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2015 Assessment of Mercury in the Savannah River Site Environment and Responses to the Agency for Toxic Substances and Disease Registry 2012 Report on Assessment of Biota Exposure to Mercury Originating from the Savannah River Site

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Citizens Advisory Board Briefing

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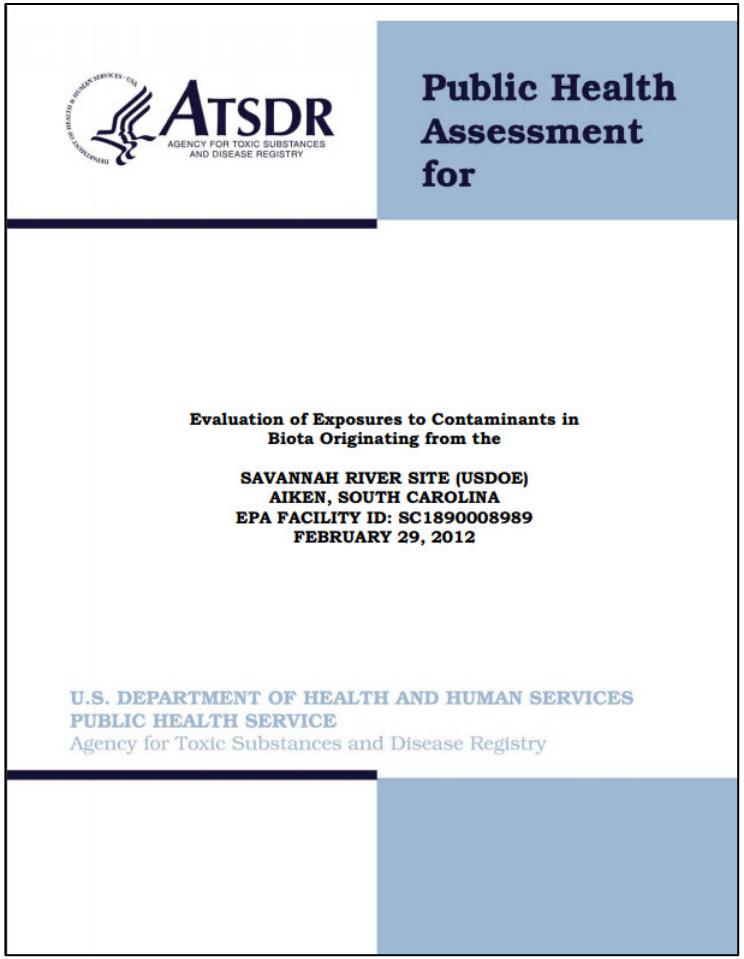
Background

- Agency for Toxic Substances and Disease Registry issued a report 2012 "*Evaluation of Exposures to Contaminants in Biota Originating from the Savannah Rive Site (DOE)*"
- Report was produced by reviewing available monitoring data collected by the Savannah River Site (SRS), South Carolina Department of Health & Environmental Control (SCDHEC), and Georgia Department of Natural Resources (GADNR) for both on-site and off-site locations along the Savannah River.
- Monitoring data for both water and biota were collected during the years 1993-2008.
- An additional scientific literature search was conducted to determine chemical contaminants measured in biota at or near SRS during the same time frame.



Conclusions from the ATSDR regarding Mercury

- Mercury, a non-radioactive contaminant, was identified as a chemical of concern based on records of measurement in the edible portions of biota.
- "Mercury contamination in fish from the Savannah River, both upstream, along, and downstream of SRS, has been well documented by stated agencies. However, the contribution of mercury from SRS-related activities to the river system is not known."
- "If subsistence fishers do no follow the recommended consumption guidance, consuming large amounts of fish, especially species that typically accumulate mercury such as large mouth bass, bowfin, and catfish from certain portions of the Savannah River might increase health risks associated with mercury exposure, especially to sensitive populations (e.g. fetuses and nursing infants whose mother ingests mercury-contaminated fish."

ATSDR Final recommendations

- DOE should continue to monitor all types of biota consumed by humans both on and off the site until all remediation actions are completed and no old or new sources of contamination remain.

- DOE should keep informed of the types of biota consumed by humans and provide adequate monitoring for those types that may be contaminated by site activities. *There were limited or no data available from 1993 to 2008 for review on some animals potentially consumed by humans, such as alligators, rabbits, squirrel, ducks, turtles, and other small animals. Migratory animals such as birds and ducks that frequent SRS's contaminated ponds and streams will continue to present a pathway for possible exposure to humans.*

- DOE should periodically review potential differences in environmental monitoring results between all agencies and programs involved. This comparison should include the on-site field surveys performed on harvested animals and laboratory sampling results.

ATSDR Final recommendations

- Largemouth bass and bowfin have typically accumulated the highest concentrations of mercury. Currently, the state of South Carolina recommends not eating these two species if collected from portions of the Savannah River between Highway 119 in Jasper County U.S. to Highway 17 near Savannah, Georgia.
- DOE should consider routine environmental sampling of turtles for aquatic contaminants, especially for those chemical and radioactive contaminants found predominantly in pond and stream sediment.

