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Memorandum

To: **National Economic Research Associates**
CC: **Linda Landis**

Date: December 13, 2017

From: Enercon Services, Inc.

Subject: Technical Memorandum to Document Technology Cost Inputs for Merrimack Station

Executive Summary

The purpose of this memorandum is to document several design inputs provided to National Economic Research Associates (NERA) to support the economic analysis being performed for Public Service Company of New Hampshire's (PSNH's) Merrimack Station (the Station).

- The construction costs for implementing wedgewire half-screens at Unit 1 and Unit 2 are estimated to be $3,578,000 and $5,400,000, respectively. The permitting and engineering costs for implementing wedgewire half-screens at the Station are estimated to be a total of $1,077,000 for the two units. All estimates are provided in 2017 dollars.

- The parasitic losses associated with the implementation of wedgewire half-screens at the Station are estimated to be 172 MW-hr per year. The total annual O&M costs for wedgewire half-screens are estimated to be $29,400, in 2017 dollars. An additional O&M cost of $38,900, in 2017 dollars, is anticipated after 20 years of operation to replace the ABS air compressor. No power losses due to new condenser operating parameters or water treatment costs are anticipated for the operation of wedgewire half-screens at the Station.

- The procurement and installation of the wedgewire half-screen system would take approximately 18 weeks for each unit. Therefore, the implementation of the technology at Unit 1 would be expected to be complete approximately 18 weeks after the finalization of all necessary permits, and the implementation of the technology at Unit 2 would be expected to be complete approximately 70 weeks after the finalization of all necessary permits[1].

- The estimated costs for implementing closed-cycle cooling using mechanical draft cooling towers at the Station are presented in the 2007 Response to EPA's CWA § 308 Letter (2007 Response). Based on various site and technological changes, the capital costs presented in the 2007 cost estimate should be increased by 30%.

- The useful life of both the mechanical draft cooling tower and the wedgewire half-screens is 30 years.

Development of Technology Cost Information

Several design inputs are provided to support the economic analysis, including estimates for the equipment / structure costs of wedgewire half-screens and closed-cycle cooling using mechanical draft cooling towers, as well as a discussion of the expected construction timelines and useful life for each technology. Additionally, the monthly average intake flows and capacity factors for the Station for the years 2007-2016 are provided. The details for each of these design inputs are developed and presented below.

Wedgewire Half-Screen Cost Estimate

A cost estimate for the implementation of wedgewire half-screens at the Station was developed and is presented in Attachment 1. This cost estimate is an ASTM E2516-11 Class 5 cost estimate (Reference 1), which is a high-level estimate that is intended for use in screening and feasibility determinations. Vendor quotes, construction estimation tools and previous project

[1] It is assumed that the installation of the screens would occur concurrent with a portion of the year when the Station has traditionally had a low capacity factor to reduce outage-related costs and electricity supply grid impacts. Therefore, screen installation may not begin immediately following finalization of necessary permits, and the schedule would be adjusted as necessary to align the installations with periods of low Station operation.

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experience were utilized for this estimate. All wedgewire half-screen costs are presented in 2017 dollars.

The permitting and engineering costs for implementing wedgewire half-screens at the Station are estimated to be $1,077,000 for the two units. The total construction costs for Unit 1 and Unit 2 are estimated to be $3,578,000 and $5,400,000, respectively. Attachment 1 shows an itemized cost estimate which has tabulated categories of procurement, implementation, contingencies, permitting, and construction management costs. Sources for each cost estimate are also included within the table.

The estimated implementation schedule (described in more detail below) shows that approximately six weeks of outage would be required for dredging and backfilling the river bed in front of the intake structures as well as installing the screens and supporting structures. This six-week outage period would occur during the last six weeks of the full 18-week procurement and installation duration for each unit, as denoted on the construction schedule in Attachment 2. It is assumed that the installation of the screens would be planned to coincide with periods of low operation, reducing the costs of the construction-related outage as well as the impact to the electricity supply grid.

The parasitic losses associated with the implementation of wedgewire half-screens at the Station would consist of the power required for operating the air burst system (ABS) used to clean the screens. These parasitic losses are estimated based on the assumption that a 75 hp compressor is used that runs 24 hours per day from April 1st through July 31st and once a week for four hours from August 1st through March 31st. Under this operating scenario, the annual power required to operate the ABS is calculated to be 172 MW-hr, as shown below.

$$\left[\left(24\ \frac{hours}{day} * 122\ days * 75\ hp\right) + \left(4\ \frac{hours}{week} * 35\ weeks * 75\ hp\right)\right] * \frac{0.0007457\ MW}{1\ hp} = 172\ MW - hr$$

During the year where the Unit 1 screens have been installed but the Unit 2 screens have not, the power required to operate the ABS would be less than the 172 MW-hr calculated above. The ABS power requirements are directly related to the number of screens. Therefore,

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approximately 2/7 of the total parasitic losses, or 49 MW-hr, would occur during the year where only the Unit 1 screens are in operation.

