The Planning and Design Journey from Septic Tanks to Water Reclamation Utilizing MBR/UV Technology

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ABSTRACT

The Carnation Wastewater Treatment Facility produces "unrestricted use" Class A reclaimed water quality in the Puget Sound region of Washington State. The process of providing a treatment facility and associated discharge in a city with inadequate onsite wastewater treatment systems has taken several attempts and decades to accomplish. Despite its relatively small size, this project's success has required extensive coordination, complex stakeholder outreach, flexible and innovative design, and establishment of key partnerships.

KEYWORDS: MBR, reclaimed water, wetlands enhancement, septic, partnership

INTRODUCTION

The residents and businesses in the City of Carnation (City), Washington have been working to solve the challenge of inadequate, and in some cases failing, on-site wastewater treatment systems for a number of years. The City, with an area of 1.1 square miles, lies in an environmentally and culturally sensitive area of the Pacific Northwest. Nested within a pristine setting of King County (County), the nearby stretch of Snoqualmie River includes spawning grounds for Chinook and Coho salmon as well as habitat for a number of other documented special-status species. In addition, the area is within the hunter-fisher-gatherer territory of the Snoqualmie and Tulalip Tribes. Stakeholders are concerned about the preservation of wildlife habitats and cultural heritage as well as maintaining current property values, insuring public health, and promoting the area's aesthetic beauty.

Located within the East King County Groundwater Management Area, most of the valley surrounding the City is designated as a critical aquifer recharge area (King County, 2004). The City's main potable water supply is a 380-gallon-per-minute (gpm) capacity, gravity-fed natural spring, located to the southwest of the city limits (Figure 1). The existing water system also includes a well with a 700-gpm capacity serving as a backup source located within the city limits, a storage reservoir, and transmission/distribution mains. Potable water from the spring is directed to an intake structure, chlorinated, and conveyed to the central distribution system.

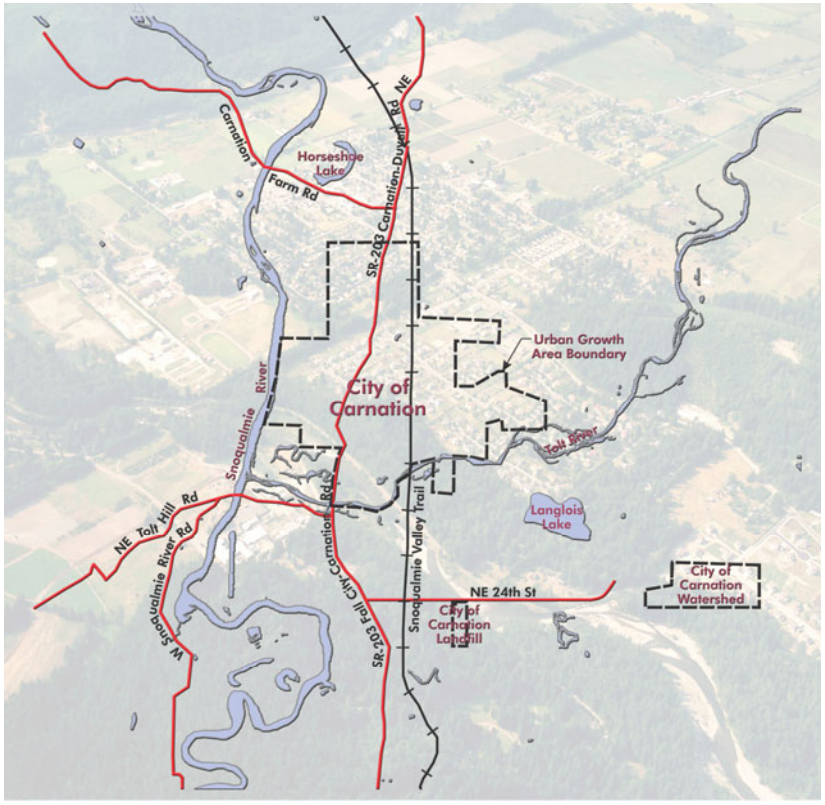

Figure 1: The City of Carnation is an incorporated city within King County located on the Snoqualmie River within the Snoqualmie Valley.

Historically, the City has relied on a system of individual septic tanks and drain fields for wastewater treatment and disposal. In 1987, Public Health - Seattle & King County (Public Health) declared the City a public health hazard area based on the number of inadequate septic systems and the likely contamination of the unprotected aquifer from which drinking water is derived. At that time, Public Health made the declaration based on the soil conditions within the City, documented illegal sewage disposal repairs, and informal surveys confirming inadequate systems. Due to the costs associated with a lot-to-lot survey and comprehensive ground water studies, Public Health was unable to determine the full extent of the health threat. Since then, Public Health has taken the step of restricting property use or prohibiting remodeling projects in cases where the long-term protection of public health could be at risk. Legal repairs to existing septic systems on inadequately sized lots may require a notice of nonconforming repair on the property deed of records. Public Health issued a letter on September 28, 2005 indicating that due to continued public exposure to surfacing sewage and untreated sewage entering the groundwater aquifer, current on-site sewage disposal practices in the City are clearly inadequate and present a Severe Public Health Hazard to the community.

