DISCUSSION PAPER

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

Discussion Paper 4-4– Water Treatment Plant Site Development Considerations

Prepared by: Keith Kohut and Rick Corbett

Issued: March 12, 2010
Previous Issue: None

1 Introduction

In this discussion paper, the site size requirements for the proposed Englishman River water treatment plant are estimated. This includes supportive infrastructure such as the intake works and low lift pump station, residuals management facilities, clearwell and treated water pump station. Access roads and parking, stormwater management and site landscaping are also incorporated. This discussion paper identifies relative site elevation considerations and features that would improve the sustainability of the proposed plant. This paper concludes with a discussion on the type of intakes that could be used for the proposed plant.

2 Plant Layout and Footprint

A conceptual layout of the proposed water treatment plant and supporting infrastructure was required to approximate the size of property needed to house the site. Discussion Paper DP 4-3 identified several potential water treatment scenarios. At this stage, it is prudent to base the size of the plant site on the treatment scenario that requires the largest footprint. The reasoning is that it is better to have extra space on site to construct the plant than it is to discover late in design that insufficient space is available. This conservative approach will also allow some flexibility should previously unknown features or challenges need to be addressed in the design.

The water treatment plant and its supporting infrastructure were sized to provide the design 2050 demand of treated water. As detailed in Discussion Paper DP 3-2, a range of potential 2050 design flows were calculated, based on varying per capita demands and on the level of participation from the Township of Qualicum Beach. The largest potential design flow, projected to be 48 ML/d by 2050, was chosen to ensure adequate property is available at this stage of planning.

2.1 Treatment Plant

Of the treatment plant scenarios listed in DP 4-3, Scenario 2 – Conventional Treatment, has the largest footprint requirements. The conceptual plant layout will therefore be based on Scenario 2. The design criteria used to size the plant are summarized in **Table 2-1**. It was assumed that the preliminary treatment to remove large debris such as branches and pebbles from the raw water will be conducted at the intake. A discussion on intake design is provided in Section 5.

Table 2-1
Water Treatment Plant Design Criteria

Process / Treatment Plant Feature	Design Assumptions
Coagulation	• Coagulant introduced using pumped flash mixer or in-line jet mixer. (1) • A second, parallel coagulant injection point included to act as contingency should the first coagulation point need to be temporarily taken off-line.
Flocculation	• Width and number of flocculation trains, sedimentation tanks, and filter basins are the same to keep particulate removal processes in a uniform, compact shape. • Minimum 30 minute flocculation time. • Each flocculation train to consist of three identical tanks in series, each mixing at progressively slower speeds.
Sedimentation	• Sedimentation tanks include settling tubes to improve settling efficiency and reduce footprint requirements. (2) • Minimum 90 minute detention time. • Minimum 0.2 mm/s floc settling speed.
Filtration	• Deep bed media filters used. (3) • Design filter loading rate of 12 m/hr. (4) • Two redundant filter units included. (5)
Ultraviolet Irradiation	• Reactors located in pipe gallery behind filters.

Process / Treatment Plant Feature	Design Assumptions
Chemical Rooms and Administration Offices	• Each chemical stored in its own separate room. • Separate room for a scrubber which will capture any harmful gases should a chemical leak occur. • All option rooms identified in DP4-3 included. • Chemical rooms placed along one edge of building to allow easy access when restocking chemicals. • Administration offices grouped together near head of plant. • One long side of building open for expansion if plant capacity is increased after 2050.

Notes:

(1) Pumped flash mixers and in-line jet mixers are compact, and force the coagulant to rapidly disperse by using a mechanical mixer near the injector or by pumping coagulant against a diffuser plate.

(2) Settling tubes are installed on roughly 75% of the surface of a settling tank, and force water to travel through the tubes in a diagonal direction instead of straight up to exit the tank. This lengthens the treated water's detention time and allows for more particulates to settle.

(3) The increased depth of the deep bed media filters allows for higher loading rates and a smaller footprint.

(4) Typically a 15 m/hr loading rate can be assumed for deep bed filters. However, media filtration piloting currently being done for the City of Nanaimo has demonstrated lower filtration capacities. Assuming similar water behaviour from the Englishman River, a more conservative 12 m/hr would be appropriate.

(5) At any time one filter could be off-line for backwashing and a second filter could be off-line for maintenance, hence the need for two redundant filters. The remaining filters would be sized to treat the plant's full design capacity. For the maximum design flow, this translates to four filters in operation plus two redundant units. For the minimum design flow, this translates to two filters in operation plus two redundant units.

Using these design criteria the water treatment plant building will have an approximate footprint of 2600 m^2.

