Minimize Your Footprint and Maintenance Headaches With Self-Cleaning Trench-Type Wet Well Design

Tarlton W. "Trooper" Smith II

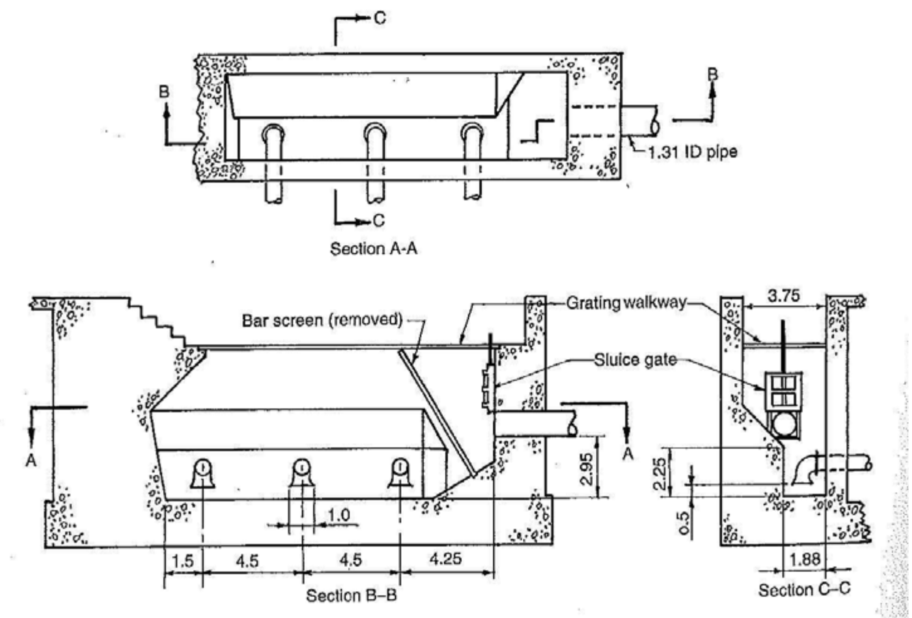

Figure 1. Illustrative View of Kirkland Pump Station

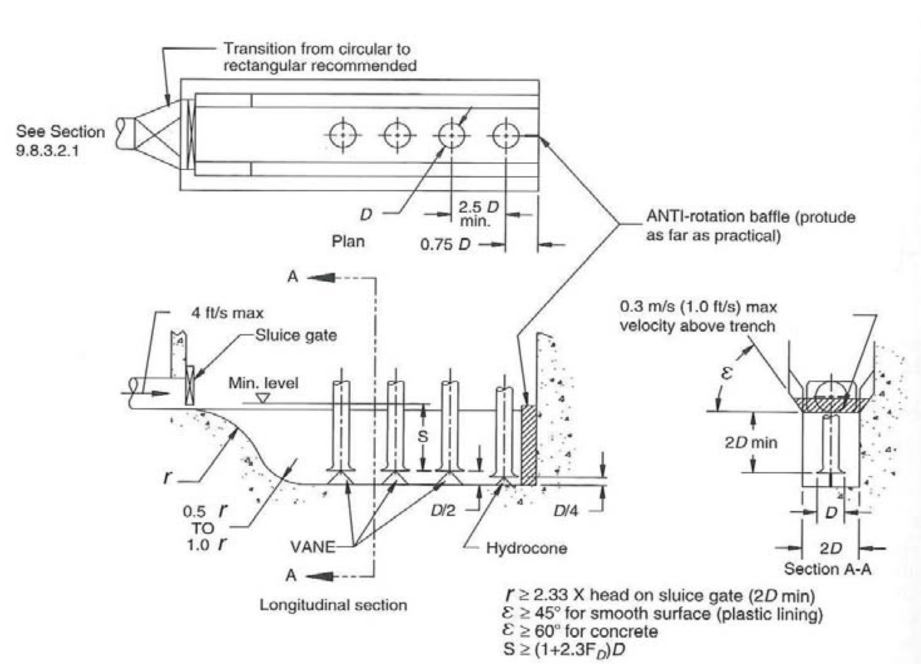

Figure 2. ANSI/HI 9.8 Pump Intake Design (1998)

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Trench-Type Wet Wells

History

Trench-type wet wells were invented by D.H. Caldwell in 1964. Subsequently, 27 wet wells of this configuration were constructed for Seattle Metro (present-day King County Department of Environmental Services) based on the prototypical Kirkland Pump Station (Figure 1). The Seattle Metro and Kirkland pump stations were observed to be more efficient compared to other station designs of the era, especially in regard to storage requirements and dewatering processes.

