Environmental Considerations

The intake at Site 1 would be in areas that have already been disturbed by the construction of the Highway 19 and railway crossings, so its impact is expected to be minimal. The intake and river crossing will need to be done during a window where the impact on the river's fish is minimized. This window can be determined through a more detailed environmental assessment and consultation with the Department of Fisheries and Oceans. The water treatment plant would be located in an abandoned gravel pit with little recovery growth observed on site, therefore the environmental impact of the water treatment is also expected to be minimal.

Two areas along the raw water supply main route have been flagged:

- Red Alder bottomland located on the east side of the raw water main corridor, and
- A Shore Pine grove located near the southwest corner of the treatment plant site.

These types of habitat are considered scarce and therefore should be avoided.

Site 1A – Intake and Water Treatment Plant at Site 1

A Provisional Operation Rule for the Arrowsmith Lake Reservoir requires sufficient flow release to ensure a 1.6 m^3/s flow at the MOE1 flow gauge by Highway 19A. This may impact the amount of water that can be pumped from the intake during summer months.

Key Advantages and Disadvantages

The intake site is suitable for a riverbank style intake, which is relatively easy to maintain and operate. There is ample space behind the Public Works Yard for the water treatment plant, which allows more flexibility to add sustainable and capital-saving features and develop hydraulically superior configurations. The plant site will have little environmental impact and is in a private location. At the same time the site is adjacent to the Public Works Yard which should ease operator access.

However there are several disadvantages to this site. The steepness of the west riverbank means that access to the site needs to come from the north through private property on Martindale Road. The river crossing can only be done during a seasonal window that has a minimal impact on fish populations. To avoid scarce habitat near the water treatment plant site and soil creep areas the raw water transmission main may need to cut through a portion of the privately-owned property. If this site is selected different routing options will be examined.

In summary, the site is very good for a water treatment plant but there are some challenges to constructing the intake and raw water supply main.

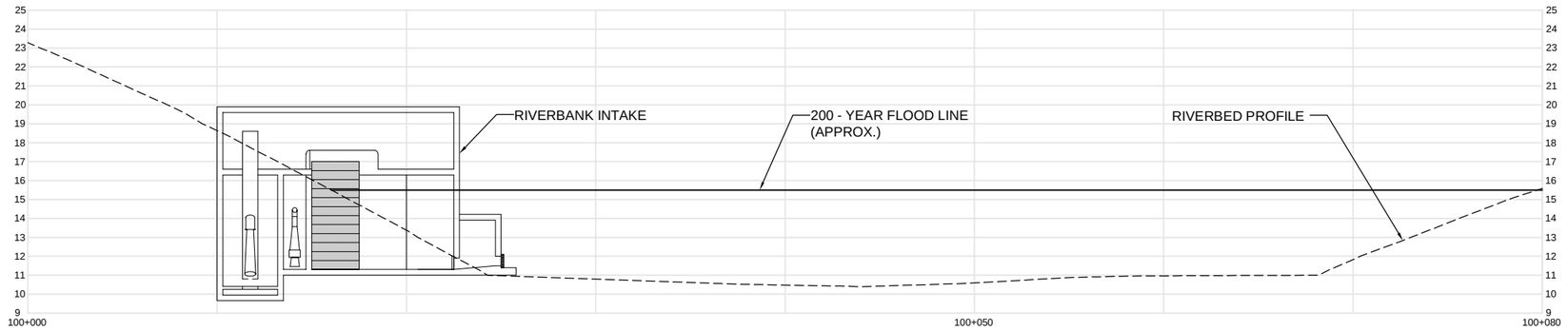
Site 3 – Intake and Water Treatment Plant at Site 3

Description

The site is located just upstream of the Highway 19A river crossing. At this location there is a bedrock face on the outer bend of the Englishman River where the water is relatively deep. These features are favourable for a riverbank intake. Water from the intake would be pumped to the water treatment facility on the same site. **Figure 4-6** shows a conceptual layout of the intake and treatment plant at Site 3 and **Figure 4-7** shows the corresponding hydraulic profile. At this stage of design, the treatment facilities are configured to fit all on one site, occupying five small properties. If this site is selected as the preferred site for the treatment plant, the option of locating some of the infrastructure on properties on the west side of Martindale Road could be examined.

The largest property houses a motel, and is detailed in the Koers memorandum entitled “Intake/Water Treatment Plant Site Shortlist”. The three western-most properties were not discussed in the Koers memorandum, but are detailed in Appendix F.

The intake configuration would be the same as described for Site 1A, consisting of trash screens, traveling screens, fish return pumps and vertical turbine pumps.



SITE 1
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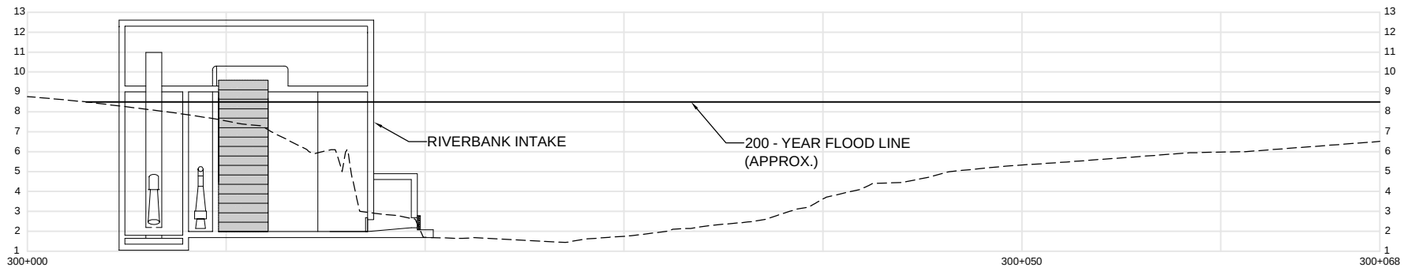
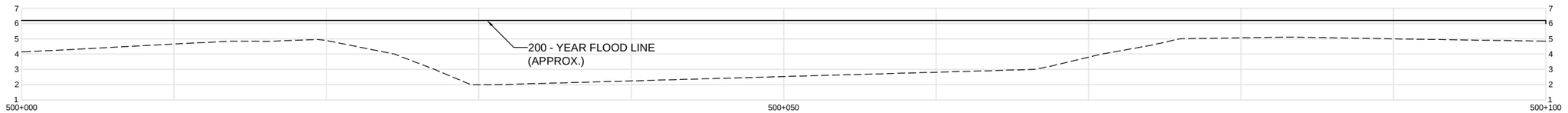


