# Response to Bechtel Assertions Regarding Potential for Cooling Tower Recirculation at Southern Location (Parking Areas)

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December 16, 2013

Bechtel provides, in its December 11, 2013 review of its Phase I decision-making regarding cooling tower siting at Diablo Canyon Power Plant, a series of rationalizations for opting not to propose cooling towers at the Diablo Canyon southern (parking lots) location. None of these rationalizations are supported with documentation to allow verification of the legitimacy of the claim. The rationalizations are listed below in the order they are presented in the Bechtel write-up, and are addressed in the subsequent sections of this Powers Engineering response.

"When there are several cooling towers located on one site, the proper placement of the towers in relation to each other is an extremely important consideration. The reason is to minimize the occurrence of interference, where the hot, humid exhaust air from one cooling tower is entrained into the air inlet of an adjacent tower which raises the inlet wet bulb temperature of the impacted tower and results in decreased thermal performance (increased hot water temperature). If there is not adequate space provided between cooling towers they will not perform as designed."

"For this reason, Bechtel consulted with the cooling tower manufacturers that provided the designs for the towers proposed in the DCPP report and obtained the recommended minimum spacing required between the towers, specific to each tower type."

"The Phase I Study considered the following criteria in siting the cooling towers for the closed cooling water option:

- Proper spacing to obtain the best performance using good engineering practices
- Minimizing the effects on existing plant infrastructure and operations"

"Routing piping between the proposed cooling towers and the turbine building would also prove challenging. There are critical plant structures at the southern location that could not be relocated and are in the corridor through which the circulating water return ducts/pipes would have to pass. There may not be sufficient space to accommodate the ducts/pipes without removal of the critical plant structures."

"Based on the significant excavation required for the towers, combined with the pipe routing complexities and fact that the current main access route and plant facilities are all located south of the plant it becomes evident that the southern area is not the optimum location for the towers and the Phase I study concluded that the north location would be the more acceptable solution."

## Bechtel Statement That There Is a Required Minimum Spacing for Cooling Tower Segments Is Incorrect

Cooling tower manufacturers provide recommendations for spacing between adjacent cooling tower sections. These recommendations are intended <u>to assure a relatively minimal tower size</u>

adjustment to compensate for recirculation and interference effects of warm moist exhaust air from one cooling tower section entering into the air inlets of the adjacent section. These spacing recommendations are not requirements, and placing cooling tower sections closer together than the recommended minimum is not a fatal design flaw. It does mean the cooling tower sections will potentially be incrementally less effective at design conditions than they would otherwise be if the spacing met the manufacturer minimum spacing. This is a performance issue, not a technical feasibility issue.

Using either Diablo Canyon Units 1 or 2 as hypothetical examples, the end result of choosing spacing between cooling tower sections that is substantially less than the manufacturer's minimum recommended spacing could be that the output loss increases from 20 MW to 25 MW at cooling tower design conditions. The trade-off for closer spacing of the cooling tower sections is less output.

The issue of how much recirculation is tolerable if back-to-back cooling towers are constructed at the southern location is a cost-benefit issue, not a technical feasibility issue. The question is whether the increase in lost generation caused by recirculation offsets the avoided expense of large amounts of excavation and building relocation to locate the cooling towers to minimize or eliminate the potential for recirculation.

To get a sense of the scale of this cost-benefit, assume that recirculation effects result in an average additional generation loss of 5 MW per unit at Diablo Canyon, or about 0.5 percent of total net output, compared to cooling tower spacing that meets manufacturer minimum recommendations. This is a combined loss of 10 MW. Using Bechtel's assumptions that the units operate at a 90 percent capacity factor (about 8,000 hours per year) and the average price of wholesale electricity is $46.76 per MW-hour, the annual replacement power cost would be approximately $4 million per year.[1,2]

This annual replacement power cost of $4 million for recirculation effects used in this example compares to a capital cost delta between ClearSky™ linear cooling towers in the southern location and Bechtel's proposed cooling tower alternatives of $8 billion to $10 billion. This comparison assumes the all-in capital cost of the ClearSky™ towers does not exceed the 2008 TetraTech back-to-back cooling tower cost estimate of approximately $1.6 billion.