The original designs were further improved by Dr. Robert Sanks, Ph.D., in the early 1990s, when he discovered that flow during pump down was much too slow (0.9 ft per second [ft/s] on average) for complete cleaning. As a result, the cleaning process only removed the majority of the recently deposited sludge layer and left a hardened 2-in. sludge layer. Dr. Sanks began to test the effect of fluid velocity on the rate of grit movement with river sand to find the minimum velocity for effective sludge removal. He discovered that a minimum velocity of 5 ft/s was required to move sand at a practical rate. In addition, a 1:3.3 scale model of the Kirkland Pump Station demonstrated that, at its current flow rate, only a fraction of the sand was ejected at pump down equilibrium. Sanks, Jones, and Sweeney added a curved ramp from the inlet pipe invert to the trench floor, adjusted the last pump to a lower floor clearance at a quarter of its diameter, and inserted a baffle between the last pump and the wall. A

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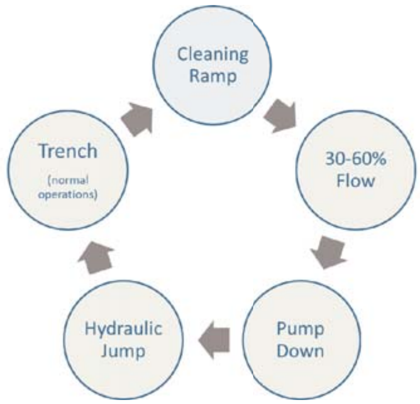

Figure 3. Self-Cleaning Phases of a Trench-Type Wet Well

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resulting high velocity produced a hydraulic jump that homogenized the sludge, which increased cleaning efficiency to 45 to 100 times the efficiency of the Kirkland model (Figure 1); however, even with the improvements, trench-type wet wells did not gain popularity until they were included in the second edition of *Pumping Station Design* and the ANSI/HI 9.8 Standard, Pump Intake Design, in 1998 (Figure 2). Since that time, a third edition of *Pumping Station Design* was released in 2008 and a new ANSI/HI 9.8 Standard was released in 2018.

Application

Trench-type wet wells have been found to be suitable for various design parameters, as shown in the case studies that follow. Wet pit and dry pit/wet pit with vertical turbine solids handling (VTSH), and submersible and/or nonclog centrifugal pumps are compatible with trench-type wet wells. They can also be applied to potable water, activated sludge, and raw wastewater operations. Potential problems could arise due to minimal storage capacity, increased depth, and clogging issues without the use of pumps; however, these wells are exceptional in creating a superb hydraulic environment for pump intakes, minimizing footprint size and floor area (reducing sludge accumulation), and reducing maintenance costs.

Self-Cleaning Operation

The self-cleaning cycle occurs at pump down (Figure 3). The cleaning system employs an upstream isolation gate (in most designs), which reduces influent flow. An ogee ramp, which causes water to cascade and create enough sweeping across the wet well bottom to keep any material suspended, provides a hydraulic jump that assists in moving massed sludge and scum to the pump farthest from the influent side. As the water level decreases, the far pump runs at full speed, increasing the scouring velocity and forcefully ejecting the solids.

Case Studies

Trinity River Authority Plant

Design and construction of a self-cleaning, trench-type wet well at the Central Regional Wastewater System Treatment Plant of the Trinity River Authority (TRA) reduced its initial investment, reduced environmental impact, and, through its self-cleaning features, achieved significant operational efficiencies and long-term savings in maintenance costs. The TRA anticipated increased return activated sludge (RAS) flows at the plant, and a feasibility report recommended a horizontal, nonclog centrifugal pump station (wet pit/dry pit) for the site (Figure 4).

Analysis of the proposed site in the preliminary design phase indicated a variety of conflicts between the recommended pump station and surrounding structures, pipelines, and utilities. The design team studied alternatives and determined that the horizontal configurations required resolution of the significant conflicts.