The wedgewire half-screens would have relatively minimal operation and maintenance (O&M) requirements. These requirements would include ABS inspections and operation, inspections and operations of the butterfly valves, and inspections and cleaning of the wedgewire screens. It is estimated that approximately 495 man-hours would be required annually for these O&M activities. The development of this man-hour estimate is presented in detail in Table 2-3 of Reference 7. This estimate is for preventative/routine maintenance only and does not include repair or replacement time.

The United States Bureau of Labor Statistics provides periodic reports on the cost of labor across the country. The most recent such report at the time of this assessment was released September 8, 2017. This document reported a national average hours cost to employer of $62.13 for private sector employees working in utilities (Reference 2, Table 10). Based on the city cost factor for Manchester, NH from RS Means, this rate is multiplied by 0.956 to account for geographic differences in local labor rates. Therefore, an adjusted rate of $59.40 is used. Using this rate, the total annual O&M costs for wedgewire half-screens is estimated to be $29,400, in 2017 dollars. This annual O&M cost is largely independent of the number of screens, and is expected to be incurred in full beginning with the Unit 1 installation.

An additional O&M cost that should be considered is the replacement cost of the air compressor used for the ABS. The useful life of the air compressor for the ABS is expected to be 20 years (Reference 9). Therefore, after 20 years of operation, a cost of $38,900, in 2017 dollars, should be included to account for the replacement of the air compressor (Reference 10).

If wedgewire half-screens were to be implemented at the Station, operation of the existing traveling water screens would not be necessary while the wedgewire screens are in use (April 1st to July 31st). Therefore, when considering changes in the parasitic loads, it is expected that the existing traveling water screens would only operate when the wedgewire screens are not in use. Operation during this timeframe would match the current traveling water screen operation at the Station.

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No power losses due to new condenser operating parameters or water treatment costs are anticipated for the operation of wedgewire half-screens at the Station.

Wedgewire Half-Screen Construction Timeline

The implementation of wedgewire half-screens at the Station would consist of several different stages, including detailed engineering design, permitting, procurement, mobilization, construction and tie-in, start-up testing, and demobilization. It is assumed the detailed engineering required for implementation would occur in parallel with the permitting process and would be complete by the time all necessary permits are finalized. The year in which construction will commence is not currently known and will not be known until EPA makes a final Best Technology Available (BTA) determination. PSNH may appeal EPA's final BTA determination, and PSNH counsel has advised that an appeals process would be expected to last 42 months after the NPDES permit effective date. Therefore, assuming a NPDES permit effective date of July 1st, 2019[2], permitting and engineering costs would be incurred starting on January 1st, 2023, and would be anticipated to last six months. Once all necessary permits have been finalized, procurement and construction of the wedgewire half-screens could begin.

The implementation of wedgewire half-screens at the two units would occur in two separate phases. In Year 1, the Unit 1 system procurement and installation would occur. That system would be tested and monitored for the remainder of the year and the lessons learned would be applied to the procurement and installation of the Unit 2 system, which would occur in Year 2. The procurement and installation of the wedgewire half-screen system would take approximately 18 weeks for each unit. Therefore, the implementation of the technology at Unit 1 would be expected to be complete approximately 18 weeks after the finalization of all necessary permits. Similarly, after incorporating the lessons learned from the Unit 1 design and installation, the implementation of the technology at Unit 2 would be expected to be

[2] Should the effective date of the NPDES permit be delayed beyond July 1st, 2019, the engineering, permitting, and construction schedules would also be delayed. Based on the assumption that screen procurement would start on July 1st, the delay in the construction schedule may be longer than the delay of the NPDES permit effective date, depending on the timing.

complete approximately 70 weeks after the finalization of all necessary permits. The estimated schedule is shown in detail in Attachment 2.

As shown in Attachment 2, for both units there would be an approximately six-week long outage required for the screen installations that would occur during the last six weeks of the full 18-week procurement and installation duration. These outages would be required for dredging and backfilling of the river bottom in front of the intake structures as well as for installing the concrete slabs and walls, ABS and screen piping, riprap, and the wedgewire half-screens. In order to reduce the costs of the construction-related outages as well as the impact that the outages would have on the electricity supply grid, it is assumed that the installation of the screens could be planned to coincide with periods of low operation. Therefore, screen installation may not begin immediately following finalization of necessary permits, and the schedule would be adjusted as necessary to align the installations with periods of low Station operation.

For the economic analysis, it should be assumed that procurement of the screens for each unit would begin on July 1st of the respective year, with mobilization and construction beginning 10 weeks later, as shown in Attachment 2. It is expected that installation starting at this time would coincide with periods of low Station operation, and would occur after the river velocities have begun to slow and before the heavy debris season. Once the screens are installed, it is assumed that they would operate from April 1st to July 31st of each year, corresponding to the peak entrainment season.

