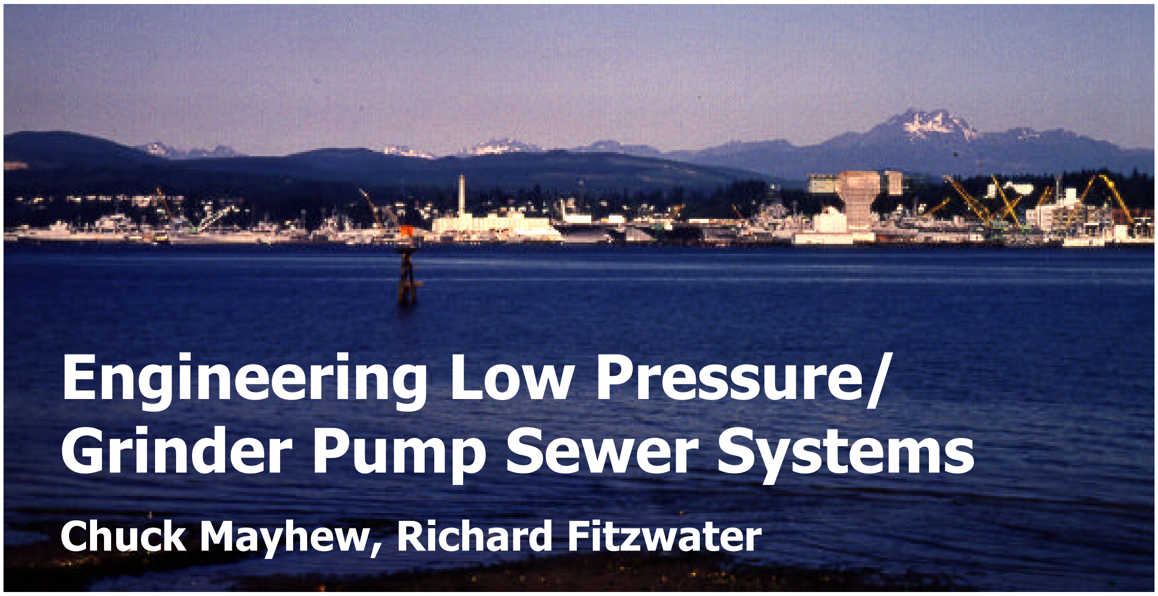

Engineering Low Pressure/ Grinder Pump Sewer Systems

Chuck Mayhew, Richard Fitzwater

The Beach Drive area, located directly across Sinclair Inlet from the Bremerton Naval Shipyard, is an area of magnificent water and mountain views.

Project Background

The science of civil engineering involves identifying problems, evaluating alternatives, and providing solutions that effectively meet the needs of those involved. Civil engineers are particularly interested in solving problems to improve the way people live and work and protect the integrity of the environment.

Kennedy/Jenks Consultants was recently asked to solve a common waterfront problem – failing septic systems. The Puget Sound region of western Washington includes hundreds of miles of private saltwater and lakefront property. In 1993, the Bremerton-Kitsap County Health District (Health District) began sanitary survey tests along a 5-mile stretch of coastline known as Beach Drive. The results of the testing revealed failing septic systems in 21 percent of the existing 215 homes. In some cases, a septic tank or drain field did not even exist, and the homeowner's sewage discharged directly to the bay. The Health District estimates a typical failure rate of 5 percent in areas served by septic systems; the 21% failure rate constituted a public health emergency.

The high percentage of failing septic systems was attributed to a number of factors:

1. The average age of the septic systems along Beach Drive was approximately 50 years. Some systems had been rehabilitated, and newer homes typically possessed more elaborate, pumped systems, but most of the systems had never been improved.

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2. The geographic and topographic conditions along Beach Drive are not conducive to adequate treatment by traditional septic systems. Although the soil conditions along Beach Drive range from clay to solid rock, clay is the predominant soil type on private property. The homes with failing systems were located along the beach against a very steep hillside that contributed copious runoff.