### It Is Not Uncommon for Adjacent Cooling Tower Sections to be Placed More Closely Together than the Minimum Spacing Recommended by Manufacturers

It is not uncommon for adjacent cooling tower sections to be placed more closely together than the minimum spacing manufacturers recommend to avoid significant recirculation and interference effects. See Figures A and B for two examples of closer spacing. Figure A is the cooling tower at the 605 MW Vermont Yankee Nuclear Plant. Figure B is the cooling tower for one of two 700 MW units at the Centralia (WA) coal-fired power plant.

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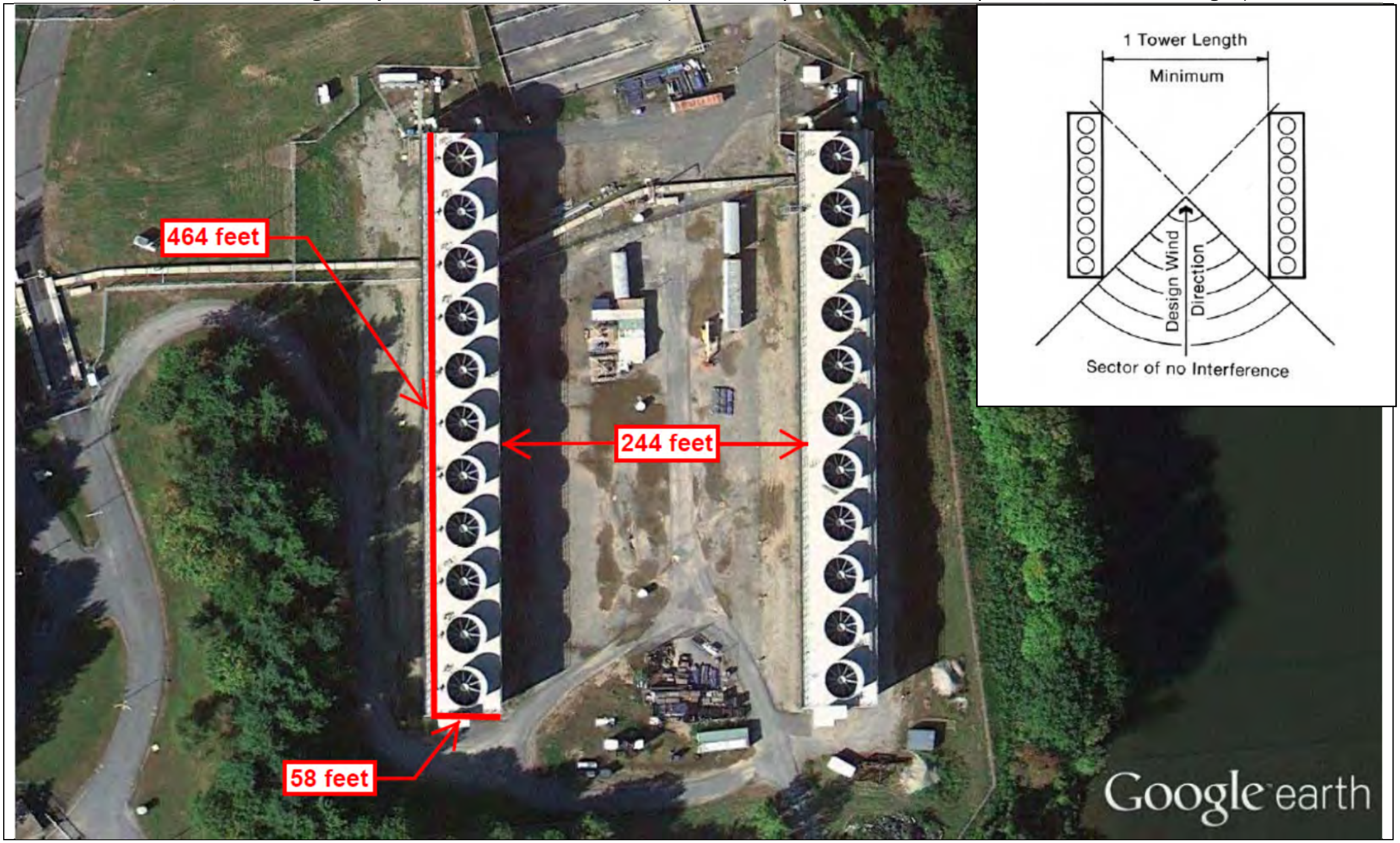
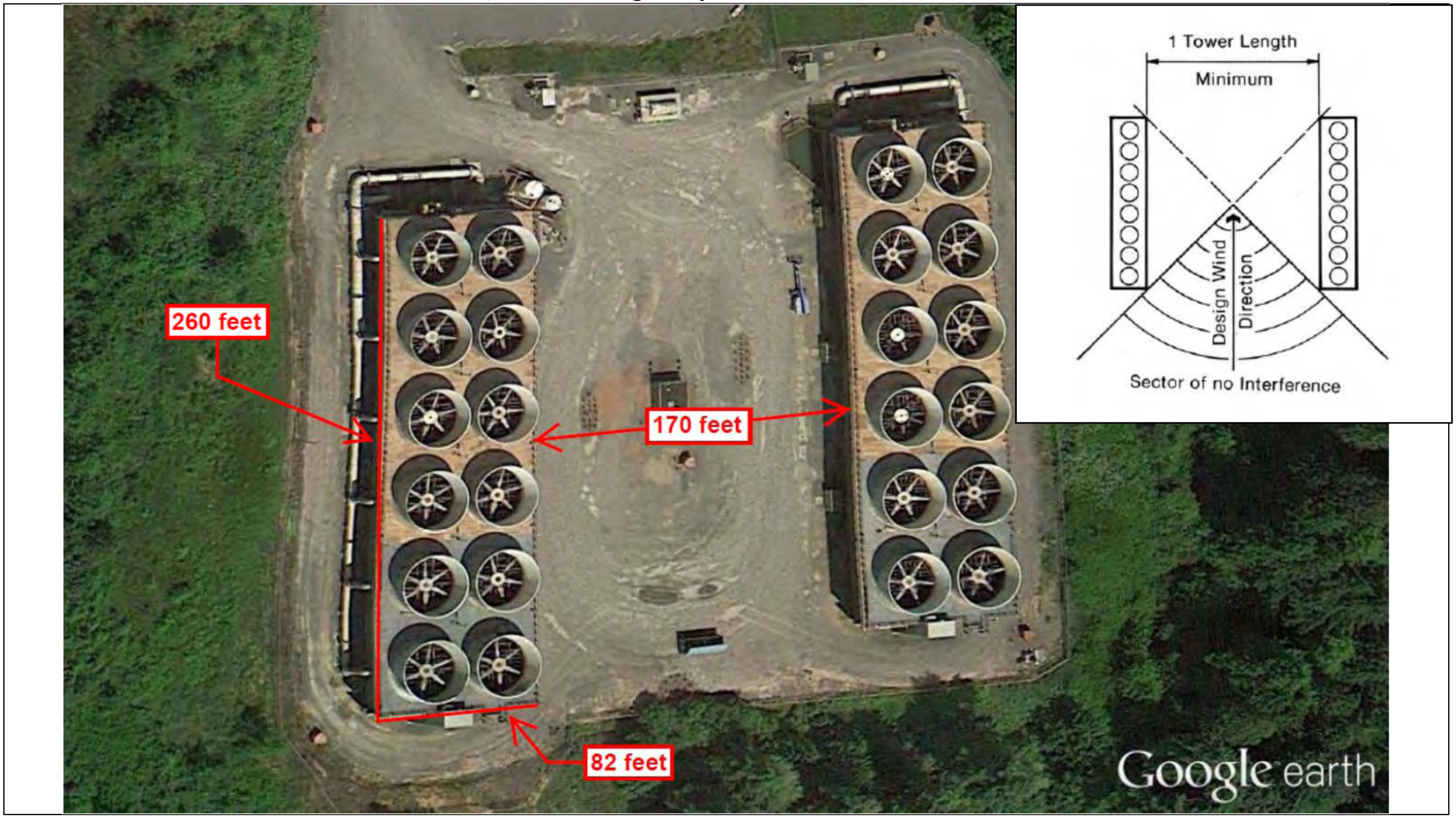
[1] Bechtel report, p. 193. "PG&E provided the basis for calculating replacement power costs at $46.76/MWG."
[2] 10 MW x 8,000 hours/yr x $46.76/MW-hour = $3.74 million per year.

