Estimated Environmental Benefits Associated with ARRA-Funded Green Project Reserve Projects

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Summary Report

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When the American Recovery and Reinvestment Act of 2009 (ARRA) was signed into law, it included a Green Project Reserve (GPR) provision for the Clean Water State Revolving Fund (CWSRF) program. The GPR was designed to encourage communities to pursue projects or project components that incorporated any of the four following categories: energy efficiency improvements, water efficiency improvements, green infrastructure, and environmentally innovative activities. The ARRA GPR specified that 20 percent of each state's federal CWSRF funding be directed toward these types of projects.

One of the challenges associated with the introduction of the GPR into the CWSRF program was how to identify, measure, and quantify all of the anticipated environmental benefits that may be associated with each category of green project. As part of a larger effort to assess the impact of the ARRA GPR on the CWSRF program, EPA conducted a study to measure the following environmental benefits of selected GPR projects:

- Anticipated energy savings and the amount of renewable energy created
- Water savings and volume of water reused
- Stormwater flow treated through green infrastructure applications and technologies
- Greenhouse gas emission reductions

EPA developed a comprehensive report, *Estimated Environmental Benefits Associated with ARRA-Funded Green Project Reserve Projects* that provides detailed information on their efforts to model the environmental benefits for 180 ARRA GPR energy efficiency, water efficiency, and green infrastructure projects. Environmentally innovative projects were not included in the analysis due to significant project variances within this category that could not be objectively measured. This summary report provides an overview of the data collection efforts, assumptions and methodologies, research limitations, and results found in the comprehensive report.

Data Collection

The ability to collect quantifiable data from GPR projects would enable the EPA and state CWSRF program managers to better articulate the social, environmental, and economic benefits that communities may realize when implementing a green project to address wastewater infrastructure and stormwater management challenges. Before beginning their data collection efforts, EPA developed GPR project subcategories for each category of projects to facilitate analysis and more effectively model environmental benefits. For example, there are seven subcategories within the water efficiency improvement category of projects that include meters (ME), reuse/reclamation (RE), and high efficiency fixtures (WF).

EPA gathered project information for as many projects as possible, including project descriptions and funding amounts from the EPA Clean Water Benefits Reporting (CBR) database and GPR project business cases collected by EPA's Office of the Chief Financial Officer and EPA Regional offices.[1] Information was also collected from ARRA GPR project files during EPA's SRF annual reviews in sixteen states between July and October 2011.[2] In order to capture a geographically diverse, representative sample of projects, EPA targeted states across the country with the largest number of projects in each of the three GPR categories.[3] The resulting dataset included 89 energy efficiency improvement projects, 23 water efficiency improvement projects, and 68 green infrastructure projects. Out of a total of 641 GPR projects, excluding those in the environmentally innovative category, data from 180 projects (27 percent of all ARRA GPR projects) was collected and analyzed to model quantifiable environmental benefits.

Assumptions and Methodologies

EPA developed a Microsoft Excel-based spreadsheet model for each project category that could be used to estimate the anticipated environmental benefits that are shown in the table below.

Quantifiable Environmental Benefits

Energy Efficiency	Water Efficiency	Green Infrastructure
• Energy Savings • Alternative Energy Generated • Embedded Water Savings (from not having to generate electricity) • Reduced Greenhouse Gas Emissions • Total Cost Savings	• Water Savings • Alternative Water Generated • Embedded Energy Savings (from not having to pump and treat the water/wastewater) • Reduced Greenhouse Gas Emissions (from reduced embedded energy use) • Total Cost Savings	• Stormwater Runoff Avoided • Avoided Energy Use (from not having to treat stormwater) • Reduced Greenhouse Gas Emissions (from avoided energy use for not having to treat stormwater) • Total Sediment, Nitrogen, and Phosphorous Reduction • Total Cost Savings

EPA used information on the key data inputs (provided at the end of this report) obtained from business cases and/or GPR project files to calculate benefits using the spreadsheet models. When quantified environmental benefits were reported in the data that was collected, EPA recorded those values. These were used when insufficient data was available to calculate benefits.

Assumptions for the models were taken from extensive peer-reviewed literature and research from the National Renewable Energy Laboratory, U.S. Energy Information Administration, Electric Power Research Institute, and previous EPA studies, among others. The full report provides a detailed account of the methodology and calculations used to model and then extrapolate the estimated environmental

[1] Business cases were developed by SRF assistance recipients to demonstrate that a project will achieve identifiable and substantial benefits that qualify as GPR benefits.

[2] ARRA GPR project files kept at state CWSRF program offices included but were not limited to: CWSRF project applications, environmental review documentation, facility plans and other engineering reports, bid and contract documents, and loan agreements.

[3] The sixteen states where ARRA GPR project files were reviewed included: AL, CA, HI, IL, IN, KY, LA, MD, MA, MS, NJ, NY, PA, SC, TN, TX

benefits for the three GPR categories of energy efficiency, water efficiency, and green infrastructure, and for each subcategory within these three categories.

Once the benefits for individual projects were calculated, EPA compiled the estimated benefits for all the projects in each subcategory into a summary table to analyze the quantifiable environmental benefits associated with each project and project category as a whole. The total cost savings associated with each project was also calculated.

Using the modeled benefits, EPA extrapolated the potential environmental benefits for all ARRA GPR projects, based on the percent of projects that the modeled benefits represented. EPA then summed the extrapolated benefits from each project subcategory to obtain an estimate of the total benefits for all projects in each of the three project categories.

Limitations

During the process of analyzing the data, it was observed that the type and the quality of the information available in each of the project files varied significantly between projects. It is also important to note that there was a relatively small sample size of project data analyzed. For a statistically valid sampling, 241 projects would have needed to be included, and this study was only able to gather data on 180 projects. This is largely due to an abbreviated timeline within which the study had to be completed, as well as the nature of the data. Much of the data required to perform an in-depth analysis and allow EPA to quantify and model estimated benefits is generally not included in state CWSRF project files; it is only available at the community level. EPA did not have the resources to visit SRF assistance recipients to collect data.

Many projects included more than one GPR category and multiple subcategories. For instance, several projects had multiple water efficiency components (e.g. meter installation and water reclamation) as well as several energy efficiency components (e.g. high efficiency pumps and solar power). This made it difficult to determine which project costs and cost savings were associated with each project subcategory, as costs were not typically broken down to the subcategory level in the available data.

Other limitations identified during the course of developing the benefits models are associated with the underestimation of environmental benefits. There were a number of projects that could not be classified into an established subcategory because the data provided was vague or insufficient, or described benefits that were more qualitative in nature. EPA could not include these projects in the benefits analysis, and as a result the total extrapolated benefits may be underestimated.

Results

In total, EPA was able to model environmental benefits for 32 percent of the energy efficiency projects, 22 percent of the water efficiency projects, and 27 percent of the green infrastructure projects. EPA modeled environmental benefits for at least one project in each subcategory with the exception of uncategorized projects, unspecified green stormwater improvement projects or other BMPs projects, and three water efficiency subcategories. The comprehensive report provides the estimated average and total environmental benefits modeled, as well as the total extrapolated benefits for all ARRA-funded energy efficiency, water efficiency, and green infrastructure projects.

On average, each energy efficiency project is estimated to save:

- Over 2 million kilowatt-hour (kWh)
- 4 million gallons of water (associated with reduced energy use)
- 1,000 metric tons of greenhouse gas emissions
- More than $200,000 per year

On average, each water efficiency project is estimated to save:

- Over 200 million gallons of water per year
- 300,000 kWh and 180 metric tons of greenhouse gas emissions per year by not having to supply and treat the saved water/wastewater
- More than $1 million per year

On average, each green infrastructure project is estimated to:

- Reduce stormwater runoff by 22 million gallons
- Save nearly 4,000 kWh and 2 metric tons of greenhouse gas emissions
- Reduce total suspended solids, total phosphorous, and total nitrogen loadings by over 7,500 pounds, 10 pounds and 100 pounds, respectively
- Save more than $2,500 per year

Conclusion

This study revealed the difficulty in extrapolating numbers for cost savings and environmental benefits from a subset of projects to whole categories of projects. Many of the projects that were included in the data analysis demonstrate significant environmental benefits, but there was considerable variation in the type and size of projects between subcategories, and even within subcategories, which made it difficult to accurately extrapolate these benefits to entire GPR project categories.

The results of this report indicate that the application of the environmental benefits modeling to estimate water and energy savings, as well as pollutant removal efficiencies and greenhouse gas emission reductions, may be more appropriate if applied on a project-by-project basis. The spreadsheet models represent useful tools for the CWSRF program in the analysis of anticipated benefits associated with individual projects, which can help identify good opportunities for the integration of green and conventional gray infrastructure technologies to achieve the most environmentally beneficial outcomes. The assumptions used in the spreadsheet models also present a compendium of methodologies for estimating environmental benefits that can serve as a comprehensive resource and potential educational and training tool. This resource can be used by CWSRF program managers as well as communities and utilities to calculate the environmental benefits of wastewater infrastructure and stormwater management projects, and help identify those that most effectively and efficiently improve and protect water quality and public health.

As part of a separate study, EPA is collecting and analyzing available project performance information from ARRA GPR water and energy efficiency improvement projects in order to document actual environmental benefits. This information can provide a baseline for benefits comparison and can be used by itself or in conjunction with the spreadsheet models described in this report as a decision-making tool for communities that are considering implementing water and energy efficiency projects.