3. The average annual precipitation in the Bremerton-Port Orchard area is 51 inches per year, resulting in saturated soil conditions many months of the year.

4. Many homeowners had not maintained their septic tanks and drainfields.

The combination of these factors resulted in the unusually high failure rate.

The Health District subsequently declared a public health hazard and mandated that homeowners with failing systems either make the necessary repairs to their existing system or connect to the public sewer system. The homeowners with failed systems faced repair bills of $15,000 to $18,000 to replace the septic tanks and drainfields according to local codes or to install new high-tech filtration units. Many homeowners recognized that connection to the public sewer was an affordable alternative that would provide a long-term health benefit to the area. Fortunately, the jointly owned Port Orchard-Kitsap County Sewer District No. 5 secondary treatment facility was located at one end of the Health District's test area.

Formation of Utility Local Improvement District

A handful of proactive homeowners assembled to form the Beach Drive Sewer Committee. The Committee's goal was to rally the community in an effort to build a public sewer to serve the properties along the waterfront. With the treatment plant located adjacent to Beach Drive and in sight of many homes, the Committee anticipated a quick, relatively inexpensive sewer project. However, when the Committee approached the Kitsap County Sewer District No. 5 (District) about connecting to the public sewer, they encountered a number of significant hurdles:

1. The Washington State Growth Management Act (GMA) prohibits the extension of urban services (including sewer collection systems) into designated rural areas such as Beach Drive. This statute prohibited various state and local agencies from approving design and construction of the sewer system along Beach Drive.

2. Because the entire area proposed for sewer service was located outside the current District boundary, the entire area would have to undergo a lengthy annexation.

3. Substantial capital costs were required to plan, design and build the system.

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The Sewer District cooperated with the community and was willing to provide sewer service to the Beach Drive area if the problems could be solved. The District recommended that the Committee work closely with the District Engineer, Kennedy/Jenks Consultants, to resolve the problems confronting the project. Kennedy/Jenks Consultants helped the Committee obtain a GMA statutory exemption for a declared health hazard.

The Engineer also assisted the citizen's Committee with the petition process for annexing and creating a utility local improvement district (ULID) to finance the sewer project's capital costs. Washington State statute provides legislation enabling formation of a ULID to allow capital facilities to be built. The ULID statute requires the landowners within the ULID to assess themselves the costs of planning, designing, and building the improvements. The ULID is enclosed within a specified boundary, and creation of the ULID (by the petition method) requires the signatures of at least 51 percent of the area landowners. The petition requesting creation of the Beach Drive ULID was signed by 71 percent of the landowners.

Analysis of Sewer System Alternatives

Prior to creation of the ULID, the Committee asked Kennedy/Jenks Consultants to examine the various sewer system alternatives available for use in the Beach Drive area. Because the homeowners were assessing themselves for the capital costs of the project, the primary reason for the alternative analysis was to find the alternative with the least expensive construction cost. However, as the District Engineer, Kennedy/Jenks Consultants' responsibility was to find the alternative with the lowest life cycle costs [construction plus operation and maintenance (O&M)] for the District. The District had committed its resources to the sewer project early in the process and was responsible for preserving the community's public health. At the same time, the homeowners were under a mandate from the Health District to correct their failing systems or face court-ordered fines and condemnation.

The Engineer evaluated four systems for the Beach Drive area: 1) gravity sewer system that required three pump stations, 2) septic tank and effluent pumping (STEP) system, 3) vacuum system, and 4) low pressure/grinder pump system. Each system could be reasonably designed and constructed and they were each evaluated based on the District's needs (minimizing capital and long-term O&M costs) and the homeowners' needs (minimizing capital costs). Minimizing capital costs was critical to the District as well, because the properties within the ULID could not be assessed capital costs in excess of the sewer connection's assessed benefit to the property. In other words, if the capital cost assessment for a particular property was $15,000, but its appraised value increased by only $10,000, the District would be legally required to assume the $5,000 difference.

