City of Richmond

Water Treatment Plant

Preliminary Design Report for

Replacement of [redacted]

August 24, 2012
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[redacted]

Prepared for WRA by Shah & Associates, Inc.

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EXECUTIVE SUMMARY

The City of Richmond has retained Whitman, Requardt & Associates, LLP (WRA) and Shah & Associates, Inc. (S&A) to provide design services for the replacement of [redacted] at the City of Richmond Water Treatment Plant. This Preliminary Design Report presents the design parameters, design alternatives and construction sequence required for preparation of biddable contract documents for this project. Towards this end, the following tasks were performed:

1. Review of the design drawings and equipment shop drawings for the existing substation installation.
2. Field investigation of the existing substation installation.
3. Assessment of the condition of the existing equipment.
4. Preparation of drawings of the existing installation and proposed demolition.
5. Preparation of concept drawings of the proposed new work.
6. Development of design and construction alternatives.
7. Preparation of most probable cost of the substation replacement alternatives.

Based on the investigations and evaluations described in this report, six alternatives for accomplishing the desired substation replacement were evaluated with the goal of minimizing the cost of the substation replacement and the length of time that the plant operates [redacted] The six alternatives are as follows:

1. Replacement of the substation in the same location with a site-assembled substation.
2. Replacement of the substation in the same location with a prefabricated, skid mounted substation.
3. Temporary relocation of the existing substation and installation of the new substation in the location of the existing substation.
4. Installation of a temporary, transportable substation and installation of the new substation in the location of the existing substation.

5. Installation of a new site-assembled substation in a new location.
6. Installation of a new prefabricated substation in a new location.

Table E-1: [redacted] Replacement Alternatives

System Configuration	Description	Most Probable Cost Estimate per System
ALT #1 Site-Assembled Replacement for [redacted]	Appendix D, sheet D2	$1,106,832
ALT #2 Prefabricated Replacement for [redacted]	Appendix D, sheet D3	$713,832
ALT #3 Temporarily Relocate Existing [redacted] During Replacement of [redacted]	Appendix D, sheet D4	$1,181,832
ALT #4 Install Temporary [redacted] During Replacement of [redacted]	Appendix D, sheet D5	$788,832
ALT #5 Site-Assembled [redacted] in New Location	Appendix D, sheet D6	$1,216,114
ALT #6 Prefabricated [redacted] in New Location	Appendix D, sheet D7	$793,114

Direct replacement of the new substation in the same location with a prefabricated substation and without provisions for temporary service has the least expensive construction cost; however, it requires the longest period of operation of the Plant [redacted] For this reason, it is recommended that a temporary transportable substation be provided as outlined in Alternative 4. The evaluation in Section 5 indicates that Alternative 4 will result in the shortest period of operation [redacted] and has the highest reliability, highest ease of construction, highest O&M safety and lowest Plant personnel involvement of the alternatives. Alternative 4 is within the budget for this project of $1,383,750.

SECTION 1

INTRODUCTION

1.1 Purpose and Scope

The City of Richmond has retained Whitman, Requardt & Associates, LLP (WRA) and Shah & Associates, Inc. (S&A) to provide design services for the replacement of [redacted] at the City of Richmond Water Treatment Plant.

The purpose of this project is the maintenance replacement of one-half of the main electrical service equipment for the WTP [redacted]

The scope of the project is the replacement of an [redacted] New civil and structural improvements will be provided for the substation line up as required to accommodate the selected alternative.

This project is justified because the equipment has exceeded its design life of 30 years, is obsolete and the [redacted]

The purpose of this Preliminary Design Report is to present the design parameters and construction constraints of this project and to provide reference materials for the decisions required to be made by the City in order for the Design Team to proceed with the preparation of biddable contract documents for this project. Towards this end, the following tasks were performed:

1. Review of the design drawings and equipment shop drawings for the existing substation installation.
2. Field investigation of the existing substation installation.
3. Assessment of the condition of the existing equipment.
4. Preparation of drawings of the existing installation and proposed demolition.
5. Preparation of concept drawings of the proposed new work.
6. Development of design and construction alternatives.
7. Preparation of most probable cost of the substation replacement alternatives.

