

I sincerely appreciate the time, effort, and constructive suggestions provided by all reviewers, and have attempted to address all comments in a clear and direct manner following each comment below (*Response*). However, if you believe that further work is needed in this regard, please let me know and I will take immediate action.

Regards, Bob Clark

----- *Review comments follow* -----

Reviewer:

Report Accessibility:

Overall I found the reports each had clear objectives with the descriptions of the research and the application of methodology to be appropriate and quite comprehensive. However, I did find that the presentation in all reports was, at times, difficult to follow and not accessible to a reader who was not an expert in the field. While I understand that this is necessary to complete the work at the level of rigour required, I provide the following suggestions to enable a broader audience to engage with the work completed:

- It was not apparent to me who the intended audience is for these reports. A clear statement of the primary audience would enable the reader to better position themselves as they interpret and evaluate the findings.

Response: My understanding, confirmed by Water Security (WSA) personnel, is that the primary audience is composed of individuals tasked with developing the agricultural water management policy – these individuals possess technical skills and should be able to understand the approaches used as well as the results and conclusions. However, to reach a broader (and non-technical) audience, I have attempted to make the summaries and recommendations – those arising from the most reliable results – more accessible (e.g., Executive Summary).

Each of the reports should include a detailed glossary of terms. I found that all reports used many terms that are likely not generally understood, and without a clear and precise definition the results can be difficult to interpret correctly. I do recognize that some terms (not all) are defined within the text but having a well-placed glossary that can readily be referred to will significantly contribute to reader understanding. I would also suggest that equivalent terms across reports should be defined and applied consistently.

Below I provide an incomplete list of the terms I thought required definition in a glossary:

- Habitat suitability index
- Carrying capacity (removed from the report)
- Riparian
- Bootstrap procedure
- Species richness
- Species abundance

Response: A Glossary of Technical Terms has been included near the beginning of the document. The glossary is composed of 2 parts, one addressing ecological terminology and the other listing statistical terminology. During revisions, the term “carrying capacity” was removed from the report.

- Report 2 highlights loss of historic wetlands in the Canadian prairies at 40% to 70% due to drainage. This is a dramatically different value than the loss rates used, particularly in Report 1 and Report 4, of approximately 8% to 20%.

Response: The wording of the report has been modified somewhat to clarify context and reconcile the various estimates. These revisions also address comments (below) from other reviewers.

- All of the reports highlighted significant levels of uncertainty with respect to the results. This makes the interpretation and the application of the results difficult. This is clearly not unexpected in any analysis addressing more complex environmental issues. The Intergovernmental Panel on Climate Change (IPCC) has developed a terminology framework to address confidence and certainty with respect to climate science. I would suggest a similar approach applied to the findings of these reports could make the results more accessible and useable by relevant stakeholders. I have attached a basic summary of the terminology used by the IPCC to represent levels of confidence and likelihood of an outcome to illustrate this point:

Scales of scientific confidence used by the IPCC.

http://www.ipcc.ch/publications_and_data/ar4/wg1/en/ch1s1-6.html

Response: When appropriate, the IPCC terminology has been adopted (and referenced) in Part A to address confidence or certainty regarding specific results. In Part B, uncertainty is expressed by using the error terms (e.g., root mean square error or 95% confidence interval) associated with each statistical model, as reported in Figures and(or) Tables.

Report Concerns:

- In Report 4 it was highlighted that the predicted impact of “current wetland scenarios” are likely underestimated due to overestimated current wetland area in most or all basins due to the assumption that partially drained wetland retain 50% of their historical wetland area. As the authors highlight, “... the impact of “current wetland scenarios” should be considered much higher than reported in this study, with “current” losses of wetland area being up to 50% higher than estimates shown in this report”. I am not completely sure if this is an artifact of errors in the CWI information or due to assumptions used in the specific research. Nonetheless, this seems to be an important concern that needs to be carefully acknowledged.

Response: For consistency, analyses in all reports used the same assumptions about how wetlands were drained (by quarter section) and how much water could be retained (i.e., 50%) in partly drained or partly filled wetland basins. That there is considerable variation in the magnitude and spatial extent of wetland drainage is now acknowledged more clearly in the wildlife habitat report.

- In Report 4 the recent report by Rahman (2021) was highlighted. The authors of Report 4 summarize that “...wetland drainage density is underestimated in southeastern Saskatchewan where landscape contouring is a more common drainage method than trench-like ditching that occurs further north. This explains the higher estimated increase in EDA for the Assiniboine River

basin using the quarter section method. Most importantly, this example also suggests that “current” wetland retention scenarios were likely overestimated in this study, resulting in potentially underestimated impacts of current wetland retention scenarios on runoff volumes.” I would suggest that with agricultural producers having greater access to improved GPS technology and remote sensing tools along with improvements in drainage equipment, land contouring is becoming a more viable alternative to manage surface water on agricultural land. As a result, this approach to identify drainage could be a significant gap in the data the reports are based on.

