

Health Consultation

PFAS in Surface Water Bodies in the Town of Stella Oneida County, Wisconsin

Prepared by the
Wisconsin Department of Health Services



**WISCONSIN DEPARTMENT
of HEALTH SERVICES**

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Summary

The Wisconsin Bureau of Environmental and Occupational Health (BEOH) in the Department of Health Services (DHS) reviewed environmental data collected in surface water in and around the Moen chain of lakes in Oneida County, Wisconsin. The purpose of this review was to evaluate health hazards associated with contamination in surface water. High concentrations of per- and polyfluoroalkyl substances (PFAS) were found in surface water in many of the surface water bodies investigated.

PFAS were found at levels that pose a health hazard to all individuals that recreate in Snowden Lake. To reduce risk of health effects, **we recommend reducing the amount of time spent in Snowden Lake doing activities during which you may accidentally drink lake water, such as swimming or playing in the water.**

PFAS were also found at levels that pose a health hazard to children that play in the water at the two summer camps along Snowden Lake and the Moen Lake chain. To reduce risk, **we recommend reducing the amount of time dedicated to water-based activities at these camps, such as swimming, water-skiing, or playing in the water.**

PFAS were found at a high level in fish through the Moen Lake chain. In conjunction with the Department of Natural Resources (DNR), **we recommend consuming no more than 1 fish meal per month for any fish caught in these waters.** Due to an existing mercury advisory, women under 50 and children under 15 should not consume any walleye larger than 19”.

Background

In the summer of 2022, the Wisconsin Department of Natural Resources’ (DNR’s) Bureau of Drinking Water and Groundwater launched a project designed to understand PFAS occurrence in the shallow groundwater of Wisconsin by sampling 450 wells throughout the state. During this study, sample results from a well in the Town of Stella, in Oneida County, indicated high levels of PFAS compounds (> 10,000 nanograms per liter (ng/L, equivalent to parts per trillion) perfluoro-n-octanoic acid (PFOA)). Because of this result, the DNR sampled wells of nearby private well owners to better understand the extent of contamination in the area. This additional sampling found other private wells in the area with very high levels of contamination (> 40,000 ng/L PFOA and > 5,000 ng/L perfluoro-n-octanesulfonic acid (PFOS)). Of the 35 wells that were sampled, 24 have PFAS concentrations above DHS’ recommendations for consumption (private well sampling overview available on the DNR website¹).

As part of a follow-up investigation, surface water samples were taken in the summer and fall of 2023 at a number of surface water bodies around the Town of Stella (see map of sampling locations and results in Appendix A, Figures A1 and A2):

- Moen Lake and its chain (Second Lake through Fifth Lake)
- Snowden Lake
- Stella Lake
- Spur Lake

¹ <https://dnr.wisconsin.gov/topic/PFAS/Stella.html>

- Ginty Lake
- Lake Thompson
- George Lake
- Starks Creek
- Twin Lakes Creek
- Pelican River

This report serves to evaluate the surface water PFAS data and provide recommendations for best use of these water bodies.

Moen Lake is primarily fed from the north and west, while the chain from Second Lake through Fifth Lake is fed from the east. Groundwater flow is suspected to be generally northeast to southwest, with the highest PFAS levels in private wells found to the northeast of Fifth Lake. Snowden Lake is a seepage lake, fed entirely from groundwater, with no inlets or outlets. The Moen chain of lakes eventually drains into the north branch of the Pelican River, which meets with the Wisconsin River just south of Rhinelander.

Due to this water flow, the site was divided into four distinct operable units: Moen Lake, Snowden Lake, Upstream of the Moen Lake chain, and the chain of lakes from Second Lake through Fifth Lake, including the Pelican River downstream to the confluence with the Wisconsin River.

Community description and concerns

Community demographics

An estimated 1,500 people live in and around the area with PFAS contamination or around the Moen Lake chain and related waterbodies year-round. This estimate does not include individuals that visit the area to use the water bodies, such as vacationers, campers, anglers, etc. They are predominantly white and English-speaking. Residences are a mix of year-round homes and summer vacation homes. The area is not predominantly disadvantaged according to national indexes, but the recently discovered widespread environmental burden has not yet been taken into account. Considering that the population is predominantly older, has lower income, and lacks internet access, we consider our health consultation and education for the community about this environmental contamination further warranted.

Community concerns

Concerns that arose during a listening session in the area included using contaminated water for gardening, risk from dermal contact with water, and community health impacts. Along with many year-round residential properties, there are many second homes/summer cabins in the area. There are two sleep-away youth summer camps adjacent to surface water bodies in the area, during which we would expect extended elevated exposure to surface water during recreational activities.

Sampling data

Water samples were taken at 11 sites throughout the Moen chain of lakes and surrounding water bodies. A map of sample locations and results for PFOA and PFOS can be seen in Appendix A,

Figure A1.² Additional sampling was conducted on Snowden Lake, which can be seen in Appendix A, Figure A2. A complete list of surface water analytes and measured values is available in Appendix A, Table A1. Fish tissue samples were collected from Fifth lake, and a complete list of fish tissue sample results is available in Appendix A, Table A2.

Scientific evaluations

Exposure pathway analysis

Primary exposure to PFAS in surface water is expected through incidental ingestion of surface water. Activities that may contribute to this exposure include swimming, kayaking or canoeing, tubing or waterskiing, fishing, and other various watersports and water-based activities. Dermal absorption of PFAS in water is not anticipated to be a meaningful source of exposure, due to the extremely low dermal penetration coefficients.³

Due to the presence of two summer camps, residences, and public access points on impacted waters, it is expected that these water bodies are routinely used through the summer months for recreation and year-round for fishing. Incidental ingestion is likely highest during swimming, tubing and waterskiing, or other activities where the mouth is near the water or when spray is created.