Purpose for the 2015 Assessment of Mercury in the Savannah River Site Environment

Follow up report was prepared to:

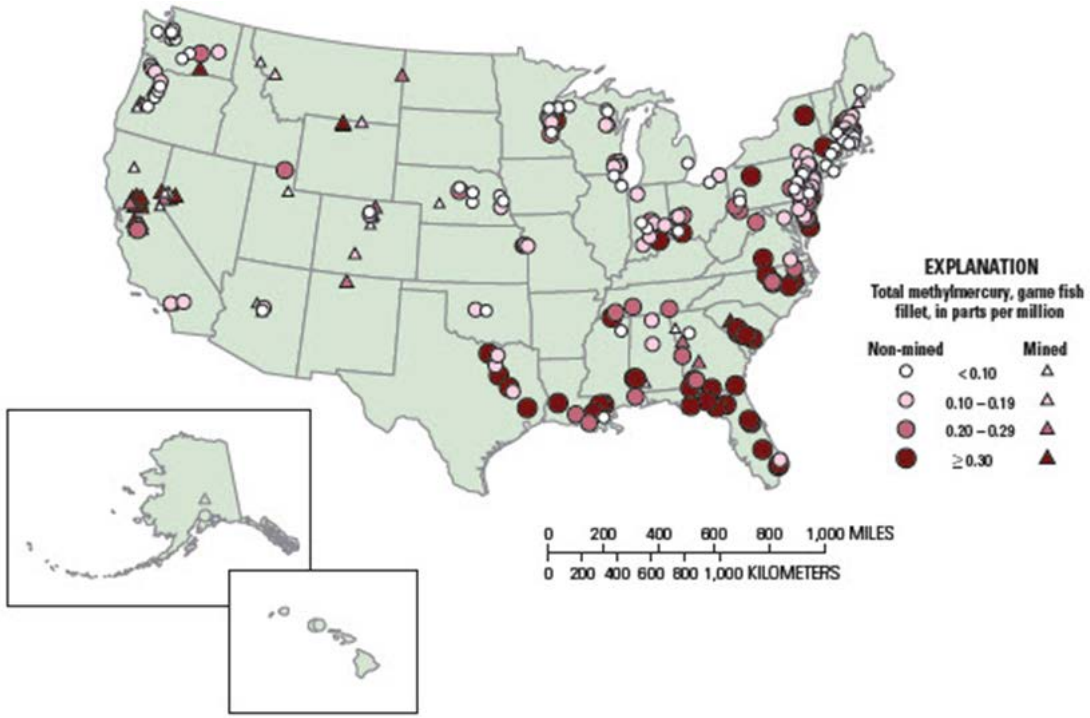
1. Update the current status of mercury in the SRS environment and the current understanding of mercury in aquatic systems in the southeast.
2. Specifically Address the ATSDR recommendations

- Report is divided into three primary sections
  - Section 2.0 - Current understanding of mercury in aquatic systems as presented through reviews conducted by the U.S. Geological Survey (USGS) and the U.S. Environmental Protection Agency (EPA).
  - Section 3.0 – Identifies sources of mercury specific to the SRS and to the Savannah River through atmospheric deposition, historical releases from industrial sources, and historical usage and release from SRS operational activities,
  - Section 4.0 – New information not included in the ATSDR report

- The U.S. Geological Survey (USGS) recently completed a study of available scientific literature, datasets and monitoring data since the late 1990s and conducted an assessment of mercury in the nation's streams (Wentz et al., 2014).
  - methylmercury concentrations in fish exceed the U.S. Environmental Protection Agency (EPA) criterion for protection of human health at about one in four streams across the U.S.;
  - wetlands increase the amount of inorganic mercury that is converted to methylmercury;
  - mercury emission reduction strategies need to consider global mercury sources in addition to domestic sources; and
  - existing mercury monitoring programs focus mostly on methylmercury concentrations in fish, and lack design elements and data to link these levels to mercury sources.