Response: Limitations of the classification system – and possible errors and underestimation of past drainage – have been mentioned briefly in the revised report (Part B, Methods).

- The Steward and Kantrud wetland classification system uses vegetation patterns and plant species to determine wetland permanence and wetland class. Therefore, I felt that there should be more discussion about the impacts on the results of assuming that wetlands less than 0.5 acres are predominantly Class 1 and 2 wetlands, wetlands less than 3 acres are predominantly Class 3 wetlands and wetlands less than 5 acres are predominantly Class 5 wetlands. I understand the reason for using wetland size as a proxy for wetland permanence but the limitations of this assumption should be clearly stated. Consistent with this comment the author of Report 2 states that *“Seasonal wetlands (Class 3) cannot be defined exclusively by size category, due to a wide range of areas in this class, but WSA wetland inventory data indicate that many wetlands < .10 ha (0.25 acres) are typically Classes 1 and 2. An extremely careful examination of the existing data might provide deeper insights into defining sizes of class 3 wetlands....”*.

Response: The need to very carefully evaluate size-Class relationships (including an assessment to reliably identify Class III seasonally-flooded ponds) is already highlighted in the report, as noted by the reviewer. No further modifications were made.

Report Applications:

... if possible, completing focused marginal analysis, even as a preliminary case study, would be quite informative to management decisions and policy development. This analysis would better inform cost-effective policy approaches that provide levels of environmental quality.... (and) Developing tradeoff curves representing levels of ecosystem functions, ecosystem services, and potentially economic costs, would enable a more informed application of the research results.

Response: In my opinion, these are excellent suggestions (another reviewer also raises this point below); marginal/trade-off analyses would be very useful. While such analyses are beyond the scope of the current work, this suggestion could be addressed by WSA when the economic analysis has been completed.

Reviewer

Page 3

Which parts of the prairies? 70% seems too high for most of the region. Even 40% is likely higher than the actual number in many parts of Alberta.

Response: Wording was modified to indicate that only some areas of the prairies have sustained such high levels of drainage, whereas most areas have overall lower wetland losses due to drainage (with high spatial variability).

Given the length of the report, a table of content at the beginning may be useful.

Response: a Table of Contents has been included.

Page 6

This is not in the reference list. (Feon et al.)

Response: Citation of this paper has been corrected, and it appears in the reference list.

Page 10

'Temporary wetland' is an odd word. Wetlands are permanent fixtures of the landscape. They are not 'temporary' features. A proper term would be 'seasonally flooded wetland' or 'ephemerally flooded wetland'. Stewart and Kantrud (1971), in their wetland classification, discussed seasonal ponds, not seasonal wetlands.

Response: Wording has been adjusted and the terms clarified in various parts of the report (and "pond" terms are reported in the Glossary along with the Stewart and Kantrud 1971 citation). While many people do use the terms "wetland" and "pond" interchangeably, there is well-established terminology surrounding the use of "wetland basin", "pond", and various terms that refer to typical lengths of flooding duration (e.g., seasonally flooded pond).

Page 11. Is this a common terminology? What does it exactly mean? [agricultural wetlands]

Response: The term "agricultural wetlands" has been modified or explained in the text.

Page 16. What is the basis of this assumption? A sentence or two of explanation will be useful.

Response: The decision to assume that 50% of wetland basin area retained pond water in partly drained and partly filled basins was based on discussions among assessment team members and WSA personnel. The assumption has no direct bearing on the historical estimates, nor does it affect the estimates derived in each wetland retention scenario. The most serious implication of this assumption relates to whether or not there is interest in estimating "current" wetland area, as discussed below and in the report.

Page 17. 'Historic wetland area' could be a bit confusing, because it sounds like pre-drainage condition (i.e. pre-agriculture). Some clarification will be useful.

Response: *Historic wetland area is assumed to approximate conditions that existed prior to drainage, and represents the starting area estimate (100%) for the wetland retention scenarios.*

Page 20. See my comment on page 10. [ephemeral and temporary wetlands]

Response: *Wording has been modified to be more consistent with accepted terminology.*

Page 21. What kind of data are these? Are these a small number of site-specific studies, or a systematic and well-designed survey of large areas? Will it be useful to interview farm operators and get their perspective on this?

