Land Management Research Program and National Water Quality Program

Appendix 3. A Structured Decision Analysis for Management and Mitigation of Cyanobacterial Harmful Algal Blooms at Rockland Lake State Park—Results From a Structured Decision-Making Workshop, February 10–14, 2020, Troy, New York

Scientific Investigations Report 2022–5053, Appendix 3

U.S. Department of the Interior
U.S. Geological Survey

Cover. Left: Rockland Lake in Rockland Lake State Park, New York, June 2018. Right: An algal bloom in Rockland Lake, Rockland Lake State Park, August 2012. Photographs by the New York State Office of Parks, Recreation and Historic Preservation.

Appendix 3. A Structured Decision Analysis for Management and Mitigation of Cyanobacterial Harmful Algal Blooms at Rockland Lake State Park—Results From a Structured Decision-Making Workshop, February 10–14, 2020, Troy, New York

By Claudia Mengelt, Michael C. Runge, Jennifer Graham, Gabriella Cebada Mora, Rebecca Gorney, Riley Buley, Lianne Ball, April Brun, Lauren Townley, Natalie Browne, Jesse Jaycox, Lindsey DeLuna, Max Garfinkle, Scott Flanagan, and Mary Anne Evans

Land Management Research Program and National Water Quality Program

Prepared in cooperation with the New York State Office of Parks, Recreation and Historic Preservation and the New York State Department of Environmental Conservation

Scientific Investigations Report 2022–5053, Appendix 3

U.S. Department of the Interior
U.S. Geological Survey

U.S. Geological Survey, Reston, Virginia: 2022

Suggested citation:
Mengelt, C., Runge, M.C., Graham, J., Cebada Mora, G., Gorney, R., Buley, R., Ball, L., Brun, A., Townley, L., Browne, N., Jaycox, J., DeLuna, L., Garfinkle, M., Flanagan, S., and Evans, M.A., 2022, A structured decision analysis for management and mitigation of cyanobacterial harmful algal blooms at Rockland Lake State Park—Results from a structured decision-making workshop, February 10–14, 2020, Troy, New York, app. 3 *of* Graham, J.L., Cebada Mora, G.M., Gorney, R.M., Ball, L.C., Mengelt, C., and Runge, M.C., A structured decision-making framework for managing cyanobacterial harmful algal blooms in New York State Parks: U.S. Geological Survey Scientific Investigations Report 2022–5053, 10 p., https://doi.org/10.3133/sir20225053.

ISSN 2328-0328 (online)

Contents

Figures

Tables

Appendix 3. A Structured Decision Analysis for Management and Mitigation of Cyanobacterial Harmful Algal Blooms at Rockland Lake State Park—Results From a Structured Decision-Making Workshop, February 10–14, 2020, Troy, New York

By Claudia Mengelt,[1] Michael C. Runge,[2] Jennifer Graham,[2] Gabriella Cebada Mora,[3] Rebecca Gorney,[4] Riley Buley,[5] Lianne Ball,[2] April Brun,[3] Lauren Townley,[4] Natalie Browne,[4] Jesse Jaycox,[3] Lindsey DeLuna,[3] Max Garfinkle,[3] Scott Flanagan,[6] and Mary Anne Evans[2]

Abstract

Rockland Lake is a surface-fed, eutrophic lake situated on the west bank of the Hudson River in Rockland County, New York. Visitors to Rockland Lake State Park enjoy recreational opportunities around and on the lake, including boating, fishing, biking, golfing, picnicking, walking, jogging, and swimming in the pool. The lake's water quality is impaired from phosphorus pollution, which has led to eutrophication and frequent cyanobacterial harmful algal blooms. In February 2020, a structured decision-making workshop was convened to explore short- and long-term strategies for responding to cyanobacterial harmful algal blooms at Rockland Lake State Park. Ten fundamental objectives were identified as part of seven categories; examples of the objectives include maximizing the aesthetic value of the Lake, recreational opportunities, educational and outreach opportunities, the health of the ecosystem (as reflected by water quality), and economic benefits; and minimizing management cost. Four alternative strategies were crafted: maintaining the current management strategies; focusing on in-lake treatments; focusing on nutrient interception; and intensive management that would make Rockland Lake a demonstration site for effective management of nutrients and cyanobacterial harmful algal blooms. Evaluation of the four strategies against the fundamental objectives revealed important tradeoffs that decision-makers need to navigate. Choosing among the four strategies was hampered by incomplete information regarding the cost of various actions. The workshop participants concluded that the consequence table and tradeoff analysis would be revised after additional information was gathered on the costs associated with each alternative strategy.

[1]U.S. Geological Survey and U.S. Fish and Wildlife Service.

[2]U.S. Geological Survey.

[3]New York State Office of Parks, Recreation and Historic Preservation.

[4]New York State Department of Environmental Conservation.

[5]Auburn University.

[6]Rockland Lake State Park.

Background

Park Setting

Rockland Lake is a surface-fed 281.6-acre eutrophic lake. Located in the Palisades Region, the lake is the centerpiece of Rockland Lake State Park and is situated above the west bank of the Hudson River in Rockland County, New York. The watershed to the northern, western, and southern sides of the lake contains a mix of low- to high-intensity development, whereas the eastern part of the watershed is largely forested (fig. 3.1). The watershed is home to extensive commercial and residential use, which affect the lake's water quality. The New York State Office of Parks, Recreation and Historic Preservation (OPRHP) owns the entire shoreline of the lake and the eastern part of the watershed (fig. 3.2).

