Comments on TPM LLC Draft Mining Land Use Plan (and supporting documents)

Submitted to: Georgia EPD

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Preface

The Georgia Surface Mining Law stipulates that mine operations protect the environment and resources of the State and that mine operations shall be consistent with land uses in the area of the mine (GA - GAC). My comments evaluate deficiencies in the MLUP with respect to providing assurance to the above issues and provide evidence that the MLUP clearly does not protect important environmental resources of the state.

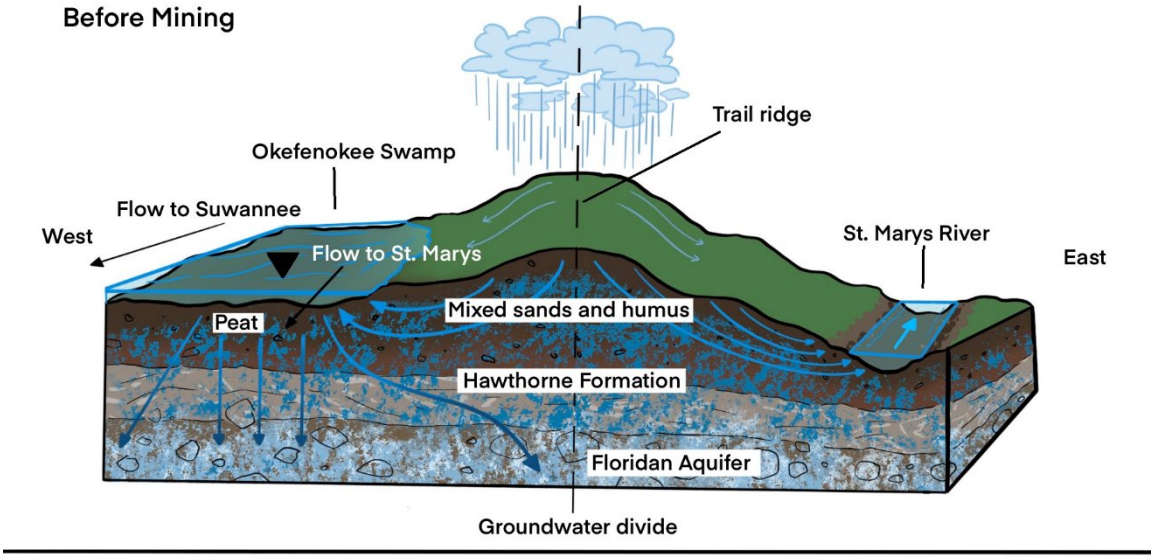
Issue 1. The MLUP and Water Use Plan do not recognize the drought-sensitivity of the Okefenokee Swamp.

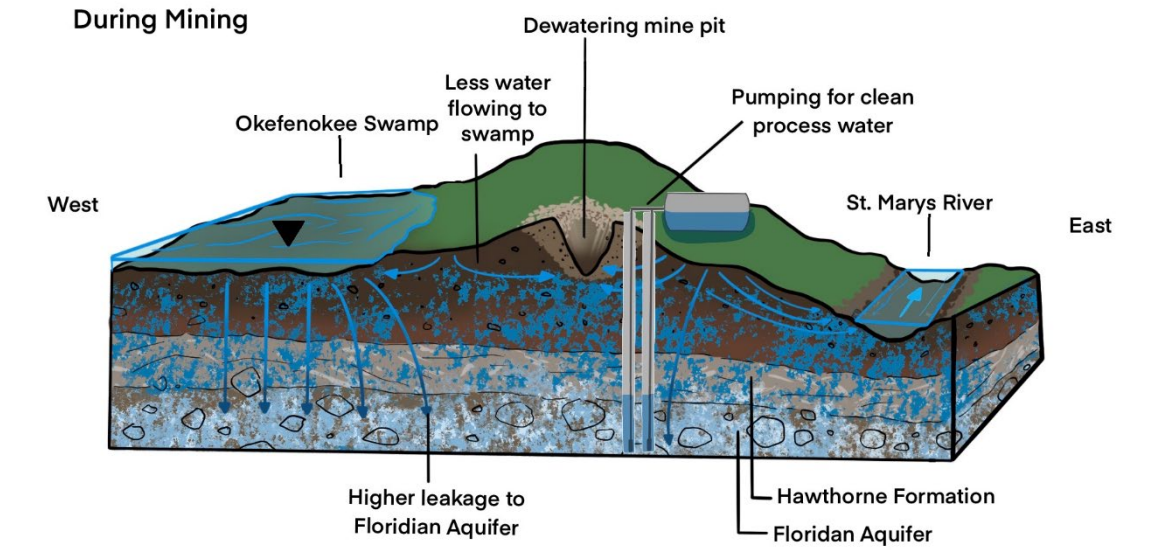
It is well-known that the Okefenokee Swamp is a drought-sensitive rain-fed system with little groundwater support; that recreational boating is difficult during droughts; and wildfires are common during droughts. The Okefenokee Swamp is mostly rain-fed (70-80%) and highly sensitive to intra- and inter-annual variability in rainfall due to meager storage within the swamp and the low amount of groundwater inputs to the swamp. The average depth of the swamp is only about 0.5 meters, and the turnover time of water in the swamp is only 3-4 months. The swamp has very little contributing area other than the swamp itself. Seventy to eighty percent of the water reaching the swamp comes from rainfall incident upon the swamp. The remainder of hydrologic inputs are from small tributary watersheds on the west and northwest edge of the swamp as well as from surficial aquifer drainage from Trail Ridge on the eastern and southeastern boundary. Trail Ridge itself is an ancient barrier island that acts as a long, tall, earthen dam that created conditions for the swamp to form (see below). Groundwater inputs from tributary watersheds and Trail Ridge provide small amounts of flow to the swamp during droughts. Water leaves the swamp by evapotranspiration, flow into the Suwanee and Upper St Marys Rivers, and leakage through the Hawthorn Formation into the underlying Floridan aquifer.

Consequently, the Okefenokee swamp is very sensitive to drought, yet the MLUP and associated water use plan make no assessment whether the consumptive water use required to operate the mine will exacerbated drought or negatively affect swamp ecology, tourism support, or wildfire risk. How much withdrawal would be too much? There is no quantitative or qualitative assessment of this question. EPD has analyzed potential effects of consumptive withdrawals on the middle St Marys River, at the Macclenny gage in Florida, but this is not relevant to the question of swamp effects. As far as the MLUP is concerned, the TPM mine could be on any old barrier island feature in the Atlantic Coastal Plain, as opposed to robbing water from the largest pristine blackwater swamp in the world and one of the premier birding, wildlife-viewing, and kayaking sites in the world.

Issue 2. The consumptive water withdrawals required by the mine operation will increase the frequency and severity of drought in the southeastern portion of the Okefenokee Swamp.

The water use plan estimates it will be necessary to continuously pump 1.128 MGD (1.74 cfs) of seepage into the mining pit to keep the pit dry. The mining pit will essentially act as a 50 foot deep well that is 500 x 100 feet in area (bottom area, the surface area will be larger), and the seepage will come from the surficial aquifer whose aquifer divide lies beneath the mine. Prior to pumping, surficial groundwater on the west side of the mine would flow to the swamp, and groundwater on the east side of the mine would flow to the lower St Marys. Consumptive use of this mining pit seepage water will thus continuously rob the swamp of 0.87 cfs of input.





Garnhart Illustration

Removing 0.87 cfs from the hydrograph of the upper St Marys as it leaves the swamp at the USGS gage at Moniac, GA will triple the cumulative duration of zero flow periods (Figure 1). Previous analysis (Hyatt 1984) has demonstrated very high correlations between flows at the Moniac gage and water levels in the southern portion of the swamp monitored by the USFWS. Thus, the tripling of zero flow periods in the upper St Marys River translates to tripling of severe drought conditions in the southeastern portion

of the swamp. Because the swamp is largely rain-fed, loss of groundwater inputs from Trail Ridge has large effects on swamp drought conditions.

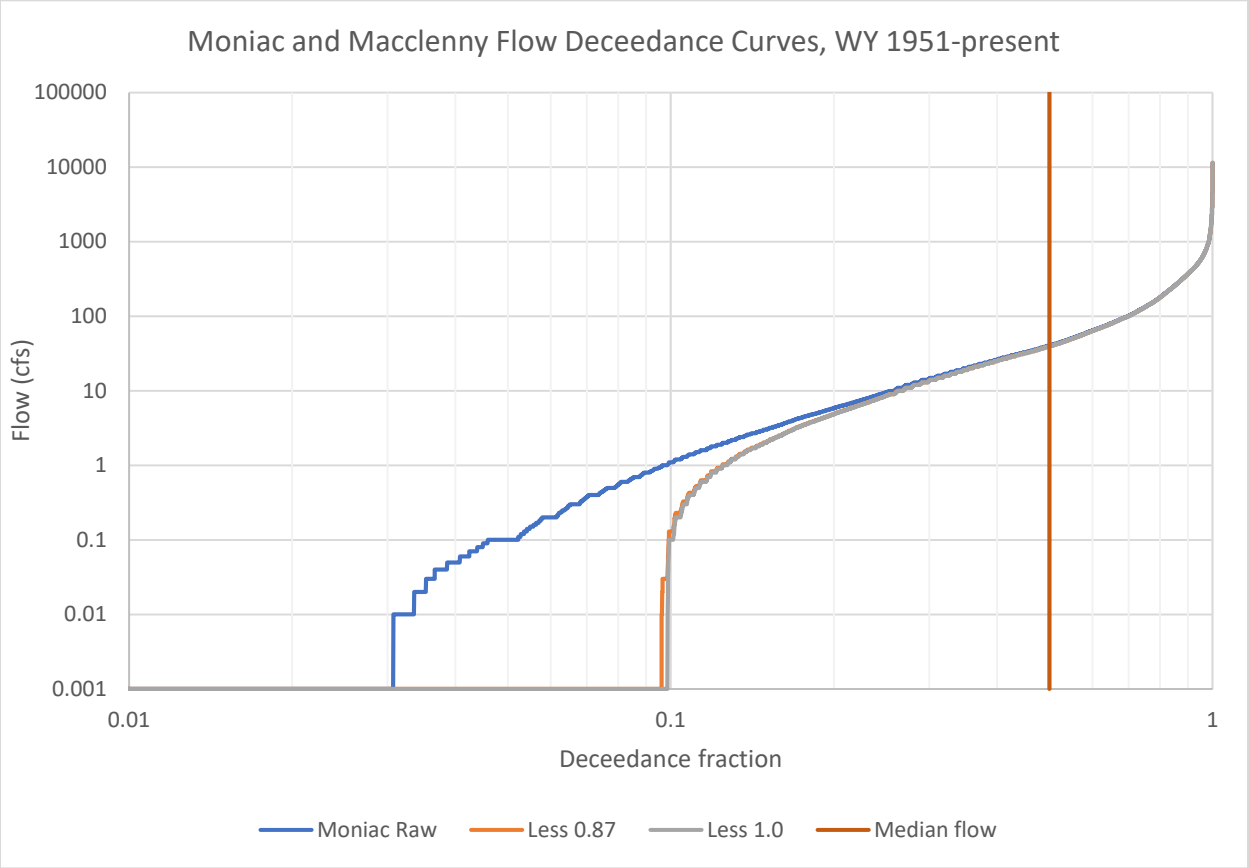


Figure 1. Flow deceedance curve for streamflows monitored at the Moniac, GA gage and flow deceedance curves removing 0.87 and 1.0 cfs from the measured hydrographs.

