8 General Site Considerations

8.1 Aesthetic Impacts

The conversion of the Stations to closed-loop cooling would require several new structures to be constructed on the site (Section 2), the largest being the hybrid cooling towers. A Visual Assessment (VA) was prepared by visual analysis expert Saratoga Associates, Landscape Architects, Architects, Engineers and Planners, P.C. (Saratoga). Saratoga evaluated the potential visual impact of these structures on the scenic resources of the region consistent with applicable state and local law and policy [Ref. 12.25]. Saratoga concluded that, given their unprecedented scale and visual impact, construction and operation of cooling towers at IPEC, singularly or collectively, cannot be reconciled with applicable aesthetic standards, practice, or precedent. Specifically, Saratoga determined that the NYSDEC Proposed Project may be incompatible with the NYSDEC Visual Policy in that it impairs scenic resources of statewide significance. Furthermore, it is concluded that mitigation techniques would have little effect.

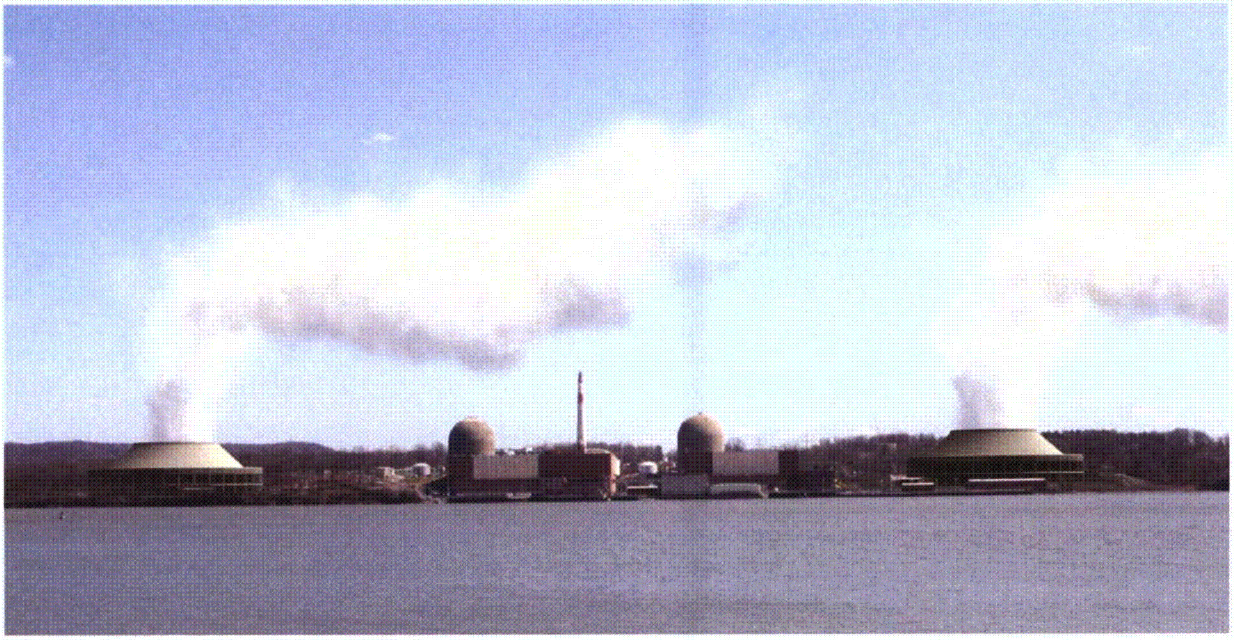


Figure 8.1 Visual Representation of Cooling Towers at IPEC[9]

8.2 Archaeological Considerations

Phase I-A and Phase I-B archeological studies were conducted by ENERCON to assess the presence of historic properties in the Area of Potential Effect (APE) from cooling tower installation at IPEC [Ref. 12.10]. The Phase I studies identified evidence of both historic and pre-historic components in the APE. Reports documenting these findings were submitted to

[9] The visual representation of cooling towers at IPEC provided is for wet-mode operation of the cooling towers. This has been provided to illustrate the magnitude of the plume that is created, either visible (wet-mode) or invisible (plume abated). It should be noted that even with plume abatement, a visible plume would occur under certain meteorological conditions.

the New York State Historic Preservation Office (NYSHPO). NYSHPO indicated that if a decision is made to install cooling towers, the APE should be reassessed, a geomorphological assessment should be conducted (if warranted), and a Phase II archaeological site examination should be conducted for the historic and prehistoric components identified in the Phase I studies. Additional information on the correspondence between ENERCON and NYSHPO is documented in Attachment 8.

In the event of a decision to proceed with the NYSDEC Proposed Project, a Phase II investigation would be undertaken to determine if significant archeological deposits are present. The duration and cost of a Phase II investigation is unknown at this time. Since no additional archaeological cost or schedule delay has been incorporated in this report, both cost and schedule are understated.

8.3 Local Zoning Restrictions

Entergy's counsel has advised that the NYSDEC Proposed Project will be subject to certain local zoning restrictions. IPEC is located within the M-2 Planned Industrial Zoning District of the Village of Buchanan and the Village Zoning Code establishes restrictions on both the use of, and dimensions of, structures located on property within this District [Ref. 12.2; Ref. 12.6].

8.3.1 Use Regulations

Section 211-10 of the Zoning Code authorizes "the peaceful use of atomic energy" as a principal use of the IPEC property [Ref. 12.6]. Entergy's counsel has advised that the Village may view the NYSDEC Proposed Project as a separate use, given the blasting, crushing, transport and potential sale of clean excavated spoils involved. Section 211 does not allow mining, and the Village may prohibit blasting and/or crushing operations. The Village does permit certain accessory uses, but these appear to be limited to residential uses (i.e., swimming pools, etc) and certain retail sales. Thus, obtaining the requisite zoning approvals for the NYSDEC Proposed Project is not assured.

8.3.2 Performance Standards Related to Non-Residential Uses

Section 211 of the Village Zoning Code also establishes standards for non-residential uses, including noise and air pollution standards [Ref. 12.6]. As discussed below, due to these standards, obtaining the requisite zoning approvals for the NYSDEC Proposed Project is not assured.

8.3.2.1 Noise

Section 211-23 establishes enforceable standards for noise generating activities [Ref. 12.6]. The table on the following page provides the allowable decibel levels (as measured at the property line), for each frequency range.

Frequency Ranges Containing Standard Octave Bands (cycles per second)	Octave Band Sound-Pressure Level (decibels)
20 to 75	65
75 to 150	55
150 to 300	50
300 to 600	45
600 to 1200	40
1200 to 2400	40
Above 2400	35

Adjustments to the above standards are available if the noise is "not smooth and continuous and is not radiated between the hours of 10:00 pm and 7:00 am." Because the cooling towers would be operated continuously and, therefore, would radiate noise between 10:00 pm and 7:00 am, these adjustments would not apply.

8.3.2.2 Other Forms of Air Pollution

Section 211-23 governs "other forms of air pollution" like fly ash, dust, fumes, vapors, and gases which can cause damage to health, animals, vegetation or property [Ref. 12.6]. As noted in Section 7, TRC determined that operation of the NYSDEC Proposed Project will result in emissions of greater than 100 tons per year of PM-10 and PM-2.5 [Ref. 12.29]. Thus, obtaining the requisite zoning approvals for the NYSDEC Proposed Project is not assured.

8.3.3 Dimensional Regulations

Sections 211-15 and 211-19 provide dimensional regulations for maximum building heights in the M-2 Zoning District: (a) 2.5 stories or 35 feet for principal buildings or (b) 2.0 stories or 25 feet for unattached structures accessory to a nonresidential building. The NYSDEC Proposed Project cooling towers are 165 feet tall (Section 2.1). Counsel has advised that the NYSDEC Proposed Project, therefore, will require a variance from the height limitation. Counsel has further advised that variances must be obtained from the Village Board of Appeal, and may take approximately 6 months from application to decision. This Village denied a prior attempt to obtain a variance for the construction of cooling towers at IPEC; this became the subject of extensive litigation.[10] Resolution of this litigation took 30 months from the date of the Board's variance denial to the final decision of the Court of Appeal overturning the Board's decision.

8.3.4 Site Development Plan Approval

Section 211-25 requires Planning Board approval of a final site development plan before the Village Building Inspector can issue a building permit [Ref. 12.6]. Section 211-26 indicates that this approval is discretionary and involves consideration of environmental, engineering, and aesthetic impacts [Ref. 12.6].

[10] Matter of Consolidated Edison Co. of New York, Inc. v. Hoffman, 43 N.Y.2d 598 (1978).

8.3.5 Conclusions

Entergy's counsel has advised that construction of the NYSDEC Proposed Project cannot proceed as of right. The project is dependent on approval from the Village of Buchanan, which is likely to be difficult to obtain based on past precedent. Based on precedent, it is assumed that zoning approvals and associated litigation would take approximately 36 months to resolve.

8.4 Sound Restrictions

Entergy's counsel has advised that the NYSDEC Proposed Project will be subject to certain local noise restrictions.

8.4.1 Code of the Village of Buchanan, Chapter 119

Chapter 119, Section 5 of the Village of Buchanan Code prohibits noise associated with construction or demolition between the hours of 7:00 p.m. and 8:00 a.m., if the noise can be heard by an individual with normal hearing on public property or beyond the boundaries of the property in question [Ref. 12.4]. All other loud or raucous noises likely to annoy or disturb people are also prohibited between 11:00 p.m. and 8:00 a.m. As shown in Attachment 2, the proposed locations for both NYSDEC Proposed Project cooling towers are within approximately 50 to 100 feet of the Hudson River (i.e., public property) and the Unit 3 proposed cooling tower is within approximately 50 to 100 feet of the property boundary with the Lafarge Corporation. It is, therefore, reasonable to conclude that a person of normal hearing located on the Hudson River or near the boundary with the Lafarge Corporation could hear noises associated with construction of the NYSDEC Proposed Project. As a result, it is likely that construction would be prohibited under Chapter 119 of the Buchanan Code between the hours of 7:00 p.m. and 8:00 a.m.[11]

8.4.2 Noise Impact Evaluation

The NYSDEC procedure for assessing noise effects is a tiered process that begins with a First Level Noise Impact Evaluation. The First Level Noise Impact Evaluation determines the maximum amount of sound created at a single point in time by multiple activities of the proposed project. Factors evaluated include sound characteristics (frequency and tone), receptor locations, and the resulting increase in noise from ambient levels. The Second Level Noise Impact Evaluation is subsequently performed and refines the evaluation of the noise impact potential by factoring in any additional noise attenuation that will be provided by the existing topography and fabricated structures including walls, berms, dense vegetation, or buildings. When the First and Second Level Noise Impact Evaluations indicate that significant noise effects may occur from a proposed project, a Third Level Noise Impact Evaluation is performed that evaluates the options for implementation of mitigation measures that avoid or diminish significant noise effects to acceptable levels.

[11] An ambient sound monitoring program was conducted in the vicinity of Units 2 and 3 between September 2001 and January 2002 [Ref. 12.30]. The program concluded that both cooling towers operating continuously will cause in increase in noise levels at sensitive receptors of 1 dB(A) or less. Thus, operation of the NYSDEC Proposed Project cooling towers – as distinct from construction activities –is not likely to have a recognizable noise impact.

Mitigation measures may include reducing noise frequency or impulse noise by changing equipment, modifying equipment, or using the appropriate mufflers; reducing noise duration by limiting the days of operation or hours where construction is allowed; and, reducing noise levels by increasing setbacks, erecting sound barriers, or preserving natural barriers as possible.

As stated above, construction activities to convert Units 2 and 3 to closed-loop cooling would likely be restricted to between 8:00 a.m. and 7:00 p.m. and would require a noise impact evaluation.

9 Construction and Outage Duration

As discussed in Section 2, three design alternatives are considered for closed-loop cooling at IPEC: (1) retrofit both Units to closed-loop cooling, (2) retrofit only Unit 2 to closed-loop cooling, or (3) retrofit only Unit 3 to closed-loop cooling. Conceptual construction and outage schedules have been developed for all three alternatives and are provided in Attachment 9. Considering the conceptual nature of the current design parameters and the unknown forces outside of the project's direct control, many of the tasks are aggressively optimistic and could be severely impacted as work progresses. The initial design and all permitting and licensing requirements are assumed to be completed prior to the start of construction. Construction work and field engineering would continue in tandem up to and through the recommended outage period.

Several factors could present significant scheduling challenges but were not considered for the conceptual construction and outage schedule. These issues, along with the scheduling issues addressed in this report, include but are not limited to:

- Duration of regulatory agency interactions (e.g., federal, state and local zoning/permitting/licensing restrictions).
- Prior relocation of the Algonquin gas pipeline.
- Uncertainty surrounding the large volume of uncontaminated and radiologically contaminated spoils and construction debris disposal.
- Construction delays due to the possible disturbance of tritiated groundwater pathway.
- Riverside activities and potential maritime implications.
- Archaeological concerns delaying construction or requiring resiting of the cooling towers.
- Resource availability (material, equipment, and most specifically craft labor).
- Impacts of increased plant security and the necessary construction equipment access.
- Unpredictable weather phenomena (e.g., blasting weather restrictions).

The above concerns are not all inclusive but represent some of the major challenges to the NYSDEC Proposed Project. It would be difficult to determine the exact impacts at this point based on probability or severity of the issue involved, but each would tend to increase overall cost and schedule, some substantially.

Subject to the uncertainty detailed above, Attachment 9 provides a schedule of the significant construction activities for each of the three design alternatives. It should be noted that to accurately reflect the timeframe during which construction activities would begin, the estimated local zoning/permitting duration of 36 months, provided by Entergy's counsel, is included within each schedule.

9.1 Conversion of Unit 2 and Unit 3

As discussed in Section 2.1, the conversion of both Units 2 and 3 to closed-loop cooling would require the installation of two round hybrid cooling towers and the associated piping and equipment. As shown in Attachment 9, the total length of construction would extend approximately 97 months including approximately 42 weeks of continuous forced outage. Considering the conceptual nature of the current design parameters and the unknown effects of outside forces, the scheduling of many tasks are understated and could be significantly impacted, as discussed above.

9.1.1 Online Construction Schedule

As discussed in Section 2.1, the cooling towers would be placed to the northeast and southwest of the Station's Containment Buildings, as shown in Attachment 2, Sketch ENTGNU011-SK-001. To this extent, construction activities that would not be impactive to operation, including excavation of the cooling tower basins and relocation of the Algonquin Pipelines, could be conducted with each Unit online.

Prior to construction of the cooling towers, several general site activities would have to be completed at both Units, including access road construction, fence relocation and additions, environmental protection measures, barge access construction and security modifications. Approximately 13 weeks of general construction activities would be required at Unit 2 prior to cooling tower construction.

Several additional activities would have to be undertaken at Unit 3, including relocation of the Algonquin pipelines, an existing parking lot, and the current sewage lift station and the demolition of the existing sewage treatment facilities that would result in approximately 118 weeks of general construction activities prior to the construction of the cooling tower. Therefore, construction of the Unit 2 cooling tower would be able to begin first, and, after the additional activities were finished at Unit 3, construction of the Unit 3 cooling tower could begin.

Subject to schedule uncertainty, cooling tower construction would be limited by the drilling rate of blast operations, as discussed in Section 5, and is estimated to take approximately 271 weeks at Unit 2 and 284 weeks at Unit 3 (see Attachment 9). Construction of the Unit 3 cooling tower would begin approximately 3 months after the start of construction on the Unit 2 cooling tower. As discussed in Section 5, construction of hybrid cooling towers would entail significant excavation at IPEC and would require approximately 4 years for blasting and rock removal alone.

9.1.2 Outage Construction Schedule

In contrast to those activities outlined in Section 9.1.1, due to the proximity of several construction activities to nuclear safety-related equipment and the impact on or removal of equipment necessary for power generation (e.g., circulating water pumps), certain activities would require consecutive extended construction outages. Due to the joint nature of several of the construction activities (i.e., demolition of the Riverfront area, construction of the pump houses in the existing discharge canal, etc.) the construction outages would be conducted concurrently. Approximately 42 weeks of continuous outage for the construction and implementation of closed-loop cooling would be required for each Unit. At IPEC, maintenance and refueling outages are scheduled to occur approximately every 24 months for each Unit and typically last approximately 25 days. The scheduled outages are staggered so that both Units are not offline at the same time; therefore it is likely that the extended construction outages could be scheduled to coincide with one Unit's scheduled maintenance outage.

9.2 Conversion of Only Unit 2

As discussed in Section 2.2, the conversion of Unit 2 to closed-loop cooling would require the installation of one round hybrid cooling tower and the associated piping and equipment. As shown in Attachment 9, the total length of construction would extend more than 73 months including approximately 42 weeks of continuous outage, scheduled to coincide with Unit 2 maintenance and refueling outage (i.e., a 38 week continuous forced outage). Considering the conceptual nature of the current design parameters and the unknown effects of outside forces, the scheduling of many tasks represents a best-case scenario and could be significantly impacted, as discussed above.

9.2.1 Online Construction Schedule

As discussed in Section 2.2, the Unit 2 cooling tower would be placed to the northeast of Unit 2, as shown in Attachment 2, Sketch ENTGNU011-SK-002. To this extent, construction activities that would not be impactive to operation, including excavation of the cooling tower basin, could be conducted with the Unit online.

Prior to construction of the cooling towers, several general site activities would have to be completed including access road construction, fence relocation and additions, and security modifications environmental protection. In addition to these activities, barge access construction would be required resulting in approximately 13 weeks of general construction activities prior to cooling tower construction.

Subject to schedule uncertainty, cooling tower construction is estimated to take approximately 270 weeks (see Attachment 9). As discussed in Attachment 7, construction of a hybrid cooling tower at Unit 2 would entail significant excavation and would require approximately 4 years for blasting and rock removal alone.

9.2.2 Outage Construction Schedule

In contrast to those activities outlined in Section 9.2.1, due to the proximity of several construction activities to nuclear safety-related equipment and the impact on or removal of equipment necessary for power generation (e.g., circulating water pumps), certain activities would require consecutive extended construction outages. Approximately 42 weeks of continuous outage for the construction and implementation of closed-loop cooling would be required. At IPEC, maintenance and refueling outages are scheduled to occur approximately every 24 months and typically last approximately 25 days. It is likely that the extended construction outages could be scheduled to coincide with Unit 2's scheduled maintenance outage, resulting in a non-planned forced construction outage of approximately 38 weeks.

9.3 Conversion of Only Unit 3

As discussed in Section 2.3, the conversion of Unit 3 to closed-loop cooling would require the installation of one round hybrid cooling tower and the associated piping and equipment. As shown in Attachment 9, the total length of construction would extend approximately 98 months including approximately 42 weeks of continuous outage, scheduled to coincide with Unit 3 maintenance and refueling outage (i.e., a 38 week continuous forced outage). Considering the conceptual nature of the current design parameters and the unknown effects of outside forces, the scheduling of many tasks represents a best-case scenario and could be significantly impacted, as discussed above.

9.3.1 Online Construction Schedule

As discussed in Section 2.3, the cooling tower would be placed to the southwest of the Unit 3, as shown in Attachment 2, Sketch ENTGNU011-SK-003. To this extent, construction activities that would not be impactive to operation, including excavation of the cooling tower basin and relocation of the Algonquin Pipelines, could be conducted with the Unit online.

Prior to construction of the cooling towers, several general site activities would have to be completed including access road construction, fence relocation and additions, and security modifications environmental protection. In addition to these activities, barge access construction, relocation of the Algonquin pipelines, an existing parking lot, and the current sewage lift station and the demolition of the existing sewage treatment facilities would result in approximately 118 weeks of general construction activities prior to the construction of the cooling tower.

Subject to schedule uncertainty, cooling tower construction is estimated to take approximately 288 weeks (see Attachment 9). As discussed in Attachment 7, construction of a hybrid cooling tower at Unit 3 would entail significant excavation and would require approximately 4.2 years for blasting and rock removal alone.

9.3.2 Outage Construction Schedule

In contrast to those activities outlined in Section 9.3.1, due to the proximity of several construction activities to nuclear safety-related equipment and the impact on or removal of equipment necessary for power generation (e.g., circulating water pumps), certain activities would require consecutive extended construction outages. Approximately 42 weeks of continuous outage for the construction and implementation of closed-loop cooling would be required. At IPEC, maintenance and refueling outages are scheduled to occur approximately every 24 months and typically last approximately 25 days. Subtracting the planned maintenance outage from the construction outage duration, implementation of closed-loop cooling at Unit 3 would require a non-planned forced construction outage of approximately 38 weeks.

10 Economic and Power Loss Estimates

This section estimates the costs or lost electrical generation for the five major aspects of converting IPEC Units 2 and 3 to closed-loop cooling:

- initial capital costs
- construction outage lost electrical generation
- lost electrical generation due to new condenser operating parameters
- lost electrical generation due to parasitic losses
- operation and maintenance costs, including water treatment costs

The capital costs of the closed-loop conversion include design, procurement, implementation, and startup activities, as detailed in Attachment 10. The duration of the required Unit outages described in Section 9 is used to determine the lost electrical generation.

10.1 Initial Capital Costs

The initial capital costs to convert the Stations to closed-loop cooling include the cost of engineering design; the selection, procurement, and installation of major equipment (i.e., cooling towers, pumps, valves, etc.); and the costs of closed-loop construction, including the blasting required to excavate the cooling tower areas. Capital cost estimation was done in such a way as to minimize the necessary assumptions, and relied instead on well-developed, detailed conceptual designs to increase the accuracy of the estimates. The 2003 Report (Attachment 1) lists the components and construction activities necessary for closed-loop operation, providing a high level of detail to the conceptual design estimation.

Three estimation techniques were used to determine the initial capital costs:

(1) Vendor provided budgetary estimates

Leading industry vendors were contacted for updated quotations on the major equipment and material components to allow for as accurate an estimation as possible, with the correspondence, reference material, and quotations provided in Attachment 9.

(2) Third-party detailed construction estimates

Since blasting at each of the cooling tower sites would require a unique engineering solution, a nationally recognized consultant was used to determine a conceptual design, cost, and schedule for blasting (Attachment 7).

(3) Computational estimation utilizing national production rates and cost factoring

Remaining cooling equipment and construction activities were estimated using 2009 RSMeans cost data software at MeansCostWorks.com. RSMeans is a construction cost estimating tool that provides detailed cost estimates for the construction industry including labor, piping, concrete, industrial equipment, electrical systems, and other heavy construction components.

The capital cost estimate contained in Attachment 9 combines these resources to produce a conceptual cost analysis. The major cost centers were defined and presented in line item format in order to provide flexibility in the application of cost. Some of these line items would be equally shared by both Units 2 and 3 as several of the required construction activities would be common between both Units. These common costs would not simply be cut in half and are conservatively assumed to remain if only one Unit were converted to closed-loop cooling since there would be additional costs associated with ensuring that the operating Unit not being converted would not be adversely impacted by construction at the other Unit. The engineering, design, and inspection cost was estimated at 15% of estimates which were not quoted for turn-key construction [Ref. 12.31].

The anticipated direct capital cost (presented in 2009 US dollars) for the conversion for both IPEC Unit 2 and Unit 3 is collectively estimated at a minimum of $1.19 billion without any escalation over time. The anticipated direct capital cost for the conversion of only Unit 2 is estimated at a minimum of $629 million, and the anticipated direct capital cost for the conversion of only Unit 3 is estimated at a minimum of $649 million, without any escalation over time. The one-time costs of conversion of both IPEC Units 2 and 3 to closed-loop cooling are summarized in Table 11.1.

Table 10.1 One-Time Costs of Conversion of both Units 2 and 3 to Closed-Loop Cooling

Capital Costs - Design	Estimated Cost
Design Engineering and Modification Packages	$ 25,526,000
Project Management and Support Labor	$ 44,598,000
Capital Costs - Turn-Key Estimates	**Estimated Cost**
Blasting	$ 40,108,000
Round Hybrid Cooling Tower (2)	$ 410,000,000
Relocation of Algonquin Pipeline	$ 13,800,000
Subtotal	$ 463,908,000
Capital Costs - Construction	**Estimated Cost**
Phase I - Online (Pre-Outage)	$ 89,495,000
Phase II - Offline (Outage Required)	$ 80,672,000
Subtotal	$ 170,167,000
Capital Costs - Total Work Scope	**Estimated Cost**
Subtotal	$ 704,199,000
Corporate Overheads and Work In Progress Cost (30%)	$ 211,260,000
Recommended Minimum Contingency (30%)	$ 274,638,000
Total One-Time Costs	**$ 1,190,097,000**

10.2 Lost Electrical Generation Due to Construction Outage

From the construction schedules discussed in Section 9 and detailed in Attachment 9, IPEC Units 2 and 3 would require approximately 42 weeks of continuous outage for the construction and implementation of closed-loop cooling. Maintenance and refueling outages are scheduled to occur approximately every 24 months for each Unit and typically last approximately 25 days. The scheduled outages are staggered so that both Units are not offline at the same time; therefore it is likely that the extended construction outages could be scheduled to coincide with one Unit's scheduled maintenance outage. Subtracting the planned maintenance outage from the construction outage duration, one Unit would require a non-planned construction outage of approximately 38 weeks. As Unit 2 and Unit have respective net capacities of 1078 MWe and 1080 MWe, a 42 week outage at Unit 2 and a 38 week outage at Unit 3 would result in approximately 14,502,000 MWhr of lost electrical generation. A subsequent report will address forced outage costs specifically.

As noted in Section 9, the estimated schedule is understated.

10.3 Lost Electrical Generation Due to New Condenser Operating Parameters and Parasitic Losses

As discussed in Section 3, Unit 2 and Unit 3 are water-dependent, requiring a specific quantity of cooling water at a specific design temperature, here consistently cold Hudson River water. Below this design temperature, the Stations have the capability of marginally increasing electrical production; however, above this design temperature the Stations produce significantly less electricity and could ultimately impact the low pressure turbine procedural limits. To analyze the effect closed-loop cooling would have on the Stations' electrical generation, a state-of-the-art PEPSE model for each Unit was used. As discussed in Section 3, the annual average continuous operational losses for Units 2 and 3 were determined to be 11.1 MWe and 4.7 MWe, respectively; however, operational power losses would peak during warmest conditions when electricity demand is at its highest. Over the historical data analyzed (2001-2008), the peak combined operational power loss occurred on June 7th, 2008 at 2PM, and accounted for a combined operational power loss of 85.4 MWe.

As discussed in Section 3.2.2.2, the equipment necessary to operate closed-loop cooling at Unit 2 and Unit 3 would require significant input electricity, referred to as parasitic losses. Closed-loop conversion of the Stations utilizing hybrid cooling towers would require a continuous 36.1 MWe per Unit aggregate parasitic loss (72.2 MWe, total).

The lost electrical generation from both the ongoing operational efficiency losses associated operating beyond the original condenser design conditions and the parasitic losses associated with the pumps and cooling tower fans is summarized in Table 10.2. These losses require replacement sources, as will be addressed in a separate report.

Table 10.2 Lost Electrical Generation from Conversion of both Units 2 and 3 to Closed-Loop Cooling

Lost Electrical Generation	Annual Average	Peak*
Operational Efficiency Losses	15.8 MWe	85.4 MWe
Parasitic Losses**	72.2 MWe	72.2 MWe
Total Lost Electrical Generation	88.0 MWe	157.6 MWe

*Over the historical data analyzed (2001-2008), the peak combined operational power loss occurred on June 7th, 2008 at 2PM.
**Parasitic losses are continuous, and thus the annual average and peak electrical losses are the same.

10.4 Operations and Maintenance Costs

As discussed in Section 3.3 of the 2003 Report (Attachment 1), significant operations and maintenance (O&M) support for the closed-loop cooling systems would be required. Additional O&M costs for the components added due to the conversion to closed-loop cooling were estimated by identifying the general tasks for each component, and then based on operational experience and input from vendors, quantifying the estimated required man-hours and associated costs.

Although the conversion to closed-loop cooling is complex, significant new/modified plant components would be limited to the cooling towers with their fans and booster pumps, and the appreciably larger circulating water pumps located in new pump houses. Based on the tasks identified in the 2003 Report, annual additional operations support for the closed-loop configuration is estimated to be approximately $336,000 for each Unit. Based on vendor estimates and historical data, the maintenance costs per Unit were estimated as follows:

Annual maintenance cost estimate per Unit (years 1-5)	$670,000
Annual maintenance cost estimate per Unit (years 6-15)	$1,340,000
Annual maintenance cost estimate per Unit (years 16-20)	$2,680,000

As discussed in Section 3.6 of the 2003 Report (Attachment 1), additional chemicals would be injected into the makeup circulating water to prevent micro and macro fouling of the main condenser and cooling towers. Appreciably increased costs would be associated with the increased level of water treatment required for closed-loop cooling. Local conditions could greatly affect annual costs, but an annual cost per Unit of approximately $1,005,000 would be extremely conservative (i.e., understated).

To support the equipment necessary for continuous closed-loop operation, significant operation and maintenance would be incurred. Below is a summation of these annual costs per Unit including labor and material for the hybrid cooling towers and water treatment.

Years 1 - 5	$2,011,000/year
Years 6 - 15	$2,681,000/year
Years 16 - 30	$4,021,000/year

11 Conclusions

Several site-specific conditions exist at IPEC that would challenge the feasibility of the NYSDEC Proposed Project. These challenges significantly impact the expected duration and cost of the project, which are based on conceptual design absent any practical history of closed-loop cooling retrofits at nuclear facilities.

11.1 Challenges to the NYSDEC Proposed Project

Challenges to the NYSDEC Proposed Project include, but are not limited to, the following:

- Air emissions resulting from operation of the cooling towers would exceed the National Ambient Air Quality Standards for PM_{10} and $PM_{2.5}$. Available mitigation measures would not sufficiently redress air quality concerns in a manner consistent with applicable regulatory requirements.
- Due to the size of the structures, construction and operation of cooling towers at IPEC may be incompatible with the NYSDEC Visual Policy in that they would impair scenic resources of statewide significance. The addition of the cooling towers would have a significant negative aesthetic impact on the surrounding area.
- Documented prehistoric artifacts found in the Unit 3 cooling tower location indicate that a site of archeological significance may exist.
- The construction of cooling towers cannot proceed prior to obtaining a variance from the Village of Buchanan Board of Appeal (to allow construction in excess of the maximum height allowed) and a site development plan approval from the Village Planning Board for the construction of the cooling towers. Village officials are on record in opposition of the construction of cooling towers at IPEC and local zoning approvals may be difficult to obtain.
- Algonquin Gas Transmission pipelines currently exist where the Unit 3 tower would be constructed and would require relocation. The Algonquin Gas Transmission pipelines supply approximately 50% of the natural gas demand in New England and this supply cannot be interrupted. A preliminary evaluation suggests that relocation of the pipelines may be feasible; however, further evaluation of the pipeline relocation may impact the location and/or feasibility of the Unit 3 cooling tower. Any relocation of the Algonquin pipeline would require the prior approval of the FERC.
- Excavation in the Riverfront area would intersect groundwater contamination plumes containing tritium and strontium. Construction delays may be introduced due to the disturbance of these plumes and the mitigation measures required to properly manage radiologically contaminated materials.
- Conversion of the Stations to closed-loop condenser cooling would require the excavation of approximately 2 million cubic yards of soil and inwood marble bedrock. Blast removal would be required to excavate large quantities of inwood marble bedrock at the cooling tower locations and in the piping trenches outside of the Riverfront area. Because a forced outage at both Units would represent a considerable loss in power generation, blasting operations are proposed to occur while both Units are online. A

preliminary blasting plan is based on IPEC seismic design bases; however, site-specific testing and evaluation of blast vibration on individual plant components would be required to finalize blasting limitations and methods.

- A continuous supply of approximately 27,400 gpm of makeup water would be required for evaporative cooling tower operation. Unlike the current once-through cooling, the water lost through evaporation and drift from the towers would not be returned directly to the Hudson River, but instead would represent a true loss of cooling water. This would result in a loss of Hudson River water averaging nearly 30 million gallons per day.
- The topography of the IPEC site and general space constraints limit the potential locations for cooling towers. The elevation of the tower basin must be sufficiently low to prevent damage to condenser tubes. In addition, the towers require a 700 ft diameter excavation for clearance to ensure adequate air flow. The tower locations considered in this Report address these concerns, but any required relocation may have significant feasibility impacts on the project.
- Conversion of IPEC to closed-loop cooling would be an unprecedented undertaking that would likely encounter unforeseen challenges during design and implementation. Thus, assumptions about engineering feasibility, while based on best professional judgment, do not have the benefit of either available technology or past efforts at comparable facilities.

11.2 Duration of the NYSDEC Proposed Project

The total duration of the NYSDEC Proposed Project is expected to extend almost 13 years. An eighteen month design period would precede NYSDEC approval of the project. A delay of 36 months is anticipated between NYSDEC approval and the start of construction for litigation on project permitting. The estimated length of construction for retrofit of both Units 2 and 3 would extend 97 months, and include an estimated 42 weeks of continuous forced outage and the permitting and construction period for relocation of the Algonquin pipeline. The drilling, blasting, and spoils removal would be expected to take approximately 4 years. Considering the conceptual nature of the current design parameters, the lack of comparable retrofits, and typical unknown conditions that arise in major construction projects, this schedule represents a best-case scenario; significantly longer durations than currently estimated could result.

If only Unit 2 were converted to closed-loop cooling, the total length of construction would extend more than 73 months including approximately 42 weeks of continuous outage, scheduled to coincide with Unit 2 maintenance and refueling outage (i.e., a 38 week continuous forced outage). If only Unit 3 were converted to closed-loop cooling, the total length of construction would extend more than 98 months including approximately 42 weeks of continuous outage, scheduled to coincide with Unit 2 maintenance and refueling outage (i.e., a 38 week continuous forced outage). The design and permitting periods would be similar to those for conversion of both Units.

11.3 Cost and Power Loss of the NYSDEC Proposed Project

The anticipated direct overnight capital cost for the conversion for both IPEC Unit 2 and Unit 3 is collectively estimated at a minimum of $1.19 billion without any escalation over time. If individually converted to closed loop cooling, IPEC Unit 2 and Unit 3 would have estimated capital costs of $629 million and $649 million, respectively.

As Unit 2 and Unit 3 have net capacities of 1078 MWe and 1080 MWe, respectively, a 42-week outage at both Units 2 and 3, accounting for a coincident maintenance outage at one Unit, would result in approximately 14,502,000 MWhr of lost electrical generation.

In addition to one-time costs and power loss, IPEC would also incur annual costs due to conversion to closed-loop cooling. Annual operations and maintenance costs associated with closed-loop cooling at IPEC would be more than $4 million for the first five years, with increasing costs in the subsequent years due to the need for increased equipment replacement and repair. IPEC would also incur ongoing operational and parasitic electrical generation losses. If the effect of closed-loop conversion on plant operation is averaged across the entire year, the combined operational losses due to decreased condenser efficiency would be approximately 15.8 MWe; however, operational power losses would peak during warmest conditions when electricity demand is at its highest. Over the historical data analyzed, the peak combined operational power loss occurred on June 7th, 2008 at 2PM, and accounted for a combined operational power loss of 85.4 MWe. Additional parasitic losses from the circulating water pumps and the cooling tower fans and booster pumps would add an additional 36.1 MWe per Unit in power generation losses. Summing the operational and parasitic losses, Units 2 and 3 combined would experience an average power generation loss of 88.0 MWe and peak summer power generation loss of 157.6 MWe. For reference, 157.6 MWe is enough electricity to satisfy the average power consumption of more than 1.38 million U.S. households.[12]

[12] Calculation based on the 2007 average U.S residential electricity consumption of 936 kWh and the 2007 national-level transmission and distribution loss of 6.5% [Ref. 12.32].

12 References

12.1 Barlow, G. Precision Blasting in Shadow of On-Line Plant. Electrical World. February 1, 1979. pp. 43-45.

12.2 Buchanan Village Board. Comprehensive Master Plan: Village of Buchanan, NY. March 2005. Available at URL: http://www.fpclark.com/buchanan/masterplan.html Accessed February 3, 2010.

12.3 10 CFR Part 61.55. Code of Federal Regulations, Title 10, Energy, Part 61, Licensing Requirements for Land Disposal of Radioactive Waste

12.4 Code of the Village of Buchanan. Chapter 119, Noise.

12.5 Code of the Village of Buchanan. Chapter 143, Quarrying and Blasting.

12.6 Code of the Village of Buchanan. Chapter 211, Zoning.

12.7 Consolidated Edison Company of New York, Inc. Economic and Environmental Impacts of Alternative Closed-Cycle Cooling Systems for Indian Point Unit 2. Volume No. 1. December 1, 1974.

12.8 Enercon Services, Inc. Evaluation of Alternative Intake Technologies at Indian Point Units 2 & 3. 2010.

12.9 Enercon Services, Inc. Feasibility Study for Installation of Cooling Towers at San Onofre Nuclear Generating Station. 2009.

12.10 Enercon Services, Inc. Phase IB Archeological Investigation of Potential Cooling Tower Construction Sites at Indian Point Energy Center, Westchester County, New York. July 2009.

12.11 Entergy Nuclear Operations, Inc. Applicant's Environment Report, Operating License Renewal Stage. Appendix E to Indian Point, Units 2 and 3, License Renewal Application. April 23, 2007.

12.12 Entergy Nuclear Operations, Inc. Procedure EN-DC-114. Project Management. Rev. 10. June 12, 2009.

12.13 GZA GeoEnvironmental, Inc. Final IPEC Quarterly Long-Term Groundwater Monitoring Report: Quarter Four 2008. New York, New York. September 1, 2009.

12.14 GZA GeoEnvironmental, Inc. Hydrogeologic Site Investigation Report, Indian Point Energy Center, Buchanan, New York. Norwood, Massachusetts. January 7, 2008.

12.15 Indian Point Energy Center. Procedure 2-ARP-SDF. Turbine Recorder. Rev. 24. 2007.

12.16 Indian Point Energy Center. Procedure 3-ARP-007. Panel SDF – Turbine Recorder. Rev. 27. 2009.

12.17 Indian Point Energy Center. Indian Point 2 UFSAR. Rev. 21. 2008.

12.18 Indian Point Energy Center. Indian Point 3 UFSAR. Rev. 3. 2009.

12.19 New York State Department of Environmental Conservation. Fact Sheet. New York State Pollutant Discharge Elimination System (SPDES) Draft Permit Renewal with Modification, IP2 and IP3 Electric Generating Station, Buchanan, NY. November 2003.

12.20 New York State Department of Environmental Conservation. New York State Pollutant Discharge Elimination System (SPDES) Discharge Permit. SPDES Permit Number: NY-0004472.

12.21 Nuclear Energy Institute. Water Use, Electric Power, and Nuclear Energy: A Holistic Approach to Environmental Stewardship. Washington, D.C. July 2009.

12.22 Nuclear Regulatory Commission. Website. NRC: Locations of Low-Level Waste Disposal Facilities. Available at URL: http://www.nrc.gov/waste/llw-disposal/locations.html Accessed February 3, 2010.

12.23 Rextag Strategies. Interstate Natural Gas Infrastructure Map Book. 3rd Edition. San Diego, CA. 2009.

12.24 RS Means Company, Inc. RS Means Building Construction Cost Data 2008, 66th ed. Construction Publishers & Consultants, Kingston, Massachusetts. 2008.

12.25 Saratoga Associates, Landscape Architects, Architects, Engineers and Planners, P.C. Indian Point Energy Center Closed Cycle Cooling Conversion Feasibility Study Visual Assessment. June 1, 2009.

12.26 Schumerth, Dennis. Gray & Impaired Water Cooling in Surface Condensers and Heat Exchangers. Proceedings of PWR2006 ASME Power. Atlanta, GA. May 2-4, 2006.

12.27 Spectra Energy. Algonquin Gas Transmission. Available at: http://www.spectraenergy.com/what_we_do/businesses/us/assets/algonquin/. Accessed February 3, 2010.

12.28 SPX Cooling Technologies. Cooling Tower Fundamentals. 2nd Edition. Overland Park, Kansas. 2006.

12.29 TRC Environmental Corporation. Cooling Tower Impact Analysis for the Entergy Indian Point Energy Center Westchester County, New York. Lyndhurst, NJ. September 2009.

12.30 TRC Environmental Corporation. Indian Point Peaking Facility, Sound. Draft Report 2003.

12.31 United States Department of Energy. Cost Estimating Guide. Publication No. DOE G 430.1-1. March 28, 1997.

12.32 United States Department of Energy – Energy Information Administration, Frequently Asked Questions – Electricity. Available at: http://tonto.eia.doe.gov/ask/electricity_faqs.asp. Accessed February 3, 2010.

12.33 United States Environmental Protection Agency. Hudson River PCBs. Available at: http://www.epa.gov/hudson/actions.htm. Accessed February 3, 2010.

12.34 United States Geological Survey. 2007 Minerals Yearbook, Stone (Crushed). Willet, Jason. January 2009.

12.35 United States Nuclear Regulatory Commission. Regulatory Guide 1.23, Meteorological Monitoring Programs for Nuclear Power Plants.

Attachment 1

ECONOMIC AND ENVIRONMENTAL IMPACTS ASSOCIATED WITH CONVERSION OF INDIAN POINT UNITS 2 AND 3 TO A CLOSED-LOOP CONDENSER COOLING WATER CONFIGURATION

(2003 Report)

ECONOMIC AND ENVIRONMENTAL IMPACTS ASSOCIATED WITH CONVERSION OF INDIAN POINT UNITS 2 AND 3 TO A CLOSED-LOOP CONDENSER COOLING WATER CONFIGURATION

Prepared for
Entergy Nuclear Indian Point 2, LLC, and Entergy Nuclear Indian Point 3, LLC

ENERCON Services, Inc.
Kennesaw, Georgia

June, 2003

TABLE OF CONTENTS

Summary of Report Conclusions

At the request of Entergy Nuclear Indian Point 2, LLC, and Entergy Nuclear Indian Point 3, LLC (collectively, "ENIP2/3"), Enercon Services performed an evaluation of the feasibility of converting Indian Point Unit 2 and Indian Point Unit 3 to a closed-loop condenser cooling water configuration, and an assessment of the associated economic and environmental impacts. Since comparable conversions do not exist for direct comparison, due to the complexity and extensive nature of the task, appreciable efforts were devoted to development of a feasible conceptual design, evolved to the level of detail necessary to support subsequent assessments of economic and environmental impact.

Although no method of waste heat dissipation could support Unit 2 and Unit 3 (collectively, the "Station") performance as well as the existing once-through cooling scheme, due to the turbine and condenser design which rely on the low-temperature River water, cooling towers offered the only feasible alternative. Due to Station-specific environmental characteristics, a tower with visible plume abatement and noise abatement was deemed necessary. Additionally, due to the heavily timbered site, with rocky terrain and rapid elevation changes, a tower with a minimum footprint was required to reduce overall excavation and clearing. A single round hybrid cooling tower for each unit was found to best meet the Station performance needs and minimize environmental impacts.

The selected tower type provides the minimum environmental impact of any currently available. The site aesthetics, particularly from River-side view points, are somewhat compromised by the addition of the towers, but much less so than by other alternatives. The effluent from the tower increases salt deposition in the area of the Station, but less so than other types of towers with higher effluent drift rates, and at a level comparable to existing Station background levels. Construction activities during the implementation phase will have a negative local impact with the associated increased traffic and noise, but would have restrictions to minimize the severity of their impact during construction.

Due to some extent to Station-specific conditions, the conversion to closed-loop cooling would be extremely complex and expensive, in terms of initial direct capital costs, lost generating capacity during construction outages, and the de-rating of Station generating capacity. Particular efforts were made to accurately assess direct capital costs of the proposed conversion. Assumptions were minimized by developing the conceptual design to the point that preliminary major equipment selections could be specified, and budgetary quotes obtained from vendors. The extensively revised electrical distribution system was modeled with computer software, and preliminary drawings developed. Attachments 1 and 2 of this Report include the various vendor submittals and conceptual drawings utilized to develop accurate capital cost estimates detailed in Attachment 6. The estimated direct capital cost of the conversion is $612,400,000.00, without any level of contingency. With customary cost of a performance bond and a 20% contingency, the engineering, procurement, and construction costs approach $740,000,000.00.

Since the changes to the condenser cooling systems involve the very heart of the plant, much of the conversion must be completed with both Units in a forced outage. Although much of the excavation work and cooling tower erection can be done pre-outage, new circulating water pumping stations and changes to the Station's common discharge canal force a major outage. Based on the detailed construction schedule included in Attachment 6, with as much work designated pre-outage or post-outage as possible, the forced outage duration is about 42 weeks. Again, this is an estimate without any level of contingency, and is likely greatly conservative. If the duration of a normal refueling outage, 28 days or less, is deducted from this, the duration of lost generating capacity for ENIP 2/3 is 38 weeks. At average Station generation capacities and projected short-term New York wholesale costs of electricity, this amounts to a loss of approximately 13 million megawatt-hours, at a cost of nearly $630 million dollars.

Utilizing mechanical draft cooling towers instead of once-through cooling introduces significant additional electrical loads, termed "parasitic losses", that reduce Station output. For the particular hybrid towers selected, the average annual parasitic losses can be estimated to a high degree of accuracy. The towers have "wet" and "dry" section fans, 44 in each section, at 300 and 350 horsepower, respectively. Additionally, for the closed-loop configuration, circulating water pump horsepower is also increased. The net effect is an annual average parasitic loss of approximately 26 megawatts each Unit.

Moreover, converting the condenser cooling system of an existing plant presents fundamental design problems. The heart of the design of the condenser and turbine is based of the anticipated temperature of the condenser cooling water. If the condenser cooling water is not as cold as the as-built design requires for optimal performance, then the condenser heat rejection is reduced and the backpressure on the turbine increased. With an increase of backpressure on the turbine, performance is significantly affected, and ultimately generator output is reduced. This issue is of significant consequence at the Station. River water temperatures are low throughout the year, and the condenser/turbine package was designed accordingly. Cooling towers, through evaporative cooling, cannot match the low temperature of the River intake. In the winter months the impact is lessened, but during the summer Station performance will suffer appreciably. Lost generation, at maximum load conditions, would be approximately 47 megawatts for Unit 2, and approximately 27 megawatts for Unit 3. On an annual average basis, the effect is less, but still significant at about 15 megawatts for Unit 2 and about 6 megawatts for Unit 3.

Finally, the conversion will result in increased Operation and Maintenance (O&M) costs. With the large number of high horsepower fans, associated electrical distribution system, and increased horsepower circulating water pumps, increased O&M costs are incurred. These costs increase with the number of years the equipment is in service, but can be approximated based on input from the respective vendors. Water treatment costs also increase due to the closed-loop conversion, and will add to the O&M costs. The increased annual cost for each Unit is conservatively estimated at $1.5 million/year, for years 1-5, $2.0 million/year, years 6-15, and $3.0 million/year, years 16-30, assuming an approximate thirty year remaining life for each Unit.

In final summary, the economic impact of the proposed conversion, due primarily to the scope and complexity of the change, but further increased by Station-specific issues, is enormous. The direct capital costs of the conversion approach $740 million dollars, and the associated lost generating capacity during implementation is estimated to cost approximately an additional $600 million. Annual operating expenses increase, and generating capacity is significantly decreased. There are some minor negative environmental impacts associated with the conversion; however, other than site aesthetic issues, these are interim issues associated with construction.

1.0 Background and Introduction

Indian Point 2 and Indian Point 3 were placed into service in the mid-1970's. Both Units are pressurized water reactors (PWRs), with respective net capacities of 940 MW and 970 MW. Located on the east side of the Hudson River in the town of Buchanan, each Unit utilizes a once-through type condenser cooling water system; (i.e., circulating water system) with the intakes from and a shared discharge canal to the Hudson River. The normal design flow rate of the circulating water system for each unit is 840,000 gpm.

The existing once-through circulating water scheme provides both the lowest cost method of condenser cooling and supports the highest level of Station capacity, with corresponding environmental benefits not within the scope of this Report. However, Enercon Services, Inc. (Enercon) was retained to evaluate possible configurations that may substantially reduce River intake, and the associated costs and environmental impacts. In particular, Enercon considered conversion of the existing system to a closed-loop circulating water system configuration. Although various methods of heat rejection generally exist for closed cooling water systems, the only feasible choice for Indian Point 2 and Indian Point 3 requires the use of cooling towers. This conclusion is confirmed by several other studies/reports performed in the past [References 5.1, 5.2, and 5.3]. Heat (thermal energy) is a by-product of the generation of electricity. The primary heat dissipation system, an integral part of power generation, is designed to dissipate, or transfer, this energy to the environment. In a closed-loop system utilizing a cooling tower, water from the circulating water system is pumped through the condenser and then to the cooling tower where heat, transferred to the cooling water in the condenser, is dissipated to the environment (the atmosphere) by evaporation. While different types of cooling towers exist, with varying levels of cost, performance, and environmental performance, existing site conditions effectively limited the cooling tower configurations that reasonably could be considered for Indian Point 2 and Indian Point 3.

Two critical introductory observations also warrant mention. First, Enercon is aware of no conversion of an existing operating nuclear-powered electric-generating station of the size or configuration of either Indian Point 2 or Indian Point 3 from open-cycle to closed-cycle cooling. Thus, assumptions about feasibility, while based on best professional judgment, do not have the benefit of either available technology or past efforts. Second, estimated costs are based, likewise, upon best professional judgment. Thus, given the absence of any practical applications, costs are likely to be understated. As such, the costs discussed in this Report are highly conservative.

This Report provides the following:

- A feasible conceptual design, refined to the level of detail necessary to support cost estimates and a qualitative assessment of environmental impacts resulting from the conversion. The assessment of economic impacts includes initial capital costs, installation costs, operation and maintenance (O&M) expenses, and Station capacity impacts associated with the selected configuration.

- A preliminary qualitative assessment of certain environmental impacts associated with the proposed changes is also included. Certain negative and positive impacts are identified, and preliminarily quantified. These include such issues as cooling tower plume and noise generation, site aesthetics, construction related impacts, and River intake flow.

2.0 Conceptual Design

As discussed above, we are aware of no conversion of existing operating nuclear stations from once-through to closed-cycle cooling. Even without this significant uncertainty, conversion of an existing, operating power plant from once-through condenser cooling to closed-loop condenser cooling represents a massive engineering and construction undertaking in the best of circumstances, even when site conditions are conducive to the required configuration changes. In contrast, the Indian Point site, with appreciable elevation changes, a general lack of available space, a subsurface primarily composed of solid rock, the location of a major interstate gas pipeline and the relevant aesthetic considerations (among other factors), poses significant additional site-specific challenges. While the total impact of all of these factors cannot be fully established, certain critical measures play a significant role in determining the feasibility and the appropriate configuration of any proposed closed-cycle system, as discussed in the following sections.