The City has estimated that over 12% of septic systems have failed and as many as 30% are suspected of failing. Over 90% of septic systems do not conform to current environmental standards and the Washington State On-Site Sewage Code. The City's own commerce has lost more than half of its local businesses in the last 20 years and remaining businesses cannot expand. Construction of new homes is not permitted (C. Bock, City Manager, personal

communication, September 26, 2007). Centralized wastewater treatment was determined to be the most viable solution for the long-term protection of the public's health. This included replacing on-site septic systems with a collection system and wastewater treatment facility. In addition to addressing the public health concerns, this also allowed the community to achieve the City's comprehensive plan goals, and enhance community livability. With the ability to develop again, Carnation forecasts the resulting growth to double its current population of almost 2,000 residents in less than 20 years (City of Carnation, 2004).

For the past five years, the County has been in partnership with the City to centralize and treat the city's wastewater. The King County Wastewater Treatment Division (WTD) has had many years of experience in the design, construction, and operation of wastewater treatment facilities. In addition, the County has the staffing resources to undertake such a major capital improvement project, resources that the City does not possess. In the partnership, the City designed, constructed, and now operates a vacuum sewer collection system for the conveyance of sewage to a central pump station. Concurrently, the County constructed and operates a 0.4 mgd average annual and 1.3 mgd peak flow membrane bioreactor (MBR) wastewater treatment facility.

METHODOLOGY

The City began their attempt to resolve issues with their septic tank systems in the late 1980s. Though a number of studies and evaluations were performed, the project did not progress beyond the general planning stage. The County and the City began their partnership in 2003 outlining a systematic decision process for selecting a suitable new wastewater treatment plant site, a conveyance pipeline, and an appropriate location for the plant discharge.

Siting Alternatives and Decision Process

Environmental sensitivity of the area and the need to address public concern and priorities led to a detailed planning process including multiple, detailed screenings to identify suitable alternatives. Each system alternative was separated into three elements: treatment site, conveyance routing, and discharge strategy. Each system element required the development of desirable site/route characteristics, siting goals, and evaluation criteria for the potential sites/routes to most successfully implement construction and long-term operation of the treatment system.

The study area for the treatment facility was restricted to the City's Urban Growth Area (UGA) boundary lines, consistent with the City of Carnation General Comprehensive Plan (1996). Coarse screening focused on site size, presence of surface water, relative elevation, excessive slopes, significant wetlands, compliance with growth management policies, and avoidance of special districts zoning. A coarse screening of the initial sites performed using King County's geographic information system (GIS) eliminated those that did not meet the criteria. Fine screening further ranked the identified potential sites through detailed evaluation questions based on the four main desirable site categories. Table 1 shows the desirable site characteristic developed for the identification of treatment facility sites. The rating scales and criteria developed were based on previous experience with siting processes and input from the community to measure their impact to the community, technical constraints, land use

compatibility, and surrounding environment. Potential sites with relatively low probable impacts that exhibited preferred characteristics where found to be more aligned with the siting goals than sites with higher rating scale probable impacts.

Table 1: Desirable Site Characteristics for Treatment Facility

Characteristic Group	Site Characteristics and Goals
Land Use Compatibility and Acquisition	▪ Site is developed and mitigated to be compatible with surrounding land uses. ▪ Site use is compatible with site zoning and allowable land uses. ▪ Site location is consistent with the Growth Management Act and other special district constraints. ▪ Current ownership, use, and zoning minimize acquisition complexity, and risk of project delay.
Geographic Location	▪ Site development minimizes impacts to the community such as visibility, pedestrian circulation, economic development, and traffic effects. ▪ Minimize distance, cost, and construction disruption of infrastructure. ▪ There is adequate and reliable infrastructure available near the site. ▪ The site location avoids flood prone areas to the extent required by regulation.
Technical Feasibility	▪ There is adequate useable area to allow flexibility in design, operation, expansion and mitigation of site impacts. ▪ Lifetime costs including acquisition, capital, operations, maintenance, and mitigation costs are acceptable. ▪ The site topography minimizes grading costs, and has adequate soils for development. ▪ Minimize exposure to geologic hazards, poor soil conditions, and high groundwater during construction and operation. ▪ Minimize time required to obtain the proper permits.
Environmental Impacts	▪ Minimize adverse effects to biological resources, including: threatened, endangered, and candidate species listed under the federal Endangered Species Act; endangered, threatened, sensitive, and candidate species listed under the Washington Department of Fish and Wildlife's priority habitats and species; species of concern; and any officially designated local natural habitats. ▪ Minimize impacts to sensitive areas, shorelines, or wetlands. ▪ Avoid disruptions or disturbance of hazardous material. ▪ Minimize impacts to known significant cultural resources and historic landmarks. ▪ Construct and operate facilities in a manner that protects municipal drinking water wells and groundwater resources.

This thorough vetting of each element was repeated for the conveyance routes and discharge alternatives. The decision process for final selection of alternatives focused on five equally weighted factors:

Financial implications to the City's businesses and residents paying for the new sewer system through new wastewater rates and connection charges were significant. The comparison of the alternatives in terms of overall cost included the acquisition of property and easements, capital and operations/maintenance costs, eligibility for grant funding, and the ability to meet the planned schedule.