Additionally, the water use plan estimates the mine will need to withdraw an average of 0.43 MGD or 0.67 cfs from the Floridan Aquifer for process water. Before mining, the swamp loses water mostly by evapotranspiration, secondly by outflows to the Suwannee and St Marys River, and finally by downward leakage through the Hawthorne formation and into the Floridan aquifer. USGS wells in the swamp indicate that the swamp water levels are 70-80 feet higher than Floridan aquifer levels. By reducing pressures in the Floridan aquifer, the mine's wells will slightly increase leakage from the swamp to the Floridan, exacerbating the drought effects caused by pumping out surficial aquifer water from the mine pit.

Increasing the frequency, duration, and severity of drought in the swamp will increase fire risk, reduce the number of boating days in the southeastern portion of the swamp, and alter the swamp ecosystem in multiple ways.

Issue 3. EPD's conclusion that the hydrologic effects are minor is based on inappropriate gage selection.

EPD's reliance on the St Marys River gage at Macclenny, Florida to evaluate the potential effects of the mine's groundwater withdrawals on the swamp is incorrect and unsupportable, and its consequent

conclusion that the mine will have no impact on the swamp is also incorrect. Eleven senior research hydrologists at top southeastern universities, in addition to myself, have concluded that analyzing the withdrawals against the Macclenny gage data is irrelevant to the question of whether the mine will affect the hydrology of the swamp (Appendix A). These hydrologists further concluded that the Moniac, GA USGS gage is the relevant and appropriate gage for assessing how the mine operations will affect swamp hydrology. Removal of the mine withdrawals from the hydrograph at the Moniac gage indicates that the mine operations will triple the duration and severity of drought in the southeastern portion of the swamp. EPD should rescind its publication of the TPM Mining Land Use Plan and conduct a renewed analysis of the mine's impacts on the swamp using data from the Moniac, GA gage.

Four lines of evidence support the use of flow data from the USGS gage on the North Prong of the St Marys at Moniac, GA for assessing the hydrologic effects of the mine: a) vast differences in drainage basin areas and average discharges; b) dissimilarity of the watershed characteristics; c) dissimilarity of stream sizes apparent from photographic evidence; and d) completely different conclusions drawn from flow duration curves that reveal different hydrologic controls on each basin.

There are two non-tidal USGS gages on the St Marys River: The North Prong of the St Marys River at Moniac, GA, where the river leaves the swamp, and the St Marys River near Macclenny, FL, where 3/4^{rths} of the basin is outside the swamp (Table 1).

Location	Gage Number	Basin Area	Ave. Discharge
Moniac, as N. Prong leaves swamp	02228500	160 mi^2	143.1 cfs
Where river cuts through Trail Ridge	02231000	700 mi^2	628.7 cfs

Table 1. Comparison of drainage areas and flows: Average discharges for period of record reported in USGS 2021 Water Year Summaries

For this analysis,we are fortunate to have the USGS gage at Moniac. It is the first place downstream of the swamp where flows can be practically gaged. *The Moniac gage isolates the hydrology of swamp and the St Marys headwaters. Hyatt (1984) found water levels in Sapp Prairie in the southern end of the swamp explained 81% of the variability in flows at the Moniac gage. Therefore, flow changes at the Moniac gage can be used as a surrogate to assess water level changes in the southern end of the swamp.*

From the data above we see *the basin area and average discharge at Macclenny are both 4.4 times larger than where the St Marys exits the swamp at Moniac. The St Marys at Macclenny, FL is simply a much larger river with greater resilience to a fixed withdrawal of water.*

Furthermore, the Macclenny gage flows haven't been correlated to swamp water levels. We are interested in how the mine will affect water levels in the swamp and discharges to the headwaters of the St Marys River, not the mine's effect on the mainstem of the St Marys River.

To put this in perspective, *using the Macclenny gage is basically equivalent to analyzing a Mississippi River flooding problem in Minneapolis, MN (drainage area 36,800 square miles) using Mississippi River flow data from Grafton, IL just north of St. Louis, MO (171,300 square miles, or 4.65 times larger). The Macclenny gage data cannot provide relevant data to help answer the question of whether the mine will damage the swamp as illustrated by the maps and photos below.*

Mapping the drainage areas of the two gages (Figure 2) shows that the Moniac gage receives water almost exclusively from the swamp. At the Macclenny gage, over three-quarters of the basin area is in the highlands of north-central Florida and thus feature completely different hydrologic conditions and behaviors.

The photos below show what the drainage area predicts*: the North Prong of the St Marys River as it leaves the swamp is a small creek, narrow even for canoe traffic at normal flows, very difficult for canoes at low flows, and characterized by deeply tannic swamp waters. The St Marys at Macclenny is a large river suitable for power boating. The two segments are not similar in their sensitivities to water withdrawals.*

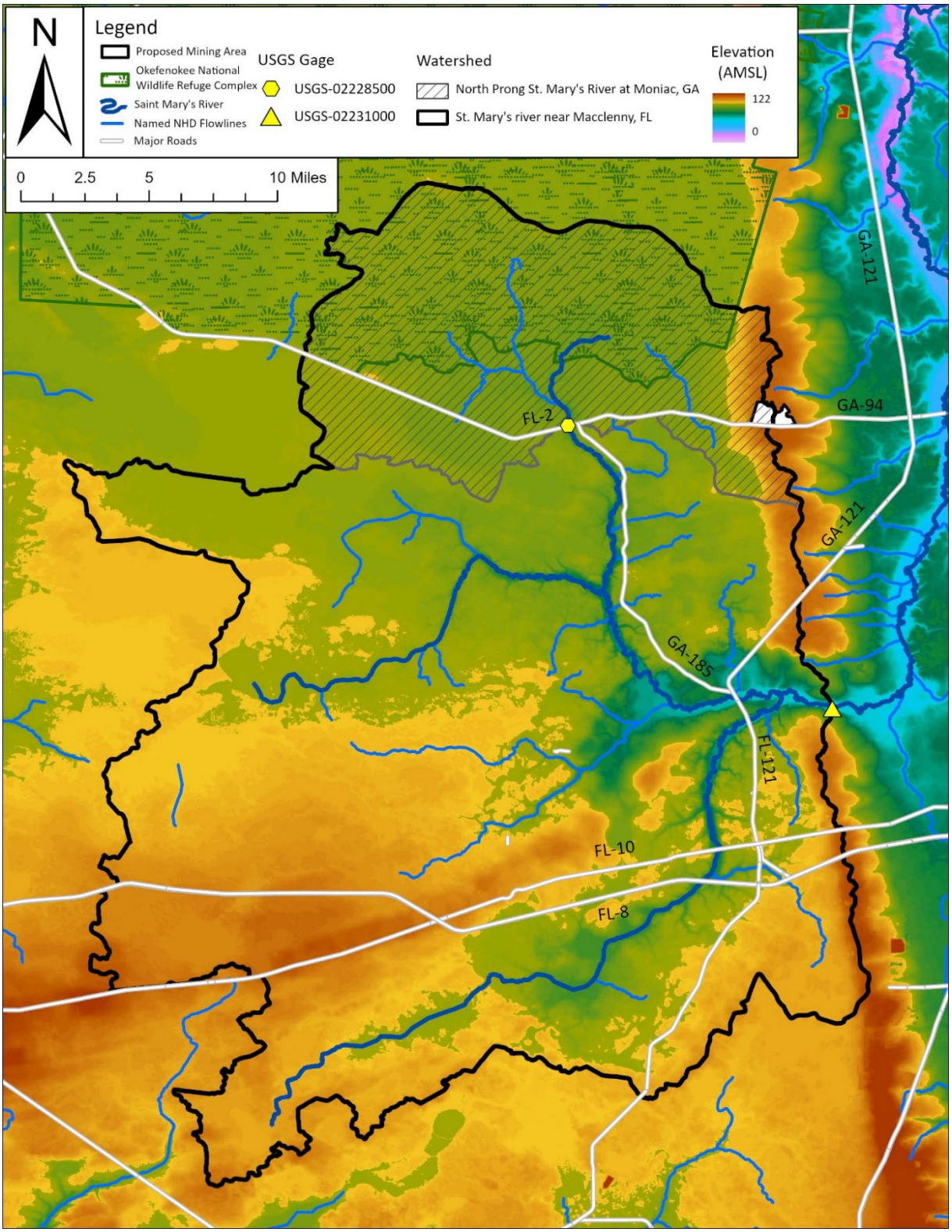
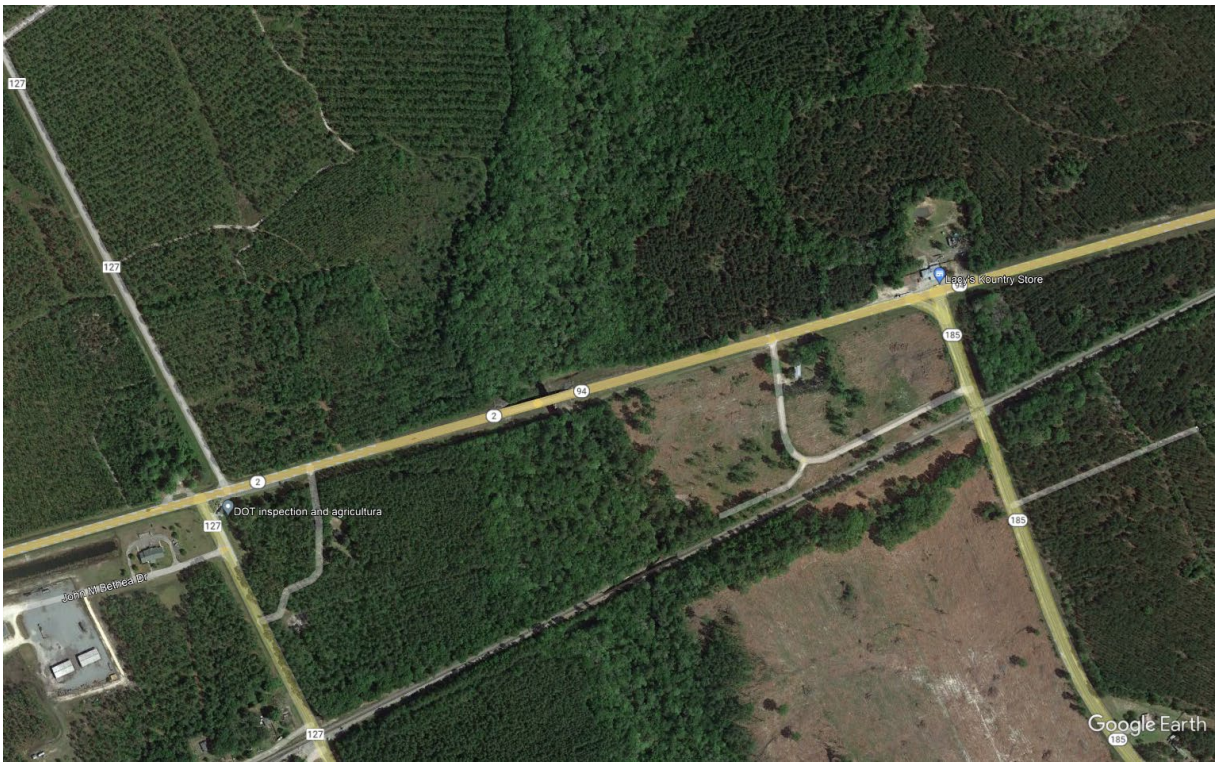