2.1 Major Components

Evaporative cooling towers are the selected mechanism for rejecting waste heat in this Report. As evaluated in previous reports [References 5.1, 5.2, and 5.3] and during the initial stages of this effort, other alternatives for heat rejection, such as evaporative ponds, spray ponds, or cooling canals, all require significantly more real estate to implement than exists at the Indian Point site. Similarly, dry cooling towers, which rely totally on sensible heat transfer, lack the efficiency of wet or hybrid towers using evaporative cooling, and thus require a far greater surface area than is available at the Indian Point. Additionally, due to their lower efficiency, dry towers are not capable of supporting condenser temperatures necessary to be compatible with either Unit's turbine design and, therefore, are not a feasible technology.

Cooling Towers

Theoretically possible cooling tower configurations are discussed below:

<u>Natural Draft Towers</u>

Of the available types of evaporative cooling towers, the natural draft "wet tower" is comparatively efficient, quiet, moderate in initial cost, moderate in footprint (i.e., 450 feet in diameter), and under appropriate circumstances, can be less costly to operate. Thus, given suitable site conditions, the natural draft tower can be a sound choice. However, natural draft towers rely on the "chimney effect" of the tower to create the required draft; hence, the tower must be very tall, approximately 450 to 550 feet in height. Therefore twin structures, one for each operating Station, approximately 450 feet in diameter and in excess of 500 feet high would be required. Figure 2.1 illustrates a typical natural draft cooling tower.

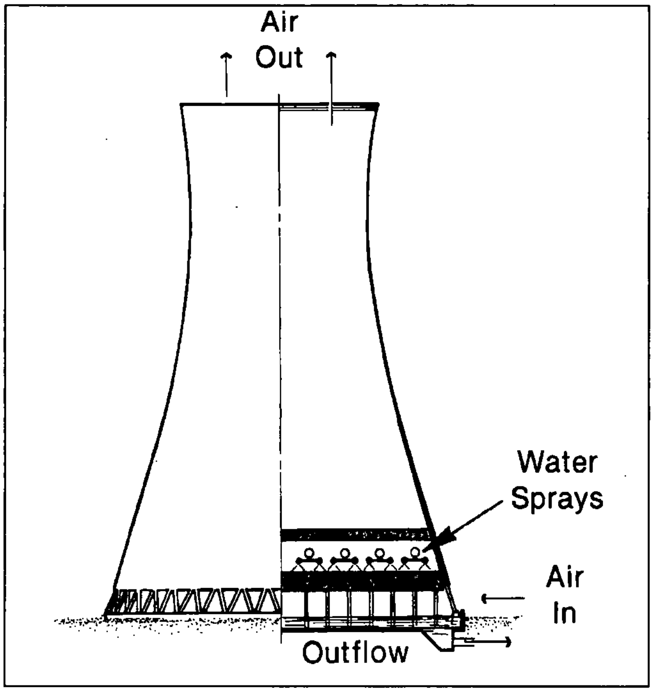


Figure 2.1 – Counterflow Hyperbolic Natural Draft Cooling Tower [Reference 5.4]

Air flow through the tower is produced by the density differential that exists between the heated (less dense) air inside the stack and the relatively cool (more dense) ambient air outside the tower. Since these towers depend on their geometric shape rather than fans for required air flow, they have low operating costs.

Hyperbolic towers are quite large. In the capacity required for Indian Point, a single tower per unit would be in excess of 500 feet in height.

Mechanical Draft Towers

A mechanical draft wet cooling tower can be comparatively efficient, typically lowest in initial cost, moderate in footprint, and with moderate operating costs. However, due to the need for forced draft fans, this type of tower has slightly higher noise levels than a natural draft tower. This technology is considered impractical for the Indian Point site, because of risks created by its associated plume. In particular, under dominant atmospheric conditions at the site, a dense visible cloud of water vapor and entrained water droplets would be emitted from the tower that could have the following negative aspects:

- Compromises Station operations, safety, and systems, particularly over time
- Interferes with plant visual-oriented security systems
- Dominates the skyline in the area of the plant
- Creates local fogging and icing conditions in winter
- Long-term shadow from plume can harm vegetation
- Associated salt deposition could harm plants in the area
- Can be ingested into tower intakes (recirculation), degrading performance.

Figure 2.2 illustrates the air flow path through a cell of a typical mechanical draft wet cooling tower, and the applicable simplified psychrometric chart.

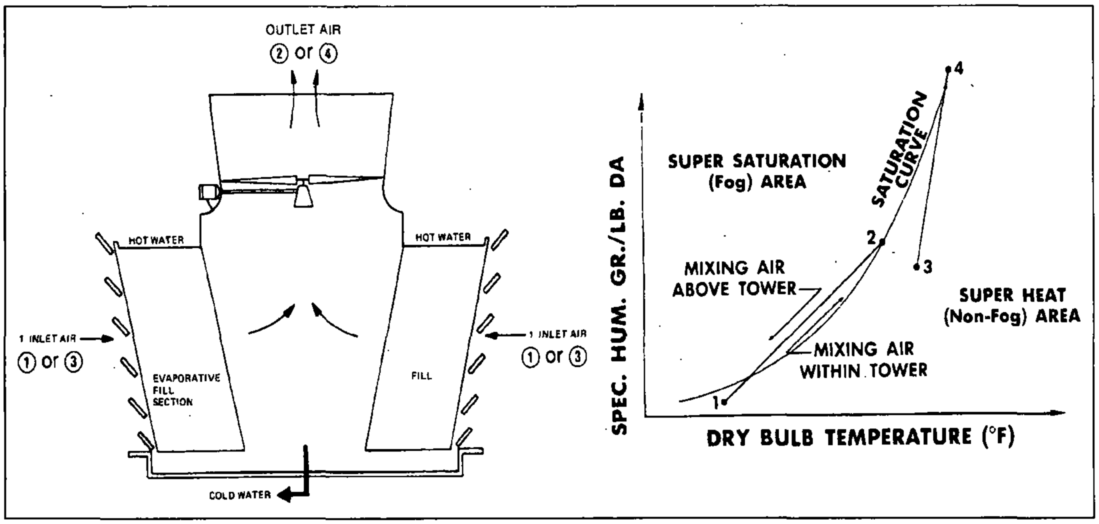


Figure 2.2 – Saturation of Air In Typical Mechanical Draft Wet Cooling Tower [Reference 5.4]

Two cases are depicted in the above figure. Case 1, during summertime, ambient air enters the tower at condition 3 and exits saturated at condition 4. After leaving the tower, this saturated air mixes with the ambient air along line 4-3, most of which mixing occurs in the invisible region below the saturation curve of the psychrometric chart. Case 2, winter ambient air enters the tower at condition 1, exiting saturated at condition 2 and returning to ambient conditions along line 2-1. As can be seen, most of this mixing occurs in the region of super-saturation, which causes the visible plume to be very dense and very persistent.

Hybrid Towers

A hybrid, also referred to as a "wet/dry" or "plume abated" cooling tower, addresses many of the shortcomings of the tower types previously evaluated, particularly as applies to the Indian Point site. Basically, a hybrid tower is the combination of the wet tower, with it's inherent cooling efficiency, and a dry heat exchanger section used to eliminate visible plumes in the majority of atmospheric conditions. After the plume leaves the lower "wet" section of the tower, it travels upward through a "dry" section where heated, relatively dry air is mixed with the plume in the proportions required to achieve a non-visible plume. Hybrid towers are slightly taller than comparable wet towers, typically ~70 feet elevation at the discharge versus 60 feet, due to the addition of the "dry" section, and may require a larger footprint. They are also appreciably more expensive, both in initial costs and in ongoing operating and maintenance costs. A potential exists for increased noise due to additional fans in the dry section, although attenuation to acceptable levels is possible, again at a cost.

Hybrid towers are available in different configurations. Figure 2.3 illustrates the air flow path through a cell of a parallel path hybrid tower, and the applicable simplified psychrometric chart.

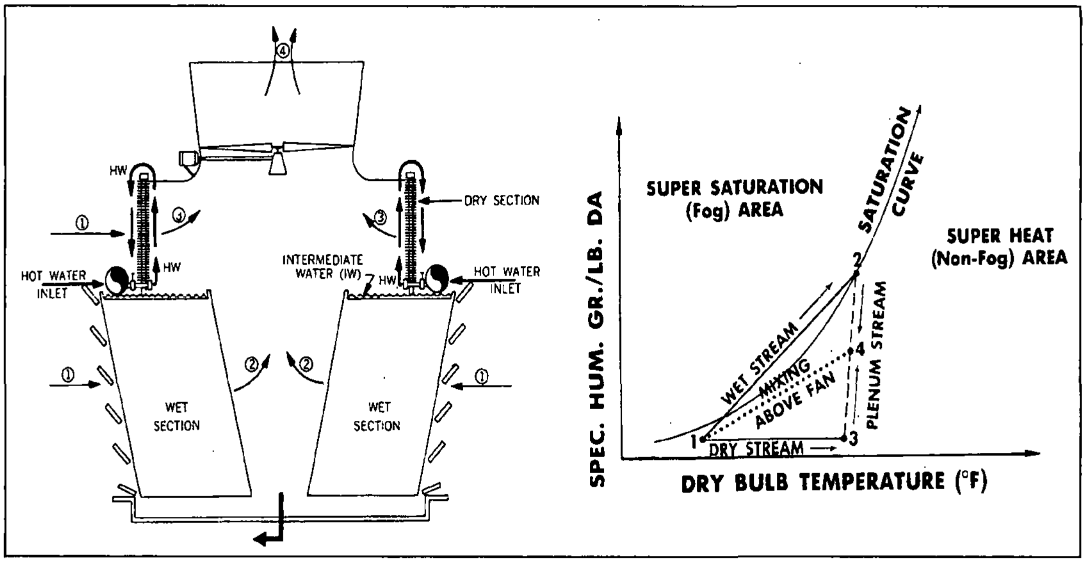


Figure 2.3- Partial Desaturation of Air In A Parallel Path Hybrid Tower [Reference 5.4]

A hybrid cooling tower is designed to drastically reduce both the density and the persistency of the plume. Incoming hot water flows first through the dry heat exchanger (finned coil) sections, the through the wet (evaporative cooling) fill section. Parallel streams of air flow across the coil sections and through the fill sections, leaving the coil sections at dry condition 3, and leaving the fill sections at saturated condition 2. These two separate streams of air then mix together going through the fans, along the lines 3-4 and 2-4 respectively, exiting the fan cylinder at sub-saturated condition 4. This exit air then returns to ambient conditions along line 4-1, avoiding the region of super-saturation (visible plume) altogether in most cases.

The round hybrid tower has attributes and features suited for power plants in general (see Figure 2.4):

- The concentrated center plume provides inherent advantages over the individual cell plumes generated by linear hybrid towers. The round hybrid tower plume is not susceptible to recirculation to the tower inlets, increasing tower performance [Reference 5.5]. Additionally, the center plume is discharged at a higher elevation, approximately 165 feet, and reaches significantly greater heights due to the flow velocity and thermal concentration created by the central discharge shroud. This feature promotes distribution of entrained salts over a much larger area, thus lowering concentrations, and largely eliminates ground level plumes that could compromise Station systems, including plant security.
- The round tower has an appreciably smaller size footprint than an equal capacity linear tower. With the high excavation costs at the Indian Point site, the smaller required footprint represents significant cost savings. The round design, at approximately 500 feet in diameter for the required capacity for each Unit, compares favorably to a linear tower that could approach 1500 feet in length, running parallel to the River shore.

- Less piping, in a simpler configuration, is required for a round tower. Only a single, or pair depending on capacity, of supply and return lines is required for a hybrid tower. For a linear tower, individual supply pipes must feed each cell. For either Indian Point 2 or 3, depending on cell size, a pair of 18- to 24-cell towers would be required per Station.
- Separate forced draft fans in front of the wet and dry sections provides operating flexibility and appreciable operational cost savings. The number of the wet section fans in operation can be adjusted to ensure optimum cooling water temperature, and speed adjustment of the dry section fans controls the required hot air flow rate for plume-free operation. Fully automated, energy saving process control is thus achieved by these towers [Reference 5.6].

Attachment 1 to this Report contains additional information relative to round, hybrid cooling towers. A caveat is warranted. The round hybrid tower represents the latest in technology. Only a single comparably sized tower currently has been constructed at a *new* (not existing) facility, and that facility is not located in the United States. As such, there is no directly applicable information regarding costs attributable to retrofitting a power plant using such a tower.

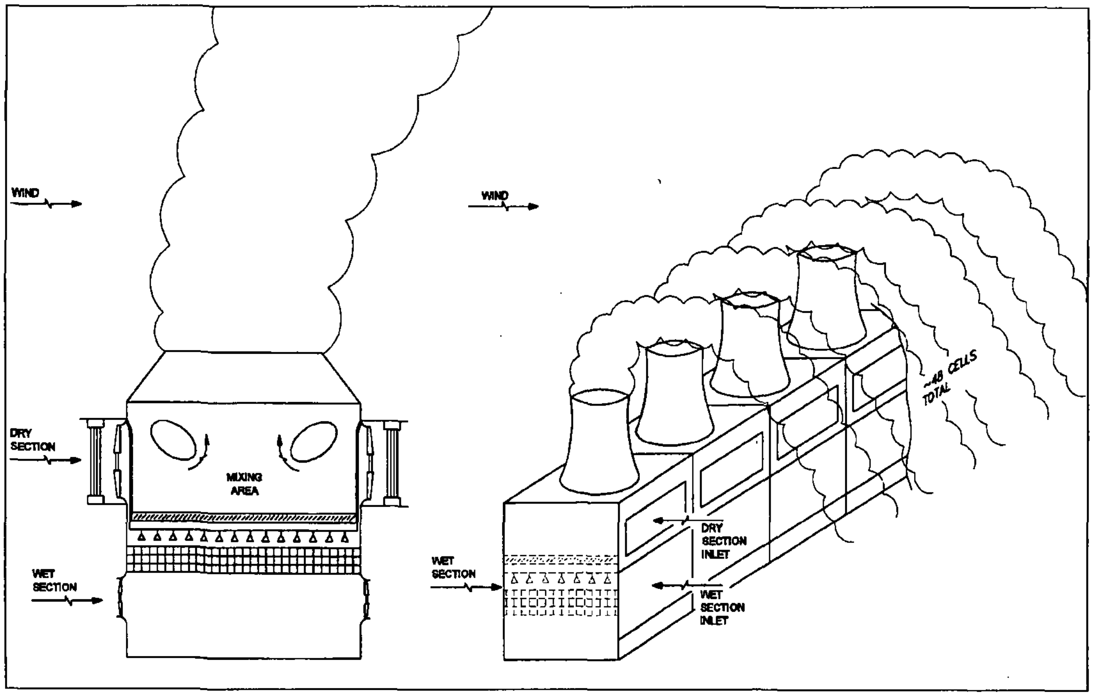


Figure 2.4 – Inherent design advantages of round hybrid tower versus linear cell-type hybrid tower.

The above figure illustrates some of the advantages of a round hybrid tower versus a linear cell-type hybrid tower. The concentrated center plume provides inherent advantages over the individual cell plumes generated by cell type linear hybrid towers. The round tower plume is not susceptible to cross-wind induced recirculation to the tower inlets, increasing tower performance. Additionally, the center plume reaches greater heights, distributing any salt deposition over a much larger area, hence lowering concentrations, as well as decreasing ground-level icing and fogging.

Dedicated fans for the dry and wet sections of the round hybrid allows efficient tower usage, with the dry section fans operating at reduced capacity when ambient conditions don't dictate their usage for plume control. Linear, cell-type hybrid towers have a single fan per cell, inducing flow through both sections, hence operate at full fan power at all times.

Circulating Water Pumps

Aside from the cooling towers, the most significant components in converting to a closed-loop condenser cooling configuration are the new circulating water pumps. Whereas the existing once-through configuration required only enough pumping head (pressure) to overcome flow losses in passing water from the River through the condenser and returning to the River, any of the above configurations requires increased pump head to pump the circulating water up to the elevated cooling tower spray headers, and overcome the significant internal flow losses of the cooling tower. Whereas the existing Unit 2 and Unit 3 circulating water pumps were designed for 21 feet and 29 feet of head respectively, the new pumps are expected to be required to produce approximately 72 feet of head. (The number of pumps is expected to stay consistent with the existing configuration; i.e., six pumps per unit. The flow capacity will be slightly decreased, from the existing pump's 140,000 gpm maximum, to approximately 117,000 gpm.) The existing pumps were designed to operate at significantly reduced flow at low River water temperatures, reducing River intake flow. Since the condenser inlet water temperature will remain largely constant with the closed-loop arrangement, single speed/flow rate pumps are adequate and appropriate for the new configuration. Attachment 1 contains reference information on the proposed new pumps.

The cooling towers and the circulating water pumps represent significant additional electrical loads. Preliminary data for the hybrid tower indicates that, at maximum conditions, (44) 300 HP fans and (44) 350 HP fans will be in-service for each tower. A new substation, fed directly from the switchyard, will be required to supply electrical power to each tower. Likewise, the existing circulating water pumps for have, respectively, 1000 HP and 1250 HP motors (at high speed). The new pumps will require an estimated 3000 HP each (single speed). A dedicated substation, fed directly from the switchyard, will be required for each new pumphouse. Attachment 1 contains reference information on the new transformers and associated electrical switchgear for both the tower substations and the pumphouse substations.

2.2 Site Layout for Conversion

Refer to Attachment 2, Sketch 01, for a simplified site layout of the proposed configuration.

The new cooling towers are relatively large due to the required capacity, the outside diameter of each tower, including noise attenuators, is approximately 560 feet. To provide construction access for tower erection and clearance for air intake, the excavation diameter for each tower will be approximately 700 feet. Height of the proposed towers is approximately 150 feet. The location for the Indian Point 2 tower is expected to be approximately 1050 feet north of the Indian Point 2 reactor, just north of the proposed interim spent fuel storage slab installation (ISFSSI) location. The location of the Indian Point 3 tower is expected to be approximately 1000 feet south of the Indian Point 3 reactor. The basin elevation of each tower is dictated by the required head for flow through the condenser, and preliminary analysis indicates an elevation of 31 feet mean sea level is required.

The location of the circulating water pumphouse is expected to change from the inlet side of the condenser (intake pumping station) to the outlet side on a modified portion of the existing discharge canal; this is to avoid overpressurizing the condenser with the new higher pressure circulating water pumps. The new enclosed pumphouses, Attachment 2, Sketch 02, would supply circulating water to the new towers via (2) 120 inch diameter, AWWA specification, concrete-lined steel pipes. As discussed above, the necessary head for circulating water flow through the condenser would be provided by the static head achieved from the elevation of the cooling tower basin. Flow from the basin to the condenser is expected to be via (2) 144 inch diameter, AWWA specification, concrete-lined steel pipes (Attachment 1).

Associated electrical power supply modifications are also shown on Sketch 01. Due to the general lack of reserve power supplies in the electrical distribution system at Indian Point, and to the appreciable power requirements of the new cooling towers and pumphouses, a dedicated substation supplied directly from the 138 kV off-site switchyard will be required at each tower and each pumphouse.

For each tower, a pre-fabricated metal building, Attachment 2, Sketch 03, would be required to house the substation transformers (Indian Point 2 only), switchgear, and tower control system. The substation for each tower must be located as close as practical to the tower, to reduce cable runs from the substation to the tower. All fans are expected to be provided with 4.16 kV windings. For the Indian Point 2 tower, the substation is expected to be supplied from the switchyard via overhead 138 kV transmission lines. On the Indian Point 3 side, the tower is expected to be supplied via combination of overhead 138 kV transmission line to a new 138 kV/6.9 kV transformer, and underground 6.9 kV duct banks to the switchgear building.

Each pumphouse must have a dedicated 138 kV transformer feeding the switchgear. For the Indian Point 2 pumphouse, the transformer is expected to be located in the Unit 1 switchyard, and 6.9 kV power is expected be fed to the pumphouse switchgear via above ground cable trays. For the Indian Point 3 pumphouse, the transformer is expected to be located in the Indian Point 3 switchyard, and 6.9 kV power will be fed to the pumphouse switchgear via a combination of ductbank and above ground cable trays.

2.3 Operational Features and Schemes

Hybrid cooling tower operation – To efficiently utilize a hybrid tower, an automated control system is required [Reference 5.6]. Whereas for the Indian Point application the wet section would likely operate at maximum capacity most of the time to maintain condenser inlet water temperatures as near as possible to current design operating parameters, the need to operate the dry section fans at a given capacity will be totally dependent on ambient conditions. A programmable logic control (PLC) system will be utilized to reduce tower operating cost (parasitic losses) to a minimum, while maintaining "plume free" (little or no visible plume) operation at or above the design plume point.

For a given ambient condition, necessary algorithms determine the optimum fan speed for the dry section to achieve the required flow between zero flow and that corresponding to full fan speed. The fans are equipped with infinitely variable speed, frequency controlled motors. Since the (44) dry section fans are 350 HP each, and are needed at full capacity only at maximum ambient design conditions, securing them or significantly reducing their flow results in appreciable reduction in parasitic losses. Ambient conditions of wet bulb temperature, dry bulb temperature, and wet section airflow input to the PLC. Based on the operating algorithms, the controller adjusts the flow of hot air from the dry section (via fan speed) that mixes with the plume from the wet section such that the resulting combined effluent plume is sub-saturated/superheated, and hence not visible.

An additional parameter for reducing operating costs of the tower will be restricting the plume abatement mode of operation to daylight hours only. Since plume abatement only eliminates visible plume, and plume visibility is not an issue at night due to darkness, there is no benefit in operating at night in the more costly plume abatement mode.

In extremely cold ambient conditions, when full operation of the wet section would result in exiting cold water (condenser inlet water) temperatures less than approximately 60°F, an alternate method of load control would be utilized. Since the wet section fans will operate at full capacity the majority of the time, specifying frequency controlled motors is an unwarranted expense. Therefore, for load control in the wet section, the algorithms input to the PLC will selectively secure wet section fans as required to reduce load capacity. For example, of the total of 48 wet section fans, 40 would be operating and 8 would be idle, the proportion of operating to idle fans determined by the exiting cold water temperature.

<u>Make-up and blowdown, cycles of concentration</u> – The water quality of the Hudson River varies over a great range, primarily relative to the River flow rate. Attachment 4 includes USGS and Indian Point Hudson River water analysis and flow rates, on a monthly basis, over a several year duration. During periods with a relatively high River flow rate, ~40,000 cu.ft./sec., the plant intake is largely fresh water with correspondingly low readings of conductivity, chlorides, and hardness:

Conductivity	= 144 microsiemens/cm
Chlorides	= 90 mg/l
Hardness	= 100 mg/l

When River flows are low, ~4,000 cu.ft./sec., the plant intake is very brackish with correspondingly high readings of conductivity, chlorides, and hardness:

Conductivity	= 13,520 microsiemens/cm
Chlorides	= 6,250 mg/l
Hardness	= 1560 mg/l

When in a closed-loop cooling configuration with cooling towers providing the heat rejection, the evaporation from the towers tends to concentrate the intake water contaminant levels and total dissolved solids (TDS). A "blowdown" flow is required to maintain a design level of "cycles of concentration" by constantly bleeding off some cooling water back to the River. The "make-up" flow must be adequate to replenish water lost to evaporation and drift (entrained water particles carried out in the tower plume), plus the blowdown flow. The cycles of concentration are predetermined based on intake water quality, and suitability of materials in the cooling tower and the condenser.

Blowdown is calculated as follows [Reference 5.4, and Attachment 1, Marley/Balcke-Durr Data]:

$$B = \frac{E - [(C-1) \times D]}{(C-1)},$$ where B = blowdown, E = evaporation, D = drift, and C = cycles of concentration

Drift can be approximated as Water Flow $_{Total}$ x 0.00001 gpm.

Evaporation $_{Wet\ Summer}$ can be approximated as Water Flow$_{Total}$ x 0.0167 gpm [Attachment 1, Marley Performance Data].

Evaporation $_{Hybrid\ Winter}$ can be approximated as Water Flow$_{Total}$ x 0.0081 gpm [Attachment 1, Marley Performance Data].

For the Indian Point Station, since the intake water quality varies dramatically based on Hudson River flow rate, an acceptable cycles of concentration is dependent on the current intake water quality. For the purpose of this Report, at worst case intake water quality, blowdown and makeup will be based on 3 cycles of concentration. Required makeup flow from the River would thus be:

Makeup = B + E + D [Reference 5.4], where $B = \frac{E - [(C-1) \times D]}{(C-1)}$, and C = 3,

Water Flow$_{Total}$ = 700,000 gpm / unit

$E_{Wet\ Summer}$ = 0.0167 x 700,000 gpm = 11,690 gpm

$E_{Hybrid\ Winter}$ = 0.0081 x 700,000 gpm = 5,670 gpm

D = Water Flow$_{Total}$ x 0.00001 gpm = 7 gpm

$B_{Wet\ Summer}$ = 5,838 gpm

$B_{Hybrid\ Winter}$ = 2,828 gpm

$M_{Wet\ Summer}$ = 17,535 gpm / unit

$M_{Hybrid\ Winter}$ = 8,505 gpm / unit

Total plant makeup from the River, summer wet mode tower operation would hence equal $M_{Wet\ Summer}$ = 35,070 gpm

Total plant makeup from the River, winter hybrid mode tower operation would hence equal = $M_{Hybrid\ Winter}$ = 17,010 gpm

Since the water quality of the intake varies so greatly, total intake flow can be further reduced by utilizing an automated control system for makeup flow that adjusts flow rates based on intake water quality. Such systems are available from a variety of providers, and typically monitor chlorides or conductivity as an indicator of overall water quality. The above makeup quantities correlate to worst-case intake water quality conditions. With better intake water quality, the cycles of concentration can be gradually increased by the control system from 3 to 5, yet still provide appreciably better circulating water quality than when using 3 cycles of concentration and worst-case water quality.

To quantify the impact on the River intake, utilizing the same formula as above, with C = 5:

Makeup = B + E + D, where $B = \frac{E - [(C-1) \times D]}{(C-1)}$, and C = 5,

Water $Flow_{Total}$ = 700,000 gpm / unit

$E_{Wet\ Summer}$ = 11,690 gpm

$E_{Hybrid\ Winter}$ = 5,670 gpm

D = 7 gpm

$B_{Wet\ Summer}$ = 2916 gpm

$B_{Hybrid\ Winter}$ = 1411 gpm

$M_{Wet\ Summer}$ = 14,612 gpm / unit

$M_{Hybrid\ Winter}$ = 7,088 gpm / unit

Total plant makeup from the River, summer wet mode tower operation, good water quality, would hence equal = $M_{Wet\ Summer}$ = 29,224 gpm

Total plant makeup from the River, winter hybrid mode tower operation, good water quality, would hence equal = $M_{Hybrid\ Winter}$ = 14,176 gpm

The total range for makeup flow to the plant varies from a maximum of 35,070 gpm to a minimum of 14,176 gpm, depending on mode of operation of the cooling towers and River intake water quality. Although a pre-determined set flow rate correlating to worst case conditions could be maintained year around, use of automated control allows reduction of makeup flow by more than 50% under optimum conditions.

Condenser cleaning and maintenance w/ closed-loop cooling – Current plant design does not incorporate a condenser cleaning system. However, during the late fall, winter, and early spring months, any one of the three condensers on either unit can be removed from service for maintenance and/or tube cleaning while the operating unit is at full power. The temperature of the River intake water is sufficiently cold to remove the full unit heat load with only two of three condensers in service. This operating scheme will not be an available option with a closed-loop cooling system due to the appreciably higher condenser inlet water temperatures. During periods of very cold ambient conditions, when cooling tower supply to the condenser is at the lowest attainable temperatures, a condenser could be taken out of service, but only with an appropriate level of load reduction from the operating unit.

A better alternative is the installation of a condenser tube cleaning system. This provides two advantages:

- Eliminates the need to take a condenser out of service for tube cleaning.
- Allows maintaining the tubes at a consistently low level of fouling.

Since the presence of fouled tubes will have a greater impact on Station output once converted to closed-loop cooling, due to higher condenser inlet water temperatures, installation of a condenser tube cleaning system is an imperative part of the plant redesign. The design of the new circulating water pump house for each unit will thus incorporate the requirements for a permanently installed condenser tube cleaning system.

3.0 Economic Estimates

Included within this section are estimates of the costs of various aspects of the conversion of Indian Point Units 2 and 3 to closed-loop condenser cooling. The capital costs of the initial conversions are quantified, including design, procurement, implementation, and startup activities, based on the conceptual design previously identified and discussed. The duration of the required unit outages, based on a timeline of critical milestones that must be worked with the associated unit off-line, is utilized to determine the resulting lost generating capacity, expressed in $MW_{HOURS\text{-}ELECTRIC}$. The new cooling towers and circulating water pumps will require operations and maintenance personnel support, and service, repair, and replacement of components; based on input from potential supplying vendors, these costs are approximated. Additionally, the new towers and circulating water pumps require an appreciable amount of power to operate, herein referred to as "parasitic losses", which effectively reduces Station output power to the distribution grid. Power consumption of the required new components can be estimated from preliminary vendor data, and hence total $MW_{ELECTRIC}$ parasitic losses determined. Finally, the conversion creates less than optimum operating parameters for the existing turbine/condenser, resulting in reduced unit output to the grid under most operating conditions. Based on existing Station performance data, and applicable input from turbine/condenser modeling software provided in Attachment 3 (PEPSE), the reduction in unit performance, in generator output $MW_{ELECTRIC}$, is be provided.

3.1 Initial Capital Costs

An accurate assessment of the capital costs associated with the proposed conversion is a critical goal of this Report. Minimizing assumptions, and relying instead on well-developed, detailed conceptual designs, greatly increases the accuracy of the ensuing estimates. In broad terms, conceptual design engineering outlined system scope definition, proposed detailed layout, equipment specification/criteria, and assisted in gathering some of the site-specific historical data. Attachment 2 to this Report includes some of the conceptual drawings utilized for subsequent construction estimates. This information was used to develop greater detail regarding associated tasks and logistics required as a minimum to successfully perform the construction for the conversion. The resulting Direct Capital Cost Estimate and Project Schedule represent well thought out approaches with a reasonable level of detail in order to generate a responsible and aggressive response.

The estimating basis relied less on theoretical national production rates and cost factoring and focused more directly toward soliciting the various assets capable of providing real world solutions. Trusted vendors were contacted for quotations on the major equipment and material components, while local contractor support assisted in developing the labor, equipment, and scheduling requirements. Attachment 1 to this Report includes vendor data and budgetary cost estimates for major equipment components. Few allowances were applied and only when time did not permit further task development or reasonable vendor contact and quotation. Nationally recognized consultants supported the evaluation and recommendation process for significant and or specialized operations to ensure practical and complete solutions.

The Direct Capital Cost Summary contained in Attachment 6 combines the data input from these resources with the defined scope of work to produce a straight forward analysis of cost and duration. The major cost centers were defined and presented in line item format in order to provide some flexibility in the application of cost. Some of these line items will be equally shared by both ENIP 2/3 as common operations required to perform the scope of work based on the premise that both ENIP 2/3 will be required to make the conversion, hence if separated, these common cost would not simply be cut in half but more realistically apply to each individual Station.

The anticipated direct capital cost (presented in 2003 US dollars) for the conversion for both ENIP2 and ENIP3 is collectively estimated at a minimum of $612 million without bonding the contractor, contingency application, or any escalation over time. Contractor bonding could add an additional cost of about $4 million while recommended contingency application would add another $123 million (based on RS Means and industry standard of 20% for conceptual estimates). The escalation of cost over the project schedule was not calculated as part of this report but represents a significant increase when calculated over the 5 year anticipated duration. Certain break-out costs are provided in Attachment 6 that justify the noteworthy cost drivers. Total estimated direct capital costs for the conversion is thus $739,680,000.00.

Appendix 6B of Attachment 6 outlines the preliminary scheduling basis for this report. Considering the conceptual nature of the current design parameters and the unknown forces outside of the project's direct control, many of the tasks are aggressively optimistic and could be severely impacted as work progresses. Therefore, the context of the following is intended to bound the minimum duration required for the project. Design engineering is assumed to begin at or about January 2005 and continue through December 2008. Anticipated construction start is in June 2005 based on having all permitting and licensing requirements in place prior to starting. Work will begin on Unit 2 in July 2005 with Unit 3 phased shortly thereafter in October 2005. Construction work and field engineering will continue in tandem up and through the recommended outage period beginning in March 2009 and extending for 10-11 months to February 2010. Total duration of the forced outage is estimated to be 42 weeks.

There were some necessary assumptions, where the final outcome of the associated issues could affect the conclusions of the Report. This Report is grounded on the assumption that Algonquin Pipeline, a division of Duke Energy, completes its independent assessment and concludes that the siting of the cooling towers, as contemplated in this Report, is acceptable to Algonquin under the existing easement agreement and otherwise. ENIP2 and ENIP3 have not received information from Algonquin regarding Algonquin's conclusion, or on the costs and technical requirements on which Algonquin may insist assuming that any such siting is acceptable. However, we anticipate that costs will be significant, particularly if Algonquin require relocations of the line, as is likely. We also anticipate that Algonquin would insist that ENIP2 and ENIP3 solely bear any such costs or expenses. Hence, an assumed cost of relocating the pipeline, based on input from another pipeline constructor, was utilized in construction cost estimates. Of course, Algonquin's estimated cost could fundamentally alter the cost assessment in this Report and, therefore, its conclusions. Further, if Algonquin completes its independent assessment and concludes that such siting is not acceptable, the siting of the cooling towers, as contemplated in this Report, is unlikely to remain technically feasible at any cost. As such, we must retain a full reservation of rights to amend or modify this Report to reflect Algonquin's decision.

Other issues that represent potentially severe cost and schedule impacts are discussed in Attachment 6 and not included in the above cost or schedule considerations. Some of these issues include but are not limited to:

- Regulatory Agency Interactions
- Public Perceptions of Blasting and Heavy Construction Activities
- Elevations in Homeland Security Levels
- Resource Availability (material, equipment, and most specifically craft labor)
- Large Volume of Spoils and Construction Debris Disposal
- Outside Power Tie-in and Availability through Con-Ed
- Riverside Activities and Potential Maritime Implications
- Unpredictable Weather Phenomena

The above concerns are not all inclusive but represent some major challenges that the construction team must focus on from the beginning and throughout the conversion. It is difficult to determine exact cost impacts or ranges thereof at this point based on probability or severity of the issue involved, but any impact would tend to increase overall costs.

3.2 Lost Generating Capacity During Implementation

From the construction schedule provided in Attachment 6, Appendix 6B, the approximate duration that Units 2 and 3 will be in a forced outage to accommodate the conversion to closed-loop cooling is 42 weeks. This represents optimum performance during the construction phase, with no contingencies or allowances for emergent activities or overruns, and assumes the maximum possible portion of the work scope being performed either pre-outage or post-outage.

A typical refueling outage for either Indian Point unit has a duration of 24 to 28 days, and the outages are performed out of phase, to minimize impact on the power grid. For purposes of this Report, it will be assumed that 4 weeks of the forced outage for the conversion will be utilized for refueling of both units. The remaining 38 weeks conservatively represent a period of lost generating capacity for the Station.

Estimating the lost generating capacity from a 38 week outage, based on a typical IP2 generator output of 1015 MW_E and IP3 generator output of 1035 MW_E:

Indian Point 2, 6.48 million megawatt hours

Indian Point 3, 6.61 million megawatt hours

Although generating capacity as well as wholesale cost of electricity vary, the approximate dollar cost of the outages, based on $48.00/MWh projected short-term cost equates to:

Indian Point 2, $311 million

Indian Point 3, $317 million

3.3 Operational and Maintenance (O&M) Cost

Additional Station O&M costs for the components added due to the conversion to closed-loop cooling can be best estimated by identifying the general tasks for each component, and then based on operational experience and input from vendors, quantifying the estimated required man-hours and associated costs.

Although the conversion to closed-loop cooling is complex, significant new/modified plant components are limited to the cooling towers with their fans and booster pumps, and the appreciably larger circulating water pumps located in new pumphouses downstream of the condensers.

Operational Support Cost

The tower selected for Units 2 and 3 is a Marley/Balcke-Durr round hybrid tower, designed with noise and plume abatement features. The hybrid design uses 44 wet section fans with motor output power of 300Hp and 44 dry section fans with motor output power of 350Hp. In addition, the dry section of the tower requires the addition of two booster pumps, each with a flow capacity of 122,500 gpm @ 26ft TDH. The pumps will run using approximately 250Hp while the dry section of the tower is required to be in operation for plume abatement. Due to the large number of active components, as well as the sheer size of the towers and their hot water distribution system, appreciable Operations support is anticipated. For purposes of this assessment, chemistry personnel (for water quality maintenance) man-hours are included/encompassed under Operations.

The anticipated manpower required for operational support of each cooling tower is tabulated below:

	Activity Description	Group	Est. Cost
Daily	• Check fans, motors, driveshafts, gear reducers • Check gear reducer oil level • Check electrical substation, transformers, switchgear • Monitor local control panel and alarm displays • Check water level in cold water basin and hot water distribution system • Check booster pumps and associated instrumentation • Sample water quality	Ops	
Cost Basis	8 hrs/day X 12 months		$146,000.00
Weekly	• Inspect hot water distribution system • Inspect fill for fouling • Check gear reducer for leakage • Adjust water quality	Ops	
Cost Basis	40 hrs/week X 12 months		$105,000.00
Notes: Cost based on O&M labor estimates of $50/hour (hourly wage + benefits)			

Manpower cost for operation of the new pumping station should be the same as for the current pumping station, therefore no cost increases were assumed.

Based on the above identified anticipated tasks, applied to Indian Point 2 and Indian Point 3, annual additional Operations support for the closed-loop configuration is estimated to be $251,000.00 for each Unit.

Maintenance Cost

The anticipated cost for preventive and corrective maintenance, including both labor and parts, of each cooling tower is tabulated below:

	Activity Description	Group	Est. Cost
Monthly	Inspect drift eliminators and fill for clogging Check gear reducer oil seals, oil level, and oil condition	Maint.	
Periodic (Quarterly estimated)	Clean and repaint fans and drivers, drift eliminators, fill, hot water distribution system Rebalance fans and driveshafts Lighting inspection or replacement	Maint.	
Semi-annual Inspection	Inspect keys, keyways, set screws & tighten bolts for fans and drivers Change oil and check vent condition for gear reducers Check fan blade clearances Check for leakage in fill, basin and hot water distribution system Inspect general condition and repair as necessary all tower components including cranes and hoists	Maint.	
Annual Inspection and Corrective Maint.	Inspect general condition of basin, suction screen and tower casing Inspect/repair fans and drivers, and tower access components, including stairs, ladders, walkways, doors, handrails Transformer Inspection Starting at year 16, replacement of fan blades, fan motors, fan gearbox, fill, drift eliminators	Maint.	
Quarterly	Lighting Inspection or Replacement	Maint.	
	Annual maintenance cost estimate (years 1-5)*		$500,000.00
	Annual maintenance cost estimate (years 6-15)*		$1,000,000.00
	Annual maintenance cost estimate (years 16-20)*		$2,000,000.00
Notes: *Based on vendor (Marley Cooling Tower) estimates/historical data			

Maintenance cost for the new pumping stations, based on utilizing the same number of pumps and appreciably the same flow rates as existing, remain virtually the same. Therefore, no additional initial/routine pumping station maintenance cost was assumed for this study.

Long-term rehabilitation and replacement costs include those costs for replacement of components such as pump impellers, motors, or entire assemblies. Major equipment rehabilitation or replacement is usually estimated to occur between 20 to 40 years after placing the equipment into operation. Rehabilitation costs for major equipment can be estimated to be 35 to 45 percent of replacement costs depending of the condition of the equipment. Other items of equipment may be replaced several times during the plant life, depending on their use, or may require only partial replacement. It is most likely that equipment, except for pump and motor, may not be replaced in kind. Therefore, the replacement cost should include all engineering and structural modification costs as well as the equipment costs [Reference 5.11].

Based on remaining plant life it was assumed that 1/2 of the pumps (3 pumps, @ approximately $800,000.00/pump) would require rehabilitation or partial replacement. When including other miscellaneous pumping station components, the estimated rehabilitation and replacement cost for one pumping station is approximately $1,500,000 for an assumed remaining plant life of 30 years. Hence, on an average annual basis, beginning at year 16, pumping station maintenance costs would increase by $100,000.00/pumping station.

Summary of Additional O&M Cost (per year, per Unit cost)

Years 1-5	$751,000.00
Years 6-15	$1,251,000.00
Years 16-30	$2,351,000.00

3.4 Parasitic Losses (Costs) Attributable To New Components

A computer simulation of the High and Medium Voltage Electrical Distribution System was created based upon estimated fan and pump horsepower requirements for the selected hybrid towers and new circulating water pumphouses. The model utilizes ETAP® PowerStation® software from Operation Technology, Inc. ETAP PowerStation is an integrated analysis tool used to design, maintain, modify, and operate electric power systems. Attachment 7 provides the single line diagrams and output reports obtained from computer simulation runs.

The information used for simulating the existing distribution demands and configuration was taken from Indian Point 2 calculation FEX-0143-00. The values of impedance and Thevenin equivalence for the Buchanan 138kV Switchyard and overhead distribution cables were found in the electrical distribution model, and the values for existing demand on the Unit 2 Station Auxiliary Transformer was provided in Attachment E of the IP2 calculation. Because FEX-0143-00 only models Indian Point Unit 2, the assumption was made that Unit 3 would have an equivalent distribution and demand; for purposes of determining electrical demand, this approximation is reasonable.

For modeling new components when vendor data for motor efficiencies and power factors is not provided, ETAP PowerStation provides industry standard data which allows reasonably precise approximations. All fan motors, booster pump motors, and circulating water pump motors were modeled using the ETAP PowerStation industry standards.

The circulating water pumps are a constant load; i.e., the are no operational variations in power consumption, all six pumps/unit operate at full capacity at all times. To address the added circulating water pump load due to the conversion to closed-cycle cooling, the power requirements of the existing pumps are simply subtracted from that of the pumps required for the closed-loop configuration.

Unit	Combined Electrical Load, Six Pumps		Additional Parasitic Losses (Pump Power)
	Existing Configuration	Closed Loop	
2	4.50 MW	13.47 MW	8.97 MW
3	4.50 MW	13.47 MW	8.97 MW

For the hybrid cooling towers, the computed results for maximum normal load, occurring during daytime winter operation with both wet and dry sections of the tower at full power, shows that the electrical power load for each tower is approximately 24MW. This load represents a corresponding parasitic loss to the output of each of the Stations. However, the load resulting from the towers varies significantly due to ambient environmental conditions. When operating only in the wet mode, during summer conditions and at night, the cooling towers require approximately 10.5 MW each, less than half the power required during winter daytime conditions.

Site meteorological data from 1998 to 2000 was utilized to determine average monthly wet bulb temperatures. Based on the average wet bulb temperature, the tower dry section utilization can be approximated; i.e., the percent of the time the dry section fans and booster pumps are operating, and hence the approximate monthly MW power usage rate.

Tower Usage $_{\text{Each Tower}}$ = wet section MW + [(usage %)(dry section MW)]

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Avg. WB (°F)	27.5	30.9	34.7	41.2	50.6	58.3	64.0	63.2	57.6	47.5	39.6	31.6
Usage (%)	70	70	60	50	50	40	30	30	40	50	60	70
U2 Usage (MW)	20.0	20.0	18.6	17.3	17.3	15.9	14.6	14.6	15.9	17.3	18.6	20.0
U3 Usage (MW)	20.0	20.0	18.6	17.3	17.3	15.9	14.6	14.6	15.9	17.3	18.6	20.0

Based on the estimated power requirements of the new circulating water pumps, and the above tabulated estimated monthly power requirements for the hybrid towers, the total average monthly parasitic losses due to conversion to closed-loop cooling is as follows:

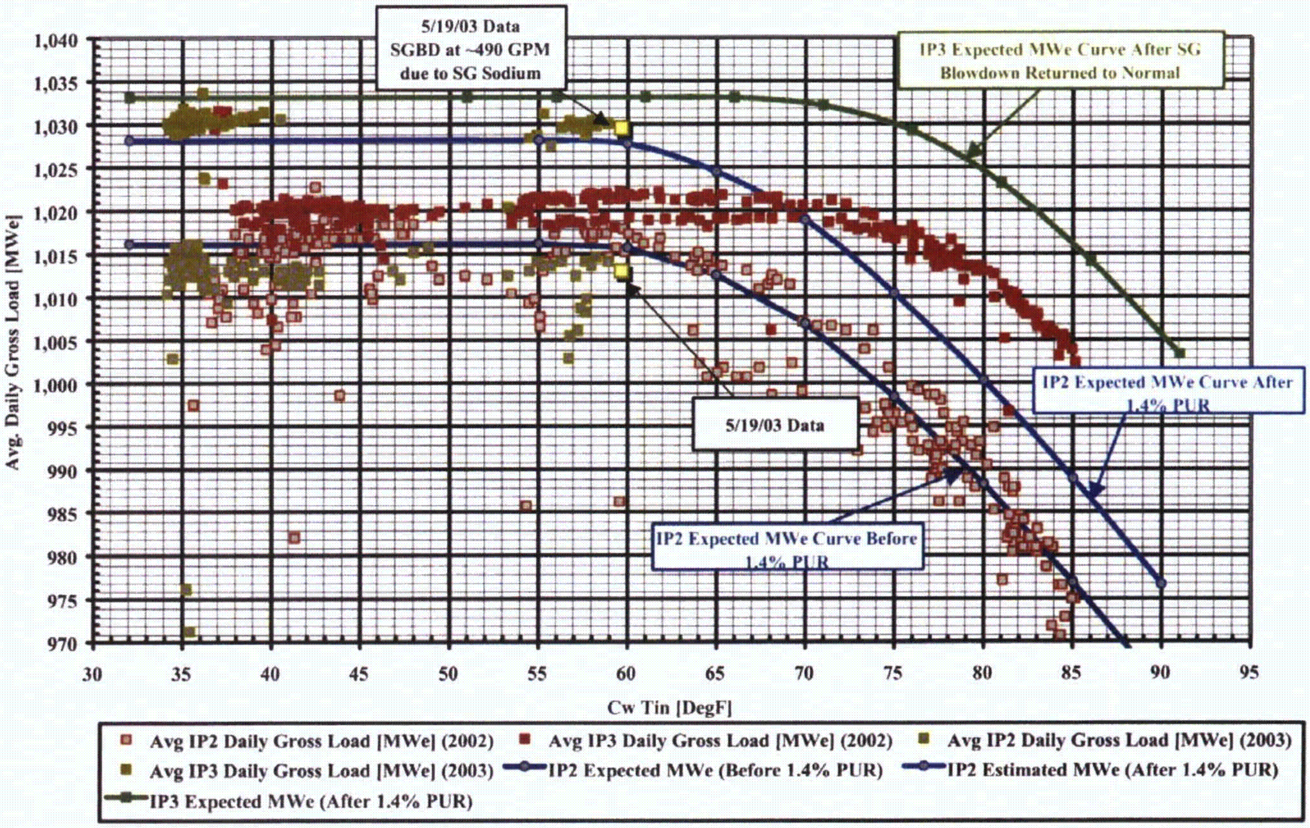
Indian Point Unit 2 = 8.97 $\text{MW}_{\text{Circ. Water Pumps}}$ + 17.51 MW $_{\text{Tower Avg.}}$ = 26.48 MW $_{\text{Avg. Loss}}$

Indian Point Unit 3 = 8.97 $\text{MW}_{\text{Circ. Water Pumps}}$ + 17.51 MW $_{\text{Tower Avg.}}$ = 26.48 MW $_{\text{Avg. Loss}}$

3.5 Costs Due To New Condenser Operating Parameters

The following graph, taken from actual plant performance data demonstrates the effect of increased circulating water inlet temperature (CW T_{in}), on gross unit output (MW_E), for Indian Point 2 and Indian Point 3 during operating years 2002 and 2003. Additional data and discussion of plant performance versus condenser inlet temperature are included in Attachment 3.

Figure 3.1 – Average IPEC CW T_{IN} / Average Daily Gross Load



As the graph clearly shows, when circulating water inlet temperatures increase, the plant gross output decreases. For Indian Point 2 the decrease in output begins as circulating water temperatures increase beyond approximately 60°F, and drop dramatically as circulating water temperatures increase beyond 70°F. For Indian Point 3, the output remains relatively constant until circulating water temperatures increase beyond 70°F.

The loss of output is due to increased condenser backpressure on the turbine. Indian Point 2 has a differently designed low pressure (LP) turbine than Indian Point 3, this accounts primarily for the increased losses at elevated River water temperatures for Indian Point 2 versus Indian Point 3; i.e., the Indian Point 2 turbine is more sensitive to, and less efficient with, increased backpressure. Figures 3.2 and 3.3 (generated via PEPSE software) indicate the relative impact of River water temperature on condenser backpressure for each unit.

Figure 3.2 – Indian Point 2 Condenser Pressure vs. River Water Temperature

(100% Power, 85% Condenser Clean, ~1 DegF Condensate Subcooling, Fast CW Pump Speed)

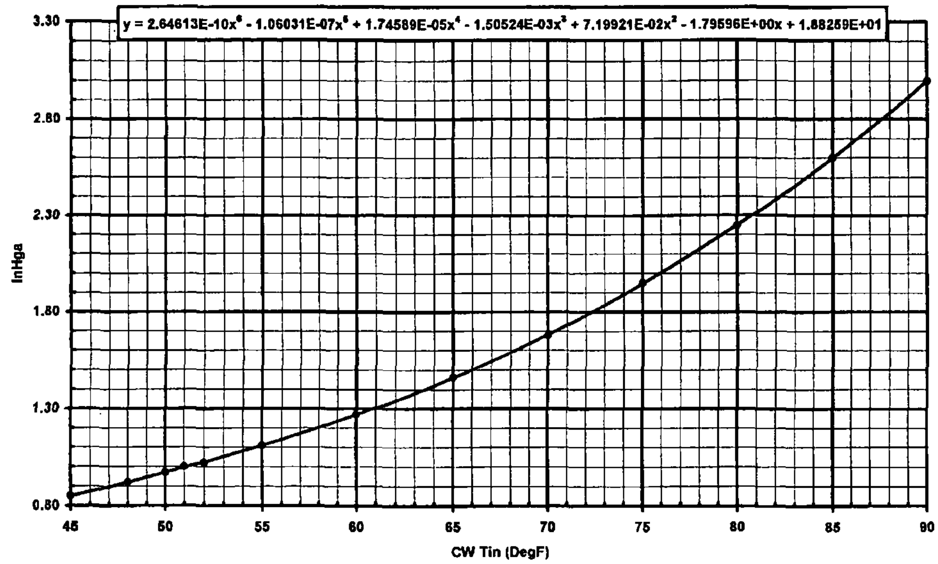


Figure 3.3 – Indian Point 3 Condenser Pressure vs. River Water Temperature

(100% Power, 90% Condenser Clean, 1 DegF Condensate Subcooling, 360 RPM CW Pump Speed)

Comparing the above graphs, it is evident that the condensers respond virtually the same to River water temperature changes:

River Water Temperature (°F)	Pressure (InHga), Unit 2 / Unit 3
60	1.28 / 1.26
70	1.69 / 1.66
80	2.25 / 2.20
90	3.00 / 2.95

Figures 3.4 and 3.5 indicate the relative impact of river water temperature on generator output for each unit.

