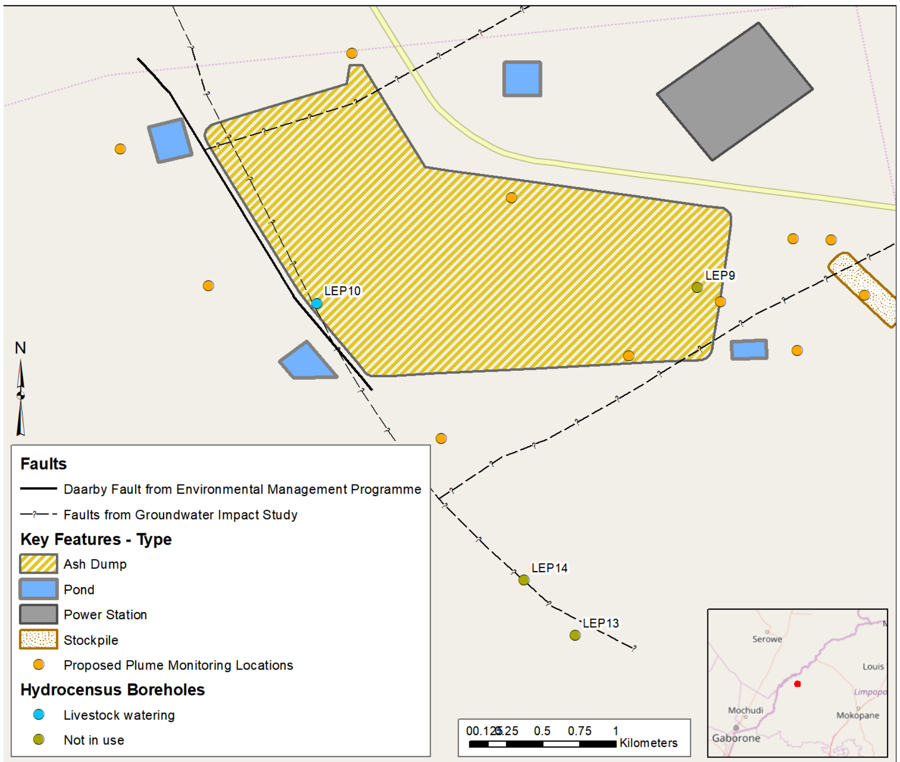
Potential Risks to Water Resources from the Proposed Thabametsi Power Plant



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ABBREVIATIONS

AMD	acid mine drainage
CCR	coal combustion residue or coal combustion residual
CFB	circulating fluidised bed
IWWMP	Integrated Water and Wastewater Management Plan
Km	kilometer
mbgl	meter below ground level
MCL	maximum contaminant level
MCLG	maximum contaminant level goal
mg/L	milligram per liter
MW	megawatt
MWh	megawatt-hour
NRC	National Research Council
PCD	pollution control dam
SWMP	storm water management plan
TDS	total dissolved solids
USEIA	United States Energy Information Administration
USEPA	United States Environmental Protection Agency
WULAR	Water Use License Application Report
WVDEP	West Virginia Department of Environmental Protection
WVEQB	West Virginia Environmental Quality Board

1. INTRODUCTION

Thabametsi Power Company (Pty) Ltd has applied for a Water Use License for its proposed Thabametsi Power Plant for approximately half of its full intended capacity of 1200 megawatt (MW) (Thabametsi FEIR).[1] If all necessary permits and licenses are approved for phase one of the project, this 630-MW coal-fired power plant—along with a coal ash dump and additional infrastructure—would be built approximately 26 kilometers (km) northwest of Lephalale in Limpopo Province (See Figure 1).

Smaller nearby settlements include Marapong and Steenbokpan (Thabametsi WULAR), and "the local population is dependent on groundwater" (Thabametsi IWWMP, p. 4-10). Five local boreholes are used for livestock watering (Thabametsi Groundwater Impact Study).

Once both phases of this project are built, the potential environmental impacts documented in this report would increase substantially. A wide range of such impacts have been identified by the applicant, including

- alteration of drainage,
- pipeline construction,
- riparian and biodiversity,
- surface water pollution,
- groundwater pollution,
- storm water and spillage,
- ash dump spillage,
- coal stock yard and acid mine drainage (AMD),
- catchment yield reduction, and
- residual impact (Thabametsi WULAR).

This report focuses on the potential risks to water resources from the coal ash dump, including its pollution control dams (PCDs). Millions of tons of coal combustion residues (CCRs) will be generated by the Thabametsi plant, which will be hazardous waste (Thabametsi FEIR). Risks to water resources from this CCR, if not properly mitigated during construction, during operation, and in perpetuity, are substantial, threatening groundwater, surface water, and wetlands.

The applicant documents risks to groundwater and the importance of mitigation measures:

> "The main potential sources of [groundwater] pollution are the ash dump and coal stockpile due to chemical weathering by oxidation of the sulphide containing minerals (mostly pyrite) in these structures, as well as other geochemical processes producing different contaminants. This is anticipated if no liners are implemented below the stockpile and ash dump at the site, or if the liners are leaking. Mitigatory measures in the form of liners could prevent groundwater contamination. A groundwater monitoring program needs to be implemented." (Thabametsi WULAR, p. 18)