USGS Report Findings - Streams of Forested Wetlands

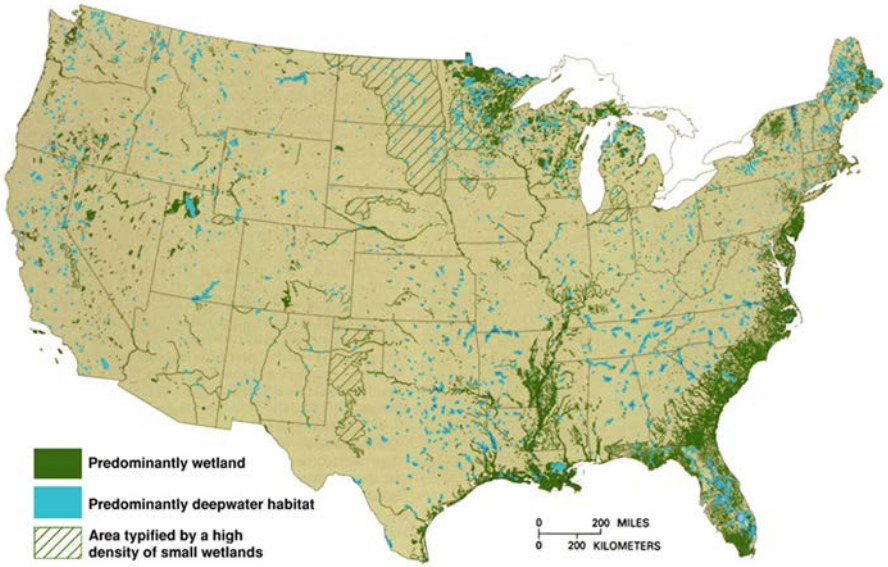
- The highest concentrations of methylmercury in freshwater fish in the nation were measured primarily in forest or wetland-dominated coastal plain streams in the southeastern United States (Scudder et al. 2009).
- Scudder et al. reported that during 1998-2005 methylmercury concentrations in largemouth bass were the highest for streams draining undeveloped basins and basins with mixed land use/land cover.



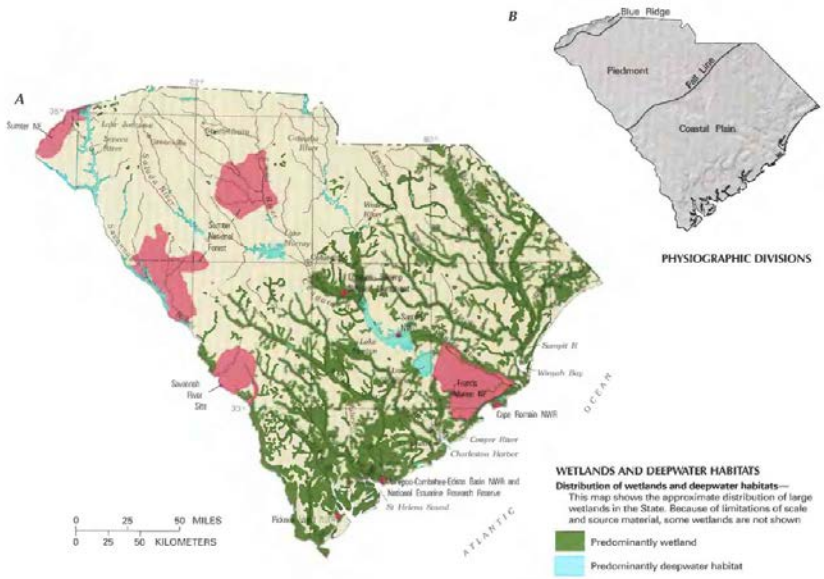
Methylmercury Concentrations in Fish across the U.S. (Image from USGS 2014 – modified from Scudder and others, 2009)

Predominance of Wetlands in the Southeast

- Wetlands can be a sink for total inorganic mercury.
- Mercury deposition into the wetlands from legacy industrial point sources, wild land fires, or atmospheric deposition.
- Presence of sulfate reducing bacteria in the wetlands easily convert inorganic mercury to the bioavailable methylmercury.



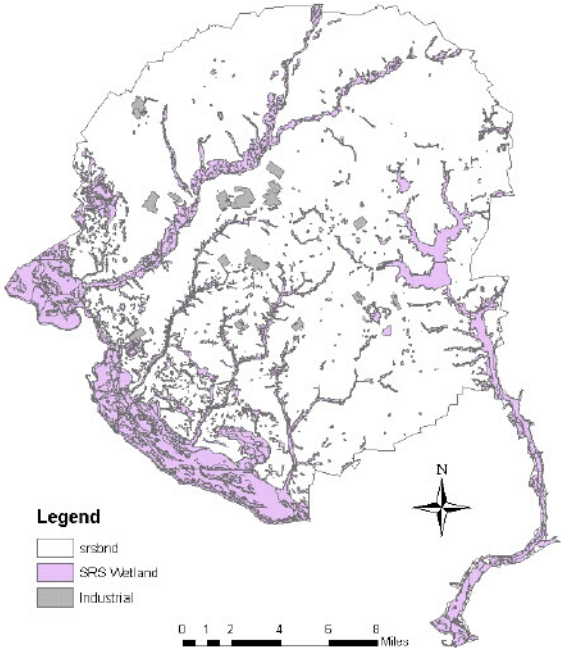
Locations of Wetland Ecosystems Across the U.S. (Photo from USGS 1996)



Wetland Distribution in South Carolina and Physiography of the State. A, Distribution of Wetlands and Deepwater Habitats, B, Physiology (Figures A and B taken from USGS 1996)

Wetlands on the SRS and Their Influence on Mercury in the Savannah River and in Biota

- Savannah River Site is 810 sq km of which
  - 5% is developed industrial
  - 73% forested (pine and mixed hardwoods)
  - 22% wetlands consisting of swamps, Carolina Bays, Streaks and Lakes
- Mercury levels in water and tissues of Asiatic Clams
  - Paller et al. 2004 deployed caged clams the creek mouths just above the Savannah River.
  - Methylmercury concentrations in the creek mouths (0.170 ng/L) were nearly twice as high as in the river (0.085 ng/L).
  - Average total mercury levels differed little between the creek mouths (2.98 ng/L) and the river (2.59 ng/L)
  - Soft tissue methylmercury levels were approximately 2.5 X higher in Corbicula from the tributary discharges plumes than those in the Savannah River upstream.
  - The difference in tissue concentrations was hypothesized to be connected to the large surface area of wetlands that drain into the tributaries.