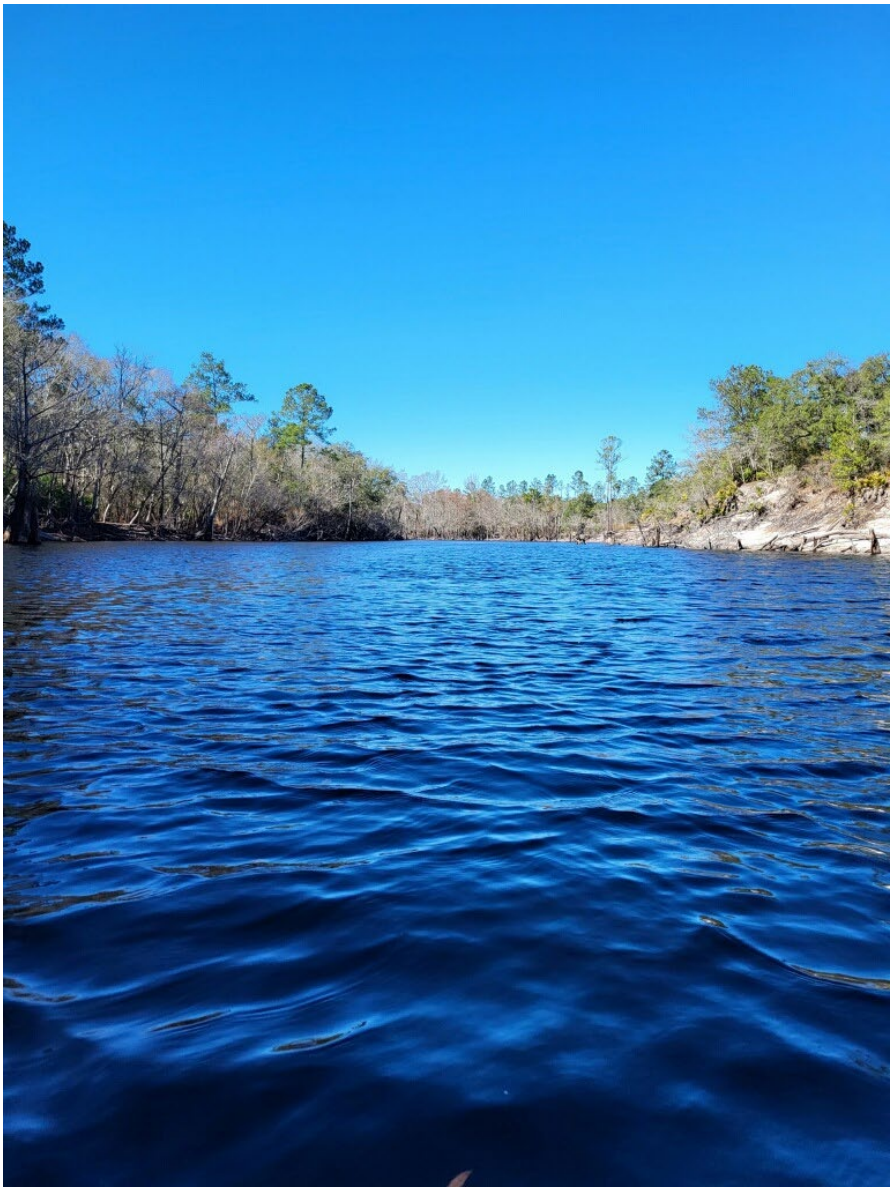
Figure 2. Map created from available DEM data and the National Hydrography Dataset (NHD) showing the major tributaries and approximate drainage areas to each gage. USGS and USFWS map a somewhat larger drainage area within the swamp. DEM-based drainage divides are difficult in flat topography.



North Prong of the St Marys River leaving the swamp where it is gaged by the USGS. The river passes under SR 94 in the small gap visible between the “2” and the “94” on the Highway, west of Lacy’s Country Store. River can’t be seen through tree cover.

USGS gage on the St Marys River near Macclenny, GA. River is 60 to 75 meters wide from bank to bank.

Top, North Prong of the St Marys River just above the Moniac gage. Bottom, looking downstream at the North Prong of the St Marys River from the gage at the SR 94 bridge. Streamflow was 40 cfs. Note deeply tannic waters characteristic of swamp waters. Emily Floore, 1/30/2023.



St Marys River at the Macclenny, FL gage site. Streamflow was 109 cfs. Photo by Emily Floore, St Marys Riverkeeper, 1/26/2023.

What do we learn if we remove 0.87 cfs from the flow records at the Moniac and Macclenny gages together, using their joint period of record from 10/01/1950 to the present (Figure 3)? We learn what we would already expect from differences in the basins: that the river is much bigger at Macclenny where flows never drop below 9.58 cfs, and where withdrawing a fixed 0.87 cfs from the flow records has no visible or practical effect on the top 99% of flows. This is VERY different from what we see at Moniac, where the river leaves the swamp. At Moniac, flows are zero for approximately 3% of the record, reflecting the drought-sensitivity of the swamp. *Removing 0.87 cfs from the flows at Moniac triples the duration of zero flows to over 9.5% of the record. Using the Moniac gage, we see that the mine withdrawals are likely to cause a large and significant increase in the frequency and severity of drought in the swamp. Conversely, using the Macclenny gage, we see nothing.*

The Macclenny flow duration curve is very flat between the first and 30th percentiles of the flow distribution, indicating that *the river at Macclenny is well supported by groundwater flows during droughts (Figures 3 and 4)*. This reflects the fact that 3/4rth of the Macclenny basin is in the northern Florida highlands outside the swamp (see map above). In comparison, the flow duration curve at Moniac is steep across all flow durations and drops precipitously below the 10th percentile, indicating that *flows at Moniac are not well supported by groundwater inputs and are very sensitive to drought.* The hydrologic inputs and behaviors at the two locations are substantially different (Figure 4). *Flows at the Macclenny gage are irrelevant to answering how mine operations might affect the hydrology of the swamp. The Macclenny gage data hide the substantial and critical hydrologic effects of the proposed mine operations*.

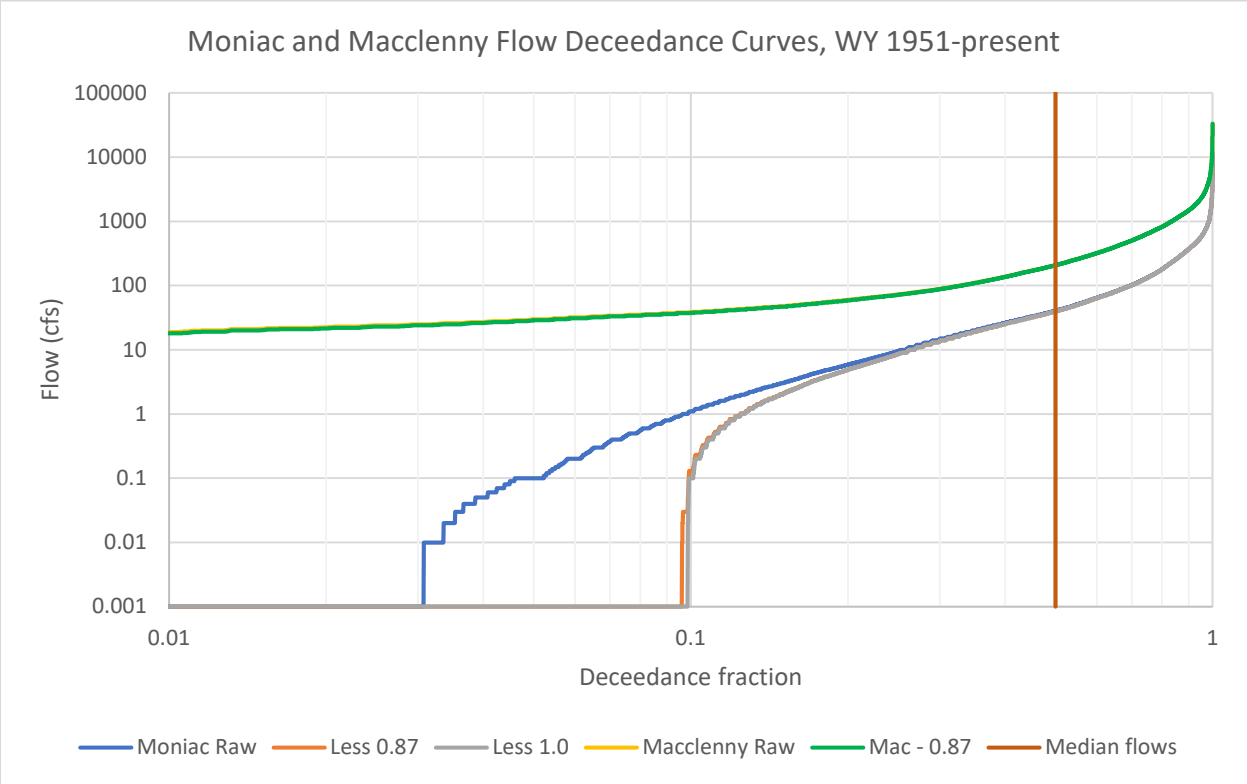


Figure 3. Flow deceedance curves, without and with withdrawals, for both the Moniac and Macclenny gages. Note, over this period of record,Water Year 1951 to the present, the Moniac gage is missing about 1000 days of data over three separate periods (out of a total of over 26,400 days), and these missing data periods have not been used in this analysis.

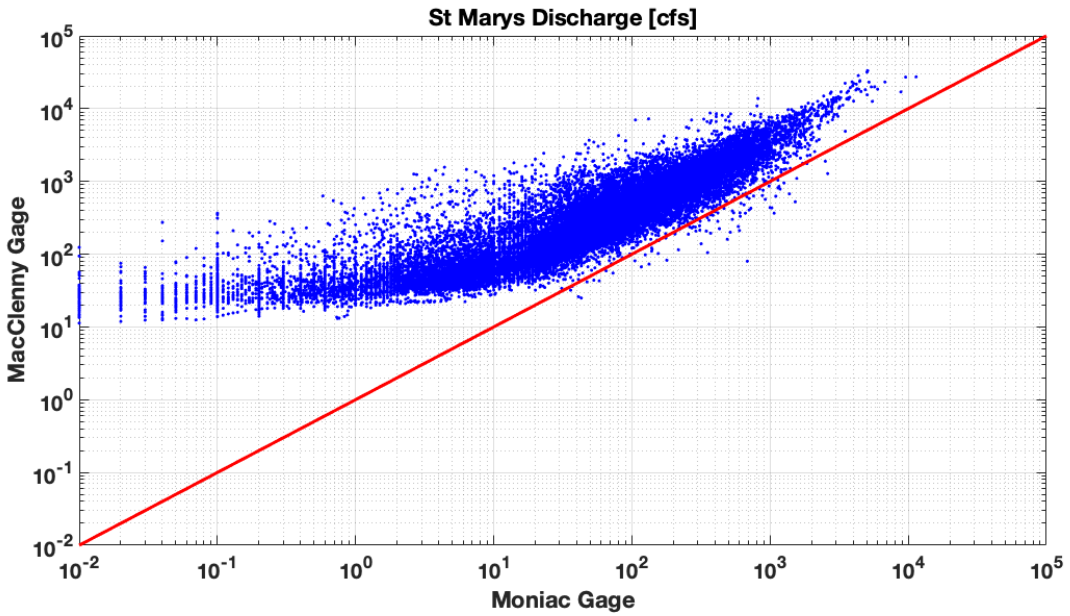


Figure 4. *Comparison of Moniac and Maclenny daily flows. At low flows, there is very high scatter and the curve is nearly flat, indicating that during low flow periods, there is very little correlation between flows at the two locations. The flattening of the curve also demonstrates the drought resilience of the larger river relative to the North Prong of the St Marys at Moniac. The red line is a 1:1 line showing when flows are the same at the two gages. Even though the Macclenny basin is 4.4 times larger, the North Prong at Moniac occasionally has higher flows during wet periods.*

Issue 4. The MLUP does not address or estimate the social and environmental costs created by increasing the frequency and severity of drought in the swamp as a result of groundwater pumping and evaporation.