Closed-Cycle Cooling Cost Estimate and Construction Schedule

In 2007, ENERCON developed a cost estimate for retrofitting the Station with closed-cycle cooling using mechanical draft cooling towers in response to EPA's information request under Section 308 of the Clean Water Act (CWA) with respect with CWA § 316(b). Cost estimates and implementation schedules were developed for two mechanical draft closed-cycle cooling configurations; one configuration for both units combined and one configuration for each unit individually. The closed-cycle cooling cost estimates provided in the 2007 Response include initial capital costs, costs due to new condenser operating parameters, costs due to parasitic losses, costs due to lost generating capacity during implementation, and O&M and water treatment costs.

For the economic analysis, the cost estimate provided in the 2007 Response should be used in conjunction with the cost increase factor described below. Specifically, the cost for converting both units at the Station to year-round closed-cycle cooling using mechanical draft cooling towers should be used (Reference 3, Section 6.2, Attachment 4). As detailed in Section 9 of ENERCON's Response to EPA's Statement of Substantial New Questions (Reference 4), various plant and technological changes have occurred since the 2007 Response was developed that would significantly impact the closed-cycle cooling cost estimate provided, the most notable of which is the installation of the new scrubber system at the Station. The installation of the new scrubber system was a very large construction project which significantly altered the available free space on site. As such, space that was assumed to be available for new piping additions in the conversion to closed-cycle cooling may no longer be available. A portion of the scrubber system installation is shown in Figure 1 to help depict the magnitude of the construction that occurred at the Station.

Figure 1: Construction of the Chimney Foundation, Part of the Scrubber System[3]

As a result, the initial capital cost estimate presented in the 2007 Response should be increased by 30% to account for the impact of these various plant and technological changes on the cost of implementing closed-cycle cooling at the Station. A more detailed justification for the 30% increase in capital costs is provided in Section 10 of Reference 4. This cost increase does not include escalating the cost to 2017 dollars and only applies to the initial capital costs. All other costs (O&M costs, costs due to parasitic losses, etc.) should be used as presented in the 2007 Response. For the economic analysis, it should be assumed that the operational losses due to increased condenser backpressure and the parasitic losses should be scaled according to the analyzed capacity factor.

The cost estimate provided in the 2007 Response did not include an allowance for permitting. RSMeans provides a "rule of thumb" permitting cost estimate of 2% of the total project cost[4]. This 2% estimate for permitting is included within the 30% increase described above. PSNH

[3] Courtesy of New Hampshire Public Radio, http://nhpr.org/post/psnh-scrubber-investigation-set-forge-ahead

[4] It should be noted that the 2% permitting cost estimate is not inclusive of any potential appeals process.

counsel has advised that if closed-cycle cooling were selected as the BTA, the appeals process would be expected to last 42 months after the NPDES permit effective date. Therefore, permitting would be expected to begin on January 1st, 2023, and would be anticipated to last 12 months.

The various plant and technological changes that have occurred since the 2007 Response was developed would also have significant impacts to the closed-cycle cooling construction schedule. As described earlier, the installation of the new scrubber system has increased site congestion and may necessitate changes to the piping design and layout of the closed-cycle cooling system presented in the 2007 Response. Therefore, the construction schedule presented in the 2007 Response is no longer applicable and should not be used in the economic analysis. It should be noted that due to the nature of the underground work required for tying-in a closed-cycle cooling system, the tie-in would not be possible during the winter months and would need to occur sometime during the April – October timeframe.

For closed-cycle cooling using mechanical draft cooling towers, operation of the existing traveling water screens at the Station would be reduced. Although the details of the makeup flow design for closed-cycle cooling have not been developed, it is anticipated that only one intake bay would be required to provide the necessary flow; therefore, only one existing traveling water screen would be required to operate. Since the makeup flow supply would be continuous, the operation of the traveling water screen would be needed year-round.

Useful Life

If Merrimack Station was converted to a closed-cycle cooling system using a mechanical draft cooling tower, the tower would be the largest cost driver for the conversion. Likewise, if wedgewire half-screens were implemented at the Station, the largest cost driver would be the screens. The useful life of both the mechanical draft cooling tower and the wedgewire half-screens is taken to be 30 years. This is consistent with the estimated technology service life values presented in Exhibit 8-19 of EPA's Technical Development Document for the Final Section 316(b) Existing Facilities Rule (Reference 5).

Intake Flow and Capacity Factor Data

Based on monitoring reports submitted to EPA, monthly average actual intake flows and capacity factors were calculated for the years 2007-2016. The monthly average intake flows for the Station in millions of gallons per day (MGD) are presented in the table below (Reference 8). Using the values presented below, the average intake flow for the three-year period of 2014-2016 is calculated to be 69.6 MGD.