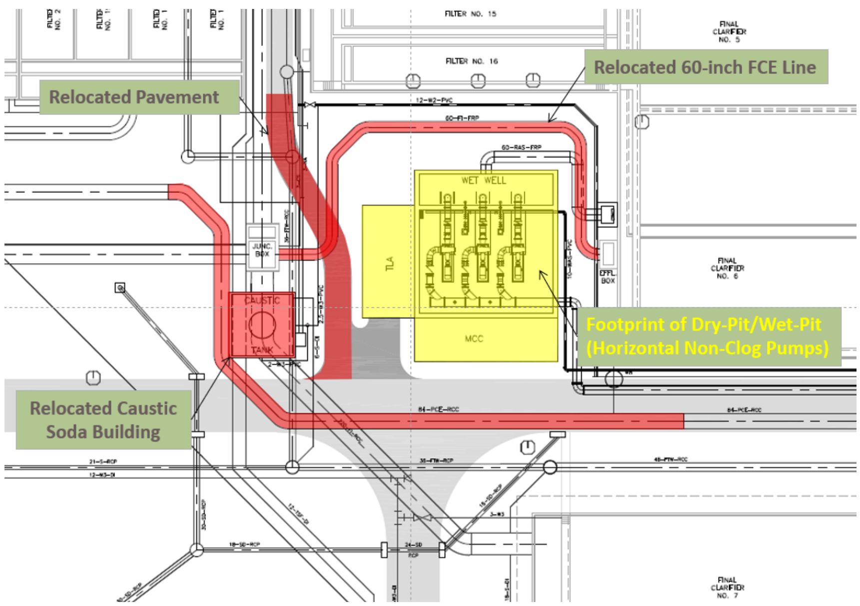

Figure 4. Footprint of a Horizontal Nonclog Pump Centrifugal Pump Station (Wet Pit/Dry Pit)

Pump Station Type	Length/Width	Depth	Capital Cost, Three Pumping Units	Opinion of Probable Construction Cost
Horizontal Nonclog Centrifugal Pump Station (Wet Pit/Dry Pit)	67'/65'	26'	$915,000	$10.9 Million
Vertical Nonclog Centrifugal Pump Station (Wet Pit/Dry Pit)	59'/54'	35'	$945,000	$11.4 Million
VTSH Pump Station (Wet Pit)	49'/43'	29'	$1,718,000	$9.5 Million
VTSH Trench Type Wet Well	57'/18'	38'	$1,718,000	$8.5 Million

Figure 5. Pump Station Design Options

Opinions of probable construction costs were as high as $11.4 million. A wet pit configuration yielded probable construction costs of $9.5 million, but the design team saw an opportunity to reduce costs further, and after research, recommended a trench-type wet well design, which was bid and awarded for construction for $8.5 million (Figure 5).

Complexity of the Project

The complexity of this project was in fitting a 50-mil-gal-per-day (mgd) RAS pump station into a site shared by the following:

- 84-in. primary clarifier effluent pipe
- 60-in. final clarifier effluent pipe
- Caustic soda storage facility
- 2- to 12-in. utility pipes, including nonpotable water, drain pipes, etc.
- Electrical duct banks
- 12-ft-wide concrete roadway

The team performed a site analysis and examined three pump station arrangements to determine their overall footprints. The wet pit yielded a smaller footprint and lower probable construction costs (Figure 6). The design team then investigated a trench-type well design, which required only an 18-ft internal width for the structure.

While VTSH pumps are used primarily for raw wastewater applications, the team researched its use of a RAS application and found that the trench-type wet well would be a suitable environment for the pumps (Figure 7).

Developing the Specifications

The team used two modeling programs, UnifCrit 2.2 and Trench 2.0 (both available from Montana State University), to calculate the parameters used in developing specifications. The team designed the ogee ramp and flow splitter to lower frictional losses and conserve energy, maximizing the hydraulic jump for more mixing of settled solids in the incoming RAS flows. The flow splitter extends from the wet well entrance to beyond the second of three pumps to minimize flow vortices developed during the cleaning cycle. This design provided high velocity to the influent RAS, thereby conserving energy and creating a powerful hydraulic jump. Specifications called for 316 stainless steel for the flow splitter.

The design team also created a hydrocone and vane for the third pump in the trench to eliminate surface vortices usually carried to the last pump (Figure 8).