SITE 3
1:150 H, 1:150 V



SITE 5
1:150 H, 1:150 V

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ARROWSMITH WATER SERVICES

CIVIL

ENGLISHMAN RIVER PROFILES

ARROWSMITH WATER SERVICES
ENGLISHMAN RIVER INTAKE
STUDY

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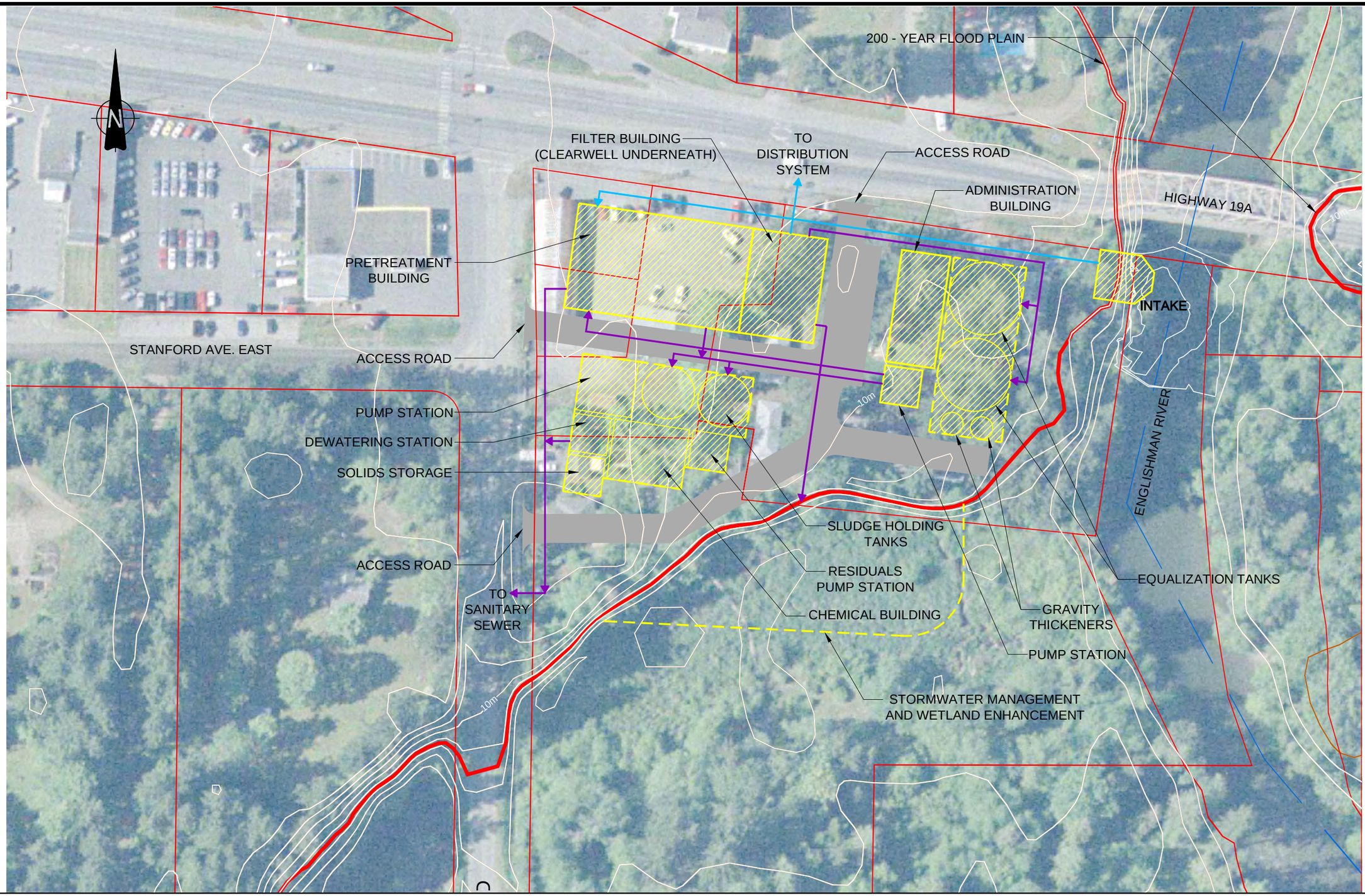
FIGURE 4-5		

P:\20092356\01_Concept_Planning\Engineering\03.04_Civil_Notes_Drawings\Site Plans\FIGURE 4-5-new.dwg
DATE: 2011-05-11, Kohn Kohut



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ARROWSMITH WATER SERVICES

CIVIL
TREATMENT PLANT SITE PLAN
SITE #3

ARROWSMITH WATER SERVICES
ENGLISHMAN RIVER INTAKE
STUDY

DRAWING NUMBER	REV. NO.	SHEET
FIGURE 4-6		

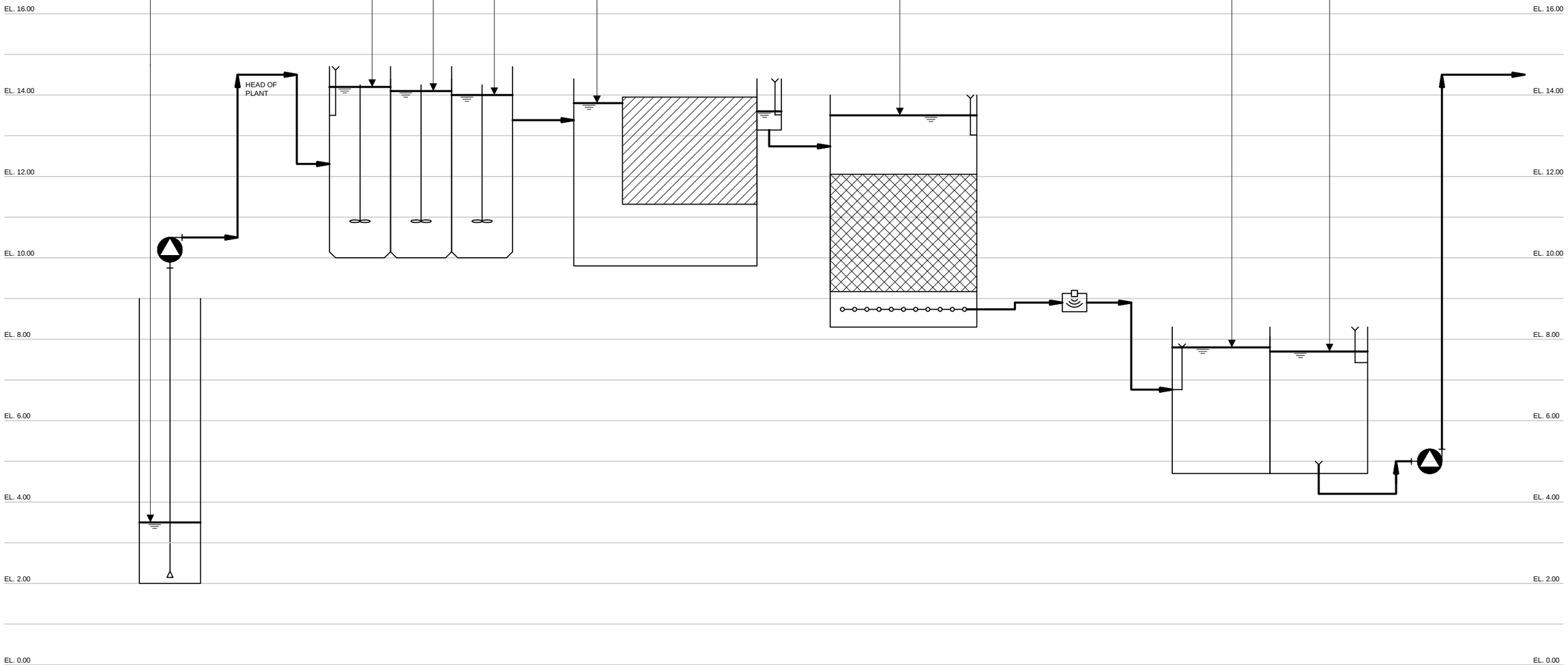
P:\20092356\07_Concept_Planning\Engineering\03.04_Civil_Notes_Drawings\Site Plans\FIGURE 4-6-new.dwg
DATE: 2017-05-11, Keith Kohut