SRS Site Wide Wetlands map as of 2005 (Image from SRS 2005)

Section 3.0 Sources of Mercury to the SRS and the Savannah River Environment

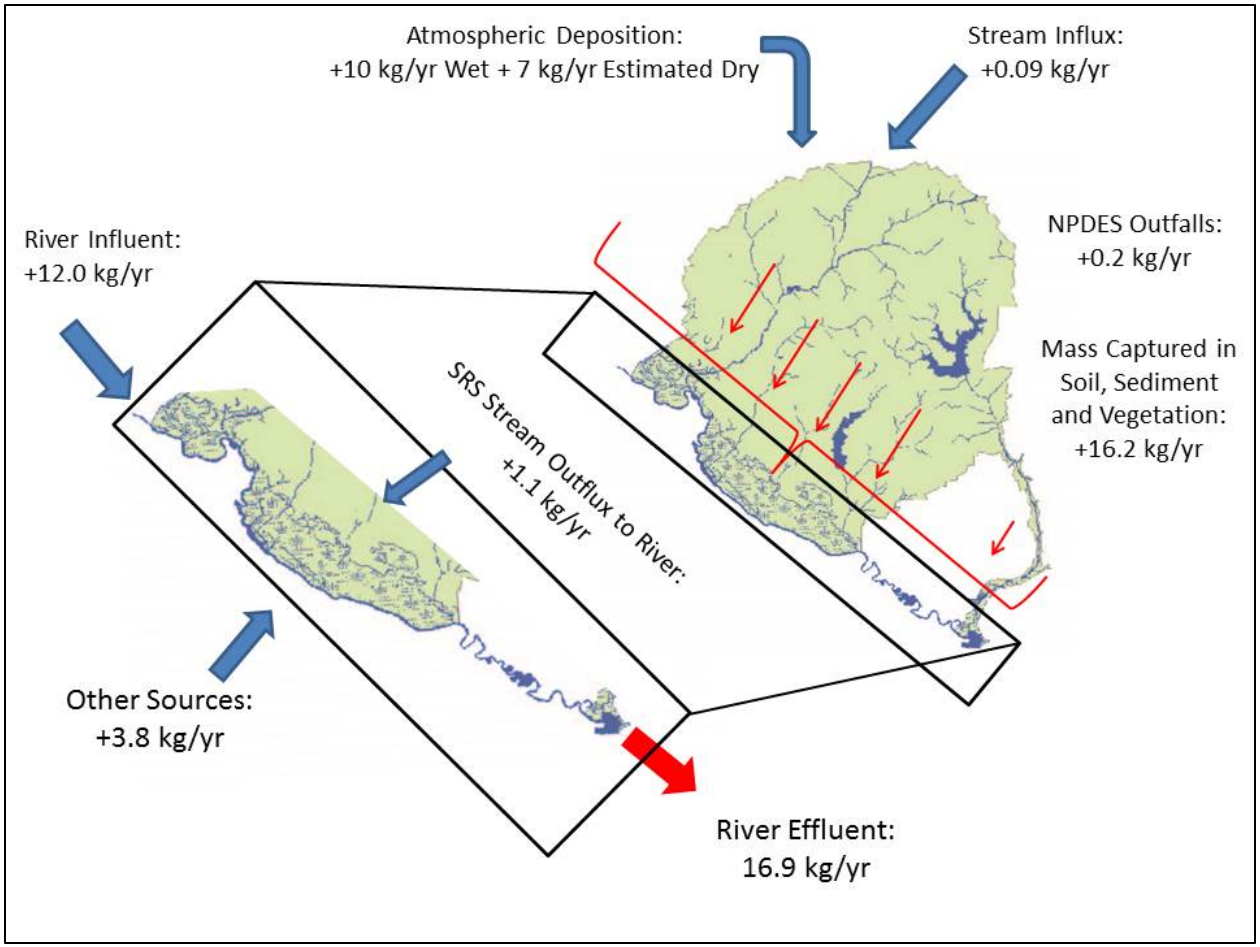
- Atmospheric Deposition
- Olin Corporation Chlor-Alkali Plant Augusta, GA
  - Operated for 47 years
  - Discharged ~12 lbs per day to the Savannah River (1965 to 1970) (EPASWL 1971 cited in Tilley and White).
  - Ends up being more than 18,000 lb of mercury discharged to the Savannah River.
- SRS Operational Activities
  - Processing aid in aluminum dissolution and chloride precipitation (Between 1959 and 1981 F-Area usage 3600 lbs and H-Area usage 840 lbs)
  - Part of the tritium facilities' gas handling system;
  - experimental, laboratory, or process support facilities; and
  - as a waste from site operations;
  - Coal burning power plants

- Extensive accountings of the use and release of mercury on the site has been performed along with assessments of mercury in the environment (Kvartek et al. 1994 and RAC 2001).
- An important source of mercury to the SRS was from releases made by upriver point sources (i.e. Olin Corporation) along the Savannah River. Savannah River water was pumped directly from the river onto the site mainly as a source of reactor cooling water and to maintain PAR Pond and L-Lake's water levels. Much of this water was then released to cooling ponds and tributaries which drain back to the Savannah River.