Community integration of a new treatment system with its many functions was considerable both within the City limits as well as to the surrounding rural community. This evaluation included detailed consideration of the resulting impact to the existing community character, visual and aesthetic parameters, and future development.

Environmental resources within the Snoqualmie Valley are important for agriculture, recreation, and a number of sensitive habitats. Protecting and possibly enhancing existing biological and cultural resources can be accomplished through mitigation measures. This factor also encompassed short-term construction impacts as well as long-term operation and maintenance requirements.

Engineering considerations required the design and engineering of a treatment facility that could both be built efficiently and reliably operate effectively into the future. This evaluation of well-proven technologies included reviewing system flexibility, flow management, technology risks and benefits, and assurances for safe and reliable operations.

Policy issues for the advancement of the broader Puget Sound region required focusing beyond either the confines of the City of Carnation or King County. These considerations are interdependent with other jurisdictions, regulatory agencies, and the natural environment. The alternative selected must remain consistent with growth management, comprehensive planning, contribute to the community, and enhance cooperation with partnerships.

Facility Conceptual Design

At the same time the County was completing the planning process for the treatment facility; the City completed a planning process for the collection system. The City's planning process resulted in recommendations for a vacuum collection system composed of 11 miles of pipeline, vacuum valve pits, vacuum pumps, vacuum tank, and sewage pumps. The City would collect its raw sewage at a central pump station and provide flow to the treatment facility through a set of constant speed sewage pumps (1 active, 1 standby). With up to four user connections designated to each small valve pit in the collection system, one of the initial challenges of designing the treatment facility was to provide an design suited to a small community system with negligible conveyance storage.

In addition, the conceptual design was dependent on the extensive evaluations of local environmental conditions performed to develop strategies for complying with permitting requirements and stringent environmental controls in conjunction with the different discharge alternatives. The Total Maximum Daily Load (TMDL) study conducted by the Washington State Department of Ecology on the Snoqualmie River dictates stringent discharge standards for the protection of both wildlife and human health (Joy, 1994). Highly treated water discharged to the evaluated Snoqualmie River must meet the *WAC 173-201A* Surface Water Quality Standards for designated use ("Salmon and Trout Spawning, Core Rearing, and Migration" [previously known as Class A]) as well as the seasonal National Pollution Discharge Elimination System (NPDES) permit requirements. TMDL parameters identified in the study included biochemical oxygen demand, ammonia, and fecal coliform bacteria; guidelines for soluble reactive phosphorus were also established (Joy, 1994).

The County made a commitment to the Carnation community that the facility design would provide highly treated effluent capable of meeting the stringent water quality discharge requirements in place to protect the sensitive surroundings. This and King County's commitment of water as a resource led to the design team's recommendation for a flexible facility design capable of adapting to current and anticipated potential future treatment requirements. Initial treatment facility evaluations examined a range of suspended, fixed-film, and hybrid processes considering capital and O&M costs, facility space requirements, and process reliability. Based on the evaluation, the County's preference to incorporate cost-effective advanced technology, and Carollo's engineering experience and judgment, activated sludge coupled with MBR technology was selected. The membranes in the MBR process provide a physical barrier to remove solids and bacteria, providing a reliable treatment process capable of filtering water to a final turbidity less than 0.2 ntu. Requiring one of the smallest overall environmental footprints, it provides reliable treatment with the flexibility to accommodate more stringent discharge regulations in the future as well as is capable of meeting Class A reclaimed water quality (Health and Ecology, 1996).

The County chose to evaluate and prequalify membrane suppliers for both the Carnation and the much larger Brightwater plant prior to developing an equipment procurement pre-bid package. This strategy was used to reduce the time for detailed design and economize on procurement efforts. Based on a detailed evaluation, the County entered into a contract with Zenon Environmental (now GE Water and Process Technologies of Ontario, Canada) as the supplier of the membranes for the Carnation facility. This contract was structured so the procured package was assigned to the Carnation Wastewater Treatment Facility General Contractor as the construction phase began. By selecting the MBR system early in the project, the membrane design progressed concurrently with the facility design and the project benefited from the membrane supplier providing an earlier integrated role.

RESULTS

Selection of Treatment System

Potential sites for the new treatment facility were evaluated through a systematic process of screening for favorable site characteristics. Coarse-screening of sites within the study area narrowed the search to 15 land parcels that met the minimal critical land use, geographic,

technical, and environmental criteria. Of the 15 identified land parcels, nine were judged to have higher designated land-use compatibility (e.g., recreational) and acquisition cost impacts and therefore lowered acceptability for locating a wastewater treatment facility. Existing uses of the nine sites included schools, parks, a historic site, and urban residential uses. Consequently, only six sites were evaluated further. These six sites were then rated based on the fine-screening criteria using GIS information, visual observation, and other County data as shown in Figure 2. Upon completion of the fine-screening evaluation, two site alternatives remained under consideration by the County.