We know that over the last 100 years large wildfires often form and spread in the swamp margins during droughts, and some of these fires, including the 2007 and 2017 fires, have burned large areas of private timberlands outside the swamp. We also know from newspaper reports that the water level in the swamp can become too low for even canoes and kayaks during droughts. However, neither the applicant nor EPD has put together a fire database or a lost boating opportunity database from which to estimate additional risks to timberlands and tourism opportunities caused by the increased drought frequency and severity that will ensue after mining commences. We know it will be worse, but we don't know how much worse. It should not be incumbent upon the public to evaluate these important questions.

EPD and the applicant will likely say it wasn't necessary to assess these risks, because the hydrologic effects of the proposed groundwater withdrawals are de minumus. But, they are only de minimus when analyzed with respect to flows at the Macclenny, FL gage, which, as previously outlined, is entirely inappropriate (see above).

Issue 5. **No consideration of water chemistry, local climate, or storage dynamics in the proposed evaporation plan.**

TPM LLC plans to use a mechanical evaporation system to evaporate all the water from pit pumping and the excess process water and thus avoid an effluent discharge permit. However, the design for the

evaporator system is not based on local climate data, mineral sands mining waters, or operational experience. The test data provided by TPM LLC is for different evaporation systems, using water of different chemistry than mineral sands waters, and conducted in different climates. Empirically and theoretically, the major environmental controls on evaporation rates are vapor pressure deficit and wind speed. As everyone familiar with south Georgia knows, humidity is very high much of the year (and vapor pressure deficits are low) and the wind often doesn't blow. In such periods, with all the evaporators adding to the humidity above the ponds, evaporation will be difficult. The public and EPD have no assurance this system will work with the mine waters passing through these evaporators in this climate. By definition, the evaporation plan is experimental.

The mining pit water and the processing water are likely to clog the evaporation system. Mineral sands process water is high in humates, total dissolved solids (TDS), and fine sediment particles (silts and clays). The process water is dark and slick to the touch (Figure 5a). The water creates a fine coating on all equipment (Figure 5b). This deposition is very likely to impair evaporator performance.

Southeast Georgia often experiences large magnitude rain storms with high intensities, particularly when tropical storms come ashore, but also when long-duration frontal systems move in from the Gulf of Mexico. During such events evaporation of water from the storage ponds will not be possible, even if the evaporators are functioning as designed. A continuous simulation of storage pond inputs over the entire period of climate record is not difficult and should be a requirement for evaluating the water management plan.

Figure 5a,b. *Process Water in Mineral Sands Mining***.** Note that the water is very turbid (dark) due to dissolved and suspended matter. Spraying this water into the atmosphere will result in evaporation of the water, but not the dissolved and suspended sediments. These will form aerosols (dust, salt) that will drift with the wind, which is mostly toward Okefenokee Swamp. Humates and fine particles in the water stick to everything (below).

Issue 6. No assessment or acknowledgement of downwind salt deposition from the evaporation system.

TPM is planning to use evaporator devices in an attempt to eliminate the enormous amounts of wastewater generated and stored onsite. This is being proposed in order to avoid discharging the wastewater to the St Marys River basin. The wastewater naturally contains high concentrations of humates and dissolved solids (see picture below), commonly referred to as salts, and the mist created by the evaporators will generate aerosols, or saline clouds, as a natural result of evaporation. Consequently, there will be "salt rain" downwind of the evaporation system. It is also uncertain what effect the humates (large organic molecules) will have on the operation of the mechanical evaporators.

Using an evaporation rate of 800 gpm and a solute concentration of 50 mg/L, the total salt load to the surrounding landscape will be about 218 kg/day, equivalent to 480 lb/day, or 0.24 US tons/day or 88 tons/year. The total dissolved solids concentration used here is from the measurements of groundwater and surface water concentrations measured and reported in the applicant's hydrogeologic investigations. However, there is no data on concentrations of total dissolved solids likely in the process water. *Having inspected the process water by sight and feel at the Mission Mine, a concentration of 100 to 200 mg/L seems more likely in the process water, and this would double to quadruple the salt deposition to a ton/day.* This salt load will reduce long-term soil productivity in the downwind areas. Given that winds in the area are often from the east, salt deposition into the swamp is inevitable. Salt deposition will have negative consequences for freshwater ecosystems and the nearby forests.

It really should not be incumbent on the public to find information on the chemistry of the process waters. Either the applicant or EPD should have provided expected ranges and averages of process water constituent concentrations in the permit materials.

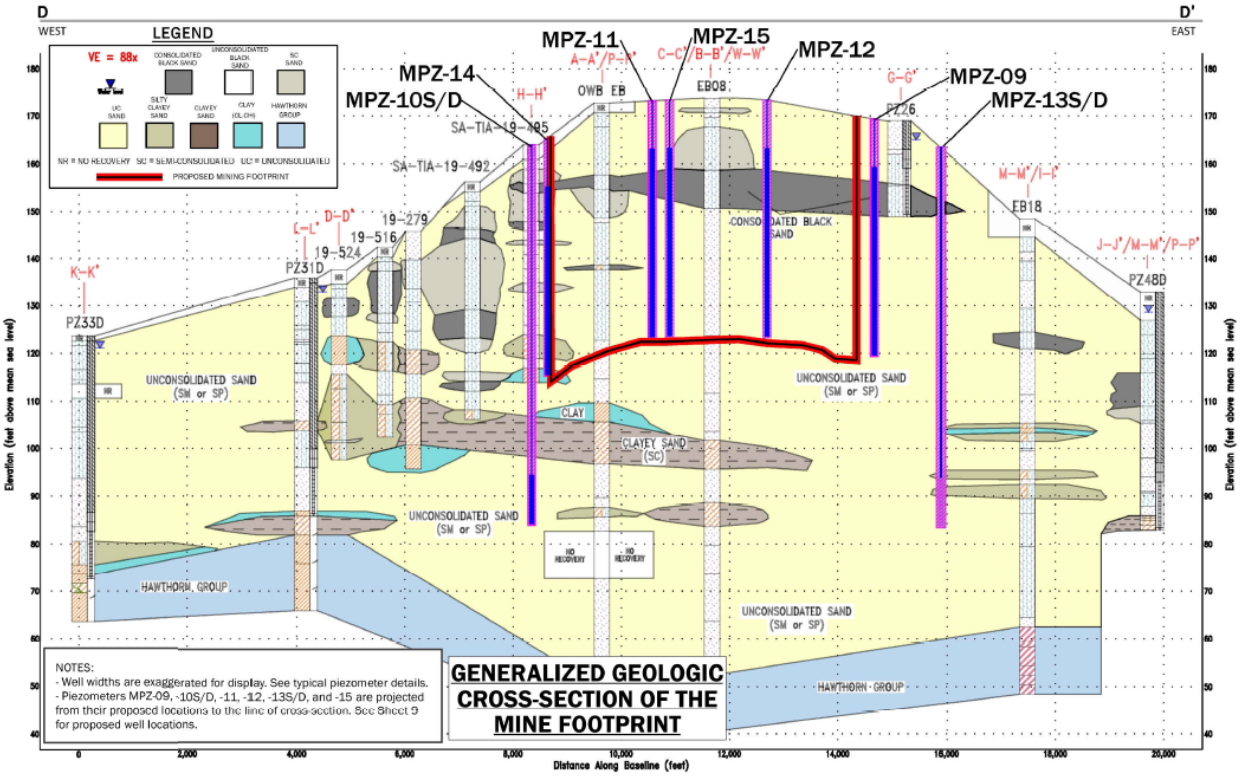
In its assessment of TPM's plan for evaporating the wastewater, EPD did not address the threat posed by these saline clouds. This oversight should be remedied by conducting an updated analysis of the evaporation process and whether evaporation can be allowed at all.

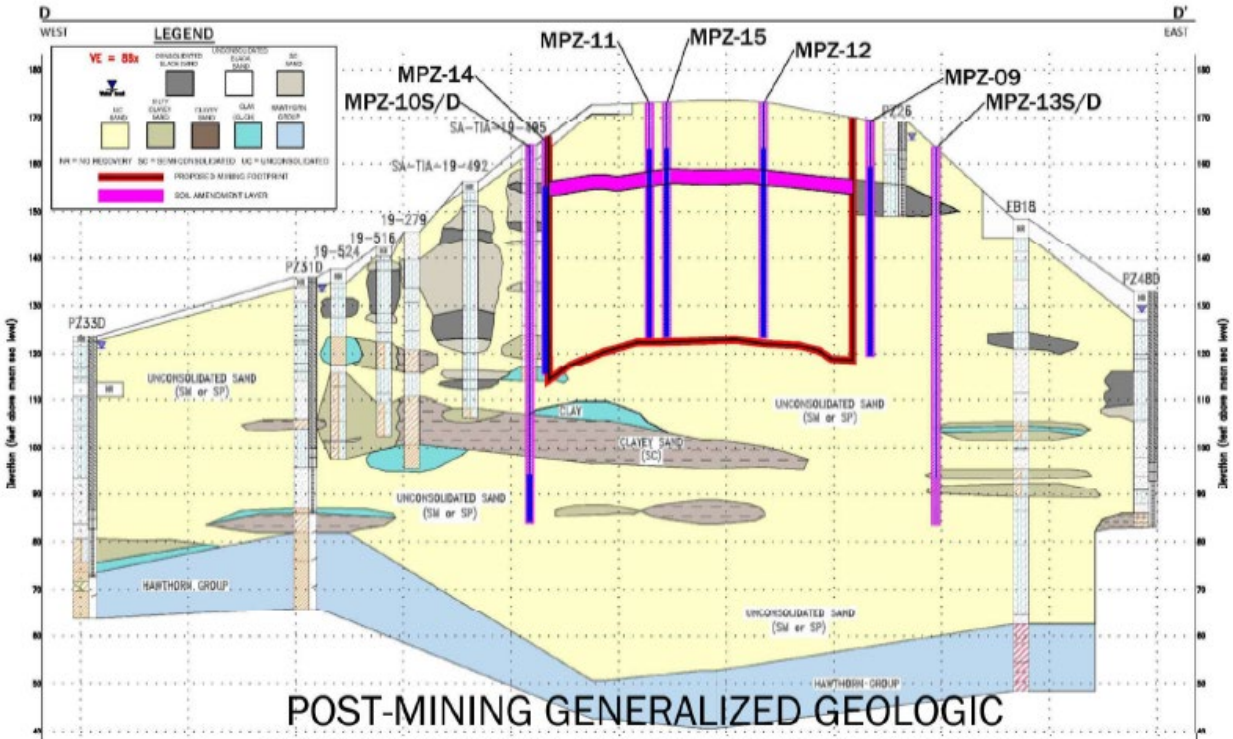
Issue 7. No plan for overflow monitoring.

If the proposed evaporation process doesn't work, *there is no plan for monitoring or addressing discharges of process water to the tributaries of the St Marys River*. The EPA already lists the St Marys River as impaired for sediments, turbidity, and dissolved oxygen, all issues that would be exacerbated by discharges from the mine. When the evaporation system fails, it will be during extended wet weather when creeks are high. It is necessary to have some plan for the likelihood of discharges in such periods. Right now there is none. *An overflow plan should answer: Where will overflow discharge occur? How will it be monitored? What will happen when it does?*

Issue 8. Impracticality of untested hydraulic barrier.

The generalized geologic cross section above shows that the proposed mining pit (below outlined in the crimson polygon) contains layers and lenses of unconsolidated sands, partly consolidated sands, consolidated black sands, and clays. Each of these layers has different hydraulic properties that affect groundwater flow and the position of the surficial water table under Trail Ridge. The effect of replacing this layered system with a uniform mixture of disturbed materials is to increase the rate at which groundwater can flow through the ridge.