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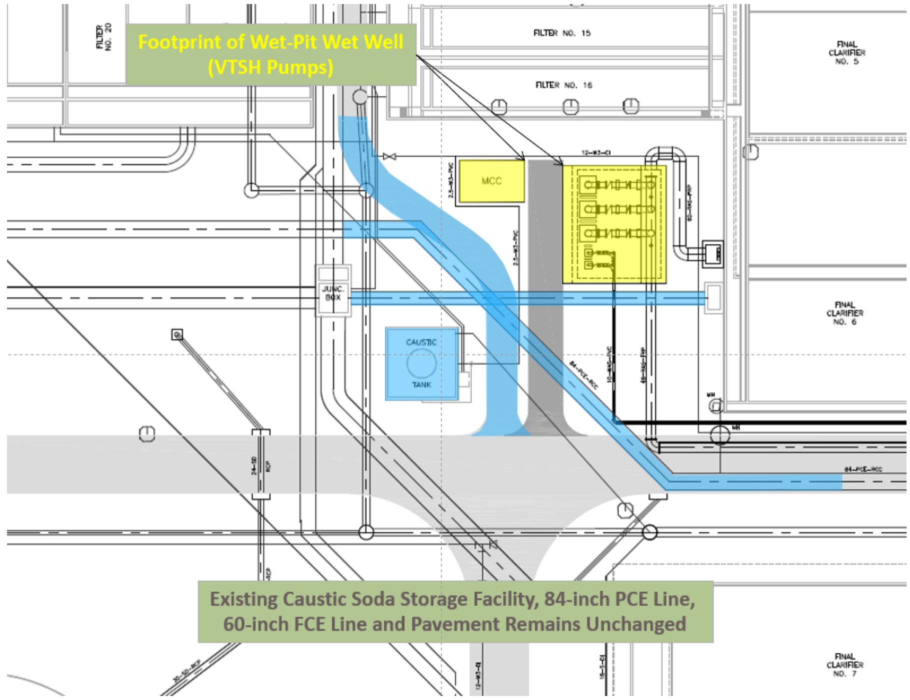

Figure 6. Footprint of a Vertical Turbine Solids Handling Pump Station (Wet Pit)

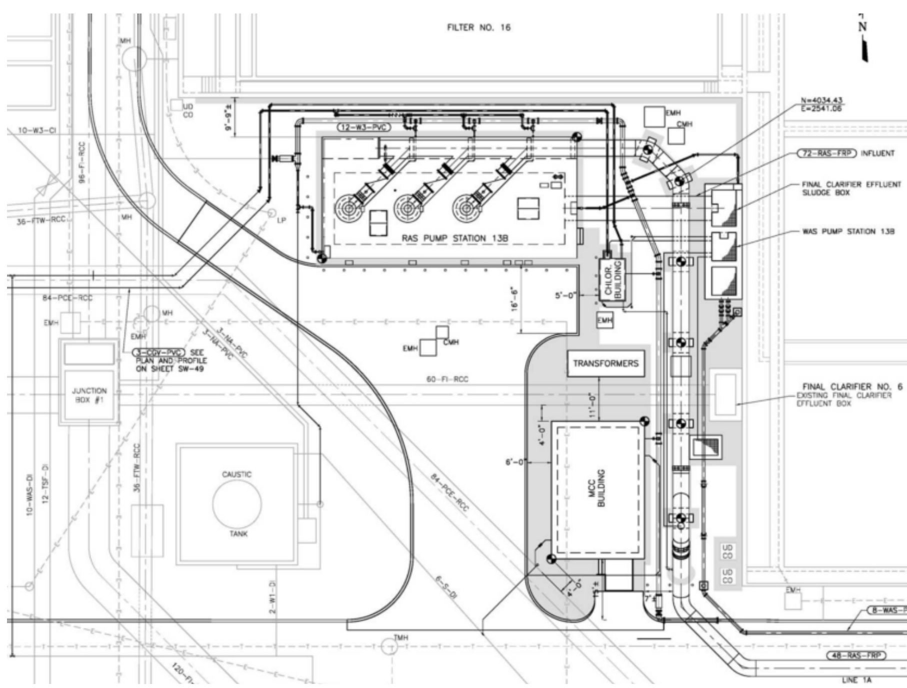

Figure 7. Footprint of a Vertical Turbine Solids Handling Trench-Type Wet Well (Wet Pit)

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Two antirotational baffle plates—one attached to the wall and the other attached to the pump—resist circulation of RAS behind the last pump.