Table 1: Monthly Average Intake Flows (MGD)

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Jan	224	202	179	234	226	157	237	217	235	84.6
Feb	246	202	185	241	221	140	256	240	257	75.3
Mar	248	234	257	256	163	95.2	227	256	177	0.3
Apr	176	69.5	228	217	97.1	4.2	5.8	88	7.2	1.6
May	141	133	228	200	107	0.3	14.3	1.1	0.1	2.5
Jun	247	189	240	252	214	32.2	80.4	10.8	12.8	0
Jul	256	181	247	254	233	184	157	98.5	26.1	99.4
Aug	256	253	73.5	244	157	103	35.6	0.2	6.3	62.9
Sep	216	192	69.5	199	28.8	0.2	22.8	22.2	24.4	5.9
Oct	244	195	58.3	29.9	41.4	0.2	0.2	4.9	16.6	3.9
Nov	256	230	100	62.9	148	90.6	20.8	175	16.8	17.6
Dec	257	221	235	216	153	242	217	84.6	27.6	145

The design intake flow for Unit 1 and Unit 2 is 59,500 gpm and 140,000 gpm, respectively (Reference 11, Page 9). These equate to a total design intake flow of 287.3 MGD. Therefore, for the 100% capacity factor sensitivity case, the design intake flow of 287.3 MGD should be used. For the 50% capacity factor case, it is assumed that the intake flow is directly proportional to the capacity factor. Therefore, 50% of the design intake flow, or 143.65 MGD should be used.

As described in the 2007 Response, it is expected that the intake flows would be reduced approximately 95% if both units at the Station were to be converted to closed-cycle cooling using cooling towers (Reference 3, Pages 52-53).

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Based on Station records, the monthly average capacity factors are presented for each unit in the tables below. Note that the Unit 1 power rating was 113 MW from January 2007 until October 2011, when it was de-rated to 108 MW (Reference 6). The Unit 2 power rating was 321 MW from January 2007 until December of 2009, when it was up-rated to 337 MW. It remained 337 MW until December of 2011, when it was de-rated to 330 MW (Reference 6).

Table 2: Monthly Average Unit 1 Capacity Factor[5]

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Jan	100.0%	90.1%	99.3%	99.6%	83.9%	69.0%	71.4%	92.7%	88.0%	30.5%
Feb	100.0%	100.0%	99.6%	90.8%	92.1%	29.6%	95.6%	78.3%	98.7%	21.0%
Mar	87.8%	99.8%	98.4%	93.0%	82.6%	54.4%	82.6%	92.0%	66.1%	0.0%
Apr	100.0%	87.0%	69.7%	33.2%	32.6%	2.9%	4.6%	27.0%	0.1%	0.0%
May	99.5%	100.0%	81.0%	31.9%	37.1%	0.0%	5.1%	0.0%	0.0%	0.0%
Jun	90.4%	89.2%	85.3%	74.9%	26.0%	12.0%	23.2%	0.0%	3.2%	0.0%
Jul	99.3%	97.7%	75.1%	83.3%	50.8%	80.3%	47.9%	28.2%	6.6%	24.0%
Aug	97.5%	92.2%	87.0%	85.5%	81.0%	18.7%	9.3%	0.0%	4.6%	14.6%
Sep	83.7%	28.4%	83.2%	76.0%	31.8%	0.0%	4.6%	8.7%	7.3%	5.1%
Oct	98.5%	6.9%	72.8%	0.6%	50.2%	0.0%	0.0%	3.1%	13.1%	0.0%
Nov	100.0%	79.5%	79.3%	54.6%	45.3%	63.8%	25.1%	63.4%	5.1%	2.8%
Dec	100.0%	94.5%	82.6%	92.6%	85.5%	82.7%	90.3%	37.3%	0.0%	67.1%

[5] Due to operational and equipment variability, Station records sometimes reported a monthly average capacity factor of slightly greater than 100%. For the purposes of this analysis, the capacity factors for these months are rounded down to 100%.

Table 3: Monthly Average Unit 2 Capacity Factor[6]

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Jan	99.9%	93.5%	100.0%	79.6%	84.8%	88.7%	90.5%	81.1%	87.1%	17.9%
Feb	85.4%	88.1%	73.7%	87.8%	91.8%	63.3%	93.8%	82.8%	95.1%	17.4%
Mar	98.2%	84.8%	99.2%	96.8%	72.7%	16.0%	71.4%	88.3%	41.3%	0.0%
Apr	53.2%	1.6%	81.2%	78.8%	50.2%	0.0%	0.0%	11.3%	1.0%	0.0%
May	13.8%	24.8%	71.9%	68.1%	10.8%	0.0%	2.8%	0.0%	0.0%	0.0%
Jun	90.9%	61.8%	79.8%	78.9%	76.1%	4.9%	18.6%	0.0%	0.0%	0.0%
Jul	96.9%	24.8%	85.9%	83.3%	79.4%	48.6%	50.0%	15.3%	1.6%	15.2%
Aug	97.0%	99.6%	0.0%	75.8%	32.9%	31.4%	7.2%	0.0%	0.0%	12.7%
Sep	76.6%	80.5%	0.0%	56.4%	0.0%	0.0%	3.7%	0.0%	6.3%	0.0%
Oct	85.4%	99.0%	0.0%	7.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Nov	100.0%	87.1%	0.0%	4.2%	46.2%	14.3%	0.0%	42.6%	0.0%	0.0%
Dec	99.2%	99.2%	77.7%	94.9%	30.0%	72.1%	61.7%	18.6%	6.6%	31.1%