Response: *The field reports of size-related drainage risk are based on systematic surveys of relatively large areas (see citations listed). Perspectives of farm operators would be extremely valuable, of course, but to my knowledge no systematic, large-sample data are available to inform this point.*

Reviewers

Page 2

Could we change "a new wetland drainage regulations" to "an agricultural water management policy"? We do have the new regs in place, i.e., The WSA Regulations, 2015.

Response: *Wording was changed to "wetland mitigation policy" following ESS comment.*

literature review?

Response: *this was not changed because the qualitative assessment involved more than a literature review – e.g., it included direct contact and communications with university and government personnel.*

could change

Response: *This modification was made.*

Could we re-frame the statement? Saying "preferential losses" could be misinterpreted as this is a preferred practice. Maybe reword to "preferentially draining smaller wetlands"?

Response: *This modification was made.*

can we replace "protected" with "conserved"? - to avoid confusion with formal designation of these wetlands as protected lands.

Response: Wording was changed, as suggested.

Page 3

should be "a wetland mitigation policy under..."

Response: This change was made.

Page 4

replace with "policies"

Response: This change was made.

Page 9

Could we reference where this figure came?

Response: Reference is now made to the PHJV 2021 Habitat Implementation Plan. The value for Saskatchewan exceeds \$550 million, per the (Canadian) National Tracking System for the North American Waterfowl Management Plan. [Another Reviewer had also provided this information and source (details below).]

Reviewer

General comments

An important general question that came to mind in the course of this review is, "Who is the audience?". If the audience will extend beyond highly technical people schooled in the areas of review, many readers will be challenged to wade through the material. If these reports are to be read beyond a narrow group of experts, more thought needs to be given to definitions of terms used, simpler and higher-level summaries of key results and the analytical decisions behind them i.e. why one approach was used over another and how those decisions affect the resulting analysis. In most cases that information is available, but it is often buried in technical discussion and will not be easily discerned by most readers, and I would put myself in that category in a number of sections of the reports I read. I would expect that policy analysts and other decision-makers will welcome more clarity here.

Response: This is an excellent comment, also raised by another reviewer, and was addressed above.

To reinforce my above point with a concrete recommendation, put more work into the summaries and recommendations, ensuring that critical analytical approaches are highlighted along with the uncertainties that go with those decisions. As for the results themselves, ensure that they are communicated clearly, along with the uncertainties and biases inherent in the numbers.

Response: Further effort (e.g., in the Executive Summary and main text) was made to address these good points.

In the three studies that used results from the Saskatchewan Wetland Inventory, I made specific comments. An apparent underestimation of historic drainage – at least to this reviewer, but was also highlighted in the hydrology study – is perhaps the most significant shortfall in the entire set of analyses. If the WLI significantly underestimates historic drainage, it affects this entire exercise.

Response: In general terms, this comment has now been addressed because some of the uncertainties in estimating drainage have been added to the report, as requested (above) by other reviewers.

Lastly, some thought should be given as to how these reports integrate, not only from a design and layout standpoint, but in terms of a synthesis of relevant information from each into a coherent summary. This was not in the terms of reference for anyone at this time, but it will be a key consideration going forward.

Response: My understanding is that the integration – which I agree is a very important step - will be conducted by WSA and(or) others.

- This estimate historic wetland losses mentioned in the summary (30%) seems to me to be quite low. It has been generally accepted that wetland loss across the prairies has been in the 40-70% range (e.g. Federal State of the Environment Report, 1991). Recent estimates of annual prairie wetland loss rates are 0.5 to 1%

Response: This point was raised by other reviewers, and has been addressed as part of the responses provided above.

- This reviewer is not familiar with the details or methodology in the Saskatchewan Wetland Inventory but, compared to other studies of wetland loss in the great plains region, the WLI-derived estimates appear to be low – in some cases where agricultural development is considerable, estimates appear to be very low. In some of the more specific studies discussed in this paper, estimates of drainage by others (e.g. Badiou 2018b as well as data from Smith Creek) are significantly higher than comparable WLI data.

Response: See the response to the previous comment.

- What appears to be consistent under-reporting of historic drainage in the Saskatchewan WLI is the most important limitation to this analysis, in my view. That said, I understand that the consultant worked with the data that was provided to him.

Response: Addressed above.

Wildlife Study: General comments

This is a thorough review of the impacts on additional agricultural drainage on wildlife in Saskatchewan. The consultant has extensive experience in this field, is well regarded among his peers and has provided an impressive analysis. Overall, I found little to challenge or question throughout the document and, for the most part, was able to follow the consultant's approach and assessments quite well.