Additional resources available to CWSRF program managers and other water quality professionals include the Alliance for Water Efficiency's Conservation Tracking Tool, which can be used to analyze the cost effectiveness and energy savings of various water conservation planning scenarios and projects.[4] The New York State Energy Research and Development Authority's (NYSERDA) website features a payback analysis tool to calculate energy and cost savings based on water and wastewater infrastructure investment costs; it is designed to assist facilities with the life cycle cost comparison of different equipment replacement alternatives. The site also includes an advanced benchmarking tool to help water and wastewater facilities track energy trends and facility performance.[5] For green infrastructure, the Center for Neighborhood Technology has developed a Green Values Stormwater Management Calculator to compare the performance, costs, and benefits of various types of green infrastructure to conventional stormwater infrastructure practices.[6] The Water Environment Research Foundation has developed a set of modeling tools, called the LID Whole Life Cost Models, to help water quality managers make decisions regarding the integration of green infrastructure practices into stormwater management.[7] The LID Whole Life Cost Models consist of a set of spreadsheet tools designed to help identify and combine capital costs and ongoing maintenance expenditures in order to estimate whole life costs for green stormwater management projects. The SUSTAIN tool, available on EPA's website, is a GIS-based tool designed to gage the effectiveness of green infrastructure in reducing runoff and pollutant loadings.[8] It was designed to help water quality professionals develop, evaluate, and select green infrastructure practices based on their cost and effectiveness.

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[4] http://www.allianceforwaterefficiency.org/uploadedFiles/Tool/2011-11-08TrackingToolWebinar.pdf

[5] http://www.nyserda.ny.gov/en/Page-Sections/Commercial-and-Industrial/Sectors/Municipal-Water-and-Wastewater-Facilities/Tools-and-Materials.aspx

[6] http://greenvalues.cnt.org/

[7] http://www.werf.org/i/a/K/Search/ResearchProfile.aspx?ReportId=SW2R08

[8] http://www.epa.gov/nrmrl/wswrd/wq/models/sustain/index.html

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1. INTRODUCTION AND BACKGROUND

EPA, with assistance from its contractors Northbridge Environmental Management Consultants and ERG, have estimated potential environmental benefits from State Revolving Fund (SRF) Green Project Reserve (GPR) projects implemented using American Recovery and Reinvestment Act (ARRA) funding. This report provides an overview of the environmental benefits modeling methodology, summarizes the estimated environmental benefits for the GPR projects, and discusses the data limitations.

2. ENVIRONMENTAL BENEFITS ESTIMATION METHODOLOGY

2.1 Project Classification

There are 752 total GPR projects listed in the Clean Water Benefits Reporting (CBR) database, available at http://66.148.13.226/cwapplications/, broken into funding categories as follows:

- 279 energy efficiency projects
- 106 water efficiency projects
- 256 green infrastructure projects
- 111 environmentally innovative projects

To facilitate environmental benefits analysis, project subcategories were established, as shown in Table 1, into which (to the extent possible) all projects could be classified based on the similarity of data inputs and assumptions necessary to calculate the environmental benefits. These classifications were made using project descriptions provided in the CBR, augmented by information collected from the relevant GPR business cases and/or GPR project files (see Section 2.3 Data Collection below for more details). In many instances, a funded project was composed of several small projects or "subprojects." To most accurately estimate environmental benefits for the overall project, EPA attempted to identify and classify each subproject into an appropriate project subcategory. In some cases, EPA could not gather sufficient information to classify a particular project into a subcategory. For the purposes of tracking and prioritization, unclassified projects were identified as "not categorized."

Table 1. GPR Project Categories and Subcategories

Code	GPR Category and Subcategory
NC	Not Categorized
EE	**Energy Efficiency**
EC	Energy-efficient components (e.g., variable frequency drives, blowers, pumps)
EP	Energy-efficient processes (e.g., low-energy treatment technology, gravity sewers, consolidation)
ER	Pipe projects or retrofits (addressing energy loss, including infiltration and inflow)
GP	Reclaimed gas power generation (including combined heat and power or cogeneration)
OR	Other renewable energy generation (including hydroelectric, geothermal, and incinerator projects)
SO	Solar power generation
WI	Wind power generation
WE	**Water Efficiency**
ME	Meter installation

Table 1. GPR Project Categories and Subcategories

Code	GPR Category and Subcategory
RE	Water reuse, reclamation, or recycling
WC	Water-efficient components
WF	Water-efficient fixtures (end use)
WP	Water-efficient processes (e.g., low-water treatment technology, piping irrigation canals)
WR	Pipes projects or retrofits (addressing water loss, including infiltration and inflow)
GI	**Green Infrastructure**
BI	Bioretention (not including rain gardens or swales)
BM	Unspecified green stormwater improvement projects or other best management practices (BMP)
GR	Green roof
PP	Pervious pavement
RG	Rain gardens
RR	Riparian and shoreline restoration
RW	Rainwater harvesting
SP	Stormwater ponds (including retention, detention, and catchment basins)
SW	Swales
VP	Vegetative plantings (including trees)
WL	Wetland
EI	**Environmentally Innovative**
BS	Biosolids
DE	Decentralized treatment
IO	Other environmentally innovative projects
LA	Land application

2.2 Identification of Quantifiable Environmental Benefits

As a first step in estimating environmental benefits, EPA evaluated the type of information provided in available GPR business cases or GPR project files (see Section 2.3 Data Collection) and developed a list of environmental benefits that could be quantified for the projects in each category, as shown in Table 2. EPA did not estimate environmental benefits for any of the environmentally innovative projects as these projects are very diverse and the environmental benefits are difficult to quantify.

Note that there are other benefits, particularly for the green infrastructure projects, such as reduced heat island effect, aesthetics, and reduced flooding, that could be not be quantified because the benefits are qualitative or the type of information necessary to quantify such benefits was not typically available in the GPR project files (see Section 5.0, Data Limitations, for further discussion). As a result, total benefits discussed in this report may be underestimated.

Table 2. Quantifiable Environmental Benefits

Energy Efficiency	Water Efficiency	Green Infrastructure
• Energy Savings • Alternative Energy Generated • Embedded Water Savings (from not having to generate electricity) • Reduced Greenhouse Gas Emissions • Total Cost Savings	• Water Savings • Alternative Water Generated • Embedded Energy Savings (from not having to pump and treat the water/wastewater) • Reduced Greenhouse Gas Emissions (from reduced embedded energy use) • Total Cost Savings	• Stormwater Runoff Avoided • Avoided Energy Use (from not having to treat stormwater) • Reduced Greenhouse Gas Emissions (from avoided energy use for not having to treat stormwater) • Total Sediment, Nitrogen, and Phosphorous Reduction • Total Cost Savings

EPA developed an Excel-based spreadsheet model for each project category that could be used to estimate the above benefits and further broke each model down into the individual project subcategories to account for variations in the information and assumptions necessary for the estimation of benefits. Table 3 lists the key data inputs EPA required to complete the models for a given project under each project subcategory.

Table 3. Key Data Inputs by Subcategory for Environmental Benefits Models

GPR Subcategory	Key Data Inputs
Energy Efficiency	
EC	• Energy savings (if reported) • Energy use before/after component replacement • Number/type of components replaced and old and new component efficiencies • Frequency of equipment use
EP	• Energy savings (if reported) • Energy use before/after process change • Frequency of process operation
ER	• Energy savings (if reported) • Energy use before/after pipe retrofit
GP	• Amount of biogas/alternative energy generated
OR	• Amount of alternative energy generated • Energy generation capacity and frequency of operation
SO	• Energy savings or alternative energy generated (if reported) • Photovoltaic production capacity and amount of sunlight exposure
WI	• Energy savings or alternative energy generated (if reported) • Energy generation capacity and duration of wind exposure
Water Efficiency	
ME	• Water savings (if reported) • Water use before and after meter replacement
RE	• Amount of water reused or supplied for reuse • Reuse water demand
WC	• Water savings (if reported) • Water use before/after component replacement • Number/type of components replaced and old and new component efficiencies • Frequency of equipment use
WF	• Water savings (if reported) • Water use before and after fixture replacement • Number and type of fixtures replaced • Frequency of fixture use

Table 3. Key Data Inputs by Subcategory for Environmental Benefits Models

GPR Subcategory	Key Data Inputs
WP	• Water savings (if reported) • Water use before/after process change • Frequency of process operation
WR	• Water savings (if reported) • Water use before/after pipe retrofit
Green Infrastructure	
BI	• Bioretention area • Drainage area
GR	• Green roof area
PP	• Pervious area
RG	• Rain garden area • Drainage area
RR	• Riparian restoration area
RW	• Cistern/rain barrel storage volume • Number of units • Rooftop drainage area
SP	• Pond volume • Drainage area
SW	• Swale area • Drainage area
VP	• Number/type of trees planted
WL	• Wetland area

2.3 Data Collection

After identifying the types of information needed to estimate the quantifiable environmental benefits, EPA gathered readily accessible project information for as many projects as possible, including project descriptions and funding amounts from the CBR database, GPR project business cases collected by EPA's Office of the Chief Financial Officer, and any GPR project files collected during EPA's previous SRF project file reviews. EPA evaluated whether the available information provided the key data inputs that would be necessary to estimate environmental benefits for each relevant project. EPA then compiled a list of all the remaining projects for which it had no data or insufficient data to run the environmental benefits models.

From the inventory of projects with missing or insufficient data, EPA prioritized its data collection efforts to obtain the most robust and representative dataset possible. EPA specifically identified and targeted states across the country with the largest number of projects in each project category to make data collection efforts cost effective and ensure that the ultimate data set was geographically diverse. EPA also attempted to target and collect data for at least one project per subcategory so that all project types could be represented in the modeled dataset.

