ONE DESIGN ENGINEER’S FAVORITE WASTEWATER PUMP STATION DESIGN FEATURES

(And Some Things To Avoid)

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THIS PRESENTATION

• Introduction
• Evolution of pump station design
• Number of pumps
• Backup/standby/reliability facilities
• Design details
• Future trends
• Case histories/Horror stories

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THE SPEAKER’S PERSPECTIVE

- Independent consulting sanitary engineer
- Smaller pump stations
- Wastewater rather than clean water
- United States versus third world
NEVER BUT NEVER QUESTION IT

ENGINEER'S

JUDGEMENT
TYPES OF PUMP STATIONS
EVOLUTION DUE TO CHANGES IN TECHNOLOGY

• Non clog pumps
• Submersible motors
• Variable frequency drives (VFDs)
• Magnetic flow meters
• Plastic liners
EVOLUTION DUE TO CHANGES IN REGULATIONS

• Confined space
• Fall restraint and arrest
• Environmental exposure
• Arc flash
WASTEWATER PUMP STATION CONFIGURATIONS

- Dry pit/wet pit.  Forever.
- Pneumatic ejectors.  1950s.
- Underground pump stations. (Smith & Loveless).  1960s.
- Suction lift pump stations. (Gorman Rupp).  1980s.
- Submersible pump stations.  1980s.
- Dry pit submersible pumps
- Small grinder pumps and small pressure sewers
DRY PIT PUMP STATION
PUMPS IN SERIES WITH A SINGLE BELT DRIVE

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POSSUM FAT?
BAD WINE??

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SAN BRUNO OLYMPIC PUMP STATION
SAN BRUNO OLYMPIC VERTICAL SHAFT PUMP STATION

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SAN BRUNO CRESTMOOR SUCTION LIFT PUMP STATION

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Underground Pump Stations
Gavilan College Pump Station
SUBMERSIBLE PUMP STATION AT A CHEESE FACTORY, SONOMA, CA

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PLAN OF SUBMERSIBLE PUMP STATION
SECTION THROUGH SUBMERSIBLE PUMP STATION
SMALL SUBMERSIBLE STATION
SMALL SUBMERSIBLE STATION
SMALL GRINDER PUMP STATION

SMALL GRINDER PUMP STATION
WITH SMALL DIAMETER FORCE MAIN
REHABS

• Many possibilities
• Dry pit submersibles in existing dry pits
• Wet well in a wet well
• Pumps in a septic tank
• Additional pumps in the wet well of a dry pit pump station
SUBMERSIBLE PUMP STATION

ADVANTAGES

• Pumping equipment not accessible to unauthorized persons
• Pump can be easily withdrawn for maintenance
• Wet well rarely has to be entered
• Minimal confined space problems
• No superstructure
• No noise
• Lower cost

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SUBMERSIBLE PUMP STATIONS

DISADVANTAGES

• Danger of falling into the wet well

• Motor requires specialized maintenance

• Electrical equipment is above ground
  • (But you can have a building)

• Requires a separate valve box
BACKUP/STANDBY RELIABILITY FACILITIES

• What are the likely causes of failure?

• What do you need?

• What do you have?
GENERATORS

• Only serve to replace utility power.

• Cannot help if electrical system is burned out.

• Do allow controls to be used.

• Provide lighting and use of electrical tools.
STATIONARY GENERATORS

• Time To Spill, Hours
• Design Decision
• <= 1
  • Probably ought to have a stationary generator, unless a spill will do little harm.
• 1 to 4
  • Case by case basis.
• >= 4
  • Probably can back the station up by other means.

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STATIONARY GENERATOR, SECLINE PUMP STATION, NORTH LAKE TAHOE

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STATIONARY GENERATORS (Cont.)

• Considerable maintenance.

• Need to be exercised. 30 minutes/month +/-.

• Noisy. (But exercise time can be selected).

• $50,000 to $100,000 in small sizes. (<= 100 KW).

• Diesel versus natural gas.
MOBILE GENERATORS

• Time to deploy.
• Traffic delays.
• Manual control, must be attended.
• Same limitations as stationary generators -- only electrical.

