Institute for Science and International Security

ISIS REPORT

September 18, 2008

Second Khushab Plutonium Production Reactor Nears Completion

Time to reenergize negotiations of a Verified Fissile Material Cutoff Treaty

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ISIS has obtained commercial satellite imagery from DigitalGlobe taken on September 3, 2008, May 18, 2008 and February 9, 2008 of the Khushab plutonium production reactor site in Pakistan. The imagery shows further construction of the second and third plutonium production reactors at Khushab (Figure 1), and that construction of the second reactor may be nearing completion. The images show a clearly visible row of cooling towers, typically built in the later phase of reactor construction (Figure 3). Given this state of construction, the second reactor could start in a year.

Once completed, these reactors will increase several-fold Pakistan's ability to make weapon-grade plutonium for nuclear weapons. The wider implication of Pakistan increasing its plutonium production capacity must not be overlooked—there is a real risk that it will exacerbate an India-Pakistan nuclear arms race and increase tensions more broadly between the two. A U.S. priority should be a verified cutoff of the production of plutonium and highly enriched uranium for nuclear weapons in South Asia and worldwide.

The September 3, 2008 imagery shows that the roof of the third Khushab reactor hall is not yet placed on top and the reactor vessel can be seen inside (Figure 2). There does not appear to be construction of any additional reactors in the imagery.

The Khushab nuclear site originally consisted of one heavy water reactor with a power of about 50 megawatts-thermal and one heavy water production facility. On July 24, 2006, ISIS released the first publicly available commercial satellite imagery of the facility showing the construction of a second plutonium production reactor at the Khushab nuclear site. On June 21, 2007, ISIS released satellite imagery showing the construction of a third plutonium production reactor on the site. Although Pakistan has not sought to

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conceal the construction of these reactors, it still has not spoken publicly about their power, treating the subject as a state secret.

More Cooling Towers

The September 2008 imagery shows, in addition to a row of eight cooling towers visible in earlier imagery, the construction of more cooling towers for the second reactor (Figure 4). The exact number and purpose of these additional towers are difficult to determine from the imagery. However, the extra towers imply that the new reactors could be larger than the first one.

The cooling towers for the second Khushab reactor appear to be of a type called mechanical draft, where the draft is driven in part by large fans. This type of cooling tower can extract more heat than similar natural draft cooling towers, such as the type found at the five megawatt-electric reactor in Yongbyon, North Korea.

For eight of the cooling towers, each measures approximately 5.25 meters in diameter. The original Khushab reactor has a row of eight cooling towers with each measuring approximately 5.25 meters in diameter as well (Figure 5). For comparison, the Algerian El Salam heavy water reactor, which was supplied by China, has six similarly-sized cooling towers (Figure 6), estimated by U.S. government experts several years ago as able to dissipate about 50-100 megawatts of heat[1]. It is unclear if the Khushab cooling towers are similar to the Es Salam towers. The cooling towers for the second reactor may be capable of dissipating significantly more heat than the Es Salam towers, or for that matter the towers at the first Khushab reactor. Nonetheless, extrapolating those values provides an initial estimate that the eight Khushab towers can dissipate about 70-130 megawatts-thermal. The additional cooling towers could increase this cooling capacity.

Another indication that the second and third Khushab reactors are larger than the first one is that they each have two identical square towers adjacent to their south-east corners (Figure 3), where the original Khushab reactor has only one of these towers (Figure 5). The purpose of the towers is unclear.[2]

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[1] The lower estimate is from Mark Hibbs, "Cooling Towers are Key to Claim Algeria is Building Bomb Reactor," *Nucleonics Week*, April 18, 1991. The upper bound is from an interview with a knowledgeable U.S. government expert. The cooling towers can dissipate far more heat than produced in the Es Salam reactor, which has a power of 15 megawatts-thermal. Thus, the Es Salam cooling towers have more heat dissipating capability than the reactor requires. In the case of the Khushab reactors, the power of the first reactor is estimated at about 50 megawatts-thermal, for a reserve less than that at the Es Salam reactor..