Figure 3.4 – Indian Point 2 Generator Output vs. River Water Temperature

(100% Power, 85% Condenser Clean, ~1 DegF Condensate Subcooling, Fast CW Pump Speed)

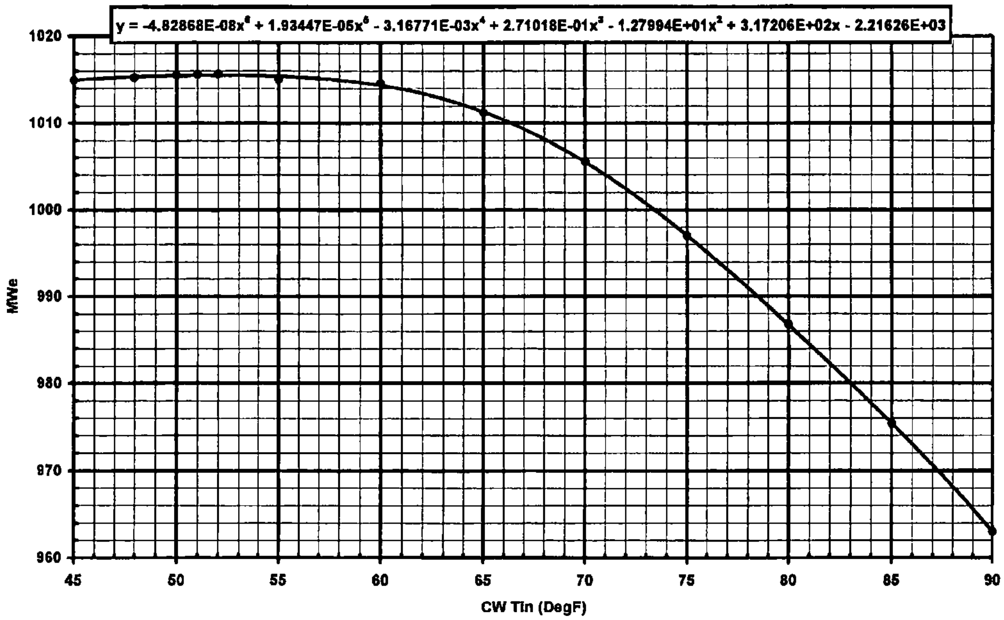
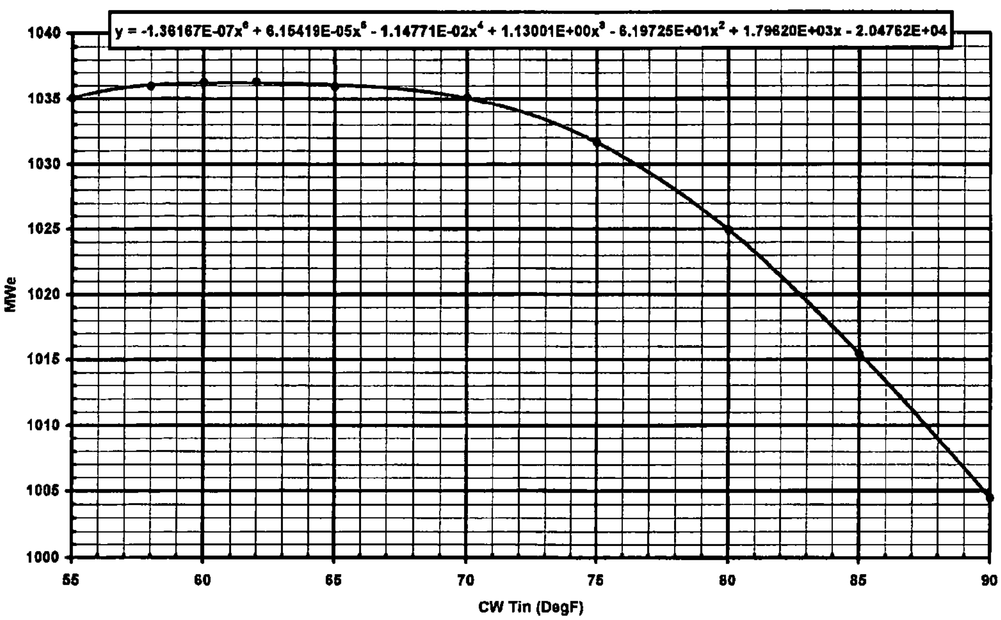


Figure 3.5 – Indian Point 3 Generator Output vs. River Water Temperature

(100% Power, 90% Condenser Clean, 1 DegF Condensate Subcooling, 360 RPM CW Pump Speed)



The difference in generator output vs. river water temperature for each unit is evident. Due to the differently designed turbine in Indian Point Unit 2, significant losses in generator output occur at appreciably lower River (condenser inlet) water temperatures.

Attempting to quantify the potential maximum loss of output, the estimated power reduction on a per unit basis is as follows;

> Indian Point 2 – Unit gross output, at circulating water temperatures less than 60°F, is approximately 1015 MW_E. Unit gross output, at circulating water temperatures approaching 88°F, is approximately 968 MW_E. Although the data points have some degree of variance, as the circulating water temperature increases from 60°F to 85°F, the unit output decreases from 1015 MW_E to 968 MW_E, a net decrease of approximately 47 MW_E.
>
> Indian Point 3 – Unit gross output, at circulating water temperatures less than 70°F, is approximately 1036 MW_E. Unit gross output, at circulating water temperatures approaching 88°F, is approximately 1009 MW_E. Although the data points have some degree of variance, as the circulating water temperature increases from 70°F to 85°F, the unit output decreases from 1036 MW_E to 1009 MW_E, a net decrease of approximately 27 MW_E.

Specifically as applies to the Indian Point plant condenser design, conversion to a closed-loop cooling configuration, with cooling towers as the vehicle for heat rejection, creates inherent limitations relative to plant performance. Whereas the Hudson River provides very cold water much of the year, consistent with the design requirements of the current condenser/turbine combination, a cooling tower is limited by the mechanism of evaporative cooling. Design of a cooling tower involves a trade-off between achievable cold water temperature, governed by approach to the maximum wet bulb temperature, and the size and cost of the tower.

For the Indian Point site, an appropriate design maximum wet bulb (reached/exceeded 0.4 % of the year, based on ASHRAE data for Newburgh, NY) is 76°F. The performance of a cooling tower is limited by the "approach" to design wet bulb temperature (see Figure 3.6). For instance, a tower designed for a 15°F approach will produce 91°F cold water when the design wet bulb of 76°F occurs (15+76=91). An appreciably (30%) larger tower, designed for a 12°F approach, would produce 88°F cold water at the same design wet bulb.

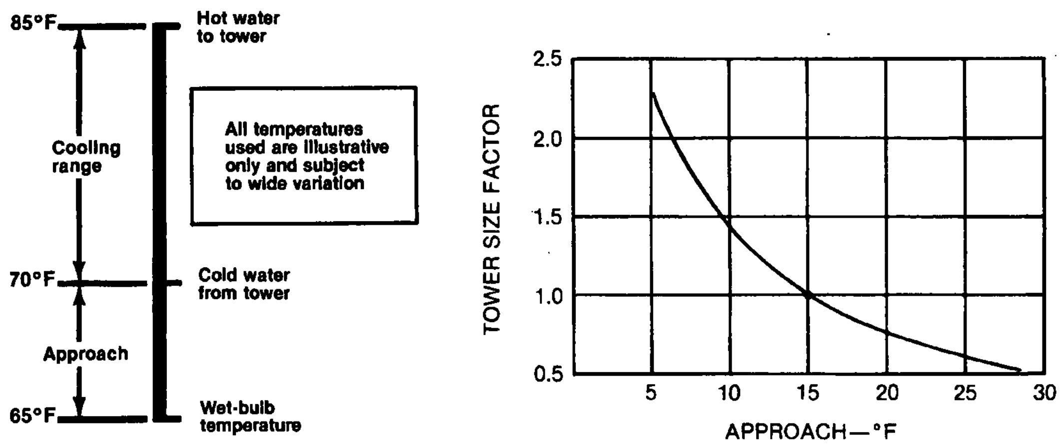


Figure 3.6 – Definition of "Approach," "Cooling Range," and relationship of approach to tower size [Reference 5.4].

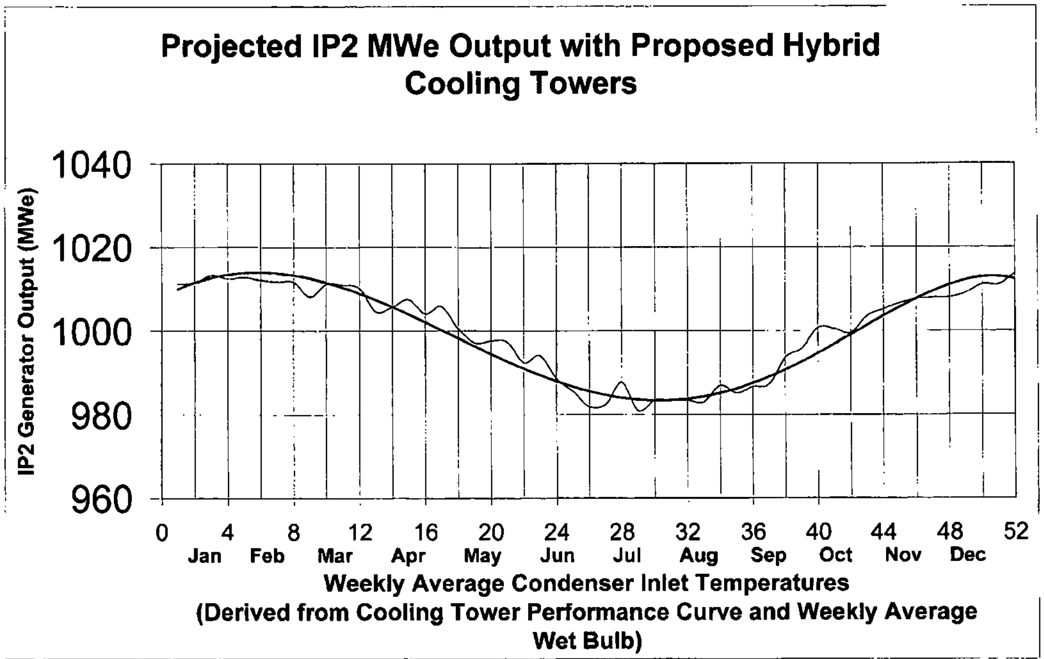
The graph on the left shows the relationship of range and approach as the heat load is applied to the tower. Although the combination of range and gpm is fixed by the heat load in accordance with Heat Load = gpm x 8.33 lbs./gal. water x range = Btu/min., approach is fixed by the size and efficiency of the cooling tower.

The graph on the right indicates how given two towers of equal efficiency, with proportionate fill configurations and air rates, the larger tower will produce colder water; i.e. have a closer approach. Important to note, from a tower cost standpoint, is the fact that the base 15°F approach tower would have had to be twice as large to produce a 7°F approach, whereas it could have produced a 25°F approach at only 60% of its size.

For the application at Indian Point, the Marley Cooling Tower Company was consulted relative to optimum tower design approach and tower sizing. Largely due to site specific restrictions and the need to utilize a hybrid tower, a tower with a 12°F approach was considered the largest that could be effectively utilized. Even with the approach limited to 12°F, the required tower would be approximately 525 feet in diameter, and would require (44) 300 HP motors for the wet section, and (44) 350 HP motors for the dry section. Since the 88°F condenser inlet water will only occur at maximum ambient conditions, and the wet section fan parasitic losses occur continuously, the 12°F approach tower design point was considered the optimum trade-off between total capacity and performance, and size, initial cost, and operating costs.

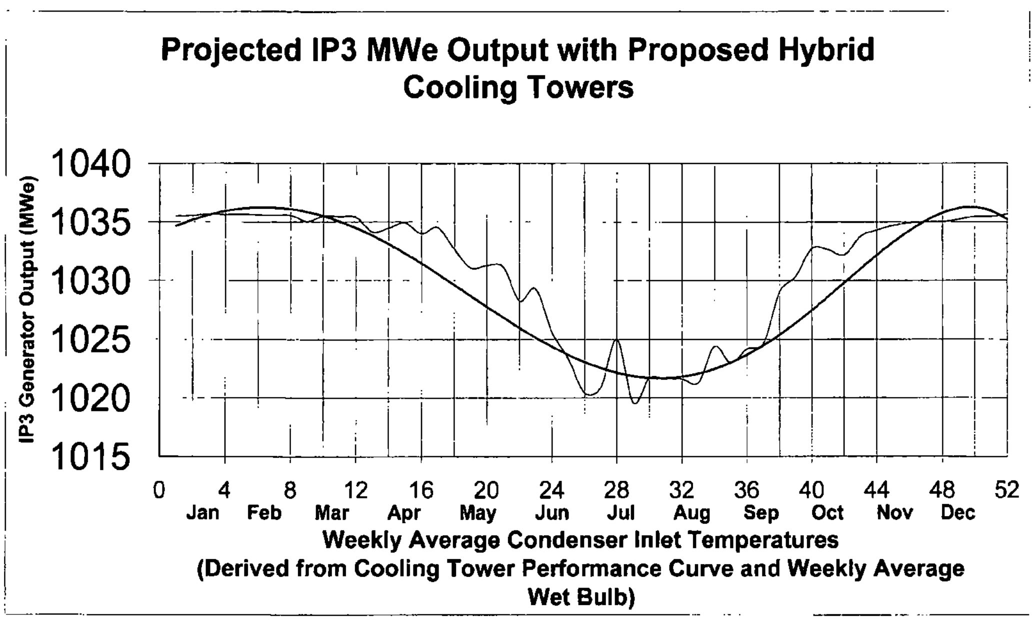
The following Indian Point 2 and 3 output curves will provide a basis for estimating post-closed-loop conversion monthly Unit output, via plotting condenser inlet (cooling tower outlet) temperature based on monthly mean wet bulb temperature, with the corresponding average monthly Unit output.

Figure 3.7 – IP2 Average Monthly Generator Output w/ Hybrid Cooling Towers



The weekly average wet bulb temperature is based upon Station meteorological data over the period of 1998 through 2000. This data is utilized to derive the corresponding weekly average condenser inlet temperature for each unit, based on the cooling tower performance curves for the proposed hybrid towers [Attachment 1, Marley Data].

Figure 3.8 – IP3 Average Monthly Generator Output w/ Hybrid Cooling Towers



By determining the impact on each operating unit's output on a weekly basis throughout the year, based on average ambient conditions, the resulting average annual impact can be estimated for each unit.

Indian Point 2 – Whereas the impact on unit output at maximum ambient conditions was previously estimated to be 47 MW_E, the estimated reduction on an annual basis is 15 MW_E; i.e., the annual average generator output with closed-loop cooling, utilizing the proposed hybrid cooling tower, is 1000 MW_E.

Indian Point 3 – Whereas the impact on unit output at maximum ambient conditions was previously estimated to be 27 MW_E, the estimated reduction on an annual basis is 6 MW_E; i.e., the annual average generator output with closed-loop cooling, utilizing the proposed hybrid cooling tower, is 1030 MW_E.

Attachment 3 includes all condenser performance data upon which these assessments and conclusions are based. Both compilations of previous actual turbine/condenser and unit output performance, as well as analytical projections based on PEPSE computer software are included.

In summary, generator output at peak (maximum ambient temperature) load conditions, following closed-loop conversion:

Indian Point 2, 968 MW_E, a reduction of 47 MW_E

Indian Point 3, 1009 MW_E, a reduction of 27 MW_E

Average annual generator output, following closed-loop conversion:

Indian Point 2, 1000 MW_E, a reduction of 15 MW_E

Indian Point 3, 1030 MW_E, a reduction of 6 MW_E

3.6 Water Treatment Costs

The existing once-through circulating water cooling system receives a minimum of water treatment. Biocides, specifically sodium hypochlorite, are added in quantities to achieve resulting concentrations as allowed by the discharge permit to minimize fouling of the condensers. Annual costs of these biocide injections are estimated to be less than $50,000.00.

With a closed-loop cooling system, water treatment requirements are dramatically increased. The cooling tower fill is subject to fouling, as are the dry heat exchanger sections. Both the quantities and frequency of biocide injections must be increased significantly to maintain the tower fill in proper condition.

Additionally, increased water treatment is necessary due to the higher concentrations of dissolved solids, chemicals, and biological agents in the system resulting from constant recirculation of the condenser cooling water. The cooling towers act as air washers as well as distilleries, constantly evaporating large quantities of water and leaving behind the non-volatile residues. The actual concentrations of these agents is wholly based on the cycles of concentration (cycles of concentration is discussed in section 2.3 of this Report), which are being used in the circulating water system.

Unlike the simple injections of biocide required for the once-through configuration, a closed-loop configuration typically utilizes a veritable cocktail of chemicals, each with specific attributes. Chemical treatment is broken into three subsections, deposition, corrosion, and biological.

Deposition

There are two forms of deposition, one being sedimentation, which is usually mitigated through piping design and the second being scaling. Scaling is a complicated condition and requires a educated approach to mitigation. In some cases scaling is necessary and useful in a piping system to prevent corrosion. For example a thin uniform coating of calcium carbonate provides corrosion protection for internal surfaces of piping, therefore this type of scaling is desirable and should be left intact where possible. The major problems arise when scaling becomes to thick and reduces heat transfer with the condenser or cooling tower. Scaling is kept under control through the use of pH control and dispersants.

Corrosion

Corrosion control is a complex science, requiring considerable knowledge of corrosion chemistry and of the system being evaluated. Corrosion is best mitigated through piping design and an aggressive chemical treatment program using pH control and corrosion inhibitors.

Biological

Biological growth or biofouling is the most difficult chemical challenge to a cooling water system since it involves a dynamic biological process. The biological process also promotes corrosion through the breakdown of chemical components and the creation of localized acids. In a closed-loop where the concentration of nutrients has increased, biofilms tend to increase on the piping internal surfaces and cooling tower fill. Control of the biofilms usually involve combining biocides with surfactant-type biodispersant to disrupt the biomatrix, allowing better penetration of the antimicrobial. Additional chemical treatments such as biodetergents may also be necessary depending on local biologicals and conditions.

Major cooling water chemicals would typically include:

Chemical type	Use/Function
sodium hypochlorite	biocide
surfactant	biocide aid
sulfuric acid	PH control
dispersant	scale prevention
phosphate	corrosion control

Appreciably increased costs are associated with this increased level of water treatment. Local conditions can greatly affect annual costs, but an annual cost per unit of $750,000.00 would be extremely conservative. Total Station costs would therefore be estimated at $1,500.000.00, and could easily approach $2,000,000.00.

4.0 Environmental Considerations

Based on the selected conceptual design, this section will identify, qualify, and quantify to the extent possible, resulting environmental impacts. Considerations and evaluations will include not only the long term positive and negative benefits, but also those interim impacts occurring during the implementation phase of the conversion.

Although resulting changes to the river intake flow will be quantified and specifically addressed in detail, the associated effect on entrainment and impingement of aquatic organisms is not included in this work scope, but rather is specifically addressed in a separate report.

4.1 Cooling Tower Plume

The potential environmental impacts attributed to the proposed cooling tower plume can be categorized as visual impact and physical impact.

The cooling tower type selected, the round hybrid tower, has specific attributes that minimize the visual impact of the tower's plume. Also termed a plume abated tower, the selected model generates no visible plume under the conditions for which it is designed, which correlates to 90% of the projected operating conditions. The selected design "plume point" is 27°F @ 90% relative humidity; i.e., the plume will start to become visible when the design plume point is exceeded, although the plume will be much less dense and/or persistent than if generated by a non-plume-abated tower. Additionally the dry section of the tower would be secured at night when plume visibility is not an issue, eliminating the considerable power consumption of the associated (44) 350 HP fans.

The potential physical impacts from a tower plume arise primary from the moisture content, which can cause icing and fogging during winter conditions, the salt content of the entrained moisture (the water vapor in the plume contains no salt) which can damage vegetation, and the heat content, which could potentially degrade Station heating, ventilating and air conditioning (HVAC) systems. It is important to note, that a hybrid tower produces an invisible plume, however, the plume still exists.

Predicted Plume Travel

As previously discussed, the round hybrid tower has inherent advantages relative to the tower plume generation and path of dissipation. To best identify plume path and trajectory, a computer code can be utilized to model the plume under site typical environmental conditions. The behavior of the plume was modeled using the SACTI code under environmental conditions typical of Indian Point. The details of this modeling effort are contained in Attachment 5 to this Report. The results of the modeling effort are summarized below.

The model predicts that the visible plumes will be short, despite the conservative saturated assumptions; i.e., assumes non plume abated "wet mode" operation only. Model output data and subsequent tabulation shows the annual length versus frequency result. The plume length is 800 m or greater only 10.5% of the time, and plumes from one tower reach the other tower only 4% of the time (when the wind is either north or south and the length is at least 800 m). These are based on 100% wet operation, so use of the hybrid dry operation will eliminate the visible plumes during daylight hours on most days.

Model output data also shows that the predominant direction of plume travel will be up or down the Hudson River (north or south), as would be expected with the prevailing winds. This effect also minimizes the inaccuracy introduced by lack of terrain modeling.

Drift and Salt Deposition

Drift is entrained water, in the form of small droplets, that exit the top of the cooling tower. When brackish water is used in evaporative cooling towers, salt dissolved in the drift may produce adverse effects on vegetation. The cooling towers proposed for Units 2 and 3 have a drift rate of 0.001%. This amounts to .00001*700,000 gpm of water evaporated = 7 gpm for each tower.

The predicted salt deposition from a single tower is shown via model output data. The predicted deposition rates of up to 73 kg/km^2 per month compare with ambient natural local deposition rates measured at an annual rate of 16 $\mu g/cm^2$month, which is 160 kg/km^2month [Reference 5.5.]

The predicted combined salt deposition from operation of both cooling towers is also demonstrated via the output data. The two-tower results show high deposition, approximately 112 Kg per Km^2 per month in the region between the towers, but still only on the order of the natural ambient deposition rate.

The description of potential injury to native trees in the immediate vicinity of Indian Point and to several food crops is presented in Table 4.1. Salt deposition from the cooling towers will combine with the natural deposition and may cause increased injury to hemlocks, dogwood, and white ash trees in the vicinity of Indian Point, however, the increased injury attributable to the operation of the cooling towers would be minimal.

Table 4.1. Potential Botanical Injury as a Function of Total Saline Deposit on Foliage

NaCl Deposit (Kg/Km^2)	Potential Injury
0 to 40[1]	No injury
40 to 100[1]	All hemlocks show signs of injury 5 to 50% of dogwood and white ash develop slight leaf spotting and some loss of fall color.
100 to 600[1]	All hemlocks, dogwoods, and white ash injured
> 600[1]	All hemlocks, dogwoods, and white ash injured 20 to 80% of silk trees, forsythia, chestnut oak, black locust, white pine, red pine, and red maple show signs of injury
660 per month[2]	Tomato and pepper plants show signs of injury
2037 per month[2]	10% reduction in corn yield
6,908 per month[2]	No reduction in yield of alfalfa and cantaloupe crops

[1]Source: [Reference 5.2, and 5.12]] This information is based on laboratory experiments to determine botanical toxicity of salt deposition on vegetation typically fond in the Indian Point area

[2]Source: [Reference 5.13]

Fogging and Icing

The results of the modeling show that the plumes are not expected to circulate to the ground, primarily because of the high release height of the towers combined with the high velocity forced exiting airflow. Thus no plume fogging or icing is expected in the vicinity of Indian Point attributable to the operation of the cooling towers.

4.2 Cooling Tower Noise

An ambient sound monitoring program was conducted in the vicinity of Indian Point 2 and Indian Point 3 between September 2001 and January 2002 [Reference 5.14]. Ambient noise levels were determined for seven representative sound receptor locations (Figure 4.1).

Existing sound levels at these locations are provided in Table 4.2.

Table 4.2: Average Measured Sound Levels (dBA)

Location	Daytime			Late Night		
	L_{90}	L_{10}	L_{eq}	L_{90}	L_{10}	L_{eq}
Saint Patrick's Church	41	50	48	42	48	46
16th Street / Broadway	38	51	50	40	46	45
Pheasant's Run	36	47	45	36	44	42
Town Hall	44	59	55	38	45	46
Bleakley Avenue / Broadway	45	61	58	38	44	42
China Pier	51	55	54	N/A	N/A	N/A
Theodore Hill Jr. Training Center	49	54	53	N/A	N/A	N/A

Source: [Reference 5.14]

The Village of Buchanan has a sound ordinance (Chapter 211-23 of the Village Zoning Code) that limits allowable sound levels from a facility by octave band levels and is applicable at the property line of the sound generating facility. The Village of Buchanan Sound Standard shown in Table 4.3.

Table 4.3: Buchanan Sound Standard

Octave Band Range (Hz)	Octave Band Center Frequency (Hz)	Sound Pressure Level (dB)
20 to 75	63	63
75 to 150	125	54
150 to 300	1250	49
300 to 600	500	44
600 to 1200	1000	40
1200 to 2400	2000	39
Above 2400	4000	34

The combined octave band center frequencies equate to an overall level of 48 dB(A).

The hybrid cooling towers will be equipped with sound attenuators. The noise level is expected to be 30dB(A) at 2,750 feet, approximately 940 feet east of the intersection of Bleakley Avenue and Broadway. The sound level at the intersection of Bleakely Avenue and Broadway is calculated to be approximately 34 dB(A). This is less than the late night ambient noise levels at this location (Table 4.2). The sound level at the residence nearest the proposed location for the Unit 3 cooling tower is calculated to be approximately 31 dB(A). The Village of Buchanan Sound Standard of 48dB(A) is met at approximately 350 feet from each tower, well within Indian Point 2 and Indian Point 3 property boundaries. The cooling towers will be constructed in the side of a hill. The topography between the cooling towers and sensitive receptors will further attenuate the sound levels. Table 4.4 presents the calculated noise level at sensitive receptors including existing background noise and the operational noise of both cooling towers.

Table 4.4 Cumulative Sound Levels and Sensitive Receptors (dB(A))

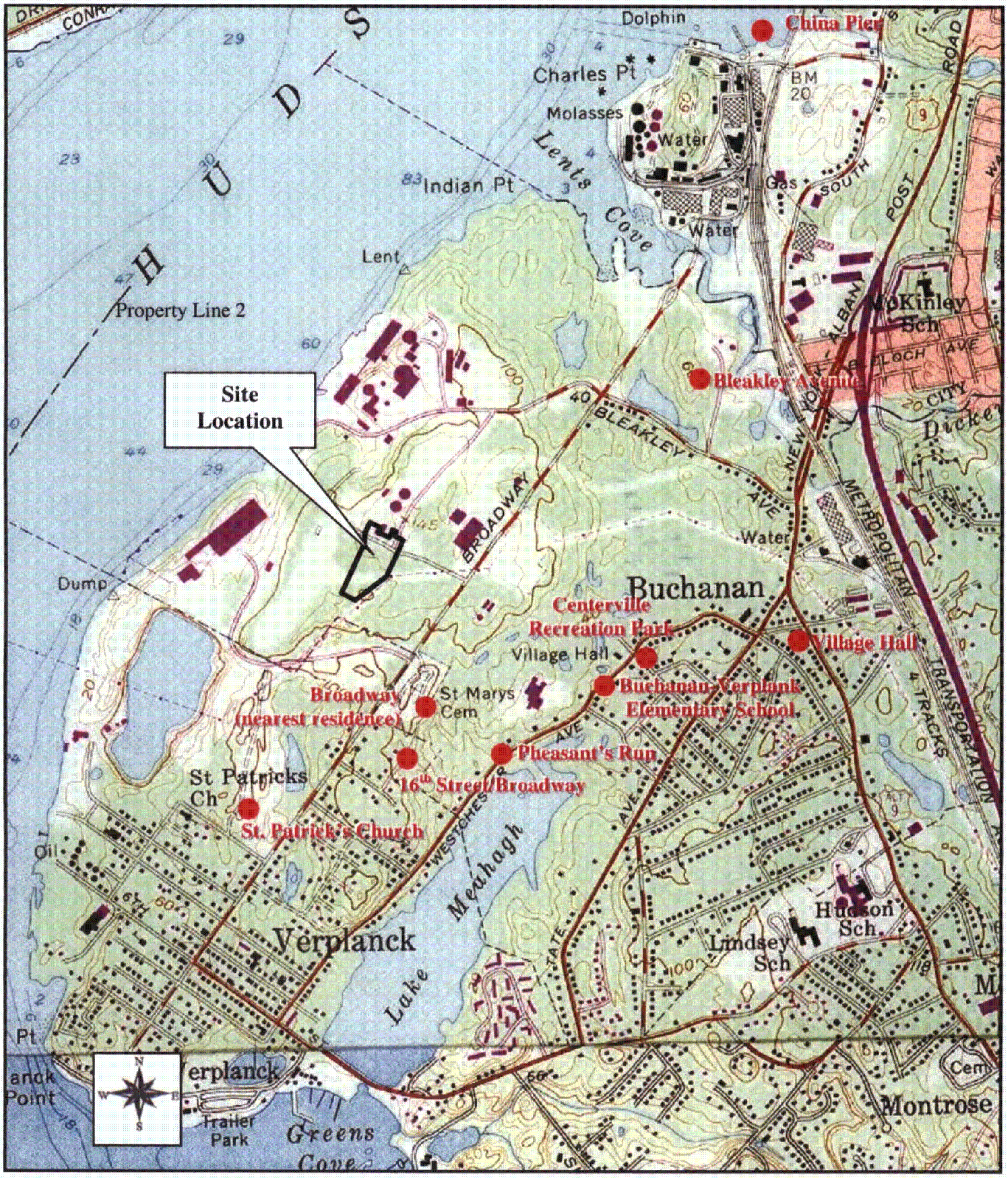
Receptor	Cooling Tower Noise Level [1]	Existing Daytime L_{90} [2]	Total Daytime Noise Level	Existing Late Night L_{90} [2]	Total Late Night Noise Level
Saint Patrick's Church	29	41	41	42	42
16th St & Broadway	30	38	39	40	40
Pheasant's Run	30	36	37	36	37
Buchanan Town Hall	28	44	44	38	38
Bleakley Ave. & Broadway	33	45	45	38	39
Elementary School	30	36	37	36	37
Nearest Residence	31	38	39	40	41
Centerville Park	30	36	37	36	37
China Pier	29	51	51	No Data	No Data

1 – Both towers operating continuously

2 – Source - [Reference 5.14]

This table reveals that both cooling towers operating continuously will cause in increase in noise levels at sensitive receptors of 1 dB(A) or less. This increase will probably not be noticed by the residents of the Village of Buchanan.

Figure 4.1, Sound Receptor Locations [Reference 5.14]



4.3 Site Aesthetics

When Indian Point Units 2 and 3 were constructed, the goal was to maintain a low physical profile for the generating Station vis-a-vis the Hudson River Valley through visual containment of Station structures within the confines of the surrounding forest-covered high ground [Reference 5.2]. Construction of the towers will require permanent modification of the terrain along the shore of the Hudson River.

The cooling towers will be located approximately 200 to 300 feet from the bank of the Hudson River at an elevation of about 30 feet mean sea level. The towers will be the largest structures on the Indian Point 2 and Indian Point 3 site. Each tower will be approximately 165 feet tall, about the height of a 14 story building, setting at an elevation of 30 feet msl, for a total height of 195 feet. Each tower will be approximately 525 feet in diameter. By comparison, the reactor containment structures are approximately 160 feet in diameter and 250 feet tall.

The cooling towers will have a substantial aesthetic impact [Attachment 2, page 2, Rendering]. An area approximately 700 feet in diameter will be excavated for each tower. In addition, approximately 1000 feet of river bank will be deforested to allow excavation for the 4 large diameter water pipes (2, 120" diameter supply pipes and 2, 144" diameter pipes to each condenser) required for each tower. Views from the Hudson River, scenic overlooks on area highways and from Palisades Interstate State Park on the western shore will be impacted. The Station is an industrial facility already visible from these vantage points, however, the addition of the two towers will make the entire facility more visible.

The clearcutting of the forest required for construction of the towers and to allow maximum airflow to the towers will remove a visual buffer from vantage points both up and down river. Because of this, as many trees between the construction sites and the river will be left as is possible. In addition, upon completion of construction, trees will be planted between the cooling towers and the River bank to reestablish a visual buffer and help attenuate noise from the operation of the towers.

The excavation for the cooling towers will cut into the side of the hills to the immediate east of the Station. These tree covered hills lie between the Station and the Villages of Buchanan and Verplanck and rise to an elevation of 130 to 145 feet, which will shield most of the tower from view, however many of the residents may still be able to see the tops of the towers above the tree tops. Because of the nature of hybrid cooling towers, no plume will be visible during the daylight hours. However, at night the towers will be run in wet mode, resulting is a plume of water vapor that may obscure the night sky for some residents.

4.4 Construction Activities

The Indian Point Station is situated on the Hudson River amid steep rolling hills ranging in elevation between 20 and 120 feet msl. Indian Point 2 and Indian Point 3 are located on the east bank of the Hudson River in the village of Buchanan. The predominant land use within a two-mile radius of the Station is residential, recreational, and commercial. The populated area of Buchanan flanks the site to the east. The Town of Verplanck lies about a half a mile to the south and the Town of Peekskill lies about 1 mile to the north.

Site Clearing and Excavation

Construction of the hybrid tower will entail significant excavation at the Station (Attachment 6). The base of the tower will be constructed on bedrock, at an elevation of about 30 feet above mean sea level. This will entail the removal of approximately 2 million cubic yards of material, primarily rock. Approximately 40 acres of land not previously disturbed will be cleared for the two cooling towers and new access roads.

The information presented here is primarily based on a survey of the vegetation of the Station environs [Reference 5.10]. The area immediately surrounding the Station is characterized by species of Eastern Deciduous Hardwood, regionally quite thick with a dense canopy. The forest has attained the codominant climax stand characteristic of a mature Eastern Hardwood forest (codominant species are defined as species of plants that, in combination, give the forest its characteristic appearance or physiognomy and may control its structure). In the intervening 30 years, the forests immediately surrounding the Station have not been cut, and remain a climax forest.

The dominant and codominant trees reported in this area were eastern hemlock (*Tsuga canadensis,* also known as Canadian hemlock), red oak (*Quercus rubra)*, white oak (*Quercus alba*), chestnut oak (*Quercus primus*), and shagbark hickory (*Carya ovata*), among others. The dominant and codominant trees were reported to range in height from 55 to 65 feet with diameter at breast height of 18 to 36 inches [Reference 5.10]. With 30 additional years of growth, many of these trees are larger now, though there is no recent quantitative information. The understory relationships in the Eastern Deciduous Hardwood forests are a ground canopy of witch-hazel (*Hamamelis verginiana*), flowering dogwood (*Cornus alternifolia*) and hickories, and a secondary canopy of eastern hemlock and witch-hazel. The forest floor is composed of up to a 2-inch layer of organic matter, mostly decaying leaves, and varying amounts of shrubs and herbs such as witch-hazel, Indian pipes, and Virginia creeper.

The impact of clear cutting this 40 acres is not easily definable. The obvious impacts include destruction of habitat for mammals that normally inhabit eastern hardwood forests, including raccoon, squirrels, opossum, and white tail deer. There is sufficient forest surrounding these areas to be cleared that forest fragmentation is not of concern. However, a large portion of the area surrounding the Station has been developed and the amount of undisturbed eastern deciduous hardwood forest in the vicinity is decreasing.

Clear cutting of the forest and subsequent excavation of the sites for the two cooling towers will alter the flow pattern of runoff from precipitation events. The volume of runoff potentially reaching the Hudson River will likely increase and the silt load of the runoff will increase because of the lack of trees and vegetation to hold the soil and slow the transport of water. Standard techniques of control of runoff will be implemented, such as silt fences and grading to control the flow of runoff during construction. Because the construction sites are so close to the river, extra protective measures to prevent runoff carrying excess silt and contaminants such as gas and oil, will be necessary. Temporary sediment retention basins may have to be constructed to prevent the increased silt load of the runoff from reaching the river. Truck and equipment washing areas will be equipped with impermeable basins to intercept petroleum contaminants. Dust from the construction site will be controlled by water sprays or, if necessary, other chemical dust suppression agents. All storage tanks containing gasoline, diesel fuel, or oils will have secondary containment to intercept spillage or leaks.

Disposal of 2 million cubic yards of material is problematic. To transport the material to an acceptable disposal site by truck, assuming 6 cubic yards per load, would entail over 300,000 round trips. The excavation is expected to take 30 months to complete. This scenario would result in unacceptable impacts due to noise and traffic volume to the Village of Buchannan and the surrounding communities. The alternative disposal scenario would be to transport the material by barge to a suitable disposal site.

Construction Noise

Clearing, pile driving, and excavation of the site for the cooling towers will generate the most noise during the 5 year construction period. Excavation is expected to take 30 months and will entail blasting. An evaluation of construction noise was done for the Indian Point Peaking Facility (Figure 4.1) and, again, the excavation and grading of the site generated the most noise [Reference 5.14]. The results, depicted in Table 4.5, show that the calculated average construction sound levels were projected to be very close to the existing daytime sound levels at all sensitive receptor locations.

Work Force

Construction of the cooling towers will require a average work force of 300 and will take an estimated 62 months. During the outage phase of the effort, the work force will peak at 600. It is anticipated that the majority of the workforce will be temporary. Only a small percentage will look for permanent residence in the area. For comparison purposes, a work force of approximately 600 is on-site during a routine refueling outage. A fluctuating work force in the Buchanan/Verplanck area is normal and the additional workers for the cooling tower construction should not cause more severe problems than typically encountered during a refueling outage. Traffic in the area is heavy and the additional workers may cause increased traffic delays, particularly along the major routes; i.e., State Routes 9 and 9A.

Table 4.5: Comparison of Calculated Average Daytime Construction Phase Sound Levels For The Indian Point Peaking Facility to Existing Daytime L_{eq} Sound Levels At Residential Receptors (dBA)

Receptor (See Figure 4.4-1)	Initial Grading and Excavation	Concrete Pouring	Building Assembly	Siding and Machinery Installation	Exterior Finish and Cleanup
	ACN / L_{eq}	ACN / L_{eq}	ACN / L_{eq}	ACN / L_{eq}	ACN / L_{eq}
Saint Patrick's Church	49 / 48	45 / 48	44 / 48	44 / 48	47/ 48
16th Street/Broadway	49 / 50	44 / 50	43 / 50	44 / 50	45 / 50
Pheasant's Run	38 / 45	33 / 45	33 / 45	33 / 45	34 / 45
Buchanan Town Hall	42 / 55	37 / 55	37 / 55	37 / 55	38 / 55
Bleakley Avenue/Broadway	38 / 58	34 / 58	33 / 58	33 / 58	35 / 58
China Pier	38 / 54	33 / 54	32 / 54	32 / 54	34 / 54
School	48 / 45	43 / 45	42 / 45	42 / 45	46 / 45
Nearest Residence	53 / 50	48 / 50	47 / 50	48 / 50	49 / 50

	Initial Grading and Excavation	Concrete Pouring	Building Assembly	Siding and Machinery Installation	Exterior Finish and Cleanup
(Broadway)					
Centerville Recreational Park	46 / 45	41 / 45	40 / 45	40 / 45	41 / 45

ACN = Average Construction Sound Level
L_{eq} = Measured Daytime L_{eq} Sound Level

The proposed sites for the cooling towers are a greater distance from sensitive receptors than the proposed location for the peaking facility (except for the Bleakley Avenue location, see Figure 4.1), so these results are directly applicable to the construction of the cooling towers.

4.5 Reduced Intake Flow

The overall objective of converting Unit 2 and Unit 3 from once-through condenser cooling to closed-loop condenser cooling is a reduction of River intake flow. Although the qualification and quantification of environmental benefits from the associated reduction in entrainment and impingement of aquatic fish and shellfish is not within the scope of this Report, the quantification of the reduction in River intake flow is a significant assessment.

Current River intake flow for ENIP 2/3 Station is as follows [References 5.8 and 5.9]:

Unit 2 Circulating Water $_{\text{Maximum*}}$	840,000 gpm
Unit 2 Service Water $_{\text{Includes some U1 flow}}$	31,000 gpm
Unit 3 Circulating Water $_{\text{Maximum*}}$	840,000 gpm
Unit 3 Service Water	20,000 gpm
Total Intake Flow $_{\text{Once Through, Maximum*}}$	1,731,000 gpm

*Flow at maximum pump performance during summer River temperature conditions.

Current plant design utilizes significantly reduced River intake flow in the winter, when cold water temperatures support reduced flow operation. At minimum flow conditions, Unit 2 circulating water flow is (6_{pumps}) x 84,000 gpm = 504,000 gpm, and Unit 3 circulating water flow is (6_{pumps}) x 69,167 gpm = 415,000 gpm [Note 1], for a combined flow of:

Total Intake Flow $_{\text{Once Through, Minimum}}$	919,000 gpm

Note 1: (6_{pumps}) x 54,000 gpm = 324,000 gpm is the theoretical Unit 3 minimum flow, and is the target minimum flow when it will support plant operation. A minimum flow of 415,000 gpm is always attainable in winter, hence was used for conservatism.

River intake flow for the Station following conversion to closed-loop cooling is as follows:

Typical summer conditions,

Unit 2 Circulating Water Makeup $_{\text{Average Summer}}$	16,000 gpm
Unit 2 Service Water $_{\text{Includes some U1 flow}}$	31,000 gpm
Unit 3 Circulating Water Makeup $_{\text{Average Summer}}$	16,000 gpm
Unit 3 Service Water	20,000 gpm
Total Intake Flow $_{\text{Closed Loop}}$	83,000 gpm
Total Intake Flow $_{\text{Once Through, Maximum}}$	1,731,000 gpm
Reduction In River Intake Flow $_{\text{Maximum}}$	95.2%

Typical winter conditions,

Unit 2 Circulating Water Makeup $_{\text{Average Winter}}$	7,800 gpm
Unit 2 Service Water $_{\text{Includes some U1 flow}}$	31,000 gpm
Unit 3 Circulating Water Makeup $_{\text{Average Winter}}$	7,800 gpm
Unit 3 Service Water	20,000 gpm
Total Intake Flow $_{\text{Closed Loop}}$	66,600 gpm
Total Intake Flow $_{\text{Once Through, Minimum}}$	919,000 gpm
Reduction In River Intake Flow $_{\text{Minimum}}$	92.8%

Although the summer and winter makeup rates utilized above are both based on average values, since the makeup flow will vary (be controlled) based on River water chemistry, the maximum variance on the percentage reduction in River intake flow is less than +/- 1%.

5.0 References

5.1 *Economic and Environmental Review of Closed Cooling Water Systems for the Hudson River Power Plants,* Power Tech Associates, Paramus, New Jersey, November 1999.

5.2 *Economic and Environmental Impacts of Alternative Closed-Cycle Cooling Systems for Indian Point Unit 2,* Consolidated Edison Company of New York, Inc., Volume No. 1, December 1, 1974.

5.3 *Economic and Environmental Impacts of Alternative Closed-Cycle Cooling Systems for Indian Point Unit 3,* Consolidated Edison Company of New York, Inc., Volume No. 1, January 1976.

5.4 *Cooling Tower Fundamentals,* Marley Cooling Tower Company, Second Edition, 1998.

5.5 *Circular Hybrid Cooling Towers,* Cooling Technology Institute, Paper No: TP00-11, Ph.D. Andreas Streng, February 2000.

5.6 *Minimizing the Power Consumption of Hybrid Cooling Towers by Process-Controlled Mode of Operation,* Paper of Oral Presentation, 9th Cooling Tower and Spraying Pond Symposium, International Association for Hydraulic Research, Walter Tesche, September, 1994.

5.7 *ASHRAE Fundamentals,* American Society of Heating, Refrigerating and Air Conditioning Engineers, 2001 edition.

5.8 *Indian Point Station, Unit No. 2, System Description No.. 23, Circulating Water System,* Revision 3, April 1985.

5.9 *Indian Point. 3, System Description 23.0, Circulating Water System,* Revision 2, December 27, 2001.

5.10 *Vegetation Survey of the Indian Point Environs*, Prepared for Consolidated Edison Company, Dames & Moore, March 1973.

5.11 *Engineering Manual 1110-2-3105, Mechanical and Electrical Design of Pumping Stations*, U. S. Army Corps of Engineers, Changes 1 and 2, Nov. 30, 1999.

5.12 *Effects of Aerosol Drift Produced by the Cooling Tower at the Indian Point Generating Station on Native and Cultivated Flora in the Area,* Boyce Thompson Institute, Yonkers, New York, 1974.

5.13 *Umatilla Generation Project, Final Environmental Impact Statement*, Bonneville Power Administration, DOE/EIS-0324.

5.14 *Indian Point Peaking Facility, Sound,* TRC Environmental, Draft Report 2003, with background noise survey data from 2001 and 2002.

6.0 Attachments

Attachment 1
Major Components; Vendor Data and Reference Information

1. Marley/Balcke-Durr; Hybrid Cooling Towers
2. Marley/Balcke-Durr Hybrid Tower; Data, Performance Curves, and Pricing
3. Balcke; GKN 2 Hybrid Tower
4. Johnston Pump; Circ Water Pumps Data and Performance Curves
5. Mercer Rubber; Expansion Joints
6. Northwest Pipe; AWWA Concrete Lined Pipe

HYBRID

COOLING TOWERS

**COOLING TOWERS
WITHOUT VISIBLE PLUME**

Marley

Balcke-Dürr Energietechnik & Thermal Engineering International

VISIBLE PLUME – AN AVOIDABLE PROBLEM

Every wet cooling tower generates a visible plume which can be very extensive particularly in cold and/or humid weather. It is the physical functioning principle of a wet cooling tower, in which the water to be cooled is essentially cooled by evaporating a small proportion thereof, which causes the plume. When it leaves the cooling tower, the visible plume therefore consists only of small water droplets and is normally neither dangerous nor environmentally hazardous.

Such plume can, however, lead to negative reactions such as:

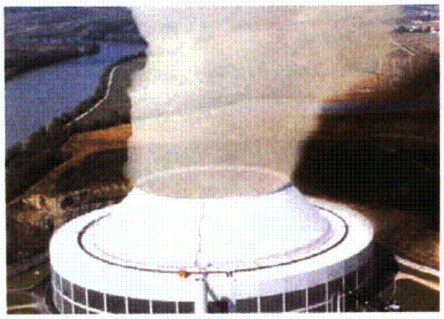
- complaints and objections from local residents
- problems relating to acceptance and approval at plant locations
- corrosion and ice formation on components in the vicinity
- endangering of nearby traffic routes (roads and railways) in the case of larger cooling towers
- in the case of very large cooling towers a considerable amount of shadow is caused in the vicinity which can have negative effects, for example, on agricultural areas

Visible cooling tower plume in most cases harmless but nevertheless giving grounds for complaint, in particular in cold weather and when there are traffic routes in close proximity

This was the reason why Balcke-Dürr developed the concept of the "hybrid cooling tower" several decades ago. In principle this hybrid cooling tower is a wet cooling tower in which the plume is mixed with a dry, hot air stream prior to leaving the cooling tower. This air stream is generated in heat exchangers, the water to be cooled serving as the heating medium. No additional energy is therefore required to heat the air. The quantity of hot air added is such that the plume leaving the cooling tower is undersaturated and remains undersaturated even when it is mixed with the ambient air. Consequently it remains invisible.

Normally, cooling with the plume being invisible is only possible when a dry cooling tower without evaporation is used. This involves, however, higher capital investment costs and the cold water temperature achieved are higher compared to those of a wet cooling tower.

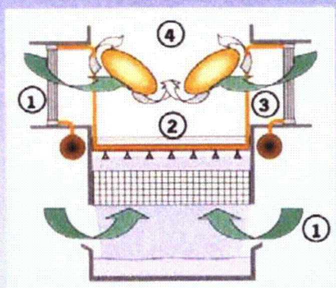
Hybrid cooling towers of the Balcke-Dürr design are amongst the technically most advanced cooling towers of this type. To date we have built such towers exclusively as round structures which are best suited to the large flow rates of water to be cooled (please refer to pages 6/7). Some examples of our hybrid cooling towers are set out on the following pages.

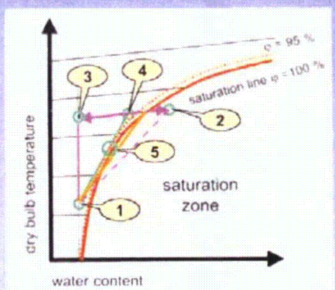


The problem: visible plume

The solution: Balcke-Dürr hybrid cooling tower

PHYSICAL FUNCTIONING PRINCIPLE OF A HYBRID COOLING TOWER:





Principle sketch of a hybrid cooling tower. The method of operation of a hybrid cooling tower is illustrated in the "Mollier h, x-diagram" on the right side.

1. Ambient air being fed to the cooling tower.
2. Plume leaving the cooling fill (the so-called wet section of the cooling tower). When emerging from purely wet cooling towers, this plume mixes with the ambient air. In this case the cooling tower plume mixes with the ambient air along the mixing line (dotted connecting line between 1 and 2).
3. Heated air stream leaving the dry section heat exchanger. The air is heated in the dry section at a constant level of humidity.
4. Mixed air streams from wet and dry sections. The air leaves the cooling tower in this state. The mixing line (green connecting line between 1 and 4) distinguishes the possible degrees to which the exhaust air is mixed with the ambient air.
5. Smallest distance between the mixing line and the saturation line (humidity of the air = 100 %) when the air leaving the hybrid cooling tower mixes with the ambient air. If the mixing line does not intersect or touch the saturation line, then no water condenses out. In this case the plume is not visible.

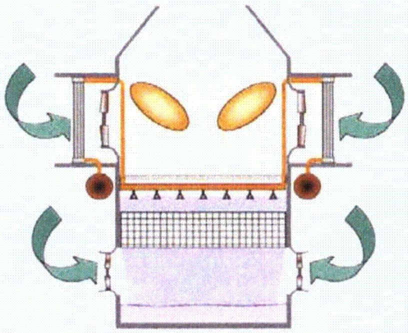
THE TOP CLASS – HYBRID COOLING TOWER OF A ROUND DESIGN

Balcke-Durr hybrid cooling towers are the ideal solution for power stations and chemical plants in which large water flows need to be cooled. Recirculation and interference occur in large cell-type cooling towers, i.e. the hot cooling tower plume is sucked back into the air inlets. This significantly reduces the thermal performance of the cooling tower and additional cells would have to be built in order to compensate for the reduction in performance. Recirculation and interference problems are hardly ever experienced in round cooling towers due to their greater overall height.