Section 4.0 Sources and Implications of Mercury in the SRS Environment

- Halverson et al. 2008 reported a preliminary mass balance for total mercury at the SRS.
- Inputs included mercury discharged from
  - SRS facilities to NPDES outfalls
  - Mercury transported to the site in the Savannah River upstream of the Site boundary
  - Mercury entering the SRS via stream originating outside the site boundaries, and
  - Atmospheric deposition.
- Outputs included mercury transported down the SR at the downstream site boundary and re-volitalization.
- Accumulation locations include upland soils, water column, sediments and biota

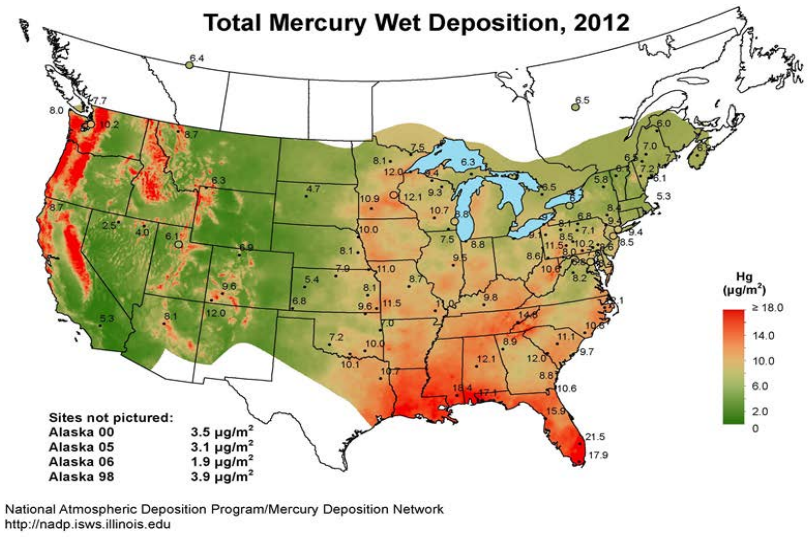
Mass Balance



95% of the deposited mercury was being retained in soils, sediments, water bodies or vegetation or being re-emitted to the atmosphere.

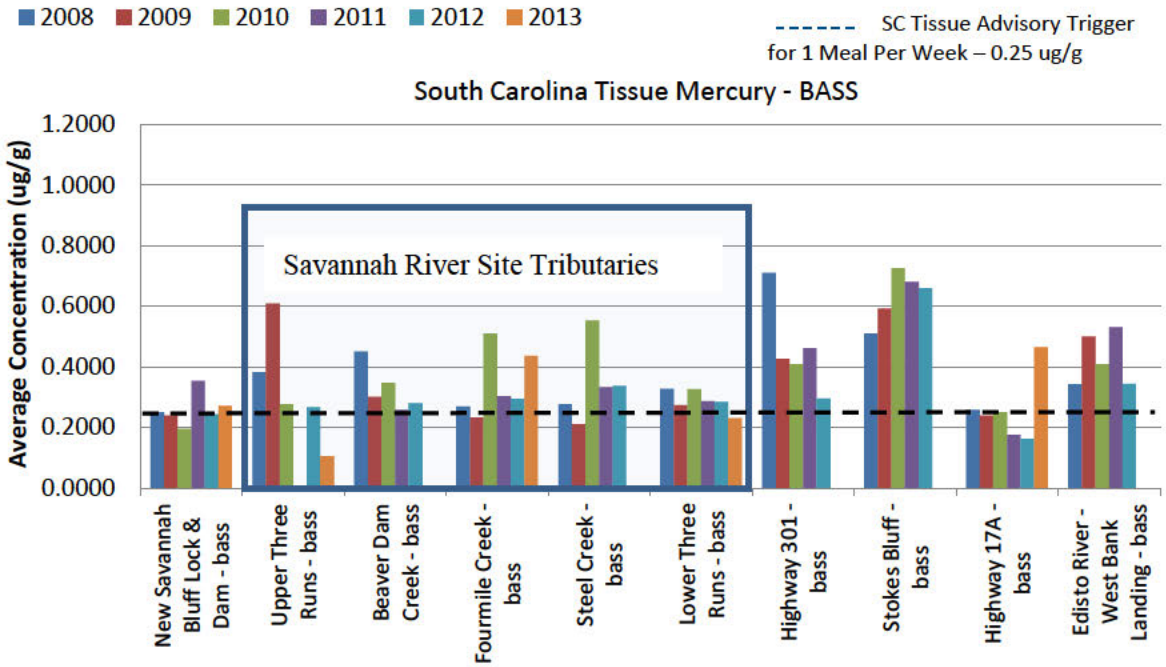
National Atmospheric Deposition Program (NADP)