EPA did not specifically prioritize and target uncategorized ("NC") projects, because the existing information reported in the CBR and initially available to EPA was insufficient to determine the type of project that was funded. In addition, EPA did not specifically target unspecified ("BM") green infrastructure projects, because either not enough information about the project was provided to classify the project by its type or the type of green infrastructure project was very unique, and the environmental benefits were difficult to quantify.

Between June and October 2011, EPA visited the environmental protection offices for the following 16 targeted states to review and obtained copies of GPR project review files for the relevant GPR projects:

- Alabama
- California
- Hawaii
- Illinois
- Indiana
- Kentucky
- Louisiana
- Maryland
- Massachusetts
- Mississippi
- New Jersey
- New York
- Pennsylvania
- South Carolina
- Tennessee
- Texas

While on site, EPA looked through GPR project files including loan applications, engineering reports, plans and specifications, environmental assessments, and business cases, attempting to identify project descriptions and details and values for the key data inputs. EPA obtained copies of all relevant project information and scanned and electronically saved the documents onto an external hard drive to serve as a data record for this project.

2.4 Data Representation

Of the 641[1] energy efficiency, water efficiency, and green infrastructure GPR projects listed in the CBR database, EPA gathered business cases, engineering reports, loan applications, plans and specifications, and/or environmental assessments for 438 of these projects. Upon further review of the project documentation, EPA only had sufficient information to model environmental benefits for 180 projects. As shown in Table 4, these 180 projects represent 27 percent of the total GPR projects and 33 percent of the total GPR project funding.

Broken down by project category, EPA was able to model 32 percent of the energy efficiency projects, 22 percent of the water efficiency projects, and 27 percent of the green infrastructure projects.

[1] There are 752 total GPR projects listed in the CBR database. For the purpose of discussing the data representation, EPA excluded the 111 environmentally innovative projects, because it did not model environmental benefits for any of these projects.

Table 4. Representation of Projects Included in Environmental Benefits Models

Project Category	Total Number of Projects[2]	Number of Projects Represented	Percent of Projects Represented	Total Dollars Funded	Funding Represented	Percent of Funding Represented
Energy Efficiency	279	89	32%	$613,662,983	$237,544,699	39%
Water Efficiency	106	23	22%	$155,553,019	$30,190,854	19%
Green Infrastructure	256	68	27%	$204,666,942	$52,594,959	26%
Total	**641**	**180**	**28%**	**$973,882,944**	**$320,330,512**	**33%**

Table 5 and Figures 1, 2, and 3 show the geographic distribution of projects included in each of the environmental benefits models. Represented projects are located in 33 states across the country. Region 7 was the only EPA Region with projects for which EPA could not model any environmental benefits.

[2] In some cases, a project was incorrectly classified in the CBR based upon the projects expected environmental benefits. EPA reclassified these projects into the appropriate category to estimate the environmental benefits. Therefore, the total number of projects in each category does not match what was originally reported in the CBR. The total number of projects; however, remains the same.

Table 5. Distribution of GPR Projects Included in Environmental Benefits Models by EPA Region and State

State	Energy Efficiency Projects			Water Efficiency Projects			Green Infrastructure Projects		
	Total Number	Number Represented in Model	Percent Represented in Model	Total Number	Number Represented in Model	Percent Represented in Model	Total Number	Number Represented in Model	Percent Represented in Model
Region 1									
CT	1	0	0%	0	0	NA	0	0	NA
MA	11	0	0%	0	0	NA	1	1	100%
ME	3	0	0%	0	0	NA	4	1	25%
NH	11	0	0%	0	0	NA	10	0	0%
RI	1	0	0%	0	0	NA	1	0	0%
VT	6	0	0%	0	0	NA	2	0	0%
Total	**33**	**0**	**0%**	**0**	**0**	**NA**	**18**	**2**	**11%**
Region 2									
NJ	14	6	43%	1	0	0%	0	0	NA
NY	45	32	71%	9	4	44%	21	16	76%
PR	3	0	0%	0	0	NA	0	0	NA
Total	**62**	**38**	**61%**	**10**	**4**	**40%**	**21**	**16**	**76%**
Region 3									
DE	1	0	0%	1	1	100%	2	0	0%
MD	3	1	33%	1	0	0%	27	11	41%
PA	8	2	25%	0	0	NA	34	17	50%
VA	5	0	0%	6	0	0%	1	0	0%
WV	2	1	50%	1	1	100%	5	0	0%
Total	**19**	**4**	**21%**	**9**	**2**	**22%**	**69**	**28**	**41%**
Region 4									
AL	5	5	100%	0	0	NA	0	0	NA
FL	2	1	50%	3	0	0%	0	0	NA
GA	3	0	0%	4	2	50%	3	1	33%
KY	5	3	60%	0	0	NA	7	0	0%
MS	3	2	67%	0	0	NA	0	0	NA
NC	0	0	NA	1	0	0%	13	10	77%
SC	4	0	0%	1	0	0%	1	0	0%
TN	2	0	0%	4	3	75%	1	0	0%

Table 5. Distribution of GPR Projects Included in Environmental Benefits Models by EPA Region and State

	Energy Efficiency Projects			Water Efficiency Projects			Green Infrastructure Projects		
State	**Total Number**	**Number Represented in Model**	**Percent Represented in Model**	**Total Number**	**Number Represented in Model**	**Percent Represented in Model**	**Total Number**	**Number Represented in Model**	**Percent Represented in Model**
Total	**24**	**11**	**46%**	**13**	**5**	**38%**	**25**	**11**	**44%**
Region 5									
IL	23	0	0%	18	0	0%	14	1	7%
IN	20	12	60%	2	0	0%	1	0	0%
MI	7	1	14%	0	0	NA	7	3	43%
MN	3	2	67%	1	0	0%	0	0	NA
OH	16	10	63%	1	0	0%	17	1	6%
WI	9	1	11%	2	0	0%	7	0	0%
Total	**78**	**26**	**33%**	**24**	**0**	**0%**	**46**	**5**	**11%**
Region 6									
AR	1	1	100%	0	0	NA	1	0	0%
LA	0	0	NA	6	3	50%	1	0	0%
NM	3	0	0%	3	2	67%	0	0	NA
OK	2	1	50%	1	0	0%	9	2	22%
TX	3	1	33%	2	0	0%	2	1	50%
Total	**9**	**3**	**33%**	**12**	**5**	**42%**	**13**	**3**	**23%**
Region 7									
IA	9	0	0%	0	0	NA	3	0	0%
KS	7	0	0%	1	0	0%	11	0	0%
MO	5	0	0%	2	0	0%	1	0	0%
NE	5	0	0%	4	0	0%	4	0	0%
Total	**26**	**0**	**0%**	**7**	**0**	**0%**	**19**	**0**	**0%**
Region 8									
CO	3	1	33%	2	0	0%	0	0	NA
MT	6	1	17%	2	2	100%	4	0	0%
ND	0	0	NA	1	0	0%	0	0	NA
SD	2	0	0%	0	0	NA	2	0	0%
UT	1	0	0%	0	0	NA	7	0	0%
WY	2	0	0%	2	0	0%	1	0	0%

Table 5. Distribution of GPR Projects Included in Environmental Benefits Models by EPA Region and State

State	Energy Efficiency Projects			Water Efficiency Projects			Green Infrastructure Projects		
	Total Number	Number Represented in Model	Percent Represented in Model	Total Number	Number Represented in Model	Percent Represented in Model	Total Number	Number Represented in Model	Percent Represented in Model
Total	**14**	**2**	**14%**	**7**	**2**	**29%**	**14**	**0**	**0%**
Region 9									
AZ	4	0	0%	5	0	0%	1	0	0%
CA	2	1	50%	9	5	56%	25	3	12%
HI	2	1	50%	1	0	0%	0	0	NA
NV	1	0	0%	3	0	0%	0	0	NA
Total	**9**	**2**	**22%**	**18**	**5**	**28%**	**26**	**3**	**12%**
Region 10									
AK	2	1	50%	0	0	NA	1	0	0%
ID	1	1	100%	0	0	NA	0	0	NA
OR	0	0	NA	4	0	0%	0	0	NA
WA	2	1	50%	2	0	0%	4	0	0%
Total	**5**	**3**	**60%**	**6**	**0**	**0%**	**5**	**0**	**0%**
Total	**279**	**89**	**32%**	**106**	**23**	**22%**	**256**	**68**	**27%**

NA: Not applicable. The percent of projects represented in the model is not applicable if the state did not fund any projects in that project category.