A round hybrid cooling tower also requires less space than a large cell-type plant. Finally less piping is needed, as in round cooling towers only one hot water pipe leads to the cooling tower whilst in cell-type cooling towers one individual pipe has to be allocated to each cell.

Round hybrid cooling towers have separate forced draught fans in front of the wet and dry sections. Whilst the speed of the wet section fans is adjusted to ensure the required cooling water temperature, the appropriate speed adjustment of the dry section fans controls the required hot air flow rate for plume-free operation. Optimal, energy-saving process control can therefore be achieved in such cooling towers.

Another positive aspect is the architectural design of hybrid cooling towers.



Hybrid cooling tower with forced draught fans

Hybrid cooling towers of a round design equipped with sound attenuators for a combined heat and power station in Germany. (Fig. 1+2)

Round cooling tower for an Italian refinery. (Fig. 3)

Hybrid cooling tower of a round design equipped with sound attenuators for a German nuclear power plant – the definite world champion of its class. (Fig. 4)

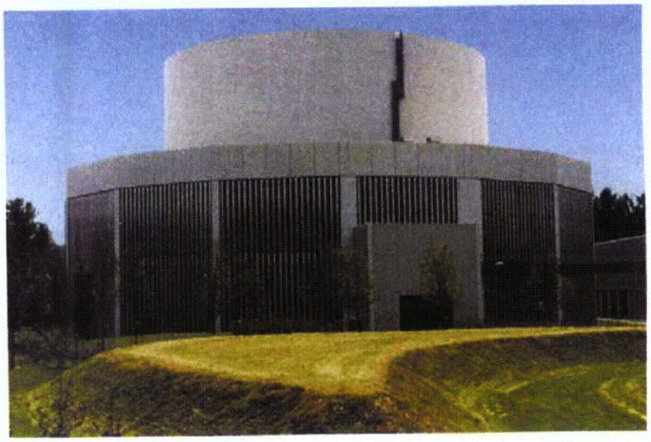


Fig. 2

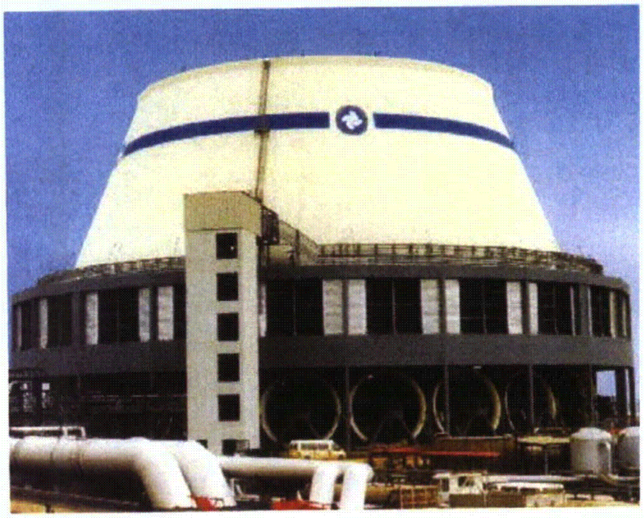


Fig. 3

Fig. 1

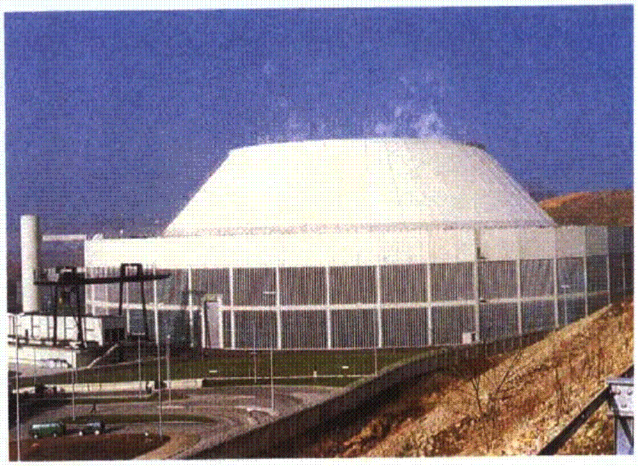


Fig. 4

KEY COMPONENTS OF A HYBRID COOLING TOWER

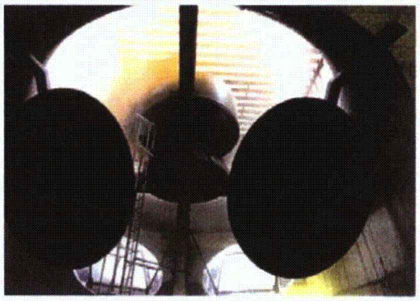


Fig. 1

COMPONENTS ESSENTIAL TO THE FUNCTIONING OF A HYBRID COOLING TOWER ARE:

- mixing ducts or mixing discs (Fig. 1 and 2),
- low-noise fans (Fig. 3),
- heat exchangers for the dry section (Fig. 4),
- rubber ball cleaning system for the inside of the heat exchanger tubes,
- pressurised water cleaning system for outer finned tube surfaces,
- evacuation equipment,
- bypass systems.

HEAT EXCHANGER – QUALITY AT THE HIGHEST LEVEL

Balcke-Dürr heat exchangers are produced at the company's own production facilities and guarantee the highest quality. The production staff can select from a wide range of materials such as C-steel, stainless steel, nonferrous metal, aluminium in order to provide the appropriate tube material for any medium.

C-steel, stainless steel, copper or aluminium are used as fin material for the finned heat exchanger tubes. When tubes or fins are made of C-steel the finished tubes are hot-dip galvanised to protect them against corrosion.

FANS – LOW SOUND POWER LEVEL BUT A HIGH DEGREE OF EFFICIENCY

Low-noise fans are an absolutely essential component of an environmentally sound hybrid cooling tower design.

The low-noise fan drives and the invisibility of the plume contribute significantly to compliance with the optical and acoustic requirements of environmental regulations.

The low-noise running of the fans designed especially by Balcke-Dürr ensures that optimal efficiency is achieved at a low sound power level.

Fig. 2

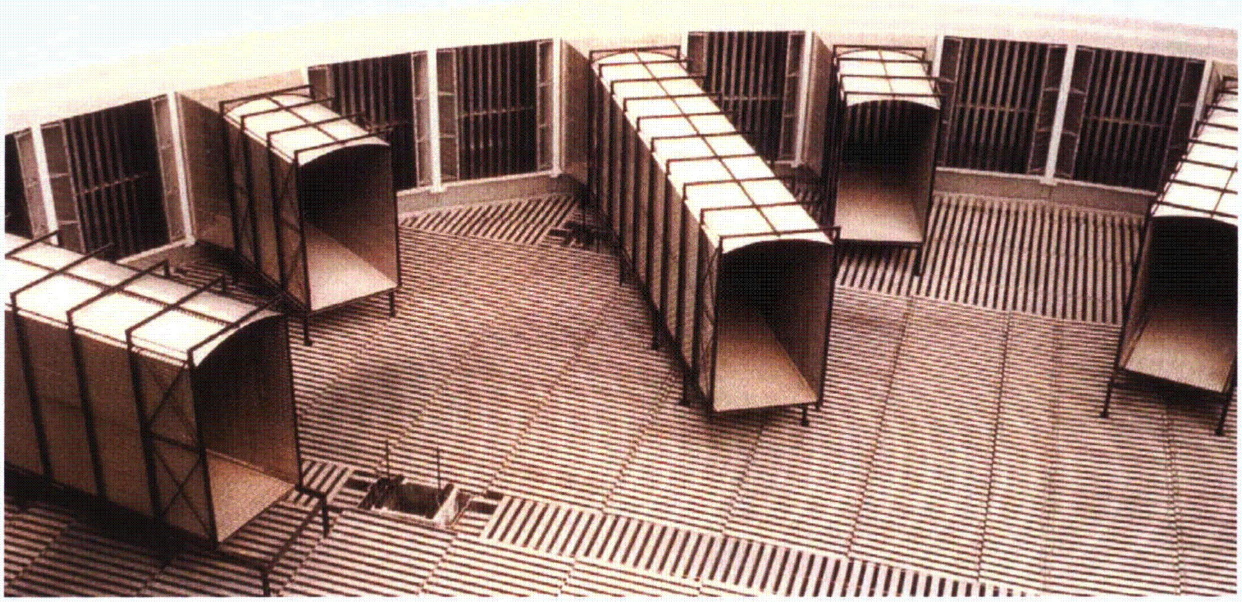


Fig. 3

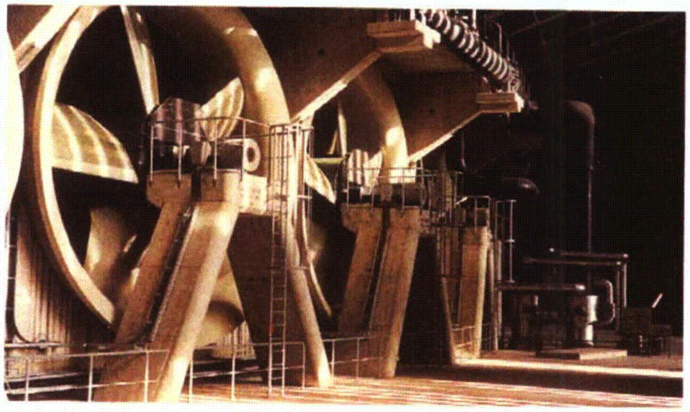
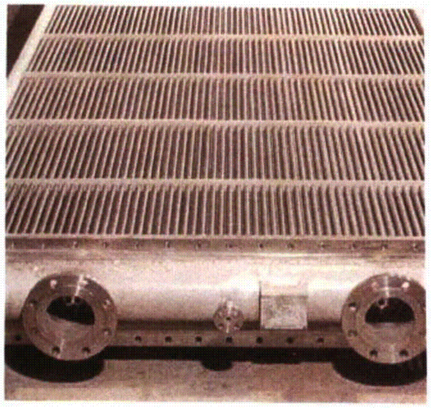


Fig. 4



MIXING SYSTEMS – PATENTED EFFICIENCY

The mixing systems patented by Balcke-Durr ensure compliance with the guaranteed invisibility of plume. Appropriately designed mixing discs and mixing ducts generate the vortices required to mix the immense air flows.
Effectiveness and low pressure drop are the main features of these mixing systems.

CLEANING EQUIPMENT – CUSTOM-BUILT FOR EASY MAINTENANCE

A custom-designed heat exchanger for the dry section requires an appropriate cleaning system in order to keep the fouling factor as low as possible.
Rubber balls ensure that the inner tube walls are kept clean during continuous operation in a large cooling tower. In cell-type cooling towers it is preferable to use a cleaning fluid. Manual or semi-automatic water jet cleaning equipment ensures thorough cleaning of the tube outer surfaces/fins. The cleaning equipment is used once or twice per year.

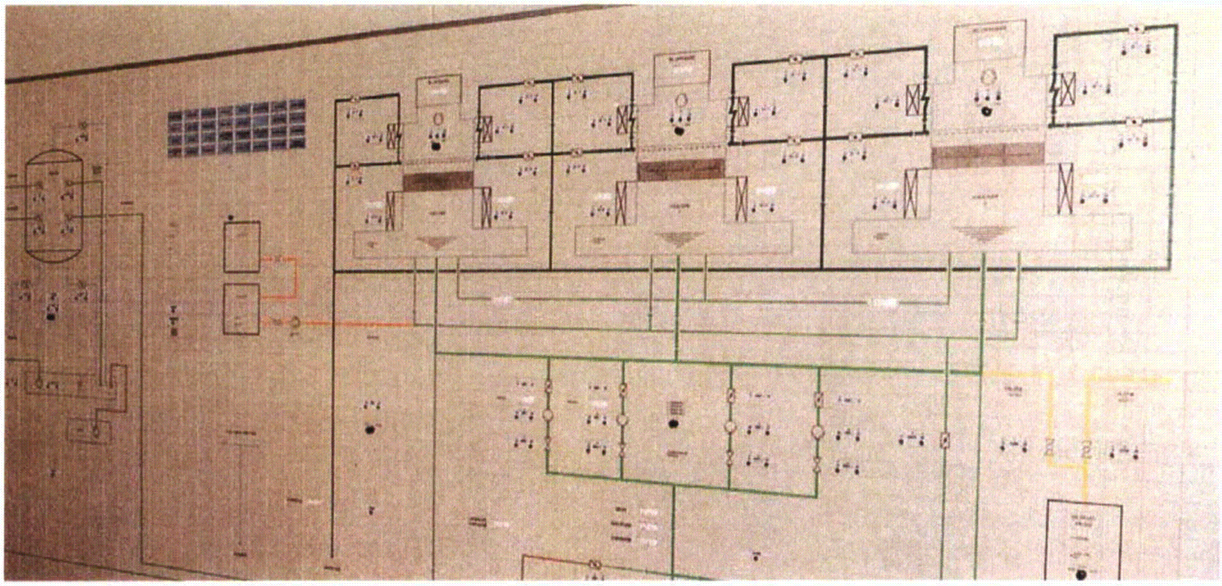
EVACUATION – ONLY APPLIED WHEN REQUIRED

The syphon-principle mode of operation has to be applied in order to operate the dry section economically. Accumulation of inert gases may disturb or interrupt the syphon effect. It may be necessary to use evacuation equipment depending on the design and configuration of the heat exchanger.

BYPASS SYSTEMS – FLEXIBLE MODE OF OPERATION

In principle it should be possible to operate a hybrid cooling tower purely as a wet cooling tower or purely as a dry cooling tower in order to guarantee 100% availability. To do this, the plant section not in operation must be suitably and reliably bypassed. Controlled valves in conjunction with overflow weirs ensure absolutely reliable operation.

AUTOMATIC PROCESS CONTROL AND INSTRUMENTATION – GUARANTEE FOR OPTIMAL OPERATION



Control panel for a hybrid cooling circuit

When operating hybrid cooling towers it is extremely important to ensure optimal adjustment to the mode of operation so that:

- operation is plume-free irrespective of the changing ambient meteorological conditions
- the cooling water temperatures being a function of the cooling water flow rate, the heat rejection rate and the changing ambient air conditions are as required
- power consumption of the cooling tower fans is minimised

The automatic hybrid cooling tower process control developed by Balcke-Dürr which comprises the latest instrumentation and control technology including Programmable Logic Control (PLC) systems guarantees:

- fully automatic operation to ensure invisibility of plume or minimum plume
- maximum profitability with minimal power consumption
- maximum reliability and availability of the plant
- minimal personnel expenses

The automatic process control for hybrid cooling towers is designed and engineered by an experienced team of experts at Balcke-Dürr who are well-versed in cooling tower operation and have specific technical expertise in instrumentation and control technology.

Upon request, we can also supply optimal automated process control for the entire cooling circuit (please refer also to our brochure "Industrial Cooling Water Supply Systems")

From: John.Arntson@marleyct.spx.com
Sent: Friday, May 23, 2003 4:35 PM
To: sbeaver@enercon.com
Cc: JIM.VANGARSSE@marleyct.SPX.COM
Subject: Revised Performance Data

Tower Type:
Counterflow, forced draft, plume abated (hybrid) with low noise fans & sound attenuation baffles.

Tower Geometry:
OD= 524.8 ft
Overall Ht. = 168 ft.
ID exit cone: 241.4 ft.
No. fans (wet section) = 44 (Motor output power = 300 HP)
No. fans (dry section)= 44 (Motor Output Power = 350 HP)

Wet Section Data:
Flow = 700,000 gpm
Plan area of fill: 121660 ft2
Fill Type: 6 ft. PVC low fouling film (MCT FC-18)
DE type / drift rate: Cellular PVC (MCT TU-12)/ drift rate .001%
Distribution system: FRP headers/PVC pipes
Nozzles: High efficiency polyproplyene

Dry Section Data:
Flow= 245,000 gpm
Element type: 4 row/ 2 pass
Tube type: 1" OD Titanium
Fin Type: 2.25" OD Aluminum fins @ 11 fins/in ("L" fin)
Tube length = 49 ft.
No. tubes/ bundle = 218
No. bundles = 264

Thermal Data:
Wet design condition: (77 WBT, 89 CWT, 109 HWT)
HP (motor output wet section) = 270 HP, evaporation rate = 1.67%, Vexit= 1233 fpm

Hybrid Operation@ plume abatement design point(27 WBT @ 90 % RH)
HP (MOP wet section) = 300 HP, evaporation rate = .81%, CWT = 59 °F, Vexit=2260 fpm
HP (MOP dry section)= 350 HP

Note: evaporation rate at summer conditions with dry section in operation will be approx. 1.47%. CWT= 88 ° F approx.

Pumping Head:

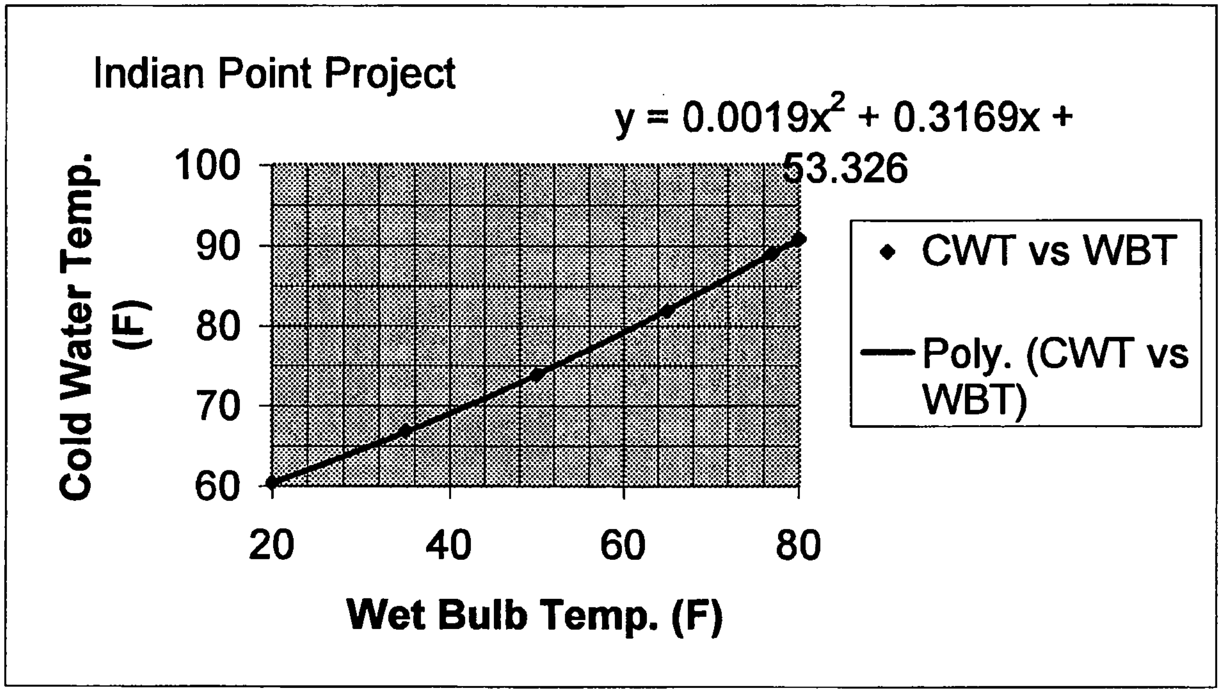
Main Pumps:
700,000 gpm @ 45 ft. TDH

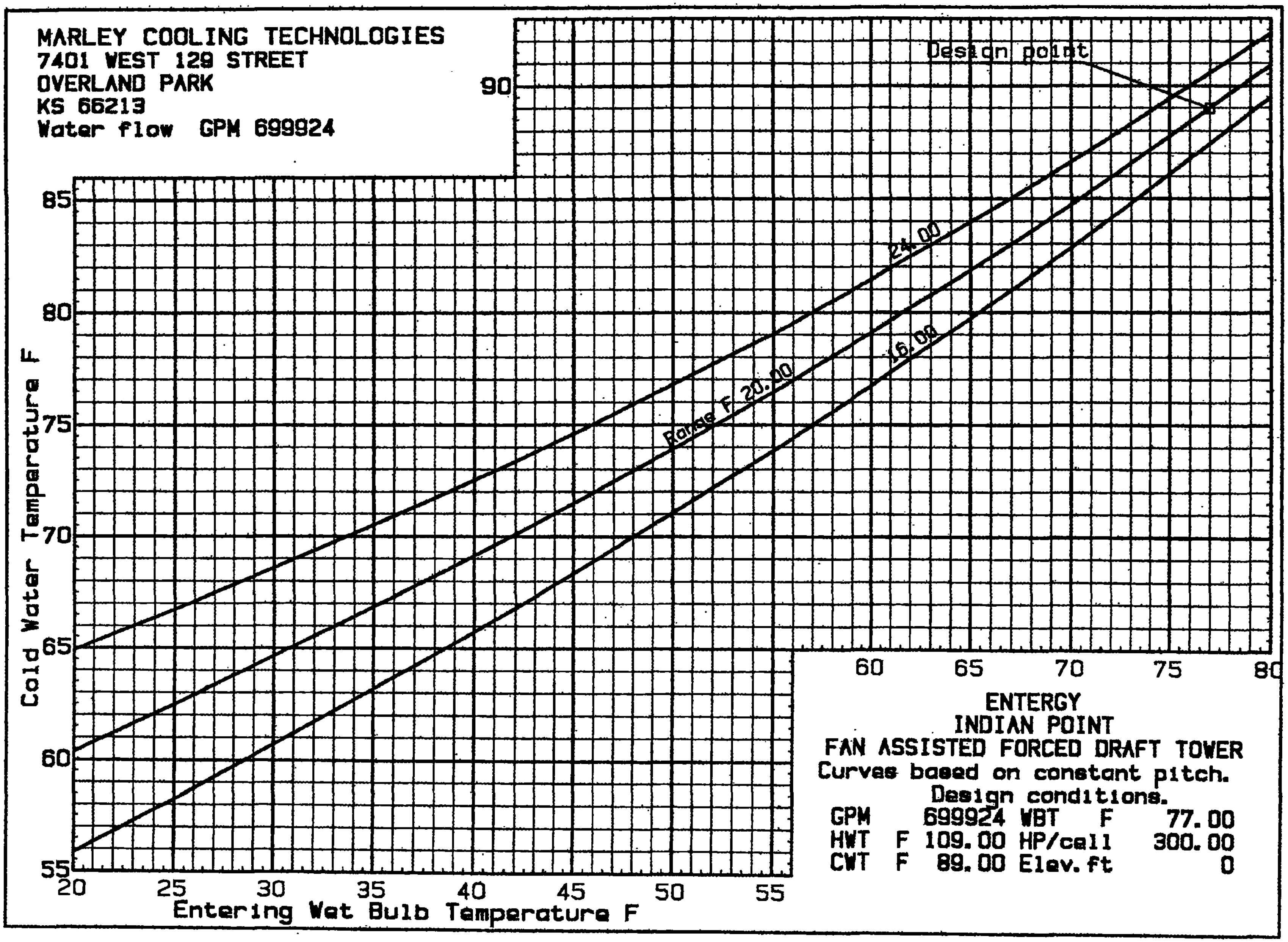
Booster Pumps:
245000 gpm @ 26 ft

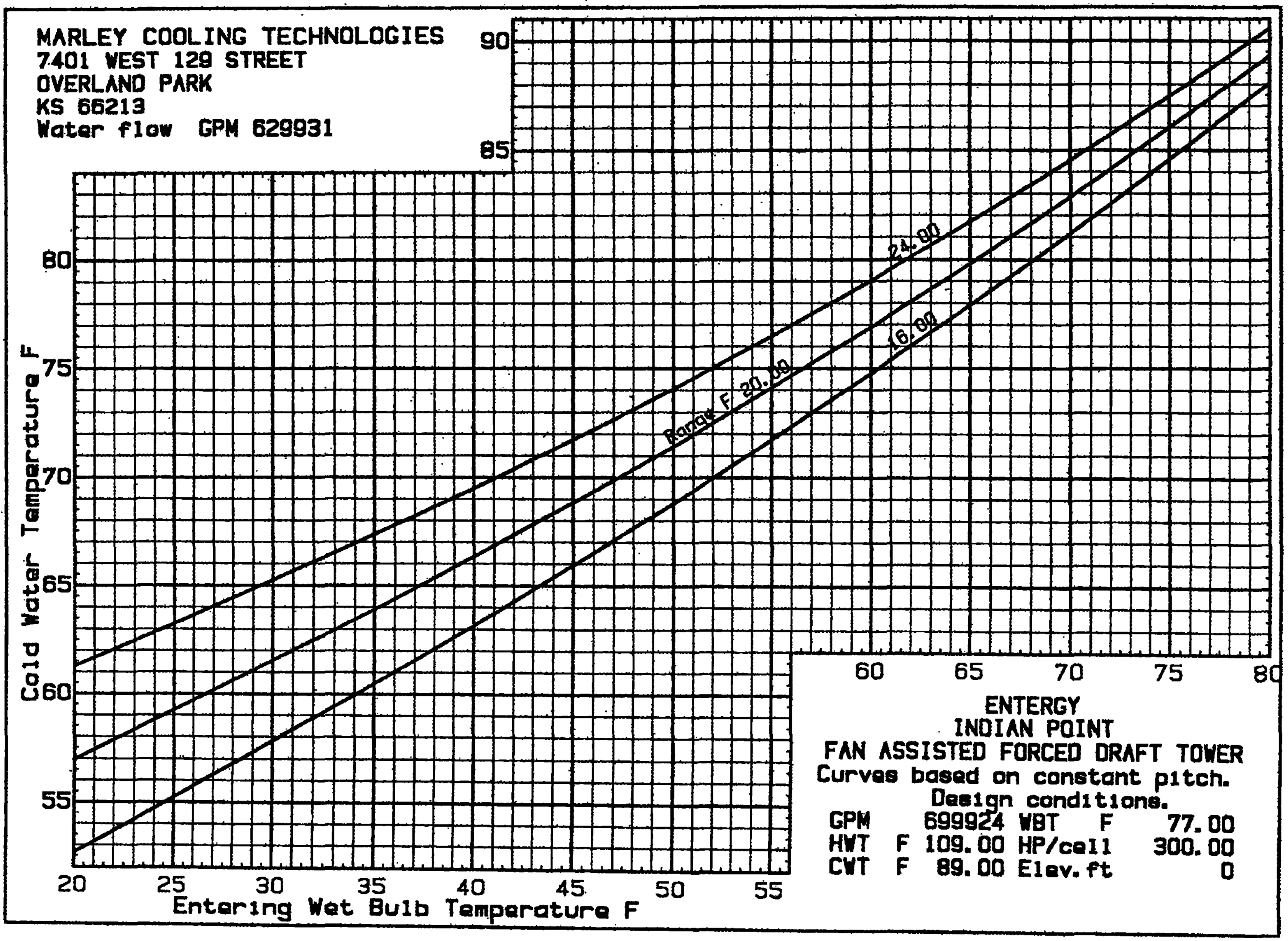
John K Arntson
Marley Cooling Technologies, Inc.

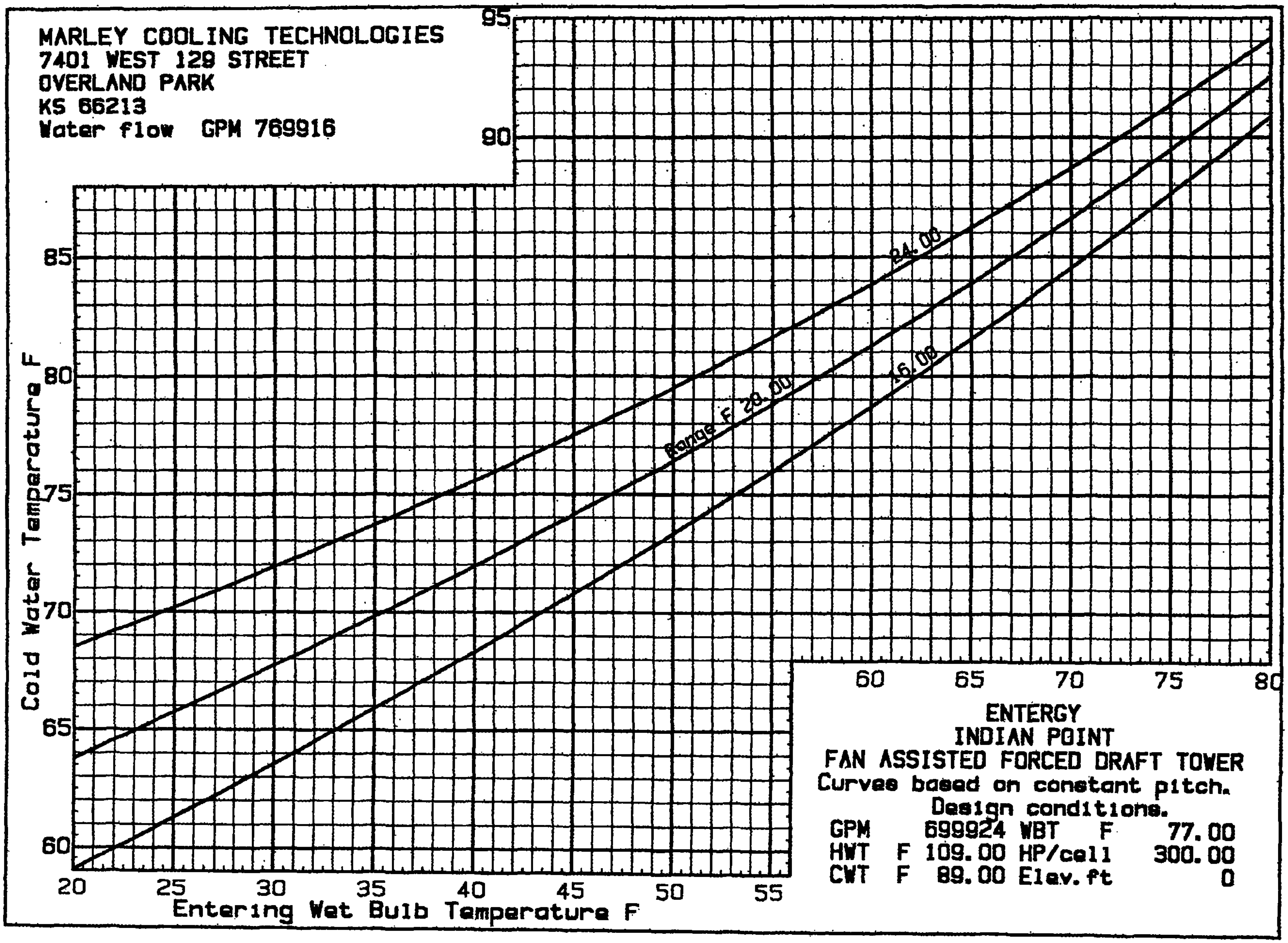
Phone: 913-664-7854
Fax: 913-693-9633
E-mail: john.arntson@marleyct.spx.com

WBT	CWT
20	60.37
35	66.86
50	73.92
65	81.86
77	89.00
80	90.91




MARLEY COOLING TECHNOLOGIES
7401 WEST 129 STREET
OVERLAND PARK
KS 66213
Water flow GPM 699924
Design point
24.00
Range F 20.00
16.00
Cold Water Temperature F
Entering Wet Bulb Temperature F
55
60
65
70
75
80
85
90
20
25
30
35
40
45
50
55
60
65
70
75
80
ENTERGY
INDIAN POINT
FAN ASSISTED FORCED DRAFT TOWER
Curves based on constant pitch.
Design conditions.
GPM 699924 WBT F 77.00
HWT F 109.00 HP/cell 300.00
CWT F 89.00 Elev. ft 0


MARLEY COOLING TECHNOLOGIES
7401 WEST 129 STREET
OVERLAND PARK
KS 66213
Water flow GPM 629931
Cold Water Temperature F
Entering Wet Bulb Temperature F
Range F 20.00
24.00
16.00
ENTERGY
INDIAN POINT
FAN ASSISTED FORCED DRAFT TOWER
Curves based on constant pitch.
Design conditions.
GPM 699924 WBT F 77.00
HWT F 109.00 HP/cell 300.00
CWT F 89.00 Elev. ft 0


MARLEY COOLING TECHNOLOGIES
7401 WEST 129 STREET
OVERLAND PARK
KS 66213
Water flow GPM 769916
Cold Water Temperature F
Entering Wet Bulb Temperature F
Range F 20.00
24.00
16.00
95
90
85
80
75
70
65
60
20
25
30
35
40
45
50
55
60
65
70
75
80
ENTERGY
INDIAN POINT
FAN ASSISTED FORCED DRAFT TOWER
Curves based on constant pitch.
Design conditions.
GPM 699924 WBT F 77.00
HWT F 109.00 HP/cell 300.00
CWT F 89.00 Elev.ft 0

INDIAN POINT 09-22-1997 01:17:38
Page 1 of 3

Cold water, fan power & evaporation calculated. (w/o corrections)

Water flow GPM	Dry bulb F	Rel. hum. %	Wet bulb F	Range F	Fan power HP	Evap. %	Cold water F
699924	88.56	60	77.00	20.00	300.00	1.71	89.00
699924	23.23	60	20.00	20.00	320.56	1.10	60.37
699924	40.09	60	35.00	20.00	315.89	1.28	66.86
699924	57.35	60	50.00	20.00	310.84	1.44	73.92
699924	74.72	60	65.00	20.00	305.16	1.60	81.86
699924	92.01	60	80.00	20.00	298.61	1.74	90.91
699924	23.23	60	20.00	16.00	326.12	0.83	55.38
699924	40.09	60	35.00	16.00	320.73	0.99	62.85
699924	57.35	60	50.00	16.00	315.02	1.14	70.81
699924	74.72	60	65.00	16.00	308.73	1.29	79.58
699924	92.01	60	80.00	16.00	301.64	1.42	89.37
699924	23.23	60	20.00	24.00	315.66	1.39	64.44
699924	40.09	60	35.00	24.00	311.55	1.58	70.18
699924	57.35	60	50.00	24.00	307.02	1.75	76.53
699924	74.72	60	65.00	24.00	301.83	1.92	83.80
699924	92.01	60	80.00	24.00	295.75	2.07	92.25

ENTERGY
INDIAN POINT

09-22-1997 01:17:38
Page 2 of 3

Cold water, fan power & evaporation calculated. (w/o corrections)

Water flow GPM	Dry bulb F	Rel. hum. %	Wet bulb F	Range F	Fan power HP	Evap. %	Cold water F
629931	23.23	60	20.00	20.00	323.26	1.07	56.86
629931	40.09	60	35.00	20.00	318.26	1.26	63.84
629931	57.35	60	50.00	20.00	312.90	1.44	71.37
629931	74.72	60	65.00	20.00	306.92	1.60	79.78
629931	92.01	60	80.00	20.00	300.11	1.75	89.31
629931	23.23	60	20.00	16.00	328.58	0.81	52.14
629931	40.09	60	35.00	16.00	322.84	0.95	60.10
629931	57.35	60	50.00	16.00	316.82	1.14	68.53
629931	74.72	60	65.00	16.00	310.25	1.29	77.75
629931	92.01	60	80.00	16.00	302.90	1.43	87.98
629931	23.23	60	20.00	24.00	318.55	1.35	60.73
629931	40.09	60	35.00	24.00	314.12	1.55	66.95
629931	57.35	60	50.00	24.00	309.29	1.74	73.77
629931	74.72	60	65.00	24.00	303.81	1.92	81.53
629931	92.01	60	80.00	24.00	297.46	2.08	90.48

ENTERGY
INDIAN POINT

09-22-1997 01:17:39
Page 3 of 3

Cold water, fan power & evaporation calculated. (w/o corrections)

Water flow GPM	Dry bulb F	Rel. hum. %	Wet bulb F	Range F	Fan power HP	Evap. %	Cold water F
769916	23.23	60	20.00	20.00	318.02	1.13	63.67
769916	40.09	60	35.00	20.00	313.65	1.30	69.73
769916	57.35	60	50.00	20.00	308.87	1.45	76.36
769916	74.72	60	65.00	20.00	303.45	1.60	83.86
769916	92.01	60	80.00	20.00	297.15	1.73	92.49
769916	23.23	60	20.00	16.00	323.79	0.85	58.45
769916	40.09	60	35.00	16.00	318.72	1.00	65.47
769916	57.35	60	50.00	16.00	313.29	1.15	73.01
769916	74.72	60	65.00	16.00	307.26	1.28	81.35
769916	92.01	60	80.00	16.00	300.40	1.41	90.75
769916	23.23	60	20.00	24.00	312.95	1.43	67.91
769916	40.09	60	35.00	24.00	309.11	1.60	73.24
769916	57.35	60	50.00	24.00	304.85	1.77	79.17
769916	74.72	60	65.00	24.00	299.91	1.93	86.01
769916	92.01	60	80.00	24.00	294.08	2.07	94.00

Sam Beaver

From: John.Arntson@marleyct.spx.com
Sent: Thursday, June 05, 2003 12:31 PM
To: sbeaver@enercon.com
Cc: JIM.VANGARSSE@marleyct.SPX.COM
Subject: Indian Point Budgetary Pricing

Sam,
Please see the attached spreadsheet for the revised pricing.

The main changes are a significant reduction in the cost of the fintube bundles, cost of the exterior structure based upon a preliminary design, and elimination of other costs which were included in other categories in the previous breakdown. I have been working on the cost of the exit cone but so far have not tied this price down (a fabric membrane structure). What we have in now should be very conservative.

The pricing is now in the ballpark of escalated GKNII when adjusted for titanium tubes and labor rates.

Indian Point Study
Budgetary Pricing (6/5/03)

Cooling Tower

Item (Delivered & Installed)		**Price**
Fin Tube Bundles with titanium tubes	$	27,400,000
Mechanical equipment including VFD's	$	17,250,000
Dry section inlet and return piping	$	3,540,000
Wet tower section and mixing tunnels	$	32,900,000
Sound attenuation	$	10,800,000
Concrete wall @ fans	$	5,725,000
Exterior galv. steel structure with concrete deck incl. Ladders, platforms, stair towers	$	7,460,000
Exit cone (erected)	$	13,300,000
Rolling Doors or Louvers (erected)	$	882,000
Misl. equipment, supervision, & labor	$	5,443,000
Budgetary Total =	**$**	**124,700,000**

Preliminary Material/Labor Breakdown: 2/3 / 1/3

Cooling Tower Basin, Foundations, Misl. Concrete Supports

Concrete:	11400
Rebar:	1140
Budgetary Price =	**$ 15,800,000.00**

Preliminary Material/Labor Breakdown: 30 % / 70%

BALCKE

BALCKE GmbH

GKN2_E02.DOC

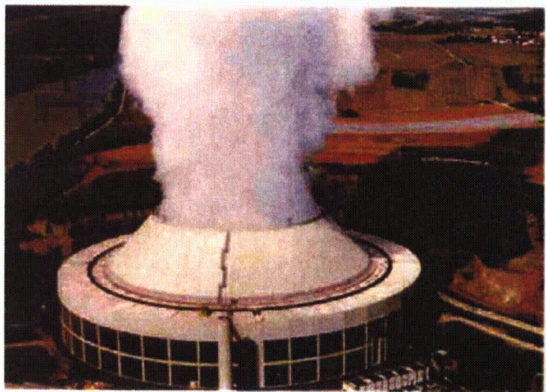
PROJECT FACTS

HYBRID COOLING TOWERS

Project	:	Circular Hybrid Cooling Tower with forced draught axial fans
Client	:	Neckarwerke
Plant	:	GKN 2
Location	:	Neckarwestheim – Germany
Start of erection/commissioning	:	1984/1985
Design	:	Balcke-Dürr
Planning	:	Balcke-Dürr

Technical data

Total water flow	:	158,000	m^3/h
Hot water temperature	:	39.6	°C
Cold water temperature	:	26.0	°C
Wet bulb temperature	:	8.0	°C
Dry bulb temperature	:	10.0	°C
Wetted base area	:	17,00	m²
Diameter at the base	:	160	m
Total height	:	51.0	m



This is the largest cooling tower of this type worldwide. The pictures show the effect if the dry section is shut down (left picture) or in operation (bottom picture).

For further information please contact: BALCKE GmbH
Department: Wet Cooling
Hans-Joachim-Balcke-Strasse
D-46049 Oberhausen

Web: http://www.recooling.com
Email: info@balcke-duerr.de
Phone: +49-(0)208-833-7681
Fax: +49-(0)208-833-7699

Flow Products

a Division of PCC Flow Technologies LP

Johnston Pump / PACO PUMPS / CROWN Pump / General Valve
800 Koomey Road, Brookshire, Texas 77423: Phone 281-934-6199, Fax 281-934-6194
From: Melvin B. Asher: Johnston Pump Co. Applications Specialist-3 *Email:* masher@flow-products.com

Att: James Hubbard of: Enercon Services. Inc.Kennesaw GA Date: May 23, 2003
Phone: 770-919-1931 ex 299 Fax: 770-919-1932

Subject: Pump Information
Quote Number: 03MA-0437 BUDGET

We are pleased to offer the following quotation. Attached please find a hydraulic print out, Scope page with pricing, outline drawing and performance curve.

All pricing is FOB Brookshire TX. Freight will be added as incurred, payment terms are net 30 days, this quotation valid for 30 days from today. Johnston standard terms and conditions will apply.

The delivery is 26 weeks after receipt of a clean purchase order and release to manufacturing. Our design criteria is per Hydraulic Institute "HI" standard.

Regards

Mel Asher
Cc: Jerry Harrelson

Johnston Pump Company

Date: April 30, 2003
Proposal Number: 03MA-0437
Project: Indian Point Nuclear
Prepard For: Jerry Harrelson , James Hubbard of ENER
Pump Designation: Hudson River Pumps
Quantity: 12
Prepared By: Mel Asher

Quotation

Conditions of Service			
G.P.M.	117000	Min. Submergence Req.	184 in.
T.D.H.	72.00	Liquid	Brackish Water
Pump RPM	446	Specific Gravity @ P.T.	1.030
BHP @ Rating	2525	Pumping Temperature	Amb
Bowl/Pump Efficiency	88.2% / 86.7%	Viscosity	1.00
NPSHR	40'	Down Thrust @ Design	42700 lb.

Description			
Type	JT (Turbine)	Discharge Flange	84 in. x 150 lb.
Model/No. of Stages	~~72THC/1~~ 70KMC-1	Impeller Type	Enclosed
Total Pump Length (TPL)	33 ft. - 0 in.	Bell Dia.(in):	96 in.
Lubrication	Product Lubricated	Curve Number	EC-0832
Column Type	Flanged	Coating Location	None
Column Size	84 in.	Testing	None
Lineshaft/Pumpshaft Size	6.5 in. / 6.5 in.	Witnessed / Non-Witnessed	
Discharge Head Type	JTAUF		

Materials of Construction			
Discharge Head	316ss	Enclosing Tube	None
Packing	John Crane 1340	Bowl	316ss
Stuffing Box	316ss	Impeller	316ss
Column	316ss	Wear Ring: Impeller/Bowl	316ss / none
Lineshaft/Pump Shaft	316ss / 316ss	Bowl Bearing	Rubber
Lineshaft Bearing	Rubber	Strainer	None
Bearing Retainers	316ss	Coating	Standard

Driver Information			
Driver Manufacturer	General Electric	Thrust Capacity (Down)	42690 lb.
Horsepower/R.P.M.	3000 / 446	Frame:	
Phase/Cycle/Volts	3 / 60 / 4160	S.F.: 1.00	
Insulation/Enclosure	/ WP-1	B.D.: 60 in.	
Shaft Type/Coupling	VSS / SRC		

Pricing			
Pump Price (each)	$ 612,470.00	FOB: Brookshire, TX	
Testing Price (each)			
Driver Price (each)	$ 165,650.00	FOB: Motor Manufacture	
Total Unit Price (each)	$ 778,120.00	Terms: Net 30 days	
Pump/Driver Weight:	18500 lb. / 56000 lb.	Prices do not include any applicable taxes	
Delivery Pump/Driver	26 ~~16 to 18~~ weeks ARA	Prices are firm for 60 days	

Adders / Notes	
GRAND TOTAL	$9,337,440.00
	9337440

Johnston Pump Company

Design Sheet

Pump Description Hudson River Pumps

JP Quote Number	03MA-0437	Quoted By:	Mel Asher	Date	30-Apr-03
Prepared For:	Jerry Harrelson , James Hubbard of ENERCON			Project:	Indian Point Nuclear
Number Of Units	12				

Gallons Per Minute	117000	Pump Length	33 Ft.		0 inches
Total Head	72.00	R.P.M..	446	Fluid:	Brackish Water
Temperature	Amb	Viscosity:	1.00	S.G..	1.030
Suct. Pres. (psig)	4	Vapor Pres.	1 1	Dsch Pres(psig)	36.10
Bowl Assembly:	70 ~~72THS~~ KMC	No. of Stages:	1	NPSHA	Un-known
Inducer Stage:	N/A	B.A. Weight:	18500	NPSHR	40
Bowl Assy Length(In.)	85.5	Disch. Dia.(In.):	84	Disch. Head	JTAUF
Column Dia.(In.):	84	Bell Dia.(In):	86		

☑ Flanged Column ☐ Can Pump ☐ Mechanical Seal ☑ Strainer

Product Lubricated

Pump Performance Correction Factors

	Materials	Factor	Head*	Capacity*	Efficiency
One, Two or Three Stages	1	1.00			
Special Material Bowl	316ss	0.99			
Special Material Impeller	316ss	0.99			
Viscosity of Liquid	1		1.00	1.00	1.00
Total Product			73.46	119375.57	88.21

☑ Velocity Head ☐ Thrust Balanced

Head Calculations	ft.	Pump Shaft Dia	6.500	Thrust, K:	500.00	37655
Total Head	72.00	Line Shaft Dia	6.5000	Length (ft.)	20.38	2369
Disch/Elbow Loss	0.36	Imp. Wt.(lb.)	3000.00	Stages	1.00	3000
Col. & Shaft Loss	0.04	Suct. Pres	4.00			-133
Velocity Head	0.71	Dsch. Press	36.10	Slv Area(sq. in.)	5.30	-191
Bowl Head	73.12			Net Down Thrust		42699

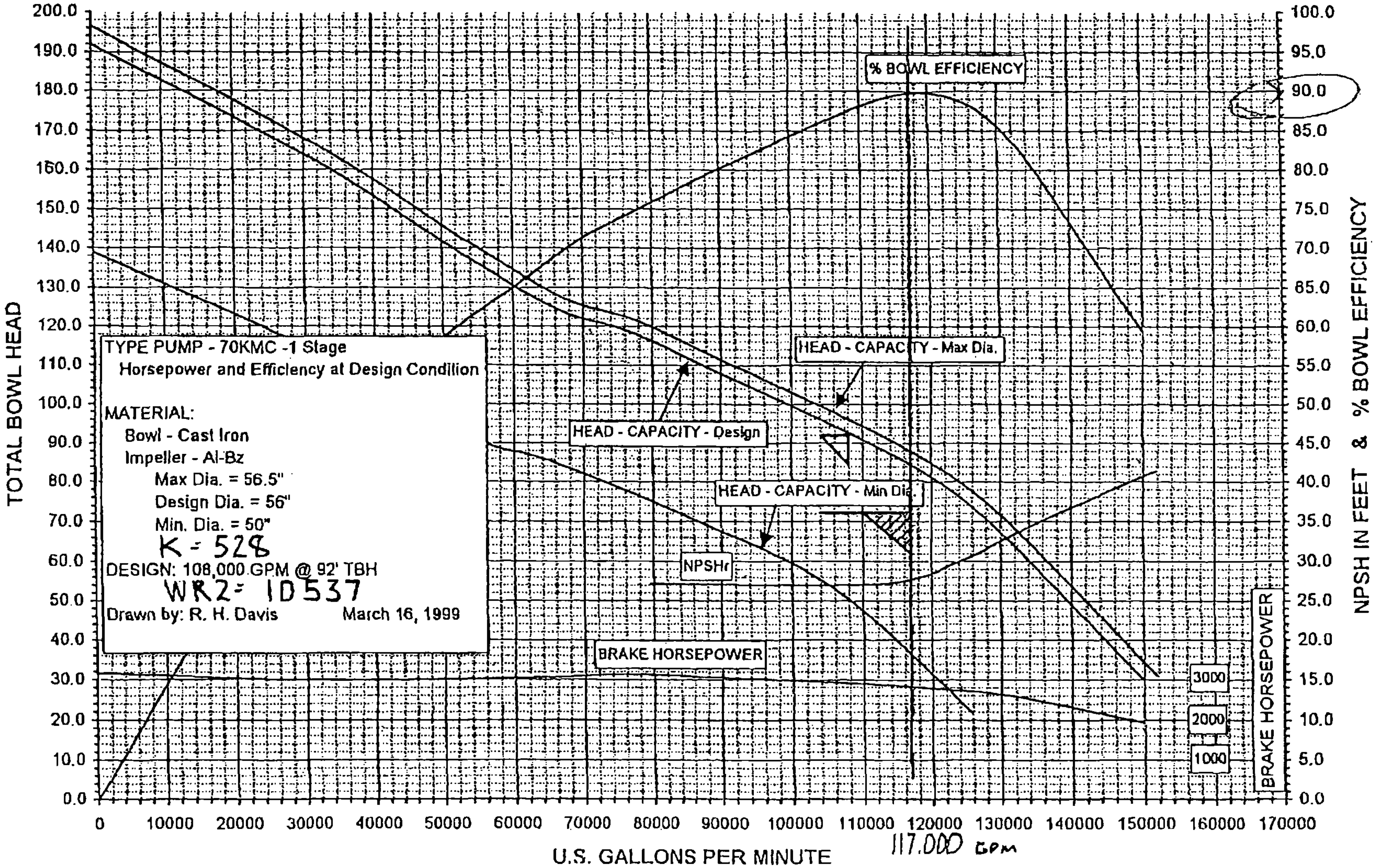
$$\text{Bowl Horsepower} = \frac{\text{Flow (GPM)} \times \text{TDH (feet)} \times \text{S.G.}}{3960 \times \text{Actual Efficiency}}$$

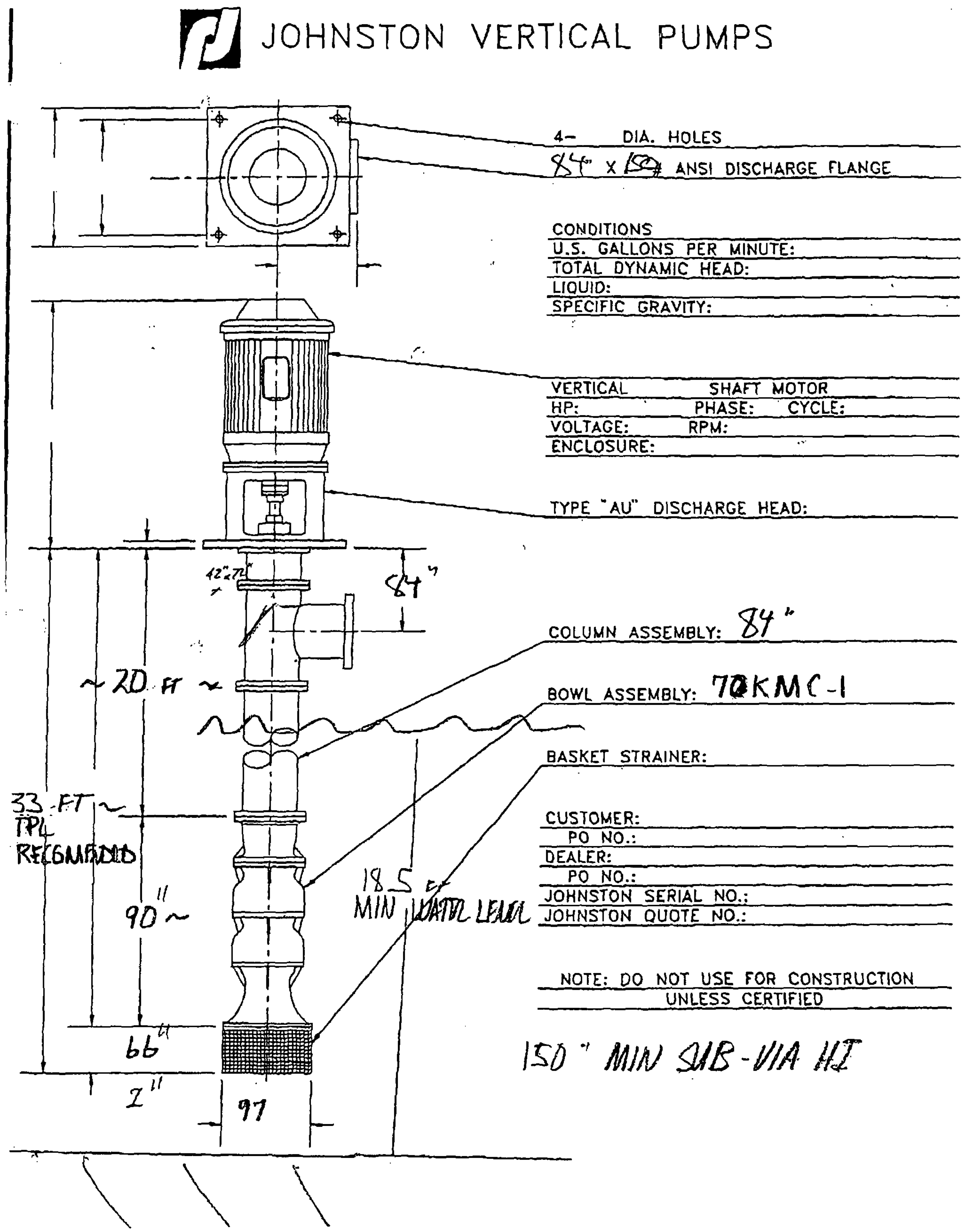
Book Eff. @ Design	90.00 %	Actual Eff	88.21 %	Bowl H.P.	2522.46
Book Eff (Q)	N/A			Shaft Friction Loss	0.92
Bearing Friction, K	4.50			Thrust Bearing Loss	1.43
				Total Pump Horsepower	2524.81
				Bowl Eff.	88.21 %
				Pump Eff.	86.78 %

*Note: Corrected head and capacity values are used for determining impeller trim only.