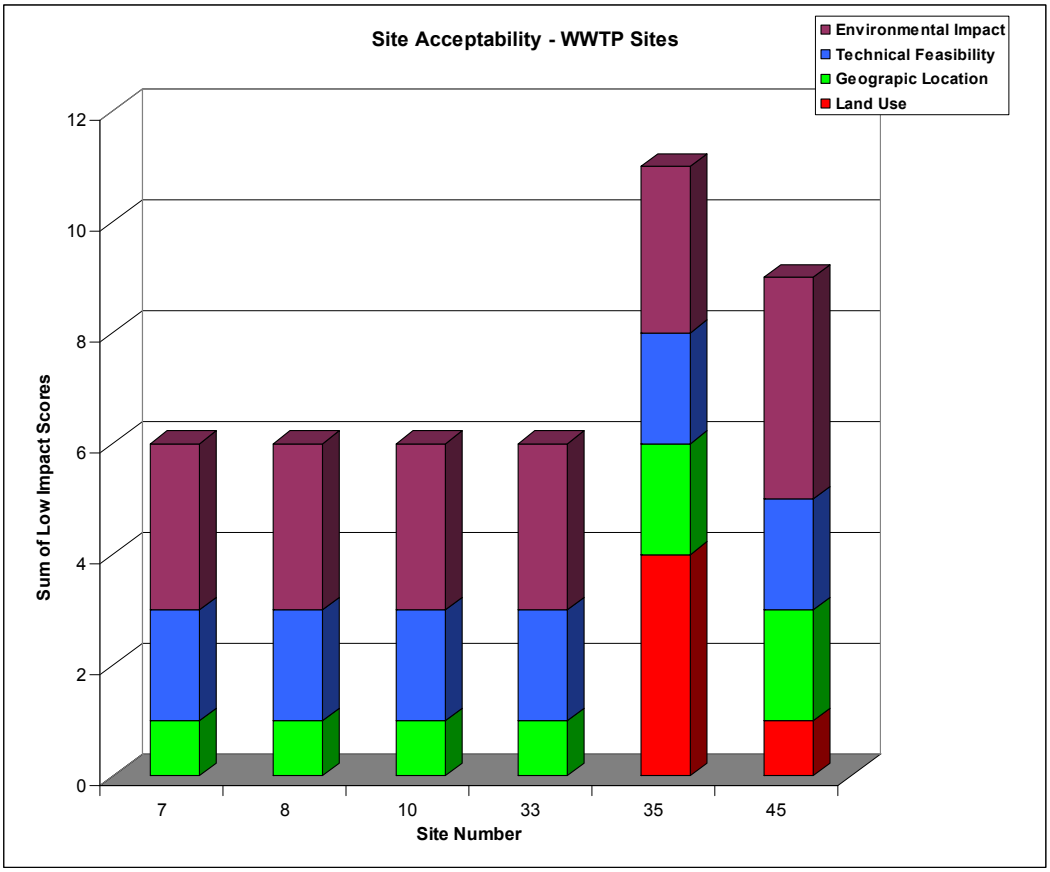

Figure 2: Treatment Facility Site Evaluation

In fall 2004, the County Executive selected the final site based on the five-decision factors initially identified. Advantages to the selected site included not requiring 1) acquisition of land from a private entity or 2) additional pumping between the vacuum pump station and the treatment facility. The selected site is also larger, more accessible, and provided for better visual screening.

A number of discharge alternatives were evaluated during the planning stages of the project including a river outfall and various methods of disposing of or applying reclaimed water such as augmenting flow for natural wetlands restoration. A river outfall discharge at the Carnation Farm Road Bridge was selected based on the financial, environmental, and engineering analysis

(Figure 3). The river outfall design allowed the effluent pipe to be mounted across a County-maintained bridge and attached to the western pier, discharging at the deepest river profile pool. This innovative approach allowed the team to eliminate extensive Section 404 and 401 federal and state permit requirements by locating the river outfall discharge point both downstream of identified prime salmon spawning areas and with minimum disturbance to the riverbed.