PFOS levels in fish were also considered, as consumption of contaminated fish may be a major PFAS exposure route for people that eat the fish that they catch. Fish consumption advisories are jointly developed by DNR and DHS based on guidelines developed by the Great Lakes Consortium for Fish Consumption Advisories Guidelines⁴, and are issued on DNR's fish consumption webpage.⁵

Surface water evaluation

Screening analysis

The DNR established surface water quality criteria for PFOS and PFOA in 2022 (Table 1).⁶ Since the water bodies under evaluation are not used as a drinking water source, we used the 95 ng/L comparison value for our assessment. DNR set these standards using an incidental surface water ingestion rate of 0.21 L/day.

² Results from Third Lake, Starks Creek, three results from the North Branch of the Pelican River, and the initial samples from Snowden Lake needed to be diluted mid-analysis to be quantified, due to their elevated levels, to ensure accurate results. Follow-up samples from Snowden Lake were diluted before analysis and closely correlated to the initial results.

³ <https://www.atsdr.cdc.gov/toxprofiles/tp200.pdf>, see chapter 3.1.1.

⁴ <https://www.health.state.mn.us/communities/environment/fish/docs/consortium/bestpracticepfos.pdf>

⁵ <https://dnr.wisconsin.gov/topic/Fishing/consumption>

⁶ <https://dnr.wisconsin.gov/topic/SurfaceWater/PFASCriteria.html>

Table 1: Wisconsin’s Surface Water Quality Criteria for PFAS (effective as of August 1, 2022)

PFOS All water bodies, due to bioaccumulation in fish	PFOA Drinking water sources, due to ingestion	PFOA Non-drinking water sources, due to incidental ingestion
8 ng/L	20 ng/L	95 ng/L

Surface water samples taken at 11 sites in water bodies in and around Stella exceeded Wisconsin’s surface water quality criteria.

DHS routinely uses a hazard index to calculate risk from ingestion of PFAS, and this approach was used in the current analysis, as several other PFAS were found in some of the samples.⁷

DHS previously developed health-based recommended groundwater standards for PFBA, PFHxA, PFNA, and PFHxS. These recommendations correspond to the concentration in water of these compounds that DHS deems to be below which adverse health effects are not expected. We used these recommended standards in our hazard index calculations as the health threshold when those chemicals were detected in samples.

Since there are no established standards or health thresholds for PFPeA, PFHpA, and 6:2 FTS in Wisconsin, we compared results to other states’ maximum contaminant levels (MCLs) and reference doses (RFDs). Because all sample results for these compounds were well below all observed comparison values, we omitted these three PFAS from further evaluation.

Evaluation of ingestion of surface water

Exposure point concentrations and exposure calculations

We evaluated the risk for individuals recreating in the surface waters around Stella by estimating annual average doses from incidental ingestion of PFOA, PFNA, PFHxS, PFOS, PFBS, and PFHxA. We calculated hazard quotients for each chemical by comparing the annual dose to a theoretical annual dose derived from the DHS-recommended groundwater standards for each chemical. We derived cumulative risk using a hazard index approach, as outlined in our 2021 memo to DNR.⁸

A table of the exposure point concentrations (EPCs, representative contaminant concentrations) for each site is outlined below (Table 2). See the Summary of Limitations and Uncertainties below for an explanation of the type of EPC used. We calculated EPCs using the ATSDR EPC Tool.⁹

We constructed health-protective exposure scenarios (Table 3) to ensure maximum applicability to residents. We applied Exposure Scenario 1, a residential scenario, to all four locations. We applied Exposure Scenario 2, a summer camp scenario, to Snowden Lake and Starks Creek

⁷ <https://www.dhs.wisconsin.gov/chemical/pfas.htm>

⁸ <https://dnr.wisconsin.gov/sites/default/files/topic/PFAS/DHSHazIndexLetter20210608.pdf>

⁹ https://www.atsdr.cdc.gov/pha-guidance/conducting_scientific_evaluations/epcs_and_exposure_calculations/index.html

through Pelican River, to reflect the summer camps that operate on Snowden Lake and Fourth Lake.

We used an incidental ingestion rate for surface water of 0.152 L/hr, the maximum applicable value for 11 to <16 year olds, as identified by the Environmental Protection Agency (EPA) in their 2019 revision of the Exposure Factors Handbook.¹⁰ This value provides the most protection for all age groups.

Table 2: Operable units, contaminants, and exposure point concentrations (EPCs)

Location	Contaminant	EPC (ng/L)	EPC type
Upstream	PFOA	3.6	Maximum
Upstream	PFOS	1.35	Maximum
Upstream	PFBA	3.86	Maximum
Upstream	PFNA	0.62	Maximum
Upstream	PFHxA	2.16	Maximum
Upstream	PFHxS	0.36	Maximum
Moen Lake	PFOA	15.8	Maximum
Moen Lake	PFOS	5.34	Maximum
Moen Lake	PFBA	3.17	Maximum
Moen Lake	PFNA	0.54	Maximum
Moen Lake	PFHxA	2.74	Maximum
Moen Lake	PFHxS	0.23	Maximum
SC through PR*	PFOA	316	95% UCL of the mean
SC through PR*	PFOS	52.1	95% UCL of the mean
SC through PR*	PFBA	29.9	95% UCL of the mean
SC through PR*	PFNA	8.66	95% UCL of the mean
SC through PR*	PFHxA	112	95% UCL of the mean
SC through PR*	PFHxS	3.1	95% UCL of the mean
Snowden Lake	PFOA	1664	95% UCL of the mean
Snowden Lake	PFOS	70.3	95% UCL of the mean
Snowden Lake	PFBA	225.9	95% UCL of the mean
Snowden Lake	PFNA	16.5	Maximum
Snowden Lake	PFHxA	815.1	95% UCL of the mean
Snowden Lake	PFHxS	26.4	95% UCL of the mean

*SC through PR: Starks Creek through Pelican River, including Second, Third, Fourth, and Fifth lakes of the Moen Lake chain, as well as Twin Lakes Creek.

