United States Environmental Protection Agency
Office of Water Washington, D.C.
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Collection Systems Technology Fact Sheet
Sewers, Lift Station

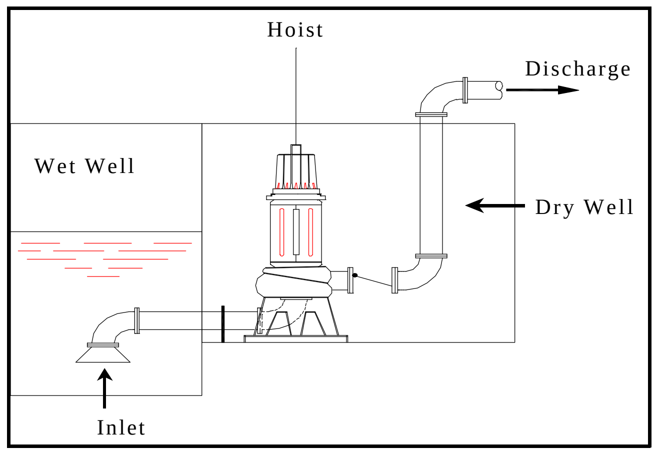
DESCRIPTION

Wastewater lift stations are facilities designed to move wastewater from lower to higher elevation through pipes. Key elements of lift stations include a wastewater receiving well (wet-well), often equipped with a screen or grinding to remove coarse materials; pumps and piping with associated valves; motors; a power supply system; an equipment control and alarm system; and an odor control system and ventilation system.

Lift station equipment and systems are often installed in an enclosed structure. They can be constructed on-site (custom-designed) or pre-fabricated. Lift station capacities range from 76 liters per minute (20 gallons per minute) to more than 378,500 liters per minute (100,000 gallons per minute). Pre-fabricated lift stations generally have capacities of up to 38,000 liters per minute (10,000 gallons per minute). Centrifugal pumps are commonly used in lift stations. A trapped air column, or bubbler system, that senses pressure and level is commonly used for pump station control. Other control alternatives include electrodes placed at cut-off levels, floats, mechanical clutches, and floating mercury switches. A more sophisticated control operation involves the use of variable speed drives.

Lift stations are typically provided with equipment for easy pump removal. Floor access hatches or openings above the pump room and an overhead monorail beam, bridge crane, or portable hoist are commonly used.

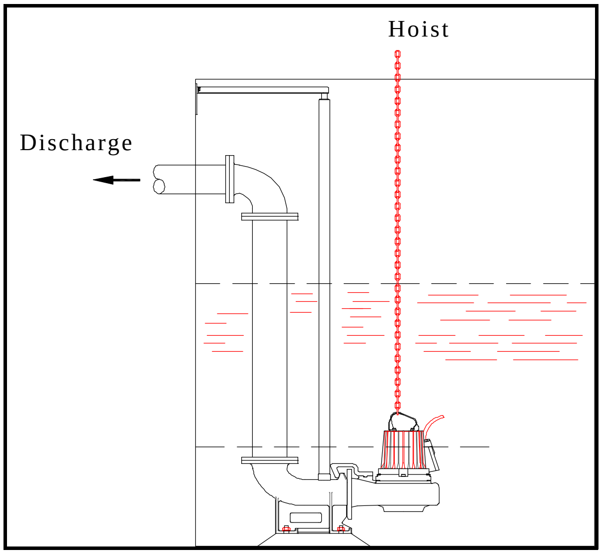
The two most common types of lift stations are the dry-pit or dry-well and submersible lift stations. In dry-well lift stations, pumps and valves are housed in a pump room (dry pit or dry-well), that is easily accessible. The wet-well is a separate chamber attached or located adjacent to the dry-well (pump room) structure. Figures 1 and 2 illustrate the two types of pumps.



Source: Qasim, 1994.

FIGURE 1 DRY-WELL PUMP

Submersible lift stations do not have a separate pump room; the lift station header piping, associated valves, and flow meters are located in a separate dry vault at grade for easy access. Submersible lift stations include sealed pumps that operate submerged in the wet-well. These are removed to the surface periodically and reinstalled using guide rails and a hoist. A key advantage of dry-well lift stations is that they allow easy access for routine visual inspection and maintenance. In general, they are easier to repair than submersible pumps. An advantage of submersible lift stations is that they typically cost less than dry-well stations and operate without frequent pump maintenance. Submersible lift stations do not usually include



Source: Qasim, 1994.