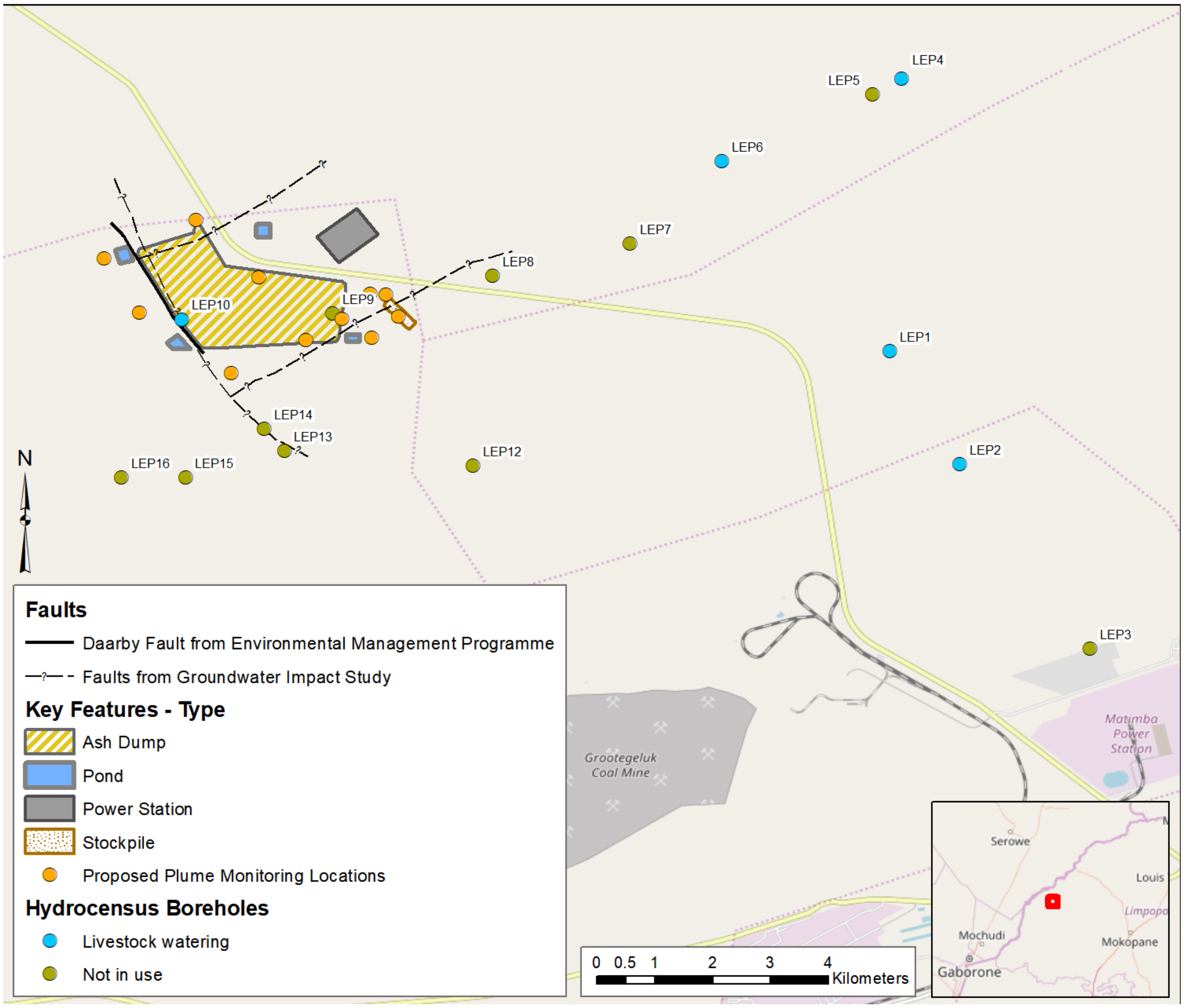
The applicant, rightfully, finds that the proposed location of the ash dump on a fault zone presents additional risk to groundwater:

> "The ash dump and stockpile are both planned to be deposited on ***fault zones which elevates the risk of groundwater contamination.*** Therefore, these facilities should either be repositioned or lined with appropriately designed liners and/or clays to reduce infiltration and percolation of leachates to the groundwater environment." (Thabametsi Groundwater Impact Study, p. 55, emphasis added)

[1] The environmental authorization process for this plant was started in 2013 by Exxaro Coal Proprietary Limited, before the applicant was changed to Thabametsi Power Project (Pty) Ltd in 2014 and then to Thabametsi Power Company (Pty) Ltd in 2015. (Thabametsi WULAR)

The applicant also documents risks to surface water quality should the mitigation measures fail: "Should the PCD's spill, the water quality within the Sandloop will become impaired." (Thabametsi WULAR, p. 18)

Figure 1: The location of the proposed Thabametsi Power Station and associated coal ash dump



Regarding wetlands, the applicant notes risks from both the coal ash dump and its associated PCDs:

- "Erosion and mobilization of ash from the ash dumps may result in the deposition of extra sediment into the wetlands. The extra ash sediment may also have negative water quality impacts. This activity is considered to be permanent (more than 15 years) in duration as it will occur for the extent of the operational phase." (Thabametsi Groundwater Impact Study, p. 23)
- "Ineffective management and poor maintenance of the pollution control dams associated with the power station may result in leaks as well as spillages from this infrastructure. The dirty water which makes its way to the wetland areas may impact on the quality of water of the systems which will have a greater impact on the ecological functioning of the system." (Thabametsi Groundwater Impact Study, p. 24)

Because of the impacts on human health and the environment that will occur absent mitigation measures, it is essential that the proposed mitigation measures be grounded in the most up-to-date science and research regarding pollutants associated with CCRs. As documented in this report, the proposed mitigation measure related to ongoing monitoring is not. It does not include the range of CCR-related trace metals that commonly discharge from CCR coal ash dumps.

Proposed mitigation measures must follow South African law and should also conform to best practices on the disposal of CCR, such as those in U.S. regulations. As documented in this report, the liner system proposed for the coal ash dump, and the location of the dump atop a fault zone, do not.

The siting of the coal ash dump and PCDs—along with the power plant and other associated infrastructure—should avoid areas that would pose the most threat to human health and the environment, should mitigation measures fail. The chosen site, atop a fault zone, is inadvisable because of the elevated risk of groundwater contamination should CCR-related pollutants leak from the ash dump or PCDs. Further, the chosen site, which partially sits atop a buffer area around the wetland, is inadvisable because of the importance and sensitivity of wetlands and the already existing cumulative impacts to wetlands based on industrial development near the proposed Thabametsi facility.

Overall, I find that the mitigation measures are insufficient, and the chosen site is unsuitable, to properly minimize the risk of groundwater, surface water, and wetland impacts from the very large proposed coal ash dump and related infrastructure. Once contamination occurs in groundwater, in particular, it may threaten human health and the environment for decades or longer.

2. COAL COMBUSTION RESIDUES

All coal-fired power plants generate CCRs. While the terms "CCR," "coal ash," "coal combustion product," "coal combustion byproduct," and "coal combustion waste" are often used interchangeably, this report follows the lead of the National Research Council (NRC) of the National Academies of Science and the United States Environmental Protection Agency (USEPA) and uses "CCR," to avoid implying that these materials are destined for particular fates. (NRC, 2006; Federal Register, 2015)[2]

While the Thabametsi plant would be one of the first CFB plants in South Africa, there is a wealth of information available from the United States regarding the generation of CCRs from these types of plants, its characteristics, and the threats that CFB CCRs pose to human health and the environment.

In general, CCRs contains high concentrations of trace elements that can discharge to groundwater and surface water, threatening human health and the environment. CCRs are by-products of coal combustion and include the non-combustible portion of the coal itself, plus residues from air pollution control technologies (NRC, 2006).

There are three general categories of CCR. The first category includes fly ash from a plant's particulate matter control device. The second includes materials from the boiler furnace: bottom ash (or bed material for CFB plants) and boiler slag. The third includes residues from air pollution control technologies. In the United States, fly ash represents 62 percent of CCRs, materials from the boiler furnace represent 18 percent, and residues from air pollution control represent 19 percent. (NRC, 2006) The proposed Thabametsi Power Station would use CFB technology and would therefore generate CCR associated with CFB plants, which can be bed material and/or fly ash. Approximately 78 percent of the CCR generated at Thabametsi would be bottom ash/bed material and 22 percent would be fly ash (Thabametsi Civil Design Report).