Figure 1. Geographic Distribution of Energy Efficiency GPR Projects Included in Environmental Benefits Model

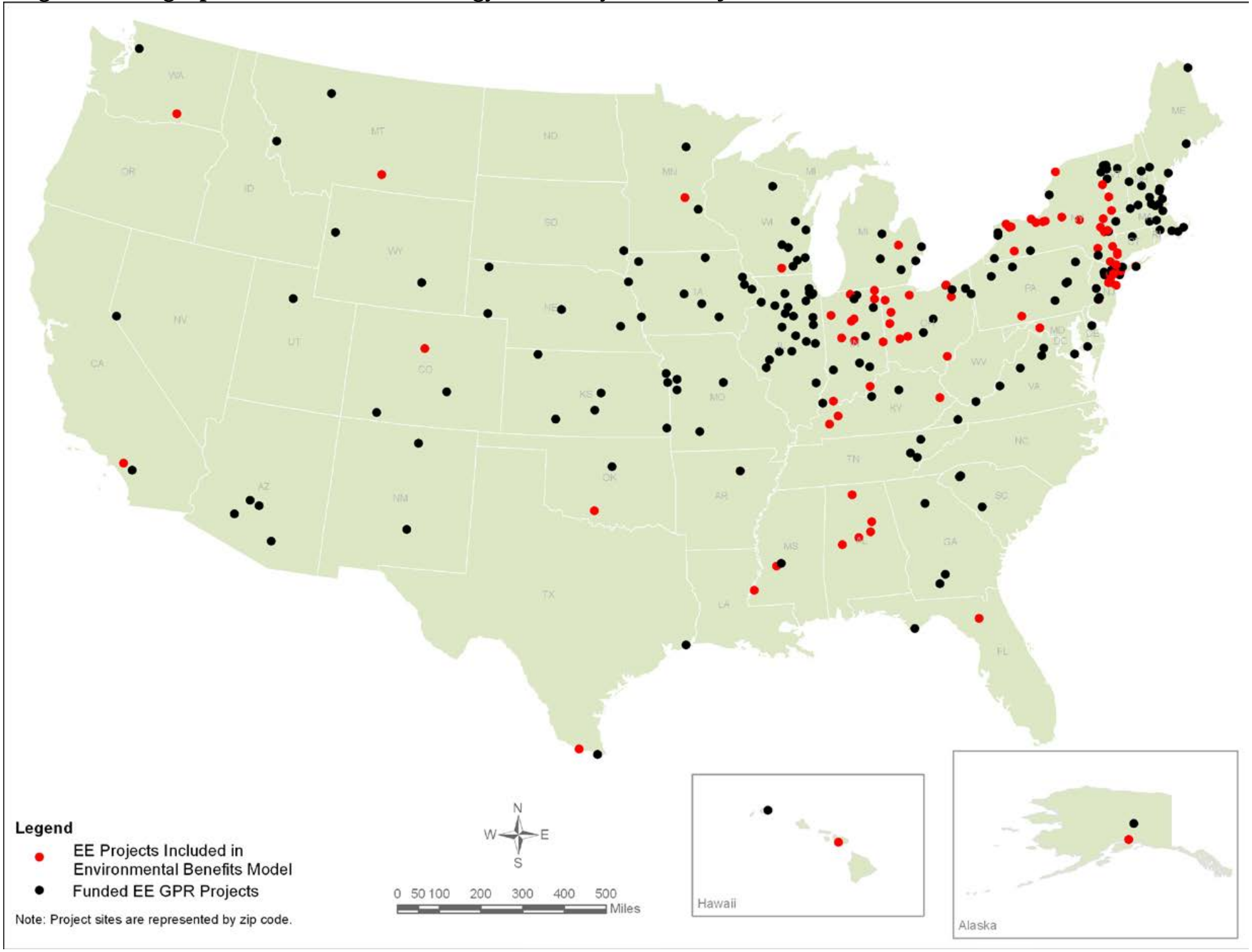


Figure 2. Geographic Distribution of Water Efficiency GPR Projects Included in Environmental Benefits Model

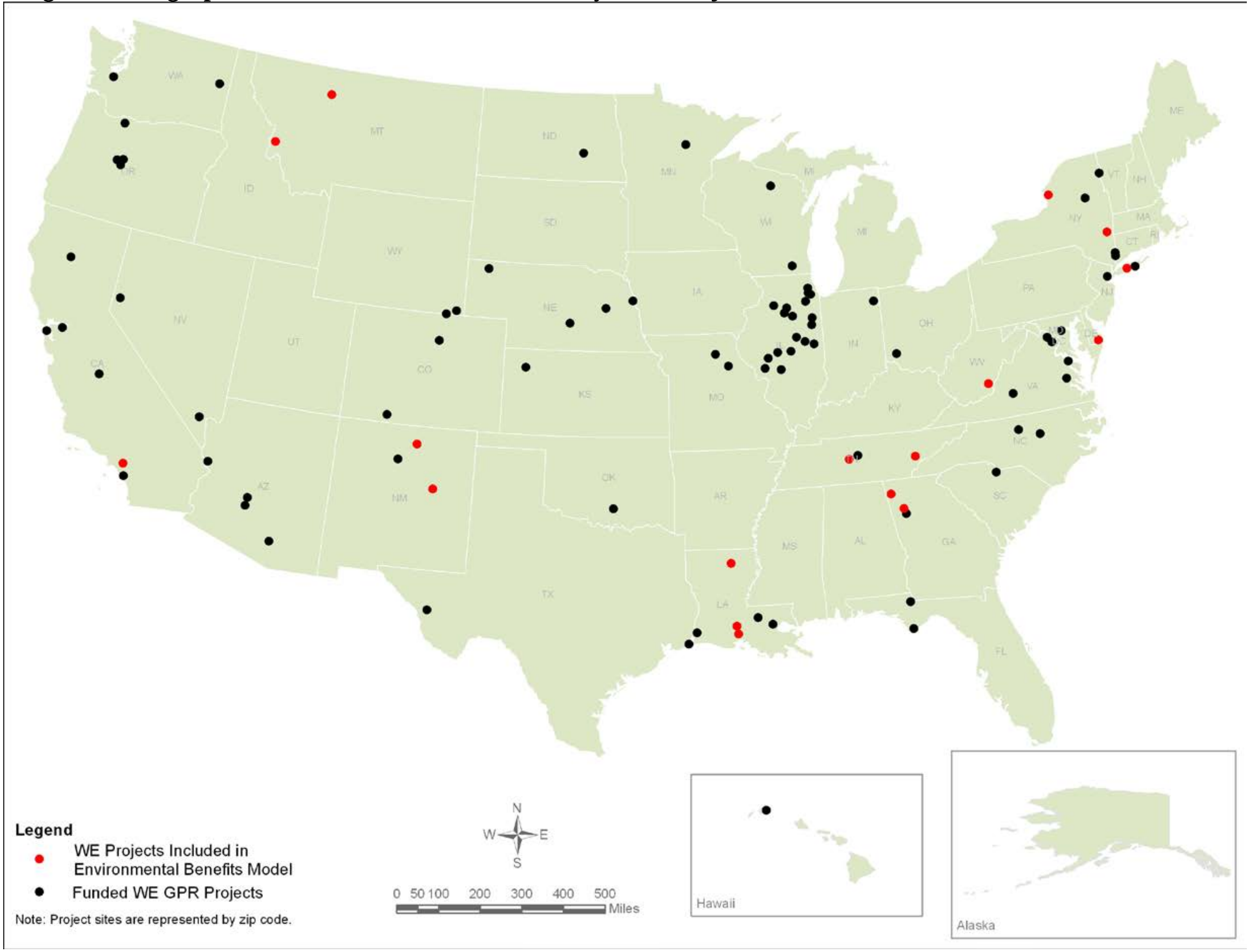
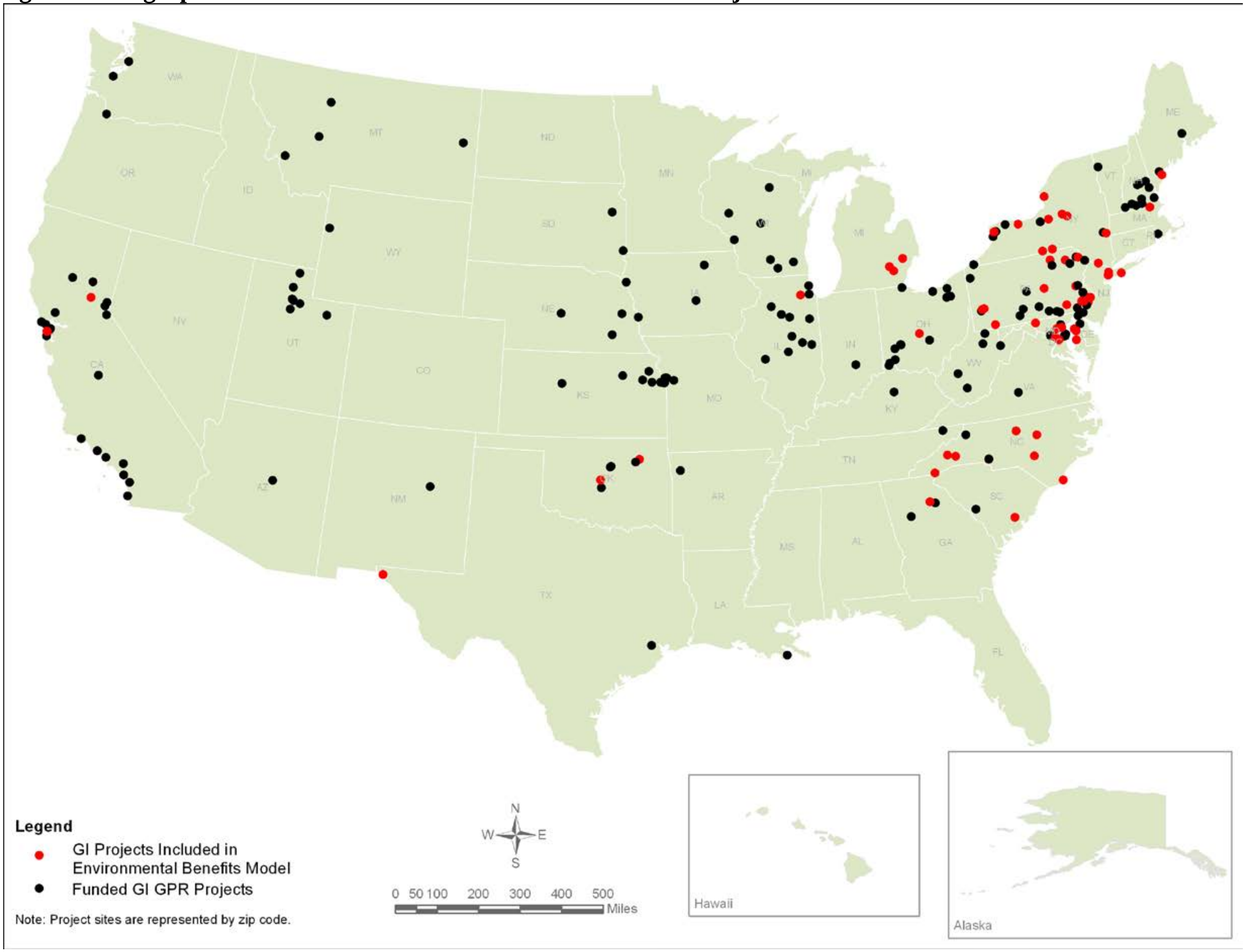


Figure 3. Geographic Distribution of Green Infrastructure GPR Projects Included in Environmental Benefits Model



Often a funded project was composed of several subprojects, many of which fell under multiple subcategories (e.g., an energy efficiency project involved the replacement of efficient components and the installation solar panels). Table 6 shows the total number of subprojects within each project category and subcategory as well the representativeness of the subprojects included in the environmental benefits models.