Rockland Lake State Park provides important outdoor recreational opportunities for diverse patrons. The park is roughly 25 miles north of New York City and, during summer months, attracts many visitors. Underserved communities from New York City, New Jersey, and Rockland County can experience fishing, boating, biking, and wildlife watching in the park. The park is also popular with local residents. The lake supports a local rowing club, and in 2020 the park issued 259 boat permits. The bike path around the lake is used by individual walkers and runners regularly and is the site of 15–20 charitable runs annually. The fields surrounding the lake host family events, weddings, soccer camps, volleyball tournaments, and several football leagues. A recently reopened nature center on the lake will provide all visitors outdoor educational opportunities through a recently erected boardwalk and various signs and displays. Visitors also use the park's pool. The current pool capacity is 3,500 people, and on busy weekends the overall number of swimmers throughout the day is 4,500–5,000. Over the previous 20 years, annual park visitation has averaged 1.1 million visitors.

Water Quality and History of Cyanobacteria

Rockland Lake is a class B lake (New York State Department of State, 2021b; 6 CRR–Y 865.6), which means the lake should be suitable for primary and secondary contact recreation and fishing (New York State Department of State, 2021a; 6 CRR–NY 701.7). The lake was sampled in 1983 and in 2008 through the New York State Department of Environmental Conservation (NYSDEC) Lake Classification and Inventory Program. Interpretation of the 2008 Lake Classification and Inventory results indicated Rockland Lake is eutrophic, with low water clarity (average 1.1-meter Secchi disk clarity) and high phosphorus (trophic state index value=56) and chlorophyll *a* (trophic state index value=52) concentrations (New York State Department of Environmental Conservation, 2008). Phosphorus was previously identified as the key pollutant of concern, and the lake was listed as impaired on the section 303(d) list of impaired waters in 2012 (New York State Department of Environmental Conservation, 2018). The main sources of the phosphorus loading are likely septic systems, stormwater, park inputs, and internal loading. High levels of phosphorus pollution and frequent CyanoHABs limit the lake from supporting contact recreation (in other words, swimming in the lake). According to local managers, CyanoHABs have occurred in the lake for decades. Part of the watershed is designated as a municipal separate storm sewer system (MS4) area, which means that the municipality is regulated by the NYSDEC and must maintain a stormwater management program to reduce pollutants carried by stormwater.

Decision Makers, Partners, and Stakeholders

The entire Rockland Lake lakeshore is within the park boundaries and is managed by the OPRHP. Approximately half of the watershed area is within park boundaries and, therefore, the OPRHP is one of the primary decision makers for in-lake and watershed management. Any in-lake water treatment might require permitting or consultation with other agencies such as the NYSDEC. Any watershed management actions will require collaboration among multiple decision makers and stakeholders, such as the NYSDEC, the OPRHP, surrounding municipalities, and residents. As a consequence of the waterbody being listed as impaired (New York State Department of Environmental Conservation, 2018), the NYSDEC—as the State regulatory agency for the Clean Water Act—is in the process of developing a total maximum daily load (TMDL) clean water plan for phosphorus. This plan is to be implemented in collaboration with the OPRHP and the surrounding municipalities and stakeholders.

Trigger and Urgency

The Governor's 2018 CyanoHABs initiative (New York State Office of the Governor, 2021) to reduce CyanoHAB effects on New York lakes increased the visibility and support for the OPRHP's broader statewide strategy to manage CyanoHABs in State park waterbodies. Rockland Lake was identified as a case study for exploring the value of structured decision making because it is representative of eutrophic lakes that experience frequent CyanoHABs. The lake is well suited to serve as a test case for a variety of potential treatment options, which could inform management strategies for other lakes across the park system or throughout New York State.

This document contains an initial analysis of options; it is not a final and complete analysis, nor is it a proposed or final implementation plan. This document includes a variety of lake management options that were discussed as part of the structured decision-making process. Not all the strategies identified are feasible, endorsed by NYSDEC, or have a regulatory pathway. Further analysis, as well as consultation with NYSDEC permit administrators, is warranted before management actions are implemented.