[2] The function of these towers is not obvious from the imagery but could reasonably be ascribed as follows. They could contain a head tank that would maintain the moderator pressure a few pounds above atmospheric, (increasing the boiling temperature a few degrees and allowing a slightly higher reactor operating power). They could also contain equipment to maintain the purity of the heavy water moderator, normally about 99.75% D_2O. Such equipment might include a distillation column for removing light water exchanged with heavy water during periods when the reactor vessel is vented to the atmosphere, or an extraction system (such as an ion exchange system), for removing contaminants such as aluminum, fission products from failed fuel elements, or other contaminants. The towers could also be associated with tritium recovery. Another possibility is that the towers contain an auxiliary safety system such as a supply of heavy water loaded with boron or gadolinium that could be used to shut the reactor down during an

Pakistan appears to have begun clearing a large plot of land adjacent to the second and third Khushab reactors (Figure 7). It is too early to determine whether or what new construction will take place in this area.

No electricity production equipment is seen in the images. This is consistent with the purpose of the reactors being to produce plutonium for nuclear weapons. Nonetheless, Pakistan could add electrical generating equipment to these reactors or add such equipment to any heavy water reactors it would build in the future.

Power of the New Reactors

The analysis we did in the July 2006 report was based on the size of the second Khushab reactor vessel, and we continue to believe that the satellite imagery depicted the actual reactor vessel. The analysis based on the vessel size led us to estimate the reactor capable of operating in excess of 1,000 megawatts-thermal.

Our 2006 report was controversial and criticized by U.S. officials and experts in the NGO community, some of whom had access to information from the U.S. intelligence community. According to a U.S. government official knowledgeable about internal U.S. studies of Pakistan's nuclear capabilities, the new Khushab reactors have each been assessed as having a power far less than 1,000 megawatts-thermal and as being "consistent" with the size of the first one. To this U.S. official, the latter statement indicates that their power will be likely 50-100 megawatts-thermal, larger than the first one and up to double its size. However, this official cautioned that the United States may not have specific information on the power of the new reactors, and its assessment has uncertainties that could mean that the actual power is underestimated.

ISIS continues to assess that the power of each of the two new reactors is likely significantly larger than the first one. However, we recognize that the information at hand is insufficient to provide high confidence in our past assessment. **Reflecting this uncertainty and awaiting more information, we currently assess that the reactors will have a power of about 100 megawatts-thermal or more.**

An expert who has worked with ISIS on evaluating the Khushab reactors, with over 50 years of experience in building and operating U.S. heavy water reactors, has assessed that there is a better than even chance that the power of the second and third Khushab reactors is or will eventually be substantially larger than that of the first one. Even if each of the reactor's nameplate power was as low as 50-100 megawatts-thermal, he has assessed that Pakistan could still greatly expand its power in the future. This analysis assumes a certain degree of Pakistani competence in building and operating heavy water reactors, which he assesses to be within Pakistan's reach.

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accident scenario that involved the inoperability of the normal control system. All of these possibilities are consistent with accepted design criteria for heavy water reactors whose purpose is to produce plutonium or tritium for nuclear weapons.

If each of the two new Khushab reactors operates at 100 megawatts-thermal, the two reactors combined could produce enough plutonium for 8-10 nuclear weapons per year.[3] The first Khushab reactor's plutonium production capacity is about 2-3 nuclear weapons per year.