INTAKE WET WELL | FLOCCULATORS | SEDIMENTATION TANKS | FILTERS | UV REACTORS | CLEARWELLS

XXX	TANK HEIGHT	9.0	14.7	14.7	14.7	14.3	14.0	8.3	8.3
XXX	DESIGN FLOW 48 ML/d	3.5	14.2	14.1	14.0	13.8	13.5	7.8	7.7

200 YEAR FLOOD LEVEL: 8.5m

APPROX. LOW WATER LEVEL: 3.5m



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ARROWSMITH WATER SERVICES

ENLISHMAN RIVER INTAKE AND TREATMENT FACILITIES

PROCESS MECHANICAL
SITE 3 HYDRAULIC PROFILE

DRAWING NUMBER	REV. NO.	SHEET
FIGURE 4-7		

P:\20092356\01 - Concept_Planning\Engineering\03.07_Process_Mech_Notes_Drawings\Working_Dwgs\FIGURE 4-7 - new.dwg
DATE: 2011-05-17, Keith Kohut

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Site 3 – Intake and Water Treatment Plant at Site 3

The useable footprint at Site 3 is relatively small because a large portion of the property, at the base of a cliff, is not suitable for plant infrastructure. The lower property is a wetland, traversed by Shelley Creek, and is also well within the 200-year flood plain. With the limited space available on the upper section of the site, the treatment plant has been separated into several smaller buildings to allow the infrastructure to fit into irregularly-shaped corners of the property and improve on-site access. The clearwell is located underneath the filter building.

The site is adjacent to the Highway 19A bridge and will therefore be very prominent to the public. The appearance of the site, in terms of architectural features and landscaping, will therefore have a greater importance. The pump stations and storage tanks would be hidden inside a building to improve the site appearance.

Site access will primarily be off Martindale Road to reduce the impact on highway traffic. A one-way access lane would allow traffic to exit to Highway 19A. It is assumed that power would be supplied from the power lines on Highway 19A.

Liquid waste from the dewatering equipment and the water treatment plant would be sent to the sanitary sewer main located on Martindale Road. Treated water from the plant would be stored in the clearwell and pumped to the distribution main on Highway 19A. As part of the upgrades to the distribution system, the treated water main would tee at Highway 19A, with one section heading east across the Englishman River and the other section heading west along Stanford Avenue. The east-bearing main would be attached to the Highway 19A bridge to cross the river.

It is assumed that stormwater runoff and neutralized overflow from the plant would be directed to the Shelley Creek wetland. As part of construction the wetland would be enhanced to allow a greater volume of water loading. This would improve the local habitat and remove sediments from the runoff before it reached the river.

Geotechnical Considerations

Site 3 is the most geologically stable of the sites reviewed. The west bank of the river consists of bedrock favourable for a riverbank intake. The rest of the site is well drained, consisting of gravel, sand, silt, clay and peat. The static groundwater level is expected to be well below the upper portion of the site. The seismic Site Class is likely C to D, but infrastructure founded on competent bedrock could be Site Class B.

Site 3 – Intake and Water Treatment Plant at Site 3

Hydrology Considerations

The 200-year flood plain raises quite high at this site, just short of the top of the bed rock riverbank. The intake should be designed so that the intake and wet well are low enough to allow sufficient water to enter the intake during low water level periods while the ceiling of the wet well should be above the flood plain. An example profile of the intake is provided in **Figure 4-5**. Variations in Englishman River water levels can be accurately determined at this site as the MOE1 monitoring station, detailed in DP 4-1, is located immediately downstream. The nearest rapids to Site 3 are approximately 160 m upstream, therefore it is unlikely that frazil ice will be a concern.

Environmental Considerations

Site 3 is located upstream of Highway 19A and therefore will be less vulnerable should accidental spills occur near the bridge. The treatment plant site is already heavily disturbed from construction of the existing motel and businesses, therefore the environmental impact will be minimal. The COP has requested that the handful of mature Douglas-fire trees on the site be preserved if possible. For the current layout it is unlikely the trees can be preserved unless they are relocated. If Site 3 is the recommended treatment plant location, more compact plant layouts can be designed which will provide greater flexibility to avoid the Douglas-fir trees.

The Shelley Creek wetland is considered a sensitive ecosystem, thus construction activities should attempt to minimize their impact on the wetland. A more detailed environmental assessment would be required to determine the optimal method to introduce runoff and chlorine-neutralized overflow water to the wetland.

A Provisional Operation Rule for the Arrowsmith Lake Reservoir requires sufficient flow release to ensure a 1.6 m^3/s flow at MOE1. This may impact the amount of water that can be pumped from the intake during summer months.

Key Advantages and Disadvantages

Site 3 is favourable for a riverbank intake in terms of having a stable bedrock riverbank, appropriate water depth, upstream position from Highway 19A, and little risk of frazil ice. The MOE1 monitoring station is immediately downstream of the site and provides a substantial amount of historical data on river behaviour in the area. The rest of the site is favourable in that the soils are stable and the environmental impact of construction would be low.

However, Site 3 offers some challenges. The site is adjacent to Highway 19A and would be a prominent feature of the COP. In addition to security concerns, this means that a greater effort will be required in architecture and landscaping design to make the plant appealing to the public, coming at an increased construction cost. The useable footprint of the site is compact, limiting the possible configurations available.

Site 3 – Intake and Water Treatment Plant at Site 3

In summary, the site is favourable for a riverbank intake but its prominent exposure to the public and the small site footprint pose some challenges.

Site 5 – Intake and Water Treatment Plant at Site 5

Description

Site 5 is located at the intersection of Martindale Road and Turner Road, just north of the existing Englishman River intake and chlorination facility. The river is relatively shallow at this site, as shown in the river profile in **Figure 4-5**, which means that a riverbank intake cannot be effectively used. Based on the operational difficulties of the existing infiltration gallery just upstream, a riverbank filtration system was assumed for the intake. Insufficient data is available to accurately predict the number of collector wells that would be required for the riverbank filtration system. Four were assumed for this layout. The well sizes were based on case studies with similar capacities. A submersible pump in each collector well would move water from the wells to the water treatment plant on the opposite end of the site. A conceptual layout of Site 5 is provided in **Figure 4-8**, and the corresponding hydraulic profile is shown in **Figure 4-9**.