**Figure A. Cooling Tower for 605 MW Vermont Yankee Nuclear Plant (One Unit),**
**~1/2 Tower Length Separation Between Sections** (SPX/Marley recommended separation is 1 tower length)




Note: insert shows SPX/Marley recommended minimum cooling tower section spacing, Bechtel Dec. 11, 2013 response, Attachment 2.

**Figure B. Cooling Tower for One of Two 700 MW Centralia, WA Coal-Fired Units, ~2/3 Tower Length Separation Between Sections**

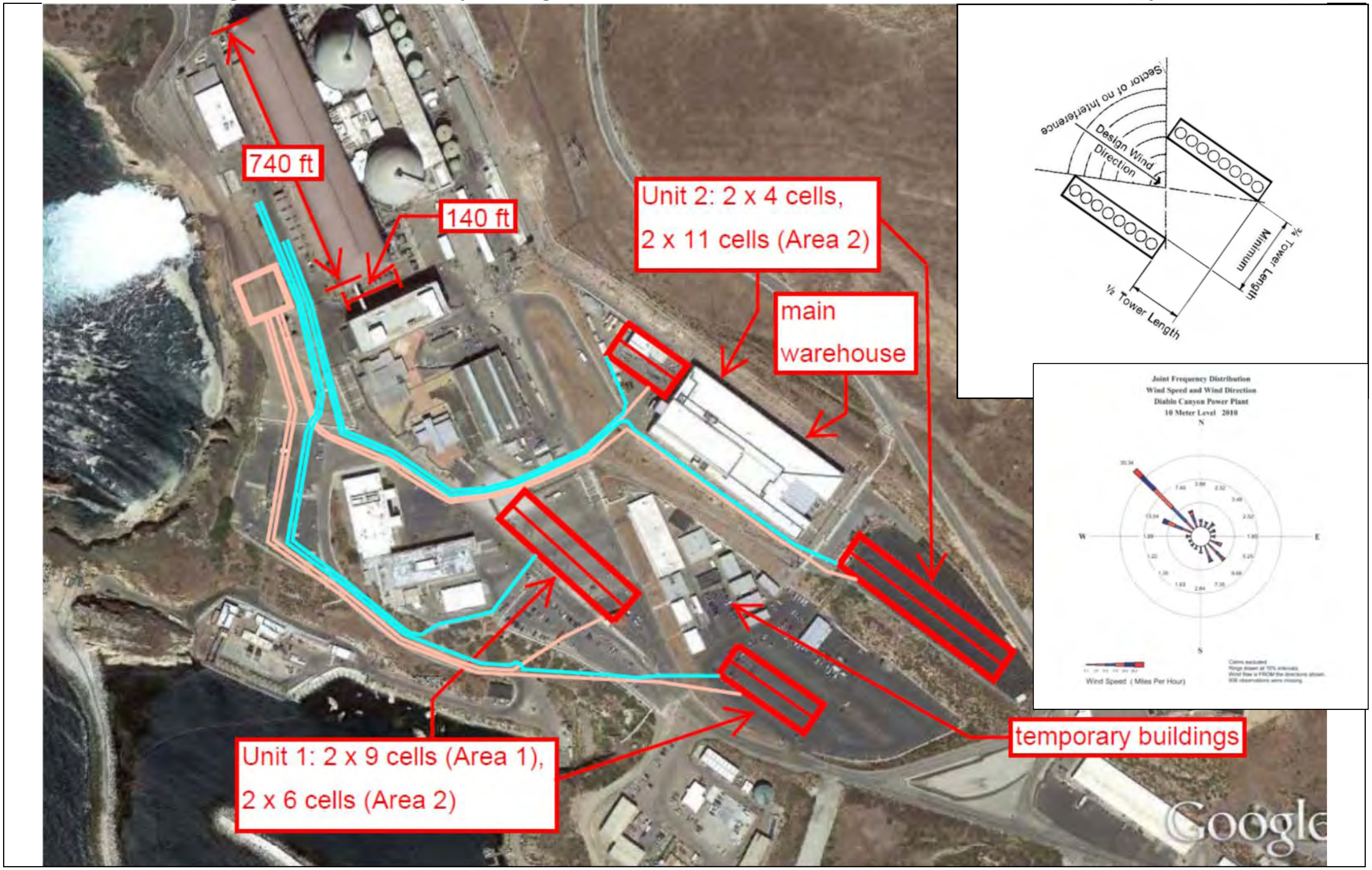



Note: insert shows SPX/Marley recommended minimum cooling tower section spacing, Bechtel Dec. 11, 2013 response, Attachment 2.

Attachment A to Bechtel's December 11, 2013 response is an excerpt from "Cooling Tower Institute Technical Sub-Committee #2 Report on the Study of Recirculation (PFM-110)." The excerpt used by Bechtel states "*Subsequent tests and additional data on cooling tower recirculation indicate that regardless of tower, size, type or configuration, the tower should be oriented so that the longitudinal axis of the tower should be parallel to the wind direction for minimum recirculation*." That is exactly the situation for ClearSky™ linear cooling tower sections at the Diablo Canyon southern location. The tower sections would be parallel to the prevailing wind direction. This is shown in Figure 3 below, for 30-cell ClearSky™ cooling towers at the southern location. The 30-cell configuration has the advantage of avoiding any structure relocation.

Based on the SPX/Marley recommended spacing guidelines for cooling tower sections, minimal recirculation would be expected with the 30-cell ClearSky™ configurations shown in Figure C.

**Figure C. 30-Cell ClearSky Cooling Towers for Units 1 and 2, No Structure Removal Necessary**




Insert 1: SPX/Marley recommended minimum cooling tower section spacing, Bechtel Dec. 11, 2013 response, Attachment 2.
Insert 2: PG&E windrose for Diablo Canyon Power Plant site.

### Bechtel Did Not Evaluate the One Cooling Tower Design, a Back-to-Back Inline Configuration, that Would Avoid Any Excavation at the Southern Location