2.1 Trace elements

CFB plants burn coal, discard coal, and limestone, and CFB CCRs contain non-volatile trace elements, which are found in naturally-occurring minerals in the coal and tend to be concentrated in CCRs as a result of the combustion process. "Trace elements" refer to substances that, although found in low concentrations, still present threats to human health or the environment when they are found in water. These include, for example, antimony, arsenic, barium, beryllium, boron, cadmium, chromium, cobalt, copper, lead, mercury, molybdenum, nickel, selenium, silver, and thallium. (NRC, 2006)

Some trace elements have nutrient value at low concentrations, but trace elements can also be toxic at higher concentrations. For many of the trace elements found in CCR, USEPA has issued National Primary Drinking Water Regulations under the federal Safe Drinking Water Act, which are used to regulate and provide goals for drinking water quality. Maximum contaminant levels (MCLs) are enforceable standards, while maximum contaminant level goals (MCLGs) are non-enforceable public health goals.[3] (USEPA, 2009)

USEPA has issued MCLs and/or MCLs for many CCR-related trace elements. For example, the arsenic MCL, 0.01 milligrams per liter (mg/L) and MCLG (0 mg/L) protect against an increased risk of cancer, skin damage, and problems with circulatory systems. The antimony MCL and MCLG (both 0.006 mg/L) protect against an increase in blood cholesterol and a decrease in blood sugar. MCLs and/or MCLGs are also provided for

[2] Much of this chapter is taken directly from expert testimony provided by Evan Hansen before the West Virginia Public Service Commission, including direct quotations not marked as such in this chapter (Hansen, 2017).

[3] MCLGs are "The level of a contaminant in drinking water below which there is no known or expected risk to health. MCLGs allow for a margin of safety and are non-enforceable public health goals." (USEPA, 2009) MCLs are "The highest level of a contaminant that is allowed in drinking water. MCLs are set as close to MCLGs as feasible using the best available treatment technology and taking cost into consideration. MCLs are enforceable standards." (USEPA, 2009)

barium, beryllium, cadmium, chromium, copper, lead, mercury, selenium, and thallium to protect against a wide variety of human health problems. (USEPA, 2009)

More recently, USEPA notes “that risks from arsenic ingestion are linked to an increased likelihood of cancer in the skin, liver, bladder and lungs, as well as nausea, vomiting, abnormal heart rhythm, and damage to blood vessels…and risks from molybdenum ingestion are linked to higher levels of uric acid in the blood, gout-like symptoms, and anemia.” (Federal Register, 2015, p. 21451)

2.2 Regulation in the United States

In addition to federal regulation of many CCR-related trace elements under the Safe Drinking Water Act, states such as West Virginia have adopted surface water quality standards for many of these trace elements to protect human health and aquatic life under the federal Clean Water Act and corresponding state laws and regulations.[4]

Also in the United States, federal and state agencies have taken actions to protect human health and the environment specifically from trace elements in CCRs. At the federal level, USEPA issued regulations in 2015 regarding the disposal of CCR in landfills and impoundments that recognize: “The available information demonstrates that the risks posed to human health and the environment by certain CCR management units warrant regulatory controls.” (Federal Register, 2015, p. 21302) These regulations require the installation of groundwater monitoring wells at all CCR landfills and surface impoundments for the following constituents: antimony, arsenic, barium, beryllium, boron, cadmium, calcium, chloride, chromium, cobalt, fluoride, lead, lithium, mercury, molybdenum, pH, radium 226 and 228 combined, selenium, sulfate, thallium, and total dissolved solids (TDS).

The West Virginia Department of Environmental Protection’s (WVDEP’s) Coal Combustion By-Product Utilization Policy (WVDEP, 1998) requires the submission of an Application for Coal Ash Utilization when CCRs are proposed to be used on a coal mine. This form requires water quality sampling and analysis for a range of constituents: alkalinity, aluminum, antimony, arsenic, boron, cadmium, chloride, chromium, copper, hardness, iron, lead, manganese, nickel, pH, phenolics, selenium, silver, sulfate, thallium, TDS, total suspended solids, and zinc. Also, to conform with this Policy, Clean Water Act permits for coal mines that receive CCR are subject to additional surface and groundwater monitoring of CCR leachates for constituents that include trace elements.

Pennsylvania issued regulations on the beneficial use of coal ash in 2010. Water quality sampling is required for total concentrations of aluminum, antimony, arsenic, barium, beryllium, boron, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, molybdenum, nickel, potassium, selenium, silver, sodium, sulfur, thallium, vanadium and zinc. Water quality sampling is required for leachable concentrations of aluminum, ammonia, antimony, arsenic, barium, beryllium, boron, cadmium, calcium, chloride, chromium, cobalt, copper, fluoride, iron, lead, magnesium, manganese, mercury, molybdenum, nickel, nitrate, nitrite, potassium, selenium, silver, sodium, sulfate, thallium, vanadium and zinc.[5]

2.3 The Committee on Mine Placement of Coal Combustion Wastes

The NRC’s Committee on Mine Placement of Coal Combustion Wastes (“the CCR Committee”) was convened in response to a request from the U.S. Congress to examine “the health, safety, and environmental risks associated with using coal combustion wastes (CCWs) for reclamation in active and abandoned coal mines.” (NRC, 2006, p. 22). It was charged with addressing 11 points, which included, among others, the adequacy of surface water and groundwater data collection, impacts on aquatic life, whether CCRs and mines they are

[4] See, for example, West Virginia Code of State Rules § 47-2.
[5] Pennsylvania Code § 25-290.201.

being placed on are adequately characterized to ensure that monitoring programs are effective and water is not degraded, and whether clear performance standards are set and assessed for projects that use CCR for beneficial purposes. (NRC, 2006, p. 22-23)

While the CCR Committee observed that placing CFB CCR at coal mines can, in some situations, reduce the generation of acid mine drainage (AMD) due to its alkaline and cementitious properties, it also observed that "…some uncertainty remains regarding the long-term stability of cementitious ash and whether these low hydraulic conductivities can be maintained in the environment over time" (NRC, 2006, p. 67). The CCR Committee also documented that CCR contains high levels of trace elements and that CCR placement on coal mines can mobilize these pollutants and pollute groundwater and surface water, threatening human health and the environment. This pollution can occur quickly or can take place over months or years. Additional key observations and conclusions include the following:

- "…[T]he committee concludes that the presence of high contaminant levels in many CCR leachates may create human health and ecological concerns at or near some mine sites over the long term." (NRC, 2006, p. 4)
- "Contaminants derived from CCRs have the potential to enter drinking water supplies, surface water bodies, or biota at unacceptable concentrations…, thereby creating risks to human health and the environment." (NRC, 2006, p. 59)
- "Contaminants entering groundwater can be transported away from the CCR source area potentially resulting in the degradation of drinking water supplies or of surface-water quality." (NRC, 2006, p. 76)
- "Large contaminant plumes could form where leaching rates are moderate to high, where there is substantial water flow through the CCRs…, and where the CCR emplacement zone covers a sizable aereal extent." (NRC, 2006, p. 78)
- "…it may take many years before groundwater contamination from CCR mine disposal reaches down-gradient monitoring wells." (NRC, 2006, p. 78)
- "…CCRs may be effective in neutralizing AMD and therefore reducing the overall transport of contaminants from the mine site. However, several potentially toxic constituents in CCRs are mobile at neutral or alkaline pHs. Thus, the committee concludes that acid neutralization will not reduce the mobility of all contaminants of concern from the CCR." (NRC, 2006, p. 79)

2.4 Documented pollution from the placement of coal combustion residues on coal mines

2.4.1 *West Virginia*

A review of four sites in the U.S. state of West Virginia at which CCRs were placed on coal mine sites without liners reveals trace element water quality impacts linked with the use of CCR. These sites demonstrate how important it is for mitigation measures, including the liner, to work flawlessly at Thabametsi, because if the Thabametsi liner system fails, pollution similar to that witnessed at these sites would be expected.