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Construction cost estimates for each alternative were as follows:

System Alternative	Estimated Construction Cost	Estimated Annual O&M Cost
Gravity Sewer System (including three pump stations)	$8,420,000	$25,000
STEP System	$2,336,000	$12,600
Vacuum System	$2,222,000	$14,700
Grinder Pump System	$1,912,000	$10,710

The Engineer recommended the grinder pump system because it offered the lowest capital cost to the homeowner, minimized O&M costs, and reduced the risk of assumption of capital cost in excess of assessments to the District.

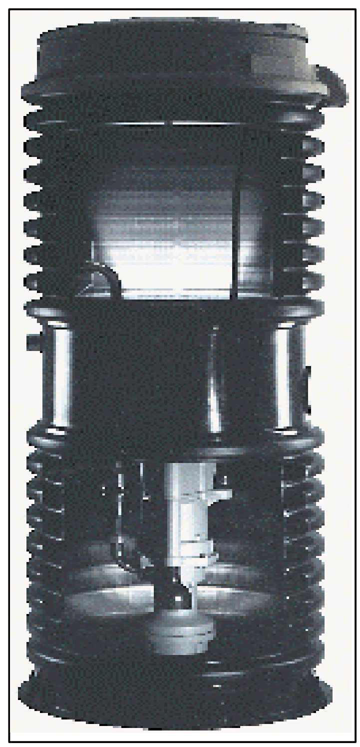
Selection of Environment One Grinder Pumps

Kennedy/Jenks Consultants had previously designed several grinder pump projects. Together, these projects involved more than 1,000 grinder pumps from three different manufacturers. Based on that experience and the O&M data collected, the Engineer recommended that the District use Environment One (E-1) grinder pumps. The E-1 grinder pumps had a proven track record of exceptional reliability and serviceability. Moreover, the E-1 pump was the only grinder pump that could efficiently satisfy the head requirements along Beach Drive.

Environment One Grinder Pump

The Environment One grinder pump is characterized by:

- A self-contained unit with integral wet well/dry well
- Field adjustable accessway to accommodate varying sewer invert and grade elevations
- Simple core design that allows replacement and/or service in the field
- A progressing cavity pump that produces a nearly constant flow rate over a wide range of head conditions
- A standard 1 hp motor that is interchangeable on any E-1 model
- Pressure switches as opposed to float switches
- Stainless steel discharge piping.



Cutaway view of E-1 Model 2010 grinder pump

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Operation and Maintenance (O&M) Costs

In 1986, Kennedy/Jenks Consultants designed more than 900 E-1 grinder pumps for installation around four lakes south of Tacoma, Washington. Based on data collected by Pierce County Utility, annual maintenance costs for this system averaged $51 per pump per year between 1990 and 1994. Pierce County also had 46 centrifugal grinder pumps in a different system with average annual maintenance costs of $243 per pump during the same period. The utility attributes the difference in maintenance costs between the centrifugal and progressive cavity (E-1) pumps to the need for regularly scheduled maintenance for the float switches in the centrifugal grinder pump units. A major factor in the low maintenance costs for the E-1 pumps is the 11-year average mean time between service calls (MTBSC).