POST-MINING GENERALIZED GEOLOGIC CROSS-SECTION OF THE MINE FOOTPRINT

To mitigate the effect of this mixing on the hydrology of the ridge, TPM LLC proposes to place a layer of bentonite clay (the fuschia band in the post-mining X-section above) at the approximate location of the current consolidated black sands lens during the process of returning the sands to the pits. In order for this to create the desired impediment to flow, this layer will have to placed and compacted so that it is a continuous layer with inconsequential gaps and irregularities. This seems like a good idea, but it will be very difficult to execute, particularly when the operation intends to mine and fill 10 to 15 acres per month. Excavation and backfill will occur continuously, in a pit approximately 100 feet by 500 feet at the bottom, and the bentonite layer will have to be placed at exactly the right elevation above mixed sands place below it and then covered by mixed sands placed above it. It will be very difficult to create a continuous layer that doesn't have gaps and mismatched elevations, and thus it is unlikely to work as intended.

Issue 9. Mitigation plan deficiencies.

The mitigation plan for the Twin Pines LLC Saunders Demonstration Mine will likely result in a scrubby low productivity forest and the loss of nearly all wetland habitat currently existing in the mining area.

In short, the mitigation plan consists of the following steps and problems:

1. Stockpile the topsoils. Note, there is no discussion of separating wetland and upland topsoils, which have very different characteristics, different microbial ecology, and different seedbanks.

2. Following mining, contour the surface to the pre-existing topography, minus the depth of topsoil. Note, the plan does not mention any effort to map the topsoil depths prior to excavation. Note: there is

no mention that the mine will have removed a small fraction of the soils, so the surface elevation will drop commensurately.

3. Spread the topsoil over the surface. Note, there is no discussion of putting wetland topsoils in the wetland areas or upland topsoils in the upland areas.

4. Seed the bare soils with various grasses to reduce erosion. The planned mixes of grasses are mostly non-natives and not selected for the soils and climate.

5. Allow natural regeneration of vegetation from the seedbank in the soils.

6. Two years following topsoil placement, plant native trees, mostly longleaf pine in the mesic uplands, slash pine in the wet uplands, and pond cypress in the wetlands. Planting plan includes some difficult-to-source trees such as pond pine, and loblolly bay. Sourcing the required number of pond cypress trees will be difficult at best. The market for some of the target tree species is not large. When this land reverts to commercial timber production, the trees will be replaced with loblolly pine, so most of the tree planting plan is for nought.

Additional notable omissions include:

There is no mention of covering the topsoils to protect them from erosion by rainfall and to reduce volatilization of organic matter.

There is no mention of lining the wetlands with clays to hold water. If the water table drops due to the loss of soil layering and the increased hydraulic conductivity, the post-mining water table will likely be too low to create wetlands on the surface.

There is no mention of the fact that the low-conductivity, poor-infiltration, humic Bh horizon on the upland soils will be lost, so water availability for trees in the summer will be greatly diminished, and tree growth will be very poor. This is what we see on much of the former mined lands in the Florida section of Trail Ridge (see below).

There is no mention of the likely water table drop following mixing of the sands (which increases hydraulic conductivity) and the associated problems with reestablishing wetlands.

There is no mention of re-establishing the drainage swales that connected the wetlands on Trail Ridge to the tributary streams draining east, south, and west.

There is no discussion of the sand deficits common to mineral sands mine reclamation that necessitate creating lakes in the post-mining topography.

The importance of soil texture, structure, organic matter content, and horizonation.

Soil is not dirt that we stand upon. Soil is a complex living system with structure developed in concert with biological communities (plants, invertebrates, burrowing animals) over thousands of years and microbiology developed over decades and centuries. Native plant communities have evolved partly in response to the water holding capacities and nutrient cycling capacities of soils.

Natural soils are layered (below), and the layers have fundamentally different textures, structures, water holding characteristics, organic matter content, and biological function. Soils on the TP LLC mining site

are of the Spodosol soil order, meaning that they have developed a concentrated layer of organic matter called a humic horizon. In the photo of the Lynn Haven series at right, there is a thin dark topsoil layer (A horizon), a light colored E horizon, and a dark humic Bh horizon. These humic B horizons move water slowly, and allow water to pond above them during the winter when evapotranspiration rates are low. These humic horizons are essential to the natural function of both wetland and upland soils of the lower Coastal Plain.

Eliminating the structure and biology of the soils by replacing them with mixed sands from the first 50 feet of Trail Ridge will fundamentally alter the ecosystems founded upon the soil. Revegetation of the reclaimed mine site will be possible, but restoration of the native ecosystem will take thousands of years of soil development.

Figure 6. *The Lynn Haven soil series common in wetlands on the site*. Image from NRCS.

Summary

The proposed reclamation plan is minimalist. It basically says the mine will destroy all existing soil structure, mix wetland and upland topsoils, regrade the pre-mining surface topography (minus the 1.5% of the soils removed from the site), push the mixed topsoils back in place, and plant some trees. The only nod to the special characteristics of the site is the placement of a deep bentonite layer to mimic the hydrologic effects of the existing black sands layer. This bentonite layer is novel, and it will be difficult to place as a continuous layer. There is no track record of such placement achieving its hydrologic goals.

Employing this style of mitigation at the Trail Ridge mining sites and at nearby phosphate mines in Florida has resulted in very poor soil conditions and very poor vegetative regrowth (see example below, Figure 7).

Figure 7. *Reclaimed mine lands on Trail Ridge NE of Starke, FL*. Google Earth image. This image taken 20 years after reclamation began. There are lots of examples of poor regeneration on mineral sands and phosphate mines in Florida in terrain similar to the TPM LLC site.

Conclusions

Mineral sands mining on Trail Ridge will make drought in the southeastern portion of the swamp more frequent and more severe, and this will affect the competitive balance of plants in the swamp with cascading effects on the ecosystem. It will increase the probability of wildfires on the swamp margin, which periodically cause major problems for the region including large-scale loss of commercial timber, and it will increase the number of days on which recreational boating is not possible in parts of the swamp. Furthermore, mining on Trail Ridge will damage the tourism potential of the Okefenokee Swamp, to the detriment of the state and the region.

The mining plan fails to address several other important environmental issues, specifically the effects of salt deposition downwind of the evaporation system, the necessity of a contingency plan for unplanned discharges to the local tributaries to the St Marys River, and the need for a reclamation plan better than has been used on most mineral sands mines in Florida.

Returning to the standards of the Georgia surface mining law, it is clear the mine proposal is incompatible with nearby land uses including the ONWR, surrounding timberland, and the regional

tourist economy. Furthermore, the mining plan has serious deficiencies and unaddressed issues. Based on Georgia law, this application should be denied.

Georgia has three unblemished/untrammeled ecological/cultural resources: the Okefenokee Swamp, Cumberland Island, and Ossabaw Island. These treasures should be handed unblemished to future generations. The wise decision is to deny this permit.

Appendix 1: Letter from southeastern hydrologists

Appendix 2: Shortened CV

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February 24, 2023

Georgia EPD and Interested Parties

Re: Appropriate streamflow data for assessing how the proposed TPM LLC mine groundwater withdrawals will affect Okefenokee Swamp Hydrology

We, the undersigned research hydrologists of southeastern universities, find that the appropriate USGS gage for assessing hydrologic effects on the Okefenokee Swamp of consumptive groundwater withdrawals by the proposed TPM LLC mineral sands mine is gage #02228500, North Prong of the St Marys River at Moniac, GA. Further, we find gage #02231000, St Marys River near Macclenny, FL, chosen by GA EPD, is inappropriate for such analysis.

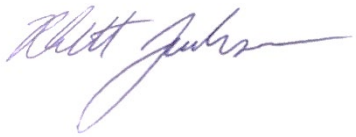
The salient hydrologic question about the mine is the degree to which it will alter the hydrology and associated ecosystem benefits of the southeastern portion of the Okefenokee Swamp. The North Prong of the St Marys at Moniac exclusively drains the southeastern portion of the swamp plus its contributing areas from Trail Ridge, and previous research has demonstrated very high correlations between flows at this gage and swamp water levels monitored by the USFWS. The geographic position of this gage is ideal for analyzing potential effects to swamp hydrology of consumptive ground water withdrawals beneath Trail Ridge.

Conversely, the data from the USGS gage at Macclenny, FL are inappropriate for direct analysis of how consumptive groundwater withdrawals by the mine will affect the hydrology of the swamp. The Macclenny gage drains a basin that is 4.4 times larger than the Moniac gage. Three-quarters of the area draining to this gage is in relative highlands of north central Florida. The hydrologic inputs to this basin and the hydrologic behavior of this basin are in no way similar to that of the southeastern portion of the Okefenokee Swamp. Furthermore, the sheer size of the basin and its flows at this gage will mask the effects a fixed withdrawal would have where the river exits the swamp.

Conclusions drawn from consumptive flow removal from the Macclenny, FL gage data cannot be applied to the question of how the Trail Ridge groundwater withdrawals will affect the swamp. To assess this question, it is necessary to use flow data from the Moniac gage.

We thank you for your attention to this important matter. We know you agree it is critical to apply the best possible data to this resource management decision affecting Georgia.

Sincerely,



Signing for:

C. Rhett Jackson, John Porter Stevens Distinguished Professor of Water Resources, Warnell School of Forestry and Natural Resources, University of Georgia

Larry Band, Ernest H. Ern Professor of Environmental Science, School of Engineering, University of Virginia

Stephen Schoenholtz, Director and Professor, Virginia Water Resources Research Center, Virginia Tech University

Kevin McGuire, Professor of Hydrology, College of Natural Resources and Environment, Virginia Tech University

Daniel L. McLaughlin, Associate Professor of Hydrology, Department of Forest Resources & Environmental Conservation, Virginia Tech University

Diego Riveros-Iregui, Associate Professor of Watershed Hydrology, Department of Geography, University of North Carolina at Chapel Hill

Ryan Emanuel, Associate Professor of Hydrology, Nicholas School of the Environment, Duke University

Matt Cohen, Professor of Water Resources, School of Forest, Fisheries and Geomatics Sciences, University of Florida

Chris Anderson, Professor of Wetland Science, College of Forestry, Wildlife and Environment, Auburn University

Courtney Siegert, Associate Professor of Hydrology, College of Forest Resources, Mississippi State University

Luke Pangle, Associate Professor of Hydrology, Dept. of Geosciences, Georgia State University

Todd Rasmussen, Professor of Hydrology, Warnell School of Forestry and Natural Resources, University of Georgia

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Tenured; Graduate Faculty

Curriculum Vitae (Abbreviated)
January 2023

1. Academic and Professional History

Academic Degrees:	Ph.D., Hydrology, Dept. of Civil and Env. Engr., Univ. of Washington, 1992
	MSE, Civil and Environmental Engineering, Duke University, 1985
	BSE, Civil and Environmental Engineering, Duke University, 1983
Directorships, Scientific Leadership:	
2016-2021	Lead Principal Investigator, Coweeta LTER (CWT)
2015-2016	Transitional lead Principal Investigator, Coweeta LTER (CWT)
2012-2021	Science Advisory Committee, CWT LTER
Administrative Positions:	
2018 – 2021	Graduate Coordinator, Warnell School of Forestry and Natural Resources
Academic Positions: The University of Georgia	
2018 – present	John Porter Stevens Distinguished Professor of Water Resources
2020 – present	Adjunct Professor, College of Engineering
2008 - 2018	Professor, Warnell School of Forestry and Natural Resources
2003 - 2008	Associate Professor, Warnell School of Forestry and Natural Resources
1997 - 2003	Assistant Professor, Warnell School of Forestry and Natural Resources
Other Academic Positions:	
1997	Visiting Lecturer, University of Washington
1996	Lecturer, Shoreline Community College, Seattle, WA
1992	Lecturer, Seattle University, Seattle, WA
Other Professional Positions:	
1994 - 1997	Senior Hydrologist and Principal, Pentec Environmental, Edmonds, WA
1992 - 1994	Hydrologist and Planner, King County Surface Water Management, WA
1987 - 1988	Part-time intern, Congressman Mike Lowry's Seattle Office, WA
1985 - 1987	Project Engineer, Los Angeles County Sanitation Districts, CA

