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WORKING PAPER

# VOLUMETRIC WATER BENEFIT ACCOUNTING (VWBA): A METHOD FOR IMPLEMENTING AND VALUING WATER STEWARDSHIP ACTIVITIES

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## EXECUTIVE SUMMARY

### Highlights


- Volumetric water benefits (VWBs) are the volume of water resulting from water stewardship activities, relative to a unit of time, that modify the hydrology in a beneficial way and/or help reduce shared water challenges, improve water stewardship outcomes, and meet the targets of Sustainable Development Goal 6.
- Volumetric water benefit accounting (VWBA) provides corporate water stewardship practitioners with a standardized approach and set of indicators to quantify and communicate the volumetric water benefits, complementary indicators to measure nonvolumetric outputs, and elements of effective water stewardship activities that increase the likelihood of generating social, economic, and environmental benefits and solving shared water challenges.
- The method we propose includes recommended indicators and calculation methods for each water stewardship activity, communication guidelines, and a three-step process for implementation: (1) identify shared water challenges and understand local context; (2) define water stewardship project activities and partners; and (3) gather data and calculate volumetric water benefits.
- The limitations of VWBA include the lack of calculation methods for sanitation and hygiene, agrochemical management, and in-stream channel rehabilitation activities, as well as the need for additional assurance to guarantee the associated social, economic, and environmental benefits.


## CONTENTS



*Working Papers contain preliminary research, analysis, findings, and recommendations. They are circulated to stimulate timely discussion and critical feedback, and to influence ongoing debate on emerging issues. Working papers may eventually be published in another form and their content may be revised.*

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- The methods proposed can be enhanced with lessons learned from pilot testing; monitoring, data collection, and analysis to strengthen hydrological models and validate assumptions; and guidance to link water stewardship activity outputs to social, economic, and environmental outcomes and impacts.

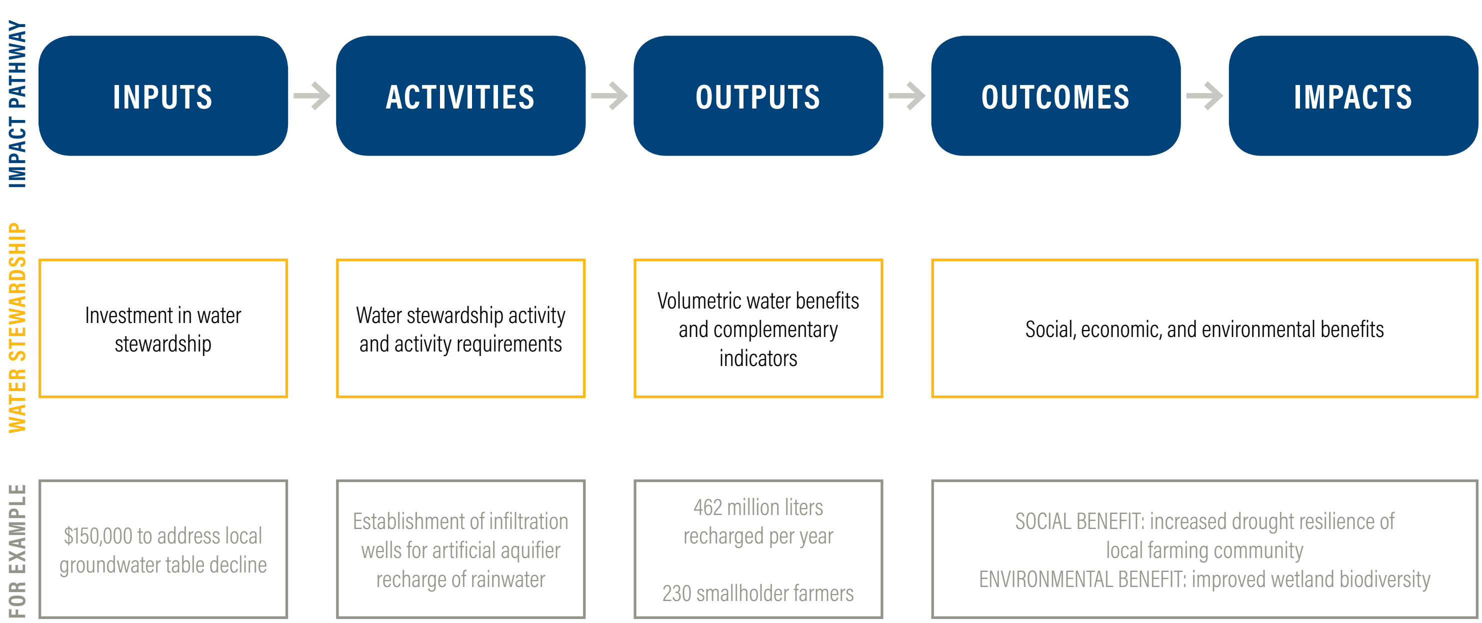
**The shared nature of water challenges is driving companies to commit billions of dollars to alleviating exposure to water risk and to balancing a volume of water equal to what they use,** through investments in watersheds and communities outside factory walls. Methods exist to estimate net benefits of these investments, but the growing demand from companies calls for a common and unified method that drives investments to address shared water challenges and contribute to public policy priorities.

**Volumetric water benefit accounting (VWBA) provides corporate water stewardship practitioners with a standardized approach and set of indicators to estimate and communicate the volumetric water benefits of water stewardship activities**. Prior to using the methods proposed, companies will require a deep understanding of their water use and exposure to risk and catchment conditions, as well as clear and well-defined corporate water stewardship goals and targets.

**Volumetric water benefits (VWBs) are the volume of water resulting from water stewardship activities, relative to a unit of time, that modify the hydrology in a beneficial way and/or contribute toward reducing shared water challenges (Figure ES-1).** Because providing a volume of water alone does not guarantee that shared water challenges are reduced, users of VWBA should also use elements of effective water stewardship activities that increase the likelihood of generating social, economic, and environmental benefits and solving shared water challenges in the catchment, and complementary indicators to measure nonvolumetric outputs of investments.

**VWBA helps calculate and communicate volumetric water benefits of activities that contribute to meeting water stewardship outcomes and SDG targets and help solve shared water challenges (Table ES-1), following a three-step method (Figure ES-2).**

Figure ES-1 | **Water Stewardship Activity Impact Pathway Modified from the Social and Human Capital Protocol**



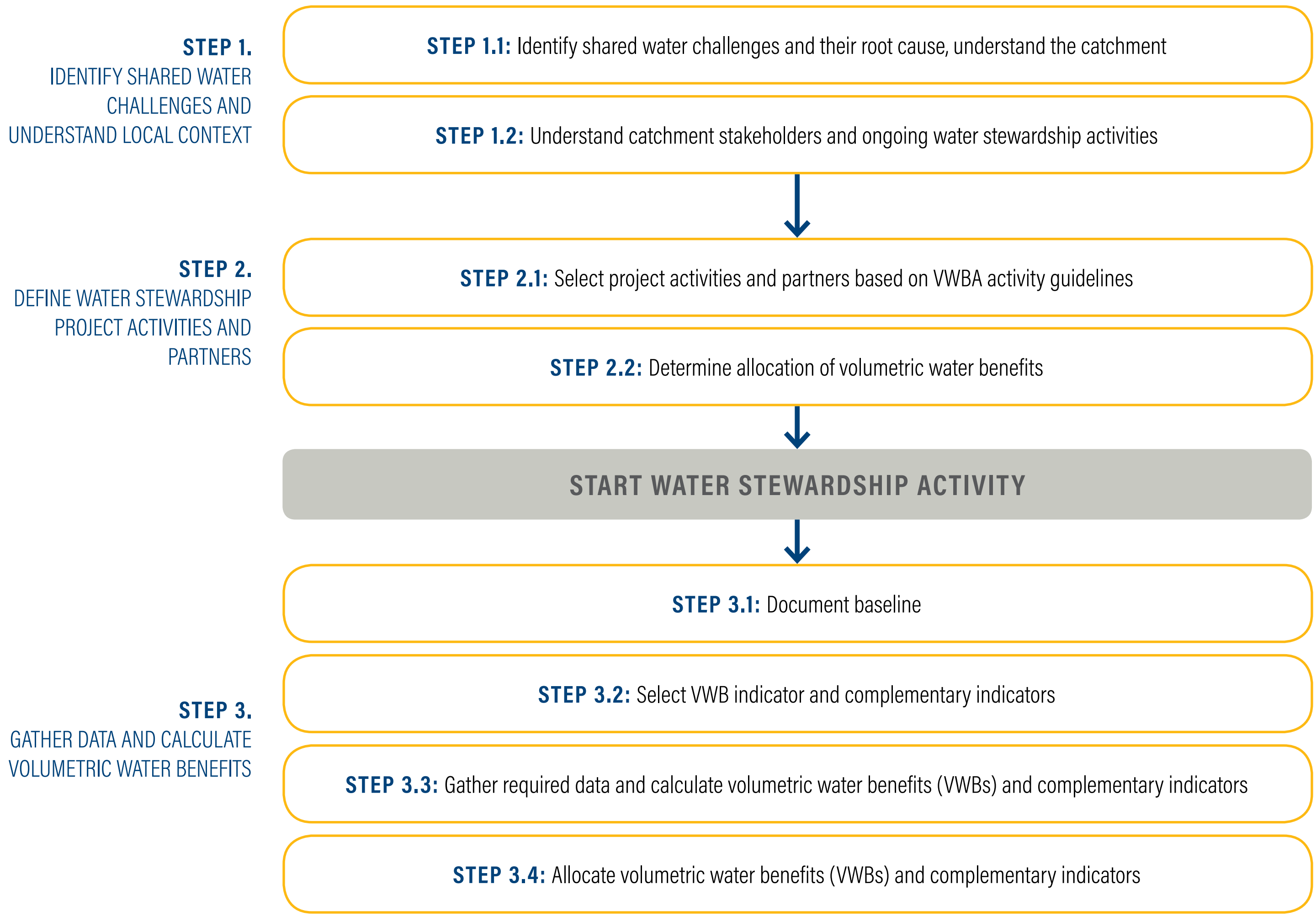

*Source:* Based on information from WBCSD (2019), modified by WRI, Valuing Nature, LimnoTech, and Quantis.

Table ES-1 | **Contributions to Water Stewardship Outcomes, Shared Water Challenges, and SDG Targets per Water Stewardship Activity Category**

| | **Water Stewardship Outcomes[a]** | **(1) Sustainable Water Balance** | **(2) Good Water Quality Status** | **(3) Good Water Governance** | **(4) Important Water-Related Areas (IWRAs)** | **(5) Safe Water, Sanitation, and Hygiene for All (WASH)** | **N/A** |
|---|---|---|---|---|---|---|---|
| | **Shared Water Challenge** | **Water quantity** | **Water quality** | **Water governance** | **Important water-related ecosystems** | **Water, sanitation, and hygiene (WASH)** | **Extreme weather events** |
| | **SDG Target(s)[b]** | **6.1, 6.4** | **6.2, 6.3** | **6.5, 6A, 6B** | **6.6., 13** | **6.1, 6.2** | **11.5, 13.1** |
| **WS ACTIVITY CATEGORY** | Land conservation and restoration | ✓ | ✓ | | ✓ | | ✓ |
| | Water supply reliability | ✓ | | ✓ | | | ✓ |
| | Water access | ✓ | ✓ | ✓ | | ✓ | |
| | Water quality | | ✓ | | ✓ | ✓ | ✓ |
| | Aquatic habitat restoration | ✓ | ✓ | | ✓ | | |
| | Water governance | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | Catalytic activities | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

*Sources:* WRI, Valuing Nature, LimnoTech, and Quantis.
*Notes*: Categories as defined in the VWBA water stewardship activity classification.
[a] AWS (2019).
[b] UN (2015).

Figure ES-2 | **VWBA Method to Calculate and Communicate WS Activity Volumetric Water Benefits**




*Sources:* WRI, Valuing Nature, LimnoTech, and Quantis.

**Recommended indicators and calculation methods are provided for each type of water stewardship activity (Table ES-2).** Recognizing the wide range of water stewardship activities and indicators available, practitioners may also take the following steps:

- Apply the calculation methods for other water stewardship activities.
- Select other indicators when credible and well-documented methods are available.
- Use simpler estimates, for example, during early-stage project evaluation and cost-benefit analysis.
- Use more detailed, robust, and complex estimates or measurements, for example to report progress, communicate publicly, and make claims associated with an organization's water stewardship activities.

**By using the method described in this working paper, organizations can communicate and make claims for the volumetric water benefits of all investments in water stewardship**. Companies can also use the method discussed in this working paper to track and communicate progress toward enterprise goals and/or targets, such as replenish, water balance, or contextual water goals, aggregating VWB across activities measured with the same indicators and clearly stating the geographic origin of the VWB provided.

**The VWBA method proposed has been developed through extensive stakeholder engagement, and trade-offs were made to ensure applicability and uptake by practitioners.** For example, estimating VWBs alone cannot provide assurance that shared water challenges are reduced and social, economic, and

Table ES-2 | **Recommended VWB Indicator Calculation Methods for the Most Commonly Implemented Water Stewardship Activities**

| CATEGORY | ACTIVITY | VWB INDICATOR | CALCULATION METHODS | APPENDIX |
|---|---|---|---|---|
| **Land conservation and restoration** | Land conservation | Avoided runoff | Curve number method | A-1 |
| | Land cover restoration | Reduced runoff | | |
| **Water supply reliability** | Agricultural water demand reduction measures | Reduced withdrawal or reduced consumption | Withdrawal method or consumption method | A-2 |
| | Operational efficiency measures | Reduced withdrawal | Withdrawal method | |
| | Leak repair | | | |
| | Consumer use efficiency measures | | | |
| | Water reuse | | | |
| | New water supply for crop irrigation | Volume provided | Volume provided method | A-3 |
| | Rainwater harvesting | Increased recharge | Capture and infiltration method | A-4 |
| **Water access** | Access to drinking water supply | Volume provided | Volume provided method | A-3 |
| **Water quality** | Agricultural best management practices (BMPs) related to conservation tillage, laser leveling, and cover crops | Reduced runoff | Curve number method | A-1 |
| | Stormwater management | Volume captured | Runoff reduction method | A-5 |
| | Constructed wetland treatment systems | Volume treated | Volume treated method | A-6 |
| | Wastewater treatment plants | | | |
| **Aquatic habitat restoration** | Wetland protection | Maintained recharge | Recharge method | A-7 |
| | Wetland restoration and creation | Increased recharge | | |
| | Legal transactions to keep water in-stream | Reduced withdrawal | Withdrawal method | A-2 |
| | In-stream barrier removal | Improved flow regime | Hydrograph method | A-8 |
| | Dam reoperation | | | |
| | Floodplain inundation/reestablish hydrologic connection | Varies based on objectives | See Appendix A-7 | A-7 |
| **Water governance** | Direct engagement in water governance and public water management | Same as the water stewardship activities they support | | A-9 |
| **Catalytic activities** | Activities that pave the way for longer-term water stewardship outcomes | Same as the water stewardship activities they support | | A-10 |

*Sources:* WRI, Valuing Nature, LimnoTech, and Quantis.

environmental benefits are provided. Solving shared water challenges requires the maintenance of hydrology improvements over time. Therefore, unless additional assurance is provided, delivering volumetric water benefits does not guarantee that the activity will result in the associated social, economic, and environmental benefits. Additionally, sanitation and hygiene, agricultural best management practices related to agrochemical management, and in-stream channel rehabilitation activities are excluded because they do not yield volumes of water that modify the hydrology and therefore cannot be quantified using the methods we describe.

**Moving forward, there are opportunities to improve and enhance VWBA.** This can be achieved, for example, by incorporating activities currently excluded or building a web-based tool to facilitate large-scale adoption. VWBA can also be enhanced with lessons learned from piloting the methods, monitoring, data collection, and analysis to strengthen hydrological models and validate assumptions, and developing guidance to link water stewardship activity outputs to social, economic, and environmental outcomes and impacts.