FIGURE 2 WET-WELL SUBMERSIBLE

large aboveground structures and tend to blend in with their surrounding environment in residential areas. They require less space and are easier and less expensive to construct for wastewater flow capacities of 38,000 liters per minute (10,000 gallons per minute) or less.

APPLICABILITY

Lift stations are used to move wastewater from lower to higher elevation, particularly where the elevation of the source is not sufficient for gravity flow and/or when the use of gravity conveyance will result in excessive excavation depths and high sewer construction costs.

Current Status

Lift stations are widely used in wastewater conveyance systems. Dry-well lift stations have been used in the industry for many years. However, the current industry-wide trend is to replace dry-well lift stations of small and medium size (typically less than 24,000 liters per minute or 6,350 gallons per minute) with submersible lift stations mainly because of lower costs, a smaller footprint, and simplified operation and maintenance.

Variable speed pumping is often used to optimize pump performance and minimize power use. Several types of variable-speed pumping equipment are available, including variable voltage and frequency drives, eddy current couplings, and mechanical variable-speed drives. Variable-speed pumping can reduce the size and cost of the wet-well and allows the pumps to operate at maximum efficiency under a variety of flow conditions. Because variable-speed pumping allows lift station discharge to match inflow, only nominal wet-well storage volume is required and the well water level is maintained at a near constant elevation. Variable-speed pumping may allow a given flow range to be achieved with fewer pumps than a constant-speed alternative. Variable-speed stations also minimize the number of pump starts and stops, reducing mechanical wear. Although there is significant energy saving potential for stations with large friction losses, it may not justify the additional capital costs unless the cost of power is relatively high. Variable speed equipment also requires more room within the lift station and may produce more noise and heat than constant speed pumps.

Lift stations are complex facilities with many auxiliary systems. Therefore, they are less reliable than gravity wastewater conveyance. However, lift station reliability can be significantly improved by providing stand-by equipment (pumps and controls) and emergency power supply systems. In addition, lift station reliability is improved by using non-clog pumps suitable for the particular wastewater quality and by applying emergency alarm and automatic control systems.

ADVANTAGES AND DISADVANTAGES

Advantages

Lift stations are used to reduce the capital cost of sewer system construction. When gravity sewers are installed in trenches deeper than three meters (10 feet), the cost of sewer line installation increases significantly because of the more complex and costly excavation equipment and trench shoring techniques required. The size of the gravity sewer lines is dependent on the minimum pipe slope and flow. Pumping wastewater can convey the same flow using smaller pipeline size at shallower depth, and thereby, reducing pipeline costs.

Disadvantages

Compared to sewer lines where gravity drives wastewater flow, lift stations require a source of electric power. If the power supply is interrupted, flow conveyance is discontinued and can result in flooding upstream of the lift station, It can also interrupt the normal operation of the downstream wastewater conveyance and treatment facilities. This limitation is typically addressed by providing an emergency power supply.

Key disadvantages of lift stations include the high cost to construct and maintain and the potential for odors and noise. Lift stations also require a significant amount of power, are sometimes expensive to upgrade, and may create public concerns and negative public reaction.

The low cost of gravity wastewater conveyance and the higher costs of building, operating, and maintaining lift stations means that wastewater pumping should be avoided, if possible and technically feasible. Wastewater pumping can be eliminated or reduced by selecting alternative sewer routes or extending a gravity sewer using direction drilling or other state-of-the-art deep excavation methods. If such alternatives are viable, a cost-benefit analysis can determine if a lift station is the most viable choice.

DESIGN CRITERIA

Cost effective lift stations are designed to: (1) match pump capacity, type, and configuration with wastewater quantity and quality; (2) provide reliable and uninterruptible operation; (3) allow for easy operation and maintenance of the installed equipment; (4) accommodate future capacity expansion; (5) avoid septic conditions and excessive release of odors in the collection system and at the lift station; (6) minimize environmental and landscape impacts on the surrounding residential and commercial developments; and (7) avoid flooding of the lift station and the surrounding areas.

Wet-well

Wet-well design depends on the type of lift station configuration (submersible or dry-well) and the type of pump controls (constant or variable speed). Wet-wells are typically designed large enough to prevent rapid pump cycling but small enough to prevent a long detention time and associated odor release.