Awards

2020 AGU EOS highlight of Lee et al. (2020)
2019 Water Resources Research Editor's Choice Award for Klaus and Jackson (2018)
2019 Editor's Citation for Excellence in Reviewing for Water Resources Research
2011 Faculty Award for Outstanding Teaching, Warnell School of Forestry and Natural Resources
2010-2011 Senior Teaching Fellows Program, University of Georgia
2008, 2002 Honors Day Acknowledgment for Outstanding Teaching
2008 Inducted into University of Georgia Teaching Academy
2003 Richard B. Russell Undergraduate Teaching Award (UGA's highest award for young faculty)

2. Instruction

i. **Courses Taught:** Regular teaching load includes three to four classes per year, including: CRSS/FORS 3060 - Soils and Hydrology, WASR 4110/6110 - Forest Hydrology, WASR 4400 - Introduction to Wetlands, WASR 8200 - Hillslope Hydrology, and, occasionally, HONS 1990H - Resource Scarcity: Technological Substitution for Land and Water. Classes taught in UNO/UGA Innsbruck Summer Study abroad program (2013, 2015, 2017): Environmental Science; Comparative Natural History: The Austrian Alps vs. Southeastern US; Glaciers, Floods, and Landslides: living in a dynamic landscape

ii. **Graduate Advising**

PhD Major or Co-Major Professor (8 graduated, 2 in-progress):
MS Major or Co-Major Professor (28 graduated, 1 in-progress):
MNR Major Professor or Co-Major Professor (5 graduated):
PhD Committee Memberships: 33 graduated, 1 current
MS Committee Memberships: 59 graduated, 2 current
*MFR/MNR Committee Memberships***:** 6 graduated, 0 current
Have hosted three visiting scholars from China.

3. Scholarly Activities

i. Publications and Presentations

Publications marked with an asterisk (*) have been refereed; those marked with a dagger (†) have been peer-reviewed.

a. Book Chapters

(13) †C. Rhett Jackson, George G. Ice, Terrance W. Cundy, Peter J. Tschaplinski, Douglas J. Martin, Jeremiah D. Groom, William J. Ehinger. 2022. Chapter 10 - Determining the Effectiveness of Contemporary Forestry BMPs: Illustrative Case Studies. ***In*** Reflections on Forest Management; Can Fish and Fiber Coexist? R. Danehy and A. Dolloff, Eds. American Fisheries Society.

(12) †Richardson, J.R., R.D. Moore, C.R. Jackson, and D.P. Kreutzweizer. 2022. Chapter 5: Current streamside forest management effects on aquatic habitat and fish. ***In*** Reflections on Forest Management; Can Fish and Fiber Coexist? R. Danehy and A. Dolloff, Eds. American Fisheries Society.

(11) †Morris, LM., and C.R. Jackson. 2015. Interactions of Soils and Land Uses with Water Quantity and Quality. *In* Ecosystem Services, Nick Comerford, Ed. ACSESS Books, Madison, WI.

(10) †Jackson, C.R, J.A Thompson, and R.K. Kolka. 2014. Wetland Soils and Hydrology. *In* Ecology of Freshwater and Estuarine Wetlands, 2nd Edition, D.P. Batzer and R. Sharitz, Editors. University of California Press.

(9) †Parker, D., J.T. Anderson, C.R. Jackson, B. Miller, and A. Rosenberger. 2014. Grand Challenge 2: Water; In A Science Road Map for Food and Water. Association of Public and Land Grant University (APLU) Experiment Station Committee on Organization and Policy – Science and Technology Committee.

(8) †Jackson, C.R. 2013. Timber Harvesting - Influence on Water Yield and Water Quality. *In* Encyclopedia of Environmental Management. Taylor and Francis, New York.

(7) †Webster, J.R., E.F. Benfield, K. Cecala, J.F. Chamblee, C. Dehring, T.Gragson, J. Hepinstall, C.R. Jackson, J. Knoepp, D. Leigh, J. Maerz, C. Pringle, and H.M. Valett. 2012. Water quality and exurbanization in southern Appalachian streams. Pages 91-106 in P.J. Boon and P.J. Raven (editors). River Conservation and Management. Wiley-Blackwell, Chichester, UK.

(6) †Jackson, C.R. 2006. Urban hydrology. *In* Encyclopedia of Water Science, S.W. Trimble, Ed. Taylor and Francis, New York.

(5) †Jackson, C.R. 2006. Wetland hydrology. Pp. 43-81 *In* Ecology of Freshwater and Estuarine Wetlands, D.P. Batzer and R. Sharitz, Editors. University of California Press.

(4) †Jackson, C.R., G. Sun, D. Amatya, W.T. Swank, M. Riedel, J. Patric, T. Williams, J.M. Vose, K. Trettin, W.M. Aust, S. Beasely, H. Williston, and G. Ice. 2004. Fifty years of forest hydrology research in the southeast - Some lessons learned. Pp. 33-112 *In A* Century of Forest and Wildland Watershed Lessons, J. Stednick and G. Ice, Editors. Society of American Foresters, Washington, DC.

(3) †Sun, G., M. Riedel, C.R. Jackson, R. Kolka, D.M. Amatya, and J. Sheppard. 2004. Influences of management of southern forests on water quantity and quality. Pp. 195-224 *In* Southern Forest Science: Past, Present, and Future, Rauscher, Johnsen, and Doudrick, Eds. USDA Forest Service Southern Research Station General Technical Report SRS-75.

(2) †Jackson, C.R. 2003. Timber Harvesting - Influence on Water Yield and Water Quality. *In* Encyclopedia of Water Science, B.A. Stewart and T. Howell, Eds. Marcel Dekker, New York. DOI: 10.1081/E-EWS 120010111.

(1) *Jackson C.R., S.J. Burges, X. Liang, K.M. Leytham, K.R. Whiting, D.M. Hartley, C.W. Crawford, B.N. Johnson, and R.R. Horner. 2001. Development and application of simplified continuous hydrologic modeling for drainage design and analysis. In *Land Use and Watersheds: Human influence on hydrology and geomorphology in urban and forest areas*, Water Science and Application Volume 2, Mark S. Wigmosta and Stephen J. Burges, Editors. Pp. 39-58. American Geophysical Union, Washington, DC.

b. Refereed and Peer-Reviewed Journal Articles

(94) *Webster, J.R., C.R. Jackson, J.D. Knoepp, and P.V. Bolstad. In Press. Can small stream solute--land cover relationships predict river solute concentrations? Hydrological Processes.

(93) *Raulerson, S., C. Sytsma, J.R. Webster, and C.R. Jackson. Published online, 2023. Watersheds and Stream Networks Viewed Longitudinally – example insights from novel spatial portrayals of watershed characteristics. River Research and Applications.

(92) *Campbell J.L, Boose E., Driscoll C.T., Dugan H.A, Groffman P.M., Jackson C.R., Jones J.B., Jones J.A., Juday G.P., Lottig N.R., Penaluna B.E., Ruess R.W., Suding K., Thompson J.R., Zimmerman J.K. 2022. Forests and freshwater ecosystem responses to climate change and variability at US LTER sites. Bioscience 72:851-870.

(91) * Ruzol, R., C.L. Staudhammer, S. Younger, D.P. Aubrey, H.W. Loescher, C.R. Jackson, and G. Starr 2022. Water use in a young Pinus taeda bioenergy plantation: Effect of intensive management on stand evapotranspiration. *Ecosphere*, *13*(6), p.e4100.

(90) *Jackson, C.R., K.K. Cecala, S.J. Wenger, J.E. Kirsch, J.R. Webster, D.S. Leigh, J.M. Sanders, J.P. Love, J.D. Knoepp, J.M. Fraterrigo, A.D. Rosemond. 2022. Distinctive connectivities of near-stream and watershed-wide land uses differentially degrade rural aquatic ecosystems. Bioscience 72:144-159.

(89) *Jackson, C.R., C. Sytsma, L. Sutter, and D.P. Batzer. 2021. Redefining Waters of the US: a Case Study from the Edge of the Okefenokee Swamp. Wetlands 41:106. DOI:10.1007/s13157-021-01512-8

(88) *Miniat, C.F., A.C. Oishi, P.V. Bolstad, C.R Jackson, N. Liu, J.P. Love, C.M. Pringle, K.J. Solomon, and N. Wurzburger. 2021. The Coweeta Hydrologic Laboratory and the Coweeta LTER Project. Hydrological Processes 35(7) 10.1002/hyp.14302

(87) *Dudley, M.P., Solomon K., Wenger S., Jackson C.R., Freeman M., Elliott K.J., Miniat C.F., Pringle C.M. 2021. Do crayfish affect stream ecosystem response to riparian vegetation removal? Freshwater Biology *66*(7):423-1435. 10.1111/fwb.13728

(86) *Vache K., Meles, M.B., Griffiths, N.A., Jackson, C.R. 2021. Ensemble modeling of watershed-scale hydrologic effects of short-rotation woody crop production Biofuels, Bioproducts & Biorefining *15*(5):1345-1359.

(85) *Rastetter, E., M.D. Ohman, K.J. Elliott, J.S. Rehage, V.H. Rivera-Monroy, R.E. Boucek, E. Castañeda-Moya, T.M. Danielson, L. Gough, P.M. Groffman, C.R. Jackson, C.F. Miniat, G.R. Shaver. 2021. Future trajectories for ecosystems in the U.S. Long-term Term Ecological Research Network: The importance of time lags. Ecosphere 12(5):e03431. 10.1002/ecs2.3431

(84) *Younger, Seth E, C.R. Jackson, Todd C. Rassmussen. 2020. Relationships among forest type, watershed characteristics, and watershed ET in rural basins of the Southeastern US. Journal of Hydrology 591: 125316. 10.1016/j.jhydrol.2020.125316

(83) *Matteson, Cody, T., C. Rhett Jackson, Darold B. Batzer, Susan B. Wilde, and Johnson B. Jeffers. 2020. Nitrogen and Phosphorus Gradients from a Working Farm through Wetlands to Streams in the Georgia Piedmont, USA. Wetlands 40:2139-2149.

(82) *Dudley, M.P., M. Freeman, S. Wenger, C.R. Jackson, and C.M. Pringle. 2020. Rethinking foundation species in a changing world: the case for *Rhododendron maximum* as an *emerging* foundation species

in shifting ecosystems of the Southern Appalachians. Journal of Forest Ecology and Management 472:118240.

(81) *Raulerson, S., C. R. Jackson, Nathan D. Melear, Seth E. Younger, Maura Dudley, and Katherine J. Elliott. 2020. Do southern Appalachian Mountain summer stream temperatures respond to removal of understory rhododendron thickets? Hydrological Processes 34(13):3045-3060.

(80) *Bitew, Menberu M., C. Rhett Jackson, David C. Goodrich, Seth E. Younger, Natalie A. Griffiths, Kellie B. Vaché, Benjamin Rau. 2020. Dynamic domain kinematic modeling for predicting interflow over leaky impeding layers. Hydrological Proccesses 34(13):2895-2910.

(79) *Coats, W.A. and C.R. Jackson. 2020. Riparian Canopy Openings on Mountain Streams: Landscape controls upon temperature increases within openings and cooling downstream. Hydrological Processes 34(8):1966-1980. doi: 10.1002/hyp.13706

(78) *Gaiser, E.E., D.M. Bell, M.C.N. Castorani, D.L. Childers, P.M. Groffman, C.R. Jackson, J.S. Kominoski, D.P.C. Peters, S.T.A. Pickett, J. Ripplinger, and J.C. Zinnert. 2020. Long Term Ecological Research and Evolving Frameworks of Disturbance Ecology. Bioscience 70(2):141-156.

