Regional hydrogeology in Wood Buffalo National Park

Field Report (Aug 21-30, 2013)

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I. Objectives

The overall objective of the project is to determine the hydrogeological regime of Wood Buffalo National Park (Alberta, Canada).

The main objective of the fieldwork in 2013 was to conduct a reconnaissance of surface phenomena associated with groundwater flow in Wood Buffalo National Park. The overall project was to observe surface manifestations of regional groundwater flow, such as springs, lakes, karstic landforms, soil salinization and vegetation. During the fieldwork, water samples from springs and lakes and soil samples from salt precipitations were collected for laboratory analyses.

During the fieldwork, 22 water samples (1 L/each) were collected from surface waters (lakes, springs) and 9 soil samples (~100 g/each) were collected from the salt plains and around the sulphur springs. The number of collected samples per site is shown in Table 1. The water samples have been analyzed for major and minor elements, oxygen and hydrogen isotopes. Electric conductivity, temperature and pH were measured on the field. Salt samples will be used to identify mineralogical composition and spectral signature of the salt minerals precipitated from discharging groundwater. The results and interpretation of these analyses are currently being processed.

The overall research method to be used in this project will be a combination of office-based remote sensing combined with ground-based observations to “ground-truth” the remotely-sensed data. The observations taken in the field may serve as a validation of hypotheses based on analysis of satellite images and air photographs. In the next phase of the research, remote sensing will be used to identify surface phenomena associated with regional groundwater flow, such as salt plains and saline soils, sinkholes, salt-tolerant vegetation, surface waters with distinct chemical composition etc.

This fieldwork in 2013 represents the first Phase of the project including ground and airborne observations of surface manifestations of groundwater flow (geomorphological and mineralogical phenomena, vegetation etc) and reconnaissance-scale water and soil sampling.

The second Phase of the project, planned for winter of 2013/2014, includes interpretation of sampling results and analyses of remotely sensed data (e.g., soil moisture content, vegetation, thermal anomalies, etc.) in order to identify other possible surface manifestations of groundwater flow and identify further study sites.

In Phase III of the project, planned for summer of 2014, detailed field investigations will be conducted on those study sites which were selected in Phase II.

II. Fieldwork

Study sites were selected prior to the fieldwork based on their significance in the hydrogeological regime (Salt Plains, Grosbeak Lake, Pine Lake, Angus Sulphur Spring). The rest of the study sites have been selected based on air observation planned for the first day of the fieldwork.

Field observations have been made on the following sites:

- Salt Plains
- Grosbeak Lake
- Pine Lake
- sulphur spring south from Nyarling River
- sulphur spring at Green Lake
- Angus sinkhole and Angus Sulphur Lake

The location of the study sites are shown on Figure 1.