References

1. E2516-11, Standard Classification for Cost Estimate Classification System, ASTM International.
2. News Release - Employer Costs for Employee Compensation – June 2017, U.S. Department of Labor, Bureau of Labor Statistics.
3. Response to United States Environmental Protection Agency CWA § 308 Letter, Enercon Services, Inc. and Normandeau Associates, Inc., November 2007.
4. Response to Environmental Protection Agency's Statement of Substantial New Qualifications for Public Comment, Enercon Services, Inc. December 2017.
5. Technical Development Document for the Final Section 316(b) Existing Facilities Rule, United States Environmental Protection Agency, May 2014.

[6] Due to operational and equipment variability, Station records sometimes reported a monthly average capacity factor of slightly greater than 100%. For the purposes of this analysis, the capacity factors for these months are rounded down to 100%.

6. Merrimack Station Unit Power Ratings Spreadsheet, provided by PSNH on 10/11/2017.
7. Supplemental Alternative Technology Evaluation, Enercon Services, Inc., October 2009.
8. Discharge Monitoring Report (DMR) Pollutant Loading Tool, United States Environmental Protection Agency, Accessed October 6, 2017, https://cfpub.epa.gov/dmr/facility_detail.cfm?fac=NH0001465&yr=2007.
9. ASHRAE Equipment Life Expectancy Chart, http://www.f22designs.com/cullum/wp-content/uploads/2013/02/ASHRAE_Chart_HVAC_Life_Expectancy%201.pdf.
10. 3-Phase 75 HP Rotary Screw Air Compressor, Ingersoll Rand, https://www.grainger.com/product/INGERSOLL-RAND-Rotary-Screw-Air-Compressor-46Z608.
11. Wedgewire Half Screen Technical Memo, Enercon Services, Inc., December 2016