Wet-well maximum detention time in constant speed pumps is typically 20 to 30 minutes. Use of variable frequency drives for pump speed control allows wet-well detention time reduction to 5 to 15 minutes. The minimum recommended wet-well bottom slope is to 2:1 to allow self-cleaning and minimum deposit of debris. Effective volume of the wet-well may include sewer pipelines, especially when variable speed drives are used. Wet-wells should always hold some level of sewage to minimize odor release. Bar screens or grinders are often installed in or upstream of the wet-well to minimize pump clogging problems.

Wastewater Pumps

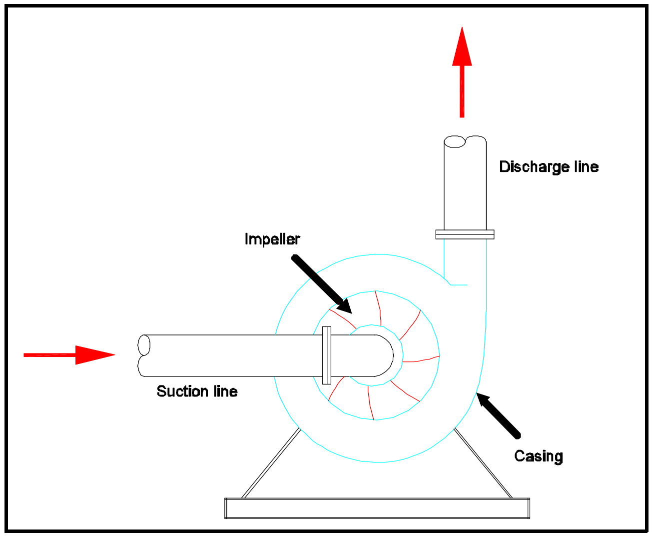
The number of wastewater pumps and associated capacity should be selected to provide head-capacity characteristics that correspond as nearly as possible to wastewater quantity fluctuations. This can be accomplished by preparing pump/pipeline system head-capacity curves showing all conditions of head (elevation of a free surface of water) and capacity under which the pumps will be required to operate.

The number of pumps to be installed in a lift station depends on the station capacity, the range of flow and the regulations. In small stations, with maximum inflows of less than 2,640 liters per minute (700 gallons per minute), two pumps are customarily installed, with each unit able to meet the maximum influent rate. For larger lift stations, the size and number of pumps should be selected so that the range of influent flow rates can be met without starting and stopping pumps too frequently and without excessive wet-well storage.

Depending on the system, the pumps are designed to run at a reduced rate. The pumps may also alternate to equalize wear and tear. Additional pumps may provide intermediate capacities better matched to typical daily flows. An alternative option is to provide flow flexibility with variable-speed pumps.

For pump stations with high head-losses, the single-pump flow approach is usually the most suitable. Parallel pumping is not as effective for such stations because two pumps operating together yield only slightly higher flows than one pump. If the peak flow is to be achieved with multiple pumps in parallel, the lift station must be equipped with at least three pumps: two duty pumps that together provide peak flow and one standby pump for emergency backup. Parallel peak pumping is typically used in large lift stations with relatively flat system head curves. Such curves allow multiple pumps to deliver substantially more flow than a single pump. The use of multiple pumps in parallel provides more flexibility.

Several types of centrifugal pumps are used in wastewater lift stations. In the straight-flow centrifugal pumps, wastewater does not change direction as it passes through the pumps and into the discharge pipe. These pumps are well suited for low-flow/high head conditions. In angle-flow pumps, wastewater enters the impeller axially and passes through the volute casing at 90 degrees to its original direction (Figure 3). This type of pump is appropriate for pumping against low or moderate heads. Mixed flow pumps are most viable for pumping large quantities of wastewater at low head. In these pumps, the outside diameter of the impeller is less than an ordinary centrifugal pump, increasing flow volume.



Source: Lindeburg, revised edition 1995.

FIGURE 3 CENTRIFUGAL ANGLE-FLOW PUMP

Ventilation

Ventilation and heating are required if the lift station includes an area routinely entered by personnel. Ventilation is particularly important to prevent the collection of toxic and/or explosive gases. According to the Nation Fire Protection Association (NFPA) Section 820, all continuous ventilation systems should be fitted with flow detection devices connected to alarm systems to indicate ventilation system failure. Dry-well ventilation codes typically require six continuous air changes per hour or 30 intermittent air changes per hour. Wet-wells typically require 12 continuous air changes per hour or 60 intermittent air changes per hour. Motor control center (MCC) rooms should have a ventilation system adequate to provide six air changes per hour and should be air conditioned to between 13 and 32 degrees Celsius (55 to 90 degrees F). If the control room is combined with an MCC room, the temperature should not exceed 30 degrees C or 85 degrees F. All other spaces should be designed for 12 air changes per hour. The minimum temperature should be 13 degrees C (55 degrees F) whenever chemicals are stored or used.