Revive Fissile Cutoff Treaty Talks

When finished, the second and third Khushab reactors will allow a significant increase in the quantity and quality of Pakistan's nuclear weapons, regardless of the outcome of the dispute about the reactors' power. If the power of these two reactors is significantly greater than 100 megawatts-thermal, or if their power is increased, these reactors would rival those that fueled the arsenals of the mid-sized nuclear weapons states, Britain, France, and China.[4] [5]

Pakistan's increase in plutonium production furthers needlessly the nuclear arms race between India and Pakistan and undermines fragile efforts at rapprochement between the two countries in other spheres. India can easily match Pakistan's actions, given its own capabilities to produce plutonium for weapons in heavy water power reactors and a breeder reactor under construction. Rather than witnessing a wasteful and dangerous surge in the production of fissile materials for weapons in South Asia, the United States should make a key priority convincing Pakistan to join the negotiations of a universal, verified, Fissile Material Cutoff Treaty (FMCT), which would ban the production of plutonium and highly enriched uranium for nuclear explosives in a verifiable manner. As an interim step, the United States should press both countries to suspend any production of fissile material for nuclear weapons.

Achieving this goal would require the United States to change its relatively new policy of seeking a cutoff treaty that does not include verification. Worried about the other side cheating on a cutoff treaty, both India and Pakistan rightly seek a verified cutoff treaty. The Bush Administration's rejection of the long-standing U.S. policy of requiring verification was a mistake that needs to be rectified. But even this change does not appear to be enough to convince Pakistan to join negotiations of a cutoff treaty. Most suspect that Pakistan wants to buy time to achieve its goal of operating the Khushab reactors to significantly increase its weapon-grade plutonium stock. But focused U.S. pressure can overcome this obstacle, particularly if the United States supports the

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[3] Each reactor is assumed to achieve a capacity factor of 60-80 percent, and each nuclear weapon is assumed to require 5 kilograms of plutonium. The Khushab I reactor is estimated as having a power of about 50 megawatts-thermal.

[4] If the power of each of the two new Khushab reactors is 250 megawatts-thermal, the two reactors combined could produce enough plutonium for about 20-25 nuclear weapons per year. If each has a power of 1,000 megawatts-thermal, then the two reactors combined could produce enough plutonium for between 80 and 100 nuclear weapons per year, assuming both operate at full power for at least 60 percent of the year.

[5] For more information on military plutonium stocks, see http://isis-online.org/global_stocks/end2003/tableofcontents.html and http://www.fissilematerials.org

conversion of the Khushab reactors to electricity production and works more actively with both India and Pakistan to limit the size of their nuclear arsenals.

Current U.S. policy has had the unfortunate effect of turning the United States into more of a concerned by-stander of Pakistan's expansion of its ability to produce nuclear weapons. It is time to make a verified FMCT a top priority again and insist that Pakistan and its rival India join these negotiations in good faith.