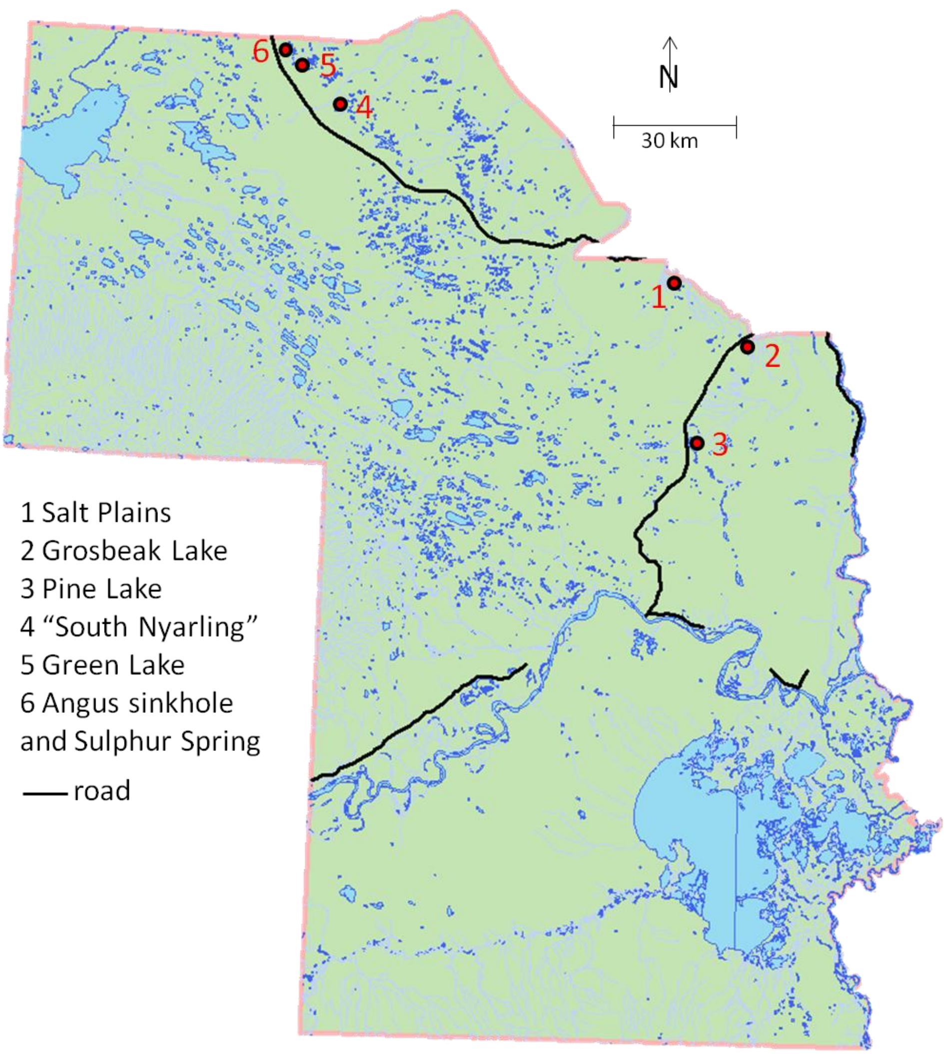


Figure 1. Location of the study sites

The schedule of the fieldwork and the number of collected water and soil samples are shown in Table 1.

Date	Proposed study sites	Collected samples	
		water	soil
22/08/2013	air tour	0	0
23/08/2013	Salt Plains	5	4
24/08/2013	Grosbeak Lake*	2	1
25/08/2013	Pine Lake, Lane Lake	4	0
26/08/2013	sulphur spring south from Nyarling River	4	2
28/08/2013	Higgins Lake**	1	0
29/08/2013	Green Lake	3	1
30/08/2013	Angus Sinkhole and Angus Sulphur Spring	2	1

Table 1. Schedule of the fieldwork, and number of collected samples at each site

* Beyond the 2 water samples at Grosbeak Lake, one additional sample was collected from the water of Salt River at the Salt River Bridge on Pine Lake road.

**Higgins Lake itself turned out to be inaccessible by hiking, one lake was sampled on the way there (location N 60° 12” 58.30” W 113° 43’ 20.69”).

1) *Salt Plains*

Extensive salt plains in the National Park can be found at the eastern border of the National Park, approximately 30 km west from Fort Smith (Figure 1). The salt plains are easily accessible from the Salt Plain Lookout (Picture 1). On the salt plains, 4 soil samples were collected for laboratory analysis to investigate their mineralogical composition and spectral features and 5 water samples were collected for analysis of water chemistry. The pH, temperature and electrical conductivity values measured on the field are shown in Table 2.