Figure 4-6 shows the majority of the site to be heavily foliaged, which agrees with the findings of the engineering team's April 12, 2010 site visit. However, a subsequent site visit on April 23 noted that a large portion of the trees on the west side of the site have been cleared. Photos of the clearing are provided in the LGL memorandum in Appendix E. The majority of the site is within the 200-year flood plain. To minimize the amount of flood control measures that would need to be implemented, the treatment plant infrastructure would be placed on the highest elevated portions of the site, which is the west side. Infrastructure would be locally raised on areas of fill to sit above the flood plain, where necessary.

The water treatment processes were placed in a single building to reduce capital costs. The clearwell is below the plant filters to minimize the footprint of disturbed area on the site. While not as prominent to the public as Site 3, the treatment plant infrastructure at Site 5 would be regularly seen by Turner Road residents and would be visible from the walking trails in the forested area to the north. Therefore some effort would be made to create architectural appealing infrastructure and to landscape the site. The storage tanks and residual pump stations would be hidden in a single building.

It was assumed that the riverbank filtration system would not be granted treatment credits. Because the collector wells are in the flood plain, flood water can bypass a significant portion of the below-ground migration path, resulting in substantially less filtration before entering the intake. Two access roads to the site would be available off Turner Road.

Site 5 – Intake and Water Treatment Plant at Site 5

Power is available from Martindale Road. Liquid waste from the dewatering station and treatment plant would be sent to the sanitary sewer line at the corner of Martindale Road and Turner Road. Treated water from the clearwell would be pumped to a tee on Turner Road. The east branch would connect to the main by the existing intake, and the west branch would continue along Turner Road.

A wetland enhancement area would be developed to receive stormwater and chlorine-neutralized treatment plant overflow. This would enhance the local habitat, as well as provide a means to safely return water to the river downstream.

A private developer has submitted an application to construct a high-density residential development on Site 5.

Geotechnical Considerations

The areas of the site above the flood plain are well drained, and consist of gravel and sand, commonly underlain with silt. The soils within the flood plain consist of approximately 3.3 m of silt, sand and gravel, underlain with a 10 m thick layer of cemented sand gravel and boulders. The groundwater table is approximately 1.5 m below surface. There is evidence of liquefaction on site, and the seismic Site Class for Site 5 is likely C to D, but possibly E to F.

Hydrology Considerations

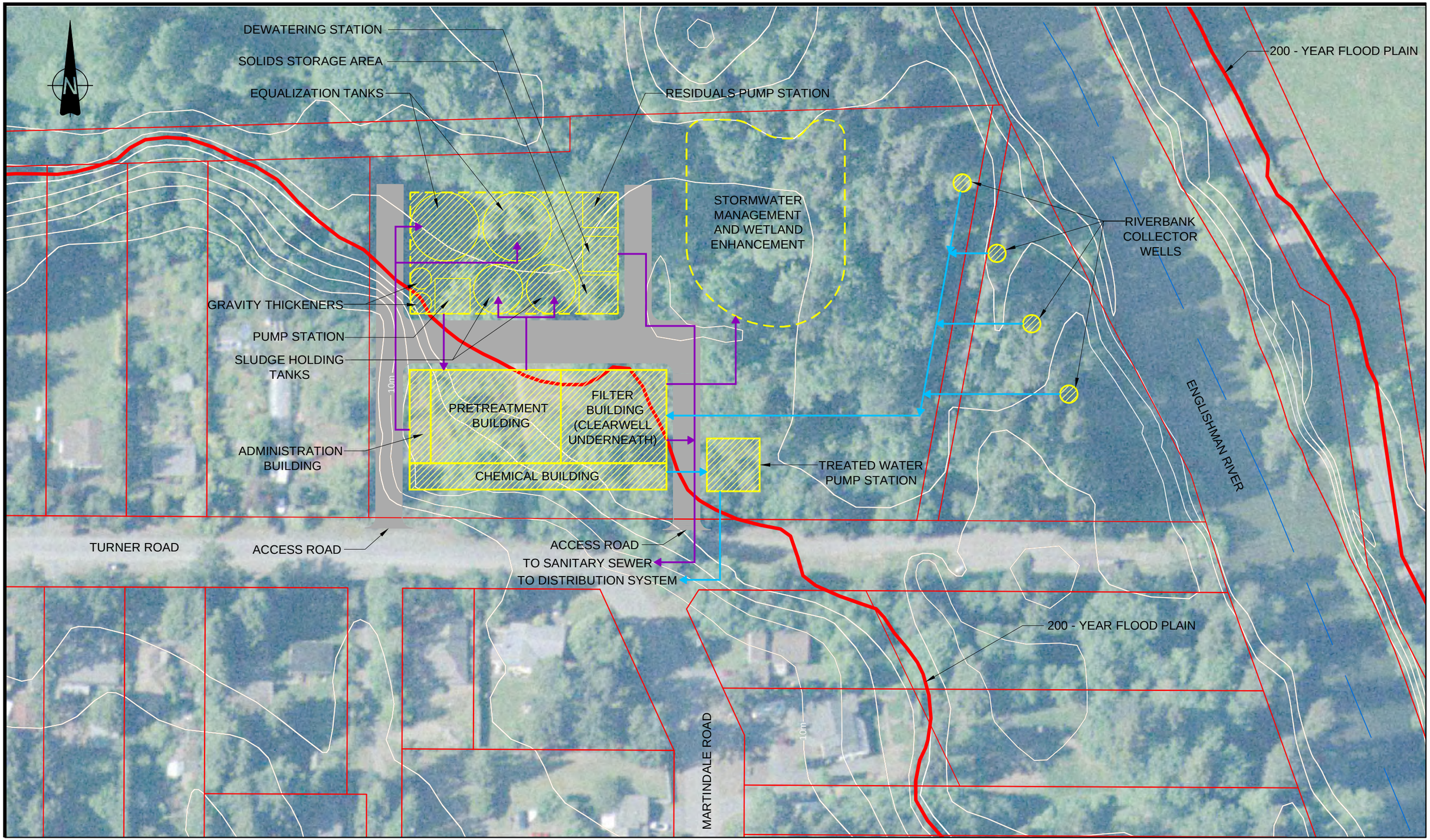
The primary hydrological concern is that majority of the site is within the 200-year flood plain. While it is assumed that infrastructure would sit on raised fill above the flood plain, the river bottleneck that occurs at the Highway 19A crossing raises some concern that altering the amount of flooded area at Site 5 could increase flooding of areas upstream.

Another concern is the uncertain performance of a riverbank filtration system at Site 5. Insufficient historical drill data was available in the area to accurately assess the hydraulic mobility through the soils, and there is concern that the layer of cemented sand and gravel could substantially reduce the amount of water the collector wells could draw. Without a comprehensive hydrogeological study, there is some risk in predicting the amount of water that could be reliably drawn through the riverbank

Due to the proximity of the site to the ocean, rises in sea level due to climate changes may result in salt intrusion at the plant.