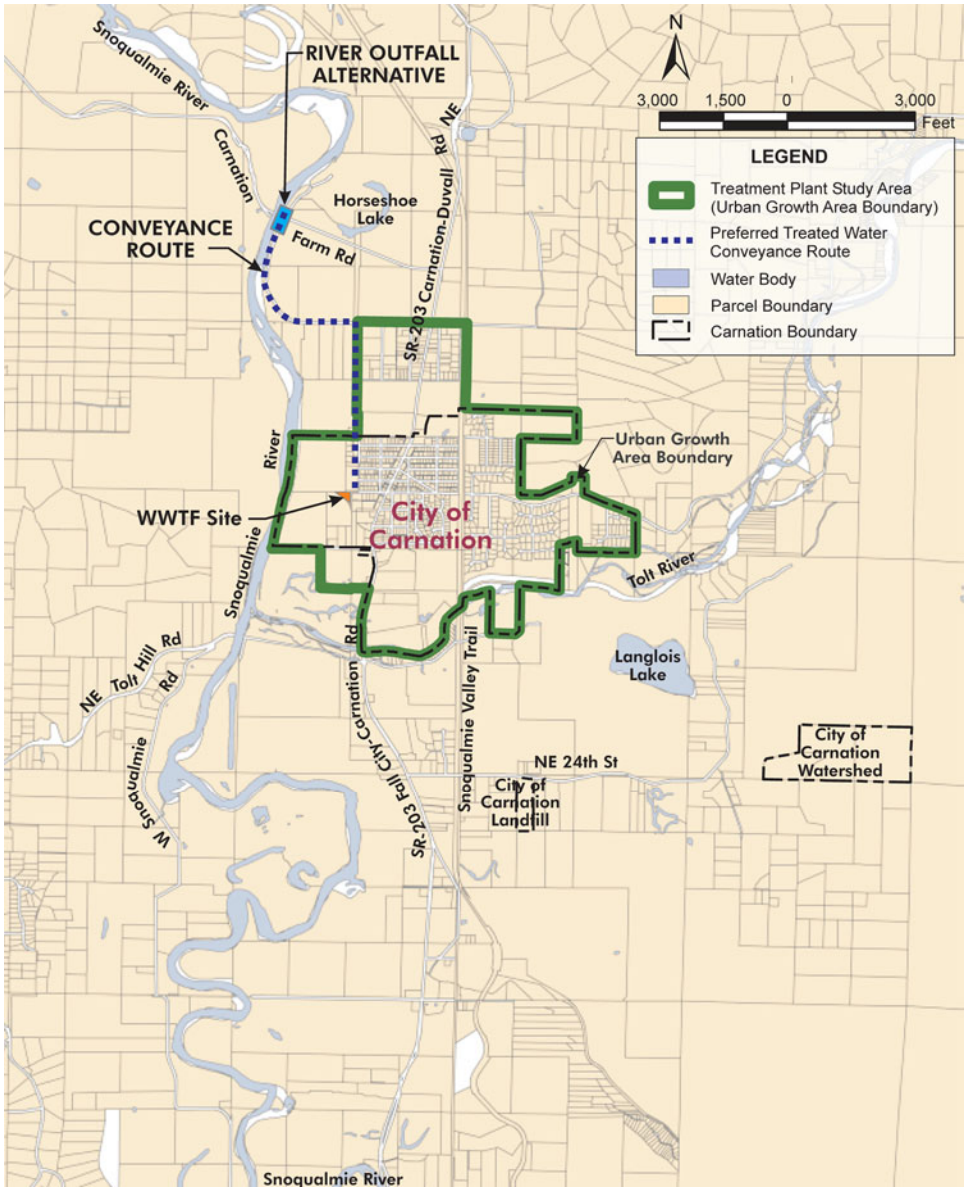

Figure 3: Selected Treatment System

Although the river discharge was initially selected as the most economic solution that would meet project requirements, the County pledged to continue pursuing potential partnerships and grants to offset additional costs associated with reclaiming the water and providing additional hydrology to enhance wetlands. Supported by many stakeholders, the alternate discharge provides an environmental amenity and an economically viable future reuse opportunity. As the design of the river outfall continued to move forward, County staff evaluated alternative wetland

enhancement locations close to the treatment facility. Based on the evaluation, a wetland in the Chinook Bend Natural Area was identified; approximately 300 feet away from the outfall to become the primary discharge location (Figure 4). The river outfall location at the Bridge will remain as a backup discharge location.