2.2 Other Buildings and Storage Facilities

Supportive infrastructure for the proposed water treatment plant was also sized. The design criteria and approximate footprint for each building and storage facility are provided in Table 2-2.

Table 2-2
Water Treatment Site Building and Storage Facility Summary

Item	Design Criteria	Area Required
Water Treatment Plant	• See Section 2.1	2600 m^2
Residuals Management Facilities	• Waste from the liquid waste holding tank (sink and washroom waste, centrate) sent to sanitary sewer. • Centrifuge used for dewatering. • Solid waste shipped off site to landfill. • Gravity thickener, equalization tank, and sludge holding tank sized for thickener to operate only two days out of every week. • Redundant equalization and sludge holding tanks.(1)	2000 m^2
Clearwell	• Two chamber clearwell.(2) • Two hours of combined clearwell storage. • Clearwells below ground to a depth of 3 m. • Clearwells have minimum baffling (T10/T) = 0.7) (3)	1400 m^2
Pump Station	• Pumping could be required to carry water between one or more of the following stages: • From intake to treatment plant. (4) • From treatment plant to clearwells. • From clearwells to filters for backwashing. • From clearwells to distribution system.	400 m^2
Overflow Pond	• Overflow water from treatment plant dechlorinated before entering overflow pond. • Water in pond is emptied through evaporation, exfiltration or direct surface water discharge, before next overflow event. • Sized to hold 30 minutes at plant's design capacity.(5) • Average pond depth of 3 m.	1000 m^2

Notes:
(1) Redundant holding tanks allow residual management operations to continue when one tank is brought off-line for cleaning or maintenance.
(2) One cell of the clearwell can be brought off-line without interfering with plant operation.
(3) The T_{10}/T ratio reflects the amount of short-circuiting that can occur in a storage vessel. A T10/T ratio of 1.0 indicates uniform mixing in the clearwell.
(4) This assumes that the intake works are located adjacent to the treatment facility and the low lift pumps are located in this pump station. If the intake and WTP are separated, the intake pumps would be located at the intake works.
(5) Sized for critical valve failing when plant is running at full capacity. It is assumed that after 30 minutes, the plant will automatically shut down or be manually shut down by operators.

2.3 Driveways and Parking

Driving within the site must also be considered. Sufficient parking is required for the operators and plant visitors. Access roads must be wide and simple enough to be navigable by loading trucks when they deliver bulk chemicals and large equipment. The preferred design, if the area is available, is an access road that loops around the plant allowing separate entrance and exit. The traffic design should allow for about ten parking spots.

2.4 Construction Space

Space required for construction equipment, contractor operations, and material storage was also incorporated into the site sizing estimate. While it is not mandatory that space adjacent to the water treatment plant be reserved for contractor use, it would lower construction costs.

2.5 Site Overall Size

Based on the preceding design criteria and assumptions the water treatment plant and supportive infrastructure will require approximately 7,400 m^2 footprint. Space requirements for access roads and landscape will vary depending on site characteristics. This might typically increase the required size by 100%, yielding an overall area requirement of about 1.5 ha. More accurate footprint estimates and plant layouts will depend on the actual size and shape of the available property.

3 Local Needs

In addition to space requirements, the characteristics listed in the following subsections should be considered when evaluating potential plant sites.

3.1 Flood Protection

The treatment plant should be located at a site where flooding is not an imminent risk. The BC Ministry of the Environment "Flood Hazard Area Land Use Management Guidelines" (MWLAP, 2004) recommends that the elevation of the underside of public buildings should be higher than the 200-year flood plain. If flood plain information is not available, the building should be at least 3.0 m higher than the natural boundary of the water body. This agrees with the Regional District of Nanaimo Flood Plain Bylaw (RDN, 2006). The City of Parksville Building Bylaw (City of Parksville, 2007) simply requires that building owners be satisfied that site will not be affected by flooding water. It is recommended to adhere to the Ministry of Environment flood hazard guidelines when selecting treatment plant sites.

3.2 Foundation Considerations

Soil conditions will have an impact on construction costs, site safety, and the effectiveness of the intake. The intake should be installed in a stable, straight channel made of bedrock or till.

Meandering sections of the Englishman River, areas close to significant tributaries, and areas with a known history of channel migration or bedload movement should be avoided, as they will reduce the effectiveness of the intake and require greater maintenance. The treatment plant site should also be located in an area with stable soils with good drainage to reduce construction costs. Areas with signs of upslope hazards, such as landslides, should be avoided due to their risk to plant operators and for the potential damage they could cause to the plant.