Environmental Considerations

The bulk of construction would occur in the area of the site that has been recently cleared of trees. The impact of construction in this area would therefore cause little environmental disturbance. However, two areas in the remaining forested area are considered sensitive. The first is a permanent water body near the ROW that crosses north near the eastern edge of the property. This water body is considered an ideal



NO.	DATE	ENG.	BY	SUBJECT

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Associated Engineering

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SCALE	1:500		
DRAWN	S. KE		
DESIGNED	K. KOHUT		
CHECKED			
APPROVED			
DATE		INITIALS	

ARROWSMITH WATER SERVICES

CIVIL
SITE PLAN
SITE #5

ARROWSMITH WATER SERVICES
ENGLISHMAN RIVER INTAKE STUDY

DRAWING NUMBER	REV. NO.	SHEET
FIGURE 4-8		

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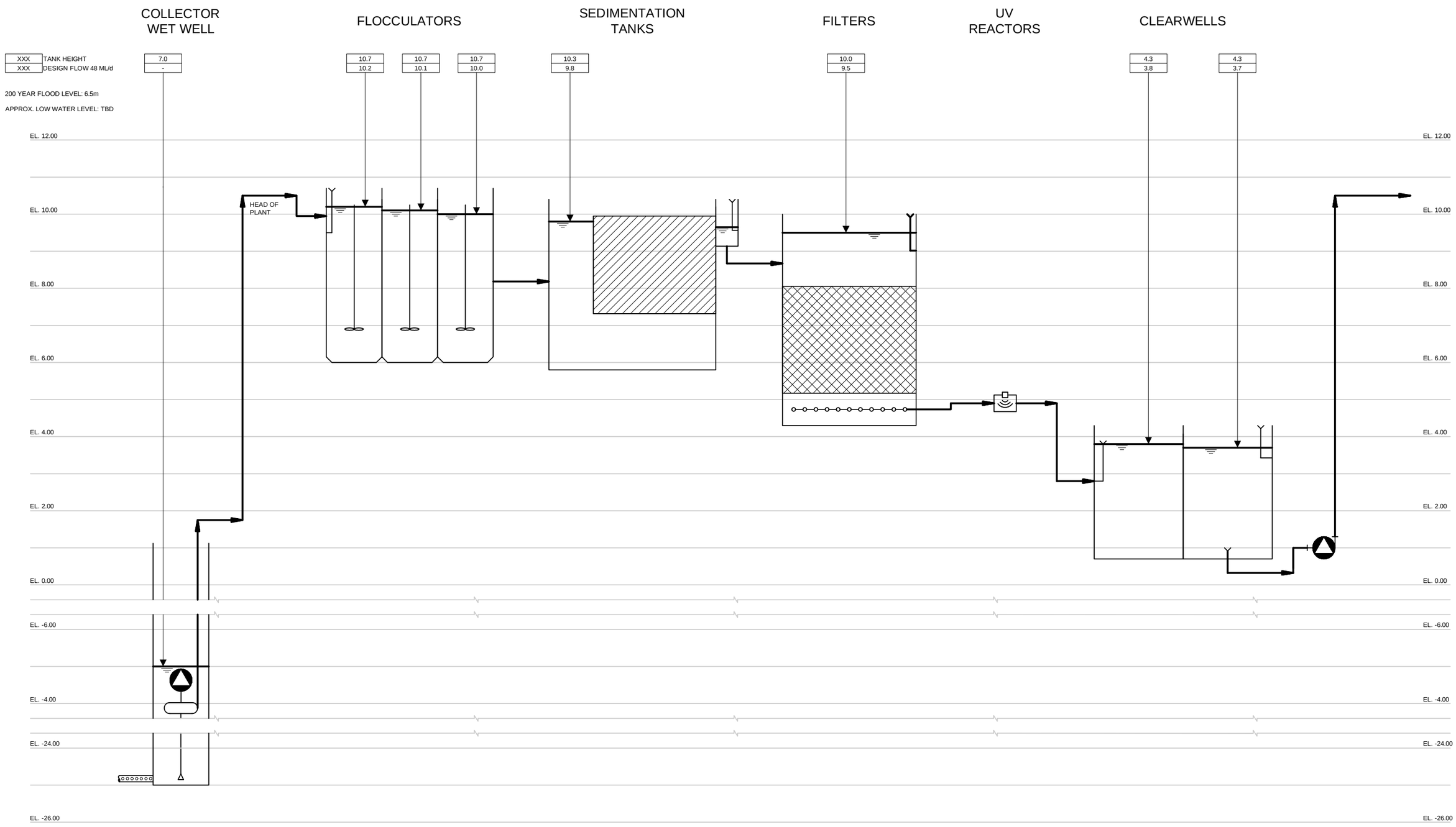
DATE: 2011-05-17, Adam Kohut



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ARROWSMITH WATER SERVICES

PROCESS MECHANICAL
SITE 5 HYDRAULIC PROFILE

ENLISHMAN RIVER
INTAKE AND TREATMENT
FACILITIES

DRAWING NUMBER	REV. NO.	SHEET
FIGURE 4-9		

Site 5 – Intake and Water Treatment Plant at Site 5

breeding habitat for Red-legged Frogs, a provincially (blue-listed) and federally (Special Concern) designated species-at-risk. The other area is along the south end of the site, where Band-tailed Pigeon, similarly designated a species-at-risk, were seen. Construction should be controlled to avoid impacting these two areas.

Key Advantages and Disadvantages

Site 5 has sufficient area to house the intake, water treatment plant, and supportive infrastructure with allowance for appealing landscaping to the site. However, the site is predominantly within the flood plain. The infrastructure could be raised above the flood plain but with the risk of flooding other riverside areas upstream. Several areas on the site have been identified as habitat for species-at-risk and a higher level of environmental control would be required to minimize impact to these areas.

A riverbank infiltration system is recommended as the intake. However the available geological information suggests that a cemented layer of sand and gravel may block subsurface water flow paths and impede the intake system. This adds a level of risk to the reliability of raw water yields in this area.

In summary, the site has sufficient area to comfortably house the treatment plant, but the site is within the 200-year flood plain and there are some risks in terms of reliable capacity for the type of intake most suitable for this site.

Site 1B – Intake at Site 3, Water Treatment Plant at Site 1

Description

This option combines the strengths of two sites. The intake would be located at Site 3, but the water treatment plant and residuals management facilities would be at Site 1. A 600 mm diameter raw water main along Highway 19A would connect the intake to the treatment plant, as shown in **Figure 4-10**.

The intake would be as described for Site 3: a riverbank intake would be constructed in a bedrock outcropping over a deep pool of the river, located just upstream of Highway 19A along the outer edge of a river bend. The intake structure would be in a location prominent to the public eye, and therefore would be designed to be aesthetically pleasing by adding architectural features and landscaping. The only infrastructure needed at this site is the intake, therefore the only property that would need to be purchased would be the motel site.

The pipeline connecting Site 3 and Site 1 would follow Highway 19A to Industrial Way, then to Herring Gull Way and crossing through the COP Public Works Yard to the water treatment plant. For the river crossing the water main would be attached to the Highway 19A bridge. The raw water main would be approximately 2 km in length.