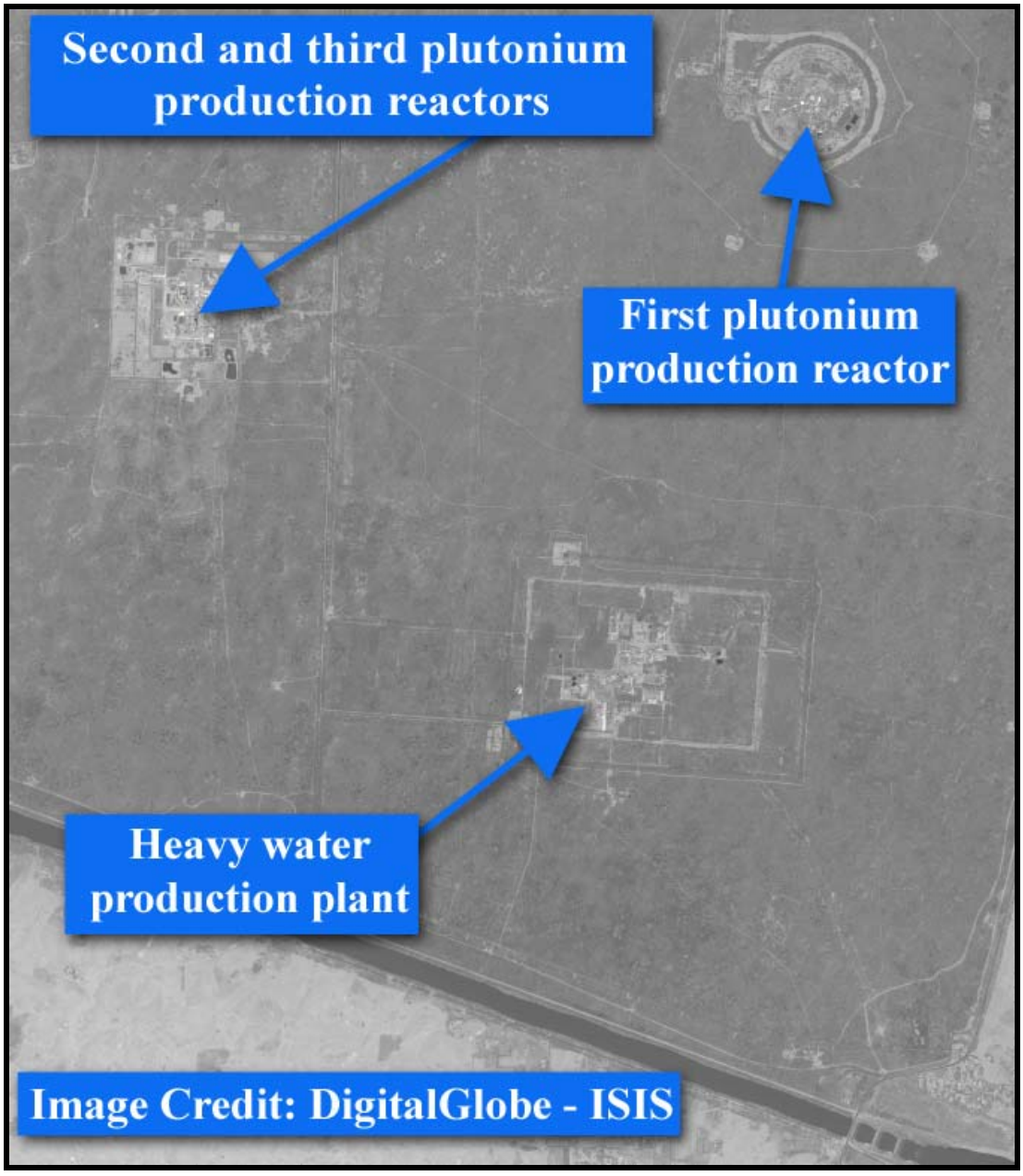

Figure 1. An overview of the Khushab nuclear site in Pakistan.

Figure 2. Third plutonium production reactor at Khushab.