3.3 Relative Elevations

For construction purposes, it is preferred that the construction site have a relatively smooth grade, free of substantial hills and valleys. Reducing the amount of cut and fill required will reduce construction costs.

It is recommended that gravity flow be used throughout the plant, as much as possible, to reduce pumping costs. Therefore it is preferred that the plant site have a gradual slope that will promote gravity flow from the head of the plant to the end. If no pumps are to be used to carry water from the plant to the clearwell, 4 m to 7 m of vertical drop is required between the head of the plant and the clearwell. For this objective, the clearwell will either need to built as a substructure or located downhill from the plant. The lower the elevation of ground upon which the clearwell sits, the less excavation is required, which will reduce construction costs.

3.4 Access Considerations

The route by which heavy machinery and loading trucks travel to and from site will need to be considered. If the plant site is accessed only via gravel, rural roads, the heavy vehicles will quickly damage the roads. If vehicles must travel through a residential subdivision to reach the plant, then disturbances to the residential area must be considered. In terms of road quality, the site will need to be accessible along paved roads that are wide enough and have sufficient turning radiuses to allow large vehicles to navigate them.

Ease of access for operators will also be a factor depending on the amount of automation planned for the plant. If operators are not stationed at the plant full time, travel time from the operator central location and the treatment plant should be less than half an hour in case an emergency occurs on site that requires immediate addressing. Rapid operator response time will be important if the plant is designed to shut down during turbidity events.

3.5 Architectural Considerations

The visual appeal of the proposed water treatment plant is dependent on how prominent Arrowsmith Water Services want the plant to be in the communities. If the treatment plant is located in public view, or if the intention is to host events or tours at the treatment plant, than architectural design becomes important to enhance the site's aesthetic appeal.

4 Sustainability Site Considerations

Several site characteristics related to sustainability have been identified below. These items are not mandatory for an optimally running plant, but if the intention is to boost the plant's sustainability, these features need to be considered at the early design stages to fully take advantage of them.

Environmental Disturbance: The plant siting should be done in a manner which limits environmental disturbance while meeting project technical requirements. Ideally, reusing a site previously owned by industry, commercial interests, or for residences reduces the amount of previously undisturbed land while simultaneously taking advantage of a site unsuitable for other applications.

Minimize Tree Clearing: Building new infrastructure in a cleared area as opposed to a site with dense foliage will have less of an impact on natural control of carbon dioxide emissions in the area. Construction in areas with less foliage will also require less heavy machinery to clear, which will reduce the amount of greenhouse gases released as part of building the proposed treatment plant.

Hydraulic Efficiency: Efforts should be made to reduce pumping requirements at the plant site wherever possible. A gradually sloping site can be favourable in that water can be moved through the plant via gravity flow.

Maximize Natural Light: It is recommended that the proposed water treatment plant be orientated to maximize natural light, which will reduce heating costs. To fully harness natural light benefits, the treatment plant site should receive a fair amount of sunlight. Sites that are often shadowed by surrounding high elevations make the optimal use of natural light more difficult.

Stormwater Run-Off Control: The treatment plant and related infrastructure should minimize their impact on the natural stormwater run-off control features. This includes avoiding construction in natural retention ponds or along significant stormwater run-off routes. Not only would construction in these areas lead to a change to run-off event intensity and duration, but additional flood control measures would be needed at the plant site to manage the high volume of run-off water that would previously flow through the area.

5 Intake Considerations

Another crucial element of the site assessment will be locating a reach along the Englishman River suitable for the proposed plant intake structure. However, relating intake requirements to site evaluations is not a straightforward process, as there are a variety of intake types, each requiring different site conditions to function properly. This section acts as an introduction to intake design.

For the Englishman River the range of potential intake designs can be grouped into the following five types:

- Infiltration gallery
- Riverbank infiltration gallery
- In-stream intake and screen
- In-stream intake with on-shore screen
- Bank intake with screen

Infiltration Gallery: An infiltration gallery involves a system of interconnected perforated pipes buried beneath the riverbed. Water is collected by percolation of river water through a designed backfill zone. An air backwash system installed above the gallery pipes, within the backfill, is required in order to maintain capacity. The existing Englishman River water treatment plant uses an infiltration gallery intake.

Riverbank Infiltration Gallery: A riverbank infiltration gallery consists of radial wells installed along the river reach, from which multiple perforated pipes extend below the riverbank. A hydraulic head differential is induced in the radial well to draw water through the riverbank into the perforated pipes. The rate of infiltration is slow, which allows the riverbank to partially filter the water being drawn in. To date the Canadian Guidelines for Drinking Water Quality and USEPA legislation does not recognize riverbank filtration as a system that grants disinfection credits. However, studies have shown that riverbank filtration can remove organic matter and *Cryptosporidium*, and lower turbidity of water entering the plant.