Sample ID	Date	Location	pH	T (°C)	Electrical Conductivity (EC) (mS/cm)
W1	23/08/2013	Salt Plains - spring	5.6	8.9	out of range
W2	23/08/2013	Salt Plains - spring	6.57	5.3	4.670
W4	23/08/2013	Salt Plains - spring	7.22	7.1	4.530
W5	23/08/2013	Salt Plains - spring	5.89	10.6	out of range
W6	23/08/2013	Salt Plains - spring	5.7	4.7	105.000

Table 2. Field measurements at the Salt Plains

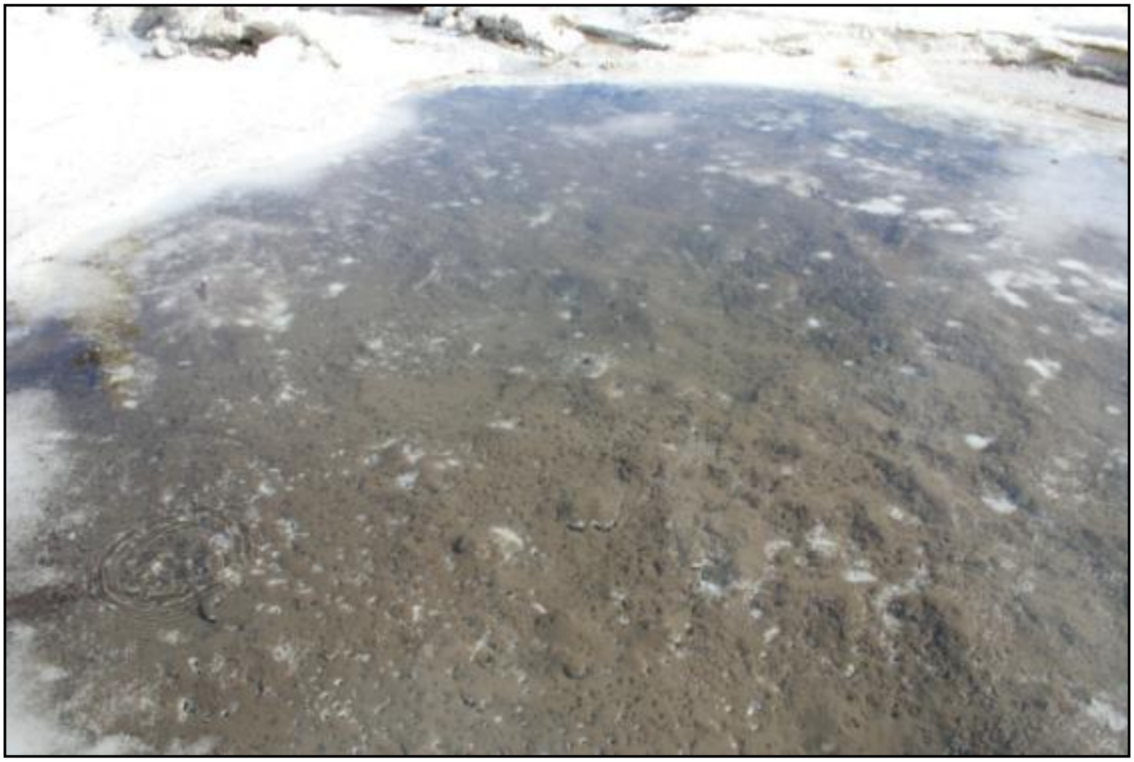
Picture 1. Overview of the salt plains from the Salt Plain Lookout

The Salt Plains is located at the edge of an evaporite escarpment where numerous springs with different water chemistry rise to the surface next to each other. During fieldwork numerous saline springs were mapped with extremely high salt content. This high salt content resulted in thick salt deposits around the spring outlet and thinner salt crust farther from the discharging point (Picture 2).

Picture 2. Saline seepage at the edge of the escarpment with salt precipitation around the outlet

Ascending groundwater was observed as both point and diffuse discharge. Point discharge was represented by springs with a definite outlet, whereas diffuse discharge was observable in a bubbling pond (Picture 3).

Typical vegetation on the salt flats was the salt-tolerant red swampfire (*Salicornia Rubra*) (Picture 4).