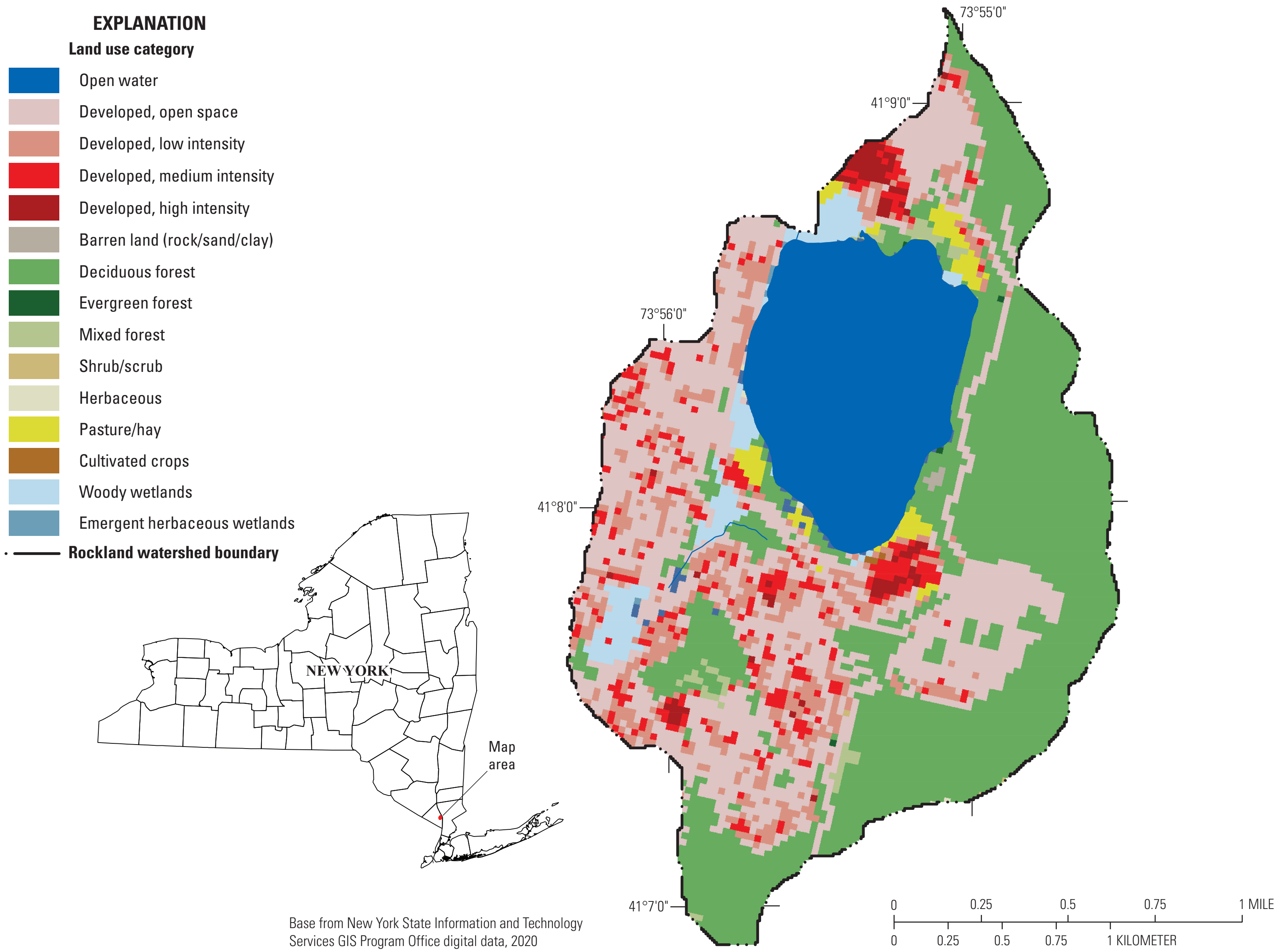
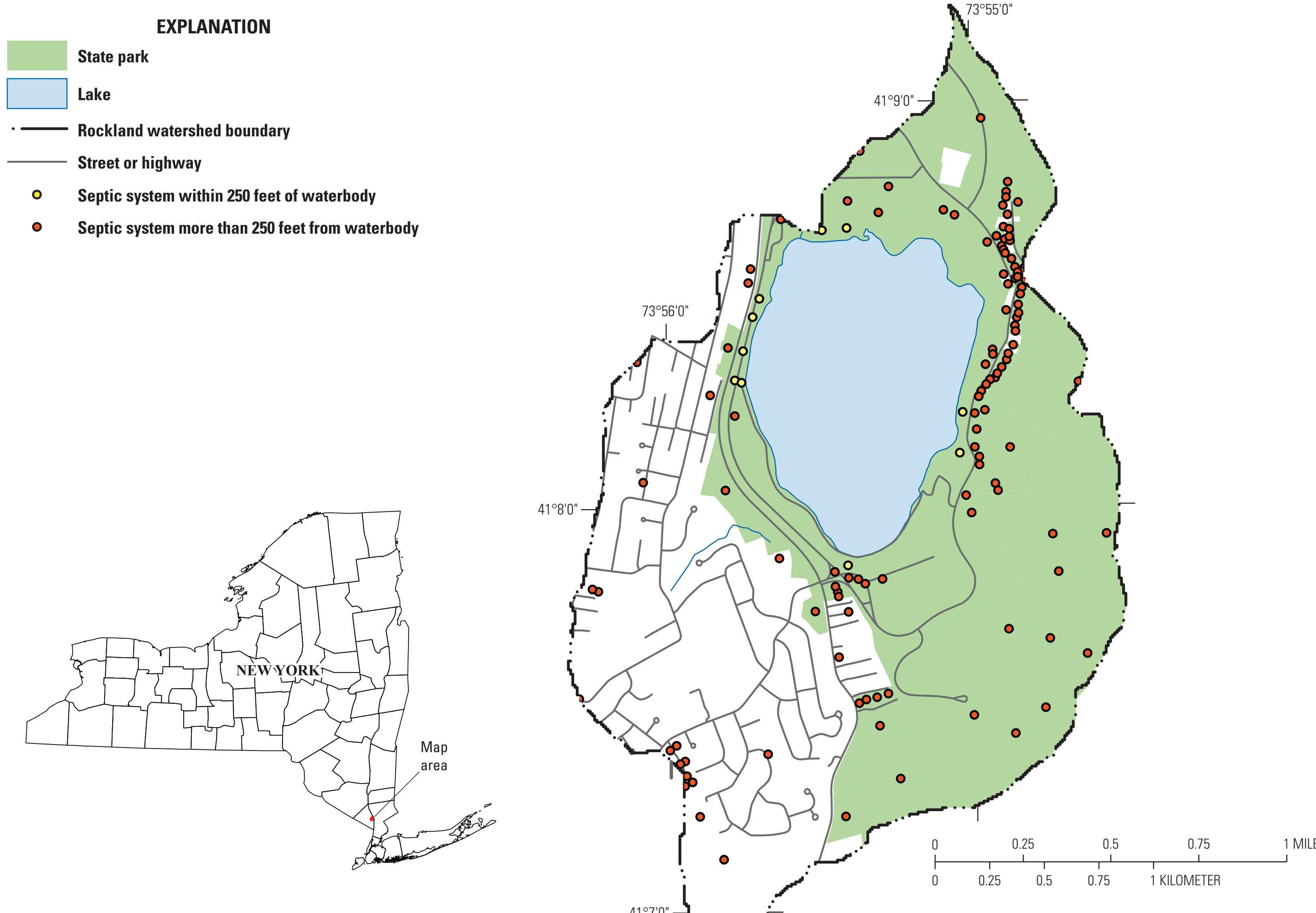