## ABBREVIATIONS

| | |
|---|---|
| **AWS** | Alliance for Water Stewardship |
| **BEF** | Bonneville Environmental Foundation |
| **BIER** | Beverage Industry Environmental Roundtable |
| **BMP** | best management practices |
| **cfs** | cubic feet per second |
| **FAO** | Food and Agriculture Organization |
| **GRI** | Global Reporting Initiative |
| **ha** | hectare |
| **HEC-RAS** | Hydrologic Engineering Center's River Analysis System |
| **ISO** | International Organization for Standardization |
| **IUCN** | International Union for Conservation of Nature |
| **LCA** | life-cycle assessment |
| **MCL** | maximum contaminant level |
| **ML** | megaliter |
| **mg** | milligram |
| **N** | nitrogen |
| **NGO** | nongovernmental organization |
| **SDG** | Sustainable Development Goal |
| **SWMM** | Stormwater Management Model |
| **TNC** | The Nature Conservancy |
| **UNEP** | United Nations Environment Programme |
| **UNICEF** | United Nations International Children's Emergency Fund |
| **US EPA** | United States Environmental Protection Agency |
| **VWB** | volumetric water benefit |
| **VWBA** | volumetric water benefit accounting |
| **WASH** | water access, sanitation, and hygiene |
| **WBCSD** | World Business Council on Sustainable Development |
| **WHO** | World Health Organization |
| **WRC** | Water Restoration Certificates |
| **WRI** | World Resources Institute |
| **WS** | water stewardship |
| **WWF** | World Wildlife Fund |

# INTRODUCTION

## Background

Water is increasingly reported as a financially material risk to organizations in both the private and public sectors (World Economic Forum 2019), and the shared nature of water challenges will require solutions at the catchment scale if these are to meaningfully reduce risk (Pegram et al. 2009). By addressing shared water challenges within a catchment, organizations across sectors can contribute to improving catchment conditions while lessening their exposure to physical, regulatory, and reputational water-related risks.

Water stewardship (WS) helps reduce water-related risks by providing companies with a roadmap to engage in sustainable water management and support public policy objectives that advance water security and reduce shared water challenges (Box 1).

Box 1 | **Water Stewardship Definition and Potential Business Benefits**

Water stewardship is water use that is socially and culturally equitable, environmentally sustainable, and economically beneficial, achieved through a stakeholder-inclusive process that involves site- and catchment-based actions.

Water stewardship is not just about helping the world; it's also about making businesses stronger and more resilient. By implementing water stewardship practices, companies can take advantage of the following opportunities to

- understand and manage water-related risks to the business;
- reduce operational costs;
- seize new business opportunities and markets;
- ensure social license to operate; and
- boost productivity and talent recruitment.

*Sources:* Based on information from AWS (2019) and CEO Water Mandate (2018), aggregated by WRI, Valuing Nature, LimnoTech, and Quantis.

There are existing tools to help companies and other organizations, such as nongovernmental organizations (NGOs), investors, and development banks, evaluate water risk by screening for shared challenges where they operate and source from (WRI 2019; WWF 2019), measuring their dependency on water (Hoekstra et al. 2011; International Standard ISO 14046 2014), and evaluating their water-risk management (Ceres 2011).

By using these tools, companies have started to commit billions of dollars to addressing shared water challenges (Box 2). In 2017 alone, companies reporting to CDP Water committed US$23.4 billion across more than 1,000 projects to tackle water risks in 91 countries worldwide (CDP 2017). Furthermore, companies are increasingly making public commitments to balance their water use through watersheds and community investments outside the plant walls (Bass and Larson 2016) (Box 3).

Box 2 | **Examples of Projects Implemented to Tackle Water Risk**

**Alcoa** invested US$115 million in its Australian operations for a filtration system that reduces freshwater use by 317 million gallons annually, simultaneously decreasing discharge.

**ITC Limited** has invested nearly $9 million in water interventions across India, constructing over 10,000 rainwater harvesting units and using demonstration farms to share best practices in efficient irrigation and soil conservation.

**U.S. National Fish and Wildlife Foundation** has provided $18 million in grants for over 800 projects in 50 U.S. states through the Five Star and Urban Waters Restoration Program to address water quality issues in priority catchments.

*Sources:* Based on information from CDP (2017) and U.S. National Fish and Wildlife Foundation (2018) aggregated by WRI, Valuing Nature, LimnoTech, and Quantis.

Box 3 | **Examples of Water Balance Commitments**

- **The Coca-Cola Company,** in 2007, set an aspirational goal to safely return to communities and nature an amount of water equivalent to what is used in its beverages and production by 2020.
- **Diageo plc,** in 2014, committed to replenishing water-stressed areas with the equivalent amount of water used in its final products by 2020.
- **Keurig Green Mountain, Inc.,** in 2016, set a 2020 target to balance the water used in the 2020 brewed beverage volume of all its beverages.
- **PepsiCo Inc.**, in 2016, set a goal to replenish 100 percent of the water it consumes in manufacturing operations located in high water-risk areas by 2025 and to ensure that such replenishment takes place in the same catchment where the extraction has occurred.
- **Cummins**, in 2017, set a goal to offset its water uses by 2020, at 15 manufacturing sites where water is in short supply, through conservation and with community improvements that either conserve or make new water sources available.
- **Intel Corporation**, in 2017, announced a commitment to restore 100 percent of its water use by 2025.
- **Heineken N.V.**, in 2019, set a 2030 goal to balance the water it takes from the local catchment through water stewardship projects that compensate for the volume it does not return at the end of its processes.

*Sources:* Based on information from the Coca-Cola Company (2018), Cummins (2018), Diageo (2019), Heineken (2019), Intel (2017), Keurig Green Mountain (2019), and PepsiCo (2019), aggregated by WRI, Valuing Nature, LimnoTech, and Quantis.

Methods to estimate the benefits of water stewardship projects (Rozza et al. 2013; Wright 2009; Gold Standard 2016) have been applied by corporate water stewardship practitioners to hundreds of projects around the world. However, increasing corporate commitments to water balance and water stewardship targets more broadly call for a common and unified method that is in line with new stakeholder expectations for how to estimate the benefits of WS activities, including the need to

- select activities that address current or projected shared water challenges;
- assess the benefit of all types of activities in a consistent way; and
- ensure that activities contribute to public policy priorities and existing WS initiatives when relevant.

Such an approach can allow companies to select activities that address water risks, advance public policy objectives, and help meet the Sustainable Development Goal for water (SDG6) in the catchments where they operate and from which they source their water.

## Objective

In response, this working paper aims to standardize an approach and set of indicators that complement existing approaches by providing a robust and consistent way to estimate and communicate volumetric water benefits of WS activities.

Given the varying terminology used to describe the volumetric water benefits of WS activities (Bass and Larson 2016), this working paper also recommends new terminology that complements existing approaches and reflects stakeholder input and practitioner experience.

The proposed approach is called volumetric water benefit accounting (VWBA) and is designed to complement existing WS tools and resources (Table 1) and help companies and other stakeholders with two principal tasks:

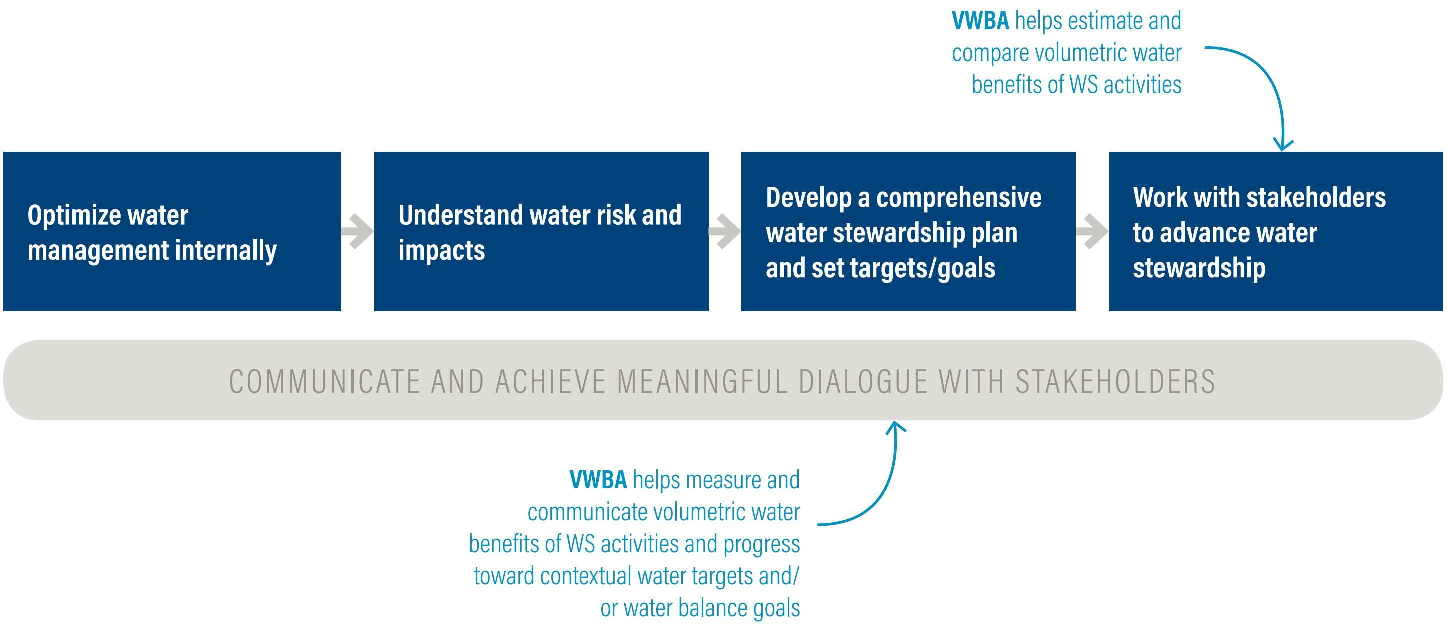
- Estimation and comparison of potential volumetric water benefits of different planned WS activities within a catchment, to help inform decision-making prior to activities taking place.
- Estimation and communication of the volumetric water benefit of ongoing or completed WS activities, to track progress toward activity objectives, as well as toward site or enterprise volumetric (Bass and Larson 2016) and contextual water targets (CDP et al. 2017).

Table 1 | **Complementarity of VWBA and Existing Corporate Water Stewardship Resources and Tools**

| CORPORATE WATER STEWARDSHIP RESOURCES AND TOOLS | | COMPLEMENTARITY OF VWBA |
|---|---|---|
| CATEGORY | EXAMPLE | |
| Global water risk assessment tools | WRI Aqueduct<br>WWF Water Risk Filter<br>Water Risk Monetizer | VWBA helps identify activities that respond to water risks and estimate the contribution of each activity to solving specific shared water challenges within the catchment. |
| Impact valuation | Natural Capital Protocol<br>Social and Human Capital Protocol | VWBA helps estimate WS activity volumetric outputs that can be used to inform outcome, impact, and dependency valuation. |
| Site- and project-level water stewardship certifications | AWS<br>Gold Standard<br>BEF's Water Restoration Certificates® (WRCs) | VWBA helps track WS activities in a consistent way, to monitor progress, and enables stakeholders to understand an organization's commitment and contribution to WS. |
| Water target setting | Contextual water targets | VWBA provides a method and indicators to track progress toward a desired end state, target, or goal. |
| Water reporting and disclosure standards | CDP Water<br>GRI303<br>SASB | VWBA provides a consistent approach to report volumetric water benefits and progress toward a desired end state, target, or goal. |

*Sources:* WRI, Valuing Nature, LimnoTech, and Quantis.

Figure 1 | **Volumetric Water Benefit Accounting in the Corporate Water Stewardship Journey**




*Source:* Based on information from CEO Water Mandate (2018) modified by WRI, Valuing Nature, LimnoTech, and Quantis.

## Volumetric Water Benefit Accounting and Corporate Water Stewardship

VWBA does not replace the need for companies to measure, understand, and address water-related risks and impacts; improve water use efficiency and stormwater and wastewater management; pursue water opportunities; engage in collective action; or advance public water policy objectives across their value chain.

Furthermore, because solving shared water challenges may call for activities that do not yield a volumetric benefit and requires that improvements in hydrology be maintained over time, delivering volumetric water benefits alone cannot reduce business risks or guarantee social, economic, and environmental benefits.

Because of this, companies will require a deep understanding of their water use and exposure to risk and catchment conditions, as well as clear and well-defined corporate water stewardship goals and targets, prior to using the method we propose.

Therefore, VWBA should be used only to estimate and compare volumetric water benefits of proposed WS activities and help measure and communicate progress of ongoing activities, as part of an organization's water stewardship strategy, goals, and targets (Figure 1).

## Target Audience

The primary audience of this working paper includes corporate water stewardship practitioners involved in the implementation and/or valuation of WS activities. Specifically, this working paper will be most useful for companies interested in responding proactively to shared water challenges, companies that are implementing, or considering investing in, WS activities and would like to estimate the activities' potential or actual benefits (Box 4).

The secondary audience includes professionals directly or indirectly involved in WS activities, such as those working in NGOs, government agencies, development banks, or local community and river basin associations.

### Guiding criteria

Based on the objective and audience, VWBA has been developed following three guiding criteria:

- VWBA should be applicable within the context of corporate decision-making and was therefore developed in close consultation with key stakeholder groups across businesses, NGOs, reporting programs, government agencies, and academic institutions from around the world to ensure that it meets the needs of our target audience.
- VWBA should yield results that are trusted by key stakeholder groups working on water stewardship. We thus recommend a standardized approach and set of indicators, informed by a multistakeholder process, that can be applied equally by all stakeholder groups.
- VWBA should be informed by published scientific methods, practitioner experience, and leading practice, as documented in Appendix A.

The rest of this working paper outlines the proposed approach and method for VWBA and provides guidance on how to apply VWBA, including detailed information for estimating the VWBs of the most commonly implemented WS activities.

Box 4 | **Sample Applications**

Support decision-making related to WS investments when evaluating different WS activities and the associated contribution to addressing shared water challenges.

Advance public water policy objectives through WS activities by aligning activities with local shared water challenges, public policy objectives, and desired water stewardship outcomes.

Monitor progress toward WS targets and goals by providing consistent metrics and guidance to measure the benefits of any WS activity over time.

*Sources:* WRI, Valuing Nature, LimnoTech, and Quantis.

## APPROACH

Building on the principles of the Natural Capital Protocol (Natural Capital Coalition 2019) and practitioner experience (Box 5), VWBA provides a consistent and quantitative approach and set of indicators to estimate the volumetric water benefits of WS activities (Figure 2).

Box 5 | **How Was VWBA Developed?**

VWBA was developed by LimnoTech, Quantis, Valuing Nature, and World Resources Institute (WRI), building on published literature and practitioner experience, most notably experience from the Coca-Cola Company in developing and implementing the world's first water replenishment strategy, as well as support from Nestlé S.A. and Danone to produce the first iteration of the VWBA.

LimnoTech, Quantis, Valuing Nature, and WRI consulted key stakeholder groups representing businesses, NGOs, reporting programs, government agencies, and academic institutions from around the world and convened multiple stakeholder groups as part of this process.

- **Expert Advisory Group,** formed in the fall of 2017, contributed by providing early input and guidance during workshops held in Washington, DC, in March 2018 and in Paris in April 2018, as well as by reviewing the proposed approach to ensure the applicability and feasibility of the VWBA method.
- **Project Funders** contributed by providing financial support and industry insights during workshops held in Washington, DC, in March 2018 and in Paris in April 2018, as well as by reviewing the proposed approach to ensure the applicability and feasibility of the VWBA method.
- **Open Consultation** allowed anyone interested to review and provide feedback on the VWBA method prior to completion.
- **World Water Week 2018**, convened by the Stockholm International Water Institute in August, hosted a session to showcase the proposed approach and collect feedback from conference attendees.
- **Alliance for Water Stewardship Forum 2017** hosted a session to showcase the proposed approach and collect feedback from conference attendees.

*Sources:* WRI, Valuing Nature, LimnoTech, and Quantis.

Figure 2 | **Water Stewardship Activity Impact Pathway Modified from the Social and Human Capital Protocol**

| | | | | | |
|---|---|---|---|---|---|
| IMPACT PATHWAY | INPUTS → | ACTIVITIES → | OUTPUTS → | OUTCOMES → | IMPACTS |
| WATER STEWARDSHIP | Investment in water stewardship | Water stewardship activity and activity requirements | Volumetric water benefits and complementary indicators | Social, economic, and environmental benefits | |
| FOR EXAMPLE | $150,000 to address local groundwater table decline | Establishment of infiltration wells for artificial aquifer recharge of rainwater | 462 million liters recharged per year<br>230 smallholder farmers | SOCIAL BENEFIT: increased drought resilience of local farming community<br>ENVIRONMENTAL BENEFIT: improved wetland biodiversity | |

*Source:* Based on information from WBCSD (2019), modified by WRI, Valuing Nature, LimnoTech, and Quantis.

## Volumetric Water Benefits (VWB)

Volumetric water benefits (VWB) are defined as the volume of water resulting from WS activities, relative to a unit of time, that modify the hydrology in a beneficial way and/or help reduce shared water challenges, including ones related to access to water, water quantity, water quality, water governance, and important water-related ecosystems.