Picture 3. Bubbling saline water seepage

Picture 4. Red swampfire (*Salicornia rubra*)

2) Grosbeak Lake

Another outstanding example of soil salinization in the National Park is the surroundings of Grosbeak Lake (Figure 1). Grosbeak Lake itself is easily accessible by a tourist trail from the Pine Lake road. The area is covered by red soil and solitary salt-corroded granite boulders with no to minimal vegetation (Picture 5). At the Grosbeak Lake, 1 soil sample and 2 water samples were collected. The pH, temperature and electrical conductivity values measured in the field are shown in Table 3.

Sample ID	Date	Location	pH	T (°C)	Electrical Conductivity (EC) (mS/cm)
W7	24/08/2013	brownish pond near Grosbeak Lake	7.36	18	4.800
W8	24/08/2013	Grosbeak Lake	7.7	20.1	out of range

Table 3. Field measurements at Grosbeak Lake

Picture 5. Moon landscape around the Grosbeak Lake

The lake is fed by saline springs discharging along the edge of the plain. Similar to the Salt Plains, salt precipitation indicates the extremely high salt content of the groundwater.

Picture 6. Saline spring and salt precipitation around the Grosbeak Lake

The only vegetation found on the plain was the salt-tolerant red swampfire (Picture 7).

Picture 7. Red swampfire along the shore of saline spring

The contrast between the saline spring and the brownish, shallow pond located next to the spring outlet (Picture 8) is apparent. The pond has a quite distinct appearance compared to the surrounding of the saline spring. It is surrounded by quite dense grass and black spruce vegetation and has no salt precipitation around it. Based on the EC values measured on field (Table 3), the total dissolved solid content of it is much lower than that of the saline spring, but still higher than that of fresh water.

Picture 8. Brownish, shallow pond NW from the saline spring outlet

The bluish-greenish coloured spots shown in Picture 9 have been observed in a small lake connected to Grosbeak Lake.

Picture 9. Unidentified bluish-greenish spot in the small lake connected to Grosbeak Lake

3) *Sulphur springs*

The sulphur springs were selected based on their distinct appearance observed from the air. During the fieldwork, sulphur springs were observed and sampled at three different sites: sulphur spring south from Nyarling River (Picture 10a), sulphur spring near Green Lake (Picture 10b) and Angus Sulphur Spring (Figure 1). All of them were fairly easy to access by hiking. At the sulphur springs/lakes 4 soil samples and 9 water samples have been collected. The measured pH, temperature and electrical conductivity values are shown in Table 4.

Sample ID	Date	Location	pH	T (°C)	Electrical Conductivity (EC) (mS/cm)
W14	27/08/2013	"South Nyarling" - lake	6.9	9.9	2.340
W15	27/08/2013	"South Nyarling" - lake	7.61	16.9	0.738
W16	27/08/2013	"South Nyarling" - lake	7.1	13.7	2.220
W17	27/08/2013	"South Nyarling" - lake	7.2	15.9	2.310
W20	29/08/2013	Green lake	6.78	12.1	2.330
W21	29/08/2013	spring near Green Lake	6.66	5.5	2.490
W22	29/08/2013	lake next to W21	7.5	15.3	1.008
W23	30/08/2013	Angus Sulphur Lake	6.41	6	2.850
W24	30/08/2013	Angus Sulphur Spring	7.26	14.6	2.040