Figure 3.1. Land cover in the Rockland Lake watershed. Land cover from the National Land Cover Database (U.S. Geological Survey, 2016).



Base from New York State Information and Technology Services GIS Program Office digital data, 2020

Septic system centroids from New York State Information and Technology Services GIS Program Office, 2019

Figure 3.2. Landownership and septic systems in the Rockland Lake watershed.

Fundamental Objectives Hierarchy for Management of Cyanobacterial Harmful Algal Blooms at Rockland Lake State Park

A. *Protect safety and health of humans and their pets*
   1. Minimize adverse health effects to humans and pets

B. *Provide safe and enjoyable recreational and interpretive opportunities*
   2. Maximize opportunities for outdoor recreation including:
      a. Fishing
      b. Boating
      c. Bird and wildlife watching
      d. Hiking
      e. Biking
   3. Maximize the aesthetic value of the waterbody
   4. Maximize educational and interpretive opportunities

C. *Protect and restore natural, historical, and cultural resources*
   5. Protect and restore natural resources

D. *Provide ecosystem and economic benefits*
   6. Maximize economic benefit
   7. Maintain water quality for its intended use (class B)

E. *Minimize costs*
   8. Minimize cost

F. *Communication*
   9. Maximize public trust through communication

G. *Learning opportunity*
   10. Promote learning that is valuable to other lakes

Objectives

Rockland Lake State Park offers a diverse set of outdoor recreational opportunities. Many of these recreational opportunities are not directly affected by CyanoHABs. The focus of the park's management objectives for CyanoHABs are on increasing aesthetic value and maximizing recreational opportunities. The fundamental objectives were organized into a hierarchy that reflects the categories of outcomes being sought by the park (see sidebar).

Public health protection is always a priority for the OPRHP and was therefore included as a fundamental objective (objective 1 in sidebar). However, public health risks associated with direct contact with CyanoHABs are considered low in Rockland Lake (see "Evaluation of Consequences"). Rockland Lake State Park provides outdoor recreational opportunities for underserved communities including fishing, boating, biking, and wildlife watching. It is important to the OPRHP that these opportunities are widely available. Maximizing opportunities for recreational activities that may be directly (such as fishing and boating; objectives 2*a*–*b*) or indirectly (such as bird and wildlife watching, hiking, and biking; objectives 2*c*–*e*) affected by CyanoHABs is a high-priority objective. Enjoyment of and participation in these activities may be reduced if CyanoHABs diminish the aesthetic quality of the lake. In addition, some visitors value the opportunity to simply be near the lake, and this experience can be negatively affected by the poor visual and olfactory aesthetics caused by CyanoHABs. Therefore, maximizing the aesthetic quality of the lake is also a fundamental objective (objective 3).

Rockland Lake State Park offers many opportunities for the public to learn about and interact with nature, and educational and interpretive information could be enhanced through revitalization of OPRHP programs and development of partner programs (objective 4). Natural resources conservation is a park priority because of its designation as a bird conservation area (New York State Office of Parks, Recreation and Historic Preservation, 2021; objective 5); Rockland Lake and surrounding wetlands and forests habitats contain habitat for waterfowl, migratory birds, bald eagles, and ospreys. Enhanced opportunities to interact with and learn about nature would also present economic benefits associated with bike and boat rentals and concessions in nearby communities (objective 6). Maintaining the water quality of the lake at levels that promote its intended use (objective 7) is central to maximizing recreational, educational, and economic benefits; aesthetic value; and natural resource conservation.

Three other objectives are important in evaluating management options for CyanoHABs in Rockland Lake. The park would like to minimize the costs of management and treatment (objective 8) to the extent possible. The park would like to continue to build trust with the public, including through effective communication about CyanoHABs in the lake and what is being done to address them (objective 9). Finally, the OPRHP believes that CyanoHABs management at Rockland Lake affords a unique learning opportunity that could inform strategies across the statewide park system (objective 10).