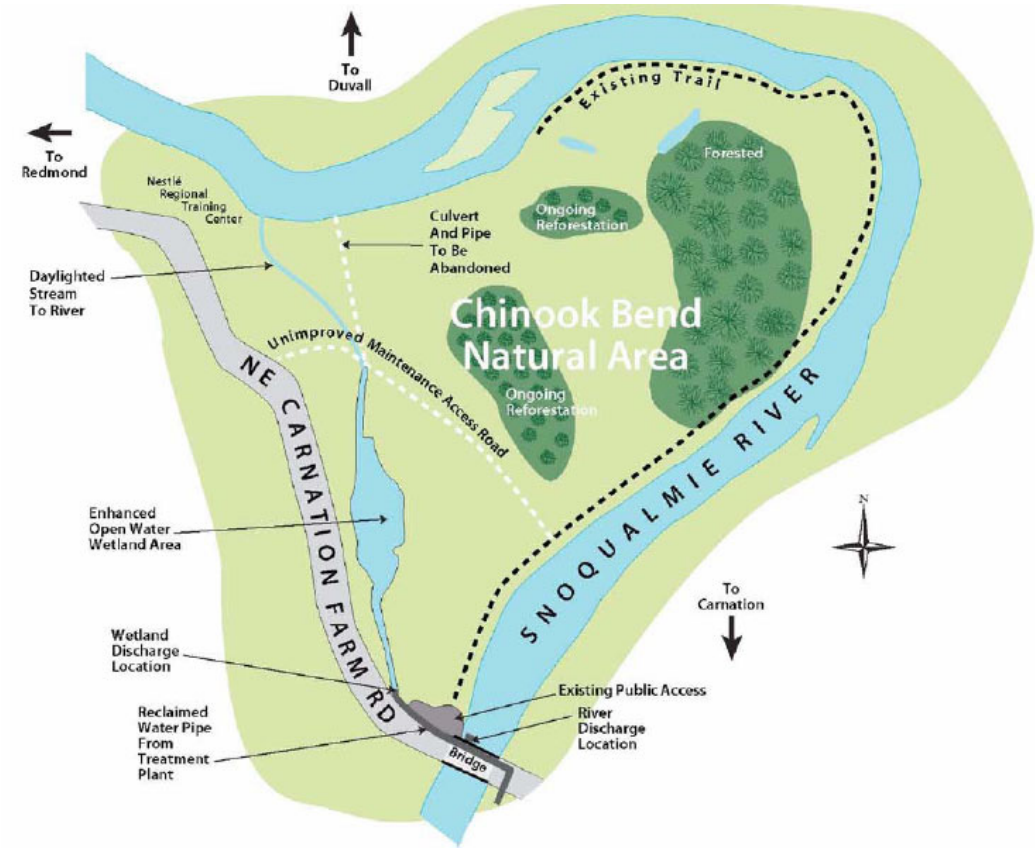

Figure 4: Discharge Locations

The Chinook Bend Natural Area is located in unincorporated King County, approximately 1 mile north of the city limits, and was donated to King County by the Nestle Corporation in 2000. The King County Water and Land Resources Division (WLRD) manages the area as an open space and habitat protection designated area. The site includes a 3-acre Class IV degraded wetland, including an open-water pond that covers approximately 1 to 2 acres (King County, 2003). At present, the site is dominated by reed canary grass and receives surface water runoff and a number of groundwater seeps. Reforestation of the area has been an on going project for WLRD for over five years. The use of reclaimed water to enhance the wetland area is consistent with the goals for the site established in the Chinook Bend Natural Area Site Management Guidelines (King County, 2003).

Design of Treatment Facility

From the spring of 2003 through the summer of 2004, the City and County developed an approach to estimate populations and wastewater flows for a 20-year planning period. Population development is documented in the City of Carnation Sewer Comprehensive Plan (2004). Table 2

summarizes the design flows and load projections for the facility. The City's population is expected to increase from 1,893 residents in 2000 to residential saturation within 10 years after the centralized sewer is established.

Table 2. Flow and Load Projections

Parameter	Projections by Major Milestone and Year		
	Startup 2008	**Full Sewer[a] 2012**	**Design Year 2030**
Flow (mgd)			
Average annual	0.21	0.32	0.37
Maximum monthly	0.27	0.42	0.48
Maximum daily	0.43	0.67	0.77
Peak hourly	0.63	0.72	1.4[b]
BOD (lb/day)			
Average annual	538	923	991
Maximum monthly	700	1,200	1,288
Maximum daily	915	1,570	1,684
TSS (lb/day)			
Average annual	538	923	991
Maximum monthly	700	1,200	1,288
Maximum daily	915	1,570	1,684

a. End of the anticipated rapid increase in population (5% annual growth rate until the buildout density is reached) after the vacuum collection system is available.
b. Allows for wet well equalization.

A number of adaptations have been made for the Carnation facility design in conjunction with membrane technology to provide the automated reliability and redundancy necessary to produce reclaimed water and to be capable of receiving flow from the collection system at all times (Figure 5). The influent is pumped from the City's vacuum pump station through a rotary drum fine screen with 2 mm perforated holes located in the Headworks Building. A second rotary drum screen serves as a standby unit. The screened influent enters the two activated sludge basin trains through a central splitter box. Each basin is composed of four zones: anoxic, anaerobic, and two aerobic. Pumps located in the membrane wetwell equalization feed the membrane tanks and progressive cavity pumps downstream provide suction to pull water through the membrane fibers. From the membrane system, the treated water is pumped through ultraviolet (UV) disinfection reactors and into a standpipe. The standpipe then provides the initial head to send the water over a mile away to the discharge locations by gravity. To clean the membranes, the closed vessel UV reactors allow for the flow to be reversed from the standpipe back through the permeate pumps. The treatment facility is equipped with a full standby UV train, which meets the disinfection dosage criteria set forth for reclaimed water.