- SRNL sponsors a monitoring and collection station that is part of the NADP.
- The station has been operational since 2001.
- During calendar year 2012 the average (volume weighted) concentration of total mercury in precipitation at SRS was 11.1 ng/L and the wet deposition rate was 12.0 **µg**/m^2. Comparing the 2012 SRS wet deposition rate to the rest of the nation the rate of 12.0 **µg**/m^2 was consistent with values measured in the southeast, but higher than those measured in the northeast and west.



Mercury in Fish

- Evaluating average mercury concentrations measured in fish collected from above, along and below SRS the bass data shows the highest mercury concentrations as compared to catfish and panfish. Average concentrations range from a minimum 0.162 (µg/g) measured in 2012 at Highway 17A to a maximum 0.726 (µg/g) at Stokes Bluff Landing in 2010.

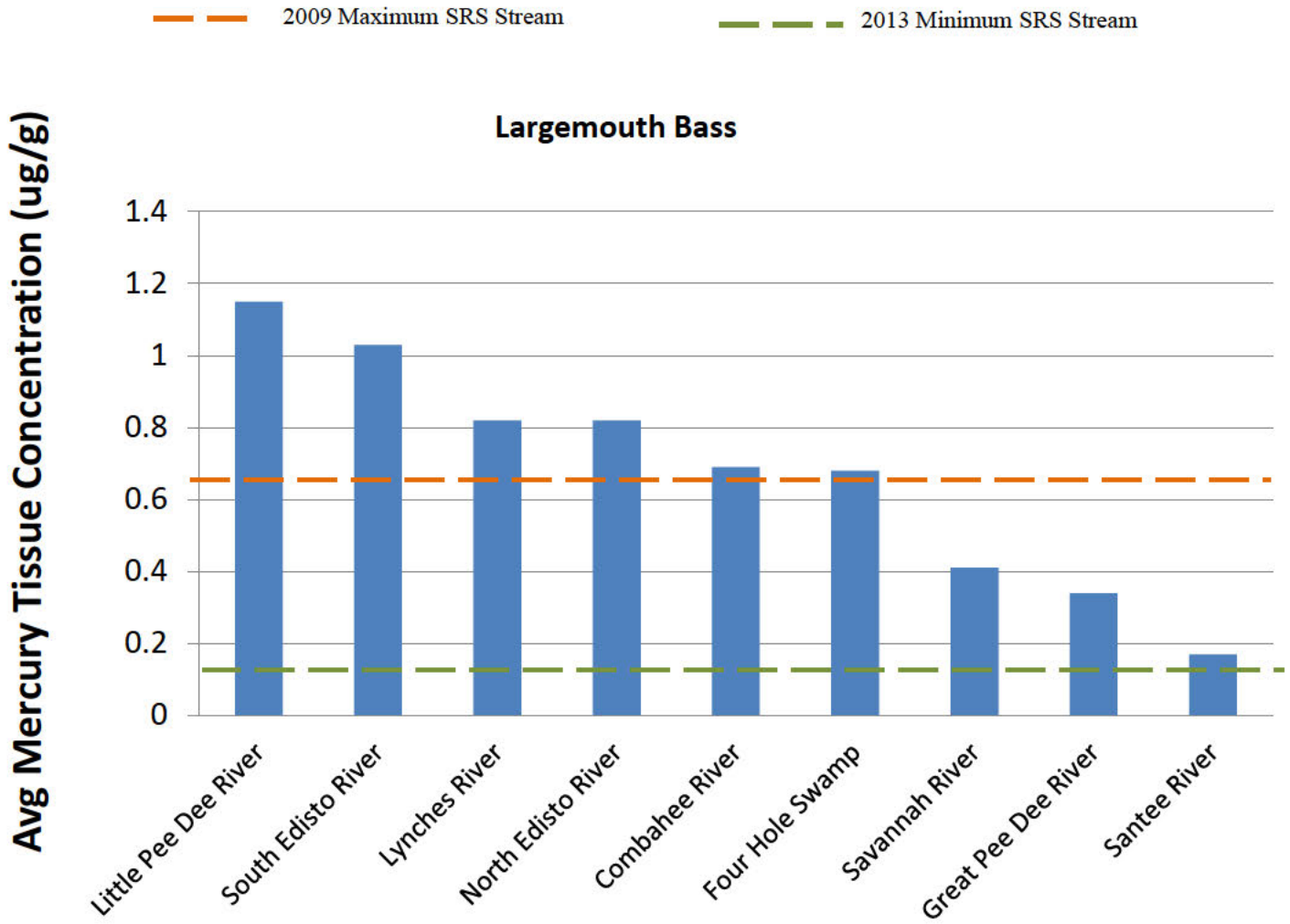


Mercury Concentrations in Bass by Location for the Period 2008 through 2013

Comparison of SRS Largemouth Bass Tissue Concentrations with Other South Carolina Rivers

- A comparison of known largemouth bass average tissue concentrations was conducted to determine if concentrations measured in fish from SRS streams were significantly different. Using average concentrations reported in the SCDHEC 2010 report, concentrations for largemouth bass collected from rivers found in the same ecoregion as SRS streams (Southeastern plains) were used for comparison.