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MOBIL GENERATOR AND QUICK CONNECT, NORTH LAKE TAHOE
MOBILE GENERATORS (Cont).

• Manual transfer switch
• The receptacle problem
• Multiple voltages. 110, 208?, 220, 440.
• Limited size. Rarely have a really big one.
MOBILE PUMPS

• Don't need the electrical facilities.

• Time to deploy.

• Traffic delays.

• Manual control, must be attended.

• Need access to the force main.
OTHER BACKUP METHODS

• Alternative power feeder
• Engine driven pumps
• Storage
• Gravity overflow/diversion
• Spare pumps
• Trucks
• Small generators. Welders.
STORAGE

- Placer County Standards allow storage in lieu of a generator

- Can be a large horizontal pipe

- There can be a large amount of "horizontal storage" in flat country

- Large tankage usually is prohibitively expensive. $2/gallon.

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GRAVITY OVERFLOW

• Overflow to a different sewer system before spilling
• May silt up if used for a long time
• Usually feasible only in flat country
ARVIN, CA.  GRAVITY OVERFLOW?

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TRUCKS

• Vactor trucks. Can load themselves.
• Tanker trucks. Need separate pumps.
• Septic service trucks.
OUTSIDE HELP

- Mutual aid from other agencies or other parts of your organization
- Equipment rental companies
- Purchases of equipment
- Local contractors
- Septic service companies

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STANDBY STRATEGY

• Which backup equipment can back up which pump stations?

• If power fails to all pump stations (the earthquake scenario), where should the available standby facilities be deployed?

• The Standby Alternatives matrix
### AVAILABLE STANDBY EQUIPMENT

#### TABLE 4-1

**LIST OF STANDBY EQUIPMENT**

<table>
<thead>
<tr>
<th>Alternative</th>
<th>GPM</th>
<th>Head, Feet</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deutz Mobile Pump</td>
<td>600</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td>Lister Mobile Pump</td>
<td>300</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Deutz and Lister Pumps</td>
<td>900</td>
<td>75</td>
<td>Both pumps together.</td>
</tr>
<tr>
<td>Electric Driven Mobile Pump</td>
<td>600</td>
<td>35</td>
<td>Requires electric power.</td>
</tr>
<tr>
<td>Teel 5 HP Trash Pump</td>
<td>200</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Edison Diaphragm Pump</td>
<td>30</td>
<td>High</td>
<td>3 HP Briggs &amp; Stratton engine.</td>
</tr>
<tr>
<td>Wilden Diaphragm Pump, Air Driven</td>
<td>20</td>
<td>High</td>
<td>Requires the 10 HP air compressor.</td>
</tr>
<tr>
<td>Ebarra Electric (3 Pumps)</td>
<td>21</td>
<td>24</td>
<td>Require electric power.</td>
</tr>
<tr>
<td>Rented Pumps</td>
<td>Any</td>
<td>Any</td>
<td>May take some time to rent.</td>
</tr>
<tr>
<td>Stationary Generator</td>
<td>50</td>
<td>KW</td>
<td>Only available at the Merced Pump Sta.</td>
</tr>
<tr>
<td>Mobile 60 KW Generator</td>
<td></td>
<td></td>
<td>Needs voltage selector switch.</td>
</tr>
<tr>
<td>Electric Arc Welder</td>
<td></td>
<td></td>
<td>Only adequate for the Sylvan Circle Pump Sta.</td>
</tr>
<tr>
<td>Rented Generators</td>
<td></td>
<td></td>
<td>May take some time to rent and may be in short supply during an areawide power failure.</td>
</tr>
<tr>
<td>City Vactor Trucks (2)</td>
<td></td>
<td></td>
<td>May not be available to the WPCP during an areawide emergency. Probably available for local failures.</td>
</tr>
<tr>
<td>Approx. 65 GPM average flow</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rented Vactor Trucks (Roto-Rooter)</td>
<td></td>
<td></td>
<td>Main office is in San Leandro. Three vactor trucks available. One hour maximum response time.</td>
</tr>
</tbody>
</table>