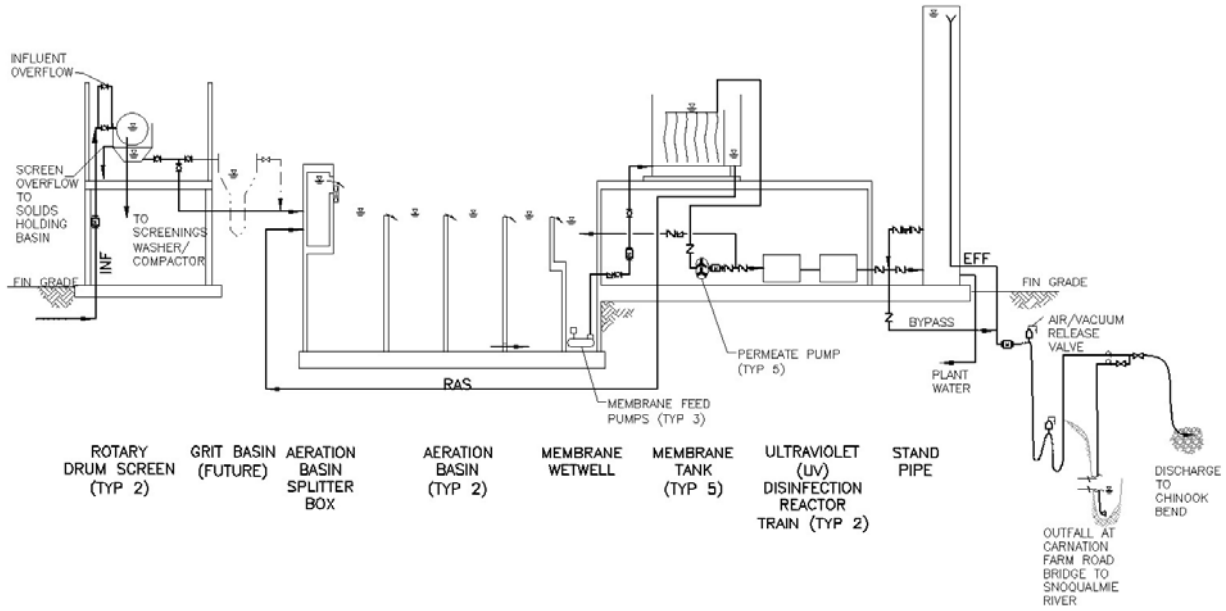

Figure 5: Hydraulic Profile

The facility is also equipped with a 900 kW standby diesel generator designed to automatically power the entire facility in the event of a utility power interruption. During a total loss of power, the facility has been additionally designed to internally divert and store raw sewage from the City's pump station. In this case, there are provisions for the flow to bypass the screens through a manual overflow pipe. Unscreened sewage that enters the overflow pipe is gravity fed to a solids holding basin. Utilizing the available remaining volume of the first basin, the bypass would then overflow into the central solids wet well, and subsequently to the second solids holding basin. When both the normal volume and the headspace of the solids basins are filled, the diverted flow will sequentially overflow to Aeration Basin 2, Aeration Basin 1, and the membrane wet well. During this time, County personnel will be able to analyze and accommodate the situation.

Sensitive to the financial burden and schedule constraints of the Carnation community, the County implemented a number of value engineering measures. These included consolidating structures, identifying reusable assets, developing alternative options for solids handling, and configuring the equipment to serve multiple purposes. In addition, sustainable design aspects were incorporated into achieving a lower overall life cycle cost, including becoming certified using of Leadership in Energy and Environmental Design (LEED) standards.

The entire treatment facility site is located on a two-acre site immediately southwest of downtown Carnation. The site is located within the redelineated FEMA 100-year floodplain. As a result, all facility structures have been elevated approximately four feet above the original site elevation. In addition, the facility footprint within the floodplain has been minimized by consolidating structures. The facility is separated into three facility/operations areas: 1) Headworks, Activated Sludge Basins, and Solids Holding; 2) MBR, UV disinfection, and

Chemical Building; and 3) Operations Building. The two story Headworks Building is located south of the activated sludge basins and solids holding basins at the center of the facility site. The MBR, UV disinfection, and chemical feed structures are located west of the activated sludge and solids holding basins. The Operations Building, located on the east end of the site, includes the administrative office, restroom facility, laboratory, electrical room, and maintenance workshop. Screening the entire facility, agronomic themed architecture for the Operations Building integrated the facility into the community's culture (Figure 6).

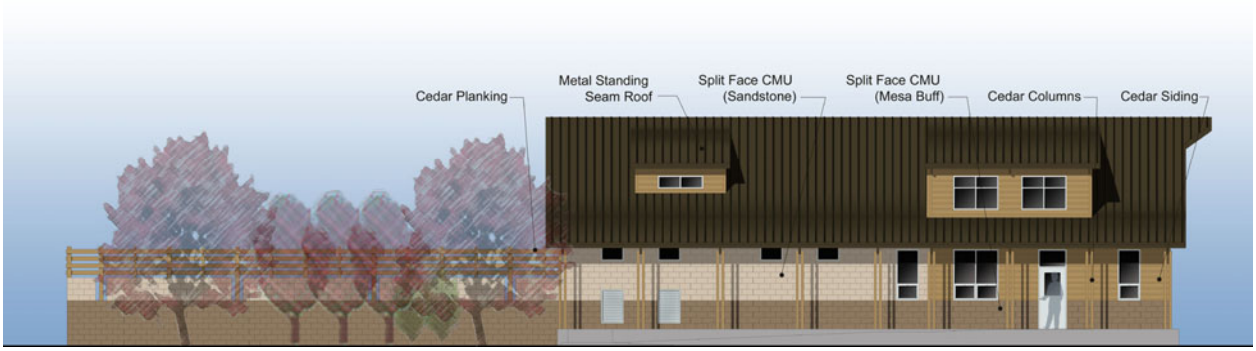

Figure 6: The Operations Building was developed with the community using an agronomic theme and incorporating sustainable LEED elements.

Spare equipment available from the County's regional treatment facilities was incorporated into the facility design. This included use of submersible mixers installed in the anoxic and anaerobic zones of the aeration basins to provide completely mixed zones. In addition, the Headworks Building, Activated Sludge Basins, and membrane tanks are all covered with foul air treated by two reconditioned fiberglass deep bed activated carbon units.

Several alternatives were evaluated to minimize the overall life cycle costs for solids handling. The most cost effective solution selected was providing gravity thickening capability onsite and then transporting to the County's regional facilities for solids stabilization. The onsite solids design provided for two aerated basins with a central wetwell. Upper and lower slide gates allow for decanting. The thickened solids can then be pumped from the central wetwell to either the head of the plant or to a tanker truck. The aeration basins also drain to the central solids wetwell for flow redistribution, as necessary.