Alternatives

During the workshop, the participants developed four alternative management strategies, using a strategy-table. These four strategies were complex—each contained many elements. To develop these strategies, first, four general categories of management actions to reduce the severity of CyanoHABs and their effects were identified. Second, within each of these categories, individual action elements were described. Finally, the four strategies were developed by selecting combinations of action elements.

Action Elements

The individual management actions (the action elements) that the park could potentially take were grouped into four categories: watershed management; in-lake management; mitigation and communication; and research and monitoring (table 3.1). The completed strategy table represents a menu of action elements that was used to develop alternative management strategies for Rockland Lake. The individual action elements are further described in the following paragraphs.

Because excess nutrients (phosphorus and nitrogen) are considered the primary cause of eutrophication and CyanoHABs, reduction of watershed nutrient loads to lakes is an important long-term management strategy (Brooks and others, 2016). Given the long history of phosphorus enrichment affecting water quality in Rockland Lake, NYSDEC is in the process of developing a TMDL clean water plan. The TMDL Clean Water Plan will provide a complete watershed model and comprehensive strategy for reducing phosphorus pollution in the watershed. Full implementation of the TMDL Clean Water Plan includes (or would include) various pollution-reducing measures and water-quality monitoring to meet water-quality goals. Potential watershed management includes nutrient removal or interception, actions to reduce erosion, installation of green infrastructure to slow storm runoff and allow vegetation and soil to capture excess nutrients, and conservation easements (table 3.1). MS4s are required to implement a stormwater management program to reduce downstream effects of stormwater runoff; public outreach and education is a component of these programs (New York State Department of Environmental Conservation, 2021). There is an MS4 area to the west of the park but within the watershed. Engagement with the MS4 community would leverage existing programs to maximize benefits to watershed and lake health. Septic systems on the east side of the park may be a potential source of nutrients if the septic systems are not properly maintained. Improved maintenance of these septic systems is a potential watershed management option. The implementation of septic pump-out programs has previously been stipulated as a requirement in MS4 permits for watersheds with completed TMDLs.

In-lake treatments can target reductions in either overall nutrient concentrations (thereby reducing nutrients available for algal growth) or algal abundance. A short summary of CyanoHABs control measures that can be considered for New York State is provided in table 1 of Graham and others (2022). Detailed summaries of in-lake management options are available in the literature (for example, Osgood and Gibbons, 2017; Burford and others, 2019) and online (for example, U.S. Environmental Protection Agency, 2020). Options discussed for Rockland Lake are briefly described herein. Given the long history of CyanoHABs at Rockland Lake, OPRHP regional and Albany staff have already implemented experimental nutrient-reduction treatments such as floating wetlands (table 3.1). Floating wetlands were installed in 2017 to remove nutrients via biological uptake and to provide shading to reduce algal growth; water samples are

Table 3.1. Strategy table for developing cyanobacterial harmful algal bloom management alternatives at Rockland Lake State Park, New York.

[Each column represents a category of action elements. Ongoing or planned management actions through 2019 are shown in blue and followed by an asterisk (*)]

Watershed	In-lake	Risk mitigation and communication	Research and monitoring
· In-tributary nutrient filters	· Floating wetlands/light shading*	· Education about eutrophication	· None
· Erosion management	· Aquatic invasive removal*	· Signs and risk education	· Periodic*
· Septic upkeep	· Nutrient deactivation and sediment capping	· Environmental education*	· Extensive monitoring of implementation
· Nutrient interception (detention ponds, sand filters, and so on)	· Ultrasonic treatment	· Alternate swim options (pools)*	
· Green infrastructure (permeable pavement, bioswales, bioretention, downspout disconnection, riparian buffers)	· Algal skimming		
· Conservation easement	· Biomanipulation		
	· Algaecide		
	· Mixing and oxygenation		
	· Nanobubbles		
	· Expanding submerged vegetation		

collected below and adjacent to these floating wetlands to evaluate effects on nutrient cycling. Rockland Lake is affected by *Trapa natans* (water chestnut), an invasive macrophyte. Water chestnut removal was initiated in 2015 and has the added benefit of removing the nutrients contained within the plant biomass. Other future in-lake alternatives potentially include nutrient deactivation and sediment capping, an in-lake treatment to precipitate nutrients out of the water column or seal nutrients within the bottom sediment (making them unavailable for algal growth). Common nutrient inactivants include alum (aluminum sulfate), lanthanum-modified clay, and iron. Another nonchemical option is ultrasonic treatment, which applies 20 kilohertz–1 megahertz sound waves to disrupt cyanobacteria cell walls and gas vacuoles. This method could potentially affect nontarget organisms and requires persistent use. Algal skimming would remove algae, algae-entrained nutrients, and potential algal toxins through physical removal. It would reduce the visible density of scums and improve the aesthetics and water quality effectively; however, the disposal of skimmed material poses a challenge, and this method would be energy, cost, and labor intensive. Lastly, one might consider biomanipulation, which involves the reduction of undesired algae through predation control by augmenting the lake's native fauna. This would target native fauna that can reduce the algal density and shift the lake to a more diverse algal community. Algaecides, such as copper-based formulations or hydrogen peroxide, kill algal cells immediately because of their cellular toxicity. However, the response is short lived. Water-quality restrictions and permitting requirements must also be considered for the application of such algaecides. Expanding native submerged vegetation would increase the amount of nutrients removed by aquatic plants. Nanobubbles are an emerging technology that produces submicrometer-sized bubbles that remain in the water column longer than larger bubbles, increasing oxygenation and potentially disrupting cyanobacterial growth. Mixing and oxygenation reduces the occurrence of bottom-water anoxia. Anoxia occurs frequently in eutrophic systems, negatively affects lake fauna, and results in the release of sediment-bound nutrients.