In-Stream Intake and Screen: An in-stream intake and screen consists of a weir that extends across the river, followed by an in-channel screen. A coanda screen is one example of in-channel screens. The coanda screen is designed to draw a portion of the water passing over it while allowing fish to continue downstream unharmed. Water drawn through the coanda screen flows to a sump located on the riverbank which is then pumped to the treatment plant. A major consideration for the suitability of this type of intake for the Englishman River is that the weir may obstruct salmon spawning runs and recreational use of the river.

In-Stream Intake and On-shore Screen: This type of intake involves a wedge intake in the river that draws water to a screening area located on the riverbank. Because there is no screen at the intake, fish can enter the intake and must be safely returned to the river. Typically, the on-shore screens are equipped with travelling screens with fish return buckets that lift fish into a return sump. Alternatively, fish can be lead to a bypass channel beside the travelling screens to the return sump. Fish are typically pumped back to the river from the sump using a fish-friendly sump pump. This type of intake allows for the intake to be positioned in any point in the river while the screens are easily accessible on the riverbank for maintenance. With use, the intake may become clogged with debris or frazil ice so occasional access must be considered during design. Design of the screen system will require close cooperation with the Department of Fisheries and Oceans (DFO) to ensure that fish damage at the screen is kept to a minimum.

Bank Intake with Screens: A bank intake system essentially consists of an air intake chamber on the riverbank. Water passes through screens, typically a combination of trash bars and travelling screens, to enter the chamber, and is pumped from the chamber to the treatment plant. The design flow rate through the screens is low enough that fish can swim away from the screens instead of being sucked towards the reservoir. Screen design requires close involvement with the DFO but does not include a fish return component.

Each of the intake types is preferable for specific river conditions. Table 5-1 summarizes some of the requirements for the intakes to consider when assessing the different reaches of the Englishman River.

Table 5-1
Intake Siting Considerations

Intake Type	Advantages	Site Requirements
Infiltration Gallery	• Minimal disruption to fish during operation • Can be installed in shallower reaches • Maintenance can be automated	• Minimal channel shifting/meandering • Low potential for frazil or anchor ice • Low suspended sediment loading • Reasonably high flow velocities at all times
Riverbank Infiltration Gallery	• Minimal disruption to fish during operation • Can be installed in shallower reaches • Maintenance can be automated • Infiltration may lower incoming organic concentrations and turbidity	• Minimal channel shifting/meandering • Low potential for frazil or anchor ice • Riverbank composed of permeable material • Stable riverbank • Reasonably high flow velocities at all times

Intake Type	Advantages	Site Requirements
In-stream Intake and Screen	• Above-ground construction	• Minimal channel shifting/meandering • Low potential for frazil ice • Low debris loading • Low recreational use of reach • Reach not part of a salmon spawning route • Stable riverbank
In-stream Intake with On-shore Screen	• Flexibility of intake position in river • Fish screen easily accessible for maintenance	• Minimal channel shifting/meandering • Low potential for frazil ice • Low debris loading • Low recreational use of reach • Reasonable water depth • Stable riverbank
Bank Intake with Screen	• Easy access for maintenance • Minimal disruption to fish during operation	• Minimal channel shifting/meandering • Low potential for frazil ice • Reasonable water depth • Stable riverbank

6 Summary

At the conceptual level, area requirements for the water treatment site were determined for the maximum design flow condition defined in DP 3-2. It was estimated that a site approximately 7,400 m^2 in area would be required to house the treatment plant and supporting infrastructure. Additional area is required to accommodate access roads, parking and landscaping. In addition to size requirements, flood protection, site access, and site appearance, should be considered, such as locating the site above the 200-year flood plain, and arranging transportation routes such that heavy machinery travelling to and from the plant will not have a major impact on local roads and residences.

Several different types of intakes could be used to draw water from the Englishman river to the proposed treatment plant, and can be grouped as follows:

- Infiltration gallery
- Riverbank infiltration gallery
- In-stream intake and screen
- In-stream intake with on-shore screen
- On-shore intake and screen

Each intake type has its own advantages, disadvantages, and site requirements.

7 References

1. Ministry of Water, Land and Air Protection, 2004. Flood Hazard Area Land Use Management Guide. May 2004.
2. Regional District of Nanaimo, 2006. Regional District of Nanaimo Floodplain Management Bylaw No. 1469.
3. City of Parksville 2007. Building Bylaw No.1387, February 2007.