STANDBY GENERATOR EVALUATION

Prepared for the City of Roseburg

Revision 1

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City of Roseburg

Standby Generator Evaluation

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Prepared by RH2 Engineering, Inc.

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Note: This evaluation was completed under the direct supervision of the following Licensed Professional Engineers registered in the State of Oregon.

Sincerely,

RH2 ENGINEERING, INC.

Signed: 1/17/2020

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Introduction

The City of Roseburg (City) has several critical facilities that currently do not have permanent standby power installed that would provide power in the event of an outage. Maintaining power to each of these facilities is critical to both provide water for the City and maintain supervisory control and data acquisition (SCADA) communications throughout the City's radio network. The City wishes to maintain the operation and integrity of its water system during times of natural disaster and inclement weather. RH2 Engineering, Inc., (RH2) has conducted site visits to document the existing facilities and prepare recommendations for the installation of standby generator systems at each facility. The facilities evaluated in this report consist of;

1. Winchester Water Treatment Plant
2. Public Works Maintenance Shop
3. Reservoir Hill
4. Dixonville Pump Station No. 2
5. Garden Valley Pump Station
6. Hawthorne Pump Station
7. Kline Pump Station
8. Ventura Pump Station

Several alternatives for each facility have been provided; these alternatives will be referenced throughout this evaluation. A summary of each alternative is as follows:

> ***Alternative 1***: Install a permanent standby generator capable of operating the minimum electrical load to maintain operation of the facility. Individual loads were identified by the City for the Water Treatment Plant (WTP) and Public Works Maintenance Shop. Minimum electrical load at the pump stations is defined as the lighting/heating load and a single booster pump operating.

> ***Alternative 2***: Install a permanent standby generator capable of operating the typical electrical load operated at the facility. Individual loads were identified by the City for the WTP and Public Works Maintenance Shop. Typical electrical load at the pump stations is defined as the lighting/heating load and all booster pumps operating.

> ***Alternative 3***: Install a generator receptacle to allow the use of a portable, trailer-mounted generator at each site. The receptacle would be sized to operate all electrical load, but functionality would depend on the size of generator provided.

Electrical Load Study and Generator Size Verification

All facilities except for Reservoir Hill contain a 277/480 Volts Alternating Current (VAC) three-phase power service; Reservoir Hill's utility power service is 120/240 VAC single-phase. A thorough examination of each facility was performed, and individual electrical loads were documented and categorized. Pump motor starters, pump motor full load amperages, and lighting transformer sizes were recorded and modeled. Beyond nameplate information, there are other parameters that must be evaluated when sizing a generator. Inrush current is used to describe the instantaneous input current drawn by an electrical device when that device is first energized. Equipment such as rotating motors, transformers, lighting ballasts, and welders are examples of devices that traditionally have high inrush current. As the device energizes it can draw much higher amperage than what it consumes while operating; therefore, these items must be examined and accounted for carefully.

When sizing a generator, the inrush current can place more strain on the generator than the full-load operation of the facility. Due to Ohm's law, one can assume that as this current increases, the power source would naturally decrease the output voltage. This balance can be measured by monitoring the voltage dip of the generator. Perhaps the most strain a generator will endure is the inrush current of a pump motor that is started across-the-line. The nature of this type of starter places the full inrush current of the motor on the generator, and that is where the largest voltage dip will occur. Traditionally, RH2 places a 15-percent voltage dip threshold on facilities; however, the 15-percent voltage dip is sometimes not feasible as it results in such an excessively sized generator that the cost is impractical. In those situations, RH2 evaluates the maximum permissible voltage dip on a site by site basis to make a reasonable assumption and recommendation. However, it should be noted that at sites with a voltage dip in excess of 15 percent, there may be the need to install a small uninterruptible power supply (UPS) on the motor starter control circuit to assist in smooth operation of the facility.

Another critical factor in sizing a generator is the total harmonic distortion (THD) of various electrical loads. THD is the parameter used to quantify the ratio of the sum of the harmonic components of a given signal by the power of the fundamental frequency. THD helps characterize an electrical system's linearity, which is significant due to a generator's limited ability to cope with the distortion. Devices such as computer power supplies and lighting ballasts contribute to the measurable THD on an electrical system.