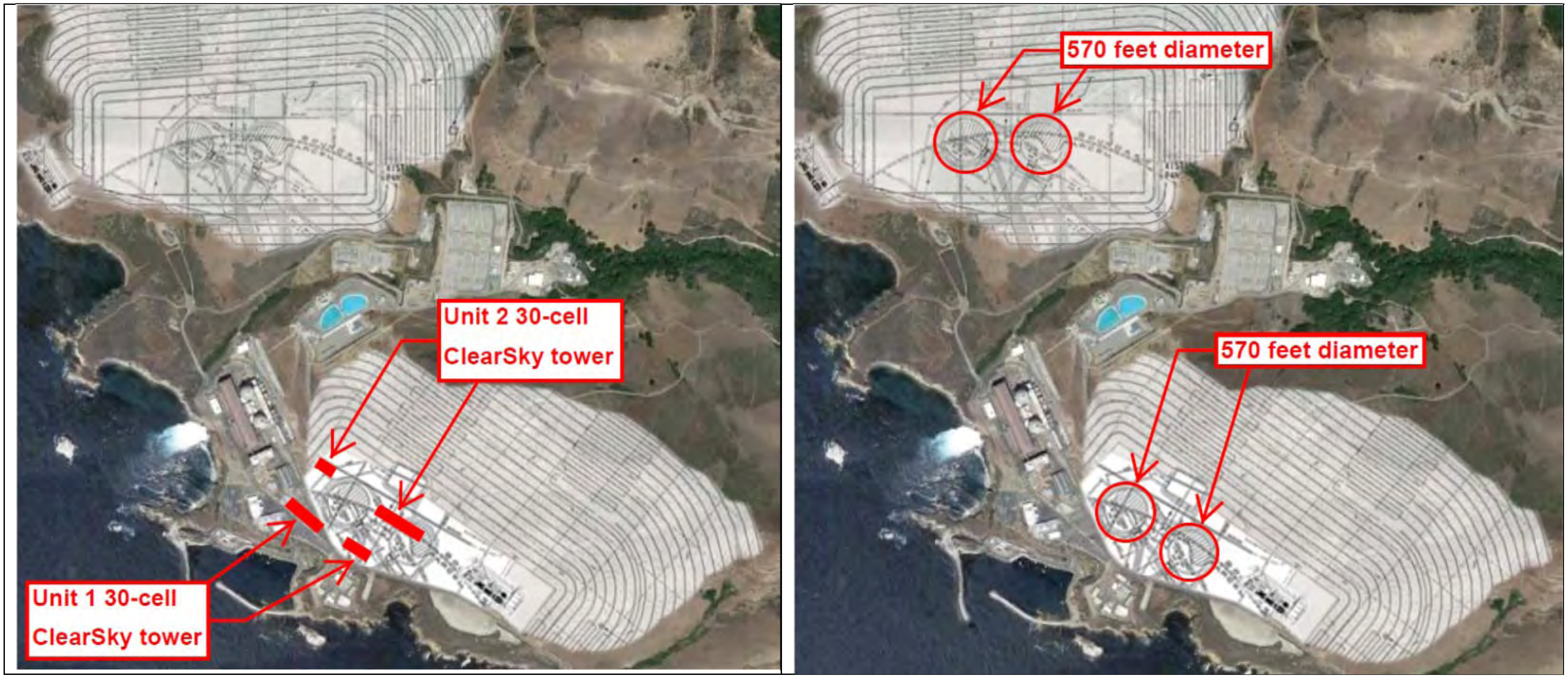
Although all recent Diablo Canyon cooling tower retrofit studies prior to Bechtel assumed back-to-back inline cooling towers at the southern location, Bechtel did not evaluate this cooling tower configuration. As Bechtel explains:

"Only the tower arrangement that is representative of the wet mechanical and hybrid towers are included here as these take the least amount of space. Refer to Figure 1. In all cases, significantly plant area is required to be excavated in order to install the (round) towers. Much of the existing structures and infrastructure in the area south of the turbine building would have to be removed and replaced at some other location. Circular hybrid towers were recommended by the cooling tower supplier as these are less sensitive to recirculation and require less plot area than the traditional hybrid towers."

Bechtel is incorrect in asserting that the round towers that it evaluated cover the least amount of space of available cooling tower options. The round towers evaluated by Bechtel take up about three times the area, including clearances around the towers, as 30-cell ClearSky™ back-to-back cooling towers. The circular shape of the round towers is the reason that placement of these towers at the southern location would require the relocation of structures, specifically a large warehouse and temporary buildings, and large amounts of excavation as shown in Bechtel's Figure 1.