In the four West Virginia sites described here, trace elements were found in outfalls, downstream surface waters, and/or in groundwater. At two sites, very high levels of conductivity and TDS, which indicate potential pollution from CCR, were also found. Data for these four sites included original field monitoring data conducted by the author of this report and/or field monitoring data collected by permittees or their consultants. These sites include: (1) Stacks Run Refuse Site Extension, (2) Albright, (3) CORESCO, and (4) New Hill West.

Results for the first two sites, the Stacks Run Refuse Site Extension and Albright, are summarized in a report entitled "Water Quality Impacts of Coal Combustion Waste Disposal in Two West Virginia Coal Mines" (Hansen and Christ, 2005)

The Stacks Run Refuse Site Extension covered 59 acres and was permitted in 1991. No coal was removed; instead, the site was to be used to dispose of coal refuse and CFB CCR. CCR was first applied at this site in early 1992 and continued for about seven-to-ten years. Based on permitted amounts, an estimated 1.5 to 2.2 million tons of CCR may have been placed at this site. (Hansen and Christ, 2005)

The Albright site was a 47-acre surface mine that was reclaimed with the use of CCR as backfill. Patriot received its permit for this site in 1989, and as of 2000, CCR placement was completed and the site was reclaimed. CCR came from three sites, and the two larger sites provided CFB CCR. (Hansen and Christ, 2005)

Permittee self-monitoring data was analyzed outfalls, instream locations, and groundwater. Very high levels of several trace elements were found in surface and groundwater downgradient from both sites. High concentrations of these pollutants often occurred when pH effects from CFB CCR were observed. High concentrations of selenium and thallium were found at the Stacks Run Refuse Site Extension almost a decade following the beginning of mine disposal of CCR.

Other key conclusions included the following:

- Monitoring documented trace metal pollution in surface waters and groundwater, and patterns of pollution over time suggested that CCR contributed to and/or mobilized trace elements into the receiving stream.
- Very high selenium and arsenic levels are also documented in groundwater beneath the Albright site.
- Very high levels of selenium have been documented downgradient from CCR disposal sites at these mines. Self-monitoring data documented selenium concentrations up to 120 times the surface water quality standard in a stream near the Stacks Run Refuse Site Extension.

Results for the third site, CORESCO, are summarized in a report entitled "Water Pollution in Crafts Run and Robinson Run, Monongalia County, West Virginia" (Hansen and Askins, 2011).

Original field monitoring data and permittee self-monitoring data were compiled in this report. Three CORESCO Clean Water Act permits discharged to Crafts Run and Robinson Run at that time. The first was for CORESCO's preparation plant, related facilities, and two refuse disposal areas. The second covers the Crafts Run Refuse Disposal facility. The third regulates discharges from the Crooked Run Quarry. The primary purpose of each of the permits was coal waste disposal. Each refuse disposal area accepted large amounts of CCR. Evidence of CCR-related trace element pollution was found in several locations along Crafts Run and Robinson Run. While boron was not detected upstream, boron concentrations were significantly higher in all other locations. Several outfalls discharged arsenic and selenium at concentrations that exceeded surface water quality criteria. Beryllium concentrations at two instream monitoring locations exceeded the surface water quality criterion. The maximum arsenic concentration at one instream monitoring location exceeded the surface water quality criterion. Also, very high levels of conductivity (exceeding 1,000 and reaching over 2,500 µmhos/cm) and TDS (exceeding 1,000 and reaching over 3,000 mg/L) were recorded. These measurements indicate potential pollution from CCR. (Hansen and Askins, 2011)

Results for the fourth site, New Hill West, are summarized in expert testimony provided by the author of this report before the West Virginia Environmental Quality Board related to a Clean Water Act permit (WVEQB, 2011). Permittee self-monitoring data from the New Hill Surface Mine Complex, where CCR has been placed as part of recent mining operations, show discharges of selenium at or above West Virginia's surface water quality criterion. Also, permittee self-monitoring data from a nearby surface mine that was mining the same coal seam and was using CCR in a similar manner as the New Hill West mine showed levels of arsenic many times higher than the West Virginia surface water quality criterion. Based on this testimony and the testimony of others, the Environmental Quality Board issued an Order that remanded this permit modification to WVDEP and required WVDEP, among other things, to include an effluent limitation for selenium and to perform a reasonable potential analysis for arsenic. In addition, conductivity concentrations reached 1,316 µS/cm from an outfall and ranged from approximately 1,300 to 2,100 in the receiving stream. TDS concentrations were also very high. The selenium, arsenic, conductivity, and TDS measurements indicate potential pollution from CCR. (WVEQB, 2011)

2.4.2 *Pennsylvania*

A 2007 report examined monitoring data from 15 sites at which CCR was placed on coal mines in the U.S. state of Pennsylvania, to determine if any degradation of groundwater or surface water has occurred. The hypothesis being tested was whether the data allow one to state definitively that the use of CCR has not caused or contributed to contamination. Detailed analyses of these sites revealed the following deficiencies:

1. "characterization of sites insufficient to establish monitoring systems that will detect pollution from ash;
2. inadequate numbers of groundwater and surface water monitoring points;
3. not enough baseline data;
4. insufficient frequency of data collection;
5. significant lapses in data collection;
6. analysis of monitoring samples at detection limits too high to monitor the creation of toxic conditions;
7. failure to monitor indicator parameters that would readily differentiate ash contamination from mine pollution;
8. inadequate records describing dates, quantities, and locations of ash placement; and
9. the absence of monitoring after the completion of ash placement." (Stant et al., 2007, p. vi)

Even so, the authors found clear indications of water quality degradation due to the placement of CCR at coal mine sites:

> "Despite these deficiencies, which occurred in varying degrees in all permits, substantive evidence exists of degradation of groundwater and/or surface water from [CCR] in two-thirds of the permits, based on rising trends in concentrations of [CCR] contaminants at relevant ash monitoring points. Specifically, the authors found that in 10 of the 15 minefills studied, coal ash contributed to degraded water quality. In three other cases, degradation was occurring but the data were insufficient to differentiate the causes of the degradation. For one minefill, water quality improvement occurred in some parameters as a result of gob removal and ash placement while coal ash appeared to cause degradation in other parameters, and at one mine site, water quality improvement occurred as a result of remining and ash placement. Even in these last two cases however, the authors found that post-project monitoring was far too brief to assert that water quality improvements were more than temporary." (Stant et al., 2007).