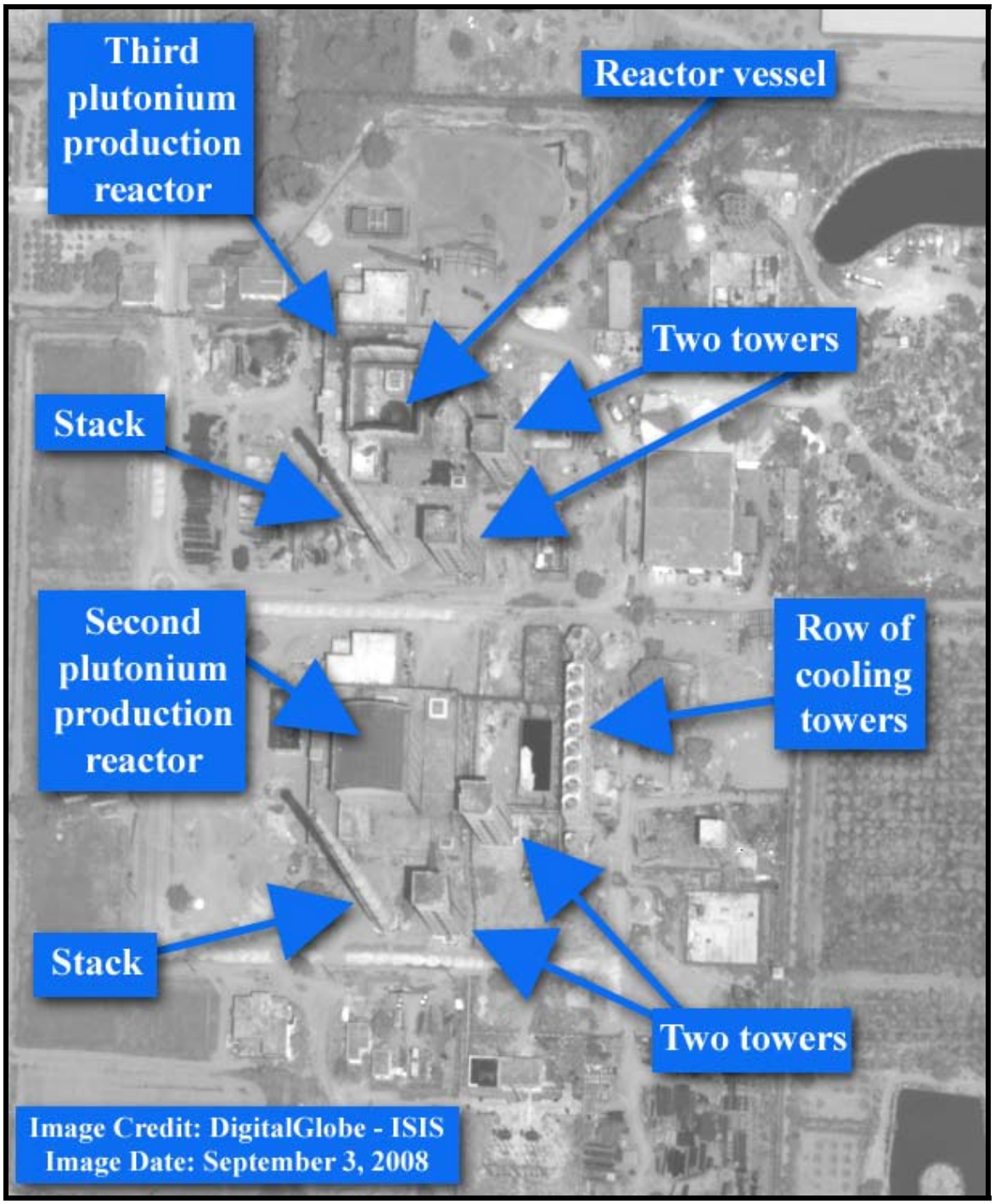

Figure 3. A close-up image of the second and third plutonium production reactors at Khushab. To the left the second Khushab reactor is a row of eight cooling towers. Two towers stand adjacent to both second and third reactors.