EPA modeled environmental benefits for at least one project in each subcategory with the exception of uncategorized projects, unspecified green stormwater improvement projects or other BMPs projects (which were not targeted for data collection), and three water efficiency subcategories, including water efficient components, water efficient processes, and pipes projects or retrofits. The majority of these water efficiency projects were located in states from which EPA did not collect any GPR information.

Table 6. Representation of Subprojects Included in Environmental Benefits Models

Project Category	Total Number of Funded Projects	Total Number of Subprojects	Number of Subprojects Represented in Models	Percent of Subprojects Represented in Models
Energy Efficiency	**279**	**349**	**117**	**34%**
EC		120	56	47%
EP		63	25	40%
ER		7	5	71%
GP		35	9	26%
OR		8	1	13%
SO		40	16	40%
WI		11	5	45%
NC		65	0	0%
Water Efficiency	**106**	**110**	**23**	**21%**
ME		13	6	46%
RE		50	16	32%
WC		1	0	0%
WF		3	1	33%
WP		10	0	0%
WR		2	0	0%
NC		31	0	0%
Green Infrastructure	**256**	**382**	**83**	**22%**
BI		30	7	23%
GR		10	7	70%
PP		28	13	46%
RG		33	7	21%
RR		69	8	12%
RW		17	6	35%
SP		24	7	29%
SW		26	3	12%
VP		27	11	41%
WL		27	14	52%

Table 6. Representation of Subprojects Included in Environmental Benefits Models

Project Category	Total Number of Funded Projects	Total Number of Subprojects	Number of Subprojects Represented in Models	Percent of Subprojects Represented in Models
BM		47	0	0%
NC		44	0	0%
Total	**641**	**841**	**223**	**27%**

2.5 Environmental Benefits Modeling Methodology and Assumptions

As discussed in Section 2.2, EPA developed a model for each project and subproject category that could be used to estimate the quantifiable environmental benefits (listed in Table 2).

When quantified environmental benefits were reported in the GPR project files, EPA recorded those values, which were used in the case that benefits could not be calculated. When the GPR project files reported environmental benefits and provided sufficient details to estimate the benefits based upon the key data inputs listed in Table 3, EPA recorded the reported values and calculated the benefits using the spreadsheet models. When the GPR project files did not include a reported value for a given benefit, EPA calculated the benefits using the spreadsheet models.

It is important to note that the type and quality of information available in the individual GPR project files varied significantly among projects. EPA established some standard assumptions to estimate the environmental benefits when the GPR project files did not contain the required information. This section outlines the methodology and major assumptions for each project category model.

2.5.1 Energy Efficiency Environmental Benefits Modeling Methodology and Assumptions

EPA developed an Excel spreadsheet-based model to calculate the environmental benefits listed in Table 2 for energy efficiency projects. The assumptions made when calculating the environmental benefits are discussed in more detail below. See Appendix A for a complete list of assumptions used in the development of the energy efficiency environmental benefits model.

2.5.1.1 General Assumptions and Methodology

For all energy efficiency projects, EPA estimated the primary benefit of direct energy savings, as well as secondary benefits associated with reduced energy use, including the reduction in embedded water savings (water saved from not having to generate the electricity) and reduced greenhouse gas emissions.

To estimate embedded water savings, EPA assumed that two gallons of water are used to generate every kilowatt hour (kWh) of electricity. This value was obtained from a report on *Consumptive Water Use for US Power Production*, published by the National Renewable Energy Laboratory in 2003, available at www.nrel.gov/docs/fy04osti/33905.pdf. With this assumption, the following equation was used to calculate embedded water savings:

$$\text{Embedded Water Savings} = \text{Energy Savings} \times 2$$

Where:

Water Savings:	Amount of water saved (gal/yr)
Energy Savings:	Reported or calculated energy savings (kWh/yr)
2:	Energy required to produce water (gal/kWh)

To estimate greenhouse gas emission reductions, EPA used region-specific greenhouse gas emission factors from the Emissions & Generation Resource Integrated Database (eGRID) Version 1.1, available at www.epa.gov/cleanenergy/energy-resources/egrid/index.html, which accounts for carbon dioxide, methane, and nitrous oxide emissions. With these assumptions, the following equation was used to calculate greenhouse gas emission reductions:

$$\text{GHG Emissions} = \text{EF} \times \frac{\text{Energy Savings}}{1{,}000} \times \frac{1}{2{,}204.622}$$

Where:

GHG Emissions:	Amount of emissions reduced (MT CO_2e/yr)
EF:	Region specific emission factor (lb CO_2e/MWh)
Energy Savings:	Reported or calculated energy savings (kWh/yr)
1,000:	Conversion from kWh to MWh
1/2,204.622:	Conversion from lb to MT

In addition, EPA estimated the total cost savings associated with the each project, taking into account energy cost savings and any difference in maintenance costs reported (either positive or negative). In many cases, the GPR project file provided the specific electricity rate charged, or reported expected project savings. When this information was unavailable, EPA used a standard electricity rate assumption of $0.1017 per kWh to estimate energy cost savings. This electricity rate assumption is the average rate charged for commercial end use across the United States, as reported by the U.S. Energy Information Administration, available at www.eia.gov/cneaf/electricity/epa/epat7p4.html. With these assumptions, the following equation was used to calculate total cost savings:

$$\text{Total Cost Savings} = (\text{Energy Savings} \times \text{Energy Cost}) - \text{Maintenance}$$

Where:

Total Cost Savings:	Cost savings for project ($/yr)
Energy Savings:	Reported or calculated energy savings (kWh/yr)
Energy Cost:	Electricity rate charged ($/kWh)
Maintenance:	Maintenance cost or savings ($/yr)

Due to the diversity of energy efficiency projects, the energy source varied between natural gas, diesel fuel, and some other energy source besides utility-supplied electricity. To simplify and allow for direct comparison of benefits, EPA converted and reported all of the energy savings values as kWh per year. Conversion of energy sources to kWh was achievable through reported

British thermal unit (BTU) equivalencies as specified by the U.S. Energy Information Administration, available at www.eia.gov.

The specific assumptions and calculations unique to each energy efficiency project subcategory are discussed in the following subsections.

2.5.1.2 Energy Efficient Components (EC) Assumptions and Methodology

Projects that replaced energy efficient components (e.g., variable frequency drives, blowers, pumps) represented 34 percent of the total individual GPR energy efficiency projects, including subprojects. To estimate the energy saved and subsequent greenhouse gas emission reductions and embedded water savings from energy efficient component projects, EPA needed to know the expected energy use before and after the retrofit/replacement. When this information was not provided in the GPR project file, EPA needed to know the following information:

- Energy use of fixtures/components prior to retrofit;
- Operating efficiency of existing fixtures/components;
- Number of fixtures/components replaced;
- Energy use of replacement fixtures/components; and
- Operating efficient of replacement fixtures/components.

The following equations were used to calculate energy savings:

$$\text{Energy Savings} = \text{Energy Use}_{\text{Before}} - \text{Energy Use}_{\text{After}}$$

$$\text{Energy Use}_{\text{Before}} = \#\text{ of Fixtures}_{\text{Before}} \times \text{Energy Use Per Fixture}_{\text{Before}} \times \text{Operating Efficiency}_{\text{Before}} \times \text{Conversion Factor}$$

$$\text{Energy Use}_{\text{After}} = \#\text{ of Fixtures}_{\text{After}} \times \text{Energy Use Per Fixture}_{\text{After}} \times \text{Operating Efficiency}_{\text{After}} \times \text{Conversion Factor}$$

Where:

Energy Savings:	Amount of energy saved from replacement (kWh/yr)
Energy $\text{Use}_{\text{Before}}$:	Energy use per fixture before replacement (varies)
Energy $\text{Use}_{\text{After}}$:	Energy use per fixture after replacement (varies)
# of $\text{Fixtures}_{\text{Before}}$:	Number of original fixtures
# of $\text{Fixtures}_{\text{After}}$:	Number of replacement fixtures
Operating $\text{Efficiency}_{\text{Before}}$:	Operating efficiency before fixture replacement (%)
Operating $\text{Efficiency}_{\text{After}}$:	Operating efficiency after fixture replacement (%)
Conversion Factor:	Conversion to kWh/yr

2.5.1.3 Energy Efficient Processes (EP) Assumptions and Methodology

Projects that improved the efficiency of processes (e.g., low-energy treatment technology, gravity sewers, and consolidation) represented 18 percent of the total individual energy efficiency projects, including subprojects. To estimate the energy saved and subsequent greenhouse gas emission reductions and embedded water savings from the new or replacement energy efficient process, EPA needed to know the expected energy use before and after the improvement. If the GPR project file did not provide the pre- and post-retrofit energy use or an estimated energy use reduction, EPA could not evaluate the energy savings associated with the project.