Notes

JOHNSTON PUMP COMPANY
Brookshire, Texas
PREDICTED PERFORMANCE CURVE PD-1198
446 RPM




JOHNSTON VERTICAL PUMPS
4- DIA. HOLES
84" x 150# ANSI DISCHARGE FLANGE
CONDITIONS
U.S. GALLONS PER MINUTE:
TOTAL DYNAMIC HEAD:
LIQUID:
SPECIFIC GRAVITY:
VERTICAL SHAFT MOTOR
HP: PHASE: CYCLE:
VOLTAGE: RPM:
ENCLOSURE:
TYPE "AU" DISCHARGE HEAD:
COLUMN ASSEMBLY: 84"
BOWL ASSEMBLY: 70KMC-1
BASKET STRAINER:
CUSTOMER:
PO NO.:
DEALER:
PO NO.:
JOHNSTON SERIAL NO.:
JOHNSTON QUOTE NO.:
NOTE: DO NOT USE FOR CONSTRUCTION
UNLESS CERTIFIED
150" MIN SUB-VIA HI
84"
~ 20 FT ~
33 FT ~
TPL
RECOMMENDED
18.5 FT
MIN WATER LEVEL
90" ~
66"
I"
97

g

GE Motors & Industrial Systems

Proposal #: MBF593MCK1
Item No. : 1
Quantity: 12
Customer: Johnston Pump
Cust. ref.: Indian Point Nuclear Hudson River
End User: Indian Point Nuclear Hudson River
Model No.: Not Applicable
Cust. spec: Quoted by description
Other specs: None

Date: 5/14/03
Folder: 3C1630
MAC T: A. Mendes
Req by: Mark Cooksey
RQN: NA
Fact Ref: NA

VERTICAL SOLID-SHAFT 3-PHASE SQUIRREL CAGE INDUCTION MOTOR					
Type	K-VSS	FL Amps	425	Estimated frame size	8770
HP @ shaft	3000	Max KVAR	Later	P-Base Diameter BD (in)	70
Sync RPM	450	LRI (%)	600	Starting Torque (%)	60
FL RPM	442	V start (%)	90	Breakdown Torque (%)	175
Poles	16	Insulation	F	Full Load Torque (lb-ft)	35650
Volts	4160	Max dBA	85 @ 3ft	WK2 (NEMA=316900 lb-ft^2)	316900
Hertz	60	Rot (ODE)	Dual	Temp Rise Class (NEMA)	B
S.F.	1 00	Altitude (ft)	3300	Temp Rise at 1.00 SF (C)	85
Enclosure	WPI	Wt (lb)	56000	Ambient Temp (C)	40
Applic / Load	Pump		Var Torque	Temp Rise Measured by	RTD
Continuous External Down Thrust (lb)			42690	Locked kva/HP; (NEMA)	6.12; (G)
Momentary External Down Thrust (lb)			99560	P.F (FL; 3/4; 1/2) (%)	77; 73; 62
Momentary External Up Thrust (lb)			3000	Standard High Efficiency (%)	95 0; 94.8; 94.0
Thrust-bearing L10 Life (yr)			1 0	Method of starting	Direct
No. of starts, coasting to rest (Cold / Hot)			2 / 1	Rotor Bar Construction	Fab Aluminum

ACCESSORIES AND SPECIAL FEATURES:
Thrust bearing: Antifriction
Thr brg lube: Self-cooled, Oil bath
Stator winding temp sensor: Pt RTD (100 Ohm); 2 per phase
Space heaters (std temperature); 120V
Non-reverse device
Guide bearing: Antifriction
Custom Polyseal insulation system
Corrosion resistant screens

EXCEPTIONS AND COMMENTS:
Quoted by description, only.

ADDITIONAL OPTIONS:

TERMS:	Conditions of sale in GEP-973 apply.
PRICE POLICY:	Price clause 1Q applies. Price valid for 30 days
PAYMENT TERMS:	Net cash 30 days from date of invoice.
DELIVERY:	27 wks FOB Norfolk, VA Freight collect to destination
TESTS SCHEDULED:	Non-witnessed routine per Buyers' Guide GEP772C.

Revisions are in bold italic (Item 1) Pg 1 of 2

MERCER RUBBER Co.

Manufacturer of Piping Expansion Joints, Duct Connectors and Industrial Hose

Enceron Services
Tel# 770-919-1931 ext#299
Fax#770-919-1932

May 16, 2003

Attn: Jim Hubbard

Thank you for the opportunity to quote our products. We are pleased to offer our Series 500 in a Single unfilled arch expansion joint, constructed of Neoprene tube and cover. Our submittal drawing, which outlines the performance capabilities of each item, has been enclosed for your review.

Your net buying prices are as follows:

Qty	Description	Unit Price	Extension
	Style 501N Single unfilled arch expansion joint, EPDM tube and cover, drilled to 150#asa		
12	84"ID X 12"F.F.	$3130.00	$37560.00
12	Galvanized retaining rings	$925.00	$11100.00
12	4 rod galvanized control assembly	$2052.00	$24624.00
12	96"ID X 12"F.F.	$3354.00	$40248.00
12	Galvanized retaining rings	$1166.00	$13992.00
12	4 rod galvanized control assembly	$2918.00	$35016.00
4	120"ID X 10"F.F.	$6171.00	$24684.00
4	Galvanized retaining rings	$1713.00	$6852.00
4	6 rod galvanized control assembly	$4925.00	$19700.00
4	144"ID X 10"F.F.	$10778.00	$43112.00
4	Galvanized retaining rings	$2438.00	$9752.00
4	6 rod galvanized control assembly	$5529.00	$22116.00
			$288756.00

Our quotation is valid for 90 days
Terms: 2% net 10/30 days

*Custom fabricated joints are non-refundable, Stock joints carry a 35% restocking fee.

Delivery: Partials in 6-8 weeks balance to be scheduled from receipt of purchase order
Freight: Allowed within the Continental U.S.A.

If you have any comments or questions, please do not hesitate to contact us.

Best regards,

Rose Mary Fardella(Rosie)
Regional Sales Manager

Enclosure: Submittal drawing # MF-8912

350 Rabro Drive • Hauppauge, NY 11788-4256 Reply to: P.O. Box 410 • Smithtown, NY 11787-0410
Phone 631-582-1524 • FAX 631-348-0279 • Email info@Mercer-Rubber.com

MERCER RUBBER Co.

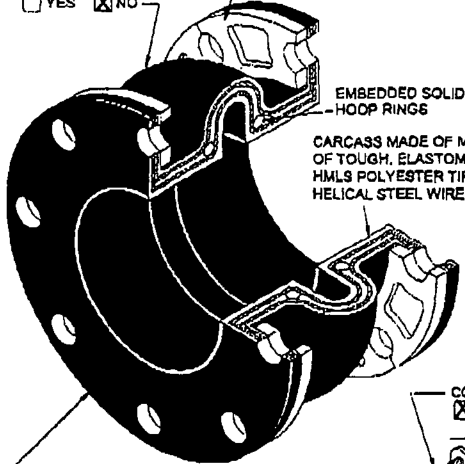
350 Rabro Drive
Hauppauge, NY 11788
Tel 631-582-1524
FAX 631-348-0279
Info @ Mercer-Rubber.com
www.mercer-rubber.com

JOB NAME	INDIAN POINT
CUSTOMER	ENTERCON
CUSTOMER P.O.	
MERCER NO.	
DATE: 5/16/03	DWG. NO. MF-8912

INVINCIBLE 501 - HEAVY DUTY EXPANSION JOINT

SPLIT RETAINING RING
☒ CARBON STEEL (PAINT OR PRIME)
☒ HOT DIPPED GALVANIZED
☐ STAINLESS STEEL (TYPE______)
☐ DUCTILE IRON (BAKED ENAMEL)

COATING OF HYPALON PAINT ☐ YES ☒ NO

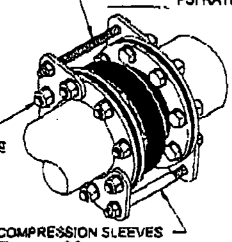


EMBEDDED SOLID STEEL HOOP RINGS

CARCASS MADE OF MULTIPLE PLIES OF TOUGH, ELASTOMER-IMPREGNATED HMLS POLYESTER TIRE CORD, OR HELICAL STEEL WIRE REINFORCEMENT

FULL INTEGRAL RUBBER FLANGE, WITH DUCK FABRIC REINFORCING, PROVIDES OUTSTANDING SEALING

CONTROL RODS ☒ YES ☐ NO
_____ PSI RATED



MATING FLANGE HARDWARE SUPPLIED BY OTHERS

COMPRESSION SLEEVES ☐ YES ☒ NO

DRILLING STANDARD 150#

Tube	Cover		Temperature Rating
☐	☐	Natural Rubber	-60°F to 180°F
☐	☐	Chlorobutyl	-60°F to 250°F
☒	☒	Neoprene	-40°F to 225°F
☐	☐	Pure Gum	-60°F to 225°F
☐	☐	Hypalon (CSM)	-40°F to 250°F
☐	☐	Nitrile (NBR/Buna N)	-30°F to 220°F
☐	☐	EPDM	-60°F to 250°F
☐	☐	Viton* (FKM)	-10°F to 250°F
☐	☐	Food Grade Neoprene	-40°F to 225°F

* MADE EXCLUSIVELY WITH DUPONT VITON ®

Arch is open unless noted below:
☐ Filled Arch - Reduced Movements 50%

Expansion joints installed in piping systems that are anchored on both sides of connectors need no control rods providing piping movements are within the tabulated allowables. Expansion joints installed in unanchored piping or connected to isolated equipment must have control rods; those control rods must be properly set so that allowable movements are not exceeded.

Initial misalignment should be kept to a maximum of 1/8".

Expansion joint flanges must be in contact with a continuous surface, or a maximum of 1/16" standard raised face. Depressions or protrusions typical of vitaulic or similar type flanges must be covered with a steel spacer flange first. Rubber flanges will not retain loose elements in valve bodies that rely on contact with a steel flange. In these applications, a steel spacer flange must be inserted between the rubber expansion joint and the valve body.

STYLE 501 DIMENSIONS, ALLOWABLE MOVEMENTS and OPERATING PRESSURES

QUANTITY	SIZE (In)	FACE TO FACE F.F. (In)	FLANGE OD (In)	DIA. BOLT CIRCLE (in)	NO. OF BOLT HOLES	DIA. OF BOLT HOLES (In)	AXIAL COMPRESSION (in)	AXIAL EXTENSION (In)	LATERAL DEFLECTION (in)	RATED WORKING PRESSURE (psi)	VACUUM RATING (IN Hg)
12	84	12	99 3/4	95 1/2	64	2 1/8	1 1/2	7/8	3/4	100	30
12	96	12	113 1/4	108 1/2	68	2 1/2	1 1/2	7/8	3/4	75	30
4	120	12	140 1/4	132 3/4	76	2 1/2	2 1/4	1	1 1/8	45	30
4	144	12	167 1/4	158 1/4	84	2 1/2	2 1/4	1	1 1/8	45	30

NOTES:

DWN	CHKD	DATE
MQ	RMF	5/16/03

DWG No. MF-8912

FORM NO. MS-1148.DWG

Northwest Pipe Company

3554 MAYER DRIVE • MURRYSVILLE, PA 15668 • 724-327-6968 • 412-951-2625 CELL

To:	ENERCON	DATE:	May 27, 2003
		PROJECT:	Indian Point Station Peeksville, NY
		OWNER:	
Attn:	Jim Hubbard	PTS NO.:	PB03-156
Phone:	770-919-1931 X299	BID DATE:	
Fax:	770-919-1932	TIME:	

Budgetary Quotation

We are pleased to offer prices for steel pipe for the above noted project for materials as listed below. The estimating prices are provided for reference only and Northwest Pipe shall not be bound by pricing or any other provisions herein. Final pricing and delivery can be provided once project requirements are finalized.

<u>Specifications</u>

Pipe: Steel pipe will be manufactured and tested in accordance with AWWA C200 from materials conforming to ASTM A 139 GR. B or C.

Fittings: Fittings will be manufactured per plans and in accordance with AWWA C208 & M11.

NDT: All straight pipe will be hydrotested in accordance with AWWA C200, section 5.2. Fittings will be fabricated from hydrostatically tested pipe. All butt welds made after the hydrotest will be magnetic particle tested. Reducers will be magnetic particle tested.

Flanges: Flanges will be in accordance with AWWA C207, Class B or D.

Interior Lining: All 84" pipe will be cement mortar lined in accordance with AWWA C205. The 120" & 144" pipe will be supplied bare for field cement mortar lining by others. An adder is noted to supply the ID of the 120" & 144" with 20 mils DFT of Polyurethane in accordance with AWWA C222.

Exterior Coating: Buried pipe will be coated 25 mils DFT with polyurethane in accordance with AWWA C222 or tape coated 80 mils in accordance with AWWA C214 & 209.

Lengths: Standard lengths for the 120" & 84" are 40ft and the 144" will be 60ft with shorter lengths as required for fittings and shipping.

Field Joints: Standard pipe will be furnished with bell & spigot lap welded joints.

Bracing: All pipe as required will be braced on each end and middle as required. This bracing is for shipping purposes only and not designed for grouting or installation loads. Any special requirements, i.e. vertical elongation etc, will be the sole responsibility of the Contractor.

File: PB03-156 Enercon

SCOPE OF WORK

Item	Description	Quantity	Unit Price	Extension
1	120" OD Welded Steel Pipe with Polyurethane coating x bare ID.	4,240 LF	$ 381.00	$ 1,615,440.00
2	120" x 90 degree 4-weld mitered elbow fabricated into the above pipe (Supplied as 2-45 Deg).	6 EA	$ 22,498.00	$ 134,988.00
3	120" x 45 degree 2-weld mitered elbow fabricated into the above pipe.	4 EA	$ 11,391.00	$ 45,564.00
4	120" x 84" x 12ft long concentric reducer fabricated into the above pipe.	1 EA	$ 28,879.00	$ 28,879.00
5	84" non-reinforced outlet fabricated into the 120" pipe - plain end. Design based on 23 PSI max pressure.	4 EA	$ 9,023.00	$ 36,092.00
6	84" OD Welded Steel Pipe with Polyurethane coating x CML ID.	1,040 LF	$ 280.00	$ 291,200.00
7	84" x 90 degree 4-weld mitered elbow fabricated into the above pipe.	10 EA	$ 14,311.00	$ 143,110.00
8	84" x 72" x 4ft long concentric reducer fabricated into the above pipe.	48 EA	$ 11,470.00	$ 550,560.00
9	96" AWWA Class B Flange – loose.	48 EA	$ 3,266.00	$ 156,768.00
10	84" AWWA Class B Flange – loose.	108 EA	$ 2,248.00	$ 242,784.00
11	72" AWWA Class B Flange - loose.	48 EA	$ 1,388.00	$ 66,624.00
12	144" OD Welded Steel Pipe with Polyurethane coating x bare ID.	4,000 LF	$ 657.00	$ 2,628,000.00
13	144" x 45 degree 2-weld mitered elbow fabricated into the above pipe.	4 EA	$ 10,391.00	$ 41,564.00
14	84" non-reinforced outlet fabricated into the 144" pipe – plain end. Design based on 23 PSI max pressure.	14 EA	$ 5,490.00	$ 76,860.00
15	144" x 84" x 20ft long concentric reducer fabricated into the above pipe.	1 EA	$ 54,050.00	$ 54,050.00
			TOTAL	**$ 6,112,483.00**

DEDUCT to supply above items with OD Tape Coating. $ 88,000.00

ADDER to supply items 1 thru 4 and 12 thru 15 with ID Polyurethane lining. $ 1,114,000.00

FOB: Prices are FOB our plant with full freight allowed to jobsite. Jobsite delivery shall specifically mean truckbed delivery as close to installation site as possible with truck under it's own power. All unloading shall be done by the buyer.

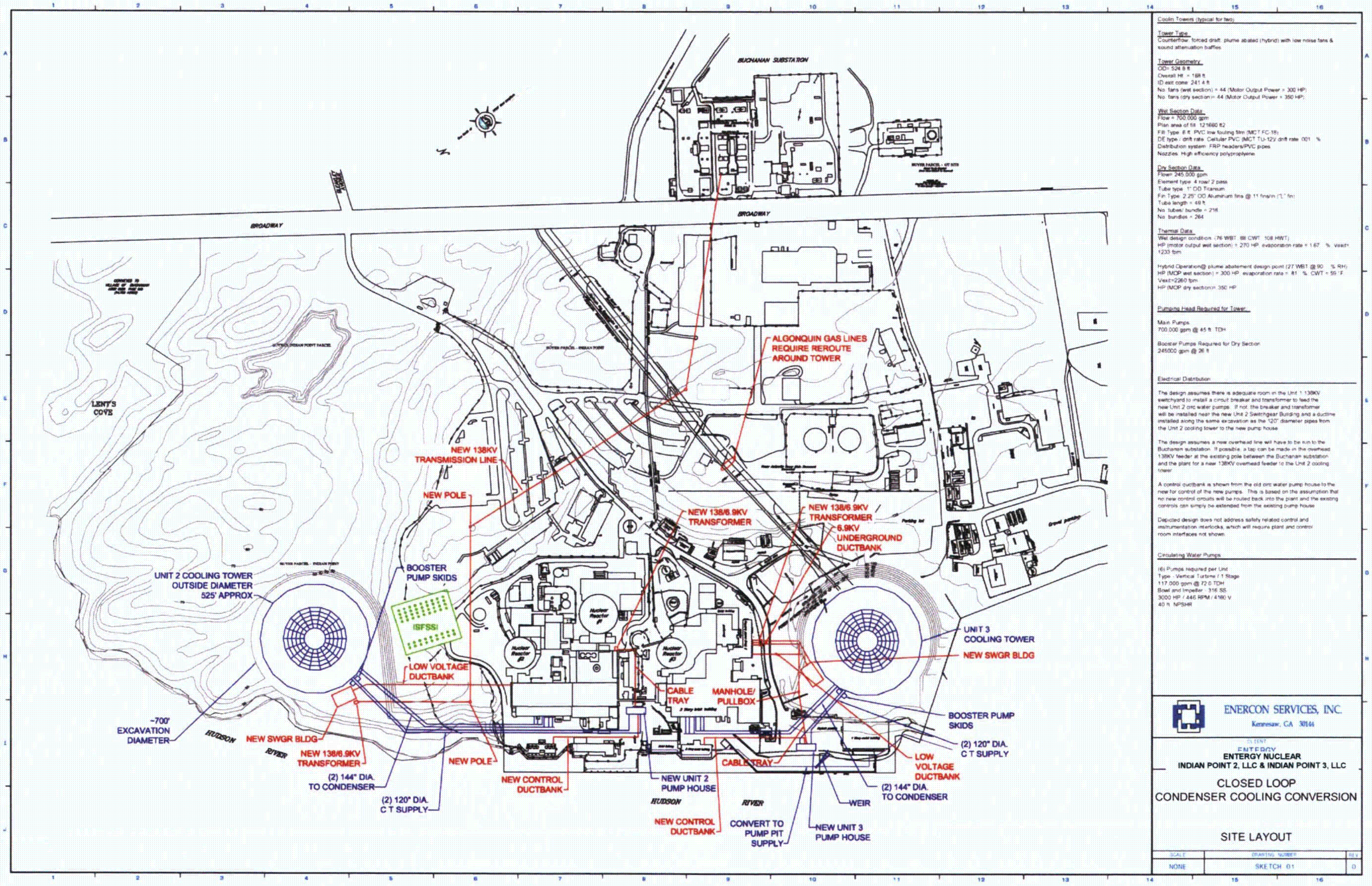
For additional information concerning this quotation, please contact Ron Brown at telephone number (724) 327-6968 or cell number (412) 951-2625.

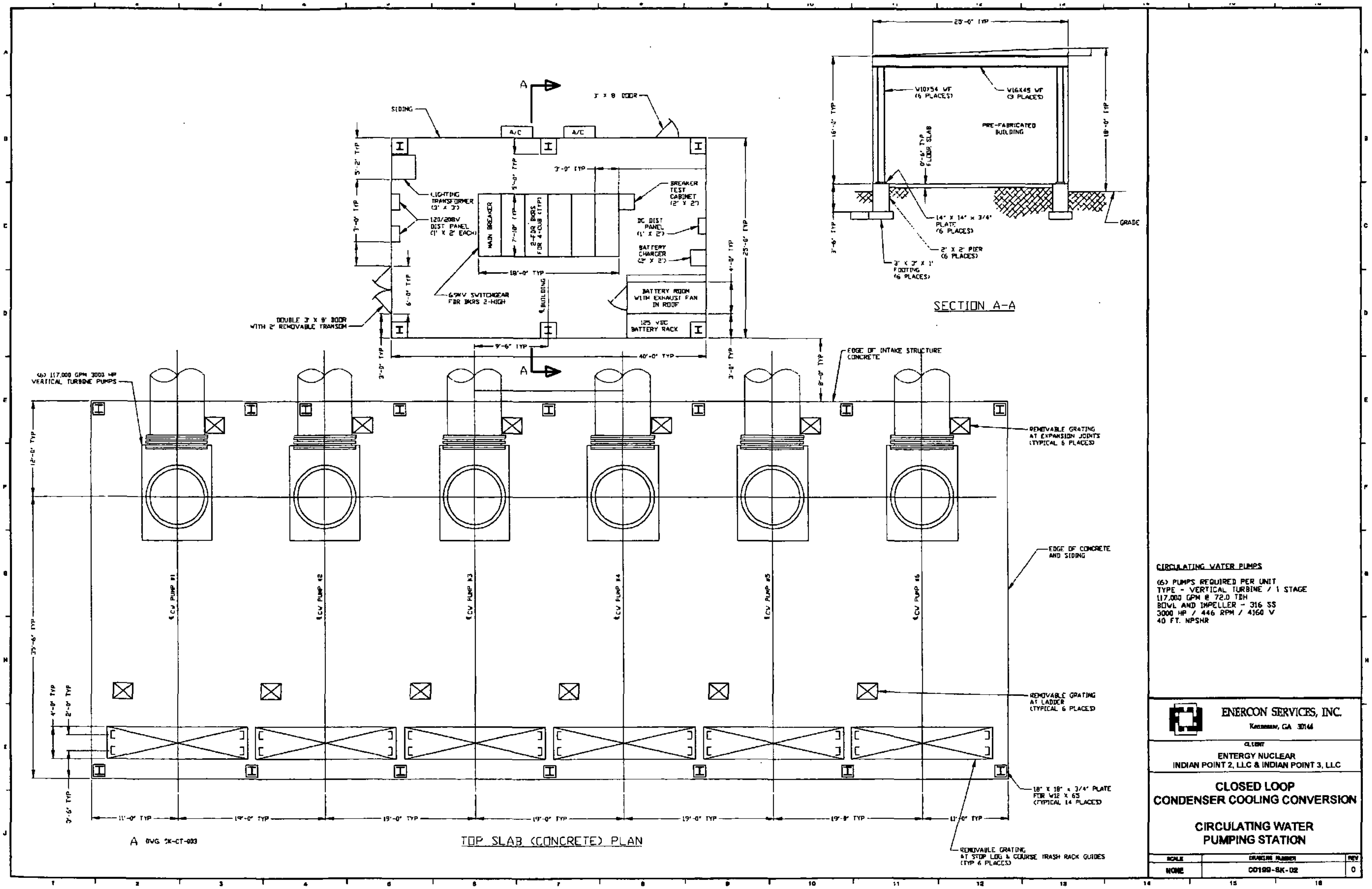
ACCEPTED IN ACCORDANCE WITH THE TERMS & CONDITIONS HEREIN EXPRESSED SUBJECT TO AWARD OF CONTRACT TO THE UNDERSIGNED.	UNLESS ACCEPTED BY BUYER WITHIN TEN (10) DAYS OF BID DATE, THIS OFFER IS SUBJECT TO REVISION AND/OR CONFIRMATION BY SELLER.
Firm:	**Northwest Pipe Company**
By:	By: [signature]
Title:	Title: Ron Brown, Sales Representative
Date:	Date: May 27, 2003

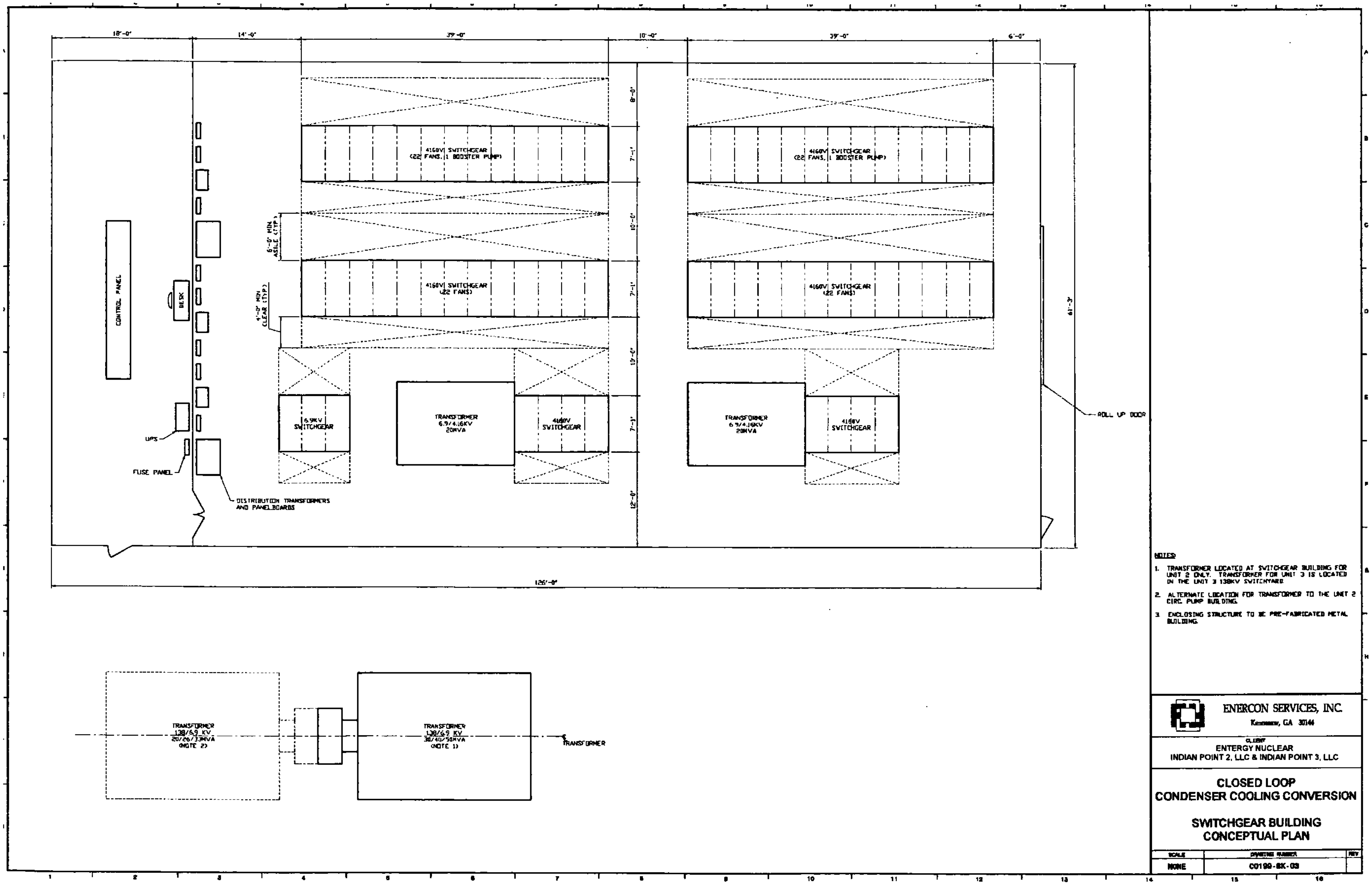
Attachment 2
Post-Modification Site Rendering and Conceptual Drawings

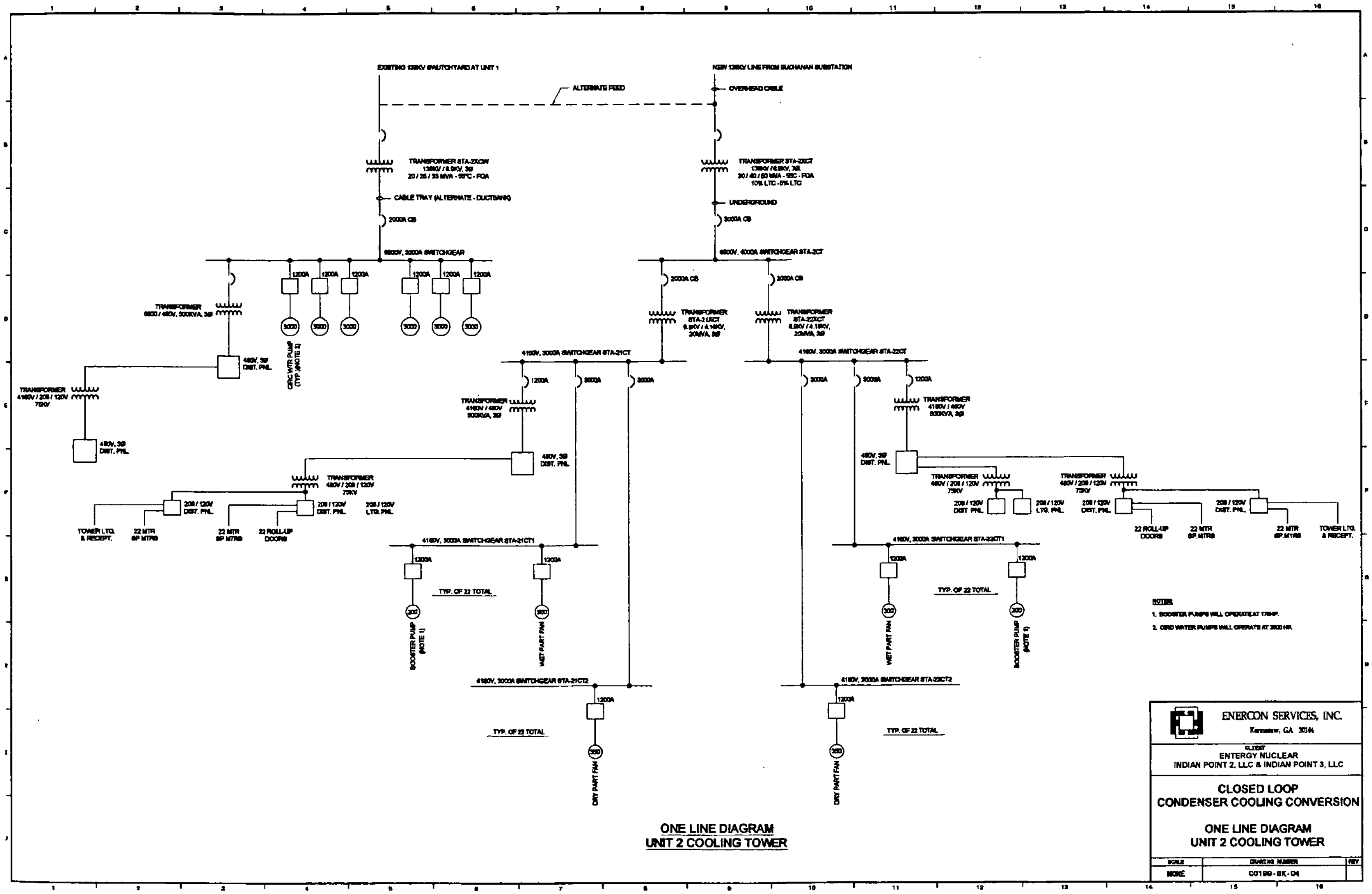
1. Site Rendering w/ Hybrid Cooling Towers
2. Site Layout Drawing
3. Circulating Water Pumping Station
4. Cooling Tower Switchgear Building
5. Unit 2 One-line Electrical Diagram
6. Unit 3 One-line Electrical Diagram

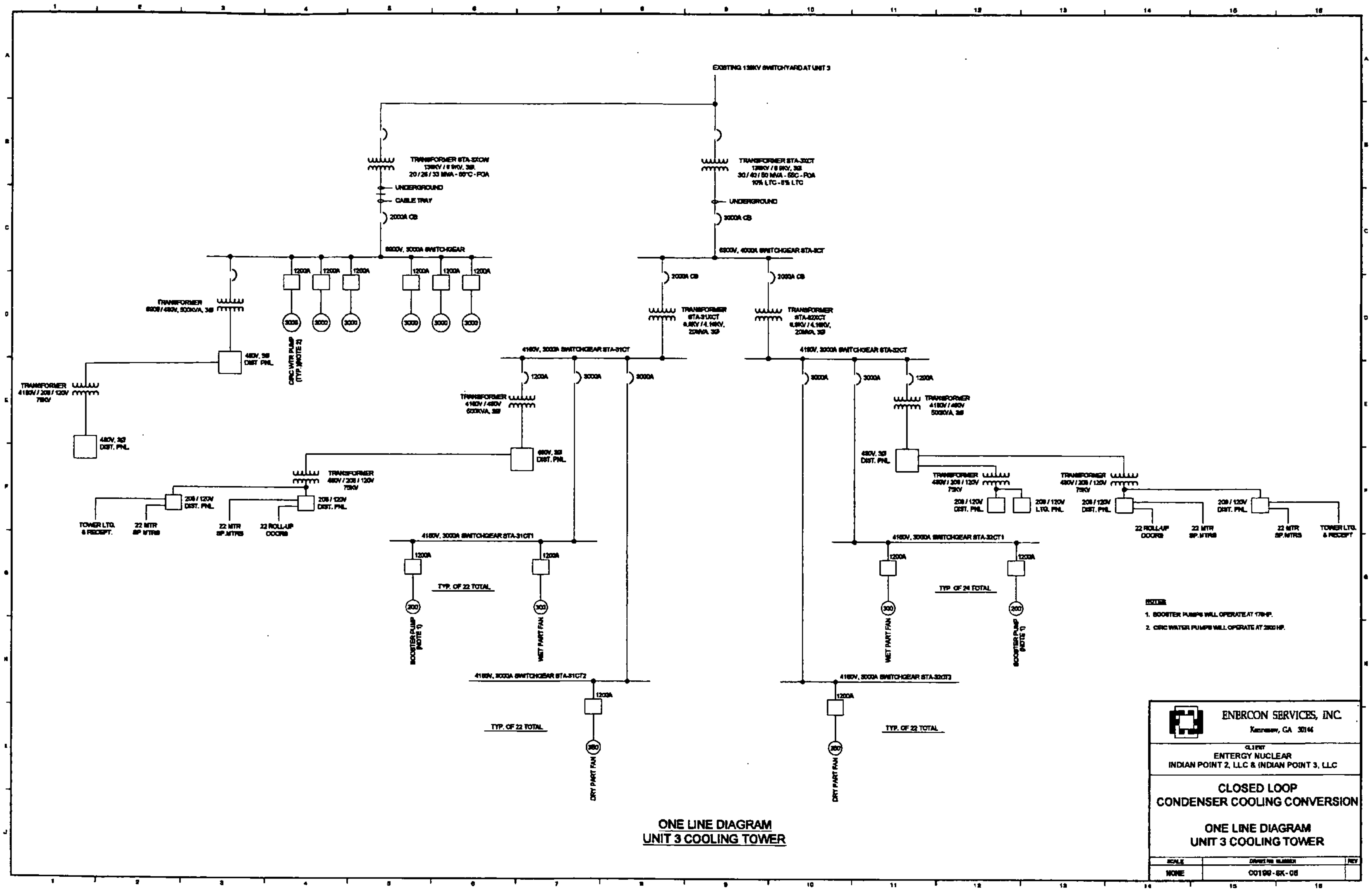
Rendering of Entergy Nuclear Indian Point 2, LLC, and Indian Point 3, LLC, Following Conversion To Closed Loop Condenser Cooling Via Hybrid Cooling Towers


BUCHANAN SUBSTATION
BROADWAY
LENT'S COVE
ALGONQUIN GAS LINES REQUIRE REROUTE AROUND TOWER
NEW 138KV TRANSMISSION LINE
NEW POLE
NEW 138/6.9KV TRANSFORMER
NEW 138/6.9KV TRANSFORMER
6.9KV UNDERGROUND DUCTBANK
UNIT 2 COOLING TOWER OUTSIDE DIAMETER 525' APPROX
BOOSTER PUMP SKIDS
ISFSI
LOW VOLTAGE DUCTBANK
CABLE TRAY
MANHOLE/ PULLBOX
UNIT 3 COOLING TOWER
NEW SWGR BLDG
~700' EXCAVATION DIAMETER
HUDSON RIVER
NEW SWGR BLDG
NEW 138/6.9KV TRANSFORMER
(2) 144" DIA. TO CONDENSER
(2) 120" DIA. C T SUPPLY
NEW POLE
NEW CONTROL DUCTBANK
NEW UNIT 2 PUMP HOUSE
CABLE TRAY
NEW CONTROL DUCTBANK
CONVERT TO PUMP PIT SUPPLY
NEW UNIT 3 PUMP HOUSE
WEIR
(2) 144" DIA. TO CONDENSER
LOW VOLTAGE DUCTBANK
(2) 120" DIA. C T SUPPLY
BOOSTER PUMP SKIDS
Coolin Towers (typical for two)
Tower Type
Counterflow forced draft plume abated (hybrid) with low noise fans & sound attenuation baffles
Tower Geometry
OD= 524.8 ft
Overall Ht = 168 ft
ID exit cone 241.4 ft
No fans (wet section) = 44 (Motor Output Power = 300 HP)
No fans (dry section)= 44 (Motor Output Power = 350 HP)
Wet Section Data
Flow = 700,000 gpm
Plan area of fill 121660 ft2
Fill Type 6 ft PVC low fouling film (MCT FC-18)
DE type / drift rate Cellular PVC (MCT TU-12)/ drift rate .001 %
Distribution system FRP headers/PVC pipes
Nozzles High efficiency polypropylene
Dry Section Data
Flow= 245,000 gpm
Element type 4 row/ 2 pass
Tube type 1" OD Titanium
Fin Type 2.25" OD Aluminum fins @ 11 fins/in ("L" fin)
Tube length = 48 ft
No tubes/ bundle = 218
No bundles = 264
Thermal Data
Wet design condition (76 WBT 88 CWT 108 HWT)
HP (motor output wet section) = 270 HP evaporation rate = 1.67 % Vexit= 1233 fpm
Hybrid Operation@ plume abatement design point (27 WBT @ 90 % RH)
HP (MOP wet section) = 300 HP evaporation rate = .81 % CWT = 59 °F
Vexit=2260 fpm
HP (MOP dry section)= 350 HP
Pumping Head Required for Tower
Main Pumps
700,000 gpm @ 45 ft TDH
Booster Pumps Required for Dry Section
245000 gpm @ 26 ft
Electrical Distribution
The design assumes there is adequate room in the Unit 1 138KV switchyard to install a circuit breaker and transformer to feed the new Unit 2 circ water pumps. If not, the breaker and transformer will be installed near the new Unit 2 Switchgear Building and a ductline installed along the same excavation as the 120" diameter pipes from the Unit 2 cooling tower to the new pump house.
The design assumes a new overhead line will have to be run to the Buchanan substation. If possible, a tap can be made in the overhead 138KV feeder at the existing pole between the Buchanan substation and the plant for a new 138KV overhead feeder to the Unit 2 cooling tower.
A control ductbank is shown from the old circ water pump house to the new for control of the new pumps. This is based on the assumption that no new control circuits will be routed back into the plant and the existing controls can simply be extended from the existing pump house.
Depicted design does not address safety related control and instrumentation interlocks, which will require plant and control room interfaces not shown.
Circulating Water Pumps
(6) Pumps required per Unit
Type - Vertical Turbine / 1 Stage
117,000 gpm @ 72.0 TDH
Bowl and Impeller - 316 SS
3000 HP / 446 RPM / 4160 V
40 ft NPSHR
ENERCON SERVICES, INC.
Kennesaw, GA 30144
ENTERGY NUCLEAR
INDIAN POINT 2, LLC & INDIAN POINT 3, LLC
CLOSED LOOP
CONDENSER COOLING CONVERSION
SITE LAYOUT
NONE
SKETCH 01
0


SECTION A-A
GRADE
PRE-FABRICATED BUILDING
TOP SLAB (CONCRETE) PLAN
CIRCULATING WATER PUMPS
(6) PUMPS REQUIRED PER UNIT
TYPE - VERTICAL TURBINE / 1 STAGE
117,000 GPM @ 72.0 TDH
BOWL AND IMPELLER - 316 SS
3000 HP / 446 RPM / 4160 V
40 FT. NPSHR
ENERCON SERVICES, INC.
CLIENT
ENTERGY NUCLEAR
INDIAN POINT 2, LLC & INDIAN POINT 3, LLC
CLOSED LOOP
CONDENSER COOLING CONVERSION
CIRCULATING WATER
PUMPING STATION
SCALE
NONE
CO199-SK-02
REV
0


CONTROL PANEL
DESK
UPS
FUSE PANEL
DISTRIBUTION TRANSFORMERS AND PANELBOARDS
4160V SWITCHGEAR (22 FANS, 1 BOOSTER PUMP)
4160V SWITCHGEAR (22 FANS)
6.9KV SWITCHGEAR
TRANSFORMER 6.9/4.16KV 20MVA
4160V SWITCHGEAR
ROLL UP DOOR
126'-0"
TRANSFORMER 138/6.9 KV 20/26/33MVA (NOTE 2)
TRANSFORMER 138/6.9 KV 30/40/50MVA (NOTE 1)
TRANSFORMER
NOTES:
1. TRANSFORMER LOCATED AT SWITCHGEAR BUILDING FOR UNIT 2 ONLY. TRANSFORMER FOR UNIT 3 IS LOCATED IN THE UNIT 3 138KV SWITCHYARD.
2. ALTERNATE LOCATION FOR TRANSFORMER TO THE UNIT 2 CIRC. PUMP BUILDING.
3. ENCLOSING STRUCTURE TO BE PRE-FABRICATED METAL BUILDING.
ENERCON SERVICES, INC.
Kennesaw, GA 30144
CLIENT
ENTERGY NUCLEAR
INDIAN POINT 2, LLC & INDIAN POINT 3, LLC
CLOSED LOOP
CONDENSER COOLING CONVERSION
SWITCHGEAR BUILDING
CONCEPTUAL PLAN
SCALE
DRAWING NUMBER
REV
NONE
C0199-SK-03


ENERCON SERVICES, INC.
ENTERGY NUCLEAR
INDIAN POINT 2, LLC & INDIAN POINT 3, LLC
CLOSED LOOP
CONDENSER COOLING CONVERSION
ONE LINE DIAGRAM
UNIT 2 COOLING TOWER
NONE
C0199-SK-04
ONE LINE DIAGRAM
UNIT 2 COOLING TOWER



ONE LINE DIAGRAM
UNIT 3 COOLING TOWER

Attachment 3
PEPSE Model Results
Plant Performance Versus Condenser Inlet Water Temperature

PEPSE Model Results
Plant Performance Versus Condenser Inlet Water Temperature

The following documents are included in this attachment (for Entergy Nuclear Indian Point 2, LLC, and Indian Point 3, LLC):

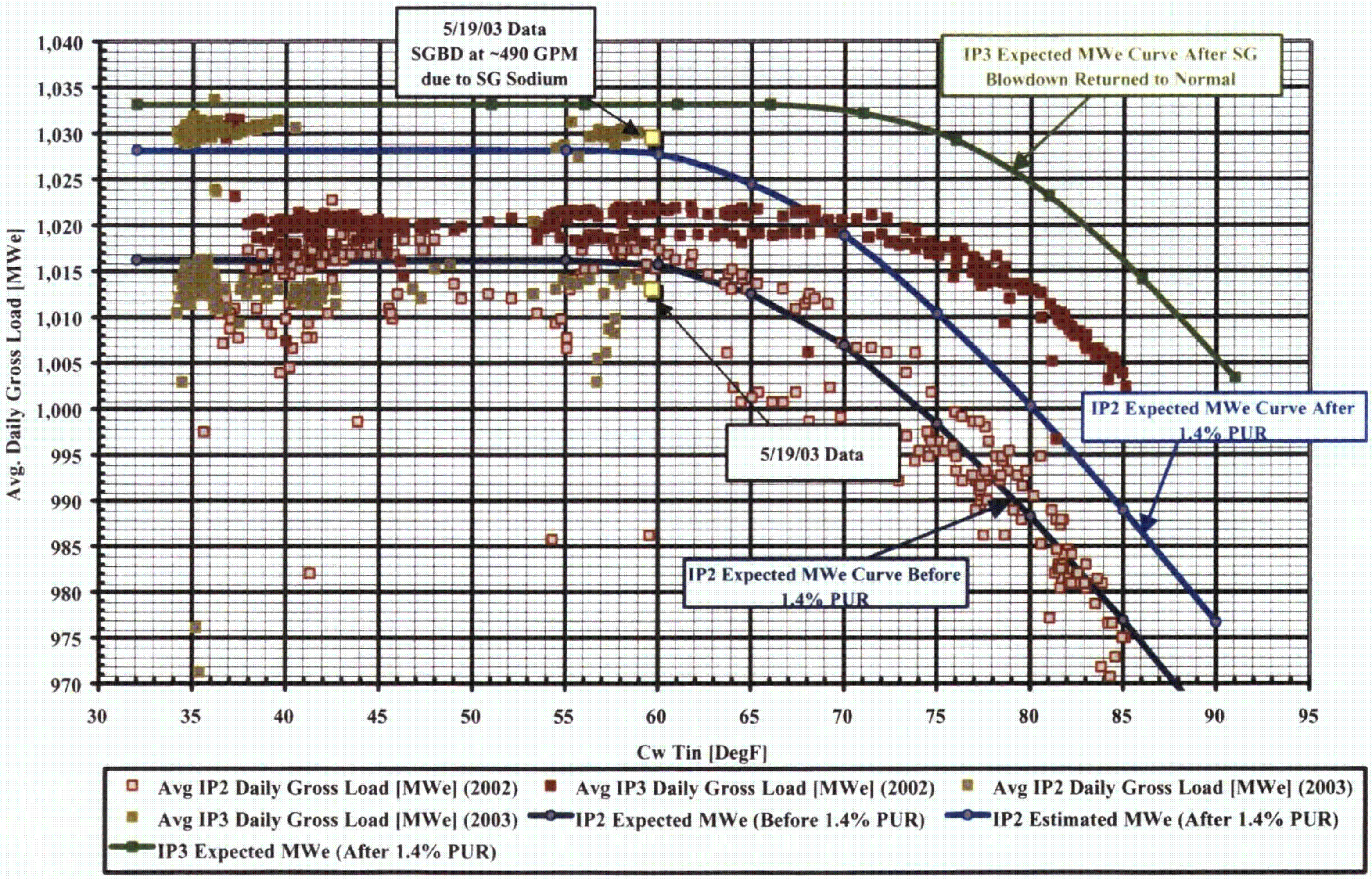
Historical plant performance, specifically relevant to Indian Point 2 and Indian Point 3 performance versus river water temperature, including,

- River Water Temperature vs. Daily Gross Output
- Monthly Condenser Backpressure
  (River Water Temperature vs. Backpressure)