Table 3: Exposure scenarios

Exposure Scenario 1 (residential)	Exposure Scenario 2 (summer camp)
1 event per day, 2 hrs per event, 4 days a week, 17 weeks a year, for 30 years. All age groups.	3 events per day, 1 hr per event, 7 days a week, 8 weeks a year, for 12 years. Ages 6 - adult.

For each of the four locations, we calculated hazard quotients for all six PFAS considered. (Table 4).

¹⁰ <https://www.epa.gov/expobox/about-exposure-factors-handbook>

Briefly, we estimated annual PFAS intake by multiplying the concentration of each PFAS by the incidental water ingestion rate and the hours spent on the water in each of the exposure scenarios, using Equation 1.

Equation 1
$$D_{ex} = ED * (IR * (t_{event} * EV)/7 \text{ days}) * EPC$$

Where:

D_{ex} = annual dose for the exposure scenario (ng)

ED = exposure duration (days)

IR = intake rate (L/hr)

t_{event} = event duration (hr/event)

EV = event frequency (events/day)

EPC = exposure point concentration (ng/L)

We then calculated a threshold value corresponding to an estimated amount of PFAS that an individual could consume annually without increased risk of health effects (see Equation 2)

Equation 2:
$$D_{hal} = ED * IR * HAL$$

Where:

D_{hal} = annual dose at the health advisory level (ng)

ED = exposure duration, 350 days

IR = intake rate, 1.316 L/d

HAL = health-based comparison value

Finally, we divided the estimated amount from exposure scenarios by the threshold value using Equation 3 to generate the hazard quotients, which we then summed using Equation 4 to calculate a hazard index.

Equation 3
$$HQ = D_{ex} \div D_{hal}$$

Equation 4
$$HI = \sum HQ$$

Where:

HQ = hazard quotient (unitless)

D_{ex} = annual dose for the exposure scenario (ng)

D_{hal} = annual dose at the health advisory level (ng)

HI = hazard index (unitless)

A value above 1.0 indicates a potential for adverse health effects.

Table 4: Hazard Quotients and Hazard Indices for different PFAS at each site and exposure scenario.

Contaminant	Upstream	Moen Lake	SC through PR, ES1 ^{a, b}	SC through PR, ES2	Snowden Lake, ES1	Snowden Lake, ES2
PFOA	0.0081	0.035	0.71	0.9	3.7	4.6
PFHxA	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
PFBA	< 0.0010	< 0.0010	< 0.0010	< 0.0010	0.0010	0.0013
PFNA	0.0047	0.0041	0.066	0.08	0.13	0.16
PFOS	0.0030	0.012	0.117	0.14	0.16	0.19
PFHxS	< 0.0010	< 0.0010	0.0035	0.0043	0.030	0.037
Hazard Index	0.02	0.05	0.9	1.1	4.0	5.0

^a SC through PR: Starks Creek through the north branch of the Pelican River

^b ES = Exposure Scenario

Health evaluations

We conducted health assessments for each of the four distinct operable units. Based on our calculations, there are no elevated risks from swimming or recreating within Moen Lake or sampled water bodies upstream of the impacted waterways, including the south branch of the Pelican River or Spur Lake.

For residents that live along Starks Creek, the Moen chain of lakes from Second Lake to Fifth Lake, and the Pelican River, there is a higher exposure to contaminants, but the cumulative impact is still expected to not pose an increased risk of health effects, as all individual contaminants are below hazard quotients of 1.0 and the hazard index is below 1.0, at 0.9. However, PFAS levels have been observed to fluctuate over time (see Summary of Limitations and Uncertainties below), so it is possible that there may be periods of time when there are increased risk.

For individuals at the summer camp that may have a more elevated exposure, there was a potential risk due to the cumulative impact. While no single PFAS exceeded a hazard quotient of 1.0, the cumulative impact resulted in a hazard index of 1.1, which indicates an elevated risk of health effects.

Based on exposure scenario 1 above, residents that live along and recreate within Snowden Lake have an increased risk of health effects, primarily due to the elevated levels of PFOA in the water. Likewise, the summer camp scenario along Snowden Lake had elevated risks of health effects, based on exposure scenario 2.

Cancer risk was not included in this assessment. The International Agency for Cancer Research recent classified PFOA and PFOS as carcinogenic, but there are not yet published cancer slope factors that can be used in risk assessment.¹¹

Children are the population most likely to encounter risk from swimming in these waters, due to behavioral and physiological differences from adults. Behaviorally, younger children are more likely to splash and may not actively keep their mouths closed during swim and recreation, and physiologically, since children have smaller bodies than adults, a similar quantity of ingested water will result in an increased dose. The two summer camps that operate on these waters have major programmatic activities related to water skills and recreation, indicating that children are likely being exposed to levels that may pose health impacts.

Evaluation of ingestion of fish

We evaluated the risk for individuals eating fish from the surface waters around Stella by comparing calculating average PFOS concentrations in fish caught from Fifth Lake (see Table 5)) to the thresholds determined by the Great Lakes Consortium, as outlined above.

Table 5: Average PFOS concentrations in fish tissue from fish caught in Fifth Lake.

¹¹ We are aware of draft cancer slope factors for PFOA and PFOS by EPA (<https://www.federalregister.gov/d/2023-05471/p-257>) and OEHHHA (<https://oehha.ca.gov/media/downloads/water/public-health-goal/pfoapfosseconddraft071423.pdf>) that can be used in cancer risk assessment, but those documents are not intended to be used as sources until finalized.