The one exception would be the consultant's detailed discussion of his approach to modelling abundance and species richness in response modelled wetland loss scenarios. It was very detailed and, frankly, beyond the capacity of this reviewer!

Response: The details of the statistical analyses are required to explain how the estimates were derived. In the Results and Discussion sections, I have tried to provide just a bit more explanation of the results so they are (hopefully) more accessible to a broader audience.

Comments that I made in the water quality review respecting the Saskatchewan Wetland Inventory also apply to this analysis. When compared to other analyses of historic drainage, including analyses in comparative catchments, the WLI generates conservative estimates. The most important implication is a conservative estimate of the impacts of wetland loss to date. This is not limitation of the consultant's work; rather it is a commentary on the dataset from which he was required to work from.

Response: No further response is needed (addressed previously).

Looking more specifically at the report, Section A is a thorough summation of relevant literature. The importance of wetlands through various life cycle phases and species-specific limiting factors has been assessed for a range of wildlife, from pollinators on up to harvestable wildlife, including large ungulates. The consultant has also considered wetland loss in the context of emerging issues such as declines in aerial insectivores, CWD and other wildlife diseases. The section on waterfowl is especially detailed, and productivity estimates for waterfowl are more refined than for any other group of bird, owing to model availability. The discussion also includes impacts by wetland type, because ecological functions differ between wetland type. The assessment of the relationship between wetlands and species at risk is also thorough, but here the consultant has had to work with data and studies that are less complete than those available for waterfowl.

Response: No response required.

In part B, the predicted impacts on species richness and abundance that came out of the models are not unexpected. Detailed discussions re: development of the model are perhaps best handled in an appendix, and the relevant assumptions and findings can be the focus of the main text.

Response: I have opted to retain the statistical models and details so that all information is provided, in sequence, in one place within the report. But, I have also tried to provide some further explanation regarding the approaches taken, and implications of the results.

It was also important that larger land cover considerations were brought into this analysis. It is reasonable to conclude that wetland drainage facilitates loss of associated grasslands, shrublands and woodlands. The impacts of wetland drainage go beyond wetlands. The extensive work completed here by the consultant points to significant and accelerating declines in species richness and abundance as wetland loss increases. Again, no surprises here from the consultant's analysis

Response: No response is needed.

Part C highlights where policies leading to significant wetland loss will contradict other established policies in Saskatchewan. Impacts on national and international agreements and conventions are also summarized. Again, the consultant's assessments of the points of apparent conflict are self-evident. This observation is not a judgement regarding wetland policy going forward: rather, it simply points out the areas where contradictory policies may arise.

Response: No response needed.

In summary, the consultant completed a thorough, well-researched review that effectively assesses the impacts of further drainage on wildlife in agricultural areas of Saskatchewan. Given the consultant's reputation in the great plains ecological research community, this is not a surprise.

Specific comments

Page 9. There is a National Tracking System for North American Waterfowl Management Plan expenditures. From 1986 to 2022 it records aggregate NAWMP expenditures in SK of \$600.4 million.

Response: Details (and source) have been provided for the period 1986-2021.

Page 16. When comparing the SK WLI's historic wetland loss estimates to other analyses of historic wetland loss, the SK estimates would appear to be very conservative. I have commented on this in greater detail for the water quality analysis but my fundamental concern - that impacts of historic drainage are considerably underestimated - would apply to this work as well.

Response: For consistency, the same assumptions and approaches to determining historic wetland area was used, per a previous response above. We simply do not know with high certainty what the current wetland area is, and addressing this deficiency is something that WSA personnel could assess further.

Page 26. I have not been able to follow the modelling discussion closely (that is not a skill-set I possess!) but the consultant's assessment here makes sense, given the limitations in predicting abundance.

Response: I have tried to ensure that the general results of the modelling have been summarized in a manner that makes them more accessible to (non-technical) readers, here and in the Executive Summary. As requested by this reviewer and others, this helps to address the information needs of a broader audience and provides information in a simpler, more accessible form.

Page 28. reasonable assessment. Actual impacts may be more significant than modeled for the reasons the consultant provides here.

Response: No response is required.

Page 31. Intuitively, an expected result.

Response: No response is required.

Page 33. The general analysis provided here is supported by extensive studies of waterfowl productivity in relation to wetland size and density. Much of research supporting this analysis has been conducted in SK.

Response: No response is required, and several published reports on this topic are referenced.

Page 35. this is a useful summary and points to a general alignment of the results in this analysis with other modelling work reported in the literature

Response: No response is needed.

Page 38. The assessment provided here - impacts of not conserving Class 1 and 2 wetlands vs impacts of not conserving Class 3 wetlands - would find general agreement among wetland ecologists

Response: No response is needed.