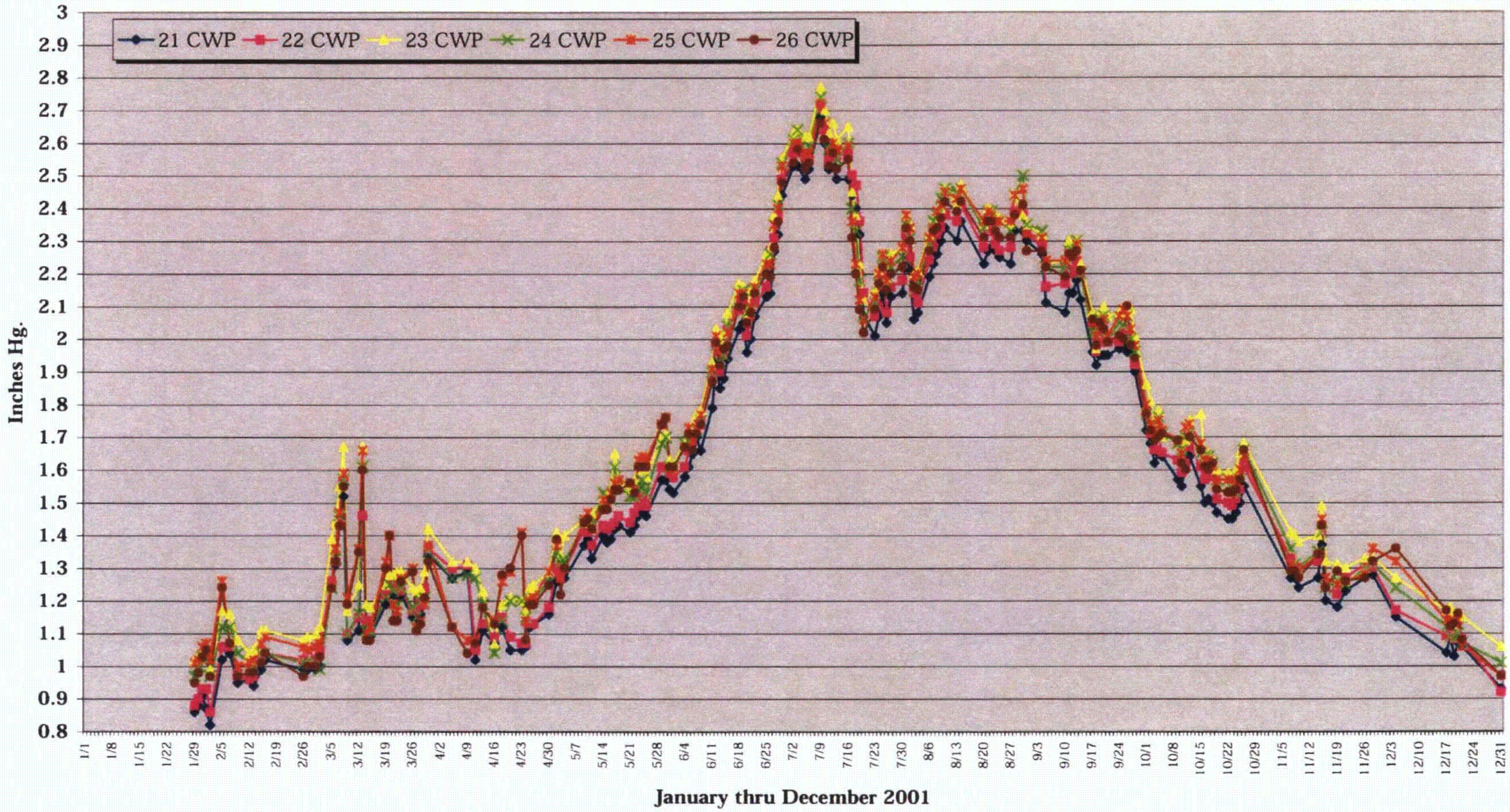
Analytical evaluation via PEPSE model of projected plant performance versus river water temperature, or as appropriate, cooling tower discharge water temperature, including,

- Tabulation of PEPSE Data
  (Generator Output/Condenser Pressure/CW_{IN}/CW_{OUT}/CW_{FLOW}/HW_{TEMP}/ΔMW_E)
- Heat Balance Diagram @ CW_{IN} =60°F, and CW_{IN} =85°F
- Graph of Condenser Pressure (InHga) vs. River Water Temperature (°F)
- Graph of Hotwell Temperature (°F) vs. River Water Temperature (°F)
- Graph of Delta Megawatts (MW_E) vs. River Water Temperature (°F)
- Graph of Generator Output (MW_E) vs. River Water Temperature (°F)

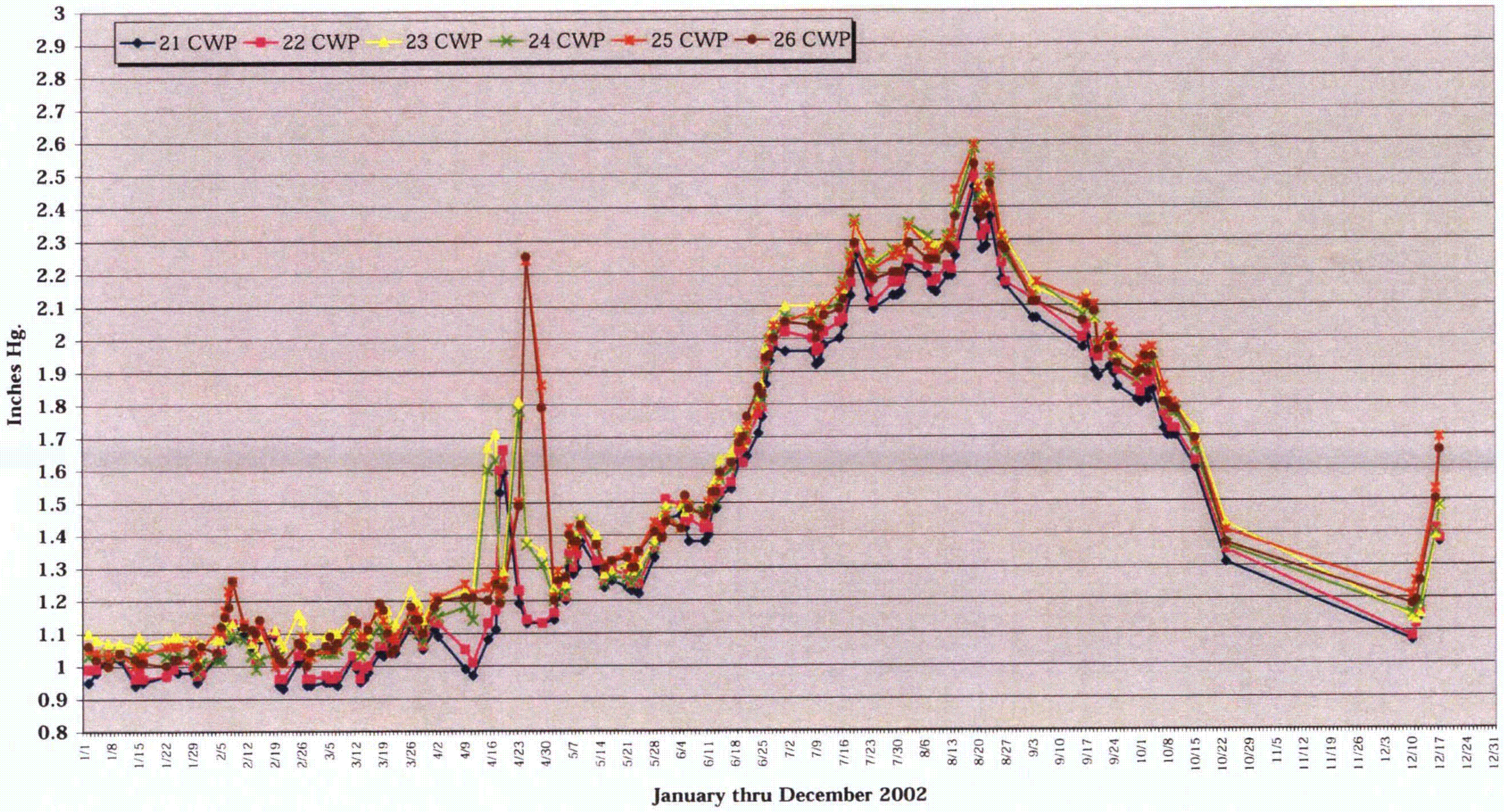
Avg. IPEC CW Tin / Avg. Daily Gross Load



Condenser Back Pressure

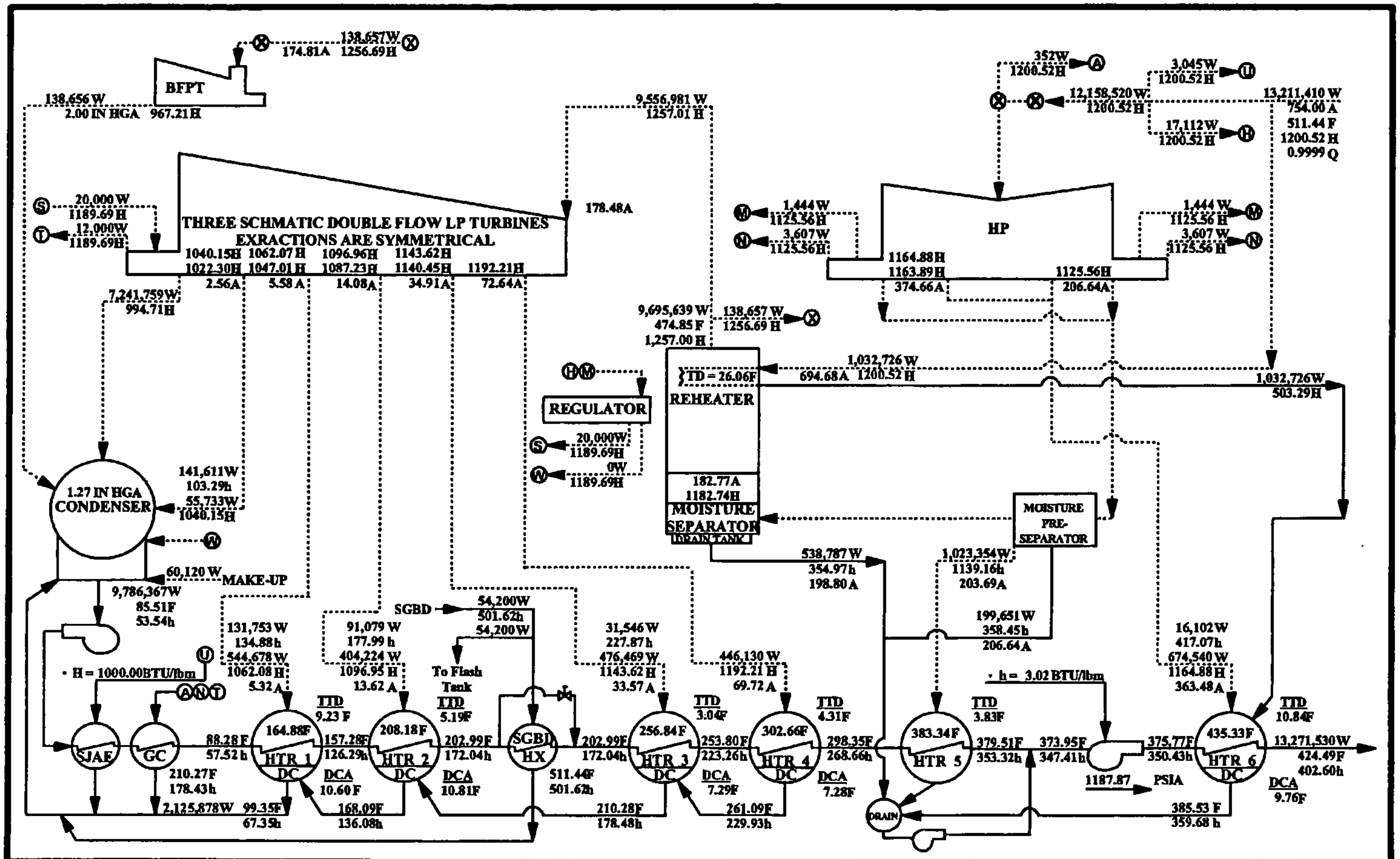


Condenser Back Pressure



IP2 PEPSE Data (Before 1.4% PUR)

Geerator Output (MWe)	Condenser Pressure (InHga)	CW Tin (DegF)	CW Tout (DegF)	CW Flow (GPM)	HW T (DegF)	Delta MWe
1014.948	0.85	45	61.72	840000	73.04	0.716
1015.274	0.92	48	64.73	840000	75.45	0.390
1015.495	0.97	50	66.73	840000	77.08	0.169
1015.606	1.00	51	67.74	840000	77.90	0.058
1015.664	1.02	52	68.74	840000	78.75	0.000
1015.031	1.11	55	71.75	840000	81.26	0.633
1014.628	1.27	60	76.77	840000	85.51	1.036
1011.228	1.46	65	81.81	840000	89.87	4.436
1005.523	1.68	70	86.87	840000	94.50	10.141
996.996	1.95	75	91.96	840000	99.28	18.668
986.814	2.25	80	97.06	840000	104.16	28.850
975.383	2.60	85	102.16	840000	109.13	40.281
962.980	3.00	90	107.28	840000	114.11	52.684



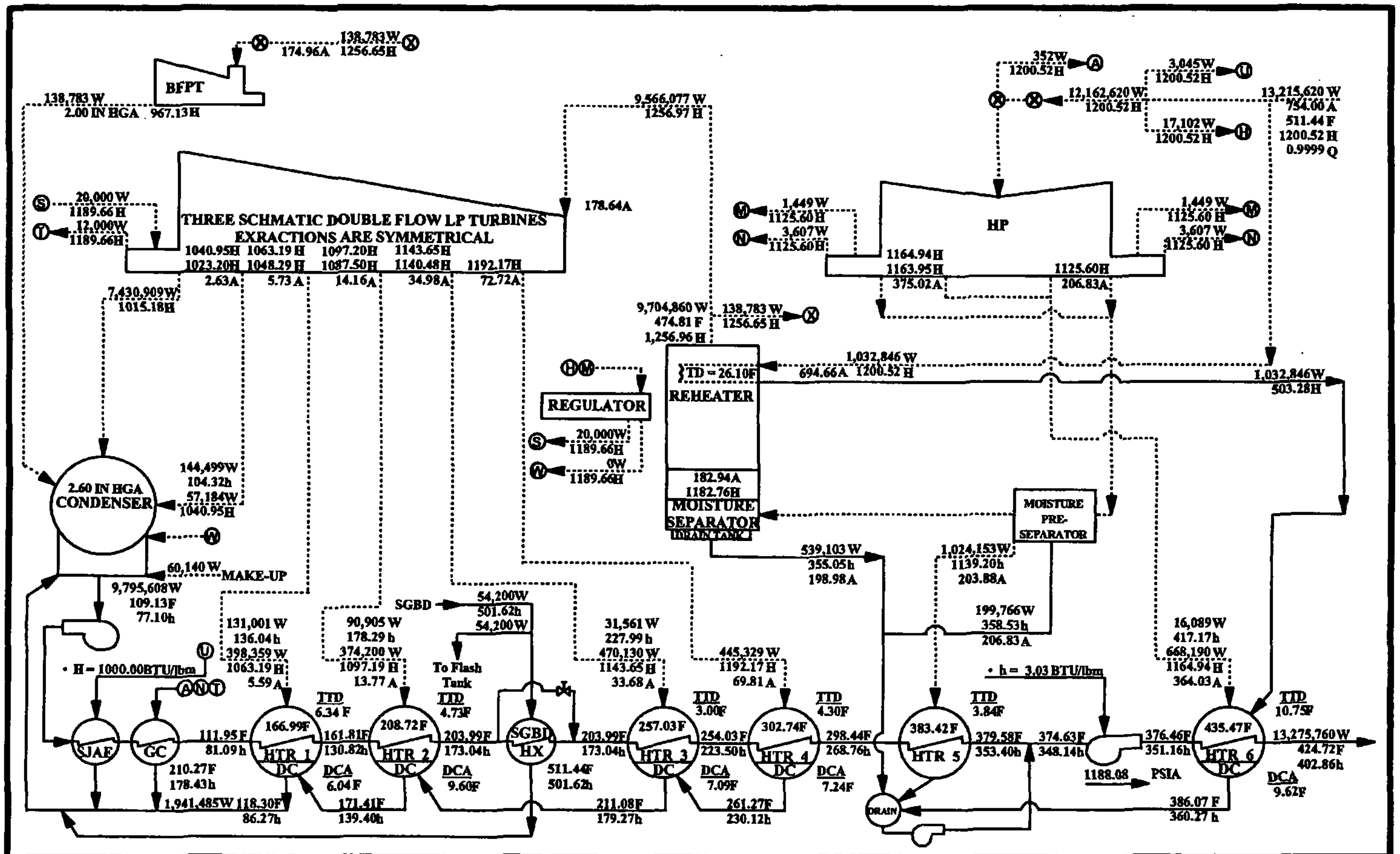
NET HEAT RATE = [13,271,530 (1200.52 - 402.60) - 60,120 (1200.52 - 501.62)] / 1,014,628 = 10,395.45 BTU / KW HR	TEP = 994.49 BTU/lbm ELEP = 972.46 BTU/lbm MECH LOSS = 3.656 KW ELECT LOSS = 8.374 KW 0.91 PF 75# H2 FWP POWER = 11,763 KW FWP EFF = 87.52 %	1028612 KW TURB - GEN UNIT TC6F - 45 IN. 668 PSIA - 497.9 F 1.5 IN.HGA 1439200 KVA 0.91 PF 22000 VOLTS 75# H2
1) Calculations are based on no radiation losses to heaters or extraction piping located in the condenser neck. 2) Primary valve and above heat rates are calculated on locus of valve points.		1,014,628 KW NET LOAD HEAT BALANCE 100.01% Rx Power

100% Pwr 60 DegF CW Tin (Before PUR)

PEPSE Run Date : 5/22/2003 PEPSE Run Status : NORM TERMINATION

Entergy

Indian Point 2
Nuclear Power Plant



NET HEAT RATE = 13,275,760 (1200.52 - 402.86) - 60,140(1200.52 - 501.62) / 975,383 = 10,813.72 BTU / KW HR	TEP = 1014.99 BTU/lbm ELEP = 1004.32 BTU/lbm MECH LOSS = 3.656 KW ELECT LOSS = 7.987 KW 0.91 PF 75# H2 FWP POWER = 11,775 KW FWP EFF = 87.52 %

1028612 KW TURB - GEN UNIT TC6F - 45 IN.
668 PSIA - 497.9 F 1.5 IN.HGA
1439200 KVA 0.91 PF 22000 VOLTS 75# H2

975,383 KW NET LOAD HEAT BALANCE
100.01% Rx Power

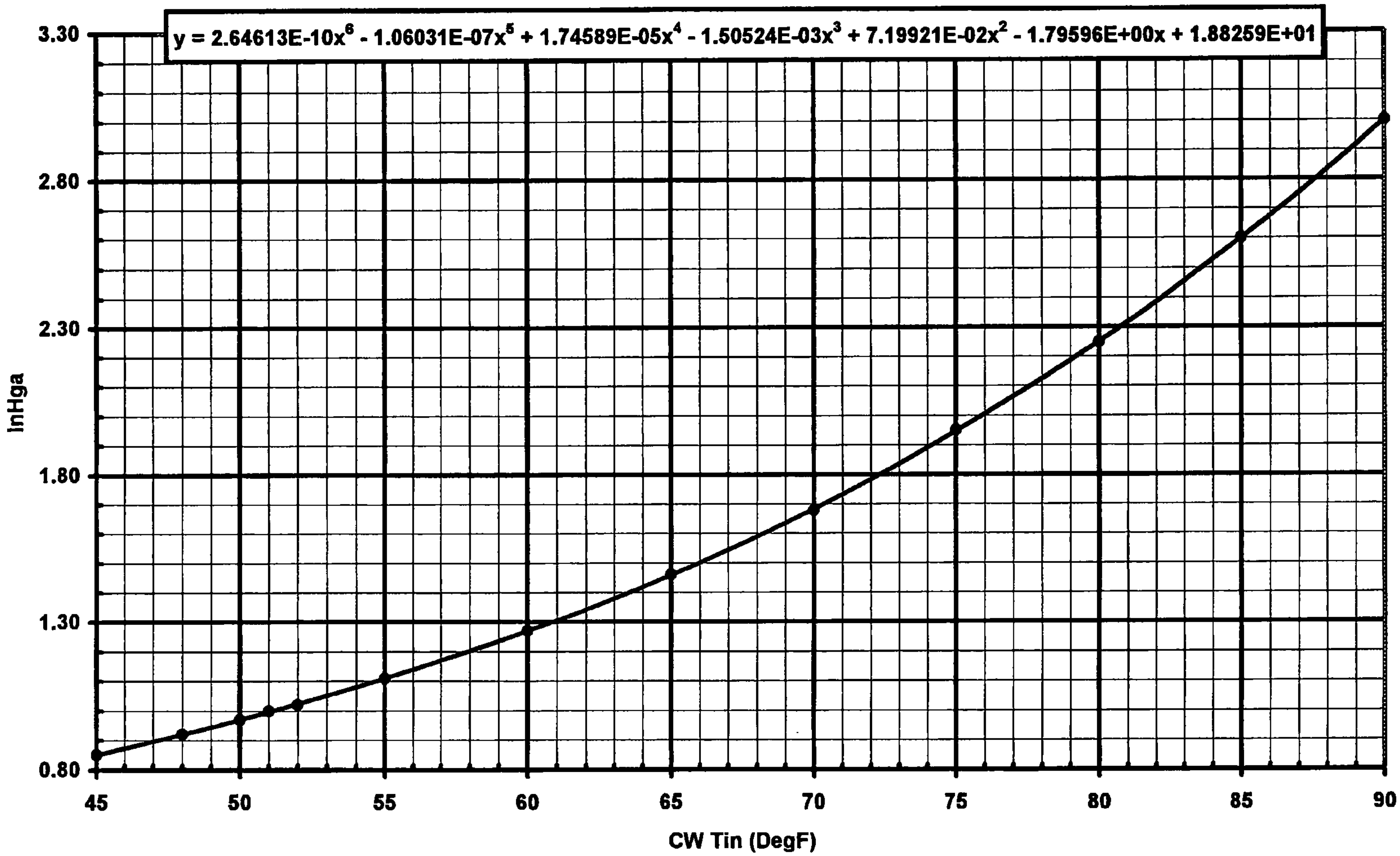
1) Calculations are based on no radiation losses to heaters or extraction piping located in the condenser neck.
2) Primary valve and above heat rates are calculated on locus of valve points.

100% Pwr 85 DegF CW Tin (Before PUR)

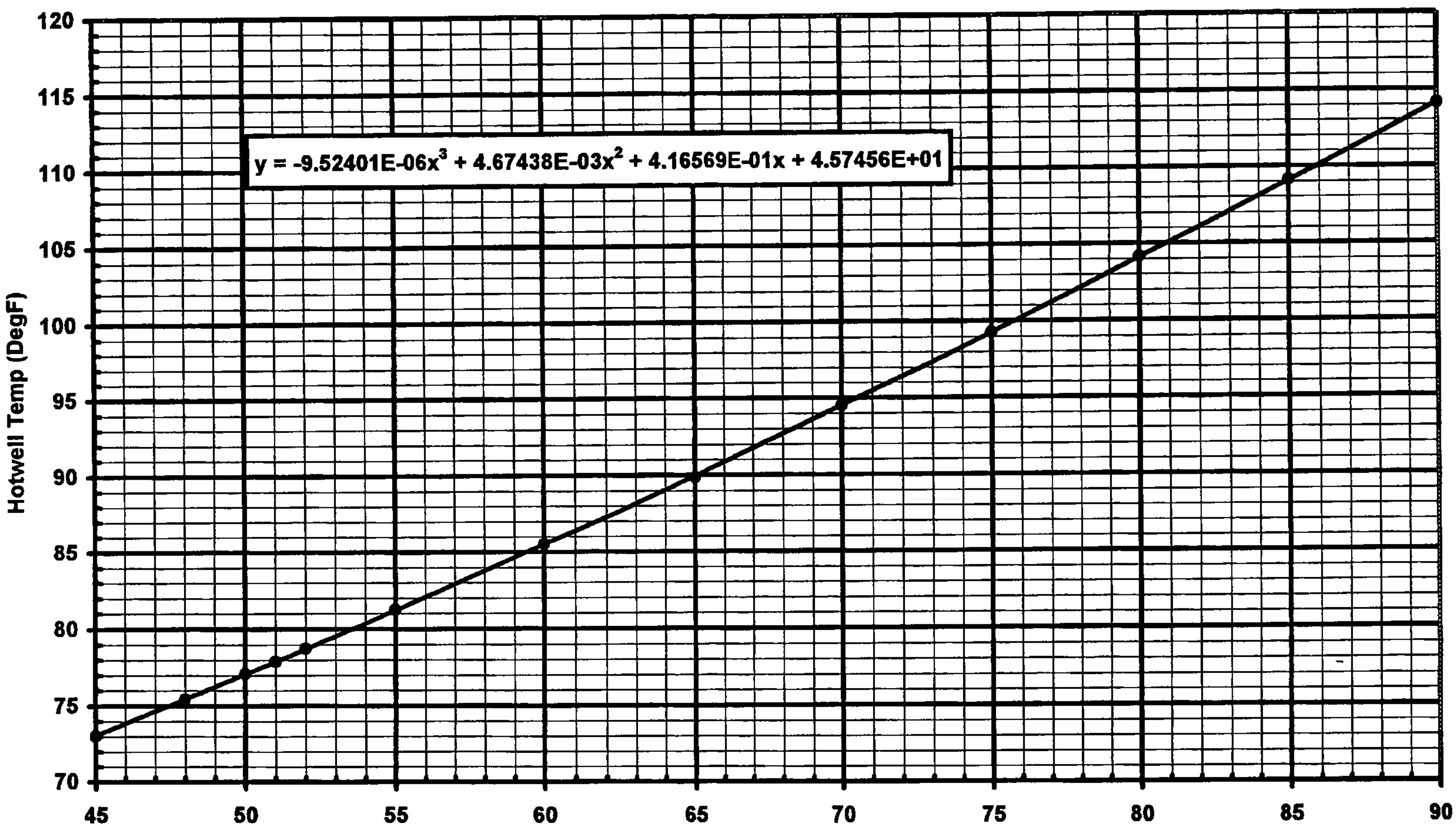
PEPSE Run Date : 5/22/2003 PEPSE Run Status : NORM TERMINATION

Entergy Indian Point 2 Nuclear Power Plant

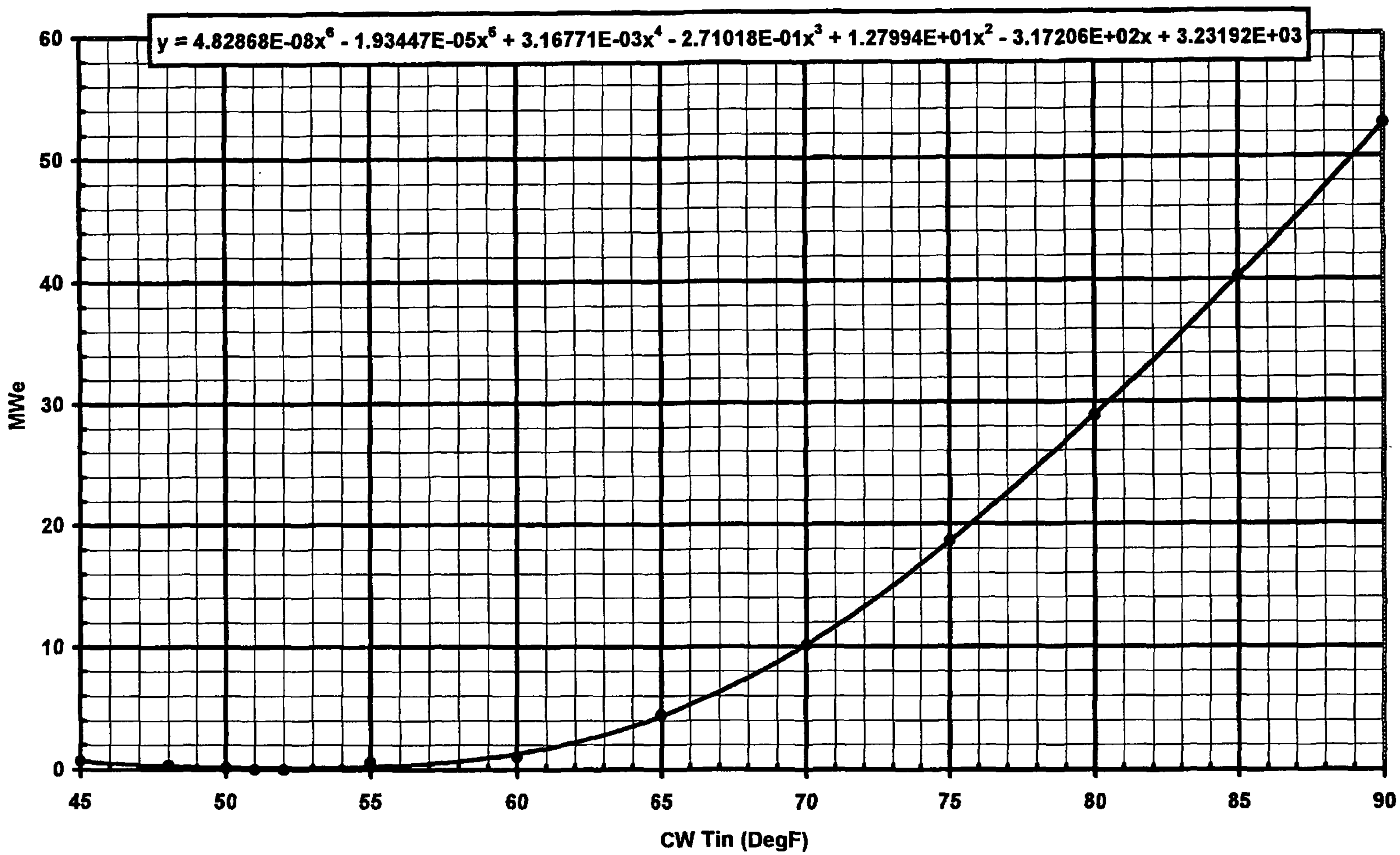
IP2 Condenser Pressure (InHga) vs River Water Temperature (DegF)
(100% Power, 85% Condenser Clean, ~1 DegF Condensate Subcooling, Fast CW Pump Speed)



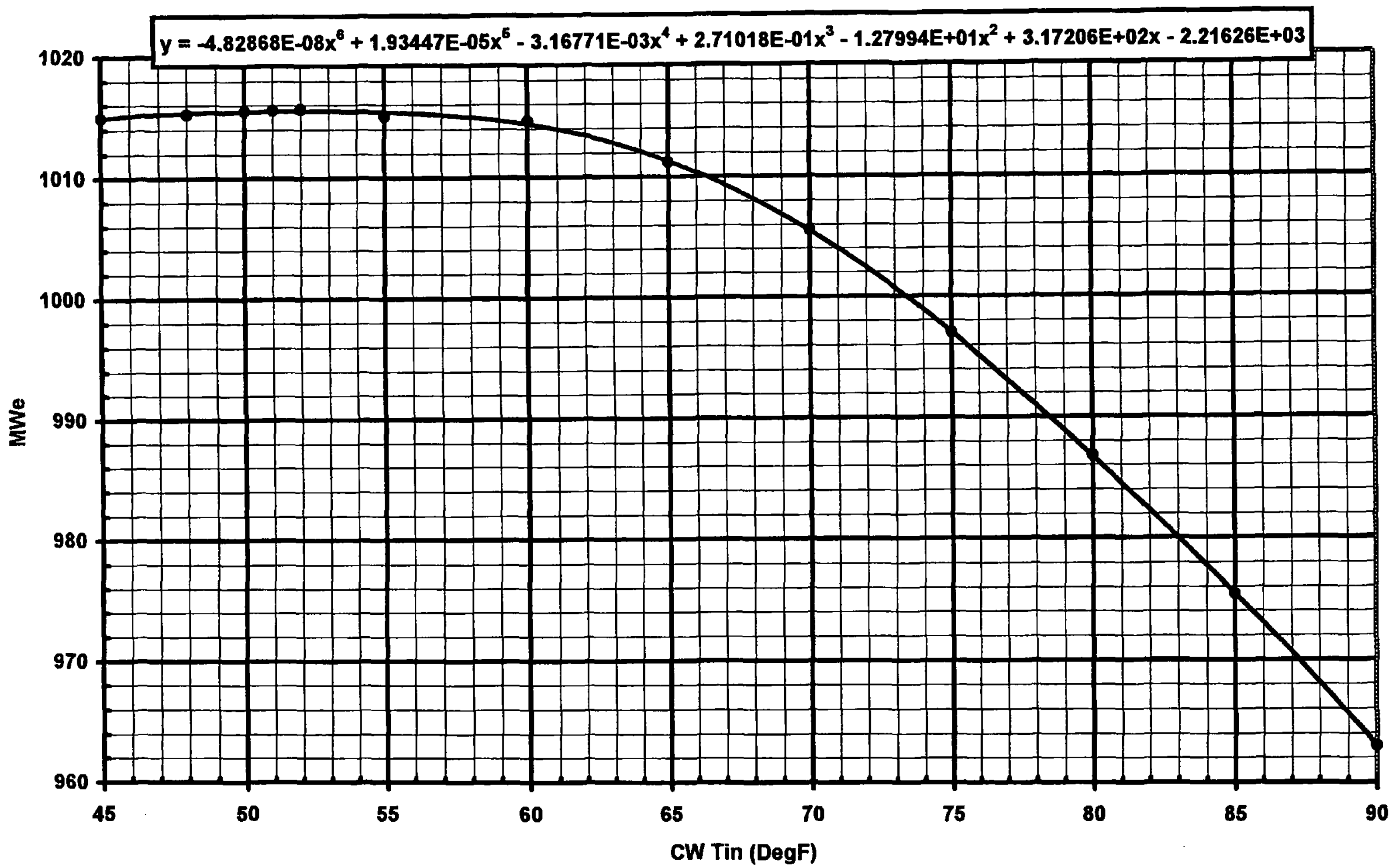
IP2 Hotwell Tempearture (DegF) vs River Water Temperature (DegF)
(100% Power, 85% Condenser Clean, ~1 DegF Condensate Subcooling, Fast CW Pump Speed)



IP2 Delta MWe vs River Water Temperature
(100% Power, 85% Condenser Clean, ~1 DegF Condensate Subcooling, Fast CW Pump Speed)

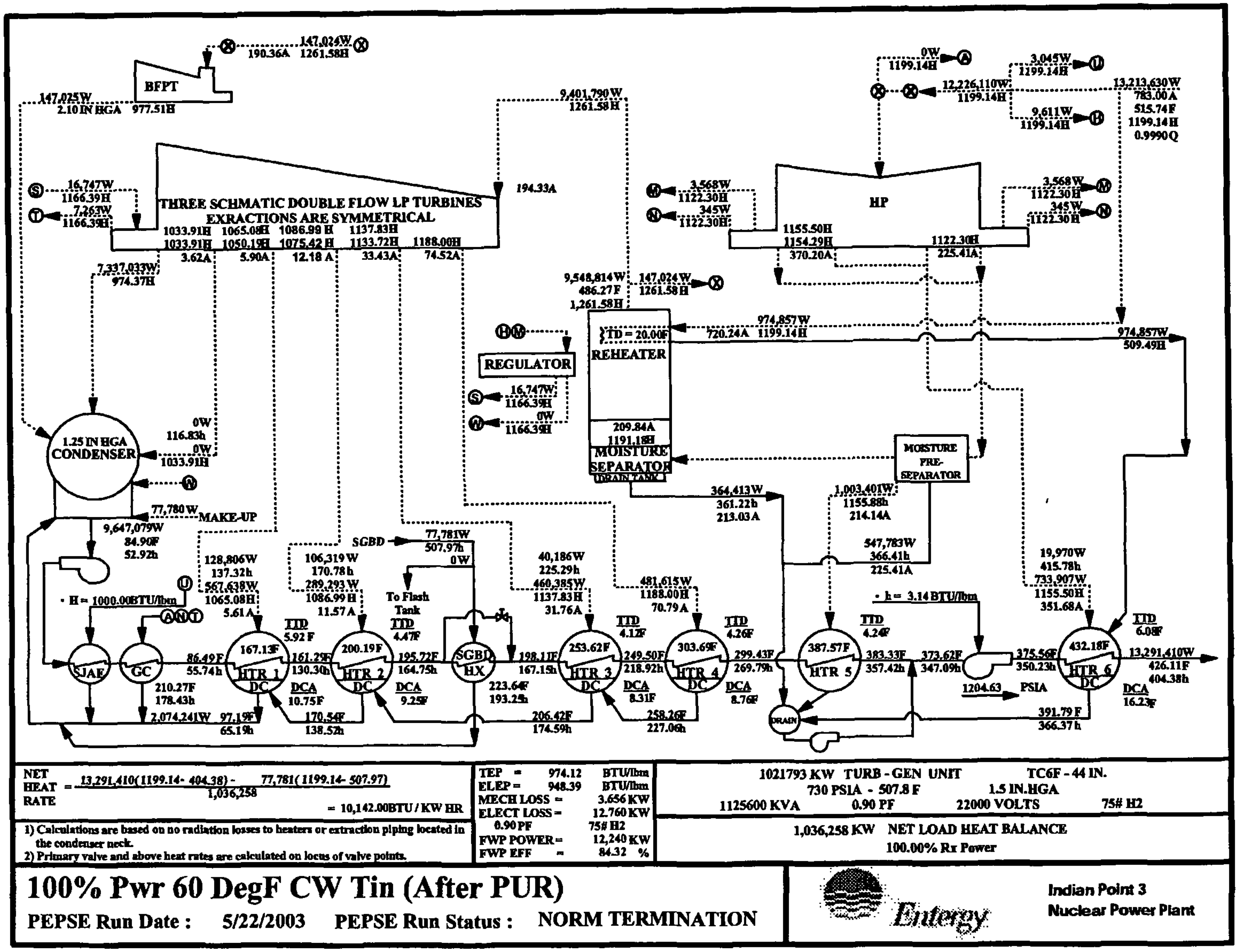


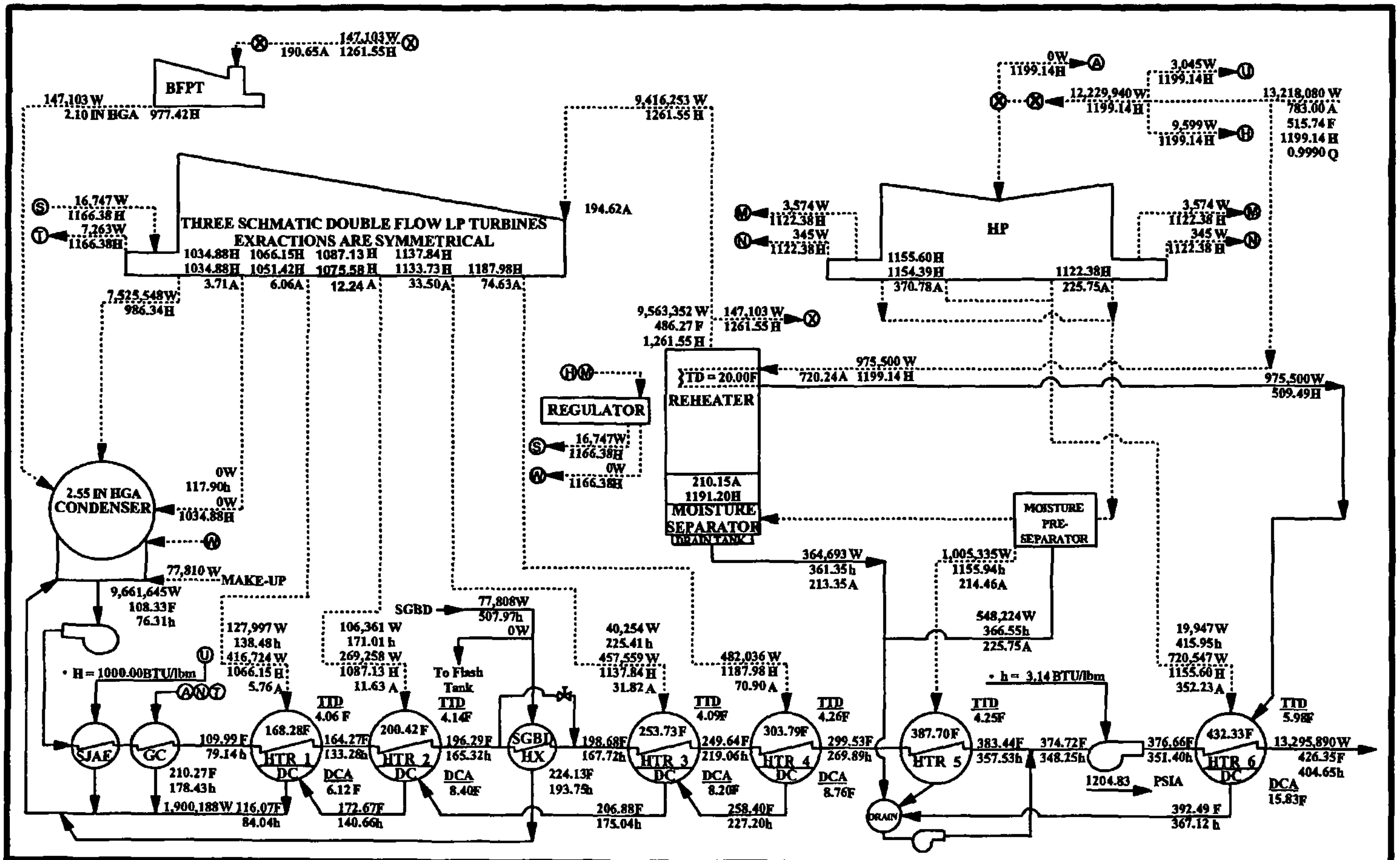
IP2 Generator Output (MWe) vs River Water Temperature (DegF)
(100% Power, 85% Condenser Clean, ~1 DegF Condensate Subcooling, Fast CW Pump Speed)



IP3 PEPSE Data

Geerator Output (MWe)	Condenser Pressure (InHga)	CW Tin (DegF)	CW Tout (DegF)	CW Flow (GPM)	HW T (DegF)	Delta MWe
1035.062	1.09	55	71.48	840000	80.64	1.243
1035.970	1.18	58	74.48	840000	83.19	0.335
1036.258	1.25	60	76.48	840000	84.90	0.047
1036.305	1.32	62	78.49	840000	86.64	0.000
1035.946	1.43	65	81.50	840000	89.23	0.359
1035.107	1.65	70	86.52	840000	93.81	1.198
1031.638	1.91	75	91.56	840000	98.54	4.667
1024.930	2.20	80	96.63	840000	103.39	11.375
1015.471	2.55	85	101.72	840000	108.33	20.834
1004.474	2.94	90	106.83	840000	113.31	31.831


BFPT
HP
THREE SCHEMATIC DOUBLE FLOW LP TURBINES
EXRACTIONS ARE SYMMETRICAL
REGULATOR
REHEATER
MOISTURE SEPARATOR
MOISTURE PRE-SEPARATOR
1.25 IN HGA CONDENSER
MAKE-UP
SJAE
GC
HTR 1
HTR 2
SGBD HX
HTR 3
HTR 4
HTR 5
HTR 6
DRAIN
To Flash Tank
NET HEAT RATE = 13,291,410(1199.14- 404.38) - 77,781(1199.14- 507.97) / 1,036,258 = 10,142.00BTU / KW HR
1) Calculations are based on no radiation losses to heaters or extraction piping located in the condenser neck.
2) Primary valve and above heat rates are calculated on locus of valve points.
TEP = 974.12 BTU/lbm
ELEP = 948.39 BTU/lbm
MECH LOSS = 3.656 KW
ELECT LOSS = 12.760 KW
0.90 PF 75# H2
FWP POWER = 12,240 KW
FWP EFF = 84.32 %
1021793 KW TURB - GEN UNIT TC6F - 44 IN.
730 PSIA - 507.8 F 1.5 IN.HGA
1125600 KVA 0.90 PF 22000 VOLTS 75# H2
1,036,258 KW NET LOAD HEAT BALANCE
100.00% Rx Power
100% Pwr 60 DegF CW Tin (After PUR)
PEPSE Run Date : 5/22/2003 PEPSE Run Status : NORM TERMINATION
Entergy
Indian Point 3
Nuclear Power Plant



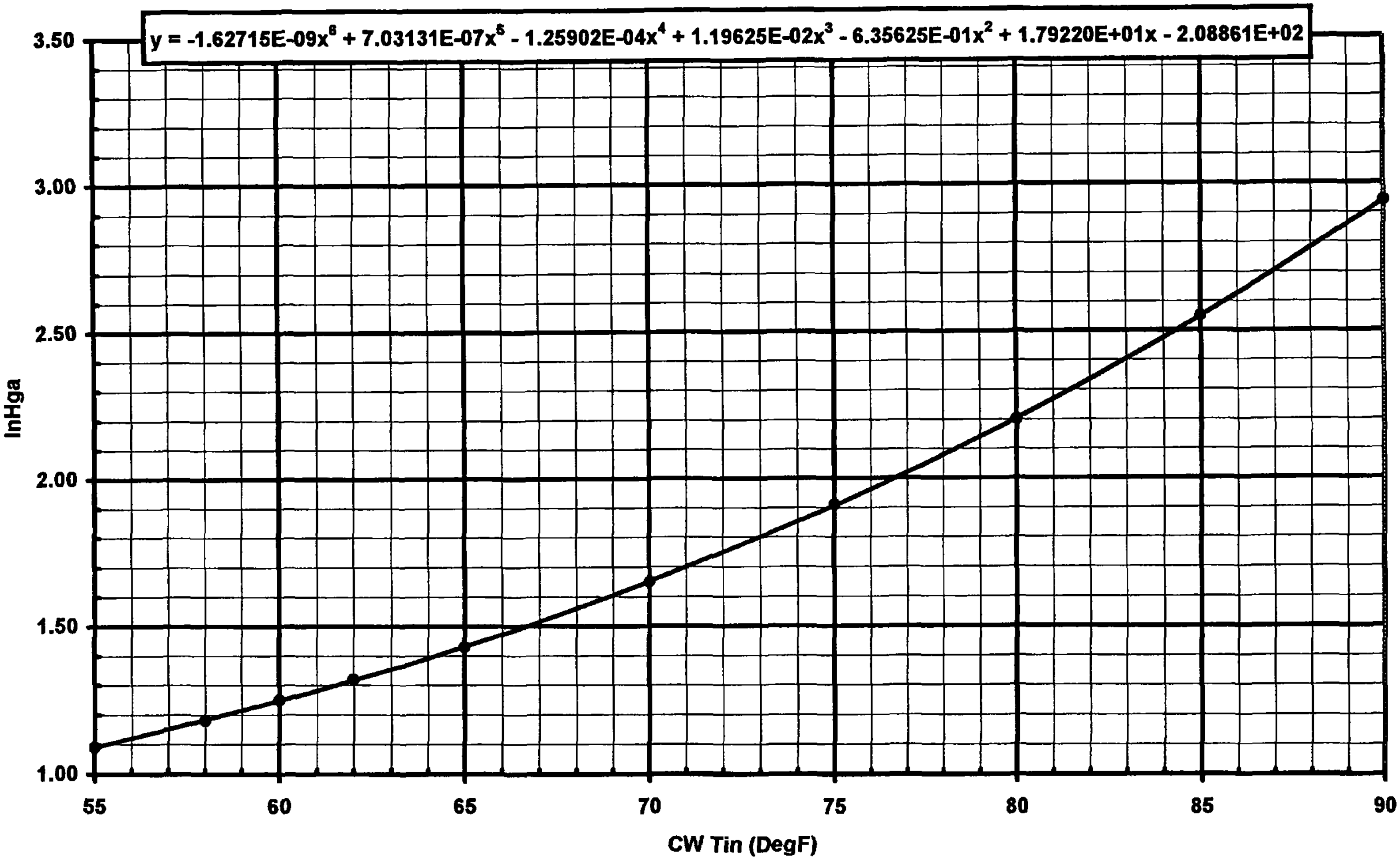
NET HEAT RATE = $\frac{13,295,890 (1199.14 - 404.65) - 77,808 (1199.14 - 507.97)}{1,015,471}$ = 10,349.61 BTU / KW HR	TEP = 986.11 BTU/lbm ELEP = 977.82 BTU/lbm MECH LOSS = 3.656 KW ELECT LOSS = 12.607 KW 0.90 PF 75# H2 FWP POWER = 12,249 KW FWP EFF = 84.39 %	1021793 KW TURB - GEN UNIT TC6F - 44 IN. 730 PSIA - 507.8 F 1.5 IN.HGA 1125600 KVA 0.90 PF 22000 VOLTS 75# H2
1) Calculations are based on no radiation losses to heaters or extraction piping located in the condenser neck. 2) Primary valve and above heat rates are calculated on locus of valve points.		1,015,471 KW NET LOAD HEAT BALANCE 100.00% Rx Power

100% Pwr 85 DegF CW Tin (After PUR)