Species	Number	Average PFOS (ng/g)	95% UCL of the mean (ng/g)
Yellow perch	9	67.9	78.3
Bluegill	10	47.7	59
Black crappie	10	75.5	96.3
Rock bass	2	33.3	98.1
Northern pike	4	56.1	59.3
Walleye	3	93.7	194.4

Per Consortium guidelines, when average PFOS levels are >50 ng/g, it is recommended to issue an advisory of no more than 1 meal/month. Four of the six fish caught (yellow perch, black crappie, northern pike, and walleye) exceeded that threshold. Bluegill was close to the threshold, and the sample size for rock bass was too low to set an advisory. Given that the 95% UCL around the mean exceeded 50 ng/g in each fish and the interconnectedness of Fifth Lake with other lakes in the Moen chain, DNR and DHS agreed that a recommendation to consume no more than 1 meal/month of these fish would be an appropriate health-protective approach.

Summary of limitations and uncertainties

There are some limitations and uncertainties with the data that should be considered during interpretation. The surface water testing through the area was limited, with only one sample taken per water body outside of Lake Snowden. There were enough samples taken in Snowden Lake and along the Moen Lake chain (Second through Fifth Lakes and the Pelican River) to use the 95% UCL as a representative protective estimate. However, upstream of the chain and within Moen Lake, we assumed the highest sample from each site was representative of a likely exposure, which may increase the hazard quotients at those sites. Each sample only represents the conditions at the time of the sample; in dynamic systems such as these surface water bodies, levels of PFAS may change in response to external inputs such as rain or groundwater infiltration. Additional surface water sampling would provide additional information as to the range of potential exposures individuals may experience.

Conclusions

We evaluated PFAS levels in four areas through Oneida County around the Town of Stella, using two different scenarios: one for residents that live on or play in the rivers and lakes, and one for children attending one of the two summer camps along the waters. We found that PFAS levels pose a health hazard to:

- Campers and camp counselors that routinely recreate at the summer camps on Snowden Lake and Fourth Lake.
- All people that live along or recreate in Snowden Lake.

We found that PFAS levels in Moen Lake, waters upstream of the Pelican River, and along the Moen Lake chain are not expected to harm people's health.

Recommendations and public health action plan

We are providing recommendations for all people that may swim or play in Snowden Lake, as well as for children and counselors that may attend or work at one of the summer camps along

Snowden Lake or the Moen chain of lakes. We have broken these recommendations into three categories: personal actions that you can take to protect yourself, health education and outreach, and additional testing.

We are not recommending completely stopping the use of these water bodies for recreation and fish meals. There are many benefits to the exercise and recreation that comes from spending time in and around water bodies, and fish are a healthy source of lean protein and other nutrients. We are providing these recommendations to make residents aware of the risks associated with PFAS levels in these waterbodies, so that they can make informed choices in how they choose to spend time in and around these water bodies.

Personal protective actions

Because of the high levels of PFAS in Lake Snowden, we recommend that all people reduce how much time is spent swimming or playing in the water. We also recommend that summer campers or counselors that spend a lot of time in the Moen Lake chain reduce the amount of time spent swimming or playing in the water.

In both situations, it is important to reduce activities where there is a higher chance of accidentally swallowing lake water. These activities include swimming, waterskiing, or playing games in the water. Activities that have a lower chance of accidentally swallowing lake water are safer. Examples of these are boating, canoeing, and kayaking.

Health education and outreach

We recommend increasing the health education provided to summer campers and parents of campers so that they are aware of the potential risks of consuming the water. We also recommend increasing health education and outreach to seasonal and full-time residents that live along the lakes and river so they are aware of steps they can take to use the lakes for recreation while reducing their exposure.

Given the high levels of PFOS in the water, if people reduce the amount of fish from these water they consume, they will reduce PFAS exposure. DHS and DNR have issued a fish consumption advisory for the Moen Lake chain, recommending eating no more than one fish meal per month for all species and sizes to reduce the risk of health effects. It should also be noted that an additional more restrictive fish advisory exists due to mercury levels: women under 50 and children under 15 should not eat walleye longer than 19”.

Additional testing

Additional surface water sampling would give a better picture of the risk posed to residents. Additional investigation into the sources of PFAS in the area may help identify methods of mitigation and remediation to reduce the amount of PFAS entering the surface water bodies.

Who prepared the document

Document prepared by Nathan Kloczko, MPH, of the Wisconsin Site Evaluation Team, using data generated by the DNR.

Appendices:

Appendix A: Sampling data and maps

Table A1: Surface water sampling results in water bodies in and around the Town of Stella.