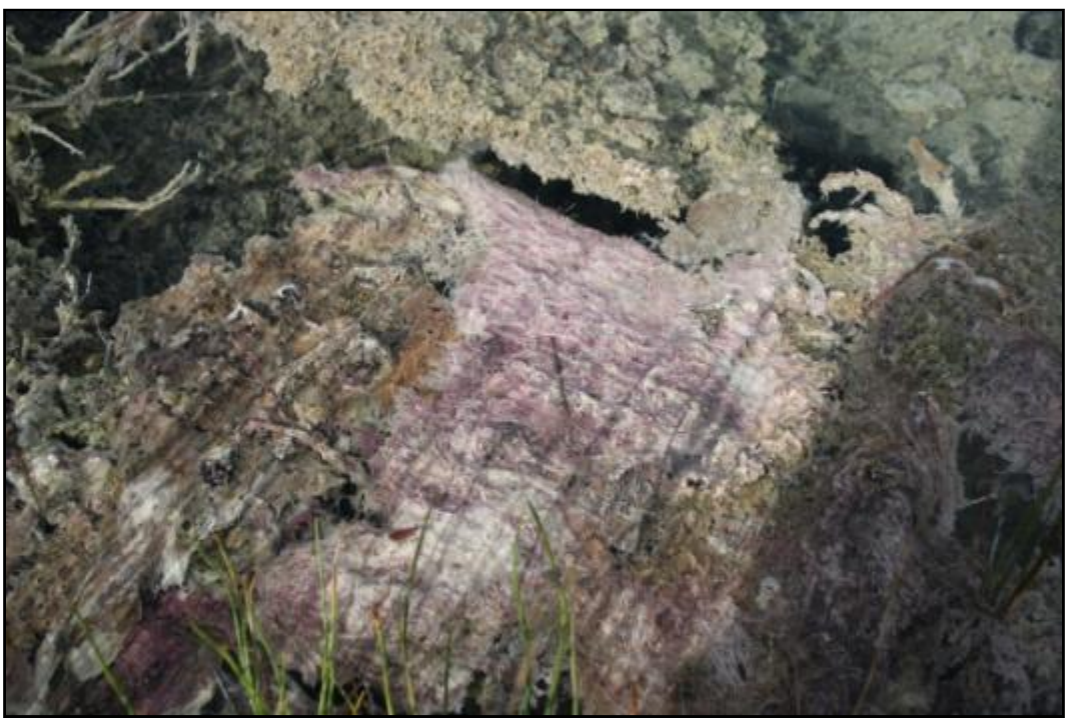
Table 4. Field measurements at the sulphur lakes /springs Table 3

All of the observed sulphur springs possessed the same features despite their different locations. It is easy to identify them either from the air – even on satellite images - or on the ground of their very distinct color and the strong hydrogen-sulfide odor.

Picture 10. a) Sulphur spring south from Nyarling River, b) Sulphur spring at Green Lake

All of the sulphurous springs/lakes have a distinct vivid greenish colour and a strong rotten egg odor caused by hydrogen-sulfide (H_2S) (Picture 11). Although no microbiological analysis has been done in this project, it can be assumed that both the green color and the presence of H_2S may be caused by sulphur bacteria activity. Picture 12 shows some bacteria-originated phenomena floating on the surface of the sulphurous lakes.

Picture 11. Sinkhole fed by groundwater



Picture 12. Bacteria-originated phenomenon on the surface of a sulphurous lake

In the surroundings of the sulphur springs/lakes, small mounds with various sizes have been observed. All of the soil mounds were covered by some kind of salt precipitation as it is seen on Picture 13.

Picture 13. Salt precipitation around sulphur springs

In all of the sulphurous lakes, stalagmite-like formations have been observed in various shapes and sizes (Picture 14, Picture 15). These were found usually soft, easily destroyable formations wrapping some plant remnants.

Picture 14. Sinkhole fed by groundwater with stalagmite-like formations on the shore

Picture 15. "Pseudo-stalagmites" in sulphurous sinkhole lakes

4) Sinkholes, sinkhole lakes

Sinkholes are important indicators of groundwater recharge on karstic areas (White, 1988); however some sinkholes can provide outlet for discharging groundwater (Salvati and Sasowsky, 2002). Sinkholes can be formed either by solution of dissoluble rocks (mostly evaporites and carbonates) or collapse of overlying formations (Figure 2).