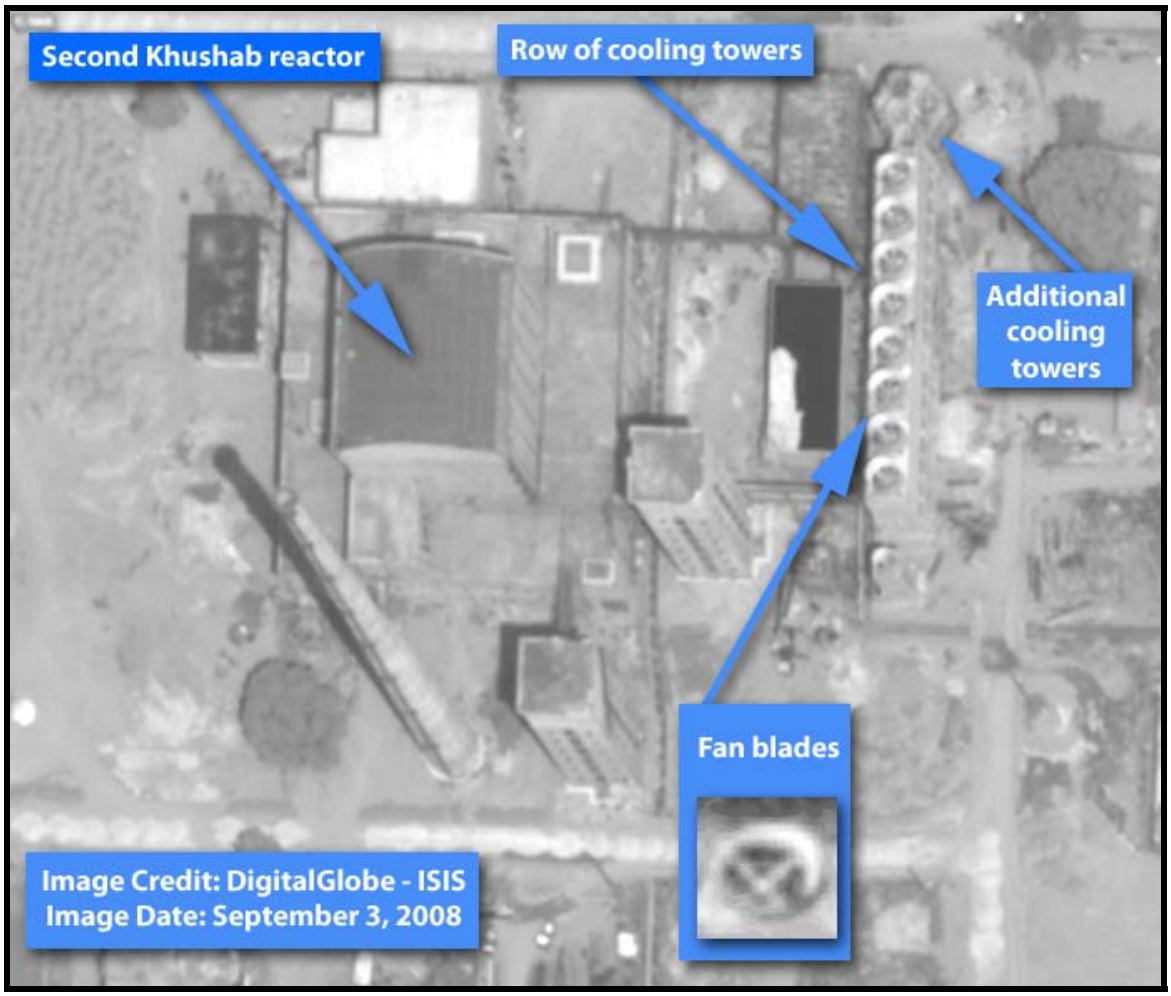

Figure 4. Close-up view of row of cooling towers with construction of additional cooling towers. The fan blades of the mechanical draft cooling towers can be seen.