Odor Control

Odor control is frequently required for lift stations. A relatively simple and widely used odor control alternative is minimizing wet-well turbulence. More effective options include collection of odors generated at the lift station and treating them in scrubbers or biofilters or the addition of odor control chemicals to the sewer upstream of the lift station. Chemicals typically used for odor control include chlorine, hydrogen peroxide, metal salts (ferric chloride and ferrous sulfate) oxygen, air, and potassium permanganate. Chemicals should be closely monitored to avoid affecting downstream treatment processes, such as extended aeration.

Power Supply

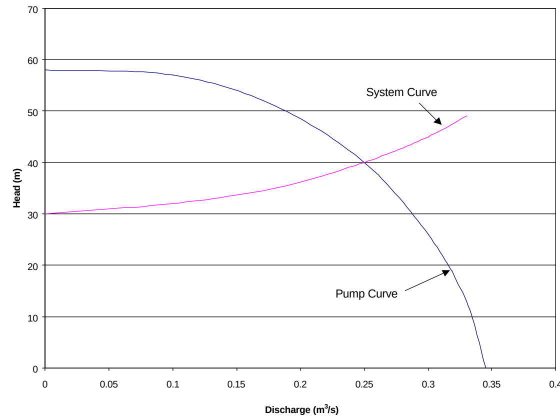
The reliability of power for the pump motor drives is a basic design consideration. Commonly used methods of emergency power supply include electric power feed from two independent power distribution lines; an on-site standby generator; an adequate portable generator with quick connection; a stand-by engine driven pump; ready access to a suitable portable pumping unit and appropriate connections; and availability of an adequate holding facility for wastewater storage upstream of the lift station.

PERFORMANCE

The overall performance of a lift station depends on the performance of the pumps. All pumps have four common performance characteristics: capacity, head, power, and overall efficiency. Capacity (flow rate) is the quantity of liquid pumped per unit of time, typically measured as gallons per minute (gpm) or million gallons per day (mgd). Head is the energy supplied to the wastewater per unit weight, typically expressed as feet of water. Power is the energy consumed by a pump per unit time, typically measured as kilowatt-hours. Overall efficiency is the ratio of useful hydraulic work performed to actual work input. Efficiency reflects the pump relative power losses and is usually measured as a percentage of applied power.

Pump performance curves (Figure 4) are used to define and compare the operating characteristics of a pump and to identify the best combination of performance characteristics under which a lift station pumping system will operate under typical conditions (flows and heads). Pump systems operate at 75 to 85 percent efficiency most of the time, while overall pump efficiency depends on the type of installed pumps, their control system, and the fluctuation of influent wastewater flow.

Performance optimization strategies focus on different ways to match pump operational characteristics with system flow and head requirements. They may include the following



Source: Adapted from Roberson and Crowe, 1993.

FIGURE 4 PUMP PERFORMANCE CURVE

options: adjusting system flow paths installing variable speed drives; using parallel pumps installing pumps of different sizes trimming a pump impeller; or putting a two-speed motor on one or more pumps in a lift station. Optimizing system performance may yield significant electrical energy savings.

OPERATION AND MAINTENANCE

Lift station operation is usually automated and does not require continuous on-site operator presence. However, frequent inspections are recommended to ensure normal functioning and to identify potential problems. Lift station inspection typically includes observation of pumps, motors and drives for unusual noise, vibration, heating and leakage, check of pump suction and discharge lines for valving arrangement and leakage, check of control panel switches for proper position, monitoring of discharge pump rates and pump speed, and monitoring of the pump suction and discharge pressure. Weekly inspections are typically conducted, although the frequency really depends on the size of the lift station.

If a lift station is equipped with grinder bar screens to remove coarse materials from the wastewater, these materials are collected in containers and disposed of to a sanitary landfill site as needed. If the lift station has a scrubber system for odor control, chemicals are supplied and replenished typically every three months. If chemicals are added for odor control ahead of the lift station, the chemical feed stations should be inspected weekly and chemicals replenished as needed.