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## TABLE 4-2

### STANDBY ALTERNATIVES FOR EACH PUMP STATION

<table>
<thead>
<tr>
<th>Standby Unit</th>
<th>Major Pump Stations</th>
<th>Minor Pump Stations</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bermuda</td>
<td>Merced</td>
</tr>
<tr>
<td></td>
<td>Peak Flow</td>
<td>Average Flow</td>
</tr>
<tr>
<td>Deutz Mobile Pump</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Lister Mobile Pump</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Deutz and Lister Pumps</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Electric Mobile Pump (+ Gen)</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Teel Trash Pump</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Edison Diaphragm Pump</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Wilden Diaphragm w Air Comp.</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Ebarra Elec. Submers. (+Gen)</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Rented Engine Driven Pumps</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Stationary Generators</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>60 KW Mobile Generator</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Electric Arc Welder</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Rented Generators</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>City Vactor Trucks</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Private Vactor Trucks (Roto-Rooter)</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

### Alternatives for Widespread Pump Station Failures

- Deutz Mobile Pump
- Lister Mobile Pump
- Deutz and Lister Pumps
- Electric Mobile Pump (+ Gen)
- Teel Trash Pump
- Edison Diaphragm Pump
- Wilden Diaphragm w Air Comp.
- Ebarra Elec. Submers. (+Gen)
- Rented Engine Driven Pumps
- Stationary Generators
- 60 KW Mobile Generator
- Electric Arc Welder
- Rented Generators
- City Vactor Trucks
- Private Vactor Trucks (Roto-Rooter)

### Additional Alternatives for Local Pump Station Failures

- City Spare Pumps
- Rented Spare Pumps
- Gravity Bypass

An "X" in a column means that this unit can provide standby support for this pump station. Bolded and underlined cells are the recommended standby alternatives in a total power failure. See Table 5-1.
# DEPLOYMENT PLAN

**TABLE 5-1**

**STANDBY EQUIPMENT DEPLOYMENT PLAN**

**FOR A CITY-WIDE POWER OUTAGE**

<table>
<thead>
<tr>
<th>Pump Station</th>
<th>Standby Resource to be Deployed</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MAJOR PUMP STATIONS</strong></td>
<td></td>
</tr>
<tr>
<td>Bermuda</td>
<td>Deutz pump.</td>
</tr>
<tr>
<td>Merced</td>
<td>On-site stationary generator.</td>
</tr>
<tr>
<td>Neptune</td>
<td>60 KW mobile generator.</td>
</tr>
<tr>
<td>Wicks Extension</td>
<td>Gravity bypass. (To be installed). Or: Lister pump.</td>
</tr>
<tr>
<td><strong>MINOR PUMP STATIONS</strong></td>
<td></td>
</tr>
<tr>
<td>Benedict</td>
<td>Connected to hospital standby power system.</td>
</tr>
<tr>
<td>Blue Dolphin</td>
<td>Gravity bypass.</td>
</tr>
<tr>
<td>Catalina</td>
<td>Wilden diaphragm pump.</td>
</tr>
<tr>
<td>San Rafael</td>
<td>Teel trash pump.</td>
</tr>
<tr>
<td>Sylvan Circle</td>
<td>48 hour storage. Electric arc welder for power. Probably easier to use the vactor truck.</td>
</tr>
<tr>
<td>Teagarden</td>
<td>Edison diaphragm pump.</td>
</tr>
<tr>
<td><strong>UNASSIGNED STANDBY RESOURCES</strong></td>
<td></td>
</tr>
<tr>
<td>Lister pump.</td>
<td>(If not needed at Wicks Extension).</td>
</tr>
<tr>
<td>First City vactor truck.</td>
<td></td>
</tr>
<tr>
<td>Second City vactor truck.</td>
<td></td>
</tr>
<tr>
<td>Electric driven mobile pump.</td>
<td>(Requires a generator).</td>
</tr>
<tr>
<td>Ebarra electric submersibles.</td>
<td>(Require generators).</td>
</tr>
<tr>
<td>Rented pumps.</td>
<td></td>
</tr>
<tr>
<td>Rented generators.</td>
<td></td>
</tr>
<tr>
<td>Rented vactor trucks.</td>
<td>(One hour maximum response time).</td>
</tr>
</tbody>
</table>