As a measure of output, VWB can be used to assess the associated social, economic, and environmental benefits of WS activities using existing methods (WBCSD 2017; Natural Capital Coalition 2019) available outside the scope of this working paper.

Solving shared water challenges requires maintaining over time improvements in hydrology and reductions in shared water challenges and translating them into social, economic, and environmental benefits. Furthermore, although it is the primary focus of the method we propose, volume is only one dimension of water stewardship activities and therefore by no means the only metric that can be used to inform decisions.

Consequently, while practical, estimating VWBs alone cannot provide assurance that shared water challenges are reduced and social, economic, and environmental benefits are provided. To address this, for best results users of VWBA should use aspects of effective water stewardship activities to increase the likelihood of generating social, economic, and environmental benefits and solving shared water challenges in the catchment.

## Elements of Effective Water Stewardship Activities

Elements of effective water stewardship activities can be used to help prioritize potential activities, in conjunction with other criteria specific to each location, such as cost, partner availability, and/or time constraints. One way to prioritize activities is to first ensure that all elements of effective water stewardship activities are met and justify the final decision using knowledge of the local operating context.

*Note*: This list was compiled based on the experience of water stewardship practitioners. It is not exhaustive but rather outlines key considerations to minimize the risk that WS activities will not deliver social, economic, and environmental benefits. Other considerations might be required given the local social, economic, and environmental context. All elements should be considered, described, and justified when claiming volumetric water benefits using the VWBA method we propose.

- **Water challenges.** WS activities should address one or more shared water challenges present at the activity location and, when relevant, help improve water governance and drive collective action.
- **Human rights.** WS activities should respect and protect all human rights, including the human right to water.
- **Partners.** Practitioners should work with reputable and experienced partners who will
  - consider, identify, and address any potential trade-offs or casualties of the WS activities; and
  - minimize the likelihood of unintended deleterious environmental, social, and economic impacts.
- **Stakeholders**. Practitioners should select WS activities that are relevant to local stakeholder needs and priorities.
- **Technology**. When WS activities require technological solutions, practitioners should apply the efficient and feasible technology available.
- **Planning and communicating.** Practitioners should have well-defined and clearly communicated
  - the targeted recipient of the estimated VWBs generated;
  - the desired social, economic, and environmental benefits to which the VWBs will contribute;
  - the baseline year and timeline during which the activity will yield VWBs;
  - a resourcing plan to ensure that maintenance costs are provided for the desired activity duration; and
  - water quality requirements, based on the intended use of the VWBs, that meet or exceed local and/or international standards.
- **Activity-specific considerations.**
  - For any activity, interventions delivering VWBs must comply with applicable regulations (e.g., water quality standards).
  - For water access, sanitation and hygiene activities must
    - ensure that drinking water at the point of collection meets international drinking quality standards, comes from an improved water source, and complies with WHO/UNICEF WASH Guidance; and
    - include adequate training for beneficiaries to efficiently store, transport, and use the drinking water provided and maintain adequate sanitation and hygiene over time.
- For activities involving water transactions,
    - ensure that the proposed transaction agreement is consistent with basin plans, local land use restrictions, water quality standards, and state and federal rules; and
    - ensure that the proposed transaction agreement does not cause injury to existing water rights. Injury occurs when a change in the use of a water right would prevent another water user from using the water to which they are legally entitled.
- For agriculture-related activities,
    - ensure that improved irrigation efficiency measures are not used to support a change in cropping pattern to a more water-intensive crop, an increase in cropping area, or irrigation of previously unirrigated land; and
    - when relevant, encourage the adoption of best practice standards for agricultural sustainability.

## Complementary Indicators

For best results, users of VWBA should employ complementary indicators to measure nonvolumetric outputs associated with the WS activity and VWB. Complementary indicators provide additional insight into the implications of the VWB and help decision-makers interpret the volumetric water benefits achieved beyond the volume of water provided. For example, the VWB of investing in a wastewater treatment plant can also be measured in pollutant load reduced (i.e., a complementary indicator) to help stakeholders better understand the improvements associated with the volume of water treated.

## Application

VWBA allows organizations to quantify VWBs using different indicators, depending on the type of WS activity, while maintaining results in a consistent unit (i.e., volume of water over time). Although the volume of water provided might not always be comparable across WS activities (e.g., some volumes will be provided to the catchment, others will be conserved and maintained in the catchment, others will be used to protect the human right to water), it does offer a consistent unit of measurement to aid in tracking and communicating progress toward commitments, targets, and goals.

By using a consistent unit, VWBA allows practitioners to estimate volumetric water benefits of past, current, or future commercial and noncommercial WS activities, anywhere across a value chain, inside or outside an organization's four walls, provided the activity responds to shared water challenges and is designed to provide social, economic, and/or environmental benefits in the catchment and community.

## Limitations

Estimating environmental, social, or economic benefits is preferable in order to ensure that WS activities deliver long-term value. However, our extensive stakeholder engagement suggests that estimating VWBs is preferable for certain applications, not as an alternative to measuring environmental, social, or economic benefits, but rather as an intermediate and practical step that can yield a consistent and standardized output measurement. Organizations interested in measuring environmental, social, or economic benefits can do so using existing methods (WBCSD 2017; WBCSD 2019; Natural Capital Coalition 2019).

Additionally, limiting VWBA to measuring activity outputs poses a challenge in sustainable water management, where solving shared water challenges requires that improvements in hydrology be maintained over time. Therefore, unless additional assurance is provided, delivering volumetric water benefits does not guarantee that the activity will deliver the associated social, economic, and environmental benefits.

Finally, three types of meaningful and relevant WS activities do not yield volumes of water that modify the hydrology and therefore cannot be quantified using the methods we describe: (1) sanitation and hygiene activities, (2) agricultural best management practices (BMPs) related to agrochemical management activities, and (3) in-stream channel rehabilitation activities (e.g., streambank stabilization). However, the benefits of these three types of WS activities can be measured with the complementary indicators described in the VWBA.

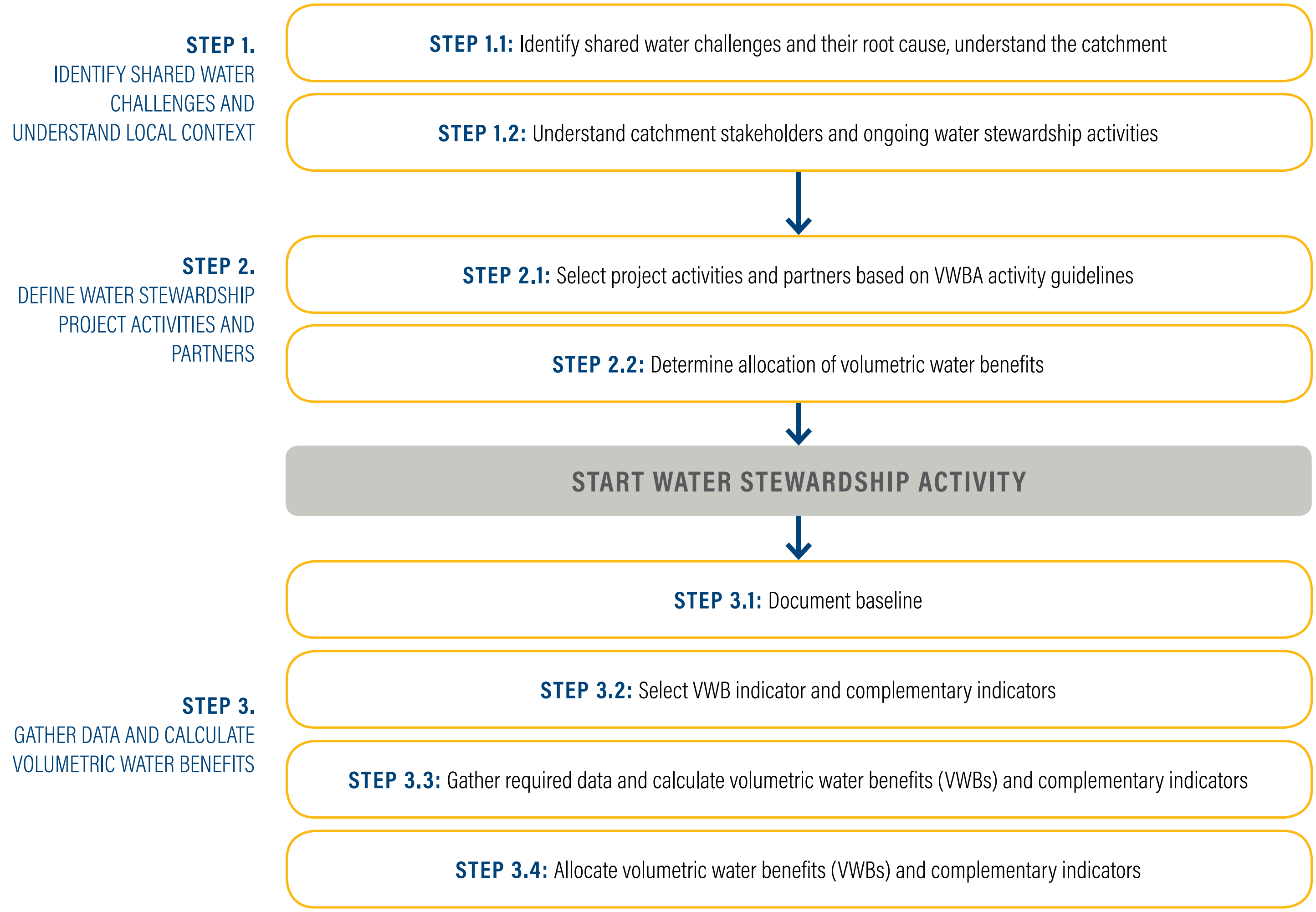
# METHOD

VWBA offers a three-step method (Figure 3), accompanied by detailed guidance and recommended resources, to estimate the volumetric water benefits of WS activities.

VWBA does not help identify social or environmental externalities or threats to business continuity that may inform where to prioritize WS activities. Instead, VWBA can be applied to activities in any location where a company operates, sources from, invests in, supplies from, or discharges to, and it gives an organization flexibility to decide how to define cost share for allocation purposes if the project has multiple funders (e.g., in-kind, or maintenance and monitoring); when to begin estimating benefits based on the type of activity and implementation timelines (e.g., when funded, when fully implemented, or the year after fully implemented); the requirements for confirming benefits after the project is complete (e.g., who, how, with what frequency); and how long benefits are counted after a project is complete.

Therefore, prior to applying the method we propose, organizations should identify priority locations for implementing WS activities based on where water is most material using publicly available resources from national and/or local water agencies, international organizations, and/or local assessment (i.e., catchments, sphere of influence, or physical scope of water stewardship activities as defined in AWS 2019, Guidance Step 1.1). Organizations should also define internal guidance for allocation of benefit, reporting, and project sustainability to ensure consistent application across activities and communicate the VWBs of all WS activities.

Figure 3 | **VWBA Method to Calculate and Communicate WS Activity Volumetric Water Benefits**




*Sources:* WRI, Valuing Nature, LimnoTech, and Quantis.

## Step 1. Identify Shared Water Challenges and Understand Local Context

### Step 1.1: Identify shared water challenges and their causes and understand the catchment

INSTRUCTIONS

The first step is to identify existing or future shared water challenges and their causes within the catchment. This will require understanding the catchment in a physical and hydrological sense, including, for example, the relative importance of groundwater and surface water and their interconnections.

Publicly available resources exist to support this process (see Table G.1.1.1), but the greatest understanding will be gained by consulting local stakeholders who work in the catchment.

Shared water challenges are defined as outlined by the targets under SDG 6, 11.5 and 13.1 (see Table G.1.1.2), indicating the most pressing issues to be addressed to achieve sustainable development. The targets under SDG 6, 11.5 and 13.1 serve as a robust framework to help identify and categorize priority shared water challenges within or between catchments and align with local and international public policy objectives.

Table G.1.1.1. | **Examples of Publicly Available Resources to Help Identify Shared Water Challenges**

| RESOURCE | LINK |
|---|---|
| Local water resources regulator or environment agency | Varies by location |
| Joint Monitoring Program (2019) | https://washdata.org/ |
| TNC's Water Fund Toolbox (2019) | https://waterfundstoolbox.org/ |
| US EPA Conducting source water assessments (2018) | https://www.epa.gov/sourcewaterprotection/conducting-source-water-assessments |
| AWS (2019), Guidance Step 1.6: Understand current and future shared water challenges in the catchment and Step 1.7: understand the site's water risk and opportunities | https://a4ws.org/download-standard-2/aws-standard-2-0-guidance/ |
| BIER, Performance in Watershed Context (2015) | https://www.bieroundtable.com/publication/peformance-in-watershed-context/ |

Table G.1.1.2. | **Shared Water Challenges as Defined by the SDG Targets**

| SHARED WATER CHALLENGES | SDG TARGETS |
|---|---|
| Water, sanitation, and hygiene (WASH) | SDG 6.1: By 2030, achieve universal and equitable access to safe and affordable drinking water for all<br><br>SDG 6.2: By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations |
| Water quality | SDG 6.3: By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally |
| Water quantity | SDG 6.4: By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity |
| Water governance | SDG 6.5: By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate<br><br>SDG 6A: By 2030, expand international cooperation and capacity-building support to developing countries in water- and sanitation-related activities and programs, including water harvesting, desalination, water efficiency, wastewater treatment, and recycling and reuse technologies<br><br>SDG 6B: Support and strengthen the participation of local communities in improving water and sanitation management |
| Important water-related ecosystems | SDG 6.6: By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers, and lakes |
| Extreme weather events | SDG 11.5: By 2030, significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations<br><br>SDG 13.1: Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters |

*Source:* UN (2015).

### Step 1.2: Understand catchment stakeholders and ongoing water stewardship activities

INSTRUCTIONS

After identifying shared water challenges, an organization should (1) know who the major water users are in the catchment and the role they play; (2) understand the political and social landscape, which may influence what activities to start with; and (3) evaluate whether water-related efforts are already in place (e.g., collective action projects, public water policy objectives, NGO activities), so the organization can assess opportunities to contribute to, or align with, them before starting new activities. For publicly available resources, see Table G.1.2.1.

GUIDANCE

Table G.1.2.1. | **Examples of Publicly Available Resources to Help Understand Catchment Stakeholders and Ongoing Water Stewardship Activities**

| RESOURCE | LINK |
|---|---|
| Local watershed, river basin, catchment plans | Varies by location |
| AWS (2019), Guidance Step 1.2: Understand relevant stakeholders | https://a4ws.org/download-standard-2/aws-standard-2-0-guidance/ |
| River Network | https://www.rivernetwork.org/ |
| TNC Water Funds Field Guide (2018) | https://waterfundstoolbox.org/water-funds-field-guide-launched |
| Water Action Hub (2018) | https://wateractionhub.org/ |
| Guide to Water-Related Collective Action (2013) | https://www.pacinst.org/wp-content/uploads/2013/02/wrca_full_report3.pdf |
| US EPA Guide to Engaging Stakeholders in Your Watershed (2014) | https://cfpub.epa.gov/npstbx/files/stakeholderguide.pdf |
| Water Risk and Action Framework (2015) | https://ceowatermandate.org/wraf/ |

## Step 2. Define Water Stewardship Project Activities and Partners

### Step 2.1.: Select project activities and partners based on elements of effective water stewardship

INSTRUCTIONS

Building on existing water-related efforts and public policy objectives whenever relevant, select project partners and potential WS activities that include elements of effective water stewardship as outlined in the “Approach” section of this working paper and address the shared water challenges identified in Step 1, including challenges related to access to water, water quantity, water quality, water governance, and important water-related ecosystems.

Successful implementation of the VWBA requires working with reputable and experienced implementing partners who can help evaluate potential trade-offs or casualties of the activities considered and minimize the likelihood of unintended negative impacts. In conjunction with other criteria, such as cost or partner availability, the list of elements of effective water stewardship can be used to prioritize among potential WS activities, by selecting projects that have the most elements of effective water stewardship to help justify the final decision. For activity classification, see Table G.2.1.1. For contributions to water stewardship outcomes, shared water challenges, and SDG targets per water stewardship activity category, see Table G.2.1.2.