(77) *Lee, R.M., K.J. McGuire, B.D. Strahm, J.D. Knoepp, C.R. Jackson, and R.D. Stewart. 2020. Revisiting the Hewlett and Hibbert (1963) hillslope drainage experiment and modeling effects of decadal pedogenic processes and leaky soil boundary conditions. Water Resources Research. 56, e2019WR025090. https://doi.org/ 10.1029/2019WR025090.

The above paper received an Editor's Highlight in EOS, the AGU newsletter.

(76) *Bitew, Menberu, Seth E. Younger, C. Rhett Jackson, Enhao Du, and Damion Drover. 2019. Wetness Index based on Landscape position and Topography (WILT): Modifying the TWI to incorporate landscape position relative to water bodies. Journal of Environmental Management 255:109863.

(75) *Rugel, K., C.R. Jackson, J. Dowd, R. McDowell, T.C. Rasmussen, and S.W. Golladay. 2019. Using hydrogeomorphic patterns to predict groundwater discharge in a karst basin: Lower Flint River Basin, southwestern Georgia, USA. Journal of Hydrology – Regional Studies 23:100603.

(74) *Webster J.R., R.M. Stewart, J.D. Knoepp, and C.R. Jackson. 2019. Effects of instream processes, discharge, and land cover on nitrogen export from southern Appalachian Mountain catchments. Hydrological Processes 33:283-304.

(73) *Caldwell, P.V., C.R. Jackson, C.F. Miniat, S.E. Younger, J.A. Vining, J.J. McDonnell, D.P. Aubrey. 2018. Woody bioenergy crop selection can have large effects on water yield: A southeastern United States case study. Biomass and Bioenergy 117:180-189.

(72) *Griffiths, N.A., B.M. Rau, K.B. Vache, G. Starr, M.M. Bitew, D.P. Aubrey, J.A. Martin, E. Benton, C. Rhett Jackson. 2018. Environmental effects of short rotation woody crops for bioenergy: What is and isn't known. Global Change Biology Bioenergy 11:554-572. doi.10.1111/gcbb.12536

(71) *McDonnell JJ, J. Evaristo, K. Bladon, J. Buttle, I. Creed, S. Dymond, G. Grant, A. Iroume, C.R Jackson, J. Jones, T. Maness, K. McGuire, D. Scott, C. Segura, R. Sidle, and C. Tague. 2018. Forest water sustainability**,** Commentary. Nature Sustainability 1:378-379.

(70) *Klaus, J. and C.R. Jackson. 2018. Interflow Is Not Binary: a Continuous Shallow Perched Layer Does Not Imply Continuous Connectivity. Water Resources Research 54, 5921–5932.

WRR Editors' Choice Award for 2018. (Awarded to less than 1% of papers published each year)
The above paper also received an Editor's Highlight in EOS, the AGU newsletter.

(69) *McDonald, J.M., D.S. Leigh, and C.R. Jackson. 2018. Continental-, Watershed-, and Local-Scale Influences on Winter Stormflow Characteristics in the Southern Blue Ridge Mountains of Western North Carolina. Journal of Hydrology 563:643-656.

(68) *Cecala, K.K., J.C. Maerz, B.J. Halstead, J.R. Frisch, T.L. Gragson, J. Hepinstall-Cymerman, D.S. Leigh, C.R. Jackson, J.T. Peterson, and C.M. Pringle. 2018. Multiple drivers, scales, and interactions influence southern Appalachian stream salamander occupancy. Ecosphere 9(3):e02150.

(67) *Jackson, C.R., J.R. Webster, J.D. Knoepp, K.J. Elliott, R.E. Emanuel, P.V. Caldwell, and C.F. Miniat. 2018. Unexpected ecological advances made possible by long-term data: A Coweeta example. WIREs Water DOI: 10.1002/wat2.1273

(66) *Jackson, C.R., R.A. Bahn, and J.R. Webster. 2017. Water quality signals from rural land use and exurbanization in a mountain landscape: What's clear and what's confounded? Journal of the American Water Resources Association 53(5):1212-1228.

(65) *Tatum, V.L., C.R. Jackson, M.W. McBroom, B.R. Baillie, E.B. Schilling, and T.B. Wigley. 2017. Effectiveness of forestry best management practices (BMPs) for reducing the risk of forest herbicide use to aquatic organisms in streams. Forest Ecology and Management 404:258-268.

(64) *Griffiths, N.A., C.R. Jackson, M.M. Bitew, A.M. Fortner, K.L. Fouts, K. McCracken, J.R. Phillips. 2017. Water quality effects of short-rotation pine management for bioenergy feedstocks in the southeastern United States. Journal of Forest Ecology and Management 400:181-198.

(63) *Jackson, C.R., E. Du, J. Klaus, N.A. Griffiths, M. Bitew and J.J. McDonnell. 2016. Interactions among hydraulic conductivity distributions, subsurface topography, and transport thresholds revealed by a multi-tracer hillslope irrigation experiment. Water Resources Research 52(8):6186-6206.

(62) *Du, E., C.R. Jackson, J. Klaus, J.J. McDonnell, N.A. Griffiths, M.F. Williamson, J.L. Greco, and M. Bitew. 2016. Interflow dynamics on a low relief hillslope: Lots of fill, little spill. Journal of Hydrology 534:645-658.

(61) *Griffiths, N.A., C.R. Jackson, J.J. McDonnell, J. Klaus, E. Du, and M. Bitew. 2016. Dual nitrate isotopes clarify the role of biological processing and hydrologic flowpaths on nitrogen cycling in subtropical low-gradient watersheds. Journal of Geophysical Research Biogeosciences *121*(2):422-437.

(60) *Frisch, J.R., J.T. Peterson, K.K. Cecala, J.C. Maerz, C.R. Jackson, T.L. Gragson, an C.M. Pringle. 2016. Patch occupancy of stream fauna across a land cover gradient in the southern Appalachians, USA. Hydrobiologia 773:163-175.

(59) *Rugel, K., S.W. Golladay, C.R. Jackson, T.C. Rasmussen. 2016. Delineating groundwater/surface water interaction in a karst watershed: Lower Flint River Basin, southwestern Georgia, USA. Journal of Hydrology: Regional Studies 5:1-19.

(58) †Drover, D.R., C.R. Jackson, M. Bitew, and E. Du. 2015. Effects of DEM scale on the spatial distribution of the TOPMODEL topographic wetness index and its correlations to watershed characteristics. HESSD MS No.: hess-2015-275 MS. (HESSD is the online discussion forum for Hydrologic and Earth Systems Science).

(57) *Marchman, S.C., M. Miwa, W.B. Summer, S. Terrell, D.G. Jones, S.L. Scarbrough, and C.R.Jackson. 2015. Clearcutting and Pine Planting Effects on Nutrient Concentrations and Export in Two Mixed Use Headwater Streams; Upper Coastal Plain, Southeastern US. Hydrological Processes 29(1):13-28.

(56) *Jackson, C.R., D.S. Leigh, S. Lynsey Scarbrough, John F. Chamblee. 2015. Herbaceous versus forested riparian vegetation: Narrow and simple versus wide, woody, and diverse stream habitat. River Research and Applications 31(7):847-857.

(55) *Scarbrough, S.L., C.R. Jackson, S. Marchman, G. Allen, J. Louch, and M. Miwa. 2015. Herbicide concentrations in first-order streams following routine application for competition control in establishing pine plantations. Forest Science 61(3):604-612.

(54) *Straight, C.A., C.R. Jackson, B.J. Freeman, and M.C. Freeman. 2015. Diel patterns and temporal trends in spawning activities of Robust Redhorse and River Redhorse in Georgia, assessed using passive acoustic monitoring. Trans. Amer. Fisheries Society 144:563-576.

(53) *Klaus, J, J.J. McDonnell, C.R. Jackson, E. Du, and N.A. Griffiths. 2015. Where does streamwater come from in low relief forested watersheds? A dual isotope approach. Hydrology and Earth Systems Science 19:125-135.

(52) *Jensen, C.K., D.S. Leigh, and C.R. Jackson. 2014. Scales and Arrangements of Large Wood in First- through Fifth-order Streams of the Blue Ridge Mountains. Physical Geography 35(6):532-560.

(51) †Jackson, C.R. 2014. Forestry best management practices: A mitigated water pollution success story. J. Forestry 112(1):47-49.

(50) †Jackson, C.R., M. Bitew, and E. Du. 2014. When interflow also percolates: Downslope travel distances and hillslope process zones. Invited Commentary. Hydrological Processes 28:3195-3200.

(49) *Long, S.L. and C.R Jackson. 2014. Variation of stream temperature among mesoscale habitats within stream reaches: southern Appalachians. Hydrological Processes 28:3041-3052.

(48) *Booth, D.B., K.A. Kraseski, and C.R. Jackson. 2014. Local and watershed-scale determinants of summertime urban stream temperatures. Hydrological Processes 28:2427-2438.

(47) *Jackson, C.R. and D.J. Martin. 2012. Comment on "Does timber harvest influence the dynamics of marine-derived nutrients in southeast Alaska streams?" Canadian Journal of Fisheries and Aquatic Sciences 69:1894-1897.

(46) *Li G., C.R. Jackson, and K.A. Kraseski. 2012. Modeled riparian stream shading: Agreement with field measurements and sensitivity to riparian conditions. Journal of Hydrology 428:142-151.

(45) *Tedela, N.H., S. McCutcheon, T.C. Rasmussen, R.H. Hawkins, W.T. Swank, J.L. Campbell, M.B. Adams, C.R. Jackson, and E.W. Tollner. 2012. Runoff curve numbers for ten small forested watersheds in the mountains of the Eastern United States. Journal of Hydrologic Engineering 17(11):1188-1198.

(44) *Harper, M.A., D.P. Batzer, C.R. Jackson, and R. Fenoff. 2012. Temporal and spatial variability of invertebrate communities in potential reference headwater streams of the Georgia Piedmont. J. Freshwater Ecology 27(2):273-285.

(43) *Palta, M.M., T.W. Doyle, C.R. Jackson, J.L. Meyer, and R.R. Sharitz. 2012. Changes in diameter growth of Taxodium distichum in response to flow alterations in the Savannah River. Wetlands 32:59-71.

(42) *Rugel, K., C.R. Jackson, J.J. Romeis, S.W. Golladay, D.W. Hicks, and J.F. Dowd. 2012. Effects of irrigation withdrawals on streamflows in a Karst environment: Lower Flint River Basin, Georgia, USA. Hydrological Processes. 26:523-534. DOI 10.1002/hyp8149.

(41) *Fraser, N., C.R. Jackson, D.E. Radcliffe. 2011. A paired watershed investigation of silvicultural BMPs revisited: BF Grant Memorial Forest, Georgia. Forest Science 58(6):652-662.

(40) *Terrell, S.B., W.B. Summer, C.R. Jackson, M.Miwa, D.G. Jones. 2011. Harvest, site preparation, and firebreak effects on hydrology and sediment transport in Coastal Plain headwater streams. Trans. Amer. Soc. Agricultural and Biological Engineers 54(6): 2117-2127.

(39) *Peterson, J.T. J. Wisniewski, J.P. Shea, and C.R. Jackson. 2011. Estimation of mussel population response to hydrologic alteration in a southeastern U.S. River basin. J. Env. Management 48:109-122. DOI 10.1007/s00267-011-9688-2

(38) *Romeis, J.J., C.R, Jackson, L.M. Risse, A.M. Sharpley, and D.E. Radcliffe. 2011. Hydrologic and phosphorus export behavior of small streams in commercial poultry-pasture watersheds. J. American Water Resources Association 47(2):367-385.