The most labor-intensive task for lift stations is routine preventive maintenance. A well-planned maintenance program for lift station pumps prevents unnecessary equipment wear and downtime. Lift station operators must maintain an inventory of critical spare parts. The number of spare parts in the inventory depends on the critical needs of the unit, the rate at which the part normally fails, and the availability of the part. The operator should tabulate each pumping element in the system and its recommended spare parts. This information is typically available from the operation and maintenance manuals provided with the lift station.

COSTS

Lift station costs depend on many factors, including (1) wastewater quality, quantity, and projections; (2) zoning and land use planning of the area where the lift station will be located; (3) alternatives for standby power sources; (4) operation and maintenance needs and support; (5) soil properties and underground conditions; (6) required lift to the receiving (discharge) sewer line; (7) the severity of impact of accidental sewage spill upon the local area; and (8) the need for an odor control system. These site and system specific factors must be examined and incorporated in preparing a lift station cost estimate.

Construction Costs

The most important factors influencing cost are the design lift station capacity and the installed pump power. Another cost factor is the lift station complexity. Factors which classify a lift station as complex include two or more of the following: (1) extent of excavation; (2) congested site and/or restricted access; (3) rock excavation; (4) extensive dewatering requirements, such as cofferdams; (5) site conflicts, including modification or removal of existing facilities; (6) special foundations, including piling; (7) dual power supply and on-site switch stations and emergency power generator; and (8) high pumping heads (design heads in excess of 200 ft).

Mechanical, electrical, and control equipment delivered to a pumping station construction site typically account for 15 to 30 percent of total construction costs. Lift station construction has a significant economy-of-scale. Typically, if the capacity of a lift station is increased 100 percent, the construction cost would increase only 50 to 55 percent. An important consideration is that two identical lift stations will cost 25 to 30 percent more than a single station of the same combined capacity. Usually, complex lift stations cost two to three times more than more simple lift stations with no construction complications.

Table 1 provides examples of complex lift stations and associated construction costs in 1999 dollars.

TABLE 1 LIFT STATION CONSTRUCTION COSTS

Lift Station	Design Flowrate (MGD)	Construction Costs (1999 $US)
Cost curve data[1]	0.5	$134,467
Cost curve data[1]	1	$246,524
Cost curve data[1]	3	$392,197
Valencia, California[2]	6	$1,390,000
Sunneymead, California[2]	12	$3,320,000
Sunset/Heahfield, California[2]	14	$2,600,000
Springfield, Oregon Terry Street Pumping Station[2]	20	$5,470,000
Detroit, Michigan[2]	750	$128,800,000

Source: [1]Qasim, 1994 and [2] James M. Montgomery Consulting Engineers, 1998.

Operation and Maintenance Costs

Lift station operation and maintenance costs include power, labor, maintenance, and chemicals (if used for odor control). Usually, the costs for solids disposal are minimal, but are included if the lift station is equipped with bar screens to remove coarse materials from the wastewater. Typically, power costs account for 85 to 95 percent of the total operation and maintenance costs and are directly proportional to the unit cost of power and the actual power used by the lift station pumps. Labor costs average 1 to 2 percent of total costs. Annual maintenance costs vary, depending on the complexity of the equipment and instrumentation.

REFERENCES

Other Related Fact Sheets

Small Diameter Gravity Sewer
EPA 832-F-00-038
September 2000

In-Plant Pump Stations
EPA 832-F-00-069
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ADDITIONAL INFORMATION

Luis Aguiar
Assistant-Director
Miami-Dade Water and Sewer Department
4200 Salzedo Street
Coral Gables, FL 33146

Eileen M. White
East Bay Municipal Utility District
P.O. Box 24055
Oakland, CA 94523

Richard R. Roll
City of Niagara Falls
Department of Wastewater Facilities
P.O. Box 69
Niagara Falls, NY 14302

Gary N. Oradat
City of Houston DPW & Engineering
Utility Maintenance Division
306 McGowen Street
Houston, TX 77006

David Jurgens
City of Fayetteville
113 West Mountain Street
Fayetteville, AR 72701

Bruno Conegliano
Water & Wastewater Utility
City of Austin, P.O. Box 1088
Austin, TX 78767

For more information contact:

Municipal Technology Branch
U.S. EPA
Mail Code 4204
1200 Pennsylvania Avenue, NW
Washington, D.C. 20460

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