Wedgewire Screen Option Construction Cost Estimate - Unit 1

Item	Description	Quantity	Unit	Unit Price	Cost	Source
Procurement Costs						
Wedgewire Screens for Unit 1	Johnson Low Profile Half T-96HCE, (49" height, 303" length), Z-Alloy	2	Each	$ 283,956	$ 567,912	Aqseptence Group, Inc. Quote
316 Stainless Steel Piping (44" NPS)	Piping from Wedgewire Screen to Intake (black steel, plain end, welded, 3/8" thickness, 44" diameter)	30	LF	$ 1,957	$ 58,715	RSMeans 2014 Line Number 33 11 13.40 1090, scaled by exponential size ratio (n=1.33), multiplied by a factor of 3 for SS**
Hydroburst System	3,000 gallon air receiver tank, compressor/motor assembly, automatic control panel, control valves	1	Each	$ 97,000	$ 97,000	Aqseptence Group, Inc. Quote
316 Stainless Steel Piping (8" NPS)	Piping from Wedgewire screen to ABS (Schedule 40, 8" diameter, includes coupling & clevis hanger assemblies)	200	LF	$ 453	$ 90,600	RSMeans 2017 Line Number 22 11 13.48 1140, multiplied by a factor of 3 for SS**
Tasks for Wedgewire Screen Implementation						
River Bed Dredging	Hydraulic dredging, pumped 1000' to shore dump, maximum	200	BCY	$ 17	$ 3,430	RSMeans 2017 Line Number 35 20 23.23 1100
Mobilization/Demobilization of Dredger	Dredging mobilization and demobilization, average of maximum and minimum	2	Each	$ 47,550	$ 95,100	RSMeans 2017 Line Numbers 35 20 23.13 0020 & 35 20 23.13 0100 Average
Backfill	Crushed stone, 3/4" - 1/2"	100	LCY	$ 42	$ 4,168	RSMeans 2017 Line Number 31 23 23.16 0100
Backfill Haul	Structural backfill, 300' haul sand and gravel	100	LCY	$ 4	$ 379	RSMeans 2017 Line Number 31 23 23.14 2400
Backfill Compacting	Compacting bedding in trench	100	ECY	$ 6	$ 575	RSMeans 2017 Line Number 31 23 23.16 0500
Riprap	Riprap and rock lining, machine placed for slope protection, 18" minimum thickness, not grouted	75	SY	$ 104	$ 7,800	RSMeans 2017 Line Number 31 37 13.10 0200
Precast Concrete Walls	Plenum walls over 3% reinforcing (4,000 psi)	225	CY	$ 2,687	$ 604,575	RSMeans 2017 Line Number 03 30 53.40 0740
Precast Concrete Foundation Pads	Foundation mat (3000 psi), over 20 CY (includes forms, rebar, concrete, placement and finish)	200	CY	$ 356	$ 71,112	RSMeans 2017 Line Number 03 30 53.40 4050
Crane on Bridge	Crane, 350-ton capacity, 80' boom, crawler mounted, 1/2 CY, 15 tons at 12' radius	1	Month	$ 37,800	$ 37,800	RSMeans 2017 Line Number 01 54 33.60 1500
Mobilization/Demobilization of Crane	Mobilization, over 75-ton capacity crane (with chase vehicle), up to 25 mile haul distance (50 mile RT)	2	Each	$ 18,575	$ 37,150	RSMeans 2017 Line Number 01 54 36.50 2400
Cable Jacks	Thirty five(35) cable jacks, 10-ton capacity with 200' cable	1	Month	$ 36,750	$ 36,750	RSMeans 2017 Line Number 01 54 33.60 6600
Operation	Daily crane crew, 80-ton truck-mounted hydraulic crane	10	Day	$ 3,900	$ 39,000	RSMeans 2017 Line Number 01 54 19.50 0500
Hydraulic Sluice Gates	316 stainless steel hydraulic sluice gate	2	Each	$ 325,712	$ 651,424	Past project experience for 96" x 166", 3.4% inflation added from 2014 to 2017 dollars
Pipe Lay Materials						
44" Elbow	44" welded elbow and 150-lb flange connection, stainless steel 316	1	Each	$ 39,760	$ 39,760	Past project experience, approximate cost of 30" elbow flanges, scaled by exponential size ratio (n=1.33), 3.4% inflation added from 2014 to 2017 dollars
44" Flange	44" welded neck flange	2	Each	$ 19,336	$ 38,672	RSMeans 2017 Line Number 22 11 13.47 6559, scaled by exponential size ratio (n=1.33), multiplied by a factor of 3 for SS**
8" Elbow	8" elbow butt-welded, stainless steel 316	20	Each	$ 1,860	$ 37,200	RSMeans 2017 Line Number 22 11 13.66 3380
8" Flange	8" slip-on welded flange connection, stainless steel 316	4	Each	$ 2,268	$ 9,070	RSMeans 2017 Line Number 22 11 13.66 6400
8" Pipe Clamp	8" pipe clamp, galvanized steel	20	Each	$ 197	$ 3,940	Carpenter and Patterson Price List CP-0114, Figure C1108
Structural	for clamp attachment	250	LF	$ 18	$ 4,500	Carpenter and Patterson Price List MS-0114, M132-RS Channel
Spring Nuts	3/8" nuts and screws	20	Each	$ 8	$ 160	Carpenter and Patterson Price List MS-0114, Regular Spring and HHC Screws
Hilti Bolts	3/8" Dia x 3 3/4" KB3, SS316	50	Each	$ 7	$ 373	HILTI Website, Item No. 282568 (1 box [50 pc] @ $373)
Dive Team	EM-385-1-1 Compliant Dive Team, 2 divers, 5 total with equipment	20	Day	$ 5,627	$ 112,540	Past Project Experience, 3.4% inflation added from 2014 to 2017 dollars
Field Service Johnson Screens	One technician for one trip consisting of 1.5 days. Additional days billed at $1,500 per day.	---	---	---	$ 4,500	Aqseptence Group, Inc. Quote
Upstream Bollards	Metal parking bumpers, pipe bollards, concrete filled/painted, 8 ft L x 4 ft diameter hole, 12" diameter	8	Each	$ 1,423	$ 11,382	RSMeans 2017 Line Number 32 17 13.13 1500 (Total O&P) and RSMeans Line Number 06 13 33.52 0220 (Bare Labor and Equipment for installation surcharge)
Mobilization	Mobilization, barge, by tug boat	100	Mile	$ 81	$ 8,050	RSMeans 2017 Line Number 06 13 33.52 0300
Hydraulic Model Study	Develop model for Unit 1 intake	---	---	---	$ 45,496	Past Project Experience, 3.4% inflation added from 2014 to 2017 dollars
Total Work Scope						
			Subtotal	---	$ 2,654,205	
			Conceptual Design Contingency	20%	$ 530,841	RSMeans 2017 Line Number 01 21 16.50 0100
			Construction Management	4%	$ 106,168	RSMeans 2017 Line Number 01 11 31.20 0350
			Unique Project Inexperience	10%	$ 265,420	RSMeans 2017 Line Number 01 21 55.50 0600
			Material Storage Area	2%	$ 53,084	RSMeans 2017 Line Number 01 21 55.50 1000
			Work Space Not Available	5%	$ 132,710	RSMeans 2017 Line Number 01 21 55.50 1400
				Procurement and Construction Subtotal	$ 3,742,429	
Location Factor						
			Manchester, New Hampshire Location Factor	95.6		RSMeans 2017 City Index 031 (Manchester, New Hampshire)
				Recommended Unit 1 Construction Budget	**$ 3,578,000**	(Rounded to Nearest $1,000)