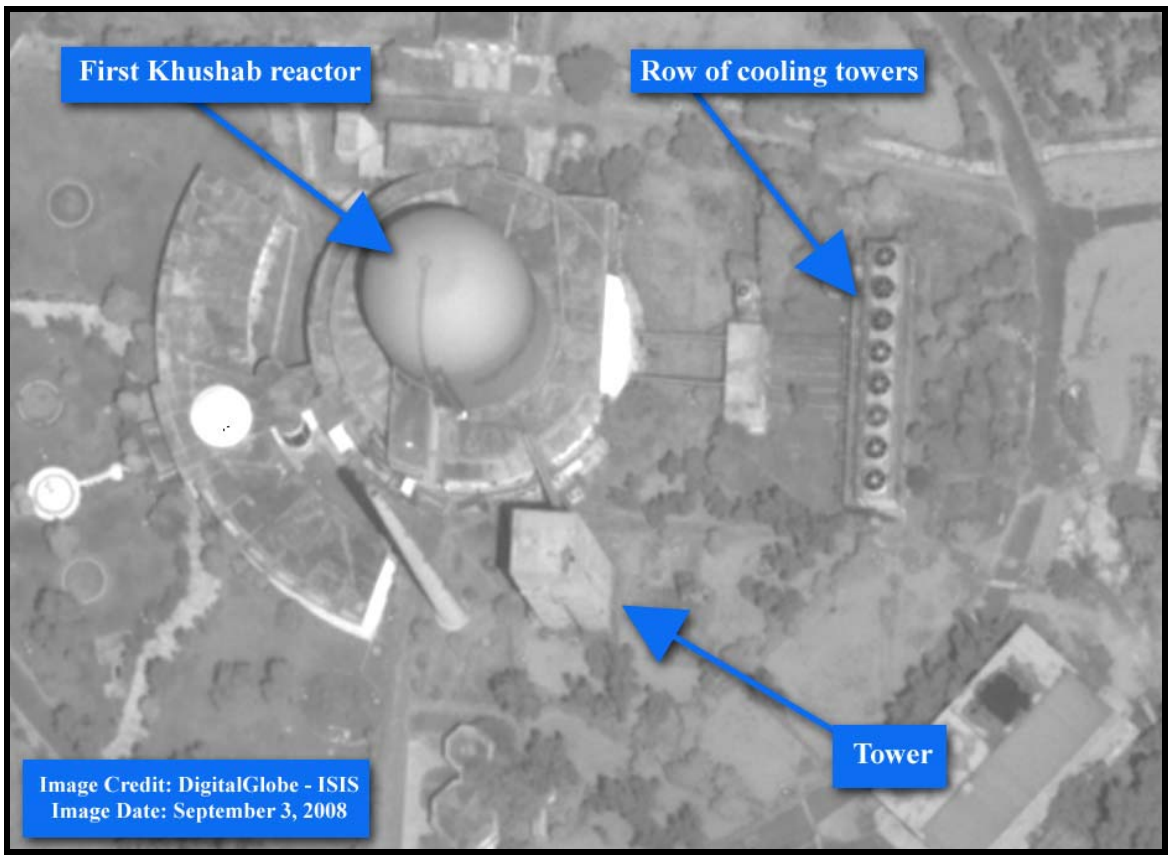

Figure 5. A close-up image of the first plutonium production reactor at Khushab. There is a row of eight cooling towers to the east of the reactor. Also adjacent to the reactor is a single tower.

