Dear Viewer,

Thank you very much for your comments. We have carefully considered your suggestions and revised the manuscript accordingly. The comments and detailed responses can be summarized as follows:

==========

Response to the Reviewer 1

1. Part of references cited in your manuscript is too old to illuminate your viewpoint, such as Page 14538, line 2; Page 14540, line 20; Page 14544, line 28, etc. It is better to refer the latest literature in you references.

Responds: In the revised paper, the following references are added to illuminate the history of non-point-source priority management areas:

Ghebremichael, L., Veith, T., and Watzin, M.: Determination of critical source areas for phosphorus loss: Lake Champlain basin, Vermont, Trans. ASABE, 53, 1595-1604, 2010.

Sahoo, G., Nover, D., Schladow, S., Reuter, J., and Jassby, D.: Development of updated algorithms to define particle dynamics in Lake Tahoe (CA‐NV) USA for total maximum daily load, Water Resour. Res., 49, 7627-7643, 2013.

Savage, J. A., and Ribaudo, M. O.: Impact of environmental policies on the adoption of manure management practices in the Chesapeake Bay watershed, J. Environ Manage., 129, 143-148, 2013.

As a geographically connected unit, watershed has been covered by many researches. And some classical references, such as Page 14538, line 2; Page 14540, line 20; Page 14544, line 28, are also cited in this paper.

2. Please reorganize the description of PMA data in Results and Discussion section, according to your figure. Parts of them are hard to be read clearly!

Responds: In the revised paper, the following contents have been added:

Abstract: “Daning River watershed was taken as a case study in this paper, which have demonstrated that the integration of the upstream input changes was vital for the final PMAs map, especially for downstream areas. Contrary to conventional wisdom, this research recommended that the NPS pollutants could be best controlled

among the upstream high-level PMAs when protecting the water quality of the entire watershed. The MAP-PMA framework provided a more cost-effective tool for the establishment of conservation practices, especially for a large-scale watershed."

Conclusion: "Based on the results obtained from this research, the integration of the upstream input changes was vital for the final PMAs map, especially for a more cost-effective allocation of those downstream PMAs. From this study, a maximum frequency of water quality target existed at the downstream river point if the pollutant removal potential at the upstream point was below a certain threshold. Contrary to the conventional wisdom, it is recommended that the NPS pollutant could be best controlled among the upstream high-level PMAs in protecting the water quality of the entire watershed."

3. Page 14547, line 1-9: Please move this paragraph to Results and Discussion section, and try to discuss the influences of water quality monitoring stations on your MAP-PMA framework calculation based on other related references.

Responds: We agree your point that "the major error of the MAP-PMA may come from the selection process of multiple assessment points." In fact, our group is doing some researches on the optimization of water quality monitoring stations from the point of nonpoint source pollution. In the revised, instead of moving **Page 14547, line 1-9** to Results and Discussion section, we revised this paragraph in a more detailed way. The following content can be found in the revised paper:

"In this research, the existing water quality monitoring stations were chosen as multiple assessment points where such were available. However, these stations were designed as a monitoring network for point source pollution and may not refer to the perspective of the NPS pollution. Therefore, by the aid of the MAP-PMA, the resolution of the current monitoring network should be improved. It is believed that the optimal design of the monitoring network, together with the MAP-PMA framework, would provide a valuable tool for effectively allocating state funds for the establishment of conservation practices where they are needed."

4. Please conclude the advantages of MAP-PMA framework based on your data obtained from the Daning river watershed.

Responds: The MAP-PMA framework provided a more cost-effective tool for the establishment of conservation practices, especially for a large-scale watershed. Our findings may broaden the forms of priority management areas and provide a valuable method for watershed nonpoint source pollution control. In the authors' view, the explicit link between the variations of upstream inputs and downstream water quality statues on which MAP-PMA is based in combination with its high practicality potential, make the MAP-PMA framework particularly interesting for watershed management.