- Nine rivers were selected for comparison and showed that the maximum average tissue concentration was measured in the Little Pee Dee River at 1.43 µg/g and the minimum concentration of 0.54 µg/g in the Santee River. The Savannah River average was 0.84 µg/g. Taking the average largemouth bass tissue concentrations collected at the mouths of the SRS streams for the last five years the maximum and minimum concentrations were measured at Upper Three Runs. The minimum concentration of 0.10 µg/g was measured in 2013 while the maximum of 0.61 µg/g was measured in 2009 (SRNS 2013).


2009 Maximum SRS Stream
2013 Minimum SRS Stream
Largemouth Bass
Avg Mercury Tissue Concentration (ug/g)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Little Pee Dee River
South Edisto River
Lynches River
North Edisto River
Combahee River
Four Hole Swamp
Savannah River
Great Pee Dee River
Santee River

Additional Surveillance - Sediments

- **Results of sediment surveillance show that mercury concentrations are below detection or below practical quantitation limits for the last six years. Results from 2013 show a detection of mercury of 0.53 µg/g at Beaver Dam Creek, but this value is within the range of background mercury levels measured in surface sediments that ranged as high as 1.00 µg/g (Kaplan et al. 2002).**

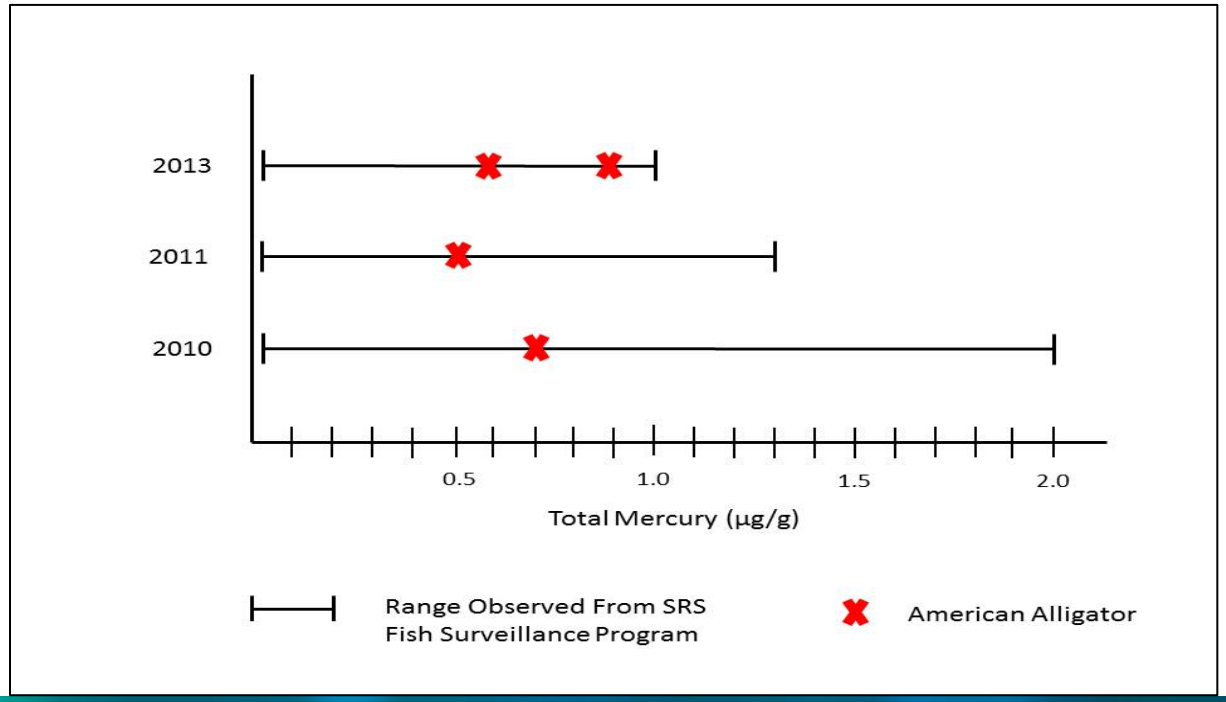
Sediment Surveillance for Mercury (µg/g)

Location	2008	2009	2010	2011	2012	2013
Upper Three Runs 4	ND	ND	ND	<0.26	<0.31	ND
Beaver Dam Creek	ND	ND	ND	<0.16	<0.13	0.53
Four Mile Creek at 125	ND	ND	ND	<0.15	<0.11	ND
Pen Branch	ND	ND	ND	<0.17	<0.17	ND
Steel Creek	ND	ND	ND	<0.12	<0.12	ND
Lower Three Runs	ND	ND	ND	<0.26	<0.14	ND
Upper Three Runs 1A	ND	ND	ND	<0.41	<0.54	ND
Tinker Creek	ND	ND	ND	<0.12	<0.12	ND
River Mile 160	ND	ND	ND	<0.13	<0.13	ND
Plant Vogtle Discharge	ND	14	11	<0.14	<0.12	ND
River Mile 118.7	ND	ND	ND	<0.16	<0.15	ND

Additional Surveillance - Alligators

SRS analyzed alligator samples donated by hunters who have harvested alligators from the Savannah River near the Site during the years 2010 to 2013.