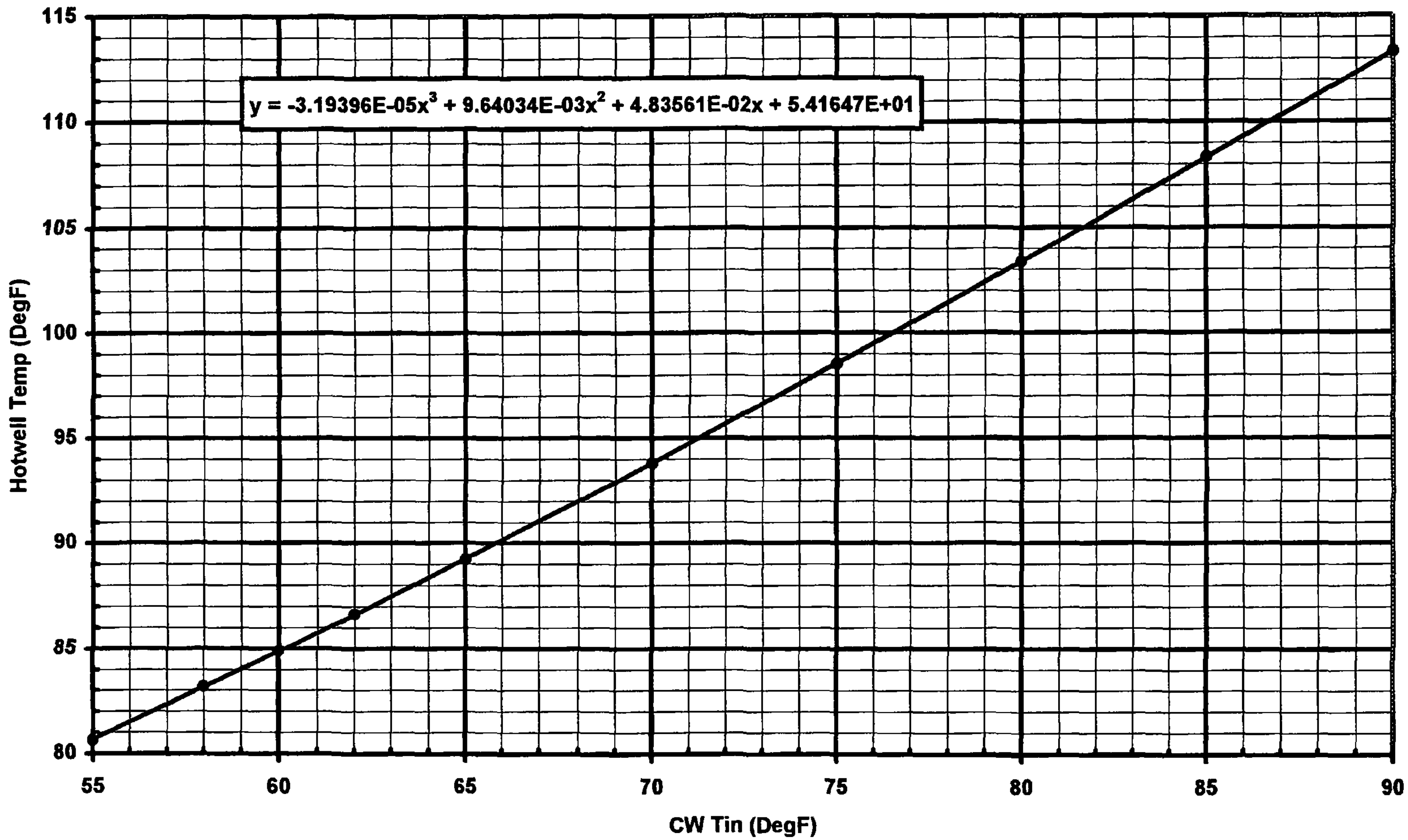
PEPSE Run Date : 5/22/2003 PEPSE Run Status : NORM TERMINATION

Entergy Indian Point 3 Nuclear Power Plant

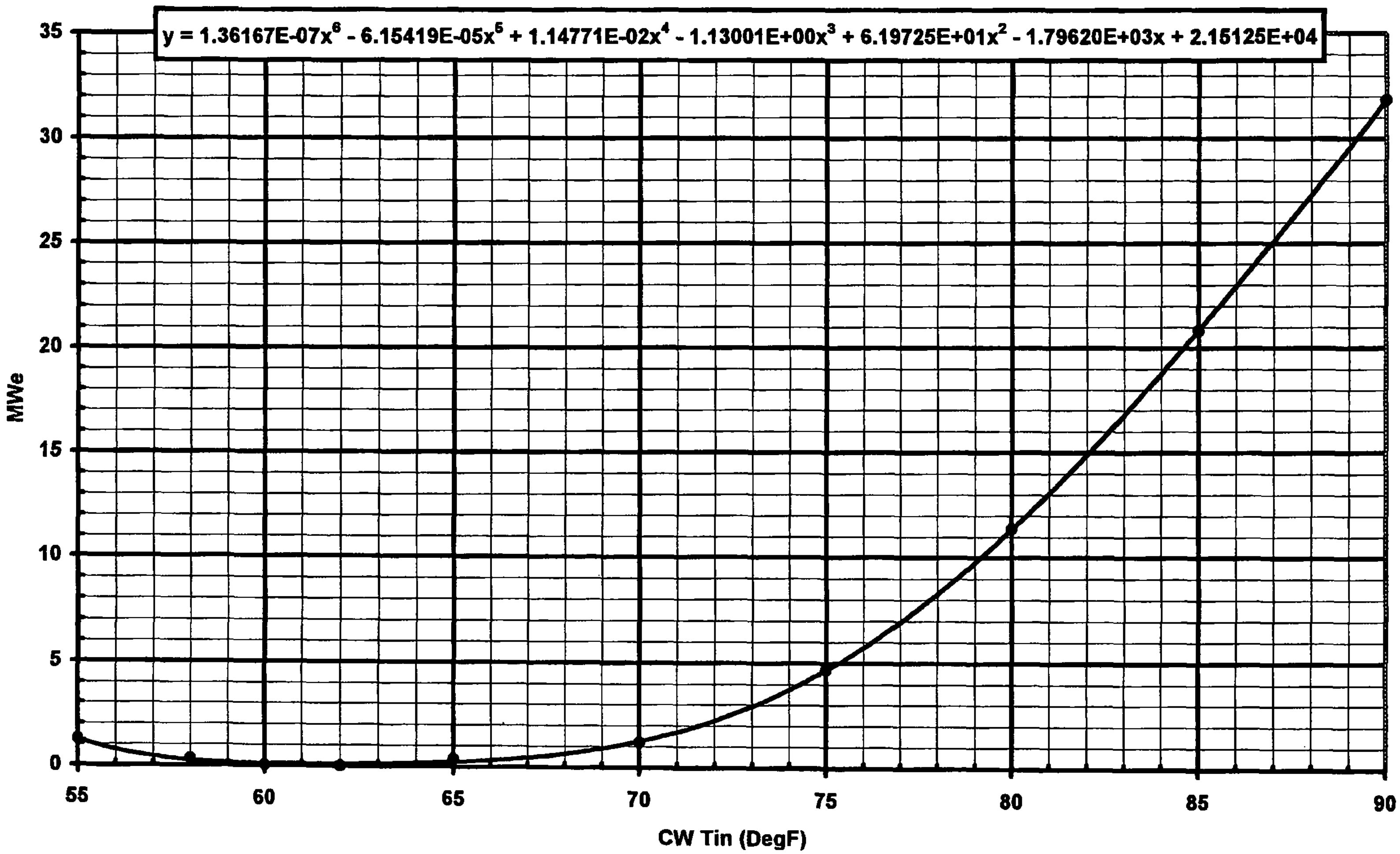
IP3 Condenser Pressure (InHga) vs River Water Temperature (DegF)
(100% Power, 90% Condenser Clean, 1 DegF Condensate Subcooling, 360 RPM CW Pump Speed)



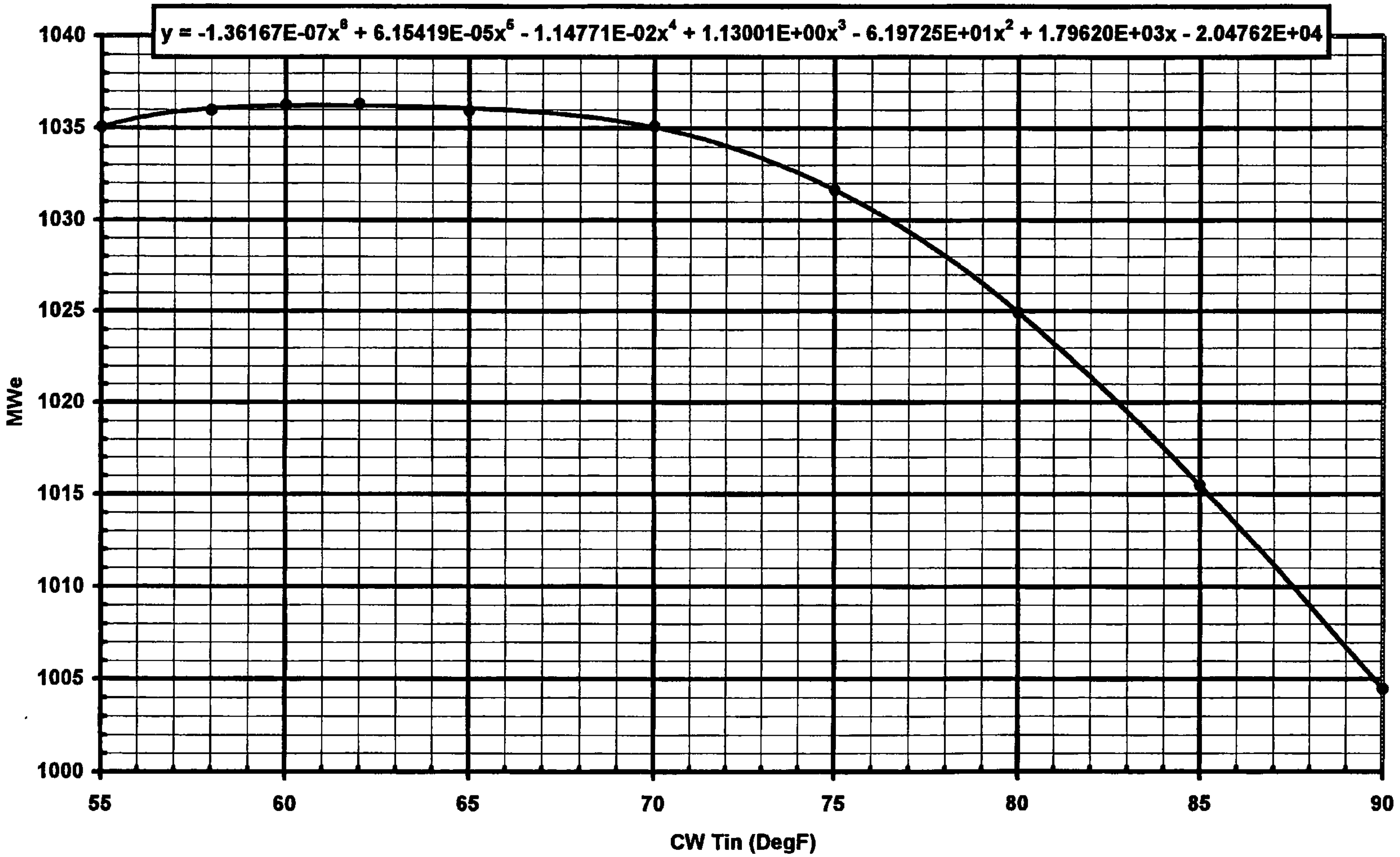
IP3 Hotwell Tempearture (DegF) vs River Water Temperature (DegF)
(100% Power, 90% Condenser Clean, 1 DegF Condensate Subcooling, 360 RPM CW Pump Speed)



IP3 Delta MWe vs River Water Temperature
(100% Power, 90% Condenser Clean, 1 DegF Condensate Subcooling, 360 RPM CW Pump Speed)



IP3 Generator Output (MWe) vs River Water Temperature (DegF)
(100% Power, 90% Condenser Clean, 1 DegF Condensate Subcooling, 360 RPM CW Pump Speed)



Attachment 4

Regulatory Issues

REGULATORY ISSUES

BACKGROUND

All changes to Indian Point Units 2 and 3 are required to be reviewed for the possible impact on the licensing basis of the plant. Changes are evaluated to determine if they would constitute a license amendment, a change to the Technical Specifications, an unreviewed environmental question or a change to the Environmental Protection Plan. If the activity results in any of the four situations above, then a licensing amendment is required. The requirement for a license amendment does not prevent an activity from being pursued, however, prior approval by the Nuclear Regulatory Commission (NRC) is required which has the potential to impact implementation schedule and would result in additional licensing costs. To this end, a review was performed of the Indian Point Units 2 and 3 licensing basis documents to determine possible impacts.

SUMMARY OF REVIEW

Indian Point Environmental Protection Plan (EPP)

EPP Section 3.1, Plant Design and Operation, states in part:

"...Before engaging in additional construction or operational activities which may affect the environment, the licensee shall prepare and record an environmental evaluation of such activity. When the evaluation indicates that such activity involves an unreviewed environmental question, the licensee shall provide a written evaluation of such activities and obtain prior approval from the Director, Office of Nuclear Reactor Regulation. When such activity involves a change in the Environmental Protection Plan, such activity and change to the Environmental Protection Plan may be implemented only in accordance with an appropriate license amendment as set forth in Section 5.3 (of the EPP).

A proposed change, test or experiment shall be deemed to involve an unreviewed environmental question if it concerns (1) a matter which may result in a significant increase in any adverse environmental impact previously evaluated in the final environmental statement (FES) as modified by staff's testimony to the Atomic Safety and Licensing Board, supplements to the FES, environmental impact appraisals, or in any decisions of the Atomic Safety and Licensing Board; or (2) a significant change in effluents or power level; or (3) a matter not previously reviewed and evaluated in the documents specified in (1) of this Subsection, which may have a significant adverse environmental impact..."

EPP Section 3.2, Reporting Related to the SPDES Permit, states that:

"...The NRC shall be notified of changes to the effective SPDES permit proposed by the licensee by providing NRC with a copy of the proposed change at the same time it is submitted to the permitting agency..."

EPP Section 3.3, Changes Required for Compliance with Other Environmental Regulations, states that:

"Changes in plant design or operation and performance of test or experiments which are required to achieve compliance with other Federal, State, or local environmental regulations are not subject to the requirements of Section 3.1 (of the EPP)."

Impact on Indian Point Units 2 & 3 Technical Specifications:

There are no Technical Specifications that would be directly impacted by the addition of new cooling towers or modified circulating water system.

Indian Point Units 2 & 3 Updated Safety Analysis Report (USAR)

Numerous sections, tables, and figures in the USAR discuss various aspects of the site layout, plant cooling water systems and the environmental impact of the operation of the plants.

CONCLUSIONS

Impact on EPP

It is not anticipated that the addition of cooling towers and modification of the circulating water systems will result in an unreviewed environmental question. This conclusion is based on the fact that the use of cooling towers as an alternate means of providing the normal plant heat sink for the plants was originally evaluated by the NRC in the Final Environmental Statement and because the evaluated changes would not result in any adverse environmental impact.. Additionally, there will not be a significant change in effluents or power level; and that no new matters which could have a significant adverse environmental impact (i.e., not previously reviewed and evaluated in the FES) will be introduced. Changes to the SPDES must be submitted to the NRC per the requirements of the Environmental Protection Plan. If it is determined during the final design phase that an unreviewed environmental question exists or a change to the EPP is required then a licensing amendment will be required.

Impact on Indian Point Units 2 & 3 Technical Specifications:

There are no Technical Specifications that would be directly impacted by the addition of new cooling towers or modified circulating water system.

Impact on Indian Point Units 2 & 3 Updated Safety Analysis Report (USAR)

Numerous changes to the USAR will be required to reflect the installation of the new cooling towers and changes to the circulating water systems and support systems. These changes are required to be performed in accordance with 10 CFR 50.59. No license amendment is anticipated for these changes.

The new cooling towers will have to be analyzed for potential influence on local meteorology and the results of the analysis presented in the USAR.

Following the final choice and siting of the new cooling towers and modified circulating water systems, impact on the flooding studies performed for the site will need to evaluated.

Following the construction of the new cooling towers and piping and/or tunnels used to interconnect the new cooling towers to the plant, monitoring of ground water elevation may be required to ensure the integrity of the new installation and its tie-in points.

Should the volume of water in the circulating water system increase due to the installation of the new cooling towers, the design maximum ground water analysis would have to be reviewed for impact of elevated water levels on safe plant operation (i.e., overturning, sliding and flotation of safety related structures). One event which could cause the design maximum ground water level to be exceeded is a rupture of a circulating water system pipeline outside the power block.

Additionally, the site electrical distribution system will require evaluation to ensure that there is no adverse impact due to the addition of new electrical loads required for the new cooling towers and modified circulating water system.

Attachment 5
Plume Model / Salt Deposition Analysis

Table of Contents

1.0 Purpose

This evaluation provides an upper bound of salt deposition around two proposed cooling towers at Entergy Nuclear Indian Point 2, LLC, and Indian Point 3, LLC, near Peekskill, New York. It is an upper bound because the software used to predict the plume characteristics, SACTI, is a code used for traditional saturated exit cooling towers. The proposed cooling towers will have a dry section for superheating the exhaust, so that visible plumes will be rare.

The model will also predict plume height, predominant direction of travel, and ground level fogging/icing.

2.0 References

1. Economic And Environmental Impacts Associated With Conversion Of Indian Point Units 2 And 3 To A Closed Loop Condenser Cooling Water Configuration, Enercon Services, Draft Dated June 2003
2. Email, Arntson to Beaver, 5/23/2003 (Attachment 1)
3. Email, Arnston to Berger, 5/22/2003 (Attachment 2)
4. User's Manual: Cooling-Tower-Plume Prediction Code, EPRI CS-3403-CCM, April 1984
5. Site Met Tower Data as transmitted by email, Monthly totals for 1/1998 through 12/2002 (5 years)
6. Mixing heights are from the EPA website at http://www.epa.gov/scram001/tt24.htm#mixing for Albany, New York, averaged over 5 years
7. Economic and Environmental Impacts of Alternative Closed-Cycle Cooling Systems for Indian Point Unit 2, Consolidated Edison Company of New York, December, 1974
8. Verplanck Station water quality data from the US Geological Service web page at http://waterdata.usgs.gov/ny/nwis.

3.0 Inputs

3.1 Site Location

1. Latitude: 41° 17' N
2. Longitude: 73° 58' W

3.2 Geometry:

Tower height: 168 ft (51m) [Ref. 2]

Tower discharge opening: 241.4 ft (73.6m) [Ref. 2]

Distance between towers: Indian Point Unit 2's (IP2's) tower is 1050 ft north of IP2's reactor, and IP3's tower is 1000 ft south of IP3's reactor. The reactor separation distance adds about another 700 ft, for a total separation of 2700 ft or 800 m. The actual line connecting the towers, based on Attachment 2 Site Layout sketch of Reference 1, is approximately 22.5° East of North.

3.3 Tower Performance Data:

Since the unit performance changes during the year, the values used are all approximate averages for the year. For example, Reference 1 shows that the two units will vary in output from 970 to 1035 MWe depending on weather and river conditions, this model assumes about 1000 MWe/unit. This rough approximation will not affect the conservative bias of the model, which increases visible plume and local deposition by the assumption of saturated rather than superheated conditions at the plume exit.

3.3.1 Total MWt:

The site consists of two units of individual output 1000 MWe each. Since nuclear plants are typically around 33.3% efficient, this means a total reactor power on the order of 2000/.333 = 6000 MWt and site waste heat on the order of 6000 - 2000 = 4000 MWt, or 2000 MWt/tower.

This waste heat estimate is consistent with cooling tower design data based on a single tower having 700,000 gpm being cooled from 109F to 89F with 1.67% evaporation. The below chart is explained as follows. 700,000 gpm of 109°F water enters the tower with enthalpy of 77 Btu/lbm. At a density of 61.9 lbm/ft^3, this 700,000 gpm converts to 96,533 lbm/s. The total energy into the tower is therefore 96,533*77 = 7.43 MBtu/s. An additional input energy term comes from the 5838 gpm of makeup water at about 60°F. This is a small term that amounts to only 0.02 MBtu/s.

The energy carried out by water is in three forms: steam vapor, cold water to the condenser, and the blowdown. The vapor is 1.67% of the total circulating flow, or .0167*96,533 = 1,612 lbm/s (11,690 gpm). The enthalpy of vapor at 89F is 1100 Btu/lbm, so this is an energy removal of 1612*1100 = 1.77 MBtu/s. The cold water exiting totals 96533-1612 = 94,921 lbm/s with an enthalpy of 57 Btu/lbm. This is an energy removal of 94,921*57 = 5.41 MBtu/s. The blowdown is of equal mass to the makeup but at 89°F, contributing 0.05 MBtu/s. The net heat given to air to complete the energy balance is 7.43+0.02-5.41-1.77-0.05 = 0.22 MBtu/s. The total heat energy taken from the liquid water is 7.43+0.02– 5.41-0.05 = 1.99 MBtu/s or 2100 MWt/tower.

Note: Reference 3 [e-mail Arntson to Beaver] specifies the tower heat removal at 2054 MWt. This value, received after above evaluation was completed, is the value used in the model runs.

Table 1: Heat Balance Used to Generate Estimates of Total Heat and Air Flow

In:	T=	109	F
(hot water)	h =	77	Btu/lbm
	m=	700000	gpm
	rho=	61.9	lbm/ft^3
	m=	96533.44	lbm/s
	U1i=	7.43	MBtu/s
In2	m=	5838	gpm
	m=	810.2914	lbm/s
(Makeup)	T=	60	F
	h=	28	Btu/lbm
	U2i=	0.02	MBtu/s
Out1	evap=	0.0167	
(vapor)	m=	1612.108	lbm/s
	T =	89	F
	h =	1100	Btu/lbm
	U1o=	1.77	MBtu/s
Out2	m=	94921.33	lbm/s
(water)	T =	89	F
	h =	57	Btu/lbm
	U2o=	5.41	MBtu/s
Out3	m=	810.2914	lbm/s
(blowdown)	T =	89	F
	h =	57	Btu/lbm
	U3o=	0.05	MBtu/s
Heat to Air	U1i+U2i-U1o-U2o-U3o=	0.22	Mbtu/s
Total heat rejected out tower plume			
	U1i+U2i-U2o-U3o=	1.99	MBtu/s
	U1i+U2i-U2o-U3o=	2099.45	MWt

3.3.2 Total Air Flow Rate:

The total tower airflow rate for the tower under this limiting condition can be found assuming the intake air is heated from 77°F to 89°F with the input of 0.22 MBtu/s. For 77°F saturated air (so that the dry bulb temperature equals the wet bulb temperature), the enthalpy from a psychometric chart is 40.5 Btu/lbm. At 89°F and the same grains of moisture/lbm dry air, the enthalpy is 43.7 Btu/lbm. This gives an airflow rate of (220,000 Btu/s)/(43.7-40.5 Btu/lbm) = 68,750 lbm/s = 31,000 kg/s per tower. Note: Reference 3 gives the value as 28,251 kg/s per tower.

To simulate hybrid operation, the air-flow is increased to represent the additional fans turned on to drive air through the dry section. This airflow can be as high as 40% of the total, so that the total airflow is 31,000 kgs/.6 = 52,000 kg/s. The SACTI model will produce more favorable plume data (less visibility and less local deposition) with this higher flow rate, but it is still bounding because the air is assumed saturated at tower exit and not superheated. Note: Reference 3 gives the hybrid flow rate as 58,570 kg/s at colder conditions.

For a year-round average, a 10% higher airflow is assumed. The 40% value is cut in half because plume abatement mode will only occur during daylight hours, and in half again because plume abatement is seasonal and flexible. At this 10% estimate, the flow rate of air is 31,000 kg/s/0.9 = 34,400 kg/s. This is rounded up to 35,000 kg/s given that the average based on 75% wet operation, 25% hybrid using Reference 3 data is 0.75*28251 + 0.25*58570 = 35,830 kg/s.

However, any lower value will be conservative in terms of plume prediction and deposition. A value of 26,500 kg/s conservatively bounds even the Ref. 3 value of 28,251 kg/s for wet operation.

3.3.3 Drift:

0.001% by References 1 and 2. This amounts to .00001*700,000 gpm = 7 gpm/tower

3.3.4 Drop Mass Spectrum

The below drop mass spectrum was supplied by Marley for traditional forced-draft towers. It is applied here, but the very low drift rate will make these less important to the final results.

Drop Dia. (µm)	Mass Fraction
10.	.0000
40.	.2610
60.	.1180
80.	.0495
120.	.0525
160.	.0435
180.	.0365
200.	.0515
220.	.0705
240.	.0875
260.	.0825
280.	.0765
290.	.0705

3.4 Water conditions

Reference 1 identifies that water conditions vary significantly during the year, from chloride concentration of 90 mg/l at high river flow rates to as high as 6250 mg/liter during low river flow rates. However, the average mg/l value is needed for the plume model to predict annual deposition rates.

Further evaluation was attempted by reviewing Verplanck Station data from the US Geological Service web page at http://waterdata.usgs.gov/ny/nwis (Ref. 8). This station is directly adjacent to the site. The readily available data is for the period of 1969 – 1975, so use of this data implies the assumption that water quality remains about the same.

Table 2: USGS Chloride Concentration Data, Verplanck Station

DATE	Mg/l	DATE	Mg/l
04/21/69	9	05/17/72	6
05/19/69	8.6	06/15/72	8
06/26/69	398	07/12/72	6
07/22/69	1000	08/09/72	379
08/18/69	92	09/07/72	1800
09/25/69	2300	10/05/72	1800
10/22/69	2620	11/01/72	1100
11/20/69	96	12/06/72	11
12/22/69	15	01/18/73	14
02/19/70	375	02/15/73	220
03/25/70	1210	03/14/73	14
04/22/70	29	04/11/73	8.7
05/21/70	1020	05/10/73	88
07/01/70	750	06/06/73	6.8
07/13/70	600	07/05/73	10
08/13/70	2100	08/01/73	410
09/09/70	2200	08/30/73	1200
10/08/70	1180	09/26/73	2300
11/12/70	1700	10/31/73	2000
12/09/70	34	11/28/73	780
01/13/71	425	01/30/74	13
02/03/71	160	03/27/74	14
03/10/71	20	04/24/74	11
04/08/71	59	05/23/74	15
05/05/71	8.3	07/10/74	13
06/02/71	170	07/31/74	1600
07/01/71	350	08/14/74	2200
07/28/71	780	09/12/74	770
08/25/71	1100	11/07/74	750
09/22/71	17	12/11/74	13
10/21/71	160	01/22/75	140
11/11/71	500	02/19/75	370
01/05/72	15	03/20/75	59
01/26/72	16	04/24/75	12
03/22/72	19	05/14/75	13
04/20/72	13		

The data is plotted below in Figures 1 and 2 indicates a clear seasonal dependence that is presumably cause by lower river flow rates in the drier summer. There is no notable year-to-year variation in this period. The average chloride concentration is 560 mg/l, with a maximum of 2620 mg/l.

Fig. 1: Chloride Concentrations vs. Time

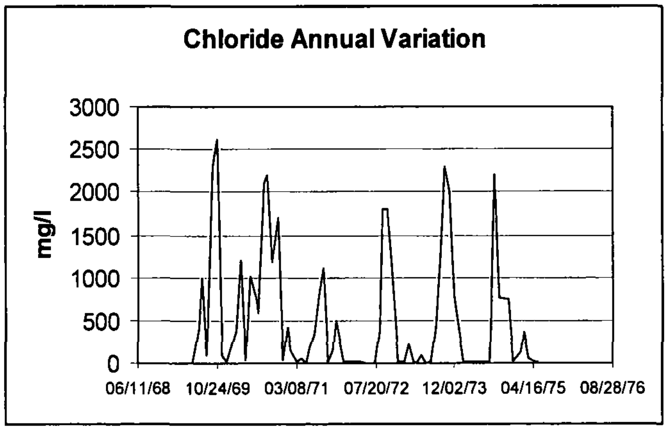
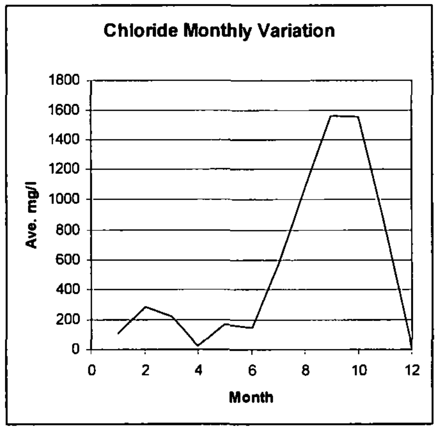


Fig. 2: Monthly Variation



It is assumed that chlorides are primarily present in sodium chloride, NaCl, or common salt. Typical ocean chloride concentration is 19,000 mg/l, and typical ocean sodium concentration is 10,500 mg/l. Since Na has atomic weight 11 and Cl 17, this ratio of Cl to Na is consistent with most of these ions being in form NaCl. Based on this reasoning, the salt concentration is roughly equal to the chlorides multiplied by the ratio of molecular weights of NaCl to Cl, or (11+17)/17. Thus Ref. 1 indicates a salinity range of from 90*28/17 = 148 mg/l to 6250*28/17 = 10,300 mg/l. The USGS data indicates a salinity range up to 2620*28/17 = 4315 mg/l with an average of 560*28/17= 920 mg/l. The USGS peak concentration is well below that of Ref. 1; this might be explained by the relatively low number of salinity "snapshots" collected and recorded in Table 2 (only 70 measurements).

A third data source is found in the 1974 Economic and Environmental Impacts of Alternative Closed-Cycle Cooling Systems for Indian Point Unit 2 (Reference 7). This report gives a salinity range of 100 mg/l to 3900 mg/l with 3500 mg/l identified as a maximum monthly average based on 45 years of data. That report also describes monthly averages from Jan to December, respectively, as being bounded by 1000, 1000, 100, 100, 100, 3500, 3500, 3500, 2500, 2500, 2500, 1000[1]. This bounding series gives an average annual salinity of 1775 mg/l.

It is concluded that, for the purposes of this annual analysis, the value of 1800 mg/l is selected based on Reference 7. The Reference 8 data is both based on fewer measurements and less conservative (in terms of predicting salt deposition) than Reference 7.

The cooling tower water has higher salt concentration than the river, due to repeated cycling. The concentration factor is bounded by 3 times during brackish conditions and 5 times during better water quality. It is judged that using a concentration factor of 4 with the bounding high annual concentration is conservative, so that the total assumed salinity in the cooling tower fluid is 1800 mg/l * 4 = 7200 mg/l. This is roughly 20% the salinity of seawater. The density of the salt assumed is, per Ref. 4, 2.17 gm/cm^3.

[1] The exact wording on pg. 6-16 of Ref. 7, is "the salinity in the river is below 100 ppm during the months of March through May, increasing from June to a maximum of 3900 ppm in August. It remains approximately at 2500 ppm in September and October, declining to 1000 ppm in December." The value of 3900 ppm is assumed to be a one day peak value, since the same document on the next page uses a 30-day drought assumption to state: "3500 ppm represents a highly probably and realistic one-month average make-up water salinity for study of botanical injury."

3.5 Local Meteorology

The site has excellent met tower data [Ref. 5]. The years 1998 through 2002 (5 years total) are utilized. The met tower data is put into CD144 format for use by SACTI. This format also calls for wet bulb temperature (Tw) and relative humidity (RH). These were calculated using standard techniques from the ground level dry bulb (db1) and dew point (dp1) temperatures. The specific calculation is as follows, where dp1, dp2, and Tw are in degrees C, RH is fractional from 0 to 1.

```
RH=Math.exp(2500000/461.5*(1/273.15-1/(273.15+dp1)))/
      Math.exp(2500000/461.5*(1/273.15-1/(273.15+db1)))
es=Math.exp(26.66082-0.0091379024*(273.15+db1)- 6106.396/(273.15+db1))
ed=Math.exp(26.66082-0.0091379024*(273.15+dp1)- 6106.396/(273.15+dp1))
if(db1!=dp1) Tw=((273.15+db1)*.6437615+(273.15+dp1)*(es-ed)/(db1-
      dp1))/ (.6437615+(es-ed)/(db1-dp1))-273.15
else Tw=db1
```

These formulas were found at http://meted.ucar.edu/awips/validate/wetblb.htm and verified for several points by comparison to http://www.sinclair.edu/community/daytonashrae/psychrometrics.htm#view.

The CD144 format also requests cloud cover information that was not available. This information is for lost solar energy only, which is not an important purpose of this evaluation. The cloud cover assumption used is that the sky is clear unless RH>0.75, in which case the sky is covered with ceiling height an arbitrary 100'.

The mixing height data was collected from the EPA website [Ref. 6]. This data is for Albany, NY, (weather station code 14735) averaged over 5 years. Albany is on the Hudson, but upstream by about 100 miles. Closer data (for Westchester Airport) can be purchased from NCDC should cooling tower construction be pursued, but it must be extracted and put into proper form by the NCDC and therefore will require some lead time.

Finally, SACTI has a year 2000 issue in that use of year 00 causes data lines to be rejected. This issue was solved by renaming years 98 through 02 to 88 through 92 in files mixhtny.tap and cdny.tap.

3.5 Terrain Modeling

The proposed tower sites lie in the Hudson River valley with hills running roughly north-south on either side. This terrain was not incorporated into the model for this assessment, however, there was an indirect incorporation by virtue of the prevailing winds guiding most plumes north and south where the terrain is fairly level. Of plumes longer than 100m. over 80% lie in the hourglass-shaped range NW to NE or SW to SE. Of plumes longer than 400m, almost 70% lie in the narrower range of NNW to NNE or SSW to SSE.

3.6 Summary of Data:

Latitude: 41° 17' N
Longitude: 73° 58' W
Tower height: 168 ft or 51 m
Tower exit dia: 241.4 ft or 73.6 m
Tower separation 800 m on a line roughly 22.5° East of North-South
Heat released: 2054 MWt/tower
Air flow: 26,500 kg/s per tower
Drift: 7 gpm/tower
Salinity: 7200 mg/l
Salt density: 2.17 gm/cm^3

4.0 Model Input Description

The plume model simulates the proposed design. Description of the input data and their values provides a description of the model itself. When run, it is necessary that the files be named prep.usr, mult.usr, and tables.usr.

It was decided to run only a single tower and superimpose the results. This was because preliminary runs showed that the resulting plume is almost always shorter than the distance between the towers (800 m). Even during the rare times that one tower's plume might extend as far as the second tower, it has risen to a much higher altitude. Therefore plume merge is not a consideration.

4.1 PREP (reads and analyzes met data, defines plume categories)

card 1: Title: Indian Point: One Mechanical Draft Cooling Tower

card 2: ISTOP: Number of hourly records (24*(365*4+366) = 43824 records).
ISKIP: 1 to process every record
IOUT: 0 to generate full listing (1 to suppress)
IMIX: 2 to use bi-daily mixing heights (contained in MIXHTNY.TAP)
IUR: 1 to use rural terrain
IWIND: 2 to use delta-T stability class method
NFOG: 1 to calculate fogging and icing
NDRIFT: 1 to calculate drift
ITOWER: 3 to model mechanical draft towers
ITAPE: 1 since data is in cd144 format
IZONE: 5 since Eastern Time Zone

card 3: ALAT: 41.28 (=41+17/60)
ALONG: 73.97 (=73+58/60)
ROUGHT: 100 cm (this is standard practice for high surrounding forest)
HREF: 10 m met tower reference height
HTERR: 0 m terrain modification (modifications not part of this assessment)

card 4: TWRHT: m tower height 51 m
TWRDM: m effective diameter, calculated as the sqrt(# towers)*single diameter so that $\pi D_e^2/4$ = total area. Since we model a single tower, the effective diameter is SQRT(1)*73.6 = 73.6 m.
TWRHE: MWt total heat rejected. Each tower is 2054 MWt.
TWRAF: Each tower is 26,500 kg/s.

card 5: twelve monthly clearness index based on data contained in the SACTI Manual (Ref. 4) Appendix B. Values are, January to December:
.37 .41 .45 .45 .46 .48 .48 .45 .47 .46 .38 .36

card 6: Twelve monthly values for average daily insolation based on data contained in the SACTI Manual (Ref. 4) Appendix B. Values are, from January to December:
5.44 8.33 12.14 15.45 18.09 19.68 19.22 16.29 13.86 10.13 6.15 4.81

cards 7 to 12: Names of files containing data or being written
cdny.tap is the met data (43,824 lines)
mixhtny.tap is the mixing height data (1826 lines)
prep.out is the output of the preprocessor
The fort files are intermediate files used by later programs.

Print out of Prep.usr:

```
Indian Point: One Mechanical Draft Cooling Tower
 43824     1 0 2 1 2 1 1 3 1 5
  41.28      73.97     100.0      10.0       0.0
  51.00      73.60    2054.0     26500.0
.37.41.45.45.46.48.48.45.47.46.38.36
 5.44 8.3312.1415.4518.0919.6819.2216.2913.8610.13 6.15 4.81
cdny.tap
fort.2
fort.3
fort.4
prep.out
mixhtny.tap
```

Input Echo from Prep.out is repeated here to verify the correct input was read.

```
***********************************************************************
  EPRI PLUME AND DRIFT ANALYSIS SYSTEM PREPROCESSOR CODE, PRE-RELEASE
  VERSION 09-01-90
  CASE STUDY: Indian Point: Two Mechanical Draft Cooling Towers
  *********************************************************************

INPUT INFORMATION
  -----------------
  SURFACE TAPE TYPE:             CD144
  TOWER TYPE:                MECHANICAL DRAFT
  TOWER HEIGHT (M):              51.00
  TOWER DIAMETER (M):            73.60
  TOWER HEAT (KW):            2054000.00
  TOWER AIR FLOW (KG/S):       26500.00
  SITE LATITUDE:                 41.28
  SITE LONGITUDE:                73.97
  SITE TIME ZONE:              EASTERN
  ROUGHNESS HEIGHT (CM):        100.00
  REFERENCE HEIGHT (M):          10.00
  RECORD STOPPING SWITCH:        43824
  RECORD SKIPPING FACTOR:            1
  HOURLY RECORD PRINT LOG:       NOT SELECTED
  BI-DAILY MIXING HEIGHT TAPE:   SELECTED
  MIXING HEIGHT TYPE:            RURAL
  FOGGING/ICING OPTION:          SELECTED
  DRIFT OPTION:                  SELECTED
```

4.2 MULT (analyzes each plume)

The output from prep is then used to model the individual two tower plumes in the Mult code. The input to Mult is as follows:

cards 1 to 3: Names of files containing data or being written
card 4: Title: Indian Point: One Mechanical Draft Cooling Tower
card 5: IOUT: 2 for maximum printout
NFOG: 1 to run fogging cases
NDRIFT: 1 to run drift analysis
NFRAD: Fogging, Ice radials. 0 leads to a default of 16, with each radial distance 100m out to 1600m.
SMAXP: 10000 m maximum distance to calculate plume
SMAXF: 1600 m maximum distance for fogging analysis
NPORTS: 1 cell
NPLATE: 0 defaults to equal NPORTS

NTWRS: 1 tower housing for MDCTs
ISOURC: 0 for multiple ports (would be 1 for a single tower)
NEXPL: 0 external plates for direct user input (no building wakes modeled)

cards 6: X, Y coordinates of tower cells. Since only a single tower is modeled, the coordinates are 0, 0

card 7: NWD: Number of critical wind directions (2), followed by values in degrees east of North: (30 degrees and 120 degrees to be cross-axis)

card 8: Wind Equivalent Array for 16 wind direction starting with north and moving clockwise in 22.5° increments 1111111111111111. Here 1 is parallel to the axis, 2 is roughly 45° to axis, and 3 is cross axis, but since we model only a single tower, the directions are all identified as 1.

card 9: TWRADM: Leave blank, only applies to CMDCTs
DA: m length of MDCT is 73.6m
DB: m width of MDCT. Each tower is 73.6' wide.
THTWR: degrees east of true North of MDCT long axis (30 is entered, but this is not used for the single tower evaluation).

cards 10: XTWR: m X-coordinate of the center of the MDCT (0)
YTWR: m Y-coordinate of the center (0)

card 11: Label to identify drift data. Drift data is based on a Marley cooling tower specific spectrum, so the label is MARLEY TOWER WITH DRIFT ELIMINATORS: DRIFT DEPOSITION SPECTRUM

card 12: NDROPS: # of drop sizes (11)
DRIFTR: gm/s total drift rate from all sources. This value is 7 gpm per tower. At 62 lbm/ft^3 density, this is:

7 gpm/7.481 gal/ft^3*62 lbm/ft^3 *1min/60s*453.59 gm/lbm
= 440 gm/s

CWSC: gm salt/gm solution. This is 7200 mg/l, or 7.2 mg/gm, or .0072 gm/gm
SDENS: gm/cm salt density. The value of 2.17 gm/cm^3 is a generic value from the plume software manual (pg. 4-54,Ref. 4).

cards 14 to end: DROPS(I) Ith drop diameter (μm).

The mult80.usr input file is as follows:

```
Indian Point: One Mechanical Draft Cooling Tower
  2  1  1  0   10000.0    1600.0  1  0  1  0  0
     0.0        0.0
  2     30.0      120.0
  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1
                73.6       73.6       30.0
     0.00       0.00

MARLEY TOWER WITH DRIFT ELIMINATORS: DRIFT DEPOSITION SPECTRUM
11          440.0   .0072       2.17
      5.0     0.00      0.0
     10.0     0.12      0.0
     15.0     0.08      0.0
     35.0     0.20      0.0
     65.0     0.20      0.0
    115.0     0.20      0.0
    170.0     0.10      0.0
    230.0     0.05      0.0
    375.0     0.04      0.0
    525.0     0.008     0.0
   1000.0     0.002     0.0
```

4.3 TABLES (averages plume results and presents results)

cards 1 to 5: Names of files containing data or being written

card 6: NSEASNQ: 5 seasons to be examined (the 5[th] is "Annual")
MM: Number of sector partitions to use in shadowing (0 results in the default of 13)

cards 7 to 16: The first card names the season, the second gives the first and last Julian day of the season.

card 17: RSTAR: Effective radius of the combined plume source, 0 leaves it to be calculated

card 18: NXL: Number of grids for length frequency (0 results in default of 100)
NXH: Number of grids for height frequency (0 results in default of 100)
NXR: Number of grids for radius frequency (0 results in default of 100)
NXS: Number of grids for shadowing table (0 results in default of 40)
NXD: Number of grids for deposition table (0 results in default of 40)

Print out of Tables.usr is as follows:

```
fort.2
fort.4
tables.out
fort.8
fort.9
  5  0
WINTER
                                335    59
SPRING
                                 60   151
SUMMER
                                152   243
FALL
                                244   334
ANNUAL
                                  0     0
0.0
  0  0  0  0  0
```

5.0 Results

The output from the final Tables manipulation is stored in tables.out. This is opened with Word, the text set to courier new, size 8, and the page format set to landscape. This allows all pages to be read without awkward line wraps. The file is subsequently saved as tables.doc, but is provided here as Attachment 3. A considerable amount of information is provided there, but key points can be summarized here:

1. Visible plumes are fairly short, despite the conservative saturated assumptions. Table 3 shows the annual length versus frequency result. The plume length is 800 m or greater only 10.74% of the time, and plumes from one tower reach the other tower only 3.91% of the time (when the wind is either north or south and the length is at least 800m). These are based on 100% wet operation, so use of the hybrid dry operation will eliminate the visible plumes during daylight hours on most days.

2. Table 3 also shows the majority of the plumes go up or down the Hudson (North or South), as would be expected with the prevailing winds. This effect also minimizes the inaccuracy introduced by lack of terrain modeling. Of plumes longer than 100m, over 80% lie in the hourglass-shaped range NW to NE or SW to SE. Of plumes longer than 400m, almost 70% lie in the narrower range of NNW to NNE or SSW to SSE.

3. The salt deposition from a single tower is shown in Table 4. These deposition rates of up to 71.59 kg/km^2month compare with ambient natural local deposition rates measured at an annual rate of 16 $\mu g/cm^2$month, which is 160 kg/km^2month (Ref. 7).

4. The salt deposition from two-tower operation is shown in Table 5. This table was developed from Table 4 by imagining an identical tower located at 800 m directly south. Each location deposition was increased by adding the superimposed deposition from the south (IP3) tower. The points that superimpose are easy to determine for the north-south line – for example, 700 m north of the IP3 tower is superimposed on 100 m south of the IP2 tower. However, since the other points are located on a radial grid, the determination of superimposed deposition was done manually for each point based on the closest point in the overlaid grid. For example, 800m west of the IP3 tower is superimposed on the point 1100m southwest of the IP2 tower (1100*cos45 ~ 800 m). The two-tower results show high deposition especially in the region between the towers, but still less than the natural ambient deposition rate.

5. Tomatoes and peppers are damaged by chloride deposition rates of 400 kg/km^2month (roughly 660 kg/km^2month of NaCl equivalent), while corn crops see a 10% reduction at 2037 kg/km^2month salt deposition, and alfalfa and cantaloupe crops show no reduction in yield up to 6,908 kg/km^2month salt deposition (based on the Umatilla Generation Project, Final Environmental Impact Statement, DOE/EIS-0324 available at the Bonneville Power Administration website www.efw.bpa.gov). Table 5 shows levels well below these by the site boundary. The highest onsite rate (111.38 kg/km^2month between the towers) plus the ambient rate of 160 kg/km^2month) is about 272 kg/km^2month.

6. Due to the high release of the tower combined with the forced airflow, the plumes do not often circulate back to the ground. As shown in Table 6, the amount of ground fogging predicted is only a few hours per year either directly north or south of the towers. These presumably can be avoided entirely by operation in the hybrid mode. Similarly, Table 7 shows icing is also only predicted for a few hours a year, and that to the south of the towers. This also should be avoidable by operation in the hybrid mode.

6.0 Conclusions

Operation of cooling towers at Indian Point Units 2 and 3 is modeled here with the bounding assumption of full time wet operation. This will over predict visible plumes, solar energy loss, local salt deposition, fogging and icing. The resulting model predictions should therefore be viewed as conservatively bounding the environmental impacts.

Even though only wet operation is modeled, this tower design has a relatively high discharge for a mechanical draft tower. This minimizes the impact of the tower, leading to predictions of fairly small visible plumes. The towers are relatively far apart, so with the short plumes expected, the two tower plumes are not expected to merge.

There is predicted a measurable increase in salt deposition, but the total levels are at worse on the order of ambient salt measurements between the two towers, and less than 25% of ambient elsewhere.