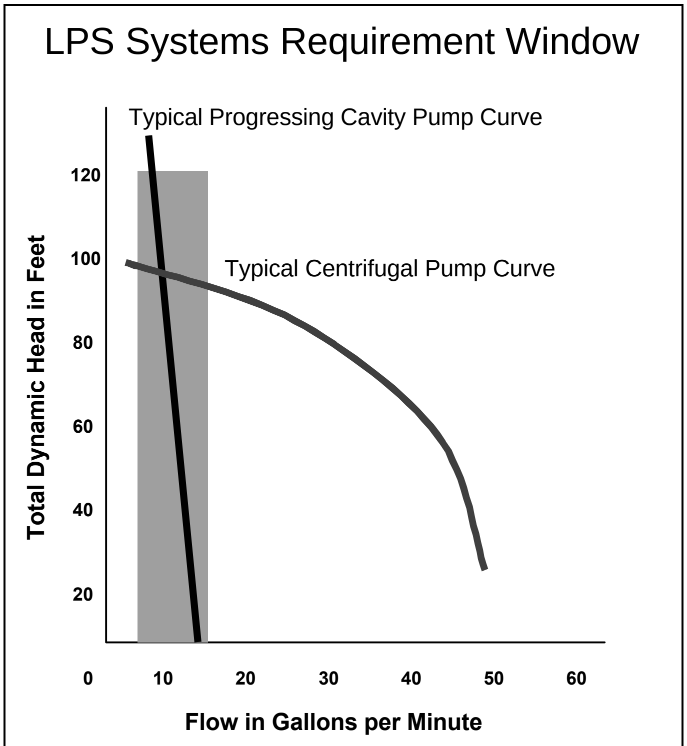
Serviceability

Simple removal and installation of the "core" to service the pump and grinder is inherent to the design of the E-1 grinder pump. The grinder pump unit consists of a high-density polyethylene (HDPE) housing and a suspended core that includes the pump, grinder, controls, and other operating parts. After the grinder pump is installed, the core can be repaired by disconnecting the electronic quick disconnect (EQD) and removing six stainless steel bolts in the accessway. District maintenance personnel can then troubleshoot the core in the field or install a replacement core and take the damaged one back to the shop for testing and repair. The homeowner experiences minimum downtime, and the District can repair and test the damaged core at its convenience in the shop.

Minimum Preventive Maintenance

One of the biggest benefits of the E-1 grinder pump is the use of pressure switches instead of float switches. Float switches are notorious for fouling with grease, and preventive maintenance is typically required for the pump to operate properly. By incorporating a sensing bell and air pressure column to actuate level controls, E-1 minimizes the need for preventive maintenance.

The E-1 grinder pump uses a progressing cavity pump rather than a centrifugal pump. The typical pump curve (right) shows that a progressive cavity pump has a nearly constant discharge rate over a wide range of



Centrifugal vs. Progressing Cavity Pump Curves

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head conditions, including negative head conditions. As a result, the cleansing velocity created by the reduced flow area at the point of blockage flushes sedimentation from the piping network. Typical operating pressures of the Beach Drive system range from 20-60 psi and shutoff for the pumps is 160 psi. The smaller the area in the pipe, the higher the velocity of the liquid because of the progressing cavity pump. Periodic maintenance and flushing of the force main are essentially eliminated.

System Design

The entire project consisted of:

- 26,900 feet of 3"to 8" forcemain;
- 22,400 feet of 1-1/4" to 2" pressurized discharge piping on private property; and
- 210 grinder pumps installed on private property;

Force Main Design

The entire system was hydraulically modeled on the computer to ensure that proper velocities were maintained and that no point in the system exceeded the maximum recommended pressure of 80 psi for the E-1 pump. The model calculated the total dynamic head (TDH) for each pump based upon the pipe sizes, number of pumps, and elevations of pipe mains and grinder pumps.

Oct-15-98 — PRELIMINARY PRESSURE SEWER - PIPE SIZING AND BRANCH ANALYSIS — Prepared By:
Watauga Beach Sewer Project — Chuck Mayhew

This spreadsheet was calculated using pipe diameters for: SDR11HDPE — Friction loss calculations were based on a Constant for inside roughness of "C" = 150