In the summer of 2012, a local hunter donated a portion of meat from two alligators. One alligator was harvested in September of 2010 (GA-003766) and the second was harvested in September of 2011 (SC-12113). Both animals were harvested from the Savannah River near Little Hell Landing. Two alligator samples were collected during 2013. The mercury results for the 2013 samples in addition to the two samples collected in 2010 and 2011 were reported in the SRNS 2013 Annual Environmental Report (SRNS 2013).



Risk Assessment Corporation report to Center for Disease Control

- Conduct a “Dose Reconstruction” of past releases leading to human exposure and dose from chemicals and radioactive releases to the offsite environment from the SRS. Evaluations were conducted for the years 1951 through 1992 by thoroughly reviewing records and documents related to environmental releases in an attempt to determine whether SRS operations resulted in elevated mercury concentrations in the Savannah River.

- Between 1959 and 1982, more than 3600 and 840 lb of mercury were released to H-Area and F-Area seepage basins, respectively (Horton 1974b, cited in RAC 2001). Use of the basins continued through 1988, after which they were capped and did not receive additional effluent. During 1972 several studies were conducted to identify mercury concentrations in the soil, seepline sediment, water and groundwater of the F- and H-Area seepage basins and Four Mile Creek sediment and water.

RAC Conclusions

- RAC 2001 report concluded:
- *"Based on mercury concentrations measured in Savannah River and Four Mile Creek sediment, however, SRS activities have not resulted in an appreciable mercury releases to the Savannah River."*
- *"Based on concentrations of mercury measured in fish collected from the Savannah River at locations above, adjacent to, and below the SRS, which were very similar, SRS activities have not resulted in measurable mercury releases to the Savannah River."*
- *"Mercury concentrations measured in fish collected from onsite ponds and streams have consistently been elevated (by about a factor of 2) relative to Savannah River fish concentration. However, concentration in fish from Four Mile Creek are similar to or lower than concentrations in fish from other onsite locations. There is little evidence to suggest that mercury from F-Area and H-Area seepage basins has resulted in elevated fish concentration Four Mile Creek or any other onsite stream. The highest concentrations appear to be in streams and reservoirs that have received reactor cooling effluent. It is unlikely that cooling effluent would contain mercury resulting from reactor operations, and it appears that the primary source of mercury at the SRS has been the continuous pumping of Savannah River water for us as a reactor coolant".*

Conclusions

- Mercury in freshwater streams is a national and global issue.

- Aquatic systems in the southeastern United States have higher overall levels of mercury in water, sediment and biota due to factors including higher rainfall levels, increased inputs from atmospheric deposition, increased amounts of wetlands that promote methylmercury production and unique hydrological systems that make methylmercury more available to biota than other systems (USGS 2014; EPA 1999; USGS 2009).

- Mercury in the Savannah River has numerous sources including atmospheric deposition (i.e. coal fired power plants, rainfall, forest fires), legacy industrial inputs (i.e. Olin Corporation, SRS), and, to a lesser extent, natural geologic deposits.

Conclusions

Recent measurements of methylmercury concentrations in water, sediment and biota (fish and clams) from SRS tributaries and the Savannah River concluded that:

- On average the concentrations in the tributary water was twice as high as concentrations in the river;
- Concentrations in clams and fish in the tributaries was twice as high as for those in the Savannah River;
- Conditions associated with the wetlands that drain these tributaries are adequate to promote methylmercury production.
- Average tissue concentrations measured in largemouth bass at the mouths of the SRS streams into the Savannah River showed that the range of concentrations was within concentrations measured in other South Carolina rivers of the same ecoregion (Southeastern Plains).

Recommendations

- More research is needed to better understand methylmercury production in the SRS tributaries, and the impact of tributary discharge on methylmercury level in the mainstem river and river biota.
- Additional research examining the relationship between flood events and aqueous mercury concentrations will be needed to fully understand and verify relationships between floodplain hydrology and mercury availability.
- A full inventory of Four Mile Creek and swampy outcrop along the first sidestream for mercury is needed along with a multiyear study movement, if any, for mercury in this system.
- A review of Par Pond and L Lake sediment is needed to determine potential influxes of mercury from disturbed sediment to the SRS Mass Balance diagram.
- A review of sediment and fish concentrations from lesser studied reactor cooling ponds (Pond A, Pond B and Pond C).
- A review of mercury in litterfall found on SRS as well as South Carolina and Georgia.

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