The following equation was used to calculate energy savings:

$$\text{Energy Savings} = (\text{Energy Use}_{\text{Before}} - \text{Energy Use}_{\text{After}}) \times \text{Conversion Factor}$$

Where:

Energy Savings:	Amount of energy saved from replacement (kWh/yr)
Energy $\text{Use}_{\text{Before}}$:	Energy use of components/process before replacement (varies)
Energy $\text{Use}_{\text{After}}$:	Energy use of components/process after replacement (varies)
Conversion Factor:	Conversion to kWh/yr

In some cases, the new process was an improvement in the sludge dewatering process at a water or wastewater treatment plant that resulted in an energy savings associated with hauling fewer biosolids. For these types of projects, if the expected energy savings or the energy savings before and after implementation of the new efficient process was not provided, EPA was able to estimate energy savings based on the reduction in miles traveled and/or days requiring travel and the fuel efficiency of the hauling vehicles. If the fuel efficiency of the hauling vehicles was not provided, EPA used an assumed average national diesel price of $3.948 per gallon obtained from the U.S. Energy Information Administration, available at www.eia.gov/oog/info/wohdp/diesel.asp, for the week of May 30, 2011. For these cases, the following equation was used:

$$\text{Energy Savings} = \frac{(\text{Distance Traveled}_{\text{Before}} - \text{Distance Traveled}_{\text{After}})}{\text{Fuel Efficiency}} \times \text{Days of Operation} \times \text{Conversion Factor}$$

Where:

Energy Savings:	Amount of energy saved from efficient process (kWh/yr)
Distance $\text{Traveled}_{\text{Before}}$:	Distance traveled before replacement (miles/day)
Distance $\text{Traveled}_{\text{After}}$:	Distance traveled after replacement (miles/day)
Days of Operation:	Days of hauling (days/yr)
Fuel Efficiency:	Vehicle fuel efficiency (mpg)
Conversion Factor:	Conversion to kWh/yr

2.5.1.4 Pipes Projects or Retrofits (ER) Assumptions and Methodology

Projects that retrofit pipes to address energy losses and reduce infiltration and inflow accounted for two percent of the total individual energy efficiency projects, including subprojects. To estimate the energy saved and subsequent greenhouse gas emission reductions and embedded water savings from pipe retrofit projects, EPA needed to know the expected energy use before and after the retrofit/replacement. If the GPR project file did not provide the pre- and post-retrofit energy use or an estimated energy use reduction, EPA could not evaluate the energy savings associated with the project.

The following equation was used to calculate energy savings:

$$\text{Energy Savings} = \text{Energy Use}_{\text{Before}} - \text{Energy Use}_{\text{After}} \times \text{Conversion Factor}$$

Where:

Energy Savings:	Amount of energy saved from replacement (kWh/yr)
Energy $\text{Use}_{\text{Before}}$:	Energy use before replacement (varies)
Energy $\text{Use}_{\text{After}}$:	Energy use after replacement (varies)
Conversion Factor:	Conversion to kWh/yr

2.5.1.5 Reclaimed Gas Power Generation (GP) Assumptions and Methodology

Projects that reclaimed gas and used it as an alternative source of energy within a process represented 10 percent of the total individual energy efficiency projects, including subprojects. To estimate the energy saved, alternative energy generated, and subsequent greenhouse gas emission reductions and embedded water savings from reclaimed gas power generation projects, EPA needed to know the amount of biogas generated and converted to electric power and/or the amount of natural gas offset due to the project. If the GPR project file did not provide the amount of biogas generated, EPA could not evaluate the energy savings associated with the project.

For those reclaimed gas power generation projects included in the model, EPA assumed that the amount of alternative energy generated was equivalent to the energy saved by the project. EPA also assumed that the greenhouse gas emission reductions associated with using reclaimed gas were solely related to the amount of energy directly replaced by using the reclaimed gas, since the gas must still either be flared or combusted to generate the replacement energy.

To estimate the project cost savings associated with the replacement of natural gas, if the cost of natural gas was not provided in the GPR project file, EPA assumed and used the state-specific rates for natural gas for the commercial sector, as reported by the U.S. Energy Information Administration, available at www.eia.gov/dnav/ng/ng_pri_sum_a_EPG0_PCS_DMcf_a.htm.

2.5.1.6 Other Renewable Energy Generation (OR) Assumptions and Methodology

Projects that utilized other renewable energy technologies accounted for two percent of the total individual energy efficiency projects, including subprojects. To calculate the energy saved from other renewable energy generation projects, EPA needed to know the expected amount of alternative energy generated and/or the amount of energy use offset due to the project. If the GPR project file did not provide the amount of alternative energy generated, EPA could not evaluate the energy savings associated with the project.

2.5.1.7 Solar Power Generation (SO) Assumptions and Methodology

Projects that utilized solar power as an alternative energy source represented 11 percent of the total individual energy efficiency projects, including subprojects. In many cases, an estimate of expected electrical generation was provided within the GPR project file and was entered into the model; however, some GPR project files only contained general design specifications for the solar project. To calculate the energy saved, alternative energy generated, and subsequent greenhouse gas emission reductions and embedded water savings, EPA needed the following information:

- Photovoltaic production capacity
- The amount of solar radiation exposure time per day

If the GPR project file did not provide the photovoltaic production capacity, EPA could not evaluate the energy savings associated with the project. If the amount of solar radiation exposure time per day was not provided in the GPR project file, EPA used a standard assumption of seven hours per day, which was documented as the exposure time for at least one of the solar projects.

The following equation was used to calculate energy savings:

$$\text{Energy Savings} = \text{Capacity} \times \text{Exposure} \times 365$$

Where:

Energy Savings:	Amount of energy saved from replacement (kWh/yr)
Capacity:	Photovoltaic production capacity (kW)
Exposure:	Solar radiation exposure time (hr/day)
365:	Conversion from day to year

2.5.1.8 Wind Power Generation (WI) Assumptions and Methodology

Projects that utilized wind as an alternative energy source represented three percent of the total individual energy efficiency projects, including subprojects. To estimate the energy savings associated with wind projects, the project must have estimated the energy savings associated with the wind project. If the GPR project file did not provide this information, EPA could not evaluate the energy savings associated with the project.

2.5.2 Water Efficiency Environmental Benefits Modeling Methodology and Assumptions

EPA developed an Excel spreadsheet-based model to calculate the environmental benefits listed in Table 2 for water efficiency. The assumptions made when calculating the environmental benefits are discussed in more detail below. See Appendix B for a complete list of assumptions used in the development of the water efficiency environmental benefits model.

2.5.2.1 General Assumptions and Methodology

For all water efficiency projects, EPA estimated the primary benefit of direct water savings as well as secondary benefits associated with reduced water use, including the reduction in embedded energy savings (energy saved from not having to pump, treat, and distribute the saved water/wastewater) and reduced greenhouse gas emissions (from reduced energy use). In most cases, the GPR project files did not provide an estimate of these secondary benefits; therefore, EPA used some standard assumptions.

To estimate embedded energy savings, EPA assumed that it requires 3.2 kWh per 1,000 gallons to pump and treat water and wastewater. This assumption comes from the Electric Power Research Institute's (EPRI) *Water & Sustainability (Volume 4): U.S. Electricity Consumption for Water Supply & Treatment - The Next Half Century*, and assumes a 10 million gallon per day water and wastewater treatment plant. Broken into its relative components, this assumption includes:

- 1.4 kWh per 1,000 gallons for water supply (for surface water), including water treatment and distribution, or 0.1205 kWh per 1,000 gallons for raw water pumping, 0.0997 kWh per 1,000 gallons for treatment, and 1.2055 kWh per 1,000 gallons for distribution
- 1.8 kWh/1,000 gallons for wastewater treatment

With these assumptions, the following equation was used to calculate embedded energy savings:

$$\text{Energy Savings} = \text{Energy Required} \times \text{Water Savings}$$

Where:

Energy Savings:	Amount of energy saved (kWh/yr)
Energy Required:	Amount of energy required for water supply and/or wastewater treatment (kWh/1000 gal)
Water Savings:	Amount of water saved (gal/yr)

To estimate greenhouse gas emission reductions, EPA used region-specific greenhouse gas emission factors from eGRID Version 1.1, available at www.epa.gov/cleanenergy/energy-resources/egrid/index.html, which accounts for carbon dioxide, methane, and nitrous oxide emissions. With these assumptions, the following equation was used to calculate greenhouse gas emission reductions:

$$\text{GHG Emissions} = \text{EF} \times \frac{\text{Energy Savings}}{1{,}000} \times \frac{1}{2{,}204.622}$$

Where:

GHG Emissions:	Amount of emissions reduced (MT CO_2e/yr)
EF:	Region specific emission factor (lb CO_2e/MWh)
Energy Savings:	Reported or calculated energy savings (kWh/yr)
1,000:	Conversion from kWh to MWh
1/2,204.622:	Conversion from lb to MT

In addition, EPA estimated the total cost savings associated with each project, generally taking into account water/wastewater cost savings (depending on the project) and any difference in maintenance costs reported (either positive or negative). In some cases, the cost of water/wastewater was provided in the GPR project file. When this information was not provided, EPA assumed that the cost was \$3.68 per 1,000 gallons to produce and supply water and \$4.57

per 1,000 gallons to treat wastewater, for a total of $8.25 per 1,000 gallons. These assumptions were obtained from the American Water Works Association 2010 *Water and Wastewater Rate Survey*, produced by Raftelis Financial Consulting.