In contrast, a long, narrow tower configuration, such as the ClearSky™ back-to-back linear cooling tower, which can be built in multiple distinct segments, can be custom fit to the limitations of the southern location to eliminate excavation and minimize or eliminate the need to impact structures. The siting advantages of the ClearSky™ back-to-back cooling tower at Diablo Canyon is shown in Figure D.

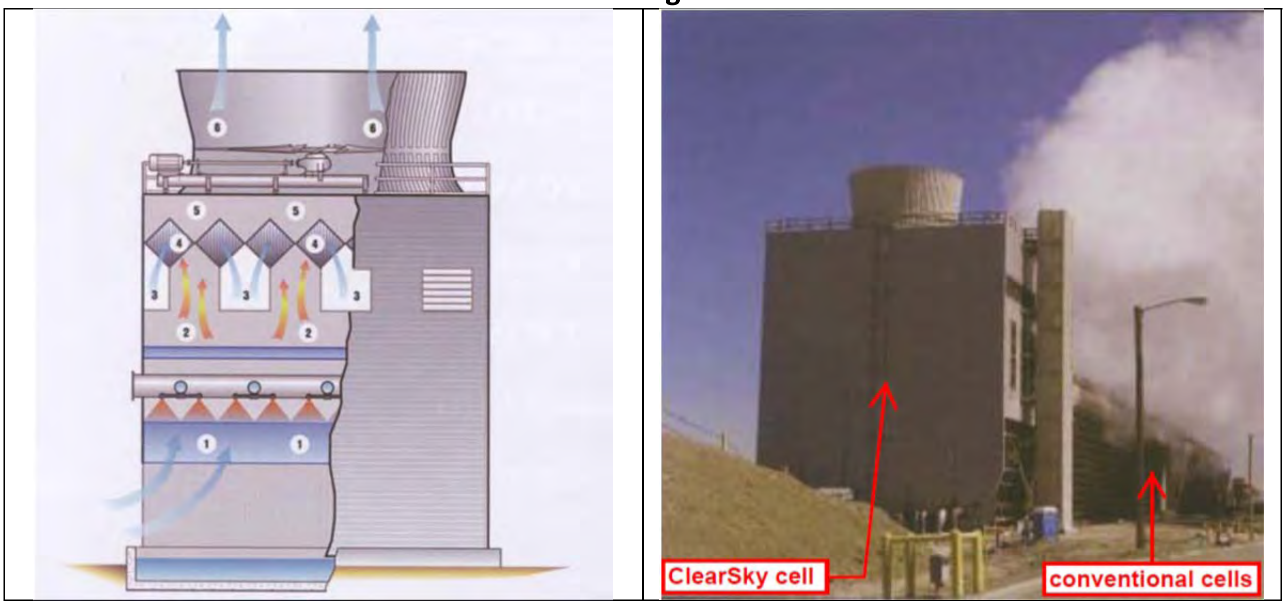
**Figure D. 30-cell ClearSky™ Southern Location (with No Excavation Necessary) Compared to Round Towers Evaluated by Bechtel with Extensive Excavation**



## SPX ClearSky™ Cooling Tower Is Simple and Reliable

The SPX ClearSky™ cooling tower is a conventional cooling tower with a no-moving –parts plastic heat exchanger located above the conventional cooling tower section. It is an elegant and simple modification to a completely proven conventional cooling tower cell. This is shown in Figure E. The fact that the first commercial ClearSky™ cooling tower is under construction is unrelated to the simplicity and reliability of the design, or of the willingness of the manufacturer to guarantee the performance of a ClearSky™ cooling tower in a specific application.

**Figure E. Cross-section of ClearSky Cooling Tower Cell, Heat Exchanger (3&4) Shown Above Conventional Cooling Tower Section**[3]




[3] P. Lindahl, K. Mortensen – SPX Cooling Technologies, *Plume Abatement – The Next Generation*, Cooling Technologies Institute Journal, Volume 31, Number 2, Summer 2010.