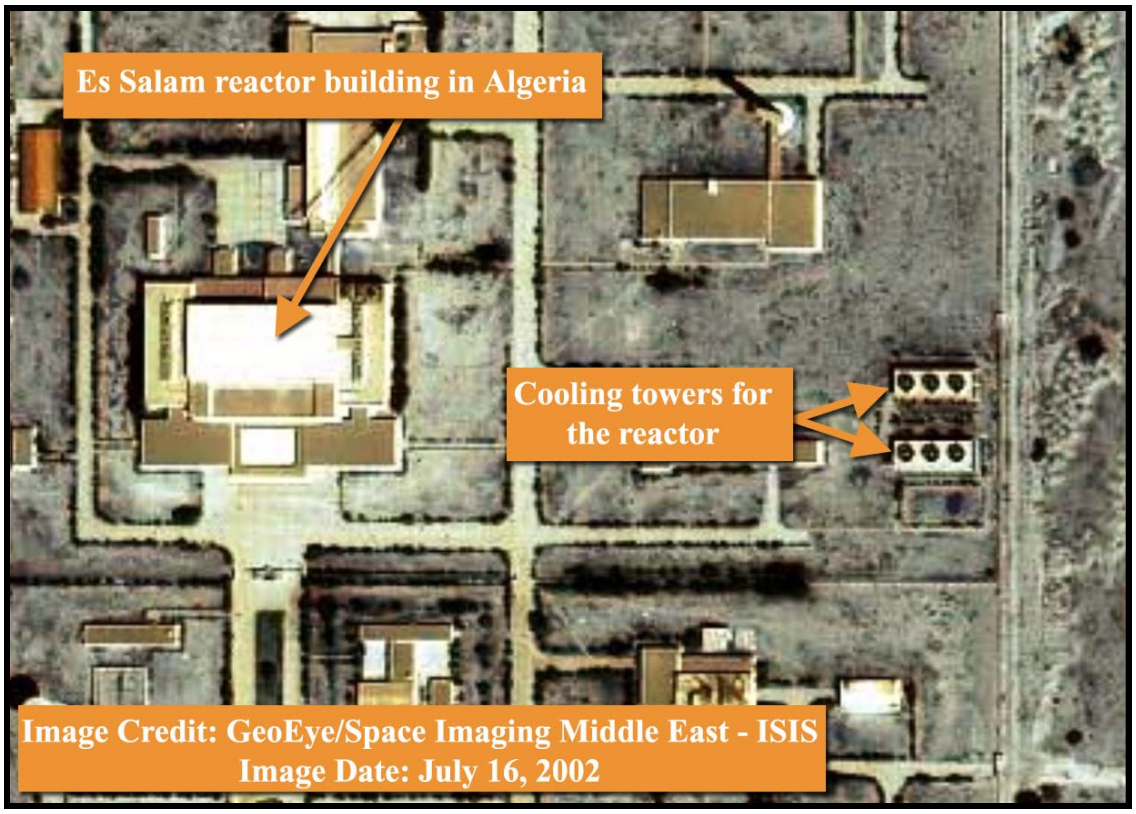

Figure 6. The Es Salam reactor in Algeria. To the right of the reactor are six cooling towers.

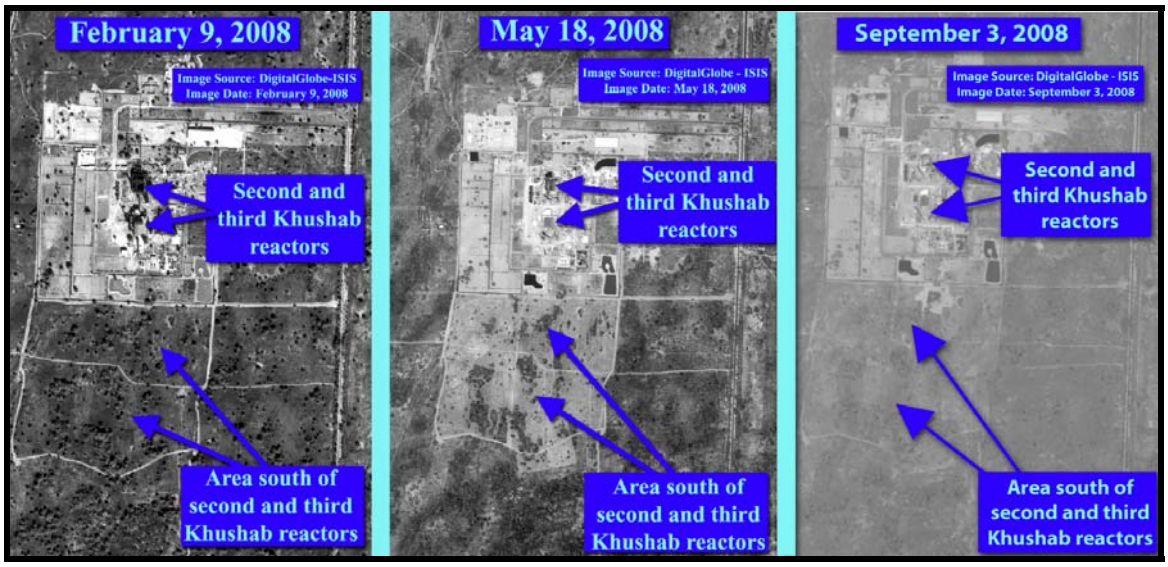

Figure 7. Comparison of February 9, 2008, May 18, 2008 and September 3, 2008 imagery of the second and third reactor site at Khushab. The area immediately south of the reactors appears to have been cleared, perhaps in preparation for further construction.