GUIDANCE

Table G.2.1.1. | **Water Stewardship Activity Classification**

| CATEGORY | ACTIVITY | DESCRIPTION |
|---|---|---|
| **Land conservation and restoration** | Land conservation (protection and preservation) | Legal mechanisms to protect land from development or conversion to a more degraded use.<br><br>Development and diversification of sustainable livelihoods. |
| | Land cover restoration | Restoration to improve vegetative health and cover, including reforestation (tree planting in large deforested areas and riparian buffers, thinning of monoculture forests, agroforestry, rotational grazing, prairie and other grassland restoration, invasive species removal, fencing. |
| **Water supply reliability** | Agricultural water demand reduction measures | Conversion from flood to drip irrigation, variable rate irrigation, advanced irrigation scheduling, soil improvements, crop conversion and fallowing to reduce irrigation need. |
| | Operational efficiency measures | Reduced direct water use. |
| | Leak repair | Detection and repair of leaks in distribution systems or buildings. |
| | Consumer use efficiency measures | Reduced water uses in homes and businesses associated with product use, appliances, and fixtures. |
| | Water reuse | Beneficial reuse to replace supply of fresh water with reused water, or provision of a new water source that supports economic development or benefits the environment. |
| | New water supply for crop irrigation | Pipes, canals, and other infrastructure to deliver water, including reused water. |
| | Rainwater harvesting | Infrastructure designed to capture and retain water during the wet season and enhance water availability. |
| **Water access** | Access to drinking water supply | Well construction or rehabilitation, water distribution, water treatment, rainwater harvesting. |
| **Water quality** | Agricultural best management practices (BMPs) | Conservation tillage, laser leveling, cover crops. |
| | | Agrochemical management (4Rs). |
| | Stormwater management | Green infrastructure including detention ponds, bio-swales, permeable pavement, rain gardens, other measures that reduce impervious area. |
| | Constructed wetland treatment systems | Systems placed on agricultural landscapes and in urban areas. |
| | Wastewater treatment plants | Facilities designed to remove pollutants from wastewater discharge. |

Table G.2.1.1. | **Water Stewardship Activity Classification (Cont'd)**

| CATEGORY | ACTIVITY | DESCRIPTION |
|---|---|---|
| **Aquatic habitat restoration** | Wetland protection | Legal mechanisms to prevent draining or alteration. |
| | Wetland restoration and creation | Rewetting of historical wetland, invasive species removal, tile drain removal, wetland creation. |
| | Legal transactions to keep water in-stream | Acquisition or leasing of water rights, source switch, seasonal forbearance agreements. |
| | In-stream barrier removal | Dam and culvert removal. |
| | Dam reoperation | Operation of dam to move toward more natural flow regime, banking and credit storage. |
| | Floodplain inundation/reestablish hydrologic connection | Natural stream channel design, grade control structures, log deflectors, floodplain reconnection, side channel reconnection/restoration. |
| **Water governance** | Direct engagement in water governance and public water management | Participation in coordination and collaboration among stakeholders, advocacy, improved water policy and planning, increased resilience and reliance on public water infrastructure systems, development of sustainable governance and financial mechanisms setting the stage for the protection and restoration of water supply catchments (e.g., water funds). |
| **Catalytic activities** | Activities that pave the way for longer-term water stewardship outcomes. | Data collection/monitoring, assessment, hydrological modeling/development of modeling tools, management plans, training, information sharing, education and awareness, and collective action convening. |

*Note:* The classification above includes the most commonly implemented WS activities by corporate water stewardship practitioners at the time this working paper was written. This list is not comprehensive, and organizations are encouraged to also consider other activities that respond to local shared water challenges and stakeholder priorities.
*Sources:* WRI, Valuing Nature, LimnoTech, and Quantis.

Table G.2.1.2. | **Contributions to Water Stewardship Outcomes, Shared Water Challenges, and SDG Targets per Water Stewardship Activity Category**

| | Water Stewardship Outcomes[a] | (1) Sustainable Water Balance | (2) Good Water Quality Status | (3) Good Water Governance | (4) Important Water-Related Areas (IWRAs) | (5) Safe Water, Sanitation, and Hygiene for All (WASH) | N/A |
|---|---|---|---|---|---|---|---|
| | Shared Water Challenge | Water quantity | Water quality | Water governance | Important water-related ecosystems | Water, sanitation, and hygiene (WASH) | Extreme weather events |
| | SDG Target(s)[b] | 6.1, 6.4 | 6.2, 6.3 | 6.5, 6A, 6B | 6.6., 13 | 6.1, 6.2 | 11.5, 13.1 |
| WS ACTIVITY CATEGORY | Land conservation and restoration | ✓ | ✓ | | ✓ | | ✓ |
| | Water supply reliability | ✓ | | ✓ | | | ✓ |
| | Water access | ✓ | ✓ | ✓ | | ✓ | |
| | Water quality | | ✓ | | ✓ | ✓ | ✓ |
| | Aquatic habitat restoration | ✓ | ✓ | | ✓ | | |
| | Water governance | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | Catalytic activities | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

*Notes:* As defined in the VWBA water stewardship activity classification, including activities that contribute to sustainable water balance, good water quality status, good water governance, important water-related areas, and safe water, sanitation, and hygiene for all.
[a] AWS (2019).
[b] UN (2015).
*Sources:* WRI, Valuing Nature, LimnoTech, and Quantis.

## Step 2.2.: Determine allocation of volumetric water benefits

INSTRUCTIONS

When relevant, allocation of VWBs is required to determine the VWBs associated with the contribution of each project partner and to avoid double counting and overclaiming of VWBs by the partners involved.

If VWBs require allocation among activity partners, the approach and principles for allocation should be determined and agreed upon with all WS activity partners before implementing the WS activity. For example, if the total benefits are allocated to three different companies based on cost contribution, there should be agreement on what is included in the total cost used for the cost-share calculation (e.g., planning, design, maintenance, monitoring, reporting). For some very large projects (e.g., water funds, projects that are expanding over time, or projects with many funders), it may be difficult to determine total costs. In these cases, it may be possible to work with the activity partners to define a portion of the project that can be 100 percent funded, eliminating the need to determine a total project cost for the entire large project. For example, for a 10,000-hectare restoration project the cost share could be viewed as either 1 percent cost share of the entire 10,000-hectare project, or 100 percent cost share of 100 hectares. Both approaches would credit the funder with a volume associated with 100 hectares restored. See also the example in Table G.2.2.1.

*Note*: It is the sole responsibility of WS activity partners to ensure that VWBs are claimed exclusively by those partners involved in the WS activity. This is particularly relevant for organizations providing goods and services associated with the WS activity to more than one organization (e.g., VWBs achieved by farmers working with buyer A should not allow buyer B to claim the VWBs achieved by working with buyer A).

GUIDANCE

Table G.2.2.1. | **Illustrative Example of VWB Allocation Based on Partner's Cost Share**

| ALLOCATION OF VOLUMETRIC WATER BENEFITS BETWEEN THREE ACTIVITY PARTNERS IN A SAMPLE LEAK REPAIR PROJECT | |
|---|---|
| Activity | Leak repair |
| VWBA indicator | Reduced withdrawal |
| VWBA indicator calculation | $VWB = Withdrawal_{baseline} - Withdrawal_{with\text{-}project}$ |
| Volumetric water benefit (in ML/year) | 1,500 ML/year – 500 ML/year = 1,000 ML/year |
| WS activity cost in US$ | $175,000 |
| Contribution – Partner 1 in US$ (%) | $100,000 (57% of total) |
| Contribution – Partner 2 in US$ (%) | $50,000 (29% of total) |
| Contribution – Partner 3 in US$ (%) | $25,000 (14% of total) |
| Allocated VWB – Partner 1 | 57% of 1,000 ML/year = 570 ML/year |
| Allocated VWB – Partner 2 | 29% of 1,000 ML/year = 290 ML/year |
| Allocated VWB – Partner 3 | 14% of 1,000 ML/year = 140 ML/year |

*Sources:* WRI, Valuing Nature, LimnoTech, and Quantis.

## Step 3. Gather Data and Calculate Volumetric Water Benefits

### Step 3.1. Document baseline

INSTRUCTIONS

The next step is to document the baseline conditions for the shared water challenge (or challenges) being addressed by the WS activities. Baseline conditions refer to the beginning point at which the variable measured by the VWB indicator will be monitored and against which progress can be assessed or comparisons made. Baseline conditions can be thought of as the "without project" conditions. In the context of VWBA, baseline conditions refer to the VWB and complementary indicator values prior to the WS activity's taking place.

*Note*: If warranted by expected changes in "without project" conditions, practitioners may choose to review and update baseline values over time, using expert judgment.

GUIDANCE

Baseline conditions can be estimated using existing empirical information available in the public domain (from government agencies, regulators, or other third-party estimates), as well as local knowledge.

### Step 3.2. Select VWB indicator and complementary indicators

INSTRUCTIONS

Based on the water stewardship activity carried out, practitioners should select an appropriate VWB indicator and complementary indicators:

- **VWB indicators** estimate the volume of water, relative to a unit of time, resulting from WS activities that modify the hydrology in a beneficial way and/or help reduce shared water challenges. See Table G.3.2.1.
- **Complementary indicators** measure nonvolumetric outputs associated with the WS activity and VWB. For example, the output of investing in a reforestation project can be measured in volume of reduced runoff (i.e., volumetric water benefit) and number of native trees planted (i.e., complementary indicator). Complementary indicators can help decision-makers interpret VWBs beyond the volume of water provided. See Table G.3.2.2.

GUIDANCE

Table G.3.2.1. | **Volumetric Water Benefit (VWB) Indicators, Measured as Volume of Water, Relative to a Unit of Time, Provided as Part of VWBA**

| VWB INDICATORS (MEASURED IN VOLUME OF WATER OVER UNIT OF TIME) |
|---|
| Avoided runoff |
| Improved flow regime |
| Increased recharge |
| Maintained recharge |
| Reduced consumption |
| Reduced runoff |
| Reduced withdrawals |
| Volume captured |
| Volume provided |
| Volume treated |

*Sources:* WRI, Valuing Nature, LimnoTech, and Quantis.

GUIDANCE

Table G.3.2.2. | **Illustrative Example of Complementary Indicators**

| SAMPLE COMPLEMENTARY INDICATORS | UNIT OF MEASUREMENT |
|---|---|
| Activity beneficiaries | Number of people over time |
| Crop yield | Mass per area over time |
| Economic welfare | Number of jobs created over time |
| Flood frequency | Frequency |
| Incidence of disease | Frequency |
| Income | Currency over time |
| Land protected and or restored | Area (e.g., square kilometers, square meters, square miles, hectares, acres) over time |
| Native trees planted | Number of trees |
| Policy, legislation, directives, standards, programs, data | Name and reference number over time |
| Pollutant load | Mass over time |
| Species protected | Number of endangered species over time |
| Stream protected or restored | Length (e.g., kilometers, meters, miles) over time |

*Note:* This list is not comprehensive. Organizations are encouraged to select complementary indicators that are relevant to the WS activity, project partners, and other stakeholders involved.
*Sources:* WRI, Valuing Nature, LimnoTech, and Quantis.

## Step 3.3. Gather required data and calculate volumetric water benefits (VWB) and complementary indicators

INSTRUCTIONS

Next, define the timescale for measuring and communicating volumetric water benefits (annual, seasonal, monthly, etc.). Special attention is required when implementing WS activities that aim to address seasonal shared water challenges, such as seasonal water scarcity and or water quality impacts, to ensure that the WS activities deliver VWBs at the right time of year and address the shared water challenges.

Based on the type of activity and objective, determine the required indicator, calculation method, and data requirements; gather data; and calculate the volumetric water benefits and complementary indicators.

For example, if a constructed wetland (i.e., activity) is designed to treat a volume of water and reduce pollution (i.e., objective) the required indicator is volume treated (i.e., output), and a complementary indicator could be the pollutant load. Similarly, for a reforestation project (i.e., activity) aimed at reducing sedimentation (i.e., objective) the required indicator is reduced runoff (i.e., output), and a complementary indicator could be the number of trees planted.

*Notes*:

- The availability of published methods for VWB quantification informed the selection of WS activities covered in this working paper. Practitioners are welcome to apply the approach we propose for other WS activities and to select other VWB indicators when credible and well-documented methods are available to estimate VWBs.
- Depending on the objective of VWBA, practitioners can choose to use simpler estimates (typically used during early-stage project evaluation and cost-benefit analysis) or more detailed, robust, and complex estimates or measurements (typically used to report progress, communicate publicly, and make claims associated with an organization's water stewardship activities).

Method selection was informed by the need for VWBA to be practical and informed by published literature, practitioner experience, and best practice. Thus, the list of calculation methods we propose (see Table G.3.3.1) is not exhaustive, and other simpler or more complex methods may exist. In any case, the method selected should be documented and clearly communicated when sharing results and/or making claims.

Furthermore, and consistent with the need for a pragmatic approach, the methods we reference allow decision-makers to estimate VWBs based on the project design characteristics and do not require empirical measurements or observations. Although not required, using empirical measurements or observations would improve the accuracy of the methods proposed.

Table G.3.3.1. | **Recommended VWB Indicator Calculation Methods for the Most Commonly Implemented WS Activities**

| CATEGORY | ACTIVITY | VWB INDICATOR | CALCULATION METHODS | APPENDIX |
|---|---|---|---|---|
| **Land conservation and restoration** | Land conservation | Avoided runoff | Curve Number method | A-1 |
| | Land cover restoration | Reduced runoff | | |
| **Water supply reliability** | Agricultural water demand reduction measures | Reduced withdrawal or reduced consumption | Withdrawal method or Consumption method | A-2 |
| | Operational efficiency measures | Reduced withdrawal | Withdrawal method | |
| | Leak repair | | | |
| | Consumer use efficiency measures | | | |
| | Water reuse | | | |
| | New water supply for crop irrigation | Volume provided | Volume Provided method | A-3 |
| | Rainwater harvesting | Increased recharge | Capture and Infiltration method | A-4 |
| **Water access** | Access to drinking water supply | Volume provided | Volume Provided method | A-3 |
| **Water quality** | Agricultural best management practices (BMPs) related to conservation tillage, laser leveling, cover crops | Reduced runoff | Curve Number method | A-1 |
| | Stormwater management | Volume captured | Runoff Reduction method | A-5 |
| | Constructed wetland treatment systems | Volume treated | Volume Treated method | A-6 |
| | Wastewater treatment plants | | | |
| **Aquatic habitat restoration** | Wetland protection | Maintained recharge | Recharge method | A-7 |
| | Wetland restoration and creation | Increased recharge | | |
| | Legal transactions to keep water in-stream | Reduced withdrawal | Withdrawal method | A-2 |
| | In-stream barrier removal | Improved flow regime | Hydrograph method | A-8 |
| | Dam reoperation | | | |
| | Floodplain inundation / reestablish hydrologic connection | Varies based on objectives | See Appendix A-7 | A-7 |
| **Water governance** | Direct engagement in water governance and public water management | Same as the water stewardship activities they support | | A-9 |
| **Catalytic activities** | Activities that pave the way for longer-term water stewardship outcomes | Same as the water stewardship activities they support | | A-10 |

*Sources:* WRI, Valuing Nature, LimnoTech, and Quantis.

### Step 3.4. Allocate volumetric water benefits (VWB) and complementary indicators

INSTRUCTIONS:

When required, allocate volumetric water benefits, based on the total volumetric water benefit achieved for a given time and the approach to allocation agreed upon with all activity partners in advance of implementing the project, as outlined in Step 2.2.

## COMMUNICATION AND AGGREGATION

### Communication

It is important to note that, for some WS activities, such as those that involve restoration, the desired end state and calculated VWB may not be achieved for some time after the implementation of the activity. Other WS activities may have actual VWBs that vary annually due to variations in precipitation and other factors. Typically, the methods report a long-term average VWB for these activities. It is important to document any assumptions when reporting VWBs.

By using the VWBA method described in this working paper, organizations can communicate and make claims for volumetric water benefits achieved in the following ways:

- By providing information on the shared water challenge addressed and how it was identified.
- By providing information on which elements of effective water stewardship activities are met, in particular
  - the targeted recipient of the estimated VWB generated;
  - the desired social, economic, and environmental benefits the VWBs will contribute to;
  - the baseline year and timeline during which the activity will yield VWBs; and
  - the resourcing plan to ensure that monitoring and maintenance costs are provided for the desired activity duration.
- By sharing the total volumetric water benefit and relevant complementary indicators, per unit of time, as well as the volumetric water benefit and relevant complementary indicators allocated to the organization, per unit of time, and details on the approach to determining allocation, in addition to the list of activity partners involved.
- By measuring and communicating VWBs of all WS activities the organization has invested in, not just those yielding outputs desired by the company.
- By using independent, third-party quantification of volumetric water benefits being claimed, per unit of time.
- By using the AWS Water Stewardship Standard 2.0 guidance for Step 5: Communicate and Disclose.
- By clearly stating the communicating period (year, month, etc.) and baseline year.