The first two management categories (watershed management and in-lake management) focus on improving lake water quality. The other two categories (mitigation and communication and research and monitoring) focus on increasing public awareness about and scientific understanding of water-quality concerns at Rockland Lake State Park. Education about eutrophication would increase the visitors' understanding about the eutrophication process and effects and draw connections to management actions being implemented in and around the lake. Signs and risk education at the park ensure that visitors understand the potential risks CyanoHABs pose to visitors as they recreate on or around Rockland Lake and other waterbodies. Rockland Lake State Park already has an Environmental education program; revitalization of this program could include education about CyanoHABs and the management actions being taken at the park. If conventional and experimental management alternatives are implemented, periodic or extensive research and monitoring could be part of the suite of actions employed at Rockland Lake State Park to enhance scientific understanding of the mechanisms that enhance or hinder efficacy.

Alternative Strategies

After the menu of potential actions (table 3.1) was developed, alternative strategies were composed. This step involved selecting specific options from each action category to include as part of an alternative strategy. The following four alternatives were envisioned for Rockland Lake.

Alternative 1.—Current management strategies ("Taking Care of Business") maintains current management actions with a few minor enhancements, such as revitalizing the education program at the park. The park would continue water chestnut removal and use of floating wetlands. Periodic monitoring would assess efficacy of the floating wetlands and overall lake water quality. Central to this alternative would be the ongoing development and planned implementation of a phosphorus TMDL for the lake.

Alternative 2.—In-Lake Treatment ("I Can See Clearly Now") includes all the actions included in alternative 1 plus additional in-lake treatments targeting direct reduction in CyanoHAB occurrence, such as algaecide, nanobubbles, and ultrasonic techniques. Along with in-lake treatments, this alternative would include enhanced monitoring to evaluate treatment efficacy, as well as outreach and education materials focused on the in-lake treatments being used.

Alternative 3.—Nutrient Interception ("Who'll Stop the Rain") emphasizes reducing watershed nutrient inputs. This alternative includes all the actions included in alternative 1, with the addition of several additional strategies of nutrient interception and reduction. In particular, Rockland Lake State Park would conduct a comprehensive assessment of stormwater management practices within park boundaries and then evaluate which stormwater-interception practices—such as rain gardens or swales—would have the greatest effect. The OPRHP would take enhanced action to implement nutrient-reduction strategies beyond what will be included in the TMDL plan.

Alternative 4.—Intensive Management ("We are the Champions") is the most comprehensive strategy. The park would implement multiple, simultaneous, in-lake treatments as well as multiple nutrient-interception approaches within the park and engage community stakeholders to extend these approaches beyond park boundaries. This alternative would turn Rockland Lake State Park into a demonstration site for CyanoHABs management, research, and outreach and education; there would be substantial investment in these activities in addition to direct management actions.

Analysis of Consequences

The four alternatives range from a low-cost maintain current actions strategy that includes existing in-lake management actions and the development and implementation of the TMDL clean water plan according to the existing timeline (alternative 1) to an expensive, intensive combination of strategies, which would result in unique research and educational opportunities at Rockland Lake State Park (alternative 4).

Regarding the performance of the alternative strategies with regard to the first objective (safety and health of humans and pets), Rockland Lake State Park offers swimming opportunities at a public pool, rather than in the lake, so exposure to CyanoHABs through primary contact recreation (recreational activities, such as swimming, that are likely to result in immersion) is unlikely. Pets are prohibited in the park from May through September, the time when CyanoHABs are most likely to occur. During the cooler months, when pets are allowed, exposure risk is low because CyanoHABs are less prevalent. None of the alternative strategies change these elements, so they do not differ with regard to the first objective.

The four alternative strategies were evaluated against the remaining objectives by using constructed scales, which scored the expected performance of each alternative as low, medium, or high for each objective. The analysis of consequences was undertaken by using the consensus best professional judgement of the participants at the workshop and is summarized in table 3.2. Because primary contact recreation is not supported within Rockland Lake State Park, and because pets are prohibited during summer months, public health risks associated with direct contact with CyanoHABs are considered low. Therefore, current park practices already minimize health risks to humans and pets (objective 1 in sidebar), and this objective was not included in the analysis of consequences. For simplicity of the consequence analysis, educational and interpretive (objective 4) and communication (objective 9) opportunities were combined, and ecosystem health (objective 5) and water quality (objective 7) were combined.