2.5 Other studies related to water quality impacts of coal combustion residues

Many peer-reviewed journal articles describe pollutants associated with CCRs. A review article of over 90 publications on CCRs finds: "Coal ash is viewed as a major potential source of release of many environmentally sensitive elements to the environment." (Izquierdo and Querol, 2012, p. 54) It further clarifies that the mobility of certain trace elements in the ash varies by pH, with some elements mobilized at low pH and other elements mobilized at low pH (Izquierdo and Querol, 2012). Other articles focus on CCR-related pollutants in South Africa (Koukouzas et al., 2011), Bangladesh (Lemly, 2017), India (Pandey et al., 2011), and China (Ruwei et al., 2013).

3. POTENTIAL RISKS TO WATER RESOURCES FROM THE PROPOSED THABAMETSI POWER PLANT

3.1 The proposed coal ash dump is very large

Because it is so large, the proposed Thabametsi coal ash dump presents a unique threat to water resources.

The proposed coal ash dump is designed to hold 200 million tons of CCR over 40 years[6] (Thabametsi Environmental Management Programme) and will cover 270 hectares (Thabametsi WULAR). An overland ash conveyor will transport ash at a rate of 280 tons/hour (Thabametsi WULAR).

Elsewhere in the record, the applicant calculates different tonnages. For example, the FEIR calculates that the Thabametsi plant will produce 257 million tons of CCR over 40 years—or about 29 percent more CCR than the coal ash dump is designed for (Thabametsi FEIR).[7] In a third location in the record, the applicant's Civil Design Report estimates CCR generation to be 95 million tons over 40 years, which is less than half the CCR for which the dump is designed (Thabametsi Civil Design Report).[8]

These discrepancies in the total tonnage of CCRs generated by the Thabametsi plant must be addressed by the applicant.

Assuming that the figure in the Layout Plan is the most accurate (200 million tons), the Thamabetsi coal ash dump would be much larger than others recently proposed in South Africa. For example, the proposed coal ash dump for the Khanyisa Power Station, near Emalahleni in Mpumalanga Province, would need to hold approximately 47 million tonnes of CCR generated over 25 years, or 1.9 million tonnes per year.[9] This converts to 52 million tons of CCR, or approximately one-fourth of the size of the proposed Thabametsi coal ash dump.

And the proposed 600-MW KiPower Power Station would produce about 49 million tons of CCR over 30 years (Campbell, 2017)—similar to the amount produced at Khanyisa, and again approximately one-fourth of the size of the proposed Thabametsi coal ash dump.

Because the proposed coal ash dump is so large, three large PCDs are proposed (33,000, 56,000, and 75,000 cubic meters), although during the initial phase of the project, only one PCD with a storage volume of 56,000 cubic meters[10] would be built (Thabametsi WULAR).

The more CCR that is placed at the coal ash dump, the larger the mass of CCR-related pollutants that will be stored in the dump and the greater the volume of CCR-related pollutants that will be in the leachate. If one or more mitigation measures fail at the dump or the PCDs, more CCR-related pollutants will be released to groundwater, with greater potential to harm human health and the environment—as compared with a release from a smaller dump. If the larger mass of CCR calculated in the FEIR is correct, then an even greater mass of harmful CCR-related pollutants will be stored at the ash dump and may be released to groundwater.

[6] The detailed layout plan for the coal ash dump states: "Ash and Waste Dump (for 40 years), Required Total to Dump = 180 000 000 tons, Actual Total of Dump = 200 000 000 tons (Density = 1)" (Thabametsi Environmental Management Programme, Appendix A)

[7] The FEIR states that 16,000 tonnes per day of hazardous waste, including ash and sorbent, will be generated (Thabametsi FEIR). This converts to 257 million tons over 40 years.

[8] The Civil Design Report states that 98,894,050 cubic meters of CCR will be generated over 30 years, which would equal 131,858,733 cubic meters over 40 years. Applying the density provided in the same report, 0.72 ton/cubic meter, this converts to 95 million tons over 40 years. (Thabametsi Civil Design Report)

[9] This figure is based on numbers provided for a 450-MW plant (Khanyisa Environmental & Social Impact Assessment Report), expanded for a 600-MW plant.

[10] The size of this PCD is 54,000 cubic meters in the detailed layout plan (Thabametsi Environmental Management Programme).

3.2 The applicant's estimated coal combustion residue production rate appears to be incorrect and may grossly underestimate CCR generation

The applicant does not provide a detailed accounting of its assumed CCR production rate. Assuming that the plant's capacity factor, or dispatch factor, is 100%, and that the plant produces 280 tons of ash per hour (the rate at which the ash conveyor operates), then the CCR production rate would equal 0.44 tons CCR per MWh. For comparison, the average CCR production rate at CFB plants in the United States is 0.84 tons CCR per MWh (USEIA, 2018).[11] The rate projected by the applicant for the Thabametsi Power Station appears to be low by about one-half.

CFB plants generate significantly more CCR per MWh than standard plants. In the United States, for example, the average CCR production rate at CFB plants, 0.84 tons CCR per MWh, is about 19 times higher than the average CCR production rate at standard units: 0.05 tons CCR per MWh.[12]

The applicant should review and revise its estimate of the amount of CCR generated each year at the Thabametsi Power Station to ensure that it includes both fly ash and bottom (bed) ash, and that the rate is consistent with existing plants in other countries. If the CCR production rate should, in fact, be doubled, then a coal ash dump of twice the planned size would be required. Doubling the size of an already-large coal ash dump would store an even larger mass of CCR-related pollutants on an inappropriate site, with the potential to further harm human health and the environment.

3.3 The proposed coal ash dump threatens groundwater

The proposed coal ash dump threatens groundwater because it is sited on top of faults. In addition, the coal ash dump will impact Borehole LEP10.

It is not disputed that the proposed coal ash dump sits atop faults. According to the applicant:

> "A number of faults traverse the proposed power station site. 2 of the approximately eastwest trending faults and 1 approximately north-south trending fault lies beneath the area of the proposed ash dump. The north-south trending fault is called the Daarby Fault and it runs though the east-west faults displacing them slightly." (Thabametsi Groundwater Impact Study, p. 11)

The applicant's Layout Plan maps the north-south trending Daarby Faultline, which is in between the western edge of the proposed coal ash dump and the eastern edge of two of the three PCDs, including the PCD proposed to be built first. The faultline is within approximately 100 meters of the dump and the PCDs. (Thabametsi Environmental Management Programme) Figure 2 maps the Daarby Faultline from the Environmental Management Programme's Layout Plan as a thick black line.

While it maps the Daarby Fault, the Layout Plan ignores the two east-west trending faultlines, which are described by the applicant as underlying the proposed ash dump. These faultlines are illustrated in a more general geological map of the area (Groundwater Impact Study). Figure 2 maps the faultlines from the Groundwater Impact Study as thinner dashed lines. Overlaying these maps illustrates that the east-west faultlines do, in fact, appear to underlie the proposed ash dump.