PFAS	Spur Lk	Stella Lk	Ginty Lk	Lk Thompson	George Lk	Moen Lk	Snowden Lk	Starks Cr @ Stella Lk Rd	Second Lk	Third Lk	Fourth Lk	Fifth Lk	Twin Lakes Cr @ Rasmussen Rd	NB Pelican R below Fifth Lk dam	NB Pelican R HWY 47	Pelican R @ Rivers End Rd	Pelican R @ Hwy 47	Pelican R mouth @ WI R
PFBA	3.28	2.77	2.45	2.75	3.02	3.17	209	18.7	48.6	22.7	29.3	26.2	7.58	23.1	22.8	3.86	12.8	11.1
PFPeA	<0.275	<0.266	0.616*	1.88	2.56	1.62	679**	57.3	157**	76.1	125	104	11.6	71.2	69.9	0.873*	36	29.2
PFHxA	0.616*	0.78*	0.552*	1.51	2.16	2.74	734**	82.3	147**	87.3	89.8**	131	13.9	76.6	74.5	0.829*	37.8	32.1
PFHpA	0.927*	0.882*	0.758*	1.15	1.95	4.05	886**	105**	173**	92.7	89.9**	120	19.2	89.5	86.5	1.03	46.8	38.9
PFOA	0.771*	1.13	1.02	1.94	3.6	15.8	1600**	374**	429**	212**	249**	294**	83.4	235**	249**	1.09	118**	96.6**
PFNA	0.422*	0.536*	0.417*	0.582*	0.623*	0.544*	15.1	2.24	5.86	2.93	4.74	6.65	7.84	9.91	13	0.448*	6.52	5.28
PFDA	<0.271	<0.262	<0.257	<0.257	<0.254	<0.262	1.72	0.293*	0.348*	<0.266	0.354*	0.438*	<0.270	0.422*	0.357*	<0.259	<0.255	<0.268
PFUnA	<0.244	<0.236	<0.231	<0.231	<0.229	<0.236	<0.244	<0.233	<0.242	<0.240	<0.234	<0.235	<0.243	<0.245	<0.234	<0.233	<0.229	<0.241
PFDoA	<0.248	<0.240	<0.235	<0.235	<0.232	<0.239	<0.248	<0.237	<0.246	<0.244	<0.237	<0.239	<0.246	<0.249	<0.238	<0.236	<0.233	<0.245
PFTTrDA	<0.378	<0.366	<0.358	<0.358	<0.355	<0.365	<0.378	<0.361	<0.375	<0.372	<0.362	<0.364	<0.376	<0.379	<0.363	<0.361	<0.355	<0.373
PFTeDA	<0.251	<0.243	<0.237	<0.237	<0.235	<0.242	<0.250	<0.240	<0.249	<0.246	<0.240	<0.241	<0.249	<0.252	<0.241	<0.239	<0.236	<0.248
PFBS	0.271*	0.289*	0.279*	0.388*	0.42*	0.297*	3.9	1.66	0.655*	0.485*	0.527	0.534*	0.364*	0.461*	0.48*	0.295*	0.431*	0.538*
PFPeS	<0.181	<0.175	<0.171	<0.171	<0.170	<0.175	2.28	0.523*	0.223*	<0.178	<0.173	<0.174	<0.180	<0.181	<0.173	<0.172	<0.170	<0.179
PFHxS	<0.177	<0.171	<0.167	<0.168	0.363*	0.228*	22.2	6.62	3.19	1.68	1.91	1.74	1.04	1.8	1.98	<0.169	1.08	1.03
PFHpS	<0.213	<0.206	<0.201	<0.202	<0.200	<0.206	4.16	1.71	0.748*	0.383*	0.556*	0.676*	1.72	1.1	2.01	<0.203	0.884*	0.762*
PFOS	0.51*	0.914*	0.818*	1.34	1.35	5.34	71.5	73.8	17.6	10.7	15.8	22.9	59.9	34.5	56.9	0.78*	27.3	22.8
PFNS	<0.184	<0.178	<0.174	<0.174	<0.172	<0.177	<0.183	<0.175	<0.182	<0.181	<0.176	<0.177	<0.183	<0.184	<0.176	<0.175	<0.173	<0.181
PFDS	<0.291	<0.281	<0.275	<0.275	<0.273	<0.281	<0.290	<0.278	<0.288	<0.286	<0.278	<0.280	<0.289	<0.291	<0.279	<0.277	<0.273	<0.287
PFDoS	<0.385	<0.372	<0.364	<0.364	<0.361	<0.372	<0.384	<0.368	<0.382	<0.378	<0.368	<0.371	<0.383	<0.386	<0.369	<0.367	<0.362	<0.380
4:2 FTS	<0.207	<0.200	<0.196	<0.196	<0.194	<0.200	<0.207	<0.198	<0.205	<0.203	<0.198	<0.199	<0.206	<0.208	<0.199	<0.197	<0.195	<0.204
6:2 FTS	<0.236	<0.229	<0.223	<0.224	<0.222	<0.228	11.7	1.3	32.6	31.2	4.64	2.87	1.53	7.38	4.38	<0.225	1.25	0.862*
8:2 FTS	<0.144	<0.139	<0.136	<0.136	<0.135	<0.139	<0.144	<0.137	<0.143	<0.141	<0.138	<0.138	<0.143	<0.144	<0.138	<0.137	<0.135	<0.142
PFOSA	0.374*	<0.172	<0.168	0.353	0.278*	<0.172	0.658*	0.486*	0.201*	<0.175	0.209*	0.185*	<0.177	0.32*	<0.171	0.213*	<0.167	0.181*
NEtFOSE	<0.357	<0.345	<0.338	<0.338	<0.335	<0.344	<0.356	<0.341	<0.354	<0.350	<0.341	<0.343	<0.355	<0.358	<0.342	<0.340	<0.335	<0.352
NMeFOSE	<0.227	<0.220	<0.215	<0.215	<0.213	<0.220	<0.227	<0.217	<0.226	<0.223	<0.218	<0.219	<0.226	<0.228	<0.218	<0.217	<0.214	<0.225

NEtFOSA	<0.323	<0.312	<0.305	<0.306	<0.303	<0.312	<0.322	<0.308	<0.320	<0.317	<0.309	<0.311	<0.321	<0.324	<0.310	<0.308	<0.303	<0.319
NMeFOSA	<0.377	<0.365	<0.357	<0.357	<0.354	<0.364	<0.377	<0.360	<0.374	<0.371	<0.361	<0.363	<0.375	<0.378	<0.362	<0.360	<0.354	<0.372
NEtFOSAA	<0.193	<0.187	<0.183	<0.183	<0.181	<0.187	2.72	0.499*	<0.192	<0.190	<0.185	<0.186	<0.192	<0.194	<0.186	<0.184	<0.182	<0.191
NMeFOSAA	<0.328	<0.317	<0.310	<0.310	<0.307	<0.316	<0.327	<0.313	<0.325	<0.322	<0.314	<0.315	<0.326	<0.329	<0.314	<0.312	<0.308	<0.323
HFPO-DA	<0.288	<0.278	<0.272	<0.272	<0.270	<0.278	<0.287	<0.275	<0.285	<0.283	<0.275	<0.277	<0.286	<0.289	<0.276	<0.274	<0.270	<0.284
DONA	<0.219	<0.212	<0.207	<0.207	<0.205	<0.211	<0.218	<0.209	<0.217	<0.215	<0.209	<0.211	<0.217	<0.219	<0.210	<0.209	<0.205	<0.216
9Cl- PF3ONS	<0.186	<0.180	<0.176	<0.176	<0.174	<0.179	<0.185	<0.177	<0.184	<0.182	<0.178	<0.179	<0.185	<0.186	<0.178	<0.177	<0.174	<0.183
11Cl- PF3OUdS	<0.181	<0.175	<0.171	<0.171	<0.170	<0.175	<0.181	<0.173	<0.179	<0.178	<0.173	<0.174	<0.180	<0.181	<0.173	<0.172	<0.170	<0.179