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DESIRABLE FEATURES -- 1

• Plastic lined wet wells (PVC or HDPE)
• Access to the force main. (With splitters?)
• Float backup for the analog level sensing system
• Manual override pump control. HOA switch.
FORCE MAIN QUICK CONNECT
• Variable frequency drives (VFDs)
• Bypass starters on VFDs
• 480, 3 phase electrical power
• Junction and transition electrical box near the wet well
• Everything above flood level
• Drainage back to the wet well (?). Increasingly required. The great leap backwards.
JUNCTION AND TRANSITION BOX NEAR WET WELL, SECLINE PUMP STA.
DESIRABLE FEATURES -- 3

• Pressure gauges, pointed upward.
• Wiggle room in the piping
• Air release valves
• Eccentric plug valves, plug on top when open
• Safety grate on hatch of wet well
• Magnetic flow meter
PRESSURE GAUGE, VICTAULIC, ARV, HORIZONTAL PLUG VALVE
MAGNETIC FLOW METER, SECLINE
PUMP STATION, NORTH LAKE TAHOE
DESIRABLE FEATURES -- 4

• Restrained joints. No thrust blocks
• Surge valve.
• Valves outside the wet well
• No check valve in vertical piping
DESIRABLE FEATURES -- 5

• P-trap rather than a flap gate on the valve vault drain
• Odor control port
• Soil bed scrubber
• SCADA (Supervisory Control And Data Acquisition) (As a minimum, remote alarms)
GOOD AND BAD

SUBMERSIBLE PUMP STATION
ODOR CONTROL PORT, SECLINE PUMP STATION, NORTH LAKE TAHOE
CARBON CANISTER ODOR SCRUBBER, SECLINE PUMP STATION
THE FUTURE???

• Crystal ball
• Ouija board
• Cast bones with Queequeg
FUTURE TRENDS IN PUMP STATION DESIGN--1

• Larger fines for spills. More emphasis on reliability.

• Mostly submersible type

• More use of dry pit submersible pumps for existing dry pit pump stations so pumps and motors are not destroyed by flooding.

• More pumps for more redundancy

• Dual force mains
FUTURE TRENDS IN PUMP STATION DESIGN -- 2

• More backup
• Flow meters
• Safety grates on wet wells
• Arc flash electrical equipment
• More SCADA
NUMBER OF PUMPS

• Capacity is with one of the largest pumps out of service.
• (For wastewater. Maybe not for potable water or stormwater).
• Maximum turndown with a VFD is around 50%
• On/off can affect treatment
• On/off can flood small sewers
NUMBER OF PUMPS FOR SMALLER PUMP STATIONS

- "Small" = 500 GPM, 5 - 10 HP
- On/off operation
- Two pumps
- Each 100% of peak flow
NUMBER OF PUMPS FOR LARGER PUMP STATIONS

• You want to handle average flow plus a little with a single pump

• Three or four typical

• More for very large flows and/or extreme peaking factors

• Different sized pumps for large peaking factors
NUMBER OF PUMPS TABLE

<table>
<thead>
<tr>
<th>No. of Pumps</th>
<th>% of Peak Flow</th>
<th>Peaking Factor</th>
<th>Average Flow As % Of Peak Flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>No Spare</td>
<td>1</td>
<td>100</td>
</tr>
<tr>
<td>2</td>
<td>100</td>
<td>2</td>
<td>50</td>
</tr>
<tr>
<td>3</td>
<td>50</td>
<td>3</td>
<td>33</td>
</tr>
<tr>
<td>4</td>
<td>33</td>
<td>4</td>
<td>25</td>
</tr>
<tr>
<td>5</td>
<td>25</td>
<td>5</td>
<td>20</td>
</tr>
<tr>
<td>6</td>
<td>20</td>
<td>6</td>
<td>16</td>
</tr>
</tbody>
</table>
CASE HISTORY

- Large pump station with two generators
- One generator new and tested
- Four pumps
- Spill of 175,000 gallons into Lake Tahoe
- How could this happen?
- Common point of failure
- Three 10 amp fuel pumps on a single 20 amp circuit