The implementation of cost saving measures was achieved without limiting operational flexibility. In lieu of the separate production, cleaning, and vacuum systems typically required for MBR systems, a single reversible rotary lobe pump system provides the necessary functions. This simplification eliminates separate air separators, backpulse pumps, backpulse storage, and reduced the number of valves and pipes. In addition, the provision of the standpipe allows the same pumps to also provide the necessary initial hydraulic head to convey the treated water to the discharge locations by gravity.

Design of Discharge Locations

The Chinook Bend wetland will become the primary discharge location for Class A reclaimed water from the facility. The Snoqualmie River outfall at the Carnation Farm Road Bridge serves as the backup discharge location. The dual discharge design utilizes a single conveyance pipeline on the downstream side of the bridge to the discharge area. At the Bridge, the discharge pipeline is supported across the lower girder as the pipeline heads to the western bank of the Snoqualmie River. Diversion valves off the west bank allow the flow to discharge to the wetland or to the outfall on the west pier of the Bridge. From the diversion vault, the reclaimed water piping entering the Chinook Bend site continues along the south edge of the property. At the discharge point, the reclaimed water discharges through a secured manhole and perforated pipe before upwelling through a river cobble pad. The cobble will promote turbulence, prevent scour, and help to maintain an aesthetic balance. The reclaimed water will continue down slope and over land to the wetland area.

The County's WTD and WLRD developed a formal partnership with Ducks Unlimited (DU) to complete the wetland discharge project and further reduce the cost of the project. DU, a national, non-profit corporation dedicated to wetland conservation has provided their engineering and wetland enhancement expertise. The County-DU partnership establishes responsibilities for each party to complete individual components of the Chinook Bend wetland enhancement project, as outlined below:

- WTD constructed a pipe extension and discharge system to add Class A reclaimed water to enhance the degraded natural wetland. The County maintains the right to use and distribute the Class A reclaimed water for flows in excess of the initial average annual discharge from the facility, as long as it meets reuse standards and is issued for reuse purposes.
- The DU restoration design focuses on the use of native plantings and the control of reed canary grass in the wetland unit by means of moist soil management utilizing a water control structure. Modifications increase the open-water area of the wetland to approximately 4 acres, and the flow from this area continues over land to the Snoqualmie River.
- As the land manager, WLRD oversees and approves activities on the site. Over the long-term, WLRD will monitor and maintain the Chinook Bend wetland in accordance with the requirements set forth in the Reclaimed Water Use Permit through an end-user agreement. Anticipated permit requirements include the periodic monitoring of plants and animals in and around the wetland as well as the maintenance of native wetland and riparian plant species.

DISCUSSION AND CONCLUSIONS

In May 2008, the Carnation wastewater facilities began startup and operation with an initial discharge to the Snoqualmie River outfall. This fall, the primary discharge location for all the treated water from the plant is planned to provide drought tolerant Class A reclaimed water hydrology to the Chinook Bend Natural Area. The sewer system and wastewater treatment facility has been recognized as the key to the City's economic, health, and community

revitalization. Successful development of the Carnation treatment system consisting of a vacuum sewer collection system, MBR treatment facility, conveyance pipeline, and dual discharge was undertaken by a series of strong partnerships.

Funding

Overall, the total project cost of the Carnation Wastewater Treatment Facility is projected to be approximately $24 million and the collection system was completed for approximately $21 million. The County has received over $15 million in low interest loans and the City has received $13 million in grants and $16 million in low interest loans to support these projects.

Through DU, the overall wetland enhancement project has received several grants to offset design, permitting and construction costs for site enhancement, which will allow the provision of Class A reclaimed water to Chinook Bend. These grants include the $122,000 North American Wetland Conservation Act Grant, the $14,000 (USDA) King Conservation District grant, and a $30,000 King County WaterWorks Grant. In addition, King County has been successful in receiving $297,350 for an Interagency for Outdoor Recreation Aquatic Lands Enhancement Account grant to fund public access improvements on the site as well.

Partnerships

King County's experience in design and operation of wastewater treatment facilities as well as staffing resources currently unavailable to the City of Carnation provided the initial partnership to undertake this major capital improvement project. The City and the County began the project by proactively working with stakeholders to gain support. This work included the appointment of an advisory citywide evaluation committee composed of citizen members selected to represent a broad range of interest groups and expertise. The committee convened during the planning stages of the project as specific siting criteria were developed and aided in evaluating the potential project sites. Through continued interaction with the community, the Operations Building was integrated into the culture in a sustainable manner.

This initial solid partnership then worked with environmental groups, the local Snoqualmie and Tulalip Tribes, the state legislature, regulatory agencies, and other stakeholders to evaluate environmental impacts and provide a supported design for discharge of the reclaimed water to enhance the natural wetland at Chinook Bend. The number of strong interagency partnerships developed through this overall project, was based on shared goals to successfully meet obligations and regulatory requirements while providing wildlife benefits and enhancing passive recreation opportunities in a forested wetland. The partnership has in completion of a long-term integrated water resource management approach consistent with policy goals made at the local, state, and national levels.

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