All concentrations in ng/L

Lk = Lake; Cr = Creek; Rd = Road; HWY = Highway; R = River; NB = North Branch

*Value between Limit of Detection (LOD) and Limit of Quantitation (LOQ)

**Sample extract diluted. True isotope dilution was not achieved. Result is approximate.

Values with (<) are below the LOD.

Table A2: Sampling results from fish tissue collected from Fifth Lake.

SAMPLE TYPE	AVG LENGTH (IN)	AVG BODY WT (KG)	GENDER	PFC PFOS (NG/G)
YELLOW PERCH	7	0.068	M	70.5
YELLOW PERCH	7.1	0.064	U	85.6
YELLOW PERCH	7.4	0.066	M	85.7
YELLOW PERCH	8.3	0.108	M	68.1
YELLOW PERCH	8.4	0.138	U	55.9
YELLOW PERCH	8.5	0.108	U	56.4
YELLOW PERCH	8.7	0.13	M	59.5
YELLOW PERCH	9.5	0.13	U	79.8
YELLOW PERCH	9.7	0.176	F	49.7
BLUEGILL	7.6	0.138	U	57.3
BLUEGILL	7.6	0.142	M	57.2
BLUEGILL	7.7	0.128	M	30.7
BLUEGILL	7.9	0.148	U	29
BLUEGILL	7.9	0.146	M	67.8
BLUEGILL	8	0.16	M	47
BLUEGILL	8	0.168	U	66.5
BLUEGILL	8	0.148	M	21.8
BLUEGILL	8.4	0.19	F	50.8
BLUEGILL	8.8	0.158	F	48.6
BLACK CRAPPIE	9.1	0.172	F	45.6
BLACK CRAPPIE	9.2	0.176	M	67.7
BLACK CRAPPIE	9.3	0.184	F	73.5
BLACK CRAPPIE	9.5	0.184	F	106
BLACK CRAPPIE	9.9	0.192	F	33.3
BLACK CRAPPIE	10	0.234	M	66.2
BLACK CRAPPIE	10.4	0.258	F	66.5
BLACK CRAPPIE	10.9	0.31	F	120
BLACK CRAPPIE	11.7	0.384	F	61
BLACK CRAPPIE	11.7	0.374	F	115
ROCK BASS	5.2	0.042	U	38.4
ROCK BASS	5.2	0.198	M	28.2
NORTHERN PIKE	16	0.358	U	58.4
NORTHERN PIKE	16.8	0.42	M	53.5
NORTHERN PIKE	23.6	1.252	U	56.1
NORTHERN PIKE	24.4	1.522	M	56.4
WALLEYE	13.1	0.356	U	99.6
WALLEYE	13.2	0.316	U	131
WALLEYE	19	1.11	M	50.6