Six alternatives have been evaluated for the substation replacement with the goal of minimizing the cost of the substation replacement and the length of time that the plant operates on a single utility feeder. The six alternatives are as follows:

1. Replacement of the substation in the same location with a site-assembled substation.
2. Replacement of the substation in the same location with a prefabricated, skid mounted substation.
3. Temporary relocation of the existing substation and installation of the new substation in the location of the existing substation.
4. Installation of a temporary, transportable substation and installation of the new substation in the location of the existing substation.
5. Installation of a new site-assembled substation in a new location.
6. Installation of a new prefabricated substation in a new location.

The report is organized as follows:

1. The condition assessment of the existing equipment is included in Section 2 of this report.
2. The design criteria for this project are included in Section 3 of this report.
3. The selection of replacement equipment is included in Section 4 of this report.
4. The evaluation of replacement alternatives is included in Section 5 of this report.
5. The basic assumptions for this design are included in Section 6 of this report.

6. The code requirements applicable to the design of this project are included in Section 7 of this report.
7. The cost estimates for the design alternatives is included in Section 8 of this report.
8. The recommendations for development of the design of this project are included in Section 9 of this report.

SECTION 2

CONDITION ASSESSMENT

2.1 Introduction

The existing design drawings and shop drawings for [redacted] were provided by the City of Richmond.

S&A conducted field investigation of the installation that included verification of Dominion Virginia Power's (DVP) incoming [redacted] feeder size, type and length; availability of spare ducts, location of penetrations of incoming and outgoing [redacted] feeders, [redacted]

Based on the investigation, the existing drawings and documentation were confirmed to be accurate.

WRA retained H&B Surveying and Mapping, LLC to survey the existing site and provide a scaled drawing of the existing topography, location of property lines, location of existing slabs and outline of existing structures.

2.2 Existing System Description

[redacted] Refer to Drawing ES-1 "Site Plan – Existing and Demolition", Drawing E-1 "Single Line Diagram – Existing and Demolition" and the "H&B Surveying and Mapping, LLC" Drawing in Appendix A.

[redacted] was installed in 1979 and was [redacted]. [redacted] and [redacted] were installed in 1992 in a major electrical upgrade to the plant and remote pumping stations. This upgrade provided the Plant with redundant electrical service feeders.

[redacted]

[redacted]

The feeder to [redacted] was replaced by DVP approximately two years ago and will remain and be reused for this project. [redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

2.3 Existing System Sequence of Operation

[redacted]

2.4 Existing Equipment Assessment

The [redacted] equipment is approximately 34 years old and has reached the end of its useful life as reliable and safe equipment. Most electrical equipment has an insulation design life of 30 years when applied in a reasonably conservative manner in the usual service conditions defined in ANSI/IEEE standards.

The equipment is in fair condition with visible corrosion on the enclosures, but no signs of serious deterioration. There are no signs of oil leakage from the transformer. The sump pump in the oil containment pit does not appear to be operational as the pit is half full with water.

[redacted] is no longer manufactured. [redacted]

In addition, the existing system does not have the [redacted]

Maintenance replacement of the equipment is highly recommended.

SECTION 3

DESIGN CRITERIA

3.1 Introduction

The design criteria used for the development of this design is outlined in this section

3.2 Design Criteria

The new equipment will be selected to provide safe and reliable electrical service for the Water Treatment Plant.

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

No modification is required for the existing utility metering.

[redacted]

[redacted]

[redacted]

[redacted]

Factory witness testing of the equipment is required by the City.

3.3 Energy Costs

The electric utility rates for the City of Richmond are negotiated through the Virginia Municipal League and Virginia Energy Purchasing Governmental Association. The electrical rate structure for the service to the Plant is based on Schedule 120 (Water Pumping Utility), Schedule C (Standby Charges) and applicable Riders. [redacted]

During the period from June 1 to September 30, the on-peak hours applicable to the billing are from 10 a.m. to 10 p.m., Monday through Friday. During the period from October 1 through May 31, the on-peak hours are from 7 a.m. to 10 p.m., Monday through Friday. All other hours are off-peak, including all hours during six holidays.

[redacted]

This sequence of operation is estimated to save the Plant $200,000 per year in electricity costs.