Cummins Power Suite (May 2019 Release) generator sizing software was used to compile the electrical loads and determine generator sizing. **Table 1** shows a summary of the generator sizes identified for the various alternatives at each site, as well as the simulated voltage dip. **Appendix A** includes the specific generator sizing reports for each site and each alternative.

Table 1
Generator Sizing Summary

Facility	Alternative 1 (Min.)	Alternative 2 (Typ.)
Dixonville Pump Station No. 2	25 kW	50 kW
Garden Valley Pump Station	150 kW	150 kW
Hawthorne Pump Station	150 kW	150 kW
Kline Pump Station	50 kW	50 kW
Ventura Pump Station	80 kW	80 kW
Reservoir Hill	N/A	30 kW
Public Works Maintenance Shop	450 kW	800 kW
Winchester WTP	900 kW	1500 kW

It is important to note is that there is no Alternative 1 scenario for Reservoir Hill due to the type of facility it is. None of the electrical loads at the site are controlled or switched and it is impractical to assume that any portion of the electrical load would not be operating at any given time.

The most complex facility evaluated in this report is the Water Treatment Plant. **Table 2** summarizes the electrical loads the generator is sized for under each alternative. The motor loads that have the largest impact between the two alternatives are the high service pumps and the intake pumps. In Alternative 1 only one intake and high service pump would be allowed to run whereas two intake and high service pumps are allowed to run in Alternative 2. Therefore, Alternative 2 allows the plant to produce more water on standby power. The intake and high service pumps are two of the largest electrical loads at the plant, so adding these loads in alternative 2 has a significant impact on the generator size and cost of the project.

Table 2
WTP Electrical Loads – Alternative 1 and 2

Electrical Load	Alternative 1 (Min.)	Alternative 2 (Typ.)
Panel LA and LB	X	X
Panel 4A00	X	X
High Service Pump No. 3		X
High Service Pump No. 4	X	X
Exhaust Fan EF-1		X
Exhaust Fan EF-2		X
Sludge Collector Drive	X	X
Sludge Transfer Valve Actuator	X	X
Flocculator Motor E1	X	X
Flocculator Motor E2	X	X
Flocculator Motor E3	X	X
Rapid Mixer No. 1	X	X
Backwash Pump No. 1	X	X
Air Compressor	X	X
Blower	X	X
Wastewater Pump No. 1	X	X
Wastewater Pump No. 2	X	X
Storage Building Distribution Panel		X
Intake Pump No. 2		X
Intake Pump No. 3	X	X
Traveling Screen No. 1	X	X
Panel LD	X	X

Fuel System Evaluation

There are two primary types of fuel systems used for standby generators of the size considered in this evaluation: 1) dual-fuel (gaseous), and 2) diesel. A dual-fuel (gaseous) generator has the ability to operate using either natural gas or propane fuel. The most common type of fuel is diesel, compromising nearly 90 percent of the market share, yet there are certain scenarios where it makes sense to utilize a dual-fuel generator instead.

A diesel generator typically uses a local fuel tank either located directly beneath the generator (commonly referred to a sub-base fuel tank) or in a separate above-ground fuel tank. Sub-base fuel tanks provide decreased costs but are limited in size. Where a fuel supply exceeds the capacity limitations of the sub-base configuration, a separate standalone fuel tank must be provided. The cost of a separate fuel tank far exceeds that of the sub-base tank due to the necessary infrastructure needed to support the fuel tank. A dedicated equipment pad along with underground fuel piping, transition sumps, and leak containment must be provided with an above-grade fuel tank. Typically, an alarm panel is provided at the fuel tank for both leak detection alarming and overfill prevention. With the City's desired 48-hour fuel supply, sub-grade fuel tanks can be provided for all sites except the Winchester WTP and the Public Works Maintenance Shop.

A dual-fuel generator can operate using either natural gas or propane. Natural gas, provided by means of a utility connection, fuels the generator when available, while a separate propane tank serves as a local backup supply of local fuel in the event of a disturbance in the utility supply of natural gas. The generator is able to detect whether the supply of natural gas is present and is capable of automatically switching to the reserve propane supply as necessary.

Diesel generators typically are advertised as having a 20,000-hour lifespan, along with excellent reliability in cold weather. The engines are industrial in nature, with low piston speed, and are designed for longevity and maintainability. Diesel fuel itself has a shelf life of 18 to 24 months, but this can be extended by using additives or by having a third-party fuel polishing service performed to remove impurities from the supply. Diesel generators are subject to "wet stacking" if they are underutilized, a phenomena where unburnt fuel can cling to the interior of the exhaust system, but this should not be an issue for this specific installation as the generators considered are not oversized.