All four alternatives were designed to improve ecosystem health and water quality (objectives 5 and 7 in sidebar) and offer opportunities for outreach, education, and communication (objectives 4 and 9) about water quality and CyanoHABs. Therefore, all alternatives had medium to high potential to maximize outcomes. Except for the low-cost, current management strategies alternative, all strategies would enhance recreational opportunities (objective 2) and increase economic benefits (objective 6). Alternatives 2–4 would likely result in increased aesthetic value (objective 3) relative to alternative 1 because of overall improvements in water quality; however, alternative 4 would likely result in some tradeoffs with respect to aesthetics because the additional monitoring and research would require instrumentation and measuring platforms visible from shore. Alternatives 2–4 would increase economic benefits (objective 6) in the park and nearby communities relative to alternative 1. Opportunities for learning through research and monitoring (objective 10) were highest for alternative 4, although alternatives 2 and 3 increased opportunities for learning relative to alternative 1. The least costly (objective 8) alternative was to maintain the current management strategies (alternative 1), and the costliest alternative was intensive management (alternative 4). The intensive management alternative would only be feasible with substantial external support.

Critical Uncertainty

Few uncertainties were identified that would impede decision making. The most important uncertainty was the missing cost estimates associated with the various management actions.

Table 3.2. Consequence analysis of the four alternatives developed for cyanobacterial harmful algal bloom management in Rockland Lake State Park, New York.

[The table shows the expected performance of each alternative for each fundamental objective (see sidebar). Green shading indicates the alternative that performs best for a particular objective, and pink shading indicates the alternative that performs the worst for a particular objective. The desired direction is indicated under each objective as either maximixing or minimizing outcomes. * indicates substantial external support is required]

Alternative	Objective 2: recreational opportunities	Objective 3: aesthetics	Objectives 4 and 9: outreach	Objectives 5 and 7: ecosystem	Objective 6: economic benefits	Objective 8: cost	Objective 10: monitor and learning
Desired direction	*Maximize*	*Maximize*	*Maximize*	*Maximize*	*Maximize*	*Minimize*	*Maximize*
1: Current management strategies	Low	Low	Medium	Medium	Low	Low	Low
2: In-lake treatment	High	High	Medium	Medium/high	High	High	Medium
3: Nutrient interception	Medium	Medium	High	High	Medium	Medium	Medium
4: Intensive management	Medium/high	Medium	High	Medium/high	Medium/high	High*	High

Tradeoffs

When weighing the tradeoffs and selecting the preferred strategy to implement, there are typically two types of challenges: first, multiple objectives to weigh and consider; and second, critical uncertainty that impedes the choice of a preferred strategy.

During the tradeoff analysis, participants concluded that implementing alternative 1 would have a low benefit for most of the objectives (table 3.2). If minimizing cost were the most important objective, alternative 1 would be the preferred alternative. The experts at the workshop estimated that alternatives 2 and 3 would perform best on three objectives each; thus, which to select ultimately depends on how decision makers weigh these objectives. Alternative 3, which focuses on intercepting nutrients before they enter the lake, would maximize education opportunities and improve ecosystem quality. In contrast, alternative 2, which focuses on in-lake treatment approaches to reduce algal biomass, would maximize benefits for recreational opportunities, the aesthetics of the lake, and economic benefits. Thus, before selecting an alternative, decision makers would need to assess the tradeoffs among these competing objectives.

The preferred management strategy will depend on how the multiple, competing objectives are weighed. At this stage of the analysis, choosing a management strategy was not possible for several reasons. First, additional detail is needed to craft a more careful consequence analysis. Some objectives will need improved performance measures and a refined scale for scoring the different alternative strategies. Additionally, the individual actions included in each alternative need to be described in greater detail. Furthermore, to improve the tradeoff analysis, cost estimates associated with implementation and an understanding of when implementation would yield benefits are needed.

A formal decision-analytical process to elicit weights for the fundamental objectives was not undertaken during the workshop, in part because of the limitations of the consequence analysis noted previously and because not all the relevant decision makers were present. A structured process to elucidate and navigate these perspectives may be needed.

Implementation Questions

Several challenges and questions that need to be addressed before moving forward with selection and implementation of a management strategy were identified:

- What is the cost of implementation? The alternative strategies all have associated costs. Cost estimates and draft budgets for each action would need to be prepared to more carefully assess each alternative.

- What is the budget for implementation? Implementation of current management strategies is focused on low-cost budget items. More intensive actions would likely have higher cost and require additional funding be sought. Are there outside sources of funding? Some of the actions included in alternative 4 would require research funding and partnerships that take time to establish.

- How are visitors linked to economic benefits? It was assumed that additional visitations would increase economic benefits, but the participants recognized a need to look more closely at this assumption. Supporting evidence would be helpful during the tradeoff analysis.

- Are additional recreational opportunities beneficial to the park and surrounding areas? Because Rockland Lake State Park attracts many visitors in the summer, the State park swimming pool can exceed capacity by 10 a.m. during the busiest days and require turning visitors away. Thus, the question was raised about how to maximize visitors' experience and opportunities given the park's capacity.

- Can we develop better metrics for assessing the consequences of these alternatives? For this workshop, constructed scales were used for the tradeoff analysis. It was recognized that developing better performance measures would improve the ability to assess the consequences, evaluate tradeoffs, and select the best alternative strategy.

Next Steps

This structured decision-making analysis for CyanoHABs at Rockland Lake State Park was developed by OPRHP regional and Albany office staff during a workshop with several partners in February 2020. During the workshop, potential management opportunities at Rockland Lake State Park were identified. Participants concluded that additional information is required before the best management alternative for Rockland Lake State Park can be selected. A more careful assessment of fundamental objectives and more detailed cost assessments for each of the management alternatives are necessary to make an informed decision. The immediate next steps for ORPHP staff are to reevaluate the alternatives on the basis of additional information—especially better cost estimates of the alternatives—and work with decision makers to identify the preferred alternative for Rockland Lake State Park.