In the United States, new CCR landfills must be located at least 60 meters from faults:

> "New CCR landfills…must not be located within 60 meters (200 feet) of the outermost damage zone of a fault that has had displacement in Holocene time unless the owner or operator demonstrates by

[11] This calculation is based on data reported to the U.S. Energy Information Administration (USEIA) for fluidized bed combustion plants that report both fly ash and bottom (bed) ash from fluidized bed combustion units.
[12] These standard units may include different fuels at the same plant, including some fuels that do not generate ash; however, this factor only accounts for a portion of the 19-fold difference between CCR production rates.

> the dates specified in paragraph (c) of this section that an alternative setback distance of less than 60 meters (200 feet) will prevent damage to the structural integrity of the CCR unit."[13]

According to the applicant:

> "Fault zones may act as preferential pathways for groundwater movement due to high levels of fracturing and subsequent porosity. These zones normally cross cut the horizontally deposited sediments at 30 to 60 degree angles. These zones are often associated with groundwater and targeted for abstraction boreholes. ***In the case of the Proposed Thabametsi Coal Fired Power Station Project area, major fault zones are abundant and these zones will most likely act as the major contaminant transport pathways.***" (Thabametsi Groundwater Impact Study, p. 39, emphasis added)

In addition to acting as a major contaminant transport pathway, a fault may make it difficult or impossible to effectively monitor groundwater—should the fault direct contaminants away from monitoring wells. Siting a coal ash dump on top of faults would therefore also increase the risk that the groundwater monitoring program is insufficient (See Section 3.4).

Siting the coal ash dump and PCDs so close to the Daarby Fault, and directly on top of two additional faults, presents significant risks to groundwater because they will facilitate rapid movement of contaminants from the ash dump, should CCR-related pollutants be released. The faults may also make it difficult or impossible to effectively monitor groundwater.

Further, the applicant's omission of the east-west faults from the Layout Plan is an important omission. The Layout Plan should be revised to include the two east-west trending faults that underlie the proposed coal ash dump, and the applicant's modeling of the potential pollution plume must include all nearby faults.

The Centre for Environmental Rights, in its Objections to the Integrated Water Use License Application, asserts that siting the coal ash dump atop a fault zone does not conform to Thabametsi's EA:

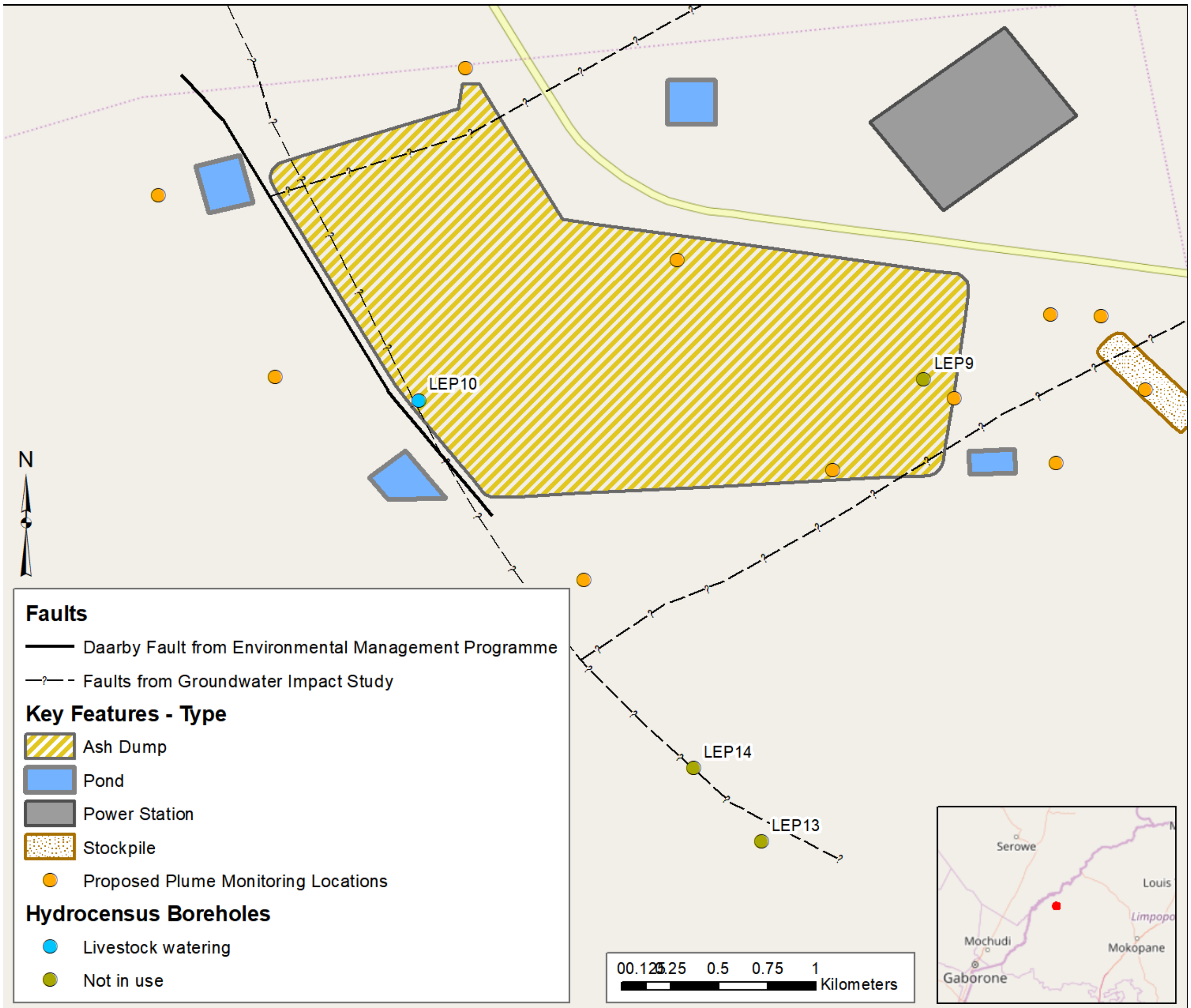
> "Thabametsi's EA, at section 17.2.11, stipulates that 'any solid materials associated with the power station such as ash dumps and stockpiles need to be located away from the faults'." (Centre for Environmental Rights, 2017, p. 4)

The proposed siting of the coal ash dump does not conform to the EA, because it is not "located away from faults."

Also related to groundwater impacts is the proposed dump's impacts on existing boreholes. According to the applicant: "a single privately owned borehole (LEP10) is likely to be destroyed during the establishment of the ash dump, which can be considered to be an impact on groundwater availability" (Thabametsi IWWMP, p. 4-15) Borehole LEP10 is used for livestock watering (See Figure 2). Further, this borehole could become a pathway for contaminant transport to the aquifer, if it is not sealed properly, and if mitigation measures are not successful.