Exceeding Client Needs

The original opinion of probable construction costs, as recommended by the previous feasibility study, was $11.4 million for the vertical nonclog centrifugal pump station; however, with the application of the trench-type wet well, this construction cost was decreased to $8.5 million, with a savings of $2.9 million. This saved the client more than the consultant's fee, which totaled $1.6 million.

Future Value to the Engineering Profession

This project has introduced many wastewater plant designers to a concept that can reduce construction costs for constricted sites and will continue to yield savings through its self-cleaning features. The design helped TRA avoid costly relocation of pipelines and structures, including concomitant permitting requirements and materials-disposal activities.

Many plants across Florida face similar challenges. Presentations by the design team have familiarized other members of the profession with the concepts introduced here, and there are other such pump stations in design now, including a pump station at a nearby plant owned by the City of Dallas. The savings to TRA exceeded the engineering fee for this project, exemplifying the value of good engineering design.

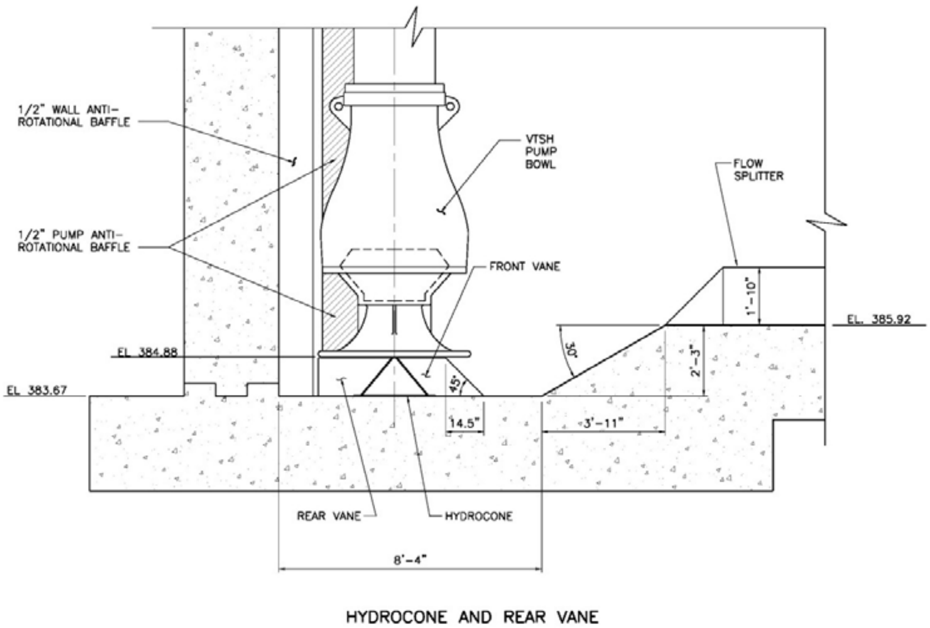

Figure 8. Hydrocone and Rear Vane Design in Pump Station 13B

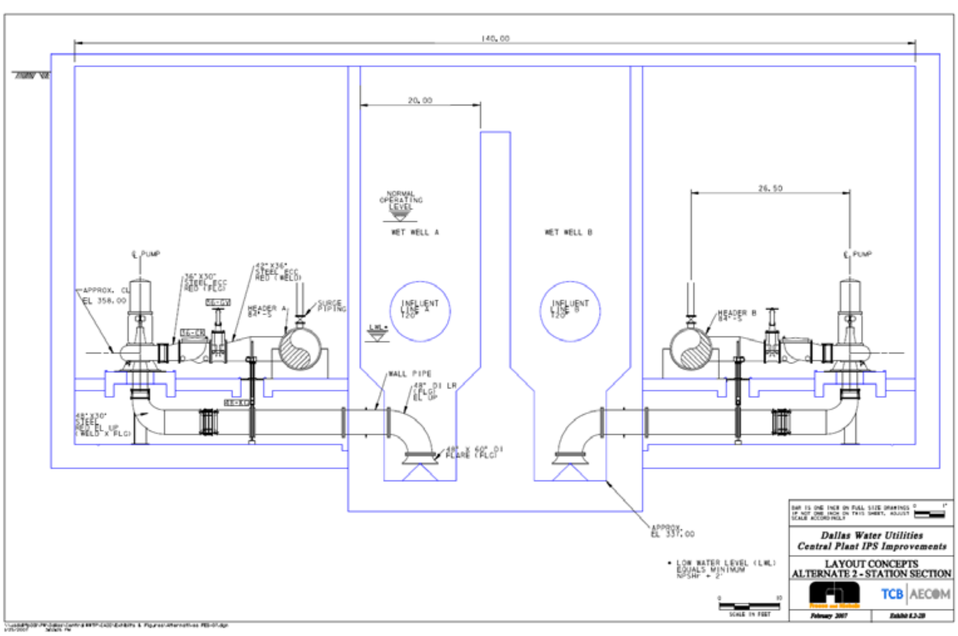

Figure 9. Layout for a Trench-Type Wet Well Dry Pit/Wet Pit Pump Station

Dallas Water Utilities Central Wastewater Treatment Plant

Trench-type wet wells were also utilized in the expansion of an existing 335-mgd wastewater treatment plant to a 425-mgd system in Dallas (Figure 9). The project involved the construction on an influent pump station, with the sewage coming from an upstream coarse screen. The pump station included six pumps (two at 1000 horsepower [HP] and four at 800 HP), with 42-in. diameter columns and 62-ft shafts, with a total of up to 20 to 80 mgd per pump. The preliminary design of a trench-type dry pump pit was considered, but the footprint savings of the trench-type VTSH pump station (Figure 10) proved to be far superior.

City of Midlothian Water Treatment Plant