Wedgewire Screen Option Construction Cost Estimate - Unit 2

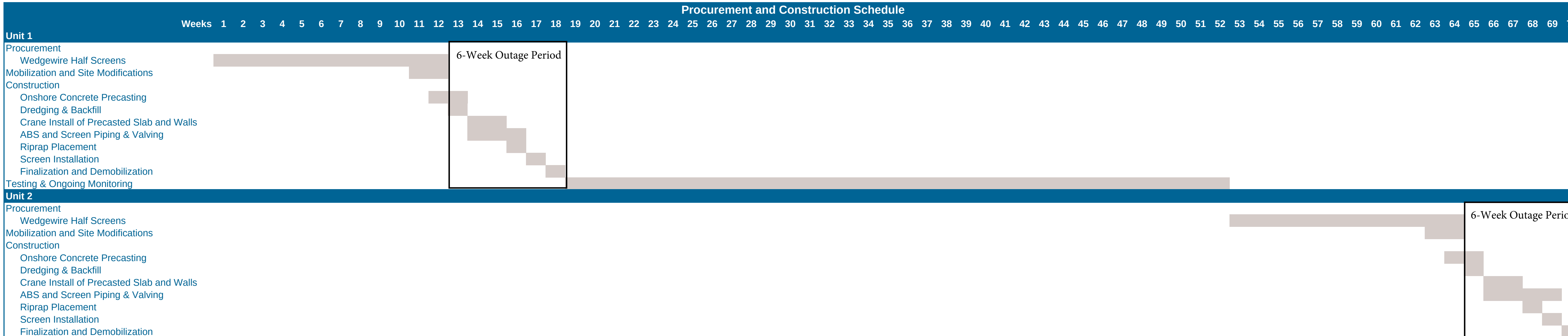
Item	Description	Quantity	Unit	Unit Price	Cost	Source
Procurement Costs						
Wedgewire Screens for Unit 2	Johnson Low Profile Half T-96HCE, (49" height, 303" length), Z-Alloy	5	Each	$ 283,956	$ 1,419,780	Aqseptence Group, Inc. Quote
316 Stainless Steel Piping (44" NPS)	Piping from Wedgewire Screen to Intake (black steel, plain end, welded, 3/8" thickness, 44" diameter)	100	LF	$ 1,957	$ 195,717	RSMeans 2014 Line Number 33 11 13.40 1090, scaled by exponential size ratio (n=1.33), multiplied by a factor of 3 for SS**
316 Stainless Steel Piping (8" NPS)	Piping from Wedgewire screen to ABS (Schedule 40, 8" diameter, includes coupling & clevis hanger assemblies)	500	LF	$ 453	$ 226,500	RSMeans 2017 Line Number 22 11 13.48 1140, multiplied by a factor of 3 for SS**
Tasks for Wedgewire Screen Implementation						
River Bed Dredging	Hydraulic dredging, pumped 1000' to shore dump, maximum	200	BCY	$ 17	$ 3,430	RSMeans 2017 Line Number 35 20 23.23 1100
Mobilization/Demobilization of Dredger	Dredging mobilization and demobilization, average of maximum and minimum	2	Each	$ 47,550	$ 95,100	RSMeans 2017 Line Numbers 35 20 23.13 0020 & 35 20 23.13 0100 Average
Backfill	Crushed stone, 3/4" - 1/2"	100	LCY	$ 42	$ 4,168	RSMeans 2017 Line Number 31 23 23.16 0100
Backfill Haul	Structural backfill, 300' haul sand and gravel	100	LCY	$ 4	$ 379	RSMeans 2017 Line Number 31 23 23.14 2400
Backfill Compacting	Compacting bedding in trench	100	ECY	$ 6	$ 575	RSMeans 2017 Line Number 31 23 23.16 0500
Riprap	Riprap and rock lining, machine placed for slope protection, 18" minimum thickness, not grouted	75	SY	$ 104	$ 7,800	RSMeans 2017 Line Number 31 37 13.10 0200
Precast Concrete Walls	Plenum walls over 1% reinforcing (4,000 psi)	225	CY	$ 2,687	$ 604,575	RSMeans 2017 Line Number 03 30 53.40 0740
Precast Concrete Foundation Pads	Foundation mat (3000 psi), over 20 CY (includes forms, rebar, concrete, placement and finish)	200	CY	$ 356	$ 71,112	RSMeans 2017 Line Number 03 30 53.40 4050
Crane on Bridge	Crane, 350-ton capacity, 80' boom, crawler mounted, 1/2 CY, 15 tons at 12' radius	1	Month	$ 37,800	$ 37,800	RSMeans 2017 Line Number 01 54 33.60 1500
Mobilization/Demobilization of Crane	Mobilization, over 75-ton capacity crane (with chase vehicle), up to 25 mile haul distance (50 mile RT)	2	Each	$ 18,575	$ 37,150	RSMeans 2017 Line Number 01 54 36.50 2400
Cable Jacks	Thirty five(35) cable jacks, 10-ton capacity with 200' cable	1	Month	$ 36,750	$ 36,750	RSMeans 2017 Line Number 01 54 33.60 6600
Operation	Daily crane crew, 80-ton truck-mounted hydraulic crane	15	Day	$ 3,900	$ 58,500	RSMeans 2017 Line Number 01 54 19.50 0500
Hydraulic Sluice Gates	316 stainless steel hydraulic sluice gate	2	Each	$ 325,712	$ 651,424	Past project experience for 96" x 166", 3.4% inflation added from 2014 to 2017 dollars
Pipe Lay Materials						
44" Elbow	44" welded elbow and 150-lb flange connection, stainless steel 316	2	Each	$ 39,760	$ 79,520	Past project experience, approximate cost of 30" elbow flanges, scaled by exponential size ratio (n=1.33), 3.4% inflation added from 2014 to 2017 dollars
44" Flange	44" welded neck flange	5	Each	$ 19,336	$ 96,679	RSMeans 2017 Line Number 22 11 13.47 6559, scaled by exponential size ratio (n=1.33), multiplied by a factor of 3 for SS**
44" Tee	44" welded tee, stainless steel 316	2	Each	$ 55,664	$ 111,328	Add 40% for tee to past project experience estimate for elbow flange
8" Elbow	8" elbow butt-welded, stainless steel 316	30	Each	$ 1,860	$ 55,800	RSMeans 2017 Line Number 22 11 13.66 3380
8" Flange	8" slip-on welded flange connection, stainless steel 316	10	Each	$ 2,268	$ 22,675	RSMeans 2017 Line Number 22 11 13.66 6400
8" Pipe Clamp	8" pipe clamp, galvanized steel	30	Each	$ 197	$ 5,910	Carpenter and Patterson Price List CP-0114, Figure C1108
Structural	for clamp attachment	500	LF	$ 18	$ 9,000	Carpenter and Patterson Price List MS-0114, M132-RS Channel
Spring Nuts	3/8" nuts and screws	50	Each	$ 8	$ 400	Carpenter and Patterson Price List MS-0114, Regular Spring and HHC Screws
Hilti Bolts	3/8" Dia x 3 3/4" KB3, SS316	50	Each	$ 7	$ 373	HILTI Website, Item No. 282568 (1 box [50 pc] @ $373)
Dive Team	EM-385-1-1 Compliant Dive Team, 2 divers, 5 total with equipment	30	Day	$ 5,627	$ 168,810	Past Project Experience, 3.4% inflation added from 2014 to 2017 dollars
Field Service Johnson Screens	One technician for one trip consisting of 1.5 days. Additional days billed at $1,500 per day.	---	---	---	$ 4,500	Aqseptence Group, Inc. Quote
Hydraulic Model Study	Develop model for Unit 2 intake	---	---	---	$ 45,496	Past Project Experience, 3.4% inflation added from 2014 to 2017 dollars