Table 3: Lengths of Plumes
(These values are based on wet operation only and are therefore bounding high)

1 ************************************ PLUME LENGTH FREQUENCY TABLE ************************************

Indian Point: One Mechanical Draft Cooling Tower

SEASON=ANNUAL

DISTANCE FROM TOWER	WIND FROM																
	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	ALL
	PLUME HEADED																
(M)	S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	SUM
100.	15.13	15.21	6.05	2.33	2.65	1.55	1.87	5.56	18.32	4.69	2.82	2.67	5.02	4.58	6.13	5.40	100.00
200.	14.07	14.03	5.45	1.98	2.16	1.21	1.53	4.82	16.50	4.07	2.42	2.40	4.60	4.35	5.86	5.02	90.47
300.	7.71	8.06	3.10	.92	.89	.47	.56	1.80	6.00	1.36	.80	.74	1.96	2.38	3.50	2.72	42.95
400.	4.20	3.92	1.49	.38	.38	.17	.18	.58	1.92	.41	.28	.25	.68	.94	1.54	1.31	18.60
500.	3.38	2.96	1.07	.25	.23	.12	.11	.39	1.26	.25	.18	.13	.39	.63	1.16	.99	13.52
600.	3.38	2.96	1.07	.25	.23	.12	.11	.39	1.26	.25	.18	.13	.39	.63	1.16	.99	13.52
700.	3.10	2.48	.82	.14	.10	.06	.04	.23	.81	.12	.06	.05	.28	.55	1.05	.86	10.74
800.	3.10	2.48	.82	.14	.10	.06	.04	.23	.81	.12	.06	.05	.28	.55	1.05	.86	10.74
900.	2.53	1.81	.59	.12	.07	.04	.03	.17	.49	.07	.03	.01	.16	.34	.70	.62	7.78
1000.	1.83	1.22	.29	.06	.04	.02	.02	.11	.24	.05	.02	.01	.07	.17	.40	.39	4.93
1100.	1.83	1.22	.29	.06	.04	.02	.02	.11	.24	.05	.02	.01	.07	.17	.40	.39	4.93
1200.	.76	.50	.10	.03	.02	.01	.02	.05	.10	.02	.01	.00	.03	.06	.15	.09	1.92
1300.	.76	.50	.10	.03	.02	.01	.02	.05	.10	.02	.01	.00	.03	.06	.15	.09	1.92
1400.	.76	.50	.10	.03	.02	.01	.02	.05	.10	.02	.01	.00	.03	.06	.15	.09	1.92
1500.	.76	.50	.10	.03	.02	.01	.02	.05	.10	.02	.01	.00	.03	.06	.15	.09	1.92
1600.	.76	.50	.10	.03	.02	.01	.02	.05	.10	.02	.01	.00	.03	.06	.15	.09	1.92
1700.	.76	.50	.10	.03	.02	.01	.02	.05	.10	.02	.01	.00	.03	.06	.15	.09	1.92
1800.	.76	.50	.10	.03	.02	.01	.02	.05	.10	.02	.01	.00	.03	.06	.15	.09	1.92
1900.	.76	.50	.10	.03	.02	.01	.02	.05	.10	.02	.01	.00	.03	.06	.15	.09	1.92
2000.	.76	.50	.10	.03	.02	.01	.02	.05	.10	.02	.01	.00	.03	.06	.15	.09	1.92

Table 4: Salt Deposition from one Tower

1 ************************************ PLUME SALT DEPOSITION TABLE (KG./(KM.**2-MO.)) **********************************

Indian Point: One Mechanical Draft Cooling Tower

SEASON=ANNUAL

DISTANCE FROM TOWER (M)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	ALL
	WIND FROM																
	PLUME HEADED																
	S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	AVG
100.	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
200.	13.01	14.90	7.47	4.02	5.86	3.89	4.09	8.43	21.87	7.48	4.61	3.45	5.00	2.75	3.16	4.61	7.16
300.	51.06	65.47	29.18	13.38	16.85	10.26	11.43	26.59	71.59	21.95	13.80	11.42	20.46	15.29	19.03	19.64	26.09
400.	42.24	55.15	22.83	8.97	10.18	5.72	6.70	17.12	51.22	14.26	8.78	7.80	16.31	14.62	19.19	16.73	19.86
500.	36.19	47.58	19.87	7.56	8.54	4.70	5.26	13.95	42.89	11.83	7.25	6.35	14.09	13.23	17.29	14.72	16.96
600.	39.79	52.64	22.16	8.18	9.09	4.95	5.54	14.86	45.61	12.57	7.65	6.76	15.59	15.19	20.00	16.45	18.56
700.	40.89	54.08	22.76	8.34	9.22	4.99	5.61	15.04	46.44	12.73	7.75	6.86	16.02	15.71	20.79	16.96	19.01
800.	39.62	52.17	21.88	7.97	8.72	4.69	5.29	14.32	44.40	12.02	7.31	6.56	15.60	15.45	20.61	16.56	18.32
900.	31.77	40.80	16.93	6.12	6.55	3.58	4.00	11.09	34.46	9.20	5.45	5.18	12.72	12.78	17.22	13.20	14.44
1000.	13.48	14.97	5.74	2.57	3.03	1.79	2.15	5.82	17.09	4.76	2.86	2.65	5.04	4.07	5.68	5.18	6.05
1100.	8.10	7.46	3.02	1.47	1.85	1.21	1.40	3.88	10.85	3.07	1.87	1.69	2.48	1.91	2.40	2.81	3.47
1200.	7.01	6.23	2.48	1.15	1.37	.90	1.19	3.15	9.23	2.55	1.53	1.40	2.07	1.63	2.07	2.43	2.90
1300.	4.73	4.51	1.83	.76	1.01	.68	.82	1.97	5.59	1.56	.93	.75	1.25	1.09	1.42	1.73	1.91
1400.	4.43	4.37	1.76	.72	.95	.65	.77	1.78	4.94	1.39	.82	.64	1.12	1.01	1.33	1.62	1.77
1500.	2.55	2.56	1.01	.35	.45	.29	.33	.77	2.38	.62	.37	.31	.58	.57	.84	.83	.93
1600.	1.62	1.63	.61	.22	.26	.16	.17	.43	1.43	.35	.21	.18	.37	.36	.54	.51	.56
1700.	1.51	1.55	.59	.22	.26	.16	.17	.43	1.41	.34	.21	.18	.37	.35	.51	.48	.55
1800.	1.51	1.55	.59	.22	.26	.16	.17	.43	1.41	.34	.21	.18	.37	.35	.51	.48	.55
1900.	1.51	1.55	.59	.22	.26	.16	.17	.43	1.41	.34	.21	.18	.37	.35	.51	.48	.55
2000.	1.49	1.54	.58	.22	.26	.15	.17	.43	1.41	.34	.21	.18	.37	.35	.51	.48	.54
2100.	1.44	1.51	.58	.22	.26	.15	.17	.42	1.40	.34	.21	.18	.37	.35	.50	.47	.54
2200.	1.44	1.51	.58	.22	.26	.15	.17	.42	1.40	.34	.21	.18	.37	.35	.50	.47	.54
2300.	1.41	1.48	.58	.22	.26	.15	.17	.42	1.35	.34	.21	.17	.36	.35	.50	.47	.53
2400.	1.32	1.42	.57	.22	.26	.15	.17	.42	1.25	.34	.21	.17	.36	.34	.49	.45	.51
2500.	1.32	1.42	.57	.22	.26	.15	.17	.42	1.25	.34	.21	.17	.36	.34	.49	.45	.51
2600.	1.32	1.42	.57	.22	.26	.15	.17	.42	1.25	.34	.21	.17	.36	.34	.49	.45	.51
2700.	1.32	1.42	.57	.22	.26	.15	.17	.42	1.25	.34	.21	.17	.36	.34	.49	.45	.51
2800.	1.39	1.47	.59	.22	.26	.16	.18	.46	1.36	.36	.22	.19	.39	.37	.52	.48	.54
2900.	1.39	1.47	.59	.22	.26	.16	.18	.47	1.38	.36	.22	.19	.39	.37	.52	.48	.54
3000.	1.39	1.47	.59	.22	.26	.16	.18	.47	1.38	.36	.22	.19	.39	.37	.52	.48	.54
3100.	1.39	1.47	.59	.22	.26	.16	.18	.47	1.38	.36	.22	.19	.39	.37	.52	.48	.54
3200.	1.39	1.47	.59	.22	.26	.16	.18	.47	1.38	.36	.22	.19	.39	.37	.52	.48	.54
3300.	1.39	1.47	.59	.22	.26	.16	.18	.47	1.38	.36	.22	.19	.39	.37	.52	.48	.54
3400.	1.39	1.47	.59	.22	.26	.16	.18	.47	1.38	.36	.22	.19	.39	.37	.52	.48	.54
3500.	1.39	1.47	.59	.22	.26	.16	.18	.47	1.38	.36	.22	.19	.39	.37	.52	.48	.54

Table 5: Salt Deposition from Two Towers Relative to the North Tower Center Point

1 ************************************ PLUME SALT DEPOSITION TABLE (KG./(KM.**2-MO.)) ***********************************

Indian Point: Two Mechanical Draft Cooling Towers
SEASON=ANNUAL

DISTANCE FROM TOWER (M)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
PLUME HEADED	S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE
100	44.4	46.44	46.44	44.4	44.4	44.4	34.46	34.46	34.46	34.46	34.46	44.4	44.4	44.4	44.4	46.44
200	59.45	60.51	22.51	19.06	20.18	14.98	21.18	25.52	38.96	24.57	21.7	12.65	17.02	14.77	15.18	50.22
300	96.67	79.42	44.04	28.42	27.94	21.35	28.52	37.44	82.44	32.8	30.89	20.62	29.66	24.49	28.23	31.47
400	85.13	69.1	28.37	24.01	21.27	11.54	10.58	26.35	60.45	23.49	11.85	12.56	25.51	23.82	28.39	28.56
500	87.41	64.7	25.41	12.85	19.63	8.58	8.41	19.54	48.48	17.42	9.8	9.42	23.29	22.43	26.49	28.98
600	111.38	64.07	27.7	13.47	11.24	8.1	7.51	19.8	50.55	17.51	9.21	9.31	18.45	18.05	22.86	30.25
700	62.76	64.34	27.71	13.63	10.62	6.96	7.39	17.42	48.82	15.11	9.14	8.42	17.89	17.58	22.66	28.38
800	39.62	62.43	26.83	11.97	10.12	5.51	6.06	15.75	45.83	13.45	7.93	7.49	17.47	17.32	22.48	27.98
900	31.77	57.65	21.88	9.7	7.74	4.35	4.43	11.52	35.87	9.54	5.8	6	14.25	14.31	18.75	33.66
1000	26.49	23.94	14.96	4.36	4.22	2.12	2.58	6.25	18.5	5.1	3.2	3.02	6.57	5.6	7.21	19.8
1100	59.16	15.02	11.74	2.68	3.04	1.38	1.83	4.31	12.26	3.41	2.21	1.9	4.01	3.44	3.93	16.04
1200	49.25	13.79	11.2	2.05	2.02	1.07	1.62	3.58	10.64	2.89	1.87	1.61	2.71	2.27	2.71	15.66
1300	40.92	27.27	8.38	1.44	1.3	0.85	1.25	2.39	6.99	1.9	1.27	0.96	1.56	1.4	1.73	22.52
1400	44.22	27.13	4.79	1.37	1.11	0.82	1.19	2.2	6.34	1.73	1.16	0.85	1.3	1.19	1.51	22.41
1500	43.44	24.44	2.48	1.3	0.61	0.46	0.75	1.19	3.73	0.96	0.71	0.52	0.76	0.75	1.02	21.44
1600	41.24	18.56	1.76	0.67	0.42	0.33	0.59	0.85	2.68	0.69	0.55	0.39	0.55	0.54	0.72	17.73
1700	33.28	7.29	1.35	0.48	0.42	0.33	0.59	0.85	2.66	0.68	0.55	0.39	0.55	0.53	0.69	6.16
1800	14.99	4.57	1.31	0.48	0.41	0.33	0.59	0.85	2.66	0.68	0.55	0.39	0.55	0.53	0.69	2.88
1900	9.61	4.57	0.94	0.48	0.41	0.33	0.59	0.85	2.66	0.68	0.55	0.39	0.55	0.53	0.69	2.88
2000	8.5	4.02	0.93	0.48	0.41	0.32	0.59	0.89	2.77	0.7	0.55	0.39	0.55	0.53	0.69	2.55
2100	6.17	3.34	0.8	0.48	0.41	0.32	0.63	0.89	2.78	0.7	0.57	0.39	0.54	0.52	0.67	1.89
2200	5.87	3.27	0.8	0.48	0.41	0.32	0.64	0.89	2.78	0.7	0.57	0.39	0.54	0.52	0.67	1.8
2300	3.96	4.04	0.8	0.48	0.41	0.33	0.64	0.89	2.73	0.7	0.57	0.39	0.53	0.52	0.67	1.3
2400	2.94	3.05	0.79	0.48	0.41	0.33	0.35	0.89	2.63	0.7	0.43	0.39	0.53	0.51	0.66	0.96
2500	2.83	2.97	0.79	0.48	0.41	0.33	0.35	0.89	2.63	0.7	0.43	0.39	0.53	0.51	0.66	0.93
2600	2.83	2.97	0.79	0.48	0.42	0.33	0.35	0.89	2.63	0.7	0.43	0.39	0.55	0.53	0.68	0.93
2700	2.83	2.97	0.79	0.48	0.42	0.33	0.35	0.89	2.63	0.7	0.43	0.39	0.55	0.53	0.68	0.93
2800	2.88	3.01	0.81	0.48	0.42	0.34	0.36	0.93	2.74	0.72	0.44	0.41	0.58	0.56	0.71	0.96
2900	2.83	2.98	0.81	0.48	0.42	0.34	0.36	0.94	2.76	0.72	0.44	0.41	0.58	0.56	0.71	0.95
3000	2.83	2.98	0.81	0.48	0.42	0.34	0.36	0.94	2.76	0.72	0.44	0.41	0.58	0.56	0.71	0.95
3100	2.8	2.95	0.81	0.48	0.42	0.34	0.36	0.94	2.76	0.72	0.44	0.41	0.58	0.56	0.71	0.95
3200	2.71	2.89	0.81	0.48	0.42	0.34	0.36	0.94	2.76	0.72	0.44	0.41	0.58	0.56	0.71	0.93
3300	2.71	2.89	0.81	0.48	0.42	0.34	0.36	0.94	2.76	0.72	0.44	0.41	0.58	0.56	0.71	0.93
3400	2.71	2.89	0.81	0.48	0.42	0.34	0.36	0.95	2.79	0.73	0.44	0.41	0.58	0.56	0.71	0.93
3500	2.71	2.89	0.81	0.48	0.42	0.34	0.36	0.95	2.79	0.73	0.44	0.41	0.58	0.56	0.71	0.93

Table 6: Hours of Fogging, Single Tower, Wet Operation

(Two tower operation would not change the hours per year predicted, but they would double the affected area, e.g., 3.3 hours of fogging both 400m south of IP2's cooling tower and 400m south of IP3's cooling tower.)

1 ************************************ HOURS OF PLUME FOGGING TABLE ************************************

Indian Point: One Mechanical Draft Cooling Tower

SEASON=ANNUAL

DISTANCE FROM TOWER (M)	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	ALL
(PLUME HEADED)	S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	SUM
100.	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
200.	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
300.	.6	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.6
400.	3.3	.0	.0	.0	.0	.0	.0	.0	.3	.0	.0	.0	.0	.0	.0	.0	3.5
500.	2.0	.0	.0	.0	.0	.0	.0	.0	.5	.0	.0	.0	.0	.0	.0	.0	2.5
600.	2.0	.0	.0	.0	.0	.0	.0	.0	.5	.0	.0	.0	.0	.0	.0	.0	2.5
700.	1.7	.0	.0	.0	.0	.0	.0	.0	.5	.0	.0	.0	.0	.0	.0	.0	2.2
800.	1.2	.0	.0	.0	.0	.0	.0	.0	.5	.0	.0	.0	.0	.0	.0	.0	1.7
900.	.5	.0	.0	.0	.0	.0	.0	.0	.5	.0	.0	.0	.0	.0	.0	.0	1.0
1000.	.5	.0	.0	.0	.0	.0	.0	.0	.5	.0	.0	.0	.0	.0	.0	.0	1.0
1100.	.4	.0	.0	.0	.0	.0	.0	.0	.5	.0	.0	.0	.0	.0	.0	.0	.9
1200.	.0	.0	.0	.0	.0	.0	.0	.0	.5	.0	.0	.0	.0	.0	.0	.0	.5
1300.	.0	.0	.0	.0	.0	.0	.0	.0	.5	.0	.0	.0	.0	.0	.0	.0	.5
1400.	.0	.0	.0	.0	.0	.0	.0	.0	.5	.0	.0	.0	.0	.0	.0	.0	.5
1500.	.0	.0	.0	.0	.0	.0	.0	.0	.5	.0	.0	.0	.0	.0	.0	.0	.5
1600.	.0	.0	.0	.0	.0	.0	.0	.0	.5	.0	.0	.0	.0	.0	.0	.0	.5

Table 7: Hours of Icing, Single Tower, Wet Operation

(Two tower operation would not change the hours per year predicted, but they would double the affected area, e.g., 1 hour of icing both 500m south of IP2's cooling tower and 500m south of IP3's cooling tower.)

```
1          ************************************* HOURS OF RIME ICING TABLE **************************************
                 Indian Point: One Mechanical Draft Cooling Tower
                 SEASON=ANNUAL
```

DISTANCE	WIND FROM																
FROM	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	ALL
TOWER	PLUME HEADED																
(M)	S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	SUM
100.	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
200.	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
300.	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.1
400.	.8	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.8
500.	1.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.0
600.	1.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.0
700.	.7	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.7
800.	.5	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.5
900.	.5	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.5
1000.	.5	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.5
1100.	.4	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.4
1200.	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
1300.	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
1400.	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
1500.	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
1600.	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0

Attachment 1: Email Arntson to Beaver, Reference 2

-----Original Message-----
From: John.Arntson@marleyct.spx.com [mailto:John.Arntson@marleyct.spx.com]
Sent: Friday, May 23, 2003 4:35 PM
To: sbeaver@enercon.com
Cc: JIM.VANGARSSE@marleyct.SPX.COM
Subject: Revised Performance Data

Sam,

Here is a quick summary. Formal data sheet to follow (just lost the one I was finishing with computer crash!).

Tower Type:
Counterflow, forced draft, plume abated (hybrid) with low noise fans & sound attenuation baffles.

Tower Geometry:
OD= 524.8 ft
Overall Ht. = 168 ft.
ID exit cone: 241.4 ft.
No. fans (wet section) = 44 (Motor output power = 300 HP)
No. fans (dry section)= 44 (Motor Output Power = 350 HP)

Wet Section Data:
Flow = 700,000 gpm
Plan area of fill: 121660 ft2
Fill Type: 6 ft. PVC low fouling film (MCT FC-18)
DE type / drift rate: Cellular PVC (MCT TU-12)/ drift rate .001%
Distribution system: FRP headers/PVC pipes
Nozzles: High efficiency polypropylene

Dry Section Data:
Flow = 245,000 gpm
Element type: 4 row/ 2 pass
Tube type: 1" OD Titanium
Fin Type: 2.25" OD Aluminum fins @ 11 fins/in ("L" fin)
Tube length = 49 ft.
No. tubes/ bundle = 218
No. bundles = 264

Thermal Data:
Wet design condition: (77 WBT, 89 CWT, 109 HWT)
HP (motor output wet section) = 270 HP, evaporation rate = 1.67%, Vexi = 1233 fpm

Hybrid Operation @ plume abatement design point(27 WBT @ 90 % RH)
HP (MOP wet section) = 300 HP, evaporation rate = .81%, CWT = 59 °F, Vexit=2260 fpm
HP (MOP dry section)= 350 HP

Note: evaporation rate at summer conditions with dry section in operation will be approx. 1.47%. CWT= 88 °F approx.

Pumping Head:

Main Pumps:
700,000 gpm @ 45 ft. TDH

Booster Pumps:
245000 gpm @ 26 ft

Regards,

John K Arntson
Marley Cooling Technologies, Inc.

Phone: 913-664-7854
Fax: 913-693-9633
E-mail: john.arntson@marleyct.spx.com

Attachment 2: Email, Arnston to Berger, Reference 3

-----Original Message-----
From: John.Arntson@marleyct.spx.com [mailto:John.Arntson@marleyct.spx.com]
Sent: Thursday, May 22, 2003 12:03 PM
To: Ralph Berger
Cc: sbeaver@enercon.com; JIM.VANGARSSE@marleyct.SPX.COM
Subject: Re: 5 data item requests URGENT

Ralph,
See below for the technical answers which you asked for and some additional technical information.
Regards,
John K Arntson
Marley Cooling Technologies, Inc.

Phone: 913-664-7854
Fax: 913-693-9633
E-mail: john.arntson@marleyct.spx.com

Ralph Berger <RBerger@enercon.com>
05/21/2003 12:34 PM

To: sbeaver@enercon.com
cc: rberger@enercon.com, John.Arntson@marleyct.spx.com
Subject: 5 data item requests URGENT

What I need is as follows:
1. - Water salt concentration (e.g., gm/liter)
2. - Water total dissolved solids
3. - Water iron salt concentration
Note: these are the concentrations in the water that actually goes through the tower. At grand gulf, we multiplied the river water concentrations by 3 because the water gets circulated and concentrations build up.

From Marley I need:
4. an estimate of air flow rates in both wet and hybrid mode (I assume there is more air flow when operating the dryers). Please identify if the air flow is associated with one or two towers.

[Marley response: For One Tower: Ambient Conditions: Wet Op.(77°F/84.9 °F), Hybrid Op.(26.2°F/27 °F)
Wet Operation: Exit air mass flowrate: 28251 kg/s @ 38.6 °C(saturated), V exit= 6.02 m/s
Wet/Dry Operation: air mass flow: 58570 kg/s @ (57.4°F WBT, 62.5 DBT),V exit = 11.48 m/s]

Finally, I guess I'm not sure how many MWt are being removed. I did a calculation based on the input I got and came up with 3300 MWt. Is that correct? If so, I am assuming that is for both towers, i.e., 1650 MWt per tower.
So request 5 is:
5. MWt (or Btu/hr) rejected per tower

[Marley response: Heat rejection by one tower (2054 MW)]

Just to reiterate my voice mail, the SACTI code is based on saturated conditions at release. Therefore my results will all be upper bounds for nearby deposition and extreme upper bounds for plume visibility. I don't know if Marley has some "rule of thumb" for the advantages of the hybrid tower, like 90% less visible plume or 50% less deposition in the local area.(Marley response: see attached paper),

Ralph

Attachment 3: Tables.doc – Plume Model Software Output

1 (total pages 100, first page only included, results tabulated within this attachment)

EPRI SEASONAL/ANNUAL TABLES PROGRAM, VERSION 11-01-90

Indian Point: One Mechanical Draft Cooling Tower

SUMMARY OF PLUME PREDICTIONS WHEN WIND IS FROM 30.0 DEGREES EAST OF NORTH

CAT NO.	PLUME LENGTH	PLUME HEIGHT	PLUME RADIUS
11	154.80	181.2	46.10
12	176.40	213.0	49.60
13	62.10	113.1	46.20
14	191.70	104.7	41.00
15	213.20	105.3	41.50
16	136.80	79.5	40.60
17	189.40	-7.6	22.10
18	238.70	1.9	26.70
19	76.40	115.9	52.70
20	234.50	242.7	62.10
21	69.30	131.9	55.60
22	260.20	313.1	69.30
23	107.70	116.1	55.90
24	154.40	144.6	70.90
25	286.10	330.1	74.10
26	123.40	128.2	57.90
27	227.60	147.3	71.90
28	133.30	129.9	59.80
29	390.00	267.1	70.10
30	144.30	131.0	59.20
31	549.70	149.7	72.70
32	164.10	133.6	61.90
33	175.10	134.1	63.30
34	185.10	135.3	63.10
35	198.20	134.0	61.70
36	207.90	135.5	63.10
37	215.20	129.0	61.80
38	244.20	141.3	64.40
39	246.90	129.4	62.50
40	281.70	137.3	63.90
41	327.80	143.5	66.80
42	726.10	364.7	87.80
43	871.10	404.3	92.80

Attachment 6
Capital Costs Assessment

Closed-Loop Cooling Water Conversion
Direct Capital Cost Associated with Engineering and Construction

Preliminary Engineering and Construction Estimate and Schedule

This Preliminary Engineering and Construction Estimate and Schedule was generated on behalf of Indian Point Unit #2, LLC and Indian Point Unit #3 LLC hereinafter referred to as "ENIP2" and "ENIP3" respectively and when collectively referred, as the "STATIONS".

The intent of developing a reasonable construction estimate/schedule in conjunction with the conceptual design revolves around providing a cost effective and programmatic method to successfully complete the requirements of that design.

To that end, the following report identifies the major construction tasks and extrapolates most of the subtasks through assumptions based on logical construction practices (Scope of Work Defined). Subsequent to this definition, the development basis for the estimate is outlined (Construction Cost Estimating Basis). A short section follows describing one of the most significant aspects for success (Craft Labor). The resulting estimate is then summarized (Cost Estimate Breakdown). Finally, this report identifies issues, not all inclusively, that pose noteworthy potential impacts to both cost and schedule that can not be adequately identified at present (Concerns and Encumbrances).

This report is a first pass toward quantifying resource requirements, duration, cost, and schedule. The conclusions reached in this first pass could be expanded and/or refined over time, it effectively bounds a reasonable lower cost and schedule limit. As design engineering continues and related concerns and encumbrances are better defined, historically, cost of construction and respective schedule durations increase.

In summary, the conversion of both STATIONS from a "Once-Through" to a "Closed-Loop cooling water system will have a minimum Direct Capital Construction Cost of $612,400,000 without contingency application. The recommended contingency based on the current conceptual state of the project is 20% or $123,280,000 as an industry standard, resulting in a total estimated cost of $739,680,000. The overall project schedule is expected to extend over approximately 62 months (> 5 years) of which the STATIONS will require an extended outage period of 10 months (42 weeks). Though most of the mentioned concerns and encumbrances could severely impact both cost and schedule, some may directly dictate the feasibility of the project itself regardless.

SCOPE OF WORK DEFINED

The overall breadth and depth of converting from a "Once-Through" to a Closed-Loop Cooling System would involve a complex and costly construction effort. The approach used to estimate the direct capital costs of construction reflects an effort to optimize both schedule and cost. The first major step toward developing a realistic construction estimate for any project rests with understanding, as much as possible, the scope of the work to be performed. The following outlines an understanding of Entergy's intent for possible modifications to the cooling water system in use at both ENIP2 and ENIP3.

The current cooling circulating water system uses the "Once-Through" technology, in short, uses a water source to supply cooling water to the unit for a single use cooling before discharging the water back to the source, the Hudson River. The stated water consumption with this method is approximately 1.7 million gallons per minute (GPM) for the STATIONS. Additional water usage for safety related service water is not considered as part of this scope of work. In order to reduce water consumption from/to the Hudson River and minimize ecological impacts, the "Once-Through" system was evaluated with respect to alternative technologies and solutions.

As a result, a hybrid-wet/dry, closed-loop cooling water system was selected as the most appropriate alternative. This attachment concerns the means, methods, and direct capital costs associated with modifying the STATION's existing systems, constructing the new systems, Startup and Testing, and final commissioning of the hybrid units – Direct Capital Cost.

As the alternative design is based on conceptual ideas and available information, construction follows suit by collecting data points on alternatives and carrying that information forward to form a reasonable implementation budget for the scope of work.

The following section also identifies the major cost centers and recommends an approach based on a variety of input resources combined with current industry standards and practical knowledge. Attachments 1 and 2 of the overall report provide additional details of equipment specifications, layouts, and cost information used in this Direct Capital Cost Report.

ENGINEERING DESIGN AND MODIFICATION PACKAGES

Engineering costs are based on a normal engineering schedule with a 40 hour work week broken into four phases. Phase one, will consist of initial analysis and studies required for issue of design and contract specifications. Phase two, prepare and issue contract specifications and preliminary design drawings for procurement. Phase three, complete and issue design calculations, construction work packages, and construction drawings. Phase four, support construction, as build drawings, and design closeout.

Task associated with these activities are:

Phase One:
- Intake flow analysis
- Electrical distribution analysis
- Circulating water flow analysis
- Engineering support for permit application
- Heat load and cooling selection analysis

Phase Two:

- Circulating water piping and foundations specification
- Circulating water pump house and foundations specification
- Motor control centers and substation specification
- Cooling tower and control system specification
- Electrical distribution specification
- Booster pump and motor specification
- Circulating water pump and motor specification
- Cooling tower makeup and blowdown design
- Relocation of security fence design
- Miscellaneous specifications and designs

Phase Three:

- Site preparation and excavation packages
- Temporary utilities package
- Pumping station packages
- Cooling tower electrical packages
- Cooling tower erection package
- Piping installation packages
- Discharge canal modification and construction packages
- Security relocation package
- Service water piping relocation package
- Miscellaneous packages

Phase Four:

- Construction support and problem resolution
- Construction walkdown and As build drawings
- Package closure and facility turnover
- Vendor Interface

MOBILIZATION AND SITE SETUP

The modifications described in the engineering section of this report reflect a significant undertaking for the construction team. Gathering appropriate resources and supporting infrastructure, getting all of this to the project site, and making respective logistics functional is the first big step.

For this project, Site Setup represents the building of a small city of construction and storage trailers, temporary utilities, temporary craft facilities along with an ample and secure laydown and storage area. Minimizing plant operational encumbrances typically means installing independent, temporary facilities and coordinating project tasks such that construction activities and personnel are isolated and do not interfere.

GENERAL SITE MODIFICATIONS

Several preliminary tasks are required before major operations commence and represent common support for the STATIONS.

1.3.1 Access Roads – In order to gain access to the work areas, approximately 4 acres will be cleared, graded, and stabilized for a 8" to 10" bed of #57 stone (Crusher Run). Both units will require an access road, the longest of which will be for ENIP2 (approximately 4000'). The access road will extend from the most practical location near the main entrance and downward to the +30' msl. elevation. These roads will require regular attention during the course of construction and related vehicle access to avoid rutting and washout.

1.3.2 Environmental Protection – Construction of the Cooling Towers will require significant tree removal, clearing, and grubbing, effectively reducing natural erosion control. Prior to disturbing the surrounding areas above the river, environmental protection in the form of silt fencing and, if required, a collection basin must be installed to prevent run-off from operations at both pad locations into the river. An adequate and regular monitoring of this protection is paramount to assure continued protection and repair of damaged components.

1.3.3 Tree Removal, Clearing, and Grubbing – Approximately 22 acres of land area must be cleared for placement of the cooling tower pads and the necessary cut back for air intake and safety zone. Both areas are heavily wooded especially the ENIP2 cooling tower pad area with larger old-growth trees. The construction estimate does not contain cost assumptions associated with any arboreal permits or subsequent impacts. Though the construction estimate anticipates performing this work along with disposal of the refuse, tree falling and trunk removal could be performed through a negotiated agreement with local timber companies in order to minimize this cost through salvage.

1.3.4 River Barge Loading Facility – Disposition of spoils is a significant issue both from a cost and logistic standpoint. Approximately 2.1 million cubic yards of mixed rock removal and disposal is estimated. Regardless of the final disposition options of this material, barge transport is the most economical and practical means to remove such large quantities (estimated at about 3-5 thousand cubic yards per day). A simple barge loading facility consisting of a docking wharf and adjustable belt conveyors will be erected at the river's edge on the ENIP2 cooling tower area side of the plant. An access road will allow for excavated material transport from the site to a loading hopper. The anticipated daily output could exceed a single barge's capacity (4000 cubic yards), therefore, multiple daily moorings may be required.

1.3.5 Relocation of Alogonquin Natural Gas Pipeline – The proposed ENIP3 cooling tower pad is located atop a portion of the Alogonquin Gas Pipeline, which acts as a major artery for the city of New York. Drawings indicate two independent lines (a 26" main and a 30" loop) extend from the source, across the proposed pad area, and on to the river crossing. These lines and the appropriate amount of Right of Way (ROW) must be relocated approximately 700 feet south of its existing location allowing for the cut back requirements of the tower. The difficulties associated with moving this line include but are not limited to safety and environmental impacts, additional earth and rock removal (blasting), and coordination of third party activities.

1.3.6 Relocation of Sewage Lift Stations – A new sewage lifting station must be constructed outside of the affected areas and tied in during a regularly scheduled outage.

1.3.7 Relocation of ENIP3 Parking – The estimate considers relocating the existing parking area used for ENIP3. The parking lot is about 5 acres and will be difficult to move without clearing additional timber or otherwise undisturbed land.

FIRST CUT EXCAVATION AT PADS AND ASSOCIATED TRENCHES

All indications from previous soil borings suggest at least fractured dolomite at or very near the ground's surface in the cooling tower pad areas leaving a mixture of sand, loam, clay, and rock at the surface. Greater than 100,000 cubic yards of this mixed earth is assumed to be either spread on site or hauled via dump truck to local landfill. This is material is not suitable for fill or compaction as part of the construction process. Excavators will essentially scrape the surface soil exposing the underlying rock for the blasting process.

PRECISION BLASTING AND ROCK REMOVAL

Next to the cost and complexity of the cooling towers themselves, excavating the pads and related trenching constitutes the largest expense for the construction project. Considering the proximity, volume, and overall complexity of this project, the input and guidance of one of the nation's leading and most respected precision blasting experts, Dr. Calvin J. Konya was solicited. After review of materials provided by the site, Dr. Konya determined that precision blasting could be safely performed within strict procedural guidelines while under the monitoring program of a qualified consultant (for more detail, see Dr. Konya's complete report attached as Appendix 6A.) Furthermore, blast removal is the only feasible excavation method based on the quantities involved (approximately 2.1 Million Cubic Yards for the STATIONS).

The consultant will play a significant role in the development of the precision blasting procedures, ordinance control, and continual monitoring of the blasting program. Dr. Konya's attached report aptly emphasizes the need to hire a professional blasting company based on a variety of criteria and not simply the lowest bidder. This team will set the standards for safe blasting. Benchmarking will be performed by placing seismographs in strategic locations around the STATIONS and in close proximity to critical or sensitive equipment for a period of six months prior to the first blast in order to measure existing background vibrations.

SPOILS CLASSIFICATION AND DISPOSITION

Previous boring information indicates a variety of sub-strata ranging from sandy loam to fractured dolomite and granite. This variety of materials poses certain difficulties but also leaves room for some creative disposition options. As material is excavated from the site, it must be classified according to material type, separated into similar material, and handled accordingly. Additional borings should be taken at specific locations of major excavations in order to better classify the spoils and provide the greatest reaction time to sub surface conditions.

Based on this preliminary information, the estimate assumes about 100,000 cubic yards will be unusable and must be disposed of in landfill while the remaining 2 Million cubic yards can be classified as suitable for other purposes. Options for spoils disposition are given below.

1.6.1 Building Reefs (Estimate Cost Basis) – The City of New York along with the Department of Environmental Conservation (DEC) are proactively building artificial reefs at sea in order to attract fish. The estimate assumes all of the suitable material can be barged to these locations and used to assist these organizations with additional reef building material. The advantages of this method include a responsible environmental use in lieu of landfill dumping and a clean and simple method of disposal. The disadvantage includes the cost associated with the dumping and permitting fees.

1.6.2 On Site Processing – Suitable materials could be processed (crushed) on site providing bedding and compaction material for construction with the remainder being sold to local companies effectively recovering some of the cost of excavation and disposal through a salvage initiative. This alternative could further reduce the cost and environmental impacts of trucking this same material to the site from an outside resource. The disadvantages include bulk disposal of unsuitable material and, additional land clearing for processing.

1.6.3 Barging to a Local Quarry – Discussions were made concerning the viability of selling suitable materials to a local quarry for processing. This method adds transport costs but recovers some cost of disposal. The ideal situation is to negotiate acceptance of all spoils for and in consideration of ownership of all useable material. Depending on the volume of usable material, negotiation could extend to the quarry excavating and removing the material after the phased blasting operation is complete.

BACKFILL AND COMPACTION

Once the rock removal and excavation is complete, each pad and adjoining trench will be back-filled with a suitable material and compacted in accordance with the site's specification. The estimate accounts for about 60,000 cubic yards of backfill.

LARGE BORE PIPING INSTALLATION

Engineering has sized the primary pipe diameters at 120" and 144" for return and supply, respectively, requiring significant trenching (some in highly congested areas) along with appropriate sheet pile shoring. Both overhead and underground utilities will challenge this process from a time and cost perspective. Trenching in this area is particularly hazardous because of a matrix of underground utilities that will require relocation and isolation. A significant portion of this work will be performed by hand, hence it will be time consuming, labor intensive, and expensive.

With some areas located along the river, the weight of concrete lined steel must be supported in the majority of areas by driving pre-cast concrete piles to bedrock (approximately 50') and constructing saddles atop to support the pipe above poor soil conditions. Much of the trenching requirement is located at or below the river level, necessitating extensive shoring and de-watering. Thrust blocks and tie-backs will be required at direction changes. Engineered fill will be placed as backfill.

Only about 1/3 of the large bore piping can be installed and tested prior to the outage of both units. This leaves over a mile of piping to be installed and tested along the service lane behind both units. Supply lines will header into the existing circulating water lines. Existing lines (where embedded in concrete) must be freed and modified to accommodate the difference in elevation. Return lines will be routed from the existing discharge canal (see pump houses below) to the appropriate cooling tower.

COOLING TOWERS

The cooling towers will be provided and installed by the supplying vendor. As part of that installation, this vendor will also form and pour the concrete basin. The footprint of each tower is about 500 feet and extends approximately 165 feet in height. The basin foundation contains multiple attachment embeds for the super structure and components. Ancillary equipment such as a switch gear (contained in a protective building), transformers, header piping, cable trays, and duct banks is required and will be installed. This operation will require a significant amount of heavy equipment support including 2 large cranes.

Once the towers are erected, the on site construction company will perform all of the mechanical and electrical inter-connects, lay a gravel bedding skirt extending 100' around the tower perimeter, install security and safety fencing, perform final grading, repair landscaping, and complete other related tasks required to the area construction.

PUMP HOUSES

Pump House construction can be performed during the on-line period as long as the discharge canal is undisturbed. This will involve heavy bank cutting, blasting and rock removal, demolition and/or relocation of some existing utilities and structures, concrete forming and pouring, and heavy equipment setting. Since the Pump Houses are located on a waterway, this work may be classified as maritime and greatly affect the cost and schedule. The estimate does not account for maritime work.

DISCHARGE CANAL MODIFICATIONS AND FINAL CONNECTIONS

The engineered design approach focused on making the minimum changes needed to accomplish the project while utilizing as much existing infrastructure as possible to minimize cost. All of the following work will require both units to be off-line.

1.1.1. The existing discharge canal will become an integral part of the closed loop cooling water system by acting as a collection basin for the condenser discharge and a pumped supply to the cooling towers. Current design requires the water level for the discharge canal to be elevated an additional 15 feet while the bottom is extended downward to at least –30 feet extending the full length of the canal. This poses specific concerns as described below.

1.1.1.1. The exterior quay wall located at the southern-most end of the canal is owned by a third party. The process for making modifications or improvements to this wall are currently unknown.

1.1.1.2. This same quay wall is constructed of interlocking sheet pilings and would not (without modifications) provide a water tight containment nor extend high enough to accommodate the additional 15 feet of water elevation.

1.1.1.3. The water velocity gates at the end of this quay wall act at least in part as a structural support and tie-back. Current design would require removal of this equipment in order to weir the end of the canal and allow sufficient flow throughout the canal.

As a result, the construction estimate assumes driving a temporary quay wall just outside of the existing and completely de-watering the canal. This serves several purposes. It allows easier dredging of the canal bottom, provides a drier environment for concrete intake construction, and allows for trench completion for ENIP3.

These activities will be followed by demolishing the above mentioned velocity gates and erecting a permanent quay wall that can extend to the desired height and be sufficiently water tight.

1.1.2. The supply and return piping extensions from the Phase I termination outside of the protected area fence must be performed while the units are off-line. Compensatory security measures must be enacted prior to breaching the protected area fence. The cost of these compensatory measures is included in the construction estimate and pro-rated to the STATIONS.

1.1.3. The rear service road is riddled with various utilities such as electrical service supply to ancillary and auxiliary systems, fire protection piping, storm water piping, instrumentation and controls, and other related systems installed around, below, and above the anticipated supply and return piping route. This makes retrofitting complicated, time consuming, and expensive. Hand excavation will be required to assure that all obstructions are removed or relocated prior to driving pile or beginning major excavation operations.

CONSTRUCTION COST ESTIMATING BASIS

RESOURCES

Rather than utilizing theoretical information solely from construction cost estimating guides, considerable effort was employed toward justifying the cost basis on many practical data points. We combined the input from a number of sources that are well-known and respected in their fields. The following outlines these resources and their contributions to providing a realistic construction estimate.

MAJOR VENDORS

The major pieces of equipment along with the primary materials were reviewed with actual vendors of these equipment pieces and material. (See Attachments 1 and 2 of the overall report for additional details)

2.1.1.1 Marley (Cooling Tower)

Marley is a respected and well known supplier of innovative cooling tower solutions to the power generating industry. Working closely with Marley, our cooling tower selection and anticipated implementation cost were coordinated.

2.1.1.2 Material Vendors

The project will require a number of different materials and, where practical, leading vendors were contacted for pricing support. All materials were quoted in 2003 dollars without escalation or other contingencies.

2.1.1.3 Equipment Vendors

Similarly, large equipment vendors were contacted for support in pricing the major equipment components identified in the conceptual design.

CONSULTANTS

2.1.1.4 Dr. Calvin J. Konya (Precision Blasting Consulting)

Because of the significant amount of rock removal required for equipment placement and trenching for piping, Dr. Konya, one of the country's leading experts on explosive engineering and precision blasting, was consulted for this phase of construction. Inducted as a life member into the National Academy of Science, his input brought both technical and real world credence to the developmental effort. (See Complete report located in Appendix 6A)

REGULATORY

2.1.1.5 NYCDOL (Prevailing Wages and Supplemental Benefits)

Since a large portion of the cost of this project involves craft labor, Enercon researched the prevailing wages for the New York City and surrounding areas in an attempt to identify the required craft categories and the cost of their services.

2.1.1.6 Federal Acquisition Requirements – FAR (Procurement)

In order to maintain fair and open competition for this work, Enercon has considered, within the context of this estimate, using the Federal Acquisition Requirements typically used for public works contracts.

2.1.1.7 US Commerce Department (Pricing Indices)

Understanding that this work will most likely occur over a 5 year period of time, our estimates, generated in today's dollars, should be escalated according to a similar pricing index average taken from the previous 5 years.

SITE SPECIFIC ASSETS

2.1.1.8 Entergy Procurement (Local Historical Cost Information)

Realistic estimating is best achieved through the application of as much historical information as possible. For this reason, Enercon discussed recent projects performed at the STATIONS in order to support this estimate.

2.1.1.9 Contractor (Local Historical Production Information)

One of the best resources to determine the productivity of the local craft remains an experienced contractor. Enercon solicited the support of The Atlantic Group which has performed work in and around the New York City area for a number of years. The Atlantic Group researched their own historical data from projects performed in this area in order to support this estimate.

INDUSTRY STANDARD

2.1.1.10RS Means (Factored Construction Cost Data)

The Means catalogue is one of the nation's most respected guidelines for estimating construction related cost of building. When other resources were unclear or not available, Enercon used the typical factored cost per commodity for the portion of work.

2.1.1.11Construction Industry Institute (CII)

CII focuses on the industrial construction and maintenance contracting industry as a trade organization devoted to continuous improvement of the means and methods used in construction. Their ideas related to the minimization of field required labor through modularization and prefabrication were considered as we built our construction strategies and cost estimates were prepared.

2.1.5.3 Engineering New Record (ENR)

Construction Cost Index, Building Cost Index, Materials Cost Index, which are updated monthly, provided some trending analysis with regard to the industry in general.

2.1.5.4 Williams Gas Pipeline (Personal Conversation)

Discussion was held with Kerry Morgan (Regional Sr. Technical Advisor) regarding relocation of existing gas pipelines in the New York City area.

WORK PHASING AND SCHEDULING

In order to minimize the overall construction cost, the estimate allows for phasing of the various tasks in order to take advantage of labor availability, scheduled refueling outages, flexible work sequencing, and spreading the total amount of work over time. In some cases, the estimate is optimistic and does not consider impacts occurring from outside forces such as regulatory, engineering, licensing, and others beyond the construction team's direct control.

PHASE I (PRE-OUTAGE)

Phase I of the Preliminary Schedule includes all work that can be reasonably performed while the units are on-line. This includes:

- Engineering and Modification Packaging
- Mobilization and Site Setup
- General Site Modifications
- Excavation and Trenching (Up to the Protected Area Fence)
- Precision Blasting and Rock Removal (Up to the Protected Area Fence)
- Tower Erection
- Electrical Equipment Installation

The intention of this phase revolves around putting as much of the work as practical prior to the outage to minimize the downtime of the facility. The schedule anticipates Phase I construction duration to begin in June 2005 and progress up to and possibly into the Outage period defined below.

PHASE II (OUTAGE REQUIRED)

Phase II includes all work that requires the units to be taken off-line such as:

- Excavation of Main Service Lane (Broadway)
- Discharge Canal Modifications
- Work at or near Existing Service Water Lines
- Tie-in of Circulating Water Supply and Return Piping

- Demolition or Rerouting of Existing Systems
- Electrical Tie-ins

Phase II is estimated to take 10 months (42 weeks) for both units beginning on or about November 2008. This is an aggressive schedule based on the volume of work to be performed and would require working double shifts to complete the construction activities. Uncertain conditions such as utility locations, labor availability, inclement weather, and/or additional engineering requirements will increase this time and subsequently the cost impacts associated with this phase.

SCHEDULE DURATION

The overall schedule for the conversion (see attached Appendix 6B) extends about 5 years from the anticipated construction start date of June 2005 predicated on the completion of engineering work beginning on or about January 2005. The construction start date is also based on having all permitting requirements completed and in place prior to mobilization, specification development or procurement operations. Considering the conceptual nature of the current design parameters and the unknown effects of forces outside of the construction team's control, many tasks are optimistic and can be severely impacted. Schedule development within the context of this report is intended to bound the minimum expected time frame for defined scope activities.

TESTING AND COMMISSIONING

Startup tests will be performed where possible after equipment turnovers, with final testing being performed at the conclusion of construction activities. All testing will be performed on an around the clock basis and in some cases (i.e. cooling tower verification tests) performed by specialized independent outside vendors. These tests will ensure components are performing to design conditions, and will verify the over-all performance of the cooling tower and associated systems once the plant is running again.

CRAFT LABOR

Craft labor including direct, indirect, and subcontracted sources constitutes approximately 40 percent of overall project cost. The construction estimate assumes a reliable and sufficient craft force on demand. Availability, work stoppages, strikes, and other similar labor issues will have an adverse effect on both construction schedule and cost.

REQUIRED CRAFT CLASSIFICATIONS

Construction for the conversion will require a variety of craft classifications. The major types of craft are outlined as follows:

- Heavy Equipment Operators
- Pipe Fitters
- Electricians
- General Laborers
- Cement Masons
- Carpenters

- Iron Workers (Structural and Reinforcing)
- Painters
- Blasters
- Waterproofers
- Insulators

The construction estimates project in excess of 3 million total effort hours for all craft.

COLLECTIVE BARGAINING AGREEMENTS VS. PREVAILING WAGE

Work at each facility is performed under a variety of collective bargaining agreements, one of the largest – GPPMA. This agreement applies to maintenance work regularly performed at the STATIONS and may not apply if this project is determined to be new construction. In order to form a basis for the anticipated labor cost, recent prevailing wage information was gathered including the base rates and supplemental benefits for the anticipated craft from the New York Department of Labor. This method complies with Federal Acquisition Requirements (FAR) standards and costs are typically based on applicable local collective bargaining agreements.

AVAILABILITY CONCERNS

3.3.1 Decline in Numbers

Craft availability is a national concern for the construction industry and has been for a number of years. Studies show a rapid decline in the replacement of retiring craft and a decreasing number of apprenticeship completion across the nation. The New York City Department of Labor expresses this concern in recently published information on their web site.

3.3.2 Competing Internal Requirements

While the units are operating, normal maintenance activities will draw the majority of local craft because of the steady nature of the work and previous employment. Hence, the majority of craft will need to be brought in from surround areas.

3.3.3 Outage Planning

A large number of qualified nuclear craft are drawn to incentive based earning opportunities at other nuclear facilities during the outage seasons (Spring and Fall). This also applies to scheduled outages for both ENIP2 and ENIP3.

3.3.4 Competing External Projects

Over the anticipated schedule duration, other large industrial projects will arise in surrounding regions and the project will compete for the same number of available craft.

PRODUCTIVITY COMPARISONS

RS Means recognizes a 30% production and cost differential between this region and the national average. Since we were able to rely on a reputable contractor familiar with local labor issues, most of the factoring was replaced with an estimate based on their experience. Where

RS Means was used to determine production rates, the national average was factored accordingly.

COST ESTIMATE BREAKDOWN

MAJOR WORK PACKAGES

Identifying and categorizing major work packages supported the estimating process and reduced the amount of typical guess work for large portions of project cost. The following represents the largest cost centers for the project and logical major work packages.

- General Conditions and Construction Management
- Cooling Tower Equipment and Erection
- Precision Blasting and Rock Removal
- Excavating and Disposal of Spoils
- Mechanical Piping and Valve Components
- Electrical Service Distribution Components
- Natural Gas Pipeline Relocation

ASSUMPTIONS AND ALLOWANCES

Many assumptions were required because of the conceptual nature of the design. The construction estimate was based on installing the proposed equipment in an effective and cost efficient manner. A site visit was performed and some general layout drawings were used to identify the scope of work and logistics requirements for installation.

Allowances were applied when time did not permit further task development or reasonable vendor contact and quotation.

CONTINGENCY AND COST ESCALATION

These two issues represent significant overall cost impacts. Industry Standard contingency for conceptual design estimates range from 20-30 percent of overall cost according to RS Means and utilized industry experience. This type of contingency relates to typical unknowns such as labor availability and productivity, inclement weather, and issues raised with final engineering designs. The construction estimate summary breaks this cost factor out from the estimate as a separate line item.

Another form of contingency attempts to quantify potential cost impacts from specific concerns and/or encumbrances based on probability and severity. This report outlines some of these construction concerns in Section 5. No allowances or contingency were applied to the construction estimate for these issues and could, when applied, severely impact the overall project schedule and cost.

The Direct Capital Cost Estimate developed for this project is based on Calendar Year 2003 dollars and has not been escalated over the scheduled duration. It assumes "overnight" engineering and construction of the project without inflation, labor rate increases, material market impacts, or other escalating criteria.

CONSTRUCTION ESTIMATE SUMMARY

The following summarizes the construction cost estimate in 2003 dollars.

Work Scope	Estimated Start	Estimated Finish	Estimated Cost
Design Engineering and Modification Packages	January 2005	December 2008	$26, 700,000
Mobilization/Setup	June 2005	September 2005	$1,500,000
General Site Modifications Access Roads Environmental Protection Fencing Modifications Barge Loading Facility Storm Drainage	July 2005	April 2006	$21,300,000
Phase I Construction (On-Line)			
ENIP2 Phase I Cooling Tower	August 2005	January 2009	
Cooling Tower			
Install Concrete Basin			$15,800,000
Install Wet Portion			$54,646,000
Install Plume Abatement			$51,794,000
Install Sound Attenuation			$18,260,000
Remaining Related Construction Activities Excavation Blasting and Rock Removal Foundation Erection Mechanical Electrical			$75,600,000
ENIP3 Phase I Cooling Tower	January 2006	August 2009	
Cooling Tower			
Install Concrete Basin			$15,800,000
Install Wet Portion			$54,646,000
Install Plume Abatement			$51,794,000
Install Sound Attenuation			$18,260,000
Remaining Related Construction Activities Excavation Blasting and Rock Removal Foundation Erection Mechanical Electrical Gas Pipeline Relocation Sewage Lift Station Relocation			$105,700,000
Phase II Construction (Outage Period)			
Common Outage Required Tasks Discharge Canal Modifications Trenching and Excavation	March 2009	August 2009	$34,900,000
IP Unit #2 Pump House Large Bore Piping	March 2009	January 2010	$35,600,000

System Tie-in			
IP Unit #3 Pump House Large Bore Piping System Tie-in	March 2009	January 2010	$28,000,000
Testing and Commissioning	January 2010	February 2010	$1,100,000
Demobilization	January 2010	March 2010	$1,000,000
Total Preliminary Construction Estimate			$612,400,000
Payment and Performance Bond			$4,000,000
Recommended Minimum Contingency	20%		$123,280,000
Recommended Engineering and Construction Budget			$739,680,000

CONCERNS AND ENCUMBRANCES

Construction of the closed loop cooling system will involve operations that at this point in time can not be fully defined or appreciated. Besides the shear volume of direct capital cost, many assumptions were made during the course of building this estimate and corresponding schedule. The following outlines some of these concerns

5.1 Construction processes involved with this conversion will be regulated by a number of agencies all with a varying degree of permitting and procedural requirements. The current construction estimate does not anticipate any of these cost with exception of the construction permit. Interaction with these regulatory agencies could not only increase the cost of the project but also create delays in the schedule.

5.2 Obvious public concern regarding blasting operations and ordinance handling at an operating nuclear plant.

5.3 Anticipated rock and earth removal exceeding 4000 cubic yards per day or a total greater than 2.1 million cubic yards. This is greater than the production of the quarry visited down river and may prove too optimistic.

5.4 Disposal of all spoils. Even with the most optimistic disposition scenario, non-useable material must be removed from the site. There is simply not enough suitable topography to support spreading the spoils on site.

5.5 The construction schedule will extend for a period of 5 years further exacerbating unknown future conditions.

5.6 Significant additional electrical power distribution system for equipment with tie-ins to outside power provided by a Con-Ed substation.

5.7 Relocating, removal, or abandonment of existing equipment some of which can not be readily identified at this time.

5.8 Excavation and piping support operations located within the protected area will be extremely time consuming with much of the work performed by hand in order to protect buried sub-structures and utilities. Pile driving at the river's edge poses particular safety hazards beyond working in tight spaces such as transmission line clearances.

5.9 All excavated material is assumed to be free from radiological or other hazardous contamination and suitable for normal disposal techniques as described above. If contamination is found during the construction process, both the construction schedule and projected cost would be severely influenced.

5.10 Proximity to the river's edge will challenge the construction team with both safety and environmental concerns. All work located at the river and within the protected area could be considered maritime operations and if so, could significantly impact the cost and schedule of the project.

5.11 Similarly, normal inclement weather is assumed, but weather phenomena such as flooding, prolonged periods of rain or cold, or other acts of God are not considered and could occur during the lengthy construction schedule of about 5 years.

5.12 Labor availability remains a primary concern with most all construction companies for a variety of reasons such as a declining replacement of retirees, competition from other regional power plant outages and competition from other large industrial projects. These problems continue to get worse each year and could affect the ability to obtain sufficient qualified craft to support the schedule.

5.13 As with the uncertainty of labor availability, both material and equipment follow similar capacity issues. Procurement cost may increase due to regional economic conditions, competing industrial projects, and so on. Expediting costs and/or substitutions may be required to meet the schedule.

5.14 All construction estimates are based on the conceptual design.

5.15 All work is assumed to be performed under normal homeland security conditions. As the threat level is increased (e.g. to elevated (yellow) or high (orange)), additional security measures will be added to the cost of the project along with the inevitable loss of production and schedule extension cost.

The driving intent of this construction estimating exercise reflect bounding the lower responsible cost for conversion. The above concerns are not all inclusive but represent some major challenges that the construction team must focus on from the beginning and throughout the conversion. It is difficult to determine exact cost impacts or ranges thereof at this point based on probability or severity of the issue involved.

APPENDIX 6A – PRECISION BLASTING AND ROCK REMOVAL REPORT

Prepared by Dr. Calvin Konya

June, 2003