Site 1B – Intake at Site 3, Water Treatment Plant at Site 1

The water treatment plant layout would be as described for Site 1A in the abandoned gravel pit. Main entry to the site would be through the Public Works Yard, but provisions would be made to allow a future secondary access point to the road ROW to the west. **Figure 4-3** shows a more detailed layout of the water treatment plant site.

Treated water would be pumped to the treated water main, which would parallel the raw water main in a shared trench, back across Highway 19A Bridge, before connecting to the distribution system. As with the raw water main, the treated water main would cross the river attached to the underside of the Highway 19A bridge.

Geotechnical Considerations

The soils of the intake site are well drained, consisting of gravel, sand, silt, clay and peat. The intake structure would rest primarily on bedrock, and could be seismic Site Class B.

A geotechnical review of the connecting path from Site 1 to Site 3 has not been done. The raw water main would follow existing highways and roads which were likely constructed on naturally stable soils or were stabilized during construction.

The water treatment plant site is sand and gravel to a depth of at least 20 m. The site is well drained and is likely seismic Site Class C to D. The intake and water treatment sites are both well above the groundwater table.

Hydrology Considerations

The intake would be designed so that the intake and wet well are low enough to allow water to enter the intake during low water level periods while the ceiling would be above the 200-year flood level, as shown in the example profile in Figure 4-4. Variations in Englishman River water levels can be accurately determined at this site, as the MOE1 monitoring station is located immediately downstream. It is unlikely that frazil ice will be a concern.

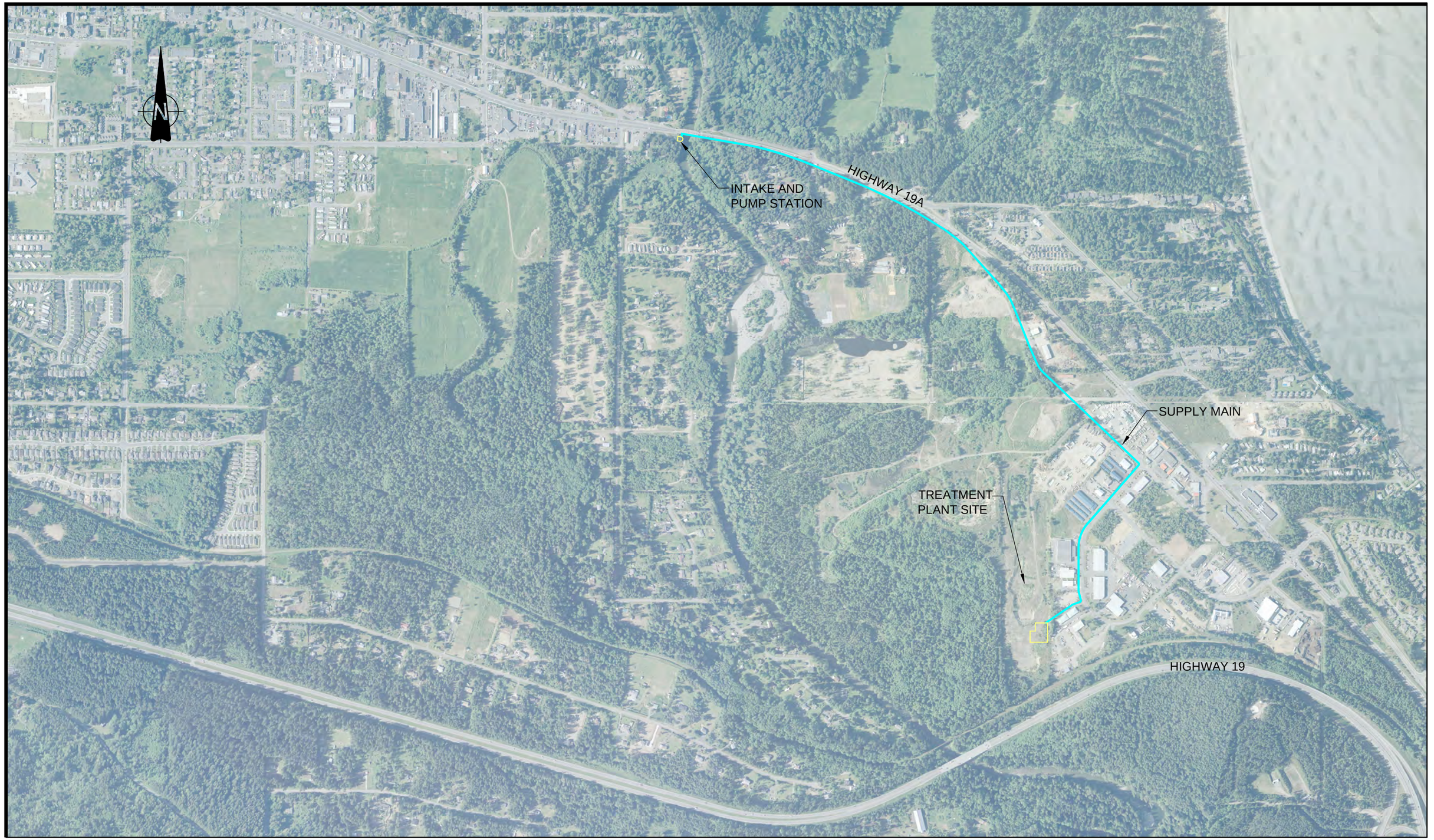
The water treatment plant site is well above the 200-year flood plain.

Environmental Considerations

As discussed for Site 3, the intake site is already heavily disturbed, so the environmental impact of intake construction will be minimal. Because of its small footprint, the intake should be easier to position to avoid the mature Douglas fir trees on site that the COP would like preserved.

An environmental assessment has not been done along the raw water main route. It is planned that the water main would be constructed within or near the Highway and road ROWs, which have already been disturbed.

As discussed for Site 1A, construction of the treatment plant at Site 1 is not anticipated to have any significant environmental impact.



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DESIGNED	K. KOHUT		
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ARROWSMITH WATER SERVICES

CIVIL
SITE PLAN
SITE #1B – INTAKE AT SITE #3

ARROWSMITH WATER SERVICES
ENGLISHMAN RIVER INTAKE
STUDY

DRAWING NUMBER	REV. NO.	SHEET
FIGURE 4-10		

P:\20092356\01_Concept_Planning\Engineering\03.04_Civil_Notes_Drawings\Site Plans\FIGURE 4-10-new.dwg
DATE: 2017-02-17, Kelly Kohut

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Site 1B – Intake at Site 3, Water Treatment Plant at Site 1

Key Advantages and Disadvantages

The bedrock, river depth, location in relation to Highway 19A and position on the river bend makes Site 3 a good location for the intake. However intake capacities may be impacted by the requirement to maintain a 1.6 m^3/s flow at the monitoring station immediately downstream.

There is ample room at Site 1 for the water treatment plant. The site is less public than the other locations, so less resources would need to be spent on architectural and landscaping features. The primary disadvantage of this option is that there are two distinct sites instead of one. Aside from the cost of the raw water main connecting the intake to the water treatment plant, having two sites will increase the operating and maintenance requirements for the COP operators.