Trench-type wet wells are also very effective in potable water treatment applications. To illustrate, the City of Midlothian utilized the trench-type wet well in the construction of a new water treatment plant (Figure 11). With a firm capacity of 9 mgd with three pumps, and an ultimate capacity for 18 mgd with five pumps, the city was able to expand its water system with minimum costs and footprint.

Fort Worth Lake Arlington Lift Station

Although yet to be constructed, a lift station for raw sewage will be utilizing a trench-type wet well in the expansion of Lake Arlington's collection system, which is in Fort

Worth, Texas. Portions of the existing wastewater collection system serving the Village Creek Wastewater Basin are at capacity, with some areas experiencing wet weather overflows. Increased conveyance capacity is necessary to handle projected growth within the basin, which also includes the wholesale customer cities of Burleson and Crowley, also in Texas. With the installation of a trench-type wet well and the use of variable frequency drives (VFDs), there is a reduction in the size of the site and maintenance costs, and an overall increase in efficiency is in the range of required flows. The lift station will have the ability to add peak-shaving storage and a parallel structure to increase capacity from 44 to 80 mgd in the future. Construction commenced in November 2019 and is scheduled to be completed by March 2022.

Optimal Conditions for Application

Trench-type wet wells are optimal for projects with limited space, solids or grit problems, or maintenance issues. Before considering this design, it's recommended to perform a cost-benefit analysis and a life cycle analysis, as well as reference and site visits to ease client and engineer concerns.

In the TRA and Dallas Water Utilities plants, the clients were unfamiliar with the equipment and uneasy about the lack of comparable size installations in their areas. The project engineers provided an extended warranty, witness performance testing, first-year contracted maintenance vibration monitoring, and a pump seminar to inform their clients of the design considerations.

While this new design was a risk for the client, the biggest driver tipping the risk-versus-benefit scale was the significant capital cost savings (up to $16 million for Dallas Water Utilities).