### Aggregation

For organizations interested in using VWBA to track and communicate progress toward meeting enterprise goals and/or targets, such as replenish, water balance, or contextual water goals, we recommend aggregating VWBs across WS activities measured with the same VWB indicators, within the same catchment, and clearly stating the geographic origin of the VWB provided.

This is critical for two reasons: first, to link the VWBs being claimed to the local context where they were generated, and, second, so as not to aggregate VWBs that are measuring opposite modifications in the local hydrology (e.g., runoff reduced and volume provided).

While we do not recommend this, each organization can decide whether additional aggregation across geographies and WS activities measured with different VWB indicators is warranted. If the organization decides that this is justified, it can aggregate across activity types across the enterprise, geographies, business units, and/or value chain, clearly communicating the limitations of such an aggregation of VWB values.

# DISCUSSION

The VWBA method we propose has been developed through extensive stakeholder engagement to help organizations account for volumetric water benefits of water stewardship activities they have supported and invested in, while advancing public policy objectives and engaging in collective action. Special emphasis has been placed on providing volumetric water benefit indicators with consistent units of measurement and methodological guidance to help make VWBA accessible to decision-makers and applicable across value chains. These methods are not overly complex but rather represent pragmatic approaches that can be applied using readily available information with a reasonable level of investment.

We made trade-offs to ensure accessibility by limiting VWBA to measuring volumetric water benefits and not the associated social, economic, or environmental benefits. This is particularly challenging in the context of sustainable water management, where solving shared water challenges requires that improvements in hydrology be maintained over time. Therefore, unless additional assurance is provided, delivering volumetric water benefits does not guarantee that the activity will deliver the associated social, economic, and environmental benefits.

Moving forward, there are opportunities to improve volumetric water benefit accounting, first by developing methods to account for the volumetric water benefits of activities currently not included and, second, by building a web-based tool to facilitate large-scale adoption of VWBA. Additionally, the methods and approaches we propose can be enhanced through experience gained by (a) piloting the application of the VWBA method discussed in this working paper; (b) investing in monitoring, data collection, and analysis that will strengthen hydrological models and validate assumptions; and (c) developing additional guidance to facilitate the conversion of water stewardship activity outputs into measures of social, economic, and environmental outcomes and impacts.

# APPENDIX A: CALCULATION METHODS AND ILLUSTRATIVE EXAMPLES

Appendices A-1–10 describe frameworks and calculation methods available to guide the calculation of VWBs for the most commonly implemented project activities. While the methods described do not demand significant resources or extensive data, some technical expertise is required for application. These appendices are not designed to provide a detailed and prescriptive "how to" manual for quantifying VWBs; rather, practitioners should view this information as general guidance to inform the quantification process.

Some considerations should be kept in mind when selecting and applying a calculation method:

- Where relevant, it is preferable to use monitored or measured volumes, with the goal of reporting results for average annual conditions. We propose calculation methods for estimating VWBs where monitoring is not possible.
- The calculation methods were selected because they represent pragmatic approaches that can be applied with a reasonable investment. However, more complex approaches such as detailed modeling analyses should be considered if available. For example, Appendix A-1 describes the Curve Number method for calculating change in runoff, but an appropriate catchment model, if available, may support a more robust analysis.
- In cases where multiple methods are relevant, the primary objective of the project should be considered when selecting an applicable calculation method. For example, Appendix A-7 describes the recharge method for wetland restoration and protection activities. However, if the primary objective of a wetland restoration project is to expand the surface water volume to provide improved aquatic habitat, then a different calculation method may be more appropriate, as discussed in Appendix A-7.
- Each project is unique, and it is not possible to capture the complexity of site-specific conditions in short method descriptions. Users should always consider project-specific characteristics when calculating VWBs. For example, Appendix A-2 describes the withdrawal and consumption method, which is applicable to projects involving fallowing of a field. Using site-specific information, the user should calculate the VWB based on the duration of the fallowing (full year or partial year).

Illustrative examples are provided for some of the methods presented in the appendices. Some are based on real case studies, some are not. The purpose of the examples is not to provide prescriptive guidance on how the methods should be applied but rather to offer insight into the application of the methods described in this working paper. Thus examples illustrate the calculation of VBA (Steps 3.1–3) and exclude information on Steps 1.1–2.2 and 3.4.

# Appendix A-1. Curve Number Method

## Activities and Indicators

The Curve Number method enables estimation of the volumetric benefit of the following activities using the referenced output indicators below:

| CATEGORY | ACTIVITIES | OUTPUT INDICATOR |
|---|---|---|
| Land conservation and restoration | Land conservation | Avoided runoff |
| | Land cover restoration | Reduced runoff |
| Water quality | Agricultural best management practices (BMPs) | Reduced runoff |

The method calculates the average annual VWB based on the project design, but there can be a time lag between the time the site is planted and the time it is fully restored, generating the modeled benefits. When communicating benefits, companies and other organizations may choose to report modeled VWBs in full, starting from year 1 when the project is fully implemented (assuming mature vegetation), or to allow for trees and other vegetation to grow over time and count an incrementally increasing VWB.

## Methodology Description

The Curve Number Runoff method (referred to in this working paper as the Curve Number method), as implemented in the Soil and Water Assessment (SWAT) model (Neitsch et al. 2011), is an empirical method for estimating runoff quantities based on land cover, use, soil, and slope, accounting for temporal changes in precipitation and soil water content. The daily runoff quantity can be estimated as follows (1):

$$Q = \frac{(P-0.2S)^2}{(P+0.8S)} \quad (1)$$

$Q$ = Runoff (millimeters)

$P$ = Precipitation (millimeters)

$S$ = Potential maximum retention after runoff begins (millimeters)

The retention parameter ($S$) is related to the curve number ($CN$) as follows (2):

$$S = \frac{25{,}400}{CN} - 254 \quad (2)$$

The retention factor $S$ is calculated as a function of potential evapotranspiration and antecedent climate. The retention parameter varies spatially due to changes in soils, land use, and slope and temporally due to changes in soil water content. The complete set of equations related to this method is provided in Neitsch et al. (2011).

To estimate runoff quantities, the equations need to be compiled on an MS Excel spreadsheet. Runoff volume is then calculated by multiplying the sum of daily runoff depth and surface area.

## Required Inputs

| EQUATION | VARIABLE | INPUT |
|---|---|---|
| Runoff depth ($Q$) (1) | $P$ = precipitation | At least three years of daily data from a nearby representative station. |
| | $S$ = retention parameter | $CN$ = Curve number representing with-project and baseline (i.e., without-project) conditions. The $CN$ (unitless) values typically range from 30 to 98 depending on the soil type and land cover characteristics (see Table 2:1-1 in Neitsch et al. 2011). |
| Retention parameter ($S$) (2) | $CN$ = curve number | Potential evaporation (PET): at least three years of daily data, matching the precipitation time series, from a nearby representative station.<br><br>Slope (average across the project area). |
| Runoff volume | | Runoff depth ($Q$).<br><br>Surface area impacted by the project activity. |

To the extent possible, a description of the "with-project" and "baseline" conditions, accompanied by site-specific photographs of project activities, should be documented and discussed to provide context to the project activities.

## Applications

- The Curve Number method calculates runoff volumes based on precipitation and site characteristics, and long-term average annual values should be reported. This method can be used to calculate the change in runoff due to land protection and land restoration activities, as well as agricultural BMPs. Several alternative approaches to estimate runoff quantities exist and could also be applied for these types of activities. The Rational method (Kuichling 1889), a very simple empirical procedure requiring a runoff coefficient and surface area, produces results with far greater uncertainty than the Curve Number method. Alternatively, complex process-based procedures such as the Green-Ampt method (Green and Ampt 1911) may be applied, but they require significantly more time and input data than does the Curve Number method.

- **Land conservation activities:** The conservation (protection or preservation) of grassland or forest to maintain native cover prevents the conversion of the land to another use (e.g., development, agriculture, grazing) and prevents the runoff and associated erosion that would have occurred if the land had not been conserved. The need for conservation and the likely future use of the land if not conserved should be established. This can be accomplished by communicating with local experts and reviewing zoning or land cover maps and available reports documenting the need for the protection project and indicating the "without-project" condition of the land if it were not conserved. The volume of surface runoff is quantified for two conditions: the "baseline" condition (the expected degraded condition of the land if it were not conserved) and the "with-project" condition (current condition with intact healthy land cover conserved). First, daily runoff volumes are calculated for each condition based on daily precipitation and other inputs. These values are summed to calculate the long-term annual average runoff volumes. The VWB is quantified (3) as the difference in annual average runoff volume between the two conditions.

$$\mathbf{VWB = Q}_{\text{“Baseline”}} \mathbf{- Q}_{\text{“With-project”}}$$

(3)

- **Land cover restoration activities.** Restoration of native cover reduces runoff and associated erosion that occurs due to loss of vegetative cover. The volume of surface runoff is quantified for two conditions: the "baseline" condition (current degraded land cover condition before the project is implemented) and the "with-project" condition (restored condition with healthy, fully mature land cover). First, daily runoff volumes are calculated for each condition based on daily precipitation and other inputs. These values are summed to calculate the long-term annual average runoff volumes. The VWB is quantified (4) as the difference in annual average runoff volume between the two conditions.

$$\mathbf{VWB = Q}_{\text{“Baseline”}} \mathbf{- Q}_{\text{“With-project”}}$$

(4)

- **Water quality activities involving agricultural BMPs.** For agricultural projects involving practices (e.g., cover crops, conservation tillage, rotational grazing), the VB is calculated as described above for land restoration activities. The VB of filter strips and grassed waterways is based on the extent to which these features reduce runoff received from upstream drainage by decreasing runoff velocity and increasing infiltration (5). First the runoff quantity ($Q_T$) from the contributing drainage area is calculated, then the runoff reduction quantity is estimated by applying a runoff reduction coefficient ($R_{coeff}$) based on literature values (Helmers et al. 2008; Sheridan et al. 1999; Fiener and Auerswald 2003).

$$\mathbf{VB = Q_T \times R_{coeff}}$$

(5)

## Illustrative Examples of How to Apply the Curve Number Method

| CASE STUDY | REFORESTATION OF RIPARIAN ZONES |
|---|---|
| Activity | Reforestation and protection of riparian zones |
| Shared water challenge(s) addressed | Degradation of quality of the main river of the catchment due to soil erosion |
| Project description | The activity invested in the creation of buffer strips of 100 m and 30 m in different zones along the main rivers. It also initiated agroforestry activities in the buffer strips, prohibited farming close to the river and its tributaries, prevented wildfires, and raised awareness through campaigns. |
| Location | Ghana |
| Project start date | 2008 |
| Project end date | 2009 (benefit continues to be generated in future years, with a progressive increase since the project establishment to reach a full maturity after a number of years) |
| Preproject (baseline) condition | Pasture or grassland on the riparian corridors |
| Postproject condition | Woodland in good condition on the riparian corridors (in this case, the company chooses to report a VWB that reflects a progressive maturity increase) |
| VWB indicator | Reduced runoff |
| VWB indicator calculations | The Curve Number method was used to quantify the runoff from the preproject and postproject conditions (at full maturity). The results show a runoff of 49 ML/year for the preproject conditions, and 43 ML/year for the postproject conditions, leading to a net runoff reduction of 6 ML/year. If the benefit is claimed at shorter term after the project, a smaller benefit would need to be calculated based on the maturity of the woodland (postproject condition). |
| Complementary indicator | The complementary indicator selected is the area with improved agricultural practices: 1,000 ha. |
| Comments | Meteorological data, soil type, and slope information were provided by a literature review and by consulting local stakeholders. |
| Other considerations | When to claim the full benefit of 6 ML/yr? How frequently should the project area be monitored to check on the condition and by whom (e.g., to ensure that there have been no fires or farming in the buffer)? For how many years after project completion will the volume benefit be claimed? |

| CASE STUDY | AGRICULTURE COVER CROPS |
|---|---|
| Activity | Planting of cover crops outside the growing season (agriculture best management practices) |
| Shared water challenge(s) addressed | Water quality issue downstream connected to the Gulf of Mexico |
| Project description | A partnership has been established with local farmers to use cover crops outside growing season over a total of 2,000 acres. All producers planted a cereal rye cover crop within a corn and soybean rotation. |
| Location | USA |
| Project start date | 2017 |
| Project end date | Ongoing |
| Preproject (baseline) condition | No cover crop used outside growing season. |
| Postproject condition | Cover crop used outside growing season. |
| VWB indicator | Reduced runoff |
| VWB indicator calculations | The Curve Number method has been applied to the baseline (preproject conditions) and postproject condition, to obtain average runoff per year (in ML/year). The results indicated a runoff of 2,448 ML/year before the project implementation and 1,682 ML/year after the project implementation, leading to a reduced runoff of 2,448 – 1,682 = 766 ML/yr. |
| Complementary indicator | The complementary indicator selected is the area with improved agricultural practices: 2,000 acres. |
| Comments | Meteorological data, soil type, and slope information were provided by a literature review and by consulting local stakeholders. |
| Other considerations | Because cover crops planting are mostly incentive based, implementation of this project should be confirmed annually. For how many years will this project be funded? If the farmer takes over funding of cover crops, will reduced benefit be claimed based on overall cost share, or will no benefit be claimed based on an annually calculated cost share? |

## Appendix A-2. Withdrawal and Consumption Methods

### Activities and Indicators

The Withdrawal and Consumption methods enable estimation of the volumetric benefit of the following activities using the referenced output indicators below:

| CATEGORY | ACTIVITIES | OUTPUT INDICATOR |
|---|---|---|
| Aquatic habitat restoration | Legal transactions to keep water in-stream | Reduced withdrawal |
| Water supply reliability | Operational efficiency measures | |
| | Leak repair | |
| | Consumer use efficiency measures | |
| | Water reuse | |
| | Agricultural water demand reduction measures | Reduced consumption (or) reduced withdrawal |

Activities that involve agricultural irrigation efficiency measures are less straightforward and may encompass a wide range of projects with varying levels of complexity. For agriculture irrigation efficiency projects, either the Reduced Consumption or Reduced Withdrawal method is applicable based on the local context. The following simple cases offer examples:

Case 1: Irrigated cropland is located in an area with competing demands for existing water resources and the water is tightly allocated. Improved irrigation efficiency measures are implemented with the objective of reducing irrigation water applied. In this context, the Reduced Withdrawal approach is applicable.

Case 2: Irrigated cropland relies on a water source that is already scarce (e.g., depleted groundwater) and the existing irrigation method results in excessive nonbeneficial consumptive (i.e., water evaporated and not used by the crop) loss of water. Improved irrigation efficiency measures are implemented with the objective of promoting sustainable use of the scarce water resource through reduction in nonbeneficial consumptive use. In this context, the Reduced Consumption approach is applicable.

The above examples illustrate that in both cases improved irrigation efficiency measures are adopted, but either the Reduced Consumption or Reduced Withdrawal method is applicable depending on the project objective and local context. If the context is less clear, the Reduced Consumption method will provide a conservative estimate of the VWB.

Many studies have reported that well-intentioned irrigation water conservation measures may have unintended consequences, in which seemingly more efficient irrigation measures can result in greater net consumptive use, ultimately lessening the water availability. This is referred to as the "water efficiency paradox" (Scott et al. 2014) or the Jevons paradox (Sears et al. 2018). This situation may arise due to change in farmers' behavioral response to an increase in irrigation efficiency, which may include change in cropping pattern to a more water-intensive crop, increase in cropping area, and irrigating previously unirrigated land, resulting in an increase rather than a decrease in consumption. However, recent studies suggest that these unintended consequences can be avoided, and there is considerable potential for water conservation in irrigated agriculture when proper consideration is given to water budget accounting and essential policies and regulations can be put in place (Richter et al. 2017; Sears et al. 2018). It should be noted that addressing unintended consequences is beyond the scope of the VWB method, but practitioners should carefully consider these factors in the project selection and implementation process.

### Methodology Description

The Withdrawal method is applied to calculate the long-term average annual reduced volume of water withdrawn for use. Withdrawal is calculated (6) as volume of water diverted from the source (i.e., surface or groundwater) based on the duration of the diversion and the diversion flow rate over that time. Withdrawal volume can also be based on the volume leased or purchased through transactions involving water rights, where the reduced volume withdrawn is reassigned to keep the water in-stream. Because the volume protected for in-stream use may be limited to a historic consumptive use fraction, the Consumption method may be more appropriate in some cases.  For both methods it is important to consider the context of the project and where the benefit accrues. For projects involving legal transactions, the reduced diversion protected for in-stream use is usually limited to the primary reach (i.e., affected or dewatered reach). Therefore, the reduced VWB we describe is applicable to the primary reach that benefits from the diverted volume. But note that the benefits of flow restoration may extend downstream beyond the primary reach to secondary reaches to achieve hydrologic connectivity as well as recreation and biodiversity benefits.