5 Estimated Costs

Conceptual level, class 'D' cost estimates were developed for the four intake and treatment plant options. The approach taken to develop the capital costs was as follows:

- Select a specific combination of water treatment processes to use for all four options as the basis of the cost comparison.

- Develop a conceptual intake and water treatment plant layout for each site option. The ultimate facility layouts reflect the Year 2050 scenario. Base construction costs in 2010 dollars were then prepared for the ultimate facility. Other direct and indirect costs, reflecting various allowances and contingencies, and land purchase costs were then added to the base construction cost. Beyond the base construction cost, the other direct costs included design contingency (10%) and construction contingency (15%) allowances. Indirect cost allowances included engineering (15%), administration (3%) miscellaneous costs (2%) and interim financing (4%). These additional factors result in a multiplier of 1.56 on the base construction costs. HST (12%) was added to the cost estimates.

- Although construction of the treatment plant and portions of the intake infrastructure could be staged, it was assumed for the cost comparisons that the infrastructure would be constructed at the same time, in 2010. Strategies for efficiently staging construction can be addressed when a single site has been selected.

Capital cost estimates for the different options are summarized in **Table 5-1**. Detailed cost estimates for the intake and treatment plant sites are provided in Appendix A. Cost estimates for distribution system upgrades are provided in Appendix B, but do not include upgrades common to all four options, namely beyond the Springwood Reservoir and past the Wallbrook Pump Station. These additional upgrades will be considered for the final preferred option. With the exception of some difference in pumping requirements, the operation and maintenance demands for each option are likely very similar. Therefore operation and maintenance costs were not developed for the site

comparison. Annual costs will be incorporated into the Class "C" cost estimates for the selected site.

Table 5-1
Summary of Capital Cost Comparison

Categories	Site 1A	Site 3	Site 5	Site 1B
Direct Construction Cost - Intake and Treatment Plant	$22,186,000	$24,309,000	$24,725,000	$22,358,000
Direct Construction Cost - Distribution Mains	$3,005,000	$1,379,000	$1,610,000	$2,289,000
Property Purchases	$964,000	$1,776,000	$835,000	$1,106,000
Design and Construction Contingency (25% of Direct Costs)	$6,539,000	$6,866,000	$6,792,000	$6,439,000
Direct Cost Subtotal	$32,694,000	$34,330,000	$33,962,000	$32,193,000
Indirect Costs	$6,539,000	$6,866,000	$6,892,000	$6,439,000
Subtotal	$39,232,000	$41,196,000	$40,854,000	$38,631,000
HST (12%)	$4,708,000	$4,944,000	$4,903,000	$4,636,000
Interim Financing	$ -	$ -	$ -	$ -
Total Capital Cost	$43,940,000	$46,140,000	$45,757,000	$43,267,000

6 Next Steps

As evidenced in the above sections, selection of the optimal site for the proposed intake and water treatment plant are dependant on more than the lowest capital cost. The new infrastructure can have a significant impact on the surrounding environment, river flows, and the local community. To incorporate all of these different factors, it is proposed that a triple bottom line (TBL) model be developed that allows economic, environmental, and social factors be simultaneously evaluated and help identify the option that is the best balance of these components. A workshop is scheduled for June 16 to review the four site options examined in this discussion paper, as well as to set up the TBL model.

Appendix A - Estimated Costs

Revision Date: June 10, 2010
Latest Revsion Keith Kohut

ARROWSMITH WATER SERVICES
ENGLISHMAN RIVER INTAKE AND WATER TREATMENT PLANT

BASIS OF COST ESTIMATES
COST ALLOWANCES
DOLLARS ARE 2010

Item	Percentage	Extension Site 1A	Site 3	Site 5	Site 1B
Direct Costs					
Base Construction Cost Estimate					
Intake		$ 1,331,064	$ 1,401,585	$ 1,470,550	$ 1,370,735
Raw Water Main		$ 359,450	$ 9,750	$ 112,750	$ 914,000
Water Treatment Plant		$ 17,410,441	$ 19,165,065	$ 19,463,505	$ 17,429,846
Contractor Profit and Overhead		$ 4,775,239	$ 5,144,100	$ 5,261,701	$ 4,928,645
Intake & WTP Total Base Cost		**$ 22,185,680**	**$ 24,309,165**	**$ 24,725,206**	**$ 22,358,491**
Distribution Main Upgrades		$ 3,005,200	$ 1,378,750	$ 1,609,500	$ 2,289,250
Property Purchases		$ 964,000	$ 1,776,700	$ 835,000	$ 1,106,400
Construction Cost Subtotal		**$ 26,154,880**	**$ 27,464,615**	**$ 27,169,706**	**$ 25,754,141**
Design Contingency	10.0%	$ 2,615,488	$ 2,746,462	$ 2,716,971	$ 2,575,414
Construction Contingency	15.0%	$ 3,923,232	$ 4,119,692	$ 4,075,456	$ 3,863,121
Subtotal		**$ 32,693,600**	**$ 34,330,769**	**$ 33,962,133**	**$ 32,192,677**
Indirect Costs					
Engineering	15.0%	$ 4,904,040	$ 5,149,615	$ 5,094,320	$ 4,828,901
Additional hydrogeological assessment		$ -	$ -	$ 100,000	$ -
Administration	3.0%	$ 980,808	$ 1,029,923	$ 1,018,864	$ 965,780
Miscellaneous	2.0%	$ 653,872	$ 686,615	$ 679,243	$ 643,854
Subtotal		**$ 39,232,320**	**$ 41,196,923**	**$ 40,854,559**	**$ 38,631,212**
HST	12.0%	$ 4,707,878	$ 4,943,631	$ 4,902,547	$ 4,635,745
Interim Financing	0.0%	$ -	$ -	$ -	$ -
Inflation to Mid-Point of Construction	0.0%	$ -	$ -	$ -	$ -
Total Budget Cost		**$ 43,940,198**	**$ 46,140,553**	**$ 45,757,107**	**$ 43,266,957**