Figure A1: Surface water sampling around Stella

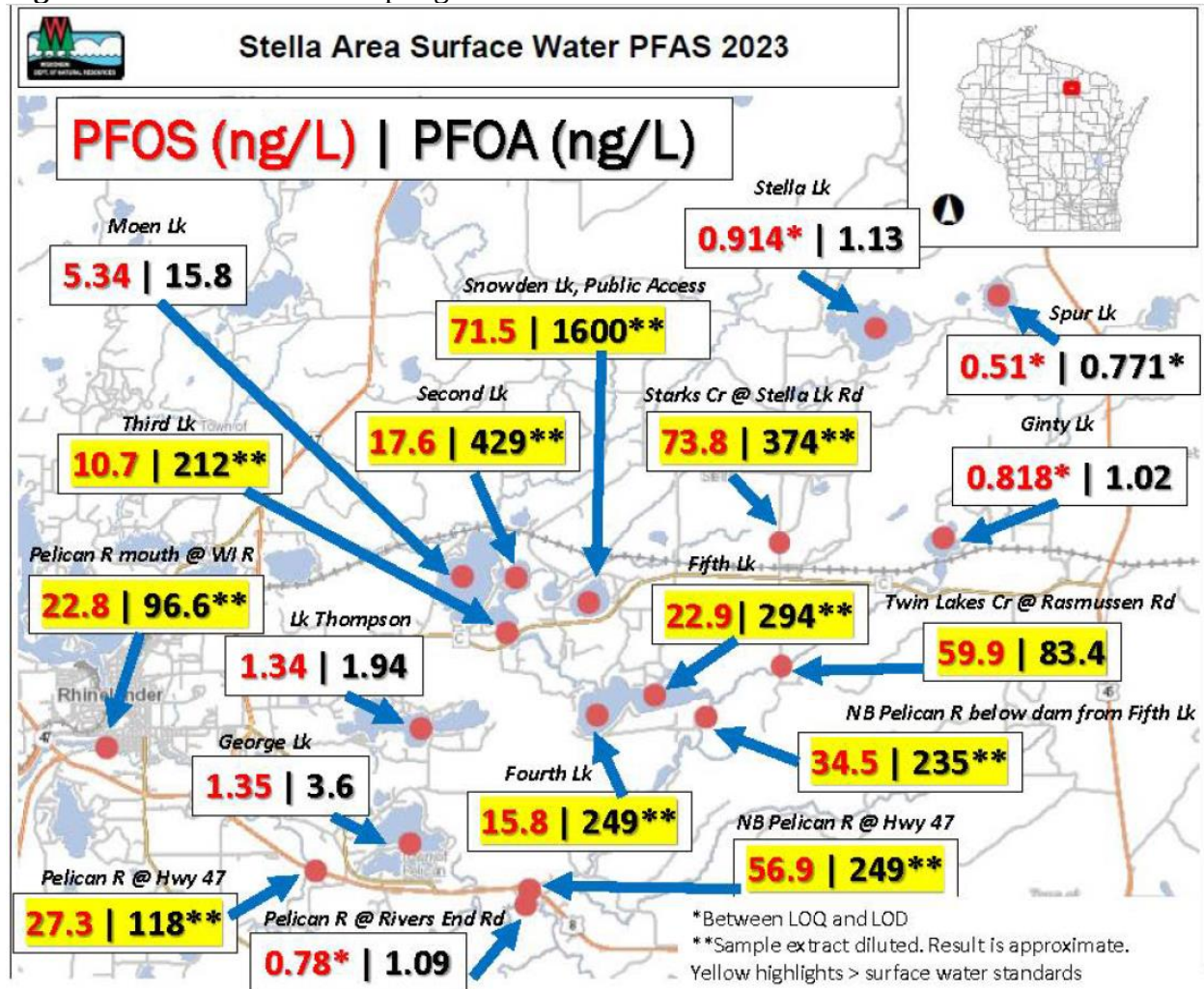
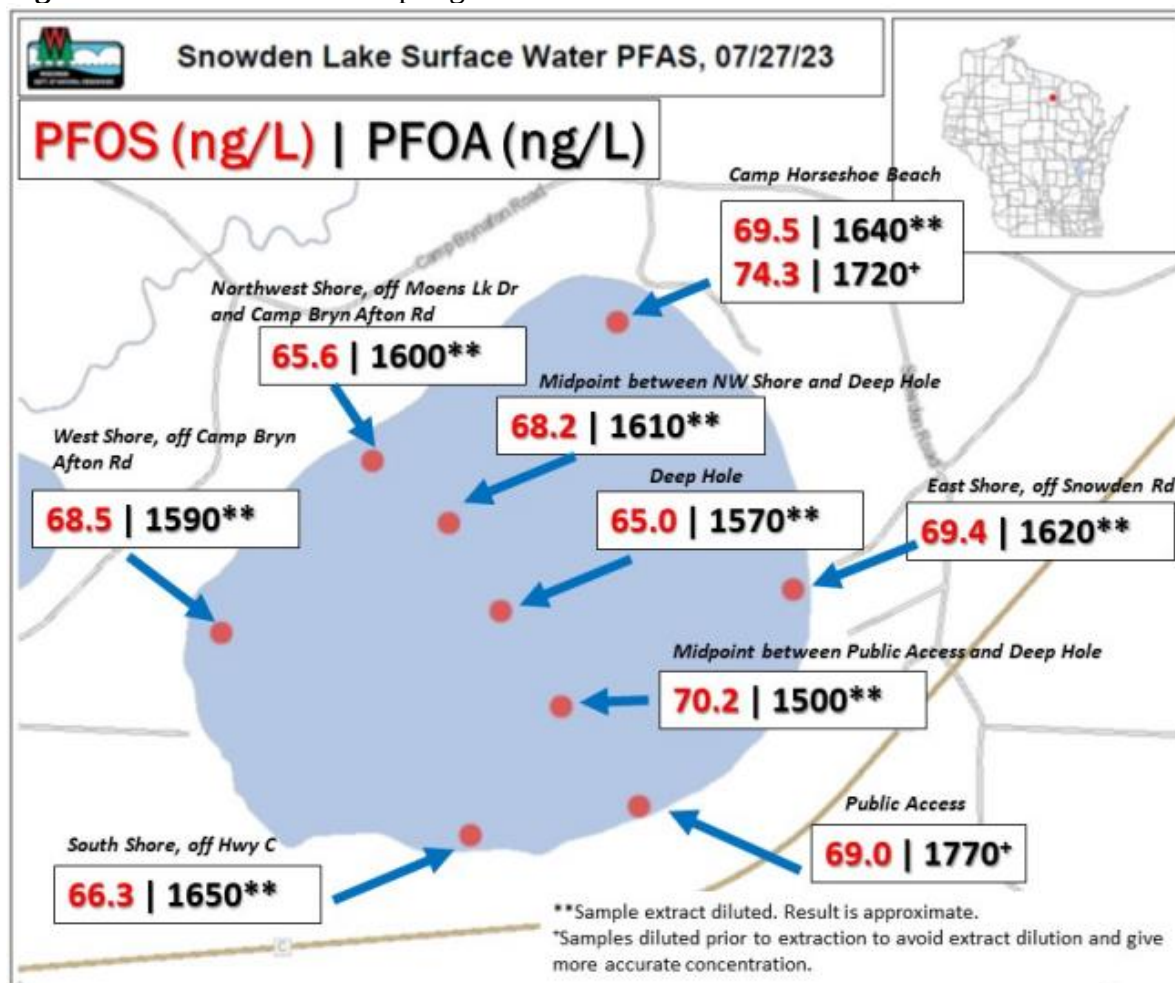


Figure A2: Surface water sampling in Snowden Lake.



Appendix B: Brief summary of ATSDR's public health assessment (PHA) process

ATSDR follows the PHA process to find out:

Whether people living near a hazardous waste site are being exposed to toxic substances.

Whether that exposure is harmful.

What must be done to stop or reduce exposure.