[13] U.S. Code of Federal Regulations § 40-257.62(a).

Figure 2: Faults in the immediate vicinity of the coal ash dump and pollution control dams



3.4 The groundwater monitoring program is insufficient

A well-designed and properly implemented long-term groundwater monitoring program is an essential mitigation measure; however, the program proposed for the Thabametsi site is insufficient because it omits key CCR-related pollutants, it does not require monitoring at wells surrounding the site in all directions, and it does not account for the area's faults, which may make it difficult or impossible to effectively monitor groundwater.

The applicant's groundwater monitoring program envisions monitoring for an abbreviated set of indicator parameters, and then switching to a full analysis of a wider range of parameters if needed (Thabametsi Groundwater Impact Study). There are several flaws with this approach.

The first flaw is that the monitoring plan does not specify what changes or thresholds would trigger the use of the full range of parameters.

The second flaw is that the monitoring plan apparently envisions revising the set of parameters frequently: "The parameters should be revised after each sampling event…" (Thabametsi Groundwater Impact Study, p. 59). Adding and removing parameters—and switching back and forth between the abbreviated and full sets of parameters—is not conducive to collecting a solid dataset upon which to make well-reasoned management decisions.

The third flaw is that certain CCR-related pollutants will not be included in the monitoring program. As described above in Chapter 2, regulations in the United States require the installation of groundwater monitoring wells at all CCR landfills for the following constituents: antimony, arsenic, barium, beryllium, boron, cadmium, calcium, chloride, chromium, cobalt, fluoride, lead, lithium, mercury, molybdenum, pH, radium 226 and 228 combined, selenium, sulfate, thallium, and TDS.

The following CCR-related pollutants are absent from the proposed Thabametsi groundwater monitoring program: antimony, arsenic, barium, beryllium, boron, cadmium, cobalt, lead, lithium, molybdenum, radium 226 and 228 combined, selenium, and thallium.

A full set of CCR-related pollutants should be included in the groundwater monitoring program, and the program should consistently monitor every one of these pollutants during each monitoring sweep. The following CCR-related pollutants should be added: antimony, arsenic, barium, beryllium, boron, cadmium, cobalt, lead, lithium, molybdenum, radium 226 and 228 combined, selenium, and thallium.

In addition to omitting important CCR-related parameters, the proposed groundwater monitoring program will not collect samples in the proper locations. As described by the applicant, the 16 existing boreholes will be used. As illustrated above in Figure 1, two of the 16 boreholes are under the proposed ash dump and presumably will not be available for monitoring (LEP9 and LEP10). None of the other 14 boreholes are located to the north or west of the proposed ash dump, even though the applicant's own plume modeling shows that any leak of pollutants from the dump would generally travel toward the west.

To remedy this oversight, the applicant proposes a monitoring network extension; these 11 proposed monitoring wells are illustrated as orange circles in Figure 2. While these locations appropriately encircle the proposed ash dump, the extension of the monitoring system to include these wells is purely speculative:

> "In Table 12 [of the Groundwater Impact Study] a monitoring network extension is proposed. These boreholes should be added to boreholes mentioned in Table 5 [of the Groundwater Impact Study] as part of an extended monitoring network and should be sited using geophysical methods. The monitoring positions are indicated in Figure 24 [of the Groundwater Impact Study] and ***show potential drilling positions. However, these positions are purely indications.*** " (Thabametsi Groundwater Impact Study, p. 61, emphasis added).

The additional 11 proposed monitoring wells that encircle the proposed ash dump site should be definitively incorporated into the groundwater monitoring plan, rather than simply being proposed. Without monitoring locations to the west of the dump, which is the direction that a pollution plume is predicted to flow, any pollution emanating from the dump would not be found via the groundwater monitoring program. This would threaten the health of any local population in that direction that is dependent on groundwater.

As described above in Section 3.3, the coal ash dump is proposed to be sited on top of faults, which would act as major contaminant transport pathways should contaminants be released from the site. In addition, faults may make it difficult or impossible to effectively monitor groundwater—should the fault direct contaminants away from monitoring wells.

Siting the coal ash dump on top of faults may make it difficult or impossible to effectively monitor groundwater.

3.5 The surface water monitoring program may not even be conducted

Surface water monitoring may not even be conducted in the vicinity of the Thabametsi coal ash dump. The applicant proposes a set of mitigation measures for surface water impacts, including a surface water monitoring program. However, immediately after describing this program, a footnote states: "The monitoring of surface water bodies may be omitted due to far distance from the resource." (Thabametsi WULAR, p. 19)

Assuming that this footnote is correct, there is a likelihood that no surface water monitoring will be conducted. It is imperative that surface water monitoring be conducted to ensure that CCR-related pollutants do not reach surface waters. If they do, then surface waters would transport these pollutants quickly downstream, presenting risks to human health and the environment. It is also imperative that the surface water monitoring program include the CCR-related pollutants described above in Chapter 2, which are also recommended for the groundwater monitoring program in Section 3.4.

3.6 The liner does not conform to accepted standards

If the coal ash dump or PCD liner were to fail, then CCR-related pollutants would drain into groundwater, threatening human health and the environment. The coal ash dump liner does not conform to accepted standards and is therefore more likely to fail.

The applicant mentions liner components in its description of the leakage detection drains:

> "Geotextile followed by HDPE will be laid onto the graded surface with a 300mm of compacted earth cover. The geotextile will be for protection of the HDPE film which will be the impermeable layer." (Thabametsi Civil Design Report, Section 2.13)

This configuration is consistent with the Drawing 23019-D4006 in the Civil Design Report, which notes an "HDPE Liner with Geotextile" and an "Earth Lining for HDPE Protection (300 Thk.)" below the coal ash dump (Thabametsi Civil Design Report, Drawing 23019-D4006).[14]

The same drawing describes the following layers, from top to bottom:

- "Ash layer
- Earth liner 300 mm (HDPE Protection)
- Geomembrane (GM – 1.5mm thick HDPE liner. Liner to comply to GRI test method GM13.
- Geosynthetic Clay Liner (GCL) – GCL with a hydraulic conductivity less than a 300mm Compacted Clay Liner (CCL). GCL to be double needle punched with a natural sodium bentonite clay core.
- Compacted In-Situ Material" (Thabametsi Civil Design Report, Drawing 23019-D4006).[15]

For comparison, federal regulations in the United States provide the following requirements for CCR landfill liners:

> "(b) A composite liner must consist of two components; the upper component consisting of, at a minimum, a 30-mil geomembrane liner (GM), and the lower component consisting of at least a two-foot layer of compacted soil with a hydraulic conductivity of no more than 1×10^{-7} centimeters per second (cm/sec). GM components consisting of high density polyethylene (HDPE) must be at least 60-mil thick. The GM or upper liner component must be installed in direct and uniform contact with the compacted soil or lower liner component. The composite liner must be:

[14] This portion of the drawing, while clearly showing the coal ash dump, labels the dump as the "Ash Stock Pile."