References Cited

Brooks, B.W., Lazorchak, J.M., Howard, M.D.A., Johnson, M.V.V., Morton, S.L., Perkins, D.A.K., Reavie, E.D., Scott, G.I., Smith, S.A., and Steevens, J.A., 2016, Are harmful algal blooms becoming the greatest inland water quality threat to public health and aquatic ecosystems?: Environmental Toxicology and Chemistry, v. 35, no. 1, p. 6–13, accessed May 3, 2021, at https://doi.org/10.1002/etc.3220.

Burford, M.A., Gobler, C.J., Hamilton, D.P., Visser, P.M., Lurling, M., and Codd, G.A., 2019, Solutions for managing cyanobacterial blooms—A scientific summary for policy makers: Intergovernmental Oceanographic Commission, and United Nations Educational, Scientific and Cultural Organization (IOC/UNESCO), report no. IOC/INF–1382, 16 p., accessed April 25, 2021, at https://unesdoc.unesco.org/ark:/48223/pf0000372221.locale=en.

Graham, J.L., Cebada Mora, G.M., Gorney, R.M., Ball, L.C., Mengelt, C., and Runge, M.C., 2022, A structured decision-making framework for managing cyanobacterial harmful algal blooms in New York State Parks: U.S. Geological Survey Scientific Investigations Report 2022–5053, 22 p., 3 app., https://doi.org/10.3133/sir20225053.

New York State Department of Environmental Conservation, [NYSDEC], 2018, 2018 Clean Water Act section 303(d) list: New York State Department of Environmental Conservation web page, accessed September 10, 2020, at https://www.dec.ny.gov/chemical/110222.html.

New York State Department of Environmental Conservation, [NYSDEC], 2008, Lake condition inventory [LCI] lake water quality summary for Rockland Lake: New York State Department of Environmental Conservation web page, accessed September 10, 2020, at https://www.dec.ny.gov/docs/water_pdf/lcirpt08rocklandl.pdf.

New York State Department of Environmental Conservation, [NYSDEC], 2021, Stormwater MS4 permit and forms: New York State Department of Environmental Conservation web page, accessed July 8, 2021, at https://www.dec.ny.gov/chemical/43150.html.

New York State Department of State, 2021a, Class B fresh surface waters, section 7 *of* Fresh surface waters: Codes, Rules and Regulations of the State of New York, title 6, chapter X, subchapter A, article 2, part 701 *of* the official compilation of codes, rules and regulations of the State of New York: Thomson Reuters Westlaw web page, accessed May 3, 2021, at https://govt.westlaw.com/nycrr/Document/I4ed819becd1711dda432a117e6e0f345?viewType=FullText&originationContext=documenttoc&transitionType=CategoryPageItem&contextData=(sc.Default).

New York State Department of State, 2021b, Table I, section 6 *of* Hackensack River-Saddle River and Greenwood Lake-Sterling Lake drainage basins: Codes, Rules and Regulations of the State of New York, title 6, chapter X, subchapter B, article 10, part 865 *of* the official compilation of codes, rules and regulations of the State of New York: Thomson Reuters Westlaw web page, accessed May 3, 2021, at https://govt.westlaw.com/nycrr/Document/I4eded09fcd1711dda432a117e6e0f345?viewType=FullText&originationContext=documenttoc&transitionType=CategoryPageItem&contextData=(sc.Default).

New York State Office of Parks, Recreation and Historic Preservation, 2021, Bird conservation areas: New York State Office of Parks, Recreation and Historic Preservation website, accessed July 8, 2021, at https://www.parks.ny.gov/environment/bird-conservation-areas.aspx.

New York State Office of the Governor, 2021, Governor Cuomo unveils 12th proposal of 2018 state of the State—Protecting New York's lakes from harmful algal blooms: Governor of New York State official website, accessed July 7, 2021, at https://www.governor.ny.gov/news/governor-cuomo-unveils-12th-proposal-2018-state-state-protecting-new-yorks-lakes-harmful-algal#_blank.

Osgood, D., and Gibbons, H., 2017, Lake management best practices—Managing algae problems: Raleigh, N.C., Lulu Press, Inc., 60 p.

U.S. Environmental Protection Agency, 2020, Cyanobacterial harmful algal blooms (CyanoHABs) in water bodies: U.S. Environmental Protection Agency web page, accessed August 26, 2020, at https://www.epa.gov/cyanoHABs.

U.S. Geological Survey, 2016, National land cover database for the continental United States (CONUS): U.S. Geological Survey database, accessed May 3, 2021 at https://www.mrlc.gov/data/nlcd-2016-land-cover-conus.

For more information about this report, contact:
Director, New York Water Science Center
U.S. Geological Survey
425 Jordan Road
Troy, NY 12180–8349
dc_ny@usgs.gov
(518) 285–5602
or visit our website at
https://www.usgs.gov/centers/new-york-water-science-center

Publishing support provided by the
Pembroke Publishing Service Center

Mengelt and others—**A Structured Decision Analysis for Managing CyanoHABs at Rockland Lake State Park, New York**—SIR 2022–5053, Appendix 3

ISSN 2328-0328 (online)
https://doi.org/10.3133/sir20225053