Page 39. These comments also point to consequences of wetland loss on other land cover types - grasslands, shrublands, woodlands. Wetland drainage is often a precursor to land conversion that results on the loss of all habitat at a given site.

Response: No response is needed.

Page 41. Difficult to disagree with this assessment

Response: No response is needed.

Page 44. In conservation circles, this is seen as a truism. Pencilled out on a spreadsheet, restoration is always vastly more expensive than developing the means to conserve existing habitats

Response: This "supportive" comment requires no further response.

Page 44. It is difficult to argue with the consultant's observations re: the disconnect between additional drainage and land clearing vs stated commitments in SK's Growth, Climate Change, Game Management plans. Given that those documents are generated in-province, that may carry more weight in policy discussions than objectives set by national/international plans.

Response: No response is needed.

Reviewer

General comments –

- Consideration of the results of the independent sections in concert, and also the need to address cumulative effects will be a valuable and much needed component of the final report.

Response: This is an important comment, also suggested by another reviewer. WSA has plans to consolidate the results from the individual reports into an overall summary of expected impacts, including cumulative impacts.

- a more comprehensive documentation of the strengths and weaknesses of the CWI and the use of recent data in this approach as the underpinning of this work.

Response: The methods and assumptions used to evaluate the imagery are covered in the cited technical documents. Assumptions associated with estimating “current” wetland area are also discussed in a bit more detail in the revised report.

- thresholds for wetland drainage was an underlying theme in the various sections, but it remains difficult, if not impossible to identify these thresholds in the absence of a defined target (see more detailed comments on water quality section). In this context it is unclear how thresholds beyond which drainage should not occur can be identified without first knowing what targets for (change to) wildlife, water export and flooding, groundwater recharge, or elemental and sediment transport are.

Response: The question of “thresholds” is briefly addressed in the text. In the context of wetland and land cover losses, impacts on birds are expected to occur immediately (i.e., weak evidence of any thresholds), and produce population declines over the long term as wetlands and natural upland habitats are converted to crop production. Still, the challenge of identifying thresholds could be a core goal of a marginal/trade-off analysis, as suggested above by another reviewer.

Specific comments

Part A

A small note that the formatting could be more consistent in a few instances. For example, on my reading, *Beneficial invertebrate pollinators and predators in wetland margins*, and SASKATCHEWAN GAME SPECIES, PRAIRIE DUCKS AND OTHER WETLAND-ASSOCIATED BIRD SPECIES, etc. occupy the same level in the heading hierarchy, but are presented differently.

Response: Formatting has been checked and adjusted on the basis of this comment.

Part B

Page 16: Given the ~10 year window of imagery used to establish this inventory and the long history of wetland drainage, it would be useful here to provide some context as to how reliably this method can identify former wetlands that have undergone some form of conversion. This is important to show a robust estimate of historical wetland coverage. Perhaps it should also be emphasized (here or elsewhere) that this is a baseline for comparison, and not necessarily a true representation of historical conditions.

Response: *This has been discussed briefly in the report, and citations are given that cover technical aspects of interpreting the imagery (e.g., Boychuck et al. 2014).*

Page 16-17: “For a small portion of the wetland inventory, very small wetlands appear as point features.” What is meant by portion here? Is this some of the geographic extent, or does portion refer to some numerical portion of the dataset, and if so how many (e.g. as a % of all identified wetlands) were in this category?

Response: *On the basis of area estimates provided in the wetland inventory, <3% of wetland area was attributed to point features; this was added to the report.*

Page 18: Some description of what is meant by basin/what data are used to demarcate basins is needed in this section. Also, in the previous section it suggests that wetland drainage is random (not linked to outlet), but here my understanding that all wetlands on certain quarter sections are drained before other quarter sections are drained? Perhaps I’ve misunderstood, but some clarification here is warranted. I see that this is partly described later (page 21), but would benefit from earlier introduction.

Response: *Technical details regarding interpretation of the imagery are given in the citations listed in this section.*

Page 21/31: The methods for the analysis described an investigation by removing wetlands according to size. In this case study, is it assumed that size is a proxy for permanence class? Perhaps the link to permanence class identified in the heading could be explained.

Response: *This has been explained in this section of the report.*

Table 5: It would be helpful to include units for wetland area.

Response: *This change was made.*

Part C

Table 9 provides an excellent synthesis, and perhaps one that could be expanded to include summaries of the aspects covered in the other summaries/reports, as an overall summary figure tying the different report components together.

Response: *This is a great suggestion. I believe that WSA will be developing an overall summary document that integrates results of all study components.*