[15] This portion of the drawing, which labeled "Proposed Coal Stock Yard Liner Layerworks, Class C Liner with Ash Layer," is presumed to illustrate the liner system for the coal ash dump because the top layer is an ash layer and because the other layers are consistent with descriptions of the liner in the text.

> (1) Constructed of materials that have appropriate chemical properties and sufficient strength and thickness to prevent failure due to pressure gradients (including static head and external hydrogeologic forces), physical contact with the CCR or leachate to which they are exposed, climatic conditions, the stress of installation, and the stress of daily operation;
>
> (2) Constructed of materials that provide appropriate shear resistance of the upper and lower component interface to prevent sliding of the upper component including on slopes;
>
> (3) Placed upon a foundation or base capable of providing support to the liner and resistance to pressure gradients above and below the liner to prevent failure of the liner due to settlement, compression, or uplift; and
>
> (4) Installed to cover all surrounding earth likely to be in contact with the CCR or leachate."[16]

Converting the thicknesses specified in the U.S. regulations to millimeters, which are used by the applicant, the U.S. regulation requires the geomembrane liner to be at least 0.76 millimeters thick, or 1.5 millimeters thick if it is an HDPE liner. The applicant specifies a thickness of 1.5 millimeters for the top HDPE geomembrane liner, which conforms to the U.S. regulation.

Under the HDPE liner, U.S. regulations require at least a two-foot layer of compacted soil with a hydraulic conductivity of no more than 1×10^{-7} cm/sec, while the applicant proposes the use of a geosynthetic clay liner with a hydraulic conductivity less than a 300-mm compacted clay liner. The applicant does not specify the thickness of the geosynthetic clay liner, nor does the applicant specify whether the hydraulic conductivity of the geosynthetic clay liner would conform to U.S. regulations to be no more than 1×10^{-7} cm/sec.

The only indication of the hydraulic conductivity of the geosynthetic clay liner is that the applicant states that it will be less than the hydraulic conductivity of a 300-mm compacted clay liner. However, 300 mm is approximately 1 foot, which is only half the thickness of clay liners required by U.S. regulations.

Additional information about the geosynthetic clay liner is needed to judge whether or not it conforms to U.S. regulations, which in my opinion are the minimum accepted standards necessary to prevent pollution. Until that information is provided, it is assumed that the coal ash dump liner does not conform to accepted standards and is therefore more likely to fail than a liner that conforms to those standards.

[16] U.S. Code of Federal Regulations § 40-257.70(b).

4. CONCLUSIONS

Phase one (630 MW) of the proposed 1200-MW Thabametsi Power Plant, coal ash dump, and additional infrastructure would have a wide range of environmental impacts. This report focuses on the potential risks to water resources from the coal ash dump, including its PCDs.

Millions of tons of CCRs would be generated by the Thabametsi plant, which would be hazardous waste. Risks to water resources from this CCR, if not properly mitigated during construction, during operation, and in perpetuity, are substantial, threatening groundwater, surface water, and wetlands.

According to the applicant, the local population is dependent on groundwater, and five local boreholes are used for livestock watering.

My conclusions are as follows:

1. Overall, I find that the mitigation measures are insufficient, and the chosen site is unsuitable, to properly minimize the risk of groundwater, surface water, and wetland impacts from the very large proposed coal ash dump and related infrastructure. Once contamination occurs in groundwater, in particular, it may threaten human health and the environment for decades or longer.
2. The applicant calculates three different total tonnages of CCR generated by the Thabametsi plant that would be disposed of at the proposed coal ash dump. These discrepancies must be addressed by the applicant.
3. The proposed coal ash dump is very large. The more CCR that is placed at the coal ash dump, the larger the mass of CCR-related pollutants that will be stored in the dump and the greater the volume of CCR-related pollutants that will be in the leachate. If one or more mitigation measures fail at the dump or the PCDs, more CCR-related pollutants will be released to groundwater, with greater potential to harm human health and the environment—as compared with a release from a smaller dump. If the larger mass of CCR calculated in the FEIR is correct, then an even greater mass of harmful CCR-related pollutants will be stored at the ash dump and may be released to groundwater.
4. The applicant's estimated CCR production rate appears to be incorrect and may grossly underestimate CCR generation. The applicant should review and revise its estimate of the amount of CCR generated each year at the Thabametsi Power Station to ensure that it includes both fly ash and bottom (bed) ash, and that the rate is consistent with existing plants in other countries. If the CCR production rate should, in fact, be doubled, then a coal ash dump of twice the planned size would be required. Doubling the size of an already-large coal ash dump would store an even larger mass of CCR-related pollutants on an inappropriate site, with the potential to further harm human health and the environment.
5. The proposed coal ash dump threatens groundwater.
    - Siting the coal ash dump and PCDs so close to the Daarby Fault, and directly on top of two additional faults, presents significant risks to groundwater because they will facilitate rapid movement of contaminants from the ash dump, should CCR-related pollutants be released. The faults may also make it difficult or impossible to effectively monitor groundwater.
    - Further, the applicant's omission of the east-west faults from the Layout Plan is an important omission. The Layout Plan should be revised to include the two east-west trending faults that underlie the proposed coal ash dump, and the applicant's modeling of the potential pollution plume must include all nearby faults.
    - The proposed siting of the coal ash dump does not conform to the EA, because it is not "located away from faults."

6. The groundwater monitoring program is insufficient.
    - A full set of CCR-related pollutants should be included in the groundwater monitoring program, and the program should consistently monitor every one of these pollutants during each monitoring sweep. The following CCR-related pollutants should be added: antimony, arsenic, barium, beryllium, boron, cadmium, cobalt, lead, lithium, molybdenum, radium 226 and 228 combined, selenium, and thallium.
    - The additional 11 proposed monitoring wells that encircle the proposed ash dump site should be definitively incorporated into the groundwater monitoring plan, rather than simply being proposed. Without monitoring locations to the west of the dump, which is the direction that a pollution plume is predicted to flow, any pollution emanating from the dump would not be found via the groundwater monitoring program. This would threaten the health of any local population in that direction that is dependent on groundwater.
    - Siting the coal ash dump on top of faults may make it difficult or impossible to effectively monitor groundwater.
7. Assuming that a footnote in the WULAR is correct, there is a likelihood that no surface water monitoring will be conducted. It is imperative that surface water monitoring be conducted to ensure that CCR-related pollutants do not reach surface waters. If they do, then surface waters would transport these pollutants quickly downstream, presenting risks to human health and the environment. It is also imperative that the surface water monitoring program include the CCR-related pollutants described above in Chapter 2, which are also recommended for the groundwater monitoring program in Section 3.4.
8. Additional information about the geosynthetic clay liner is needed to judge whether or not it conforms to U.S. regulations, which in my opinion are the minimum accepted standards necessary to prevent pollution. Until that information is provided, it is assumed that the coal ash dump liner does not conform to accepted standards and is therefore more likely to fail than a liner that conforms to those standards.

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