Dual-fuel generators typically are advertised as having a 5,000- to 6,000-hour lifespan due to their commercial grade engines. Dual-fuel generators are cleaner burning, with very little soot or carbon tracking near the exhaust. Propane has the added benefit of up to a 10-year shelf life of the local supply, mitigating the concern of fuel growing stale that exists with diesel. One considerable shortcoming of a dual-fuel generator is the inability to store a fuel supply in large quantity compared to an equivalent diesel generator. Due to the stringent requirements of large propane tanks, it is not advisable or cost effective to install a local fuel tank larger than 1,000 gallons. With the generator sizes considered as part of this study, the limitations of the fuel tank size limit the potential operating time if the generator were to rely solely on the local storage. Additionally, the fuel plumbing and leak detection requirements are more stringent, which can drive up construction costs. However, there are convenience benefits, as using a utility-provided natural gas supply lessens the need to monitor local fuel storage tank levels and top off as needed.

There are advantages and disadvantages to either fuel system; all of which play a role in determining which equipment best suits a project's needs. To accurately convey the differences between the two generators, it is wise to consider not just the technical performance of a single generator but the practical availability and performance of the common suppliers of generators. Due to their popularity, the availability of diesel generators in a variety of sizes is abundant, creating a competitive bidding atmosphere. However, the same cannot be said of dual-fuel generators; while there are multiple suppliers, the sizes between suppliers are not as standardized as their diesel counterparts. Due to the lessened availability, the bidding process can favor one supplier over another if the sizing of the generator does not strike a number that multiple manufacturers can provide.

Operating costs between the two systems vary as both efficiency and fuel prices fluctuate. For two generators of similar size, the fuel costs to operate a unit on natural gas are approximately

50 percent of those required to operate a same-sized diesel generator. However, if the dual-fuel unit must rely on the local propane fuel supply, the operating costs of the unit are nearly 400 percent of the equivalent diesel generator.

With a diesel generator there is a concern with very large fuel tanks that fuel may exceed its life expectancy if it goes unused and is not properly maintained. This would only be a concern at the Winchester Water Treatment Plant. One potential remedy to this problem is to add a fuel dispenser to a diesel tank, which would allow the City to fill vehicles and/or equipment with the on-site diesel. The benefit of this is that it both serves to cycle fuel quicker and provides an emergency source of diesel fuel during times of natural disaster. One pitfall of installing the dispenser is that if the fuel is used in road-going vehicles then the tank must be filled with road-taxed fuel, which is considerably more expensive than off-road diesel fuel that could otherwise be used for the generator. It is estimated that to add a fuel dispenser to a fuel tank would add approximately $10,000 to the total construction cost of the project.

There are several types of above-grade diesel fuel tanks available for diesel generator applications. The most common tank is a UL-142 style, which consists of a mild steel double-walled tank with spill prevention. Some owners elect to install a UL-2085 tank, which is very similar but includes an additional layer within the tank designed to provide protection against the tank breaking or severing in the event of a vehicle collision and against fire exposure. The cost estimates provided for the Winchester Water Treatment Plant and Public Works Maintenance Shop assume that a UL-142 tank is provided; to upgrade to a UL-2085 fuel tank it is estimated to add approximately $8,000per fuel tank but can vary based on capacity.

Sound Attenuation Evaluation

Sound attenuation is important to ensure that the generator installation is as least disruptive to both the facility and the neighbors as possible. For the purpose of this study, all generators are assumed to include an outdoor-rated sound-attenuated enclosure that will restrict noise to no more than 75 decibels (dB) as measured 23 feet from the generator. This is the most sound-attenuated industry standard enclosure available. Additional sound attenuation is available but requires custom fabrication and is significantly more expensive. It is estimated that to reduce to a 65 dB enclosure would add approximately $15,000 to each pump station generator, and approximately $40,000 to either the Public Works Maintenance Shop or Winchester Water Treatment Plant generator.

The City of Roseburg Code of Ordinances addresses noise concerns in Chapter 7.02 – Offense. Exemption B of 7.02.140 – Noise Disturbances states, “The use of emergency equipment required to protect life or property.” After visiting each site, RH2 did not identify any locations where noise attenuation beyond the standard 75 dB is warranted.