The specific assumptions and calculations unique to each water efficiency project subcategory are discussed in the following subsections.

2.5.2.2 Meter Installation (ME) Assumptions and Methodology

Projects that installed meters to track and correct system water loss represented 12 percent of the total individual water efficiency projects, including subprojects. To estimate the quantity of water and subsequent energy saved from meter installation projects, EPA needed to know the expected volume of water saved or the original water use and expected percent water savings. If the GPR project file did not provide this information, EPA could not evaluate the water savings associated with the project.

For all meter installation projects, EPA assumed that the embedded energy savings resulted only from not producing and distributing the recovered lost water (i.e., 1.4 kWh per 1,000 gallons) and did not include any energy savings associated with reduced wastewater treatment.

The following equation was used to calculate water savings:

$$\text{Water Savings} = \text{Water Use} \times \text{Percent Water Savings}$$

Where:

Water Savings:	Amount of water saved (gal/yr)
Water Use:	Original amount of water used (gal/yr)
Percent Water Savings:	Percent of water savings from meter installation (%)

The following equation was used to calculate total cost savings:

$$\text{Total Cost Savings} = (\text{Energy Cost} \times \text{Energy Savings}) + (\text{Water Treatment Cost} \times \text{Water Savings}) - \text{Maintenance}$$

Where:

Total Cost Savings:	Cost savings for project ($/yr)
Energy Cost:	Energy cost for supplying water ($/kWh)
Energy Savings:	Reported or calculated energy savings (kWh/yr)
Water Treatment Cost:	Cost for supplying water ($/1,000 gal)
Water Savings:	Amount of water saved (gal/yr)
Maintenance:	Maintenance cost or savings ($/yr)

2.5.2.3 Water Reuse, Reclamation, or Recycling (RE) Assumptions and Methodology

Projects that utilized water reuse, reclamation, and recycling represented 45 percent of the total individual water efficiency projects, including subprojects. To estimate the quantity of water and subsequent energy saved from water reuse, reclamation, or recycling projects, EPA needed to know the expected amount of water reused, reclaimed, or recycled or the original water use and expected percent water savings. If the GPR project file did not provide this information, EPA could not evaluate the water savings associated with the project.

To estimate the embedded energy savings, EPA determined whether the project supplied municipally reclaimed/recycled water for reuse or whether the project reused wastewater within a system from one process as makeup water in another process. For municipally supplied reclaimed/recycled water projects, EPA assumed that the embedded energy savings resulted only from not supplying potable water to the applications that use the reclaimed/recycled water (i.e., 1.4 kWh per 1,000 gallons). For projects that reuse wastewater within a system from one process as makeup water in another process, EPA assumed that embedded energy savings resulted from not treating the wastewater discharged from the first process and not supplying potable water for use in the second process (i.e., 3.2 kWh per 1,000 gallons). Similarly, EPA assumed that the water cost savings associated with supplying municipally reclaimed/recycled water included only the cost to produce water (i.e., $3.68 per 1,000 gallons, if a cost value was not reported). EPA also assumed that the water cost savings associated with reusing wastewater within a system from one process as makeup water in another process included the costs associated with not having to treat the wastewater discharged from the first process and not having to supply potable water for use in the second process (i.e., $8.25 per 1,000 gallons, if a cost value was not reported).

In addition, for municipally supplied reclaimed/recycled water projects, EPA took into account the total cost savings of revenue that might be generated from selling the reclaimed/recycled water. If the cost charged for reclaimed/recycled water was not reported in the GPR project file, EPA assumed an average rate of $2.00 per 1,000 gallons. This assumption is based on the approximated average reported charges from two municipally supplied reclaimed water projects included in the model; San Diego’s reclaimed water project, which has a rate of $1.91 per 1,000 gallons, and El Paso’s reclaimed water project, which has a rate of $2.16 per 1,000 gallons. EPA assumed that the cost to supply the reclaimed/recycled water is negligible.

The following equation was used to calculate water savings:

$$\text{Water Savings} = \text{Water Use} \times \text{Percent Recycled}$$

Where:

Water Savings:	Amount of water saved (gal/yr)
Water Use:	Original amount of water used (gal/yr)
Percent Recycled:	Percent of water recycled or reclaimed (%)

With the above assumptions, the following equation was used to calculate total cost savings:

$$\text{Total Cost Savings} = (\text{Water Treatment Cost x Water Savings}) + (\text{Reclaimed Cost x Water Savings}) - \text{Maintenance}$$

Where:

Total Cost Savings:	Cost savings for project ($/yr)
Water Treatment Cost:	Cost for treating water ($/1,000 gal)

Water Savings:	Amount of water saved (gal/yr)
Reclaimed Cost:	Cost charged for reclaimed water ($/1,000 gal)
Maintenance:	Maintenance cost or savings ($/yr)

2.5.2.4 Water Efficient Fixtures (WF) Assumptions and Methodology

Projects that utilized high efficiency fixtures to provide water savings represented three percent of the total individual water efficiency projects, including subprojects. To estimate the quantity of water and subsequent energy saved from replacement of standard fixtures with high efficiency fixtures, EPA needed the following information:

- Original fixture water use;
- High efficiency fixture water use; and
- Frequency of fixture use.

If the GPR project file did not provide this information, EPA could not evaluate the water savings associated with the project.

The following equation was used to calculate water savings:

$$\text{Water Savings} = (\text{Original Use} - \text{Replacement Use}) \times \text{Frequency}$$

Where:

Water Savings:	Amount of water saved (gal/yr)
Original Use:	Amount of water used by original fixtures (varies)
Replacement Use:	Amount of water used by replacement fixtures (varies)
Frequency:	Frequency of fixture use (varies)

The following equation was used to calculated cost savings:

$$\text{Total Cost Savings} = (\text{Water Treatment Cost} \times \text{Water Savings}) - \text{Maintenance}$$

Where:

Total Cost Savings:	Cost savings for project ($/yr)
Water Treatment Cost:	Cost for supplying water and/or treating wastewater ($/1,000 gal)
Water Savings:	Amount of water saved (gal/yr)
Maintenance:	Maintenance cost or savings ($/yr)

2.5.3 Green Infrastructure Environmental Benefits Modeling Methodology and Assumptions

EPA developed an Excel spreadsheet-based model to calculate the environmental benefits listed in Table 2 for as many green infrastructure projects as possible using project information it was able to obtain during its data collection efforts, as well as the availability of key data inputs provided in the GPR project files.

The assumptions made when calculating the environmental benefits are discussed in more detail below. See Appendix C for a complete list of assumptions used in the development of the green infrastructure environmental benefits model.

2.5.3.1 General Assumptions and Methodology

For all green infrastructure projects, EPA estimated the primary benefits of stormwater runoff avoided and pollutant loading reductions, as well as secondary benefits associated with avoided energy use from not treating stormwater and reduced greenhouse gas emissions from the avoided energy use. In most cases, the GPR project files did not provide an estimate of these benefits; therefore, EPA used some standard assumptions.

To estimate the stormwater runoff avoided, EPA assumed that 100 percent of the surface treated by each green infrastructure project (i.e., drainage area) was impervious, unless otherwise reported in the GPR project file. Although this may be an overestimation in some cases, neither the land use type nor amount of impervious surface was typically reported; therefore, EPA had no basis for which to use an alternate assumption.

To estimate pollutant loading reductions, EPA evaluated and used as a guide Maryland's Non-Point Source Load Reduction Calculator, available at www.mde.maryland.gov/programs/Water/QualityFinancing/Pages/Programs/WaterPrograms/water_quality_finance/index.aspx. EPA made some general assumptions about the pollutant removal efficiencies of the relevant green infrastructure practices, as shown in Table 7. These removal efficiencies were obtained from EPA's Office of Science and Technology's National Pollutant Removal Performance Database for Stormwater Treatment Practices, Second Edition, March 2000, and from the Stormwater Manager's Resource Center, available at www.stormwatercenter.net/.

Table 7. Median Pollutant Removal Efficiencies for Common Green Infrastructure Practices

Green Infrastructure Practice	Total Suspended Solids Removal	Total Phosphorous Removal	Total Nitrogen Removal
Stormwater Dry Pond	47%	19%	25%
Stormwater Wet Pond	80%	51%	33%
Stormwater Wetland	76%	49%	30%
Filtering Practices	86%	59%	38%
Infiltration Practices	95%	80%	51%
Water Quality Swales (open channels)	81%	34%	84%
Porous Pavement	95%	65%	82%

EPA also made an assumption about the general land use type where the projects were located to estimate the median pollutant loading concentration. Median pollutant loading concentrations by land use type, obtained from the Stormwater Manager's Resource Center, available at www.stormwatercenter.net/, are shown in Table 8. The land use type was not typically provided in the GPR project files; therefore, EPA assumed that all land use was commercial. Based on the project descriptions, this assumption is typical for a majority of the projects. It is also a conservative assumption, as commercial land use contributes the lowest concentration of pollutants among the various land use types.