**Withdrawal volume = (Diversion flow rate) x (Duration of diversion**

(6)

The Consumption method (7) adjusts the withdrawal volume to subtract return flows.

**Consumed volume = (Withdrawal volume) * (1 - Return Flow Fraction**

(7)

Return flows are the portion of water withdrawn that is returned to the source through percolation or surface runoff. The return flows may enter the same waterbody either at the location where they were withdrawn or at another location downstream (or upstream); in this later case (another location), the efficiency of the return flow must be supported with available information. Return flows vary with crop and irrigation type.

Both the Withdrawal and Consumption methods can be applied using a spreadsheet. To the extent possible, the inputs described below should correspond to average conditions to preclude the effects of wet or dry conditions.

## Required Inputs

| EQUATION | VARIABLE | INPUT |
|---|---|---|
| Withdrawal volume (6) | Diversion flow rate | Average monthly diversion flow rate (or other timescales may be used, if available) |
| | Duration of diversion | Duration of diversion |
| Consumed volume (7) | Withdrawal volume | Average monthly diversion flow rate (or other timescales may be used, if available) |
| | | Duration of diversion |
| | Return flow fraction | Return flow fraction |

To the extent possible, a description of the "with-project" and "baseline" (i.e., without-project) conditions, accompanied by site-specific photographs of project activities, should be documented and discussed to provide context to the project activities.

## Applications

Several activities can reduce the volume of water withdrawn from a source, including legal transactions (e.g., water rights leases or purchases), operational efficiency measures, leak repair, irrigation canal piping, efficiency measures, and water reuse. The reduced withdrawal volume is calculated as the difference in withdrawal volume for the "with-project" condition compared to the "baseline" condition (8). The "baseline" condition describes the current withdrawal. The "with-project" condition represents withdrawal after implementation of efficiency measures, water reuse, leak repair, or legal transactions. If metered or monitored data are not available, the withdrawal volume can be calculated.

For legal transactions, the VWB can be determined based on the water rights leased or purchased and the duration (e.g., 10 cfs of water rights are leased for in-stream flow between December and February), with the actual VWB occurring when the volume is available in-stream. The diversion flow rate can vary over time. To account for this variability, a conservative estimate of diversion flows (i.e., diversion flows representative of dry periods) should be used. When the objective is to restore streamflow in a dewatered reach or enhance streamflow for a targeted fish population, the period of diversion or flow rate may be narrowed to focus only on the period of ecological significance, such as the spawning period and/or the flow rate providing that benefit.

$$\textbf{VWB} = \textbf{(Diversion flow rate reallocated for in-stream flow)} * \textbf{(Duration)} \tag{8}$$

For measures that improve water use efficiency or repair leaks, baseline and with-project withdrawal volumes may be obtained from the water provider or facility/home water bills (reduced withdrawal for consumer use efficiency measures, such as installing low-flow showerheads, can also be based on the number of showerheads installed, the flow rate of the old and newer more efficient showerheads, and assumptions regarding daily shower usage). For water reuse projects, the reduced withdrawal volume can be calculated based on the volume reused (e.g., the volume of treated effluent used for landscaping in place of potable water). For all these applications, the VWB is calculated as the decrease in withdrawal volume (9).

$$\textbf{VWB} = \textbf{Withdrawal}_{\text{baseline}} - \textbf{Withdrawal}_{\text{with-project}} \tag{9}$$

Agricultural irrigation efficiency measures can reduce consumption by converting from less efficient irrigation methods, such as flood irrigation, to more efficient irrigation methods, such as drip irrigation, or by lining or piping conveyance ditches to reduce transmission loss. Crop conversion can also reduce consumption when crops with a higher evapotranspiration rate are replaced with crops having a lower evapotranspiration rate, or when fields are fallowed. Consumption is estimated based on withdrawal volume and adjusted to account for return flow fraction. Return flow fraction, expressed as a percentage, is the fraction of the withdrawal volume that is not consumed and is returned to the source. The reduced consumption volume is calculated as the difference in consumption volume between the "with-project" and "baseline" conditions (10). The VWB is calculated as the decrease in consumption volume.

$$\textbf{VWB} = \textbf{Consumption}_{\text{baseline}} - \textbf{Consumption}_{\text{with-project}} \tag{10}$$

## Illustrative Example of How to Apply the Withdrawal Method

| CASE STUDY | IRRIGATION EFFICIENCY FOR COFFEE FARMERS |
|---|---|
| Activity | Irrigation efficiency practices |
| Shared water challenge(s) addressed | Seasonal surface water scarcity and/or falling groundwater level, competition over allocation of water |
| Project description | The project targets coffee farmers in Vietnam's Central Highlands and aims to implement improved irrigation demand management, reaching 50,000 farmers. This project is currently being implemented, and monitoring is ongoing. The estimated volume benefit is a projection (potential benefit rather than actual benefit). |
| Location | Vietnam |
| Project start date | 2014 (first partnership established) |
| Project end date | Still running |
| Preproject (baseline) condition | It is assumed that coffee farmers use 1,000 liters (withdrawal) per coffee tree per irrigation round. There are three irrigation rounds per year. |
| Postproject condition | Projected condition: It is assumed that coffee farmers use 400 liters (withdrawal) per coffee tree per irrigation round, with a 60 percent adoption rate (estimated). |
| VWB indicator | Reduced withdrawal |
| VWB indicator calculations | With conventional irrigation practices, on average 1,000 liters of water are used per coffee tree per irrigation round, and farmers use three irrigation rounds. The hectares per farmer are equivalent to 1 ha approximatively with 1,100 trees per ha. This leads to 165,000 ML/year used for the baseline, considering all the 50,000 project beneficiaries. For the postproject condition, water use of 400 liters per tree (60% less) translates to 66,000 ML/yr, which results in 99,000 ML/year of "reduced withdrawal." The project targets a 60% adoption rate by the farmers, equivalent to absolute "reduced withdrawal" of 59,400 ML/year (potential benefit). |
| Complementary indicator | The complementary indicator selected is the number of ha with improved irrigation: 60% *50,000 ha = 30,000 ha. |
| Comments | N/A |
| Other considerations | The calculation example is a preproject estimate that assumes a 60% adoption rate. The VWBA should be calculated after the project is completed based on the actual adoption rate, volume withdrawn, and other measured inputs, if available. Additionally, life expectancy or useful life of irrigation equipment should be considered when forecasting the benefits for future years. According to the VWB method, the result is a potential benefit and not an actual benefit. |

# Appendix A-3. Volume Provided Method

## Activities and Indicators

The Volume Provided method enables estimation of the volumetric benefit of the following activities using the referenced output indicator below:

| CATEGORY | ACTIVITIES | OUTPUT INDICATOR |
|---|---|---|
| Water Access | New water supply for crop irrigation | Volume provided |
| | Access to drinking water supply | |

Water access activities provide a volume of water that contributes to improving human health and/or livelihood, as well as social or economic security. Activities may provide a new source of water or make water usable through treatment (e.g., water treatment plants, point of use treatment). Water access activities are typically located in water-stressed regions and may increase stress on water resources, although practitioners should make every effort to ensure that the water source is sustainable. Nevertheless, these are important projects with quantifiable volume benefits that make a positive difference in communities. The aggregation of these VWBs with those benefiting the environment is discussed in the "Communication and Aggregation" section of this working paper.

## Methodology Description

When a new supply of water is provided for irrigation, the flow of water should be metered if possible. Where metering is not feasible, the volume of water provided for crop irrigation (i.e., the withdrawal volume) can be estimated based on crop demand.

Metering is also preferred for drinking water access projects. However, where metering is not feasible, the volume provided can be calculated based on the number of direct beneficiaries receiving reasonable access to water. This method can be applied using a spreadsheet, provided the input data are readily available.

The VWB is calculated by multiplying the number of direct beneficiaries receiving reasonable access to water by a per-capita volume of water over the number of days of access (i.e., 365 days for full access projects). The World Health Organization and United Nations Children's Fund (WHO and UNICEF 2000) define reasonable access as the availability of at least 20 liters per person per day from a source within one kilometer of the user's dwelling. In the case where a local regulation (e.g., national regulation) defines "reasonable access to water" (or a similar concept) as more than 20 L/person/day and the project complies with the local regulation, the volume provided can be calculated based on the number of direct beneficiaries receiving this value of "reasonable access to water."

Because it can be difficult to determine who is using a particular water source, we recommend that someone familiar with the project determine the number of direct beneficiaries for drinking water supply projects.  In order to avoid overclaiming the benefit, the VWB can be capped at the minimum of the beneficiary-based VWB and the maximum daily delivery or pumping capacity, if known.

## Required Inputs

| EQUATION | VARIABLE | INPUT |
|---|---|---|
| New irrigation water supply (withdrawal volume) | Measured withdrawals | Metered flows, if available, or pump discharge rates and operating times |
| | Estimated irrigation requirements | Computer models such as CROWAT, or estimated based on crop water requirement, adjusted for rainfall and irrigation system efficiency:<br>■ Location<br>■ Irrigated area<br>■ Crop type<br>■ Crop evapotranspiration<br>■ Method of irrigation<br>■ Irrigation efficiency |
| Drinking water supply | Measured water volume | Metered flows, if available, or pump discharge rates and operating times |
| | Estimated water volume | Number of beneficiaries with reasonable access to water<br>Information regarding required per-capita availability (default is 20 L/day for full access)<br>If available, maximum delivery/pumping capacity of the new supply |

To the extent possible, site-specific photographs of project activities should be provided and should be documented and discussed to provide context to the project activities.

The quality of the irrigation water should meet relevant irrigation standards.

Drinking water at the point of collection should meet international drinking quality standards, come from an improved water source, and comply with WHO/UNICEF WASH Guidance (WHO and UNICEF 2000).

## Applications

- **New water supply for irrigation**

Water provided for irrigation supply projects should meet local irrigation quality standards. Several options are available for quantifying irrigation volume, but metering should be conducted if possible.

- Option 1: Metered data, if available, are preferred.
- Option 2: In the absence of metered flows, estimates of irrigation volumes can be based on observed surface water diversion flows and duration or groundwater pumping discharge rates and their operating hours.
- Option 3: The volume of water provided can be estimated based on the crop-specific irrigation requirement, which is based on the crop water requirement. The crop water requirement is the total water required for crop growth at a given location and can be obtained from the literature or local agricultural agencies. The irrigation requirement is estimated by adjusting the crop water requirement for available rainfall and considering the efficiency of the irrigation system.
- Option 4: Additional methods for calculating the irrigation requirement are described below:
  - The irrigation requirement can also be estimated using the location- and crop-specific blue water footprint reported in the database of the Water Footprint Network (Mekonnen and Hoekstra 2010) and accounting for irrigation efficiency (e.g., as found in Siebert et al. 2010), average crop yield, and the area irrigated.
  - The CROPWAT model developed by the Food and Agriculture Organization (FAO 2019) supports calculation of crop water requirements and irrigation requirements based on soil, climate, and crop data. Application of CROPWAT requires technical expertise.

The VWB is calculated as the average annual volume of irrigation water provided (11).

**VWB = Average annual volume of irrigation water provided**

(11)

## Access to drinking water supply

Water provided for drinking water supply, either due to a new supply or water treatment, should meet drinking water standards, and the beneficiaries should have reasonable access either in households or outside (e.g., public areas). If metered data are not available, the volume provided can be calculated based on the number of beneficiaries with reasonable access and a conservative estimate of per-capita volume provided. In this case without metered data, the annual volume provided can be calculated by multiplying the number of beneficiaries by 20 liters per person per day and 365 days per year (or a reduced number of days depending on the period of operation, e.g., if shut off for repairs). The VWB is calculated as the average volume of drinking water provided annually. If a local regulation (e.g., national regulation) defines "reasonable access to water" (or a similar concept) as more than 20 L/person/day and the project is confirmed to comply with the regulation, the volume provided can be calculated based on the number of beneficiaries receiving this value of "reasonable access to water" and 365 days per year. If the VWB is calculated and the supply capacity (based on delivery/pump capacity) is known, the VWB should be based on the minimum of the supply capacity or beneficiary-based volume to avoid overstating benefits (12).

**VWB = Average annual volume of drinking water provided**

(12)

## Illustrative Example of How to Apply the Volume Provided Method

| CASE STUDY | ACCESS TO DRINKING WATER |
|---|---|
| Activity | Repair of community water pumps |
| Shared water challenge(s) addressed | WASH needs not met; in particular, access to water |
| Project description | The specific needs of cocoa farmers in Côte d'Ivoire have been targeted in this project, developed with the International Federation of Red Cross and Red Crescent Societies as the main partner. The activity focused on addressing WASH needs comprehensively, through various specific activities of water pumps repaired or rehabilitated, latrines built, local committees established in charge of ensuring long-term service, installing handwashing facilities, awareness training, etc. The activities are multiple, and the focus chosen here is on the number of beneficiaries with access to drinking water: 109,990 by 2016. |
| Location | Côte d'Ivoire |
| Project start date | 2007 |
| Project end date | Still running |
| Preproject (baseline) condition | The assumptions are that no community members had access to safe drinking water and that no community members would have access to drinking water in the years to come. |
| Postproject condition | By 2016, beneficiaries' access to drinking water needs was covered by the project's activities. We assume that the pumps were maintained for the duration of the project until this date. There are 109,990 beneficiaries. |
| VWB indicator | Volume provided |
| VWB indicator calculations | Although the volume of water provided from the water pumps and other specific activities was not measured, based on the number of beneficiaries it is possible to calculate the volume provided, using the average needs of a person of 20 L/day (WHO and UNICEF 2000). Given that there are 109,990 beneficiaries, the total water provided is estimated by the following equation:<br><br>VWB (ML/year) = 7,300 L/year-beneficiary * 109,990 (beneficiaries) = 803 ML/year (potential benefit). |
| Complementary indicator | The complementary indicator selected is the number of beneficiaries: 109,990 beneficiaries. |
| Comments | N/A |
| Considerations | If the delivery capacity is known, consider whether it is equal to or larger than the per capita estimated VWB. Is the supply available 365 days/year or does the duration need to be adjusted for periods when the pump is being repaired? Is the cost share calculated based only on the water access activity (recommended, if possible), or on all project activities? Will benefits be claimed in full the year the project was completed, or the year after the project was completed? Is the project being monitored and maintained to ensure that the full water supply remains available 365 days/year in future years? Is the water tested to ensure that it is safe to drink? |

## Appendix A-4. Capture and Infiltration Method

### Activities and Indicators

The Capture and Infiltration method enables estimation of the volumetric benefit of the following activities using the referenced output indicator below:

| CATEGORY | ACTIVITIES | OUTPUT INDICATOR |
|---|---|---|
| Water supply reliability | Rainwater harvesting | Increased recharge |

### Methodology Description

The Capture and Infiltration method is applied to calculate the volume recharged to groundwater, based on available supply (i.e., volume draining from catchment), the volume captured by these interventions and losses associated with evaporation (if any) and use (i.e., withdrawal) (13). First, the method calculates the volume captured as the minimum of available supply (16) and storage potential (14). Storage potential is based on the design storage capacity of the intervention and the number of times it fills to capacity (15). Recharge volume is calculated by subtracting evaporation and usage losses from the volume captured as follows:

**Recharge volume = Volume captured – [Evaporation + Withdrawal**

(13)

**Volume captured = Min [Available supply, Storage potential]**

(14)

**Storage potential = Design storage capacity x Number of times filled to capacity**

(15)

**Available supply = Catchment area * Runoff coefficient * Annual rainfall**

(16)

The method can be applied using a spreadsheet.

### Required Inputs

| EQUATION | VARIABLE | INPUT |
|---|---|---|
| Recharge volume (13) | Volume captured | Available supply<br>Storage potential |
| | Evaporation | Evaporation from the intervention |
| | Withdrawal | Withdrawals from the intervention |
| Volume captured (14) | Available supply | Catchment area draining to the intervention<br>Catchment runoff coefficient<br>Average annual precipitation from a representative weather station |
| | Storage potential | Design storage capacity<br>Number of times filled to capacity |
| Storage potential (15) | Design storage capacity | Design storage capacity of the intervention |
| | Number of times filled to capacity | Number of times the intervention fills to capacity |
| Available supply (16) | Catchment area | Catchment area draining to the intervention |
| | Runoff coefficient | Catchment runoff coefficient |
| | Annual rainfall | Average annual precipitation from a representative weather station |

To the extent possible, a description of the aquifer that will benefit from artificial recharge and a description of the "with-project" and "baseline" (i.e., without-project) conditions, accompanied by site-specific photographs of project activities, should be documented and discussed to provide context to the project activities.