Total Work Scope			
Subtotal	---	$ 4,005,755	
Conceptual Design Contingency	20%	$ 801,151	RSMeans 2017 Line Number 01 21 16.50 0020
Construction Management	4%	$ 160,230	RSMeans 2017 Line Number 01 11 31.20 0350
Unique Project Inexperience	10%	$ 400,576	RSMeans 2017 Line Number 01 21 55.50 0600
Material Storage Area	2%	$ 80,115	RSMeans 2017 Line Number 01 21 55.50 1000
Work Space Not Available	5%	$ 200,288	RSMeans 2017 Line Number 01 21 55.50 1400
Procurement and Construction Subtotal		$ 5,648,115	
Location Factor			
Manchester, New Hampshire Location Factor	95.6		RSMeans 2017 City Index 031 (Manchester, New Hampshire)
Recommended Unit 2 Construction Budget		**$ 5,400,000**	(Rounded to Nearest $1,000)

Permitting and Engineering Cost Estimate - Both Units

Allowance for Permitting	2%	$ 179,560.00	RSMeans 2017 Line Number 01 41 26.50 0110
Detailed Engineering Design	10%	$ 897,800.00	RSMeans 2017 Line Number 01 21 16.50.0100
Permitting and Engineering Total		**$ 1,077,000**	(Rounded to Nearest $1,000)

Additional Line Items						
Additional Wedgewire Screen Backup	Johnson Low Profile Half T-96HCE, (49" height, 303" length), Z-Alloy	1	Each	$ 283,956	$ 283,956	Aqseptence Group, Inc. Quote
Additional Line Item Subtotal Budget					**$ 283,956**	



Notes

1. Procurement requires approximately 12 weeks, with construction drawing approval about 2-3 weeks after receipt of PO and shipment about 7-9 weeks after approval.
2. Schedule assumes no additional testing or studies prior to start of this phase of work.
3. Schedule is contingent upon suitable river and environmental conditions.