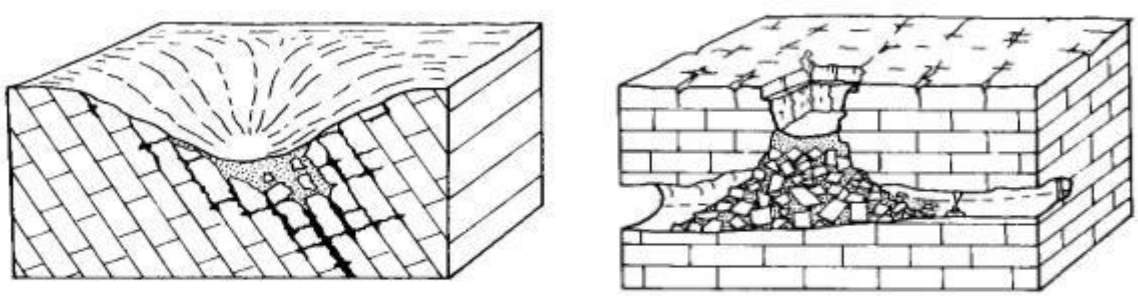


Figure 2. Development of solution and collapse sinkholes (Jennings, 1985)

Due to the presence of soluble rocks, the national park is a strongly karstified area. The dissolution of mostly evaporite formations resulted in a karstic geomorphology. In Wood Buffalo National Park most of the observed sinkholes are filled with water. Because sinkholes filled with water can represent both recharge and discharge area (White, 1988; Salvati and Sasowsky, 2002), the simultaneous examination of chemical composition of the water, the vegetation, topography and morphology is necessary to decide whether the sinkhole is fed by discharging groundwater or it is just a recharge point of the groundwater regime. Picture 16, Picture 17 and Picture 18 show some fine examples of sinkholes observed either from the air or on the ground.

Picture 16. Water-filled sinkholes (location N 60° 20’ 18.80” W 114° 18’ 46.93”)

Picture 17. Water-filled sinkholes (location N 60° 18’ 06.45” W 114° 21’ 02.94”)

Picture 18. Angus sinkhole

The project objectives include determining the hydrogeological setting of Pine Lake and its hydraulic connection to surrounding lakes, such as Lane Lake, Lynx Lake, McNeil Lake. For that reason, field observations have been made at Pine Lake and its surrounding (Figure 1, Picture 19). At the Pine Lake, 2 water samples have been collected, one at the northern and one the southern part of the lake. Two more water samples have been collected from sinkhole lakes located near the trail heading to Lane Lake. The measured pH, temperature and electrical conductivity values are shown in Table 5.

Sample ID	Date	Location	pH	T (°C)	Electrical Conductivity (EC) (mS/cm)
W10	25/08/2013	Pine Lake (North)	8.75	17.3	0.685
W11	25/08/2013	Pine Lake (South)	8.51	16.7	0.675
W12	25/08/2013	sinkhole lake towards Lane Lake	8.3	19.2	0.484
W13	25/08/2013	sinkhole lake towards Lane Lake	8.02	20.1	0.390

Table 5. Field measurements at Pine Lake and its surroundings

Picture 19. Pine Lake

III. Summary

The fieldwork conducted in summer of 2013 represents the first Phase of the Regional Hydrogeology in Wood Buffalo National Park project.

The main objective of this phase of the fieldwork was to conduct a reconnaissance of surface phenomena associated with groundwater flow in Wood Buffalo National Park, such as springs, lakes, sinkholes, vegetation, salt plains etc. During the fieldwork the following sites were visited: Salt Plains, Grosbeak Lake, Pine Lake, “South Nyarling”, Green Lake and its surroundings, and Angus Sulphur Spring. During the fieldwork, 22 water samples from springs and lakes and 9 soil samples from salt precipitations were collected for laboratory analyses. The interpretation of the results is part of Phase II and is proposed to be completed by spring of 2014.

IV. Acknowledgements

I would like to express my gratitude to Parks Canada for supporting the project.

I would like to thank the team of Wood Buffalo National Park for their immense support and assistance prior and during the fieldwork. My special thanks go to Mike Vassal and John McKinnon for their assistance and enthusiasm on the field.

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V. References

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