Zone Number	Number Of Cores In Zone	Accumulated # Of Cores In Zone	Max # Of Simultanious Operations	Max Flow In GPM	Pipe Size (Inch)	Max Velocity (FPS)	Length Of Main This Zone	Friction Loss Factor (Ft/100Ft)	Friction Loss This Zone	Accumulated Friction Loss (Feet)	Max Main Elevation	Minimum Pump Elevation	Static Head (Feet)	Total Dynamic Head (Ft)
1.00	9	9	3	33	2.00	3.57	650	2.52	16.38	128.11	40	10	30	158.11
2.00	9	18	4	44	3.00	2.19	650	0.65	4.22	111.73	40	10	30	141.73
3.00	12	30	5	55	3.00	2.74	1,000	0.98	9.82	107.51	60	15	45	152.51
4.00	20	50	6	66	4.00	1.99	950	0.41	3.85	97.69	60	10	50	147.69
5.00	30	80	7	77	4.00	2.32	2,400	0.54	12.95	93.84	35	15	20	113.84
6.00	5	85	8	88	4.00	2.65	1,100	0.69	7.60	80.89	70	25	45	125.89
7.00	4	4	3	33	3.00	1.64	900	0.38	3.43	76.72	30	19	11	87.72
8.00	15	104	8	88	4.00	2.65	1,000	0.69	6.91	73.29	28	24	4	77.29
9.00	13	13	4	44	3.00	2.19	500	0.65	3.25	69.63	14	14	0	69.63
10.00	0	117	9	99	5.00	1.95	400	0.31	1.23	66.38	15	15	0	66.38
11.00	9	9	3	33	3.00	1.64	850	0.38	3.24	68.39	20	10	10	78.39
12.00	17	143	9	99	5.00	1.95	2,400	0.31	7.36	65.15	14	11	3	68.15
13.00	4	4	3	33	3.00	1.64	550	0.38	2.10	59.89	45	42	3	62.89
14.00	11	158	10	110	5.00	2.17	1,300	0.37	4.84	57.79	10	8	2	59.79
15.00	18	176	10	110	5.00	2.17	1,000	0.37	3.73	52.95	12	9	3	55.95
16.00	32	208	11	121	5.00	2.39	2,600	0.44	11.56	49.22	12	9	3	52.22
17.00	32	240	12	132	5.00	2.60	2,200	0.52	11.49	37.66	27	12	15	52.66
18.00	32	272	13	143	6.00	1.99	3,000	0.26	7.76	26.17	12	10	2	28.17
19.00	11	283	14	154	6.00	2.14	1,200	0.30	3.56	18.41	8	8	0	18.41
20.00	3	3	2	22	3.00	1.10	500	0.18	0.90	15.75	8	10	-2	13.75
21.00	24	310	14	154	6.00	2.14	2,400	0.30	7.12	14.85	8	8	0	14.85
22.00	32	342	15	165	6.00	2.29	2,100	0.34	7.08	7.73	8	8	0	7.73
23.00	0	342	15	165	8.00	1.35	700	0.09	0.65	0.65	22	8	14	14.65

Typical model output for designing a low pressure, grinder pump system.

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Grinder Pump Design

An essential phase in the design of the grinder pump system was to meet with each homeowner at the property. The visit was crucial to address homeowner questions and concerns and to lay out the grinder pump and discharge piping locations. In many cases, homeowners were planning to remodel their homes after sewer installation. By discussing how the grinder pump works and explaining some constraints associated with the grinder pump location, the homeowner and engineer could select a location that would prevent numerous, costly change orders during construction if grinder pumps had to be relocated. The engineer designed and drafted the site plan on a laptop computer in the field. The site plan was later reproduced on 11"x17" sheets for use by the contractor during construction.

Typically, the grinder pump was located near, or occasionally inside, the existing septic tank, making the plumbing of the existing house sewer to the grinder pump more efficient. The design could not have been completed successfully without these property visits to determine the location of the existing sewer hookup at the house. Although the property visits were time consuming, they were far more beneficial to the project than the cost, because change orders constituted less than 1 percent of the project cost.

Conclusion

The Beach Drive Sewer Project was a unique application of an alternative technology. The needs of both the public agency providing sewer service and system maintenance, and the homeowners who were required to pay for the capital cost of the project, were satisfied. The District, homeowners, and Kennedy/Jenks Consultants successfully embraced a philosophy of working closely together to provide a sound design with analysis of alternatives and frequent coordination of efforts to meet the needs of all involved.

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