		Quantity	Unit	Unit Cost	Cost
	Division 1 - General Requirements				$ 136,000
	Division2 - Site Work				$ 2,118,815
	Intake				$ 279,970
	Water Main				$ 349,450
	Water Treatment Plant				$ 1,489,395
	Division 3 - Concrete				$ 6,834,057
	Intake				$ 235,312
	Water Treatment Plant				$ 6,598,745
	Division 4 - Masonry				$ 858,250
	Intake				$ 82,500
	Water treatment plant				$ 775,750
	Division 5 - Metals				$ 319,040
	Intake				$ 14,720
	Water Treatment Plant				$ 304,320
	Divison 6 - Wood and Plastics				
	Assume costs included in Division 3				
	Division 7 - Thermal and Mosture Protection				$ 290,293
	Intake				$ 25,972
	Water Treatment Plant				$ 264,321
	Division 8 - Doors and Windows				$ 60,000
	Division 9 - Finishes				$ 626,850
	Division 10 - Specialties				$ 40,000
	Division 11 - Equipment				$ 4,586,200
	Intake				$ 453,200
	Water Treatment Plant				$ 4,133,000
	Division 12 - Furnishings				
	n/a				
	Division 14 - Cranes				$ 100,000
	Division 15 - Mechanical				$ 2,031,350
	Intake				$ 93,600
	Water Treatment Plant				$ 1,937,750
	Division 16 - Electrical and Controls				$ 1,100,100
	Intake				$ 76,100
	Water treatment plant				$ 1,024,000
	Cost Summary				**$ 19,100,955**
	- Intake				$ 1,331,064
	- Water main				$ 359,450
	- Water treatment plant				$ 17,410,441
	Contractor O/H @15%				$ 2,865,143
	Contractor Profit @ 10%				$ 1,910,096
	Total				**$ 22,185,680**
	Property Purchases				
	Plan 21736	$ 437,000			
	Lot 686	$ 527,000			
		$ 964,000			

		Quantity	Unit	Unit Cost	Cost
	Division 1 - General Requirements				$ 116,000
	Division2 - Site Work				$ 1,600,870
	Intake				$ 195,190
	Water Main				$ 9,750
	Water Treatment Plant				$ 1,395,930
	Division 3 - Concrete				$ 6,986,742
	Intake				$ 301,792
	Water Treatment Plant				$ 6,684,950
	Division 4 - Masonry				$ 2,464,575
	Intake				$ 185,775
	Water treatment plant				$ 2,278,800
	Division 5 - Metals				$ 485,280
	Intake				$ 14,720
	Water Treatment Plant				$ 470,560
	Divison 6 - Wood and Plastics				
	Assume costs included in Division 3				
	Division 7 - Thermal and Mosture Protection				$ 295,883
	Intake				$ 31,218
	Water Treatment Plant				$ 264,665
	Division 8 - Doors and Windows				$ 60,000
	Division 9 - Finishes				$ 639,450
	Division 10 - Specialties				$ 40,000
	Division 11 - Equipment				$ 4,576,500
	Intake				$ 443,500
	Water Treatment Plant				$ 4,133,000
	Division 12 - Furnishings				
	n/a				
	Division 14 - Cranes				$ 150,000
	Division 15 - Mechanical				$ 2,071,000
	Intake				$ 93,600
	Water Treatment Plant				$ 1,977,400
	Division 16 - Electrical and Controls				$ 1,090,100
	Intake				$ 76,100
	Water treatment plant				$ 1,014,000
	Cost Summary				**$20,576,400**
	- Intake				$ 1,401,585
	- Water main				$ 9,750
	- Water treatment plant				$19,165,065
	Contractor O/H @15%				**$ 3,086,460**
	Contractor Profit @ 10%				**$ 2,057,640**
	Total				**$24,309,165**
	Property Purchases				
	Plan 14815	$ 669,400			
	Plan 34439	$ 308,000			
	Lot A	$ 263,500			
	Lot REM 1	$ 265,100			
	Unnumbered Lot	$ 270,700			
		$ 1,776,700			

		Quantity	Unit	Unit Cost	Cost
	Division 1 - General Requirements				$ 116,000
	Division2 - Site Work				$ 2,882,860
	Intake				$ 885,150
	Water Main				$ 112,750
	Water Treatment Plant				$ 1,884,960
	Division 3 - Concrete				$ 6,673,730
	Intake				$ -
	Water Treatment Plant				$ 6,673,730
	Division 4 - Masonry				$ 2,179,000
	Intake				$ -
	Water treatment plant				$ 2,179,000
	Division 5 - Metals				$ 481,760
	Intake				$ -
	Water Treatment Plant				$ 481,760
	Divison 6 - Wood and Plastics				
	Assume costs included in Division 3				
	Division 7 - Thermal and Mosture Protection				$ 265,095
	Intake				$ -
	Water Treatment Plant				$ 265,095
	Division 8 - Doors and Windows				$ 60,000
	Division 9 - Finishes				$ 587,160
	Division 10 - Specialties				$ 40,000
	Division 11 - Equipment				$ 4,585,000
	Intake				$ 452,000
	Water Treatment Plant				$ 4,133,000
	Division 12 - Furnishings				
	n/a				
	Division 14 - Cranes				$ 80,000
	Division 15 - Mechanical				$ 1,993,800
	Intake				$ 45,000
	Water Treatment Plant				$ 1,948,800
	Division 16 - Electrical and Controls				$ 1,102,400
	Intake				$ 88,400
	Water treatment plant				$ 1,014,000
	Cost Summary				**$ 21,046,805**
	- Intake				$ 1,470,550
	- Water main				$ 112,750
	- Water treatment plant				$ 19,463,505
	DIRECT COSTS less Contractor O/H and profit				
	Contractor O/H @15%				**$ 3,157,021**
	Contractor Profit @ 10%				**$ 2,104,681**
	Total				**$ 24,725,206**
	Property Purchases				
	Plan EPP2745	$ 835,000			
		$ 835,000			

		Quantity	Unit	Unit Cost	Cost
	Division 1 - General Requirements				$ 136,000
	Division2 - Site Work				$ 2,595,135
	Intake				$ 208,690
	Water Main				$ 904,000
	Water Treatment Plant				$ 1,482,445
	Division 3 - Concrete				$ 6,884,537
	Intake				$ 301,792
	Water Treatment Plant				$ 6,582,745
	Division 4 - Masonry				$ 892,675
	Intake				$ 116,925
	Water treatment plant				$ 775,750
	Division 5 - Metals				$ 319,040
	Intake				$ 14,720
	Water Treatment Plant				$ 304,320
	Divison 6 - Wood and Plastics				
	Assume costs included in Division 3				
	Division 7 - Thermal and Mosture Protection				$ 337,894
	Intake				$ 31,218
	Water Treatment Plant				$ 306,676
	Division 8 - Doors and Windows				$ 60,000
	Division 9 - Finishes				$ 626,850
	Division 10 - Specialties				$ 40,000
	Division 11 - Equipment				$ 4,591,000
	Intake				$ 458,000
	Water Treatment Plant				$ 4,133,000
	Division 12 - Furnishings				
	n/a				
	Division 14 - Cranes				$ 100,000
	Division 15 - Mechanical				$ 2,031,350
	Intake				$ 93,600
	Water Treatment Plant				$ 1,937,750
	Division 16 - Electrical and Controls				$ 1,100,100
	Intake				$ 76,100
	Water treatment plant				$ 1,024,000
	Cost Summary				**$ 19,714,581**
	- Intake				$ 1,370,735
	- Water main				$ 914,000
	- Water treatment plant				$ 17,429,846
	DIRECT COSTS less Contractor O/H and profit				
	Contractor O/H @15%				**$ 2,957,187**
	Contractor Profit @ 10%				**$ 1,971,458**
	Total				**$ 22,358,491**
	Property Purchases				
	Plan 14815	$ 669,400			
	Plan 21736	$ 437,000			
		$ 1,106,400			

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Appendix B - Koers Technical Memorandum