## Applications

Infiltration trenches, recharge shafts, pits, wells, checkdams, and ponds capture excess rainfall and runoff for groundwater recharge and community, economic, and/or ecosystems use. Increased recharge is calculated as the difference in recharge volume for the "with-project" condition compared to the "baseline" condition. The "baseline" condition typically has no recharge, unless the project improves the recharge capability of an existing intervention (e.g., by desilting an existing pond). The "with-project" condition represents construction of rainwater capture interventions to increase recharge.

The method is applied through the following steps:

- The *available supply* is calculated by multiplying the catchment area by the annual average precipitation (rainfall depth) and an appropriate catchment runoff coefficient.
- *Storage potential* is then calculated based on the design storage capacity of the intervention(s) and the number of times the intervention(s) fill(s) to capacity during a typical year.
- The *volume captured* is then calculated as the minimum of available supply and storage capacity.
- Finally, the *volume available* for recharge is calculated by subtracting evaporative and usage losses (for some features, such as infiltration pits and wells, the usage and evaporation losses may be negligible) from the volume captured, if applicable. The VWB is quantified as the difference in recharge volume for the "baseline" and "with-project" conditions (17).

$$\textbf{VWB} = \textbf{Recharge}_{\text{With-project}} - \textbf{Recharge}_{\text{Baseline}}$$

(17)

*Note:* For rainwater harvesting projects, typically the "baseline" recharge volume can be assumed to be 0, and the equation simplifies to VWB = "with-project" recharge.

The approach described above is most simply applied on an average annual basis. If data are available and more certainty is desired, sophisticated algorithms can be developed to support application of this approach on a daily or monthly basis, or to support a variation of this approach based on infiltration rates corresponding to each intervention.

# Appendix A-5. Volume Captured Method

## Activities and Indicators

The Volume Captured method enables estimation of the volumetric benefit of the following activities using the referenced output indicator below:

| CATEGORY | ACTIVITIES | OUTPUT INDICATOR |
|---|---|---|
| Water quality | Stormwater management | Volume captured |

## Methodology Description

The volume captured through stormwater management can be calculated using the Runoff Reduction method (Hirschman et al. 2008). This method involves two steps.

- First the volume of stormwater directed to a BMP is calculated. This supply volume is calculated by multiplying annual average rainfall by the runoff coefficients that correspond to the site land cover conditions (18).

**Supply volume = Annual average rainfall x Surface area x Runoff coefficient**

(18)

The proportional area of pervious (forest, turf, etc.) and impervious (concrete, metal, etc.) surfaces and their corresponding runoff coefficients should be considered in the supply volume calculations. This is done by calculating the supply volume associated with each surface's characteristics in the runoff contributing area and then adding to calculate the total supply volume.

- The volume captured is then calculated by multiplying the supply volume estimated in Step 1 by a runoff reduction factor corresponding to the BMP. The BMP-specific runoff reduction factor can be obtained from relevant literature (e.g., Hirschman 2018).

The VWB is calculated as the volume captured (19):

**Volume captured = Supply volume * Runoff reduction factor (%)**

(19)

### Required Inputs

| EQUATION | VARIABLE | INPUT |
|---|---|---|
| Supply volume (18) | Annual average rainfall | Annual average rainfall depth for a representative weather station |
| | Surface area | Total catchment area draining to the BMP |
| | Runoff coefficient | Land cover characteristics<br><br>Runoff coefficients corresponding to each land cover in the catchment draining to the BMP |
| Volume captured (19) | Supply volume | Annual average rainfall<br><br>Total surface area draining to the BMP |
| | Runoff reduction factor | BMP-specific runoff reduction factor (%) |

To the extent possible, a description of the "with-project" and "baseline" (i.e., without-project) conditions, accompanied by site-specific photographs of project activities, should be documented and discussed to provide context to the project activities.

*Note*: Small-scale BMPs, such as rainwater tanks and cisterns for capturing rainwater from residential rooftops, may be installed at multiple locations within the same project area. Because the individual rooftop areas may be small, the volume captured by each BMP may not be significant. In these cases, the rooftop areas can be aggregated and multiple BMP installations can be represented as a single activity to calculate the total VWB.

### Applications

Stormwater BMPs are commonly used to intercept and slow runoff from highly impervious areas, helping to reduce flooding risk and improve water quality. BMPs that are typically implemented for stormwater management include green roofs, permeable pavement, grass channels, bioretention, dry and wet swales, soil amendments, rain tanks, cisterns, ponds, and constructed wetlands.

The method is applied through the following steps:

- The BMP type and the associated inputs are identified.
- The *supply volume* is calculated based on annual average rainfall, surface area, and an appropriate runoff coefficient.
- The *volume captured* is then calculated by applying a runoff reduction factor specific to the BMP.
- The VWB is quantified as the difference in the volume captured for the "baseline" and "with-project" conditions (20).

$$\textbf{VWB} = \textbf{Volume captured}_{\text{With-project}} - \textbf{Volume captured}_{\text{Baseline}} \quad (20)$$

*Note*: For stormwater BMPs, typically the "baseline" volume captured can be assumed to be 0, and the equation simplifies to VWB = "with-project" volume captured.

## Appendix A-6. Volume Treated Method

### Activities and Indicators

The Volume Treated method enables estimation of the volumetric benefit of the following activities using the referenced output indicator below:

| CATEGORY | ACTIVITIES | OUTPUT INDICATOR |
|---|---|---|
| Water quality | Constructed wetland treatment systems | Volume treated |
| | Wastewater treatment plants | |

### Methodology Description

This method applies to constructed treatment systems that improve water quality. In some cases, these projects benefit wildlife and birds and/or increase recharge, and such projects are addressed in Appendix A-7. The approach can be applied to constructed wetland treatment systems that are designed to capture and treat non–point source runoff. It can also be applied to wastewater treatment plants (point sources).

The method involves a four-step process:

- Select locally relevant water quality target(s) relevant to the pollutant(s) of concern and tied to the recognized uses of the receiving water (e.g., designated or actual uses). If locally relevant numeric water quality criteria or quantitative guidelines do not exist, relevant guidelines or standards published by the World Health Organization (WHO), U.S. Environmental Protection Agency (US EPA), European Union, or another reputable organization may be applied.
- Confirm that the influent water does not meet the water quality target (before treatment).
- Confirm that the treated discharge meets the appropriate target(s). Attainment should be demonstrated with monitoring data where possible, or by following design specifications based on similar, well-proven demonstration systems.
- Estimate the volume of water treated annually. The volume of treated water should be metered where possible. In the absence of metered data, the design capacity of the treatment system can be used. For treatment wetlands, volume can be estimated based on surface runoff calculations as appropriate or based on another relevant method.

## Required Inputs

| VARIABLE | INPUT |
|---|---|
| Influent water quality | Monitoring data to demonstrate that the water quality of the influent water does not meet the water quality target(s) (before treatment). Samples should be collected at a defined system inlet. |
| Effluent water quality | Effluent water quality measurements, collected at a defined system outlet, to demonstrate that the water quality target(s) are met as a result of treatment |
| Metered flow | Measurements of annual flow through the treatment system |
| Estimated flow | Design capacity of the treatment system<br><br>Surface runoff calculations or other relevant method |

Additionally, provide information supporting the appropriate water quality target(s) and design capacity of the treatment system.

## Applications

- **Constructed wetland treatment systems**

The method is applied in a stepwise fashion to calculate the volume of water treated and assumes that the wetland has the capacity to treat the full volume of water intercepted.

- ☐ **Step 1**: The appropriate target(s) should address the project objectives and established impairments, and be based on locally relevant, established water quality target(s) tied to the recognized uses of the receiving water (e.g., designated or actual uses). For example, an appropriate target for a wetland system designed to treat agricultural runoff contributing to high levels of nitrate in drinking water should bring the discharge water quality to an appropriate nitrate water quality standard, such as the U.S. Environmental Protection Agency's maximum contaminant level (MCL) of 10 mg/L for drinking water. If the project objective is to provide clean water needed for irrigation, the treatment system should bring discharge water quality to an appropriate irrigation water quality target.

- ☐ **Step 2:** Water quality data collected at the inlet are evaluated to confirm that the incoming water is not meeting the target.

- ☐ **Step 3**: Water quality collected at the outlet are evaluated to determine if the system is improving water quality from a condition of not meeting the target to a condition of meeting the target. This determination may not be needed if the system is designed according to a recognized standard based on demonstration wetlands that has been tested and proven to achieve the desired water quality.

- ☐ **Step 4**: The annual flow through the wetland system should be based on metering where feasible. In the absence of metered flow data, the flow through the wetland system can be computed based on site characteristics, including drainage basin area and precipitation, and a runoff model (see Methodology Guidance A-1), recognizing that a different approach may be required for tile drainage systems (21).

**VWB = Annual volume of water treated by the treatment wetland**

(21)

- **Wastewater treatment plants**

The method is applied in a stepwise fashion to calculate the volume of water treated.

- ☐ **Step 1**: The appropriate target(s) should address the project objectives and established impairments, and be based on a locally relevant, established water quality target(s) tied to the recognized uses of the receiving water (e.g., designated or actual uses). For example, if the treatment plant is being constructed to address fecal coliform bacteria, then the target should be based on effluent standards that are appropriate for the use of the receiving water (e.g., drinking, irrigation, swimming).

- ☐ **Step 2:** Water quality data collected at the inlet are evaluated to confirm that the incoming water is not meeting the target.

- ☐ **Step 3**: Water quality data collected at the outlet are evaluated to determine if the system is improving water quality from a condition of not meeting the target to a condition of meeting the target. Water quality data collected at the inlet may not be needed if it is known that the treatment plant is receiving raw sewage; however, effluent quality data should be evaluated to demonstrate attainment of the target.

- ☐ **Step 4**: The annual flow through the wastewater treatment plant should be based on metering. In the absence of sufficient metered flow data, the annual flow through a wastewater plant may be estimated based on the design capacity of the plant (22).

**VWB = Annual volume of water treated by the wastewater treatment plant**

(22)

### Illustrative Example of How to Apply the Volume Treated Method

| CASE STUDY | WASTEWATER TREATMENT PLANT RENOVATION |
|---|---|
| Activity | Renovation of a municipal wastewater treatment plant |
| Shared water challenge(s) addressed | Water quality |
| Project description | The capacity of the municipal wastewater treatment plant was too low compared to the population: in 2002, the plant was treating effluents for 265,000 inhabitant equivalents, whereas the plant was designed for 160,000 inhabitant equivalents.<br><br>The wastewater treatment plant was renewed in 2008, and the capacity was increased to 350,000 inhabitant equivalents.<br><br>The aim of this renovation was to improve the quality of the receiving water body (river).<br><br>At that time, regulated pollutant removals applied to TSS, BOD5, COD, and nitrogen (N). |
| Location | France |
| Project start date | 2008 |
| Project end date | Still running |
| Preproject (baseline) condition | Until 2008, pollutant removal rate targets were met for TSS, COD, and BOD5. The pollutant removal target was not met for total N. |
| Postproject condition | From 2008, pollutant removal targets were met for all regulated pollutants, including total N (removal rate >80%). |
| VWB indicator | Volume treated |
| VWB indicator calculations | VWB = Annual volume of water treated by the wastewater treatment plant<br><br>The average volume treated is 12,000 ML/year<br><br>VWB = 12,000 ML/year |
| Complementary indicator | Pollutant load removed: compared to the baseline (situation before the project), the project removed 35,000 kg N/year. |
| Comments | Water quality targets are derived from the local regulation related to wastewater systems (LegiFrance 2015). |
| Considerations | Who will be responsible for the continued operation of the plant? What is the frequency of monitoring and maintenance? What parameters will be tested? Who pays for monitoring, maintenance, and reporting, and will this cost be included in the cost-share calculation? |

| CASE STUDY | CONSTRUCTED WETLAND RESTORATION |
|---|---|
| Activity | Restoration of constructed wetland |
| Shared water challenge(s) addressed | Water quality issues due to irrigation runoff and municipalities wastewater |
| Project description | The project aimed at restoring a constructed wetland established in 2007, but which stopped ensuring its service due to lack of maintenance. The project entailed revegetation, structural improvements, and water management in general. Monitoring of water and biodiversity were also installed. |
| Location | Spain |
| Project start date | 2010 |
| Project end date | 2013 |

| | |
|---|---|
| Preproject (baseline) condition | The total nitrogen indicator was used as the critical pollutant after reviewing a list of different pollutants. The limit concentration for total nitrogen was set based on a literature review and is 3.0 mg N/L. The concentration of total nitrogen in the water before the implementation of the project was 4.2 mg/L. |
| Postproject condition | After the implementation of the project, the total nitrogen concentration fell to 2.6 mg/L, with certain variability that was recorded during the year 2015 through 20 measures across the year. All the measures were below the 3.0 mg N/L threshold. |
| VWB indicator | Volume treated |
| VWB indicator calculations | The outflow of the constructed wetland was considered as the volume treated, given that its nitrogen concentration fell entirely below the threshold identified of 3.0 mg N/L. The inflow and outflow of the wetland were recorded with an average 1,735 ML/year outflow in 2015. The VWB is thus 1,735 ML/year. |
| Complementary indicator | The complementary indicator selected is the area covered by the restored constructed wetland: 25 ha. |
| Comments | N/A |
| Considerations | Will the treatment wetland need to be maintained to ensure proper operation? Who is responsible? |

## Appendix A-7. Recharge Method

### Activities and Indicators

The Recharge method enables estimation of the volumetric benefit of the following activities using the referenced output indicator below:

| CATEGORY | ACTIVITIES | OUTPUT INDICATOR |
|---|---|---|
| Aquatic habitat restoration | Wetland protection | Maintained recharge |
| | Wetland restoration | Increased recharge |
| | Floodplain inundation / reestablish hydrologic connection | Varies based on objective |

In addition to enhancing recharge, wetlands provide surface water benefits, including flow attenuation and hydroperiod regulation, aquatic habitat benefits, and water quality treatment benefits (described in Appendix A-6). If recharge is not the objective or the primary hydrologic function provided by the project wetland, an alternative approach for quantifying the VWB may be warranted. Alternative approaches may include evaluation of inundation volume, increased storage volume, or hydroperiod restoration, depending on the primary objective of the project. Additionally, some wetland projects are designed to increase groundwater storage capacity (e.g., high mountain wet meadows). For each of these approaches it is important to understand the primary objective and the volume of water, or critical flow and time period, over which it is providing the benefit.

For example, the VWB of a floodplain reconnection project may be calculated as the increased inundation volume (increased inundation area * average depth * average number of inundations). Alternatively, the VWB of a side channel reconnection project may be calculated as the minimum flow providing habitat benefits to a key species and the duration over which that benefit is provided (e.g., spawning period for a migratory fish).

### Methodology Description

Wetlands capture rainfall and runoff and the water infiltrates and may recharge an aquifer. Where recharge occurs, this method estimates the volume infiltrated based on ponded surface area and infiltration rate, accounting for the amount of time that water is retained in the wetlands.

The volume recharged is equal to the product of the wetland surface area, the infiltration rate based on soil texture, and the duration of time the wetland is inundated (23). This method is applicable for wetland types that provide recharge function.

$$\textbf{Volume recharged} = \textbf{Wetland surface area} * \textbf{Infiltration rate} * \textbf{Duration of inundation} \quad (23)$$

The method involves a simple calculation comparing recharge volume for the "with-project" and "baseline" (i.e., without-project) conditions, and applies to both protected and restored wetlands.

### Required Inputs

| VARIABLE | INPUT |
|---|---|
| Surface area | Wetland surface area, when inundated, reflecting average conditions |
| Duration | Average number of days each year that the wetlands are inundated |
| Infiltration rate | Infiltration rate specific to the soil texture underlying the wetland |

To the extent possible, a description of the aquifer that will benefit from recharge and a description of the "with-project" and "baseline" conditions, accompanied by site-specific photographs of project activities, should be documented and discussed to provide context to the project activities.

## Applications

The change in recharge volume is the primary method for calculating the VWB of protecting or restoring wetlands. However, as noted above, an alternate method may be warranted depending on the project objective.