References

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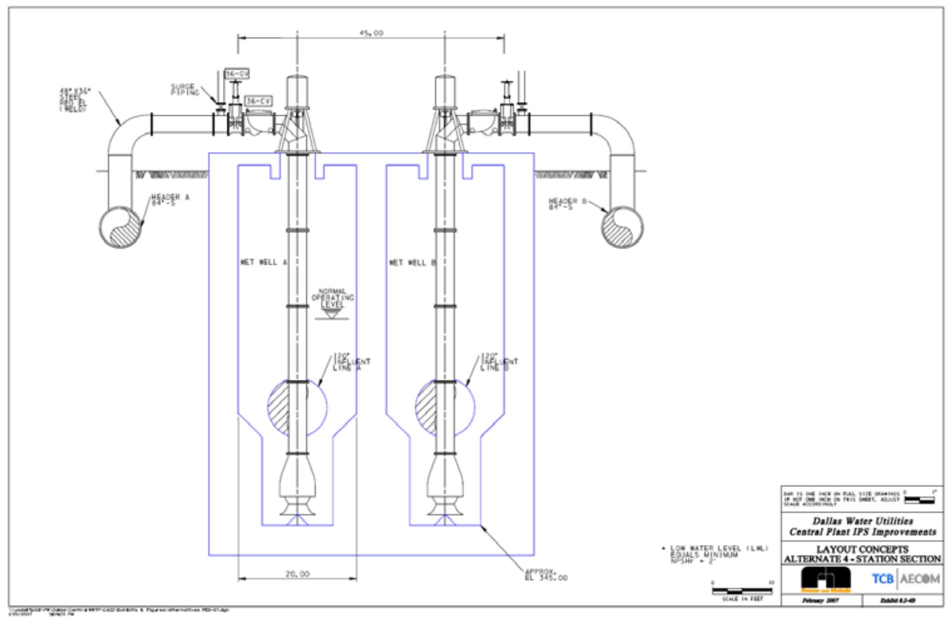

Figure 10. Layout for a Trench-Type Wet Well Vertical Turbine Solids Handling Pump Wet Pit Pump Station

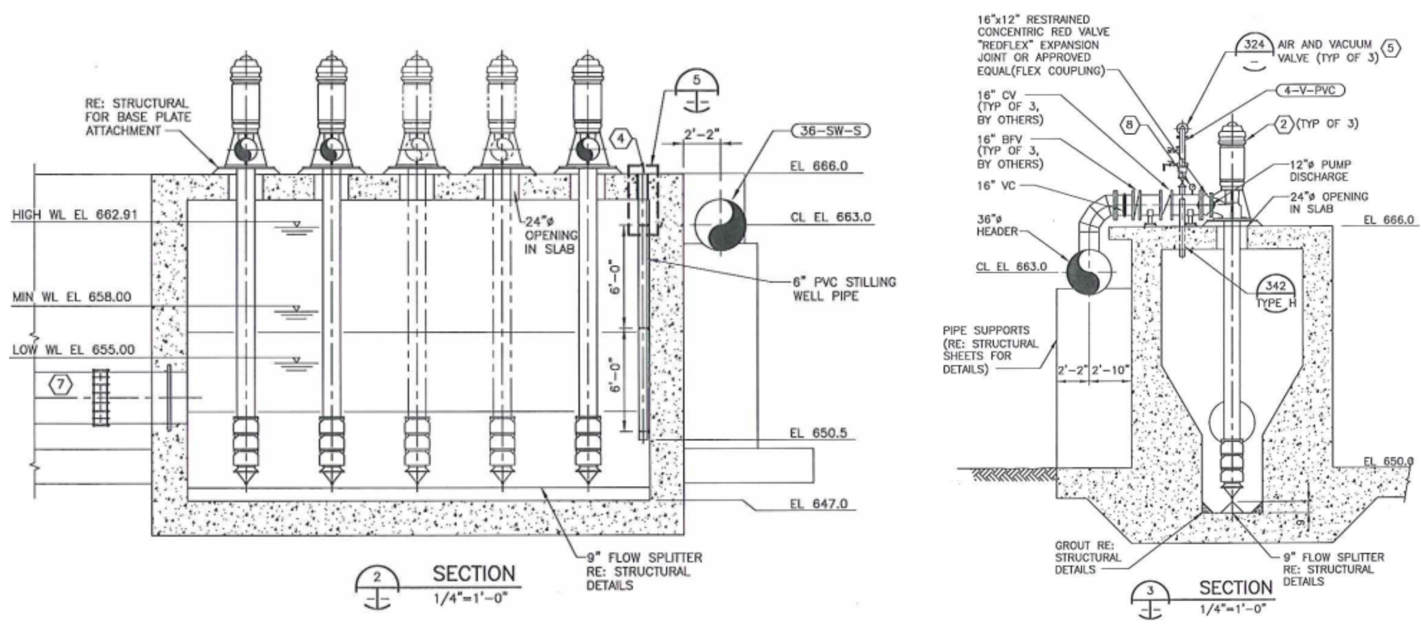

Figure 11. Section Views of Midlothian Water Treatment Plant Trench-Type Wet Well Pump Station