The PHA process is a step-by-step consistent approach during which ATSDR:

Establishes communication mechanisms, including [engaging communities](#) at the beginning of site activities and involves them throughout the process to respond to their health concerns.

Collects many different kinds of [site information](#).

Obtains, compiles, and evaluates the usability and quality of environmental and biological [sampling data](#) (and sometimes modeling data) to examine environmental contamination at a site.

Conducts four main, sequential scientific evaluations.

[Exposure pathways evaluation](#) to identify past, present, and future site-specific exposure situations, and categorize them as completed, potential, or eliminated.

[Screening analysis](#) to compare the available sampling data to media-specific environmental screening levels (ATSDR comparison values [CVs] and non-ATSDR screening levels). This identifies potential contaminants of concern that require further evaluation for completed and potential exposure pathways.

[Exposure Point Concentrations \(EPCs\) and exposure calculations](#) for contaminants flagged as requiring further evaluation in completed and potential exposure pathways. It involves calculating EPCs, using the estimated EPCs to perform exposure calculations, and determining which site-specific scenarios requires an in-depth toxicological effects analysis.

[In-depth toxicological effects evaluation](#), if necessary, based on the three previous scientific evaluations. This step looks more closely at contaminant-specific information in the context of site exposures. This evaluation can also help determine if there is a potential for non-cancer or cancer health effects.

Summarizes findings and next steps, while acknowledging uncertainties and limitations.

Provides recommendations to site-related entities, partner agencies, and communities to prevent and minimize harmful exposures.

The sequence of steps can differ based on site-specific factors. For instance, health assessors might define an exposure unit before or after the screening analysis.

For more detail on the PHA process, please visit [Explanation of ATSDR's PHA Process Evaluation](#). Readers can also refer to [ATSDR's Public Health Assessment Guidance Manual](#) for all information related to the step-wise PHA process.

August 2025 addendum

Since the publication of the original health consultation, the basis for the evaluation of incidental ingestion of drinking water changed as DHS released updated recommendations to health-based thresholds for a number of PFAS. Additionally, we received requests to include an exposure scenario that assessed risk to individuals that may be using the surface water less frequently than the high-end exposure used in the original assessment. Finally, the year-over-year impacts were not accurately assessed in the original health consultation.

With those considerations in mind, we re-ran the original health consultation exposure scenarios using the updated health-based thresholds and we developed a third exposure scenario to represent exposure for campers that only use the water periodically, using the mean incidental ingestion levels use rather than the upper 95th percentile.

Table A1: Exposure scenario using mean incidental ingestion levels

Exposure Scenario 3 (summer camp, average)
1 event per day, 1 hour per event, 5 days a week, 8 weeks a year, for 1 year. Ages 6 – 18.

The mean incidental ingestion rate for surface water for 11 to <16 year olds is 0.044 L/h, per the EPA Exposure Factors Handbook. DHS issued new recommendations for groundwater standards for PFOA, PFOS, PFHxS, and PFNA in February 2025, as well as a new methodology for evaluating cumulative impact.¹² The health-based comparison values used for the assessment are outlined below (Table A2).

Table A2: 2025 Health-based comparison values. Shaded cells indicate new, lower values from original consultation.

Contaminant	Comparison Value (ng/L)
PFOA	4
PFOS	4
PFBA	10,000
PFNA	10
PFHxA	150,000
PFHxS	10

Using the updated exposure estimates and health-based comparison values, we applied Equations 1, 2, and 3. The updated hazard quotients are outlined below in Table A3 for Snowden Lake and the other contaminated surface water bodies that exceeded surface water screening criteria. A value above 1.0 indicates a potential for adverse health effects.

Table A3: Hazard quotients for different PFAS for all exposure scenarios, using the updated health-based comparison values. Shaded cells indicate hazard quotient exceedances.

¹² <https://www.dhs.wisconsin.gov/chemical/pfas-hazard-letter-dnr.pdf>

Contaminant	Upstream, ES1 ^a	Moen Lake, ES1	SC-PR, ES1 ^b	SC-PR, ES2	Snowden Lake, ES1	Snowden Lake, ES2	SC-PR, ES3	Snowden Lake, ES3
PFOA	0.04	0.18	3.6	4.4	19	23	0.30	1.6
PFOS	0.015	0.060	0.58	0.72	0.79	0.97	0.050	0.067
PFBA	<0.0010	<0.0010	<0.0010	<0.0010	0.0010	0.0013	<0.0010	<0.0010
PFNA	0.0028	0.0024	0.039	0.048	0.074	0.091	0.0033	0.0063
PFHxA	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
PFHxS	0.0016	0.0010	0.014	0.017	0.12	0.15	0.0012	0.010

^a SC-PR: Starks Creek through the north branch of the Pelican River, including Sunset, Second, Third, Fourth, and Fifth lakes.

^b ES = Exposure Scenario

Health evaluation

Based on this updated evaluation, **we reaffirm that an elevated risk of health effects exists for children recreating in and on Snowden Lake, including for children that may be recreating in the water bodies for average amounts of time**, as opposed to the upper estimates that were evaluated in the full health consultation. A hazard index was not calculated, as there were exceedances for PFOA alone.

Additionally, an elevated risk of health effects exists for both children and adults that are recreating on the impacted waters from Starks Creek through the Pelican River, based on the high-end exposure scenarios. All previous recommendations for choosing activities that result in lower exposures apply to these waters as well. When evaluating these water bodies with the new, average exposure scenario, there did not appear to be an elevated risk.

As stated in the full health consultation, children are the population most likely to encounter risk from swimming in these waters due to behavioral and physiological differences from adults. The two summer camps that operate on these waters have major programmatic activities related to water skills and recreation, indicating that children are likely being exposed to levels that may pose health impacts, even for campers who may be participating in water-based sports in moderate or average quantities.