The replacement of [redacted] is planned to occur during the off-peak period for water demand from October to April. During the construction, it will be necessary to de-energize the feeder serving [redacted] and to operate the Plant with the feeder serving [redacted]

It is recommended that the City negotiate with DVP for the regular service rate for the feeder serving [redacted], [redacted] in order to minimize electricity costs during the substation replacement.

3.4 Cross Connection of the Existing Feeders

If the City is not able to negotiate with DVP to get the regular service rate on the feeder to [redacted] during the replacement of [redacted], a solution may be to rewire the feeders [redacted] during the

construction. This would allow operation of the plant on the less expensive feeder during the replacement of [redacted].

[redacted]

This reconfiguration will also result in splices in the cabling, [redacted] all of the replacement alternatives presented in this report can be accomplished without leaving permanent splices in the existing [redacted] feeders.

As indicated in paragraph 3.3, it is recommended that the City negotiate with DVP for a regular service rate for the feeder serving [redacted] to minimize electricity costs during the substation replacement. If negotiation with DVP is unsuccessful, the scenario presented in this paragraph can save the City most of the $200,000 [redacted] service premium, [redacted]

SECTION 4

SELECTION OF PROPOSED REPLACEMENT EQUIPMENT

4.1 Introduction

The existing [redacted] equipment will be replaced with new equipment. [redacted] Refer to Drawing ES-2 "Site Plan – New Work" and Drawing E-2 "Single Line Diagram – New Work" in Appendix A.

4.2 New Equipment Selection

The new equipment will be selected for safety and reliability.

4.2.1 [redacted] Switch

The new primary switch for the [redacted] will be a [redacted]. Refer to Appendix B for the dimensions of the proposed unit.

4.2.2 [redacted] Transformer

The new substation transformer will be a [redacted]

Refer to Appendix B for the dimensions and weight of the proposed unit.

4.2.3 [redacted] Circuit Breaker

The new [redacted] rating of the

transformer and will enable the City to take advantage of the full rating of the transformer in the future.

The calculations of the available fault current and fault duty indicate that the circuit breaker be rated [redacted] Refer to Appendix B for the dimensions of the proposed unit.

4.2.4 Protection Instruments, Relays and Indication Lights

The existing [redacted] as shown on Drawing E-2.

The new [redacted] will provide the following ANSI functions:

[redacted]

[redacted]

[redacted]

Refer to Drawing E-4 "Switchgear SG-6 Elevation – Existing, Demolition and New Work" in Appendix A.

The existing [redacted] transformer was installed in [redacted] during the 1992 electrical upgrade and will be replaced with a new [redacted] transformer [redacted]

The status of the new equipment will be annunciated [redacted] Status indications will include:

- [redacted]
- [redacted]
- [redacted]
- [redacted]

4.3 [redacted]

The existing substation is mounted on [redacted]. The new substation will be provided with a new [redacted]

The existing [redacted] and [redacted] are separated by [redacted]

4.4 [redacted]

[redacted] Two of the alternatives will require new ductbanks.

[redacted]

Refer to Drawing ES-2 "Site Plan – New Work" and Drawing E-5 "Ductbank and Manhole Sections" in Appendix A.

4.5 [redacted]

[redacted]

SECTION 5

EVALUATION OF REPLACEMENT ALTERNATIVES

5.1 Introduction

[redacted]

There is also concern over the cost of operating the Plant on the more expensive [redacted] feeder during the replacement.

Six alternatives have been developed and evaluated for reducing the length of time that the Plant is operating [redacted]. The six alternatives are as follows:

1. Direct replacement with site-assembled substation.
2. Direct replacement with prefabricated substation.
3. Temporary relocation of existing substation and installation of new substation in original location.
4. Temporary installation of transportable substation and installation of new substation in original location.
5. Installation of new site-assembled substation in new location.
6. Installation of new prefabricated substation in new location.

Refer to Appendix C for the Decision Matrix which presents these evaluations in graphic form.

5.2 Direct Replacement with Site-Assembled Substation

The existing equipment will be demolished and the new equipment will be installed in the location of the original equipment.

[redacted] will be de-energized and removed from the site. Civil and structural work will be performed to provide a [redacted]

[redacted]

[redacted]

This alternative is the third most expensive since it involves site-assembly of the substation.

5.3 Direct Replacement with Prefabricated Substation

The existing equipment will be demolished and the new equipment will be installed in the same location of the existing equipment.