5. Try to adapt statistical method to analyze the difference between the MAP-PMA and traditional targeting approach

Responds: The MAP-PMA framework, which integrates the interactions between multiple river points from upstream to downstream, is shown in Fig. 1. The upstream PMAs are first identified based on the required load reduction at the upstream assessment point. Then, the downstream PMAs are identified by the variations of pollutant fluxes at the downstream river point. The commonly-used goodness-of-fit indicator, such as Nash-Sutcliffe coefficient of efficiency (E_{ns}) was selected as the likelihood functions.

$$E_{ns} = 1.0 - \frac{\sum_{i=1}^{n} |O_i - P_i|^2}{\sum_{i=1}^{n} (O_i - \bar{O})^2}$$

where: $\{O_i | i = 1, 2, \ldots, n\}$ is the set of measured data, $\{P_i | i = 1, 2, \ldots, n\}$ is the set of predicted data and $\bar{O}$ is the mean value of measured data.

==========

Response to the Reviewer 2

. How to define a watershed "large scale" or not?

Responds: In fact, there is no exact threshold value to divide a watershed into different scale. In general, it is thought that a watershed that is smaller than 100 km^2 can be defined as small-scale watershed, while a watershed larger than 1000 km^2 can be defined as large-scale watershed. In larger watershed, the relatively small number

of water quality monitoring stations may provide a false result indicating homogeneous distribution of non-point-source priority management areas due to the dampening effect of the traditional approaches. A well designed station network, in terms of multiple assessment points, is necessary to hinder the averaging of spatial heterogeneity in large-scale watershed. Instead, the relatively heterogeneity at small scale watershed can be obtained by those traditional approaches. It is concluded that consideration of multiple assessment points is very important in studying the spatial variability of non-point-source priority management areas, particularly in larger watersheds.

2. If the pollutant is controlled at the upstream, the self-purification capacity of the downstream river is not fully used. By considering this view, how do the authors explain the advantages and disadvantages of MAP-PMA?

Responds: We agree with your idea that "If the pollutant is controlled at the upstream, the self-purification capacity of the downstream river is not fully used." However, from a water quality perspective, the scientific basis of MAP-PMA is based on the idea that the water quality at multiple assessment points should reach the required level. In this sense, the main advantage of MAP-PMA framework is integrating the upstream input changes and the downstream transport aspects of NPS pollution. This is especially important, especially for the downstream sub-watersheds. Based on our results, there was great variation between the MAP-PMAs and traditional PMAs among the downstream areas. This can be explained by the fact that the MAP-PMA focused on the pollutant load actually reaching those multiple assessment points. The disadvantage of MAP-PMA is that the self-purification capacity of the downstream river is not fully used, but this is a more cost-effective way from the perspective of the whole watershed.

3. For the traditional researchs of NPS pollution, priority sources areas (PSAs) identification is often documented. How do the authors compare which is more useful in real practices, MPAs or PSAs?

Responds: Indeed, either priority sources areas (PSAs) or priority management areas (PMAs) are widely accepted concepts, which are defined as those areas where the risk

potential of certain pollutants exceeds local loss tolerance or contributes more pollutant to the nearby water body. Comparatively, PSAs are often referred to those high-pollutant-loss areas that are of small scale or within a specific district. This idea is derived from the land resource perspective, which brings local collaborators into the cost share programs. PMAs are often referred to the impact of BMPs on the nearby water quality. As mentioned in the paper, we had taken pollution sources into account, as well as made the corresponding processing: each required load reduction is separated into its origin sources to reach a specific frequency of water quality target at multiple assessment points. In MAP-PMA framework, the sensitive areas where responsible for disproportionate load contributions to the pollutant fluxes are identified at multiple river assessment points. Based on the identification results, management practices can be positioned accurately. In this sense, "PMAs" looks more suitable than "PSAs".

4. The example of Daning River Watershed should be mentioned in the abstract. Also there are some technical corrections.

Responds: The example of Daning River Watershed have been mentioned in the abstract. Other technical errors have been revised accordingly. Please check the new manuscript.

Thank you very much for your wonderful job. Hope that our responses are satisfactory, and look forward to hearing from you. Best regards.

Best wishes,

Zhenyao Shen

Professor

State Key Laboratory of Water Environment Simulation, School of Environment,

Beijing Normal University,

Beijing,

China, 100875

Tel: +86-10-5880 0398

Fax：+86-10-5880 0398

E-mail: zyshen@bnu.edu.cn