Site and Security Evaluation

Generator location is a critical element of overall standby generator power design. The selected location must be secure from vandalism while providing adequate access for maintenance and fueling. Additionally, the generator must maintain fire code mandated clearances from buildings and other structures. Individual site plan schematics have been prepared for each facility and can be found in **Appendix B**. A summary of the design constraints and overall site preferences has been prepared for each site.

Dixonville Pump Station No. 2

The pump station is located in a rural area, where vandalism is less of a concern. The existing property has vehicle access via a driveway, with a landscaped area at the edge of the driveway. Locating the generator in the landscaped area places it adjacent to the building, minimizing site work costs. It also makes it easily accessible for re-fueling.

Garden Valley Pump Station

The pump station is located in a neighborhood, surrounded by residential homes. There is no existing site security fence. The property is covered in trees, which would need to be trimmed and/or removed to place the generator. The proposed location of the generator is to the northwest of the pump station building.

Hawthorne Pump Station

The pump station is located in a neighborhood, surrounded by residential homes. There is no existing site security fence. The slope of the site limits potential generator locations due to inaccessibility. The proposed location is to the north of the building, along the existing driveway.

Kline Pump Station

The Kline Pump Station is surrounded by a security fence. The pump station building lies adjacent to a water reservoir on the site. When evaluating generator locations, it appeared that placing it behind the pump station would not impact site accessibility, while also providing room to service and fuel the generator.

Ventura Pump Station

The pump station is surrounded by residential homes. There is no existing site security fence. The existing property has limited street access, limiting potential locations for the generator. The proposed location is to the west of the building.

Reservoir Hill

Reservoir Hill is surrounded by a security fence but is also prone to foot traffic. The overall site is large, with plenty of room to place the generator. The selected location puts the generator near the existing power service entrance, which will help reduce site work costs. The generator lies outside of the access road surrounding the reservoir.

Public Works Maintenance Shop

The Maintenance Shop is surrounded by driveways and parking lots. Much of the existing space along the perimeter of the site has been utilized for material storage. The proposed location places the generator alongside the fence, with the separate fuel tank beside it. The location allows for access to the generator without inhibiting vehicle traffic around the building.

Winchester Water Treatment Plant

The water treatment plant is surrounded by a security fence with several grassy areas beside the filter basins. The overall size of the generator and fuel tank can be accommodated by several locations on the site. The selected location places the generator near the existing power service and maintains easy accessibility for fueling and maintenance. The location also leaves room for a potential filter upgrade in the future.

Electrical System Upgrades Summary

Integrating a generator, either permanently or using a receptacle, requires the use of a transfer switch. The transfer switch allows the facility load to be powered by either the utility transformer or the generator. Typically, a permanent generator requires an automatic transfer switch, meaning that the facility can call the generator to operate and switch to the backup power supply autonomously. With a portable generator, a manual transfer switch is typically provided, which requires a user to physically operate the switch. In either instance the switch can be installed indoors or outdoors, depending on user preference. It is recommended to place an automatic transfer switch indoors where possible to extend its lifespan. With a manual transfer switch, it is recommended to place it outdoors near the receptacle for easier operation by the end-user. With either switch the electrical installation is similar; the service conductors must be intercepted and routed through the switch and then the switch is connected to the load. At some facilities, with a standalone service entrance switch, this is simpler, and at others it requires providing a new service disconnect switch. Preliminary one-line diagrams have been prepared to show the integration of an automatic transfer switch at each facility. The diagrams can be found in **Appendix C**. The one-lines remain relevant for both Alternative 1 and Alternative 2. In the case of Alternative 3 the automatic transfer switch would be replaced with a manual transfer switch, and the proposed generator would be replaced with a generator receptacle. Wiring would remain the same for Alternative 3 as the other scenarios.

The one-line diagrams indicate whether the switches would be placed indoors or outdoors, based on observations during the site visits. Final transfer switch location would be revisited during design to optimize user functionality and City preference.

Significant electrical work is necessary at the WTP due to the size of the electrical service. The existing switchboard cannot accommodate an automatic transfer switch; therefore, a new outdoor service disconnect in a switchboard is necessary to protect the line side of the transfer switch. The transfer switch itself would need to be installed in an outdoor enclosure adjacent to the new service disconnect. With the relocation of the disconnect a new grounding electrode system would need to be installed and bonded to the existing grounding grid. The equipment necessary to accommodate the 4000 Ampere (A) service entrance is extremely costly due to its size. A detailed phasing plan would be necessary to limit power outages at the site as much as possible, but it is expected that several short-term outages would be necessary to complete the installation.