[redacted] will be de-energized and removed from the site. Civil and structural work will be performed to provide [redacted]

[redacted]

[redacted]

This alternative is the least expensive since the equipment will be provided with [redacted]

[redacted]

[redacted]

5.4 Temporary Relocation of Existing Substation and Installation of New Substation in Original Location

The existing [redacted] will be relocated [redacted] and be reconnected.

[redacted] will be de-energized, relocated and reconnected to the primary feeder and [redacted] Civil and structural work will be performed to provide [redacted] for the new substation. The new substation will be installed and power and controls will be connected to [redacted]

[redacted]

[redacted]

[redacted]

This alternative is the second most expensive due to the cost of the relocation of the existing equipment.

[redacted]

5.5 Temporary Installation of Transportable Substation and Install of New Substation in Original Location

The temporary equipment will be located to a spot [redacted]

[redacted] will be de-energized and the temporary substation primary will be fed from the existing feeder serving [redacted] The secondary of the temporary substation will be connected [redacted] Civil and structural work will be performed to [redacted] The new substation will be installed and power and controls will be connected [redacted]

[redacted]

[redacted]

[redacted]

This alternative is the second least expensive due to the use of a prefabricated substation.

5.6 Installation of New Site-Assembled Substation in New Location

The new substation will be installed in a new location [redacted]
Civil and structural work will be performed to provide [redacted]

The new substation will be installed and power and controls will be connected [redacted]

This alternative has the second highest cost due to the requirements for a new equipment foundation, oil containment system and new ductbanks

5.7 Installation of New Prefabricated Substation in New Location

The new substation will be installed in a new location [redacted]
Civil and structural work will be performed to provide [redacted]

The new substation will be installed and power and controls will be connected [redacted]

[redacted]

[redacted]

[redacted]

This alternative has the third highest cost due to the requirements for new ductbanks.

SECTION 6

BASIC ASSUMPTIONS

6.1 Introduction

The basic assumptions for the development of this report are outlined in this section

6.2 Basic Assumptions

[redacted]

SECTION 7

CODE REQUIREMENTS

7.1 Introduction

The code requirements for the development of this design are outlined in this section

7.2 Code Requirements

The project will be designed to comply with all applicable local and national codes including, but not limited to, Virginia Uniform Statewide Building Code 2009, International Building Code Virginia Edition 2009, International Energy Conservation Code Virginia Edition 2009, International Fire Prevention Code Virginia Edition 2009 and National Electrical Code 2008

The Virginia Department of Health requires redundant power supplies for the Plant. [redacted]

The Arc Flash Hazard study for the Plant will be updated with the characteristics of the new equipment and new arc flash hazard labels will be placed.

All work in the manholes will be specified to comply with the confined spaces requirements of OSHA.

The new substation and associated low-impedance grounding system will be designed in accordance with NEC, NESC and IEEE.

SECTION 8

COST ESTIMATE

8.1 Introduction

The cost estimates for the alternatives for this project are outlined in this section.

8.2 Cost Estimate

The cost for Alternative 1 is tabulated on Sheet D2 of Appendix D and is $1,106,832

The cost for Alternative 2 is tabulated on Sheet D3 of Appendix D and is $713,832

The cost for Alternative 3 is tabulated on Sheet D4 of Appendix D and is $1,181,832

The cost for Alternative 4 is tabulated on Sheet D5 of Appendix D and is $788,832

The cost for Alternative 5 is tabulated on Sheet D6 of Appendix D and is $1,216,114

The cost for Alternative 6 is tabulated on Sheet D7 of Appendix D and is $793,114

SECTION 9

RECOMMENDATIONS

9.1 Introduction

The recommendations for the development of this design are outlined in this section.

9.2 Recommendations

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

Direct replacement of the new substation in the same location with a prefabricated substation and without provisions for temporary service has the least expensive construction cost; [redacted] For this reason, it is

recommended that a temporary transportable substation be provided as outlined in Alternative 4. The evaluation in Section 5 indicates that Alternative 4 will result in [redacted] has the highest reliability, highest ease of construction, highest O&M safety and lowest Plant personnel involvement of the alternatives. Alternative 4 is within the budget for this project of $1,383,750.