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ii. Research Grants (I am lead PI unless otherwise noted)

Sustainable and Equitable Urban Stream Corridors: Improving aesthetic, social, water quality, and ecological values of urban watersheds to achieve downstream rural benefits. $149,989. January 1, 2022-December 31, 2022. National Science Foundation.

GIS-driven, two-dimensional water table model based on the one-dimensional Dupuit equation for estimating water table position, transit times, and groundwater storage. $53,950. July 1, 2021 – June 30, 2023. USDA Forest Service.

Engineering With Nature ® Initiative (FP00021076). $ 2,500,000, Co-investigator of, Credit: 6%. July 1, 2020–July 29, 2021, with extensions. US Department of Army, W912HZ2020031.

Comparative Hydrologic Budgets and Water Use Efficiencies of Developing Woody Bioenergy Plantations. $498,633. Douglas P. Aubrey is lead PI. 6/1/2019-5/31/2023. USDA NIFA.

Monitoring of groundwater nitrogen gradients from plantations to streams and measurement of riparian denitrification rates. $340,000. 6/1/2017-9/30/2020. USDA Forest Service.

CWT LTER Renewal. $2,516,000. Examining long-term southern Appalachian ecosystem dynamics through interactions and indirect effects. Rhett Jackson (PI) and 31 co-investigators from nine institutions and the USFS. 3/1/2017-2/28/21. Funded by NSF.

Fluvial Processes Research Coordination Support for the NPS-Southeast Coast I & M Network. $197,754. 9/15/2016-8/31/2019. National Park Service.

Wetlands and agriculture. $264,508. Darold Batzer (Entomology) is lead PI. USEPA. 10/2015-9/2019.

Monitoring, Analysis, and Synthesis of a Watershed Scale Assessment of Hydrologic and Water Quality Responses to Intensive Cellulosic Biofuel Silviculture. $380,889. USDA Forest Service SRS. 7/1/2014-12/31/2018.

Continued Monitoring and Analysis of Hydrologic and Water Quality Responses to Basin-scale Intensive Woody Biomass Production. $262,500. US Dept. of Energy Bioenergy Technology Office. March 15, 2014 – March 30, 2016.

Total Water Use and Source Partitioning in Woody Bioenergy Crops Determined by Coupled Mass Flux and Stable Isotope Signatures. Doug Aubrey (Warnell and SREL) is lead PI. My portion is $250,958. USDA-AFRI. September 1, 2013 – August 31, 2019.

DEB 1440485. Coweeta LTER Renewal: The interacting effects of hydroclimate variability and human landscape modification in the southern Appalachian Mountains. Ted Gragson (PI) and 32 co-investigators from twelve Universities and the USDA Forest Service. Funded by NSF. $2,593,333. 2014-2016.

Sustainable Water Use and Bioenergy: Application of Isotopic Tracer Techniques to Improve Methods for Estimating Water Use in Intensively Managed Woody Crop Systems. $180,776. USDA Forest Service. December 14, 2012 – June 30, 2016.

Potential and Actual Evapotranspiration Estimation in Southeastern Watersheds Vegetated with Pine Forests Intercropped with Switchgrass. $74,352. USDA Forest Service. November 1, 2011 – December 31, 2015.

Analysis of Chemistry and Herbicide Data from the Dry Creek Paired Watershed Study. $32,050. National Council for Air and Stream Improvement. Jan 1, 2012 – June 30, 2013.

Development of a Summary of Biological, Hydrological, and Water Quality Information Relevant to the Savannah River Basin Sustainable Rivers Project. $17,900. United States Army Corps of Engineers. Sept. 20, 2011 – August 31, 2012.

Monitoring of Robust Redhorse (Moxostoma robustum) Spawning Behavior Responses to Flow and Water Quality Variation. $47,000. USGS. Sept. 1, 2011 – August 31, 2013.

Baseline Instrumentation and Watershed Characterization for Assessment of Hydrologic and Water Quality Response To Intensive Cellulosic Biofuel Silviculture. C.R. Jackson. $326,000. Funded by USDOE and USDA Forest Service. December 14, 2009 – December 31, 2014. Continuation of the same for $267,361.

Characterization of Flow Paths, Residence Times, and Media Chemistry in Complex Landscapes. C. R. Jackson (PI). $291,000. USDA Forest Service. September 1, 2009 – August 31, 2014.

Evaluation of Sediment Dynamics at Gravel Bars in the Upper Savannah River. US Department of Defense, US Army Corps of Engineers. C.R. Jackson (PI) $52,000. 9/15/2009 – 1/7/2011.

Identifying Locations of High Connectivity between Floridan Aquifer Water and Surface Waters at Lineament Intersections with Tributaries of the Lower Flint River. C.R. Jackson. $18,000. Funded by USGS. March 1, 2009 – February 28, 2010.

DEB 0823293. Coweeta LTER Renewal: Southern Appalachia on the Edge – Exurbanization & Climate Interaction in the Southeast. Ted Gragson (PI) and 29 co-investigators from eight Universities and the USDA Forest Service. Funded by NSF. $8,026,123. 2008-2014.

Lower Flint River Basin Habitat Conservation Planning. J.T. Peterson, C.R. Jackson, USGS, and GADNR. Funded by USFWS. $117,000. August 1, 2007 – July 31, 2009.

Doctoral Dissertation Research: Geomorphic and Anthropogenic Controls on Baseflow Discharge of Southern Blue Ridge Mountain Streams. NSF Doctoral enhancement grant for Katie Price under the direction of A.J. Parker and C R. Jackson. NSF. $12,000. April 1, 2007 – March 31, 2009.

Hillslope Flow Routing, Contaminant Transport, and Water Uptake in Zero-Order Watersheds Subject to Intensive Forest Plantation Management at the Savannah River Site, South Carolina. C.R. Jackson (PI). $109,000 for initial efforts. USDA Forest Service. August 1, 2004 - April 30, 2008.

A framework for trading phosphorus credits in the Lake Alatoona watershed. D. Radcliffe (PI). Co-PIs: L. Fowler, C.R. Jackson, A. Keeler, M. Risse. $550,000. USDA CSREES program. 2003-2007.

Investigation of the Effectiveness of Georgia's Silvicultural BMPs. C.R. Jackson (PI). Co-PIs: Larry Morris, Dan Markewitz, Todd Rasmussen, Dale Green, Ben Jackson. $475,000 total over four years. USEPA. 2000-2004. Additional funding provided by NCASI ($25,000) and Weyerhaueser ($16,000) for 2004-2006.

Phosphorus Storage and Transport in Headwaters of the Etowah River Watershed. $18,000. USGS Georgia WRRI. 2005.

Analysis of Hydrologic and Sediment Data from the Dry Creek Paired Watershed Study on Southlands Forest. $126,000. Funded by NCASI with in-kind support from International Paper. August 1, 2002 – April 30, 2008.

The development and evaluation of tools for evaluating flow requirements in streams in the Lower Flint River Basin, Georgia. J.T. Peterson (PI). C.R. Jackson (Co-PI). Approximately $400,000. Georgia DNR. 2001-2005.

Integrated Headwater Stream Riparian Management Study. C.R. Jackson (PI). Co-PIs: D.P. Batzer, B. Chapman, and J.B. Wallace. $87,000 over two years. Funded by National Council for Air and Stream Improvement. 1998-2000.

Assessment of the recovery of macroinvertebrate and amphibian populations following logging of headwater streams in the Coast Range of Washington State. C.R. Jackson (PI) and D.P. Batzer (Co-PI). $33,000 total over one year. Funded by Washington State Department of Natural Resources and the National Council for Air and Stream Improvement. 2001-2002.

Piedmont River Sediment Budget. C.R. Jackson (PI). Co-PIs: David Leigh, Larry West. $66,000 total ($20,000 initial, with two renewals of $40,000 and $6,000) over three years. Funded by National Council for Air and Stream Improvement. 1998-2001.

DeKalb County Dredging Assessment. Ben Jackson (PI). Co-PIs: C.R. Jackson, Jay Shelton, Terry Sturm (Georgia Tech). $130,500 total (initially $55,000 to UGA and $70,000 to Georgia Tech with $5,500 renewal for UGA). DeKalb County. 1998-2002.

Assessment of Timber Harvest Effects on Coastal Plain Depressional Wetlands. Darold Batzer (PI) and Rhett Jackson (Co-PI). $30,000 total ($10,000/year with renewal each year) over three years. Funded by Turner Foundation with cooperation and in-kind services from International Paper (formerly Union Camp). 1998-2001.

Trout stream buffer study. Jim Kundell (PI). Co-PIs: J. Meyer, L. Kramer, C.R. Jackson, and T. Rasmussen. School of Forest Resources portion totals $75,000 ($25,000 per year) over three years. Funded by the Georgia Legislature. 2000-2002.

4. Public Service

Interviewed for documentary, *Sacred Waters: The Okefenokee in Peril*, produced by the Okefenokee Protection Alliance.

Worked with UGA architects' office on Town Spring interpretative materials for the Innovation Hub. Helped with interpretive signage, 2020-2021. Was interviewed for two videos. UGA's spring of innovation - UGA Research News

Georgia Forestry Association Environmental Committee, 1999-present.

Georgia Forestry Association, Georgia Forestry Commission, and American Forests and Paper Association ad-hoc committees to revise Georgia's forestry BMPs for floodplains and ephemeral areas, 2001-present.

Organized and conducted field tours on BMP issues for industry representatives, GFC water quality foresters, NCASI Sediment group.

Provided floodplain and headwater BMP training workshops for GFC water quality foresters and industry representatives.

Assisted with GFC/NCASI Cypress Initiative 2014-2015

Hydrologic monitoring advisor to Guangdong Province Forestry Administration. Two trips to Guangdong Province, China - September 2005 and September 2006. Presented lectures to Guangdong Forestry Research Institute and South China Agricultural University. Visited water quality monitoring installations and provided advice and reference materials for the research program. Hosted Director of Hydrologic Studies of the Guangdong Forest Research Institute as a visiting scholar at University of Georgia for one year.

Southern Forest Research Partnership (SFRP) Water Team member, 2004-end of the partnership

Senate Bill 460 Rules Committee - evaluated guidelines for issuance of variances to State of Georgia stream buffer laws. 2004.

Athens-Clarke County citizens stormwater advisory committee, 2003-2004.

Co-instructor Harvest Planning continuing education short course, 2001, 2002, 2003, 2004, 2005, 2006.

Washington State Independent Science Panel - Adjunct member for technical review of State of Washington Stormwater Management Manual. 2003.

Lake Alatoona Preservation Authority Scientific Advisory Group. 2000-2003.

Lecturer and ad-hoc program committee, Forestry Agent Special Area Training (FASAT). 1998,1999, 2002.

Georgia Conservancy Sediment TMDL Technical Advisory Group. 2000-2002.

State of Georgia's Stream Buffer Variance Criteria Technical Advisory Committee. 2000. Chairperson.

Co-Chairperson, McNutts Creek Watershed Study Group. 1999-2001.

Various water quality presentations for the general public including various local chapters of the Society of American Foresters, League of Women Voters (Franklin, NC), Rotary Club (Ila, GA), Kiwanis Club, ASCE local chapter, Community Tree Council, Botanical Garden River Rambles, Greenfest Water Forum, LEAD Athens, Barrow Elementary School, Dustbowl Drought Awareness Benefit Concert, Georgia Public Television (Georgia Outdoors), Georgia Public Broadcasting, Atlanta Journal Constitution Editorials, Newsmakers with Tim Bryant WGAU radio show, Timber Talk Radio Show (Arkansas), and others.

Various water quality presentations and field trips for agencies, NGOs, and industry meetings including a Forest Hydrology and Water Quality Training Class for GAEPD, a forestry BMP field trip for a National Research Council Committee, a Forestry BMP workshop for MeadWestvaco, a Washington State DNR forested wetlands workshop, and others.