**a. Wetland protection**

When wetlands are drained, and the land is converted to other uses such as cropland or residential development, they no longer function as recharge areas. Wetland protection, accomplished through conservation easements or acquisition, protects the infiltration and groundwater recharge capacity of the wetlands. The need for protection and the likely future use of the land if not protected should be established. This can be accomplished through communication with local experts, evaluation of maps or reports describing trends in wetland losses, or evaluation of aerial or satellite imagery over time.

The recharge volume is quantified for two conditions: the "baseline" condition (drained or degraded wetland) and the "with-project" condition (current condition with intact healthy wetland). First, the annual recharge volume is calculated for each condition based on the average wetland surface area, number of days of inundation, and infiltration rate. The VWB is then quantified as the difference in annual recharge volume between the two conditions (24).

$$\textbf{VWB} = \textbf{Recharge}_{\text{With-project}} - \textbf{Recharge}_{\text{Baseline}}$$

(24)

**b. Wetland restoration**

Wetland restoration increases infiltration and groundwater recharge due to the increased volume of water stored in the wetland. The increase in recharge is quantified for two conditions: the "baseline" condition (current drained or degraded wetland) and the "with-project" condition (restored wetland). First, the annual recharge volume is calculated for each condition based on the average wetland surface area, number of days of inundation, and infiltration rate. The VWB is quantified as the difference in annual recharge volume between the two conditions (25).

$$\textbf{VWB} = \textbf{Recharge}_{\text{With-project}} - \textbf{Recharge}_{\text{Baseline}}$$

(25)

# Appendix A-8. Hydrograph Method

## Activities and Indicators

The Hydrograph method enables estimation of the volumetric benefit of the following activities using the referenced output indicator below:

| CATEGORY | ACTIVITIES | OUTPUT INDICATOR |
|---|---|---|
| Aquatic habitat restoration | In-stream barrier removal | Improved flow regime |
| | Dam reoperation | |

## Methodology Description

A hydrograph shows the rate of flow versus time past a specific point in a river. The Hydrograph method evaluates the change in the hydrograph that results from removal of an in-stream barrier or due to dam reoperation. First, this method requires hydrographs from before and after the dam or barrier removal or dam reoperation, for the time period of ecological significance. Hydrographs can be obtained from (a) a flow time series derived from stream flow monitoring or (b) a hydraulic model that simulates the baseline (i.e., without-project) and with-project conditions. Second, the with-project hydrograph is subtracted from the baseline on a daily basis. This is expected to result in both positive and negative differences, both of which can represent a return toward a more natural flow regime. The absolute value of the difference in the two hydrographs is calculated on a daily basis and then summed over the period of interest. The VWB is calculated as the volume difference between the two hydrographs (26).

$$\textbf{[Hydrograph change]}_{\text{Daily time-step}} = \textbf{[Flow]}_{\text{Baseline}} - \textbf{[Flow]}_{\text{With-project}}$$

(26)

The absolute value of the difference in the two hydrographs on a daily time-step is summed over the period of interest (27).

$$\textbf{VWB} = \sum\textbf{[Hydrograph change]}_{\text{Daily time-step}}$$

(27)

## Required Inputs

| EQUATION | VARIABLE | INPUT |
|---|---|---|
| Hydrograph change (26) | Flow - measured (preferred) | Time series of flow (cfs) downstream of the barrier/dam for the baseline and with-project conditions |
| | Flow - modeled (in the absence of measured flows) | Channel geometry<br>Barrier/dam geometry<br>Manning's coefficients<br>Time series of upstream flow |
| | Time period | Identification of time period of ecological significance based on seasonal requirements of the target species |
| Volumetric water benefit (27) | Change in flow (absolute value) | Sum of daily change in flow (hydrograph change) |

To the extent possible, a description of the "with-project" and "baseline" conditions, accompanied by site-specific photographs of project activities, should be documented and discussed to provide context to the project activities.

## Applications

In-stream barrier removal and dam reoperation are activities that help restore a more natural flow regime to a river, which is particularly important during periods of ecological significance when streamflow is a limiting factor for target species. This method requires that the user determine the relevant period for in-stream flow restoration based on the project objectives. For example, the period may be based on provision of critical low flows during the spawning season, or on restoration of peak spring flows that are necessary for floodplain reconnection to support species dispersal and growth. Additionally, the user should develop or obtain "baseline" and "with-project" hydrographs to calculate the change in the flow regime over the period of ecological significance.

Hydrographs can be measured or developed using a model. If measured flows are used, they should be monitored at a location downstream from the barrier to represent the effects of "baseline" condition and "with-project" conditions. To the extent possible, hydrographs should be compared for years with similar climactic conditions so that the difference reflects the project and not differences in rainfall.

If a hydraulic model is used, the channel and in-stream barrier geometry should be represented for the baseline and with-project conditions. Upstream flows can be measured or estimated using a drainage area ratio to a representative flow series. Simulations should be conducted for an entire year to develop the hydrographs, but the VWB calculation should focus on the period of ecological significance.

HEC-RAS (US ACE 2018) and EPA-SWMM (US EPA 2018) are examples of modeling frameworks that can be applied to develop hydrographs. Both frameworks can simulate the impact of culvert removal.

In addition to the Hydrograph method, other potential methods can be considered for evaluating in-stream barrier removal projects. One potential VWB method is based on fish habitat requirements and the premise that, due to the presence of large in-stream barriers, the optimal water depth necessary for fish passage and habitat does not occur frequently. After channel restoration, the optimal depth is achieved more frequently due to the improved channel geometry and stream conditions. This method compares the frequency of time the optimal depth is achieved and considers the flow volume associated with that time period as the benefit. Application of this method would involve the use of a hydraulic model and knowledge of species-specific requirements. In some cases, using the impounded volume may provide a simple pathway to assess VWB considering that the small barriers or dams prevented habitat functions, and the removal of these structures frees up this impounded volume and contributes to natural flow and habitat function.

## Appendix A-9. Water Governance Activities Method

### Activities and Indicators

The Water Governance Activities method enables estimation of the volumetric water benefit of activities resulting from direct engagement in water governance and public water management.

Using the Water Governance Activities method, volumetric water benefits can be estimated using the same VWB indicators required to measure the VWBs of the WS activities that the water governance activities support.

### Methodology Description

The Water Governance Activities method requires that practitioners engage in and/or support water governance and public water management interventions that result in specific water stewardship activities that can be measured using the VWBA three-step method we propose.

### Required Inputs

Prior to engaging in and/or supporting water governance and public water management interventions, practitioners should identify the specific water stewardship activities and activity beneficiaries targeted as part of the engagement in water governance and/or public water management.

Once the water governance or public water management interventions result in specific water stewardship activities, practitioners can apply the three-step method to calculate and attribute/allocate the volumetric water benefits generated by that specific activity.

### Applications

For example, industries in Kenya's Lake Naivasha area contributed to improving local water management by funding a water allocation plan to guide the establishment of multiple local water resource users' associations and implement Kenya's national water policy (CEO Water Mandate 2010).

Using the Water Governance Activities method, industries in Kenya's Lake Naivasha area can apply the Withdrawal and Consumption methods to calculate the VWB associated with water savings resulting from the activities of the local water resource users' associations, using the withdrawal reduction indicator. Following that, industries in Kenya's Lake Naivasha area could attribute or allocate those VWBs to the stakeholders that were involved in funding the implementation of Kenya's national water policy by creating local water resource users' associations.

*Note*: Given how far removed the company may be from the activities resulting from water governance activities, organizations can opt to make a qualitative claim describing the governance activity and how it translated into water stewardship outcomes.

## Appendix A-10. Catalytic Activities Method

### Activities and Indicators

The Catalytic Activities method enables estimation of the volumetric water benefit of activities that pave the way for longer-term water stewardship outcomes, such as capacity building, deployment of monitoring systems, development of catchment numerical modeling tools, or investment in open source watershed data.

Using the Catalytic Activities method, volumetric water benefits can be estimated using the same VWB indicators required to measure the VWBs of the WS activities toward which the catalytic activities contribute.

### Methodology Description

The Catalytic Activities method requires that practitioners engage in and/or support catalytic activities that result in specific water stewardship activities that can be measured using the VWBA three-step method we propose.

### Required Inputs

Prior to engaging in and/or supporting catalytic activities, practitioners should identify the specific water stewardship activities and activity beneficiaries targeted as part of the engagement in the catalytic activity.

Once the catalytic activity results yield specific water stewardship activities, practitioners can apply the three-step method to calculate and attribute or allocate the volumetric water benefits generated by that specific activity.

### Applications

For example, a company funds the implementation of an automated headgate and telemetry monitoring system on an outdated ditch system—this modernization work was needed to pave the way for many future projects among a series of ditch users to use less water and conserve water in a river. However, this work did not, by itself, generate VWBs.

Using the Catalytic Activities method, the company can apply the Withdrawal and Consumption methods to calculate the VWB associated with water savings resulting from the activities of specific ditch users, using the withdrawal reduction indicator. Following that, the company can attribute or allocate those VWBs to the stakeholders that were involved in funding the automated headgate and telemetry monitoring system on the ditch system. We recommend that the project scope and costs include both the catalytic work on the headgate and telemetry monitoring system, and the other activities that reduce the volume withdrawn or consumed. Additionally, the implementing partner should be involved in the allocation of VWBs if multiple stakeholders are making volumetric claims.

*Note*: Given how far removed the company may be from the activities resulting from catalytic activities, organizations can opt to make a qualitative claim describing the catalytic activity and how it translated into water stewardship outcomes.

# GLOSSARY

- **Activity:** The interventions whose effects on natural and social capital are considered "outputs" and can be analyzed and quantified (adapted from WBCSD 2017). A water stewardship project may encompass multiple activities.
- **Allocation:** The distribution of volumetric water benefits among organizations where multiple organizations share a common volumetric water benefit.
- **Baseline:** The beginning points at which an organization or activity will be monitored and against which progress can be assessed or comparisons made (adapted from AWS 2019).
- **Benefit:** Long-term social, economic, and environmental effects resulting from the implementation of a project or activity, either directly or indirectly, intentionally or unintentionally. Benefits, which are the ultimate result, derive from outcomes, and can also be referred to as positive impacts (those impacts which directly or indirectly, intentionally or unintentionally, generally benefit stakeholders and/or the environment) (adapted from AWS 2019). See also "Volumetric water benefit" below.
- **Catchment:** The area of land from which all surface runoff and subsurface waters flow through a sequence of streams, rivers, aquifers, and lakes into the sea or another outlet at a single river mouth, estuary, or delta (adapted from AWS 2019). It's important to consider that catchments
  - include associated groundwater areas, but surface and subsurface waters often have different catchment boundaries and degrees of connection;
  - may include the totality or portions of water bodies, such as lakes or rivers;
  - are also referred to as watersheds, basins, or subbasins; and
  - may be interconnected with infrastructure, so interventions in one can result in benefits or detriments in another.
- **Claim:** To state or declare the creation of volumetric water benefits.
- **Complementary indicators:** Measurements that provide additional insight into the implications of estimated volumetric water benefits and help decision-makers interpret the volumetric water benefits achieved beyond the volume of water provided.
- **Elements of effective water stewardship activities**: Measures of a water stewardship activity that increase the likelihood of generating social, economic, and environmental benefits and solving shared water challenges.
- **Impact:** Changes in the well-being of those affected over the longer term (WBCSD 2017). In the context of water stewardship, impact refers to the positive or negative long-term social, economic, and environmental effects resulting from the implementation of a project or activity, either directly or indirectly, intentionally or unintentionally. Impacts, which are the ultimate result, derive from outcomes. Impacts may be beneficial and called benefits (those impacts which directly or indirectly, intentionally or unintentionally, generally benefit stakeholders and/or the environment) or adverse (those impacts which directly or indirectly, intentionally or unintentionally, are generally harmful to stakeholders and/or the environment) (adapted from AWS 2019).
- **Indicator**: A quantitative factor or variable that provides reliable means to measure the achievement of outputs or outcomes.
- **Input:** The data and information necessary to estimate the volumetric water benefits of an activity.
- **Outcome:** Changes in the lives of the target population and/or environment (WBCSD 2017). In the context of water stewardship, the Alliance for Water Stewardship Standard contains four outcomes: (1) good water governance, (2) sustainable water balance, (3) good water quality status, and (4) healthy status of important water-related areas. Outcomes derive from outputs and lead to impacts (adapted from AWS 2019).
- **Output:** The results of the activity in question (WBCSD 2017). Outputs derive from activities and lead to outcomes and ultimately impacts (adapted from AWS 2019).
- **Shared water challenge:** The water-related issues that are of interest or concern in the catchment or area of interest (e.g., aquifer, municipality, town, state) and which, if addressed, will provide positive impacts or prevent negative impacts. Shared water challenges are not necessarily unique and may be the same for multiple sites or stakeholders (AWS 2019).
- **Volumetric water benefit accounting (VWBA):** Method to estimate the volumetric water benefits of water stewardship activities, and associated guidance related to planning, project selection, and assessment.
- **Volumetric water benefits (VWBs)**: Water stewardship activity outputs, estimated in volume per unit of time, that help reduce shared water challenges.
- **Water balance goal or target:** Organizational goal or target to balance a volume of water equal to what is consumed by the organization, through interventions in catchments and communities outside the four walls of the organization.
- **Water risk:** The effect of water-related uncertainty on an organization's objectives. It is important to note that water risk is felt differently by every sector of society and the organizations within them and thus is defined and interpreted differently (even when they experience the same degree of water scarcity or water stress or when it affects the same area of interest) (AWS 2019).
- **Water stewardship (WS):** The socially equitable, environmentally sustainable, and economically beneficial use of freshwater, achieved through a stakeholder-inclusive process that involves site- and catchment-based actions (AWS 2019).

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## ABOUT VALUING NATURE

Valuing Nature's mission is to help organizations integrate the value of nature and society into decision-making, by providing innovative methods, data, and experience. Samuel Vionnet founded Valuing Nature in 2015. He is an independent consultant with 10 years of experience in sustainability consulting. Before founding his organization, Samuel worked for six years with Quantis International supporting organizations worldwide on their strategies, using sustainability metrics. Valuing Nature works primarily with the private sector, advising multinational companies around the world on issues that include sustainability metrics, water stewardship, risk assessment, supply-chain management, sustainability strategy, and natural and social capital accounting. His clients include Nestlé, Tetra Pak, Ikea, Novartis, Olam, Natura, Nespresso, Samsung, and Firmenich, among others. His current focus is on economic valuation of human, social, and natural capital and flows related to the private sector. Redefining value and our economic model are at the core of the focus of Valuing Nature.

## ABOUT LIMNOTECH

LimnoTech is a leading water science and environmental engineering consulting firm headquartered in Ann Arbor, Michigan, with regional offices across the United States. We work with clients across a range of sectors and locations to address challenging water resource issues. Our staff has a national reputation for the scientific assessment of complex environmental issues and for finding innovative, effective solutions, especially as they relate to the selection and design of management alternatives for the water environment.

## ABOUT QUANTIS

Quantis guides top organizations to define, shape, and implement intelligent environmental sustainability solutions. In a nutshell, our creative geeks take the latest science and make it actionable. They deliver resilient strategies, robust metrics, useful tools, and credible communications.

With offices in the United States, France, Switzerland, Germany, Italy, and Colombia and clients around the world, Quantis is a key partner in inspiring sustainable change on a global scale.

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## ABOUT WRI

World Resources Institute is a global research organization that turns big ideas into action at the nexus of environment, economic opportunity, and human well-being.

**Our Challenge**

Natural resources are at the foundation of economic opportunity and human well-being. But today, we are depleting Earth's resources at rates that are not sustainable, endangering economies and people's lives. People depend on clean water, fertile land, healthy forests, and a stable climate. Livable cities and clean energy are essential for a sustainable planet. We must address these urgent, global challenges this decade.

**Our Vision**

We envision an equitable and prosperous planet driven by the wise management of natural resources. We aspire to create a world where the actions of government, business, and communities combine to eliminate poverty and sustain the natural environment for all people.

**Our Approach**

COUNT IT

We start with data. We conduct independent research and draw on the latest technology to develop new insights and recommendations. Our rigorous analysis identifies risks, unveils opportunities, and informs smart strategies. We focus our efforts on influential and emerging economies where the future of sustainability will be determined.

CHANGE IT

We use our research to influence government policies, business strategies, and civil society action. We test projects with communities, companies, and government agencies to build a strong evidence base. Then, we work with partners to deliver change on the ground that alleviates poverty and strengthens society. We hold ourselves accountable to ensure our outcomes will be bold and enduring.

SCALE IT

We don't think small. Once tested, we work with partners to adopt and expand our efforts regionally and globally. We engage with decision-makers to carry out our ideas and elevate our impact. We measure success through government and business actions that improve people's lives and sustain a healthy environment.