Projected Construction Cost Summary

Construction costs have been prepared for each facility and for each subsequent alternative. Overall project costs account for the generator, transfer switch, site work, fuel supply, conduit, and wire. Alternative 3 costs only include the materials and work necessary to provide a generator receptacle; they do not include the portable generators themselves. Alternative 3 costs have not been prepared for the WTP or Public Works Maintenance Shop, as a portable generator of the size necessary for the plant is not a feasible option for the City to own and operate and would not satisfy the City's fuel supply requirements. Overall costs are summarized In **Table 3**.

Table 3
Permanent Generator Construction Cost Summary

Facility	Alternative 1 (Min.)	Alternative 2 (Typ.)	Alternative 3
Dixonville Pump Station No. 2	$108,000	$125,000	$28,000
Garden Valley Pump Station	$153,000	$153,000	$24,000
Hawthorne Pump Station	$166,000	$166,000	$37,000
Kline Pump Station	$124,000	$124,000	$24,000
Ventura Pump Station	$131,000	$131,000	$24,000
Reservoir Hill	N/A	$111,000	$24,000
Public Works Maintenance Shop	$406,000	$619,000	N/A
Winchester WTP Total	$1,046,000	$1,334,000	N/A
Site Work	$77,000	$77,000	
Power Equipment	$245,000	$245,000	
Generator and ATS	$656,000	$944,000	
Conduit and Wire	$53,000	$53,000	
Control Panel	$15,000	$15,000	

Note: Alternative 3 costs only include site improvements. Generators are not included in costs.

Detailed cost estimates for each facility have been prepared and can be found in **Appendix D**. Additionally, costs for the necessary portable generators to operate the facilities have been compiled in **Table 4**. Standard generator sizes were selected that would provide functionality at the booster pump stations and reservoir. Refer to **Table 1** for the necessary generator size for each facility.

Table 4
Portable Generator Cost Summary

Portable Generator Size	Approximate Cost
50 kW	$113,000
80 kW	$122,000
150 kW	$129,000

The Federal Emergency Management Agency (FEMA) offers several generator reimbursement programs that may be applicable to the installation of one or more generators throughout the City. Specifically, the Hazard Mitigation Grant Program and Pre-Disaster Mitigation Program offer up to 75-percent reimbursement programs for qualifying generator installations. These programs exist to fund permanent generators, portable generators, and improvements necessary for generator receptacles. Applications for each site would need to be prepared and submitted to FEMA for evaluation and potential approval.

Recommendations

To provide the Alternative 1 generator option at all five pump stations would total $768,000; Alternative 2 generators drive this cost up to $788,000. In comparison, to provide generator receptacles at all five pump stations and provide two portable 150 kilowatt (kW) generators would total $411,000. It is unlikely that power outages will occur at more than two sites simultaneously. With the reservoir storage capacity of the City it is likely that portable generators could be rotated throughout the sites to maintain an operable situation until utility power has been restored at one or more sites. RH2 recommends that the City install portable generator receptacles (Alternative 3) at all five pump stations. Additionally, RH2 recommends that the City procure two 150 kW portable generators.

Reservoir Hill is a critical site due to its critical role in the radio communications of the City's supervisory control and data acquisition (SCADA) system. A power outage at Reservoir Hill results in the loss of the City to remotely monitor all of the City's water facilities. Because of the important role this site plays in the SCADA system it is recommended to install the Alternative 2 generator at Reservoir Hill.

At the Public Works Maintenance Shop it is likely that actual observed load is substantially lower than the load calculations would indicate. The overall use and function of the Maintenance Shop is such that electrical loads could be manipulated to avoid overloading the generator. RH2 recommends the Alternative 1 generator option at the Public Works Maintenance Shop.

When comparing the overall costs of the Alternative 1 and Alternative 2 generators at the Winchester Water Treatment Plant, it is apparent that there is only a 22 percent savings associated with Alternative 1. Due to the critical nature of the treatment plant and the potential for future expansion, the Alternative 2 generator is recommended for the Winchester Water Treatment Plant.