Table 8. Median Pollutant Loading Concentrations by Land Use Type

Land Use	Total Suspended Solids (mg/L)	Total Phosphorous (mg/L)	Total Nitrogen (mg/L)
Residential	100	0.4	2.2
Commercial	75	0.2	2
Roadway	150	0.5	3
Industrial	120	0.4	2.5

Based on the pollutant loading concentration, pollutant removal efficiencies of the relevant green infrastructure practices, and the amount of stormwater avoided, EPA estimated the pollutant loading reduction for total suspended solids, total phosphorous, and total nitrogen associated with each green infrastructure project using the following equations:

$$\text{Reduction} = (\text{Runoff Avoided} \times \text{Pollutant Concentration} \times 3.7854) \times \frac{1}{1{,}000{,}000} \times 2.2046 \times \text{Pollutant Removal}$$

Where:

Reduction:	Amount of pollutant reduced (lb/yr)
Runoff Avoided:	Amount of stormwater runoff avoided (gal/yr)
Pollutant Concentration:	Total P, N or sediment concentration (from Table 8) (mg/L)
3.7854:	Conversion from L to gal
1/1,000,000:	Conversion from mg to kg
2.2046:	Conversion from kg to lb
Pollutant Removal:	Median pollutant removal efficiency by stormwater treatment practices (from Table 7) (%)

To estimate secondary benefits of avoided energy use, reduced greenhouse gas emission reductions, and avoided stormwater treatment costs, EPA first determined whether the project was located in a city that treats its stormwater through a combined sewer or a municipal separate storm sewer. According to EPA’s Office of Water there are 800 cities with active combined sewer overflow permits, meaning stormwater is conveyed through a combined sewer to a wastewater treatment plant for treatment. If the project was located in a city with a combined sewer, EPA assumed that the avoided stormwater runoff provided energy savings, greenhouse gas emission reductions, and cost savings associated with not having to treat the avoided storm water. For projects in locations with a combined sewer, EPA estimated these secondary benefits. If the project was not located in a city with a combined sewer, EPA assumed that the stormwater was discharged through a municipal separate storm sewer without any subsequent treatment and thus provides no associated energy savings, greenhouse gas emission reductions, or cost savings. For projects in locations with a municipal separate storm sewer, EPA did not estimate these secondary benefits.

To estimate energy savings for projects located in areas with combined sewers, EPA assumed that it requires 1,408 kWh per million gallons to treat the commingled stormwater/wastewater. This number was obtained from the Center for Neighborhood Technology's *The Value of Green Infrastructure*, available at www.cnt.org/repository/gi-values-guide.pdf, and represents the energy use required to treat wastewater at a 10 million gallon per day advanced wastewater treatment plant without nitrification. If the size or type of treatment plant were specified in the GPR project file, EPA assumed an alternate energy usage provided in the Center for Neighborhood Technology's *The Value of Green Infrastructure* for a wastewater treatment plant matching or close to the specified characteristics.

With these assumptions, the following equation was used to calculate energy savings:

$$\text{Energy Savings} = \text{Runoff Avoided} \times \text{Treatment Energy} \times \frac{1}{1{,}000{,}000}$$

Where:

Energy Savings:	Amount of energy saved (kWh/year)
Runoff Avoided:	Amount of stormwater runoff avoided (gal/year)
Treatment Energy:	Amount of energy required to treat wastewater (kWh/1,000,000 gal)
1/1,000,000:	Conversion to gallons

To estimate greenhouse gas emission reductions, EPA used region-specific greenhouse gas emission factors from eGRID Version 1.1, available at www.epa.gov/cleanenergy/energy-resources/egrid/index.html, which accounts for carbon dioxide, methane, and nitrous oxide emissions. Note that greenhouse gas emission reductions do not account for any carbon sequestration that might occur as a result of the green infrastructure project. With these assumptions, the following equation was used to calculate greenhouse gas emission reductions:

$$\text{GHG Emissions} = \text{EF} \times \frac{\text{Energy Savings}}{1{,}000} \times \frac{1}{2{,}204.622}$$

Where:

GHG Emissions:	Amount of emissions reduced (MT CO_2e/yr)
EF:	Region specific emission factor (lb CO_2e/MWh)
Energy Savings:	Reported or calculated energy savings (kWh/yr)
1000:	Conversion from kWh to MWh
1/2204.622:	Conversion from lb to MT

To estimate cost savings associated with not treating the stormwater in areas with combined sewers, EPA assumed, unless otherwise specified in the GPR project file, that the marginal cost of treating stormwater was $0.9 per 1,000 gallons. This cost was reported in the GPR project file for the City of North Tonawanda, New York. In addition, it is within the range of stormwater treatment costs included in Chapter 3 of the University of New Hampshire's *Forging the Link* report, located at www.unh.edu/unhsc/sites/unh.edu.unhsc/files/docs/FTL_Chapter3%20LR.pdf.

With these assumptions, the following equation was used to calculate avoided stormwater treatment costs:

$$\text{Cost} = \text{Runoff Avoided} \times \text{Treatment Cost} \times \frac{1}{1{,}000}$$

Where:

Cost:	Avoided stormwater treatment cost ($/yr)
Runoff Avoided:	Amount of stormwater runoff avoided (gal/yr)
Treatment Cost:	Marginal cost for treating stormwater ($/1,000 gal)
1/1,000:	Conversion to gallons

The total cost savings for each project was estimated by subtracting any maintenance costs from the avoided stormwater treatment costs. The specific assumptions and calculations unique to each green infrastructure project subcategory are discussed in the following subsections.

2.5.3.2 Bioretention (BI), Rain garden (RG), and Swale (SW) Assumptions and Methodology

Bioretention, rain gardens, and swales behave similarly in terms of the environmental benefits they provide. These green infrastructure practices represented 23 percent of the total individual green infrastructure projects, including subprojects. To estimate the quantity of stormwater runoff avoided, pollutants removed, and subsequent energy savings associated with each bioretention, rain garden, or swale project, EPA needed the following information:

- Area of bioretention, rain garden, or swale project;
- Drainage area;
- Average annual precipitation; and
- Amount of precipitation retained and treated by the bioretention, rain garden, or swale area.

If the GPR project file did not provide the size of the bioretention area, rain garden, or swale and the drainage area, EPA could not evaluate the amount of avoided stormwater runoff associated with the project. If the annual rainfall data were not provided, EPA obtained a precipitation value from the National Oceanic and Atmospheric Administration (NOAA) for the monitoring station nearest the project location, available at http://cdo.ncdc.noaa.gov/cgi-bin/climatenormals/climatenormals.pl?directive=prod_select2&prodtype=CLIM20&subrnum. If the amount of precipitation retained and treated by the bioretention, rain garden, or swale area was not provided, EPA assumed a retention rate of 80 percent, obtained from The Center for Neighborhood Technology's *The Value of Green Infrastructure*, available at www.cnt.org/repository/gi-values-guide.pdf.

With these assumptions, the following equation was used to calculate stormwater runoff avoided:

$$\text{Runoff Avoided} = \text{Precipitation} \times (\text{Feature Area} + \text{Drainage Area}) \times \text{Precipitation Retained} \times \text{Conversion Factor}$$

Where:

Runoff Avoided:	Amount of stormwater runoff avoided (gal/yr)
Precipitation:	Average annual precipitation (in)
Feature Area:	Size of feature (ft^2)
Drainage Area:	Area treated by the feature (ft^2)
Precipitation Retained:	Amount of precipitation retained by the feature (%)
Conversion Factor:	Conversion to gal/yr

2.5.3.3 Green Roof (GR) Assumptions and Methodology

Projects that utilized green roofs to reduce stormwater runoff represented three percent of the total individual green infrastructure projects, including subprojects. To estimate the quantity of stormwater runoff avoided, pollutants reduced, and subsequent energy saved associated with green roof projects, EPA needed the following information:

- Area of the green roof project;
- Average annual precipitation; and
- Amount of precipitation retained and treated by the green roof.

If the GPR project file did not provide the area covered by the green roof project, EPA could not evaluate the amount of avoided stormwater runoff associated with the project. If the annual rainfall data were not provided, EPA obtained a precipitation value from NOAA for the monitoring station nearest the project location, available at http://cdo.ncdc.noaa.gov/cgi-bin/climatenormals/climatenormals.pl?directive=prod_select2&prodtype=CLIM20&subrnum. If the amount of precipitation retained and treated by the green roof was not provided, EPA assumed a retention rate of 60 percent, obtained from The Center for Neighborhood Technology's *The Value of Green Infrastructure*, available at www.cnt.org/repository/gi-values-guide.pdf.

EPA did not account for energy savings associated with the heating and cooling effects the green roof may have on the building, as the GPR project files did not contain sufficient information necessary to calculate this energy savings.

With these assumptions, the following equation was used to calculate stormwater runoff avoided:

$$\text{Runoff Avoided} = \text{Precipitation} \times \text{Feature Area} \times \text{Precipitation Retained} \times \text{Conversion Factor}$$

Where:

Runoff Avoided:	Amount of stormwater runoff avoided (gal/yr)
Precipitation:	Average annual precipitation (in)
Feature Area:	Size of green roof (ft^2)
Precipitation Retained:	Amount of precipitation retained by the green roof (%)
Conversion Factor:	Conversion to gal/yr

2.5.3.4 Pervious Pavement (PP) Assumptions and Methodology

Projects that utilized pervious pavement to reduce stormwater runoff represented seven percent of the total individual green infrastructure projects, including subprojects. To estimate the quantity of stormwater runoff avoided, pollutants reduced, and subsequent energy saved from pervious pavement projects, EPA needed the following information:

- Area of pervious pavement;
- Average annual precipitation; and
- Percent of precipitation retained by the pervious pavement.

If the GPR project file did not provide the pervious pavement area, EPA could not evaluate the amount of avoided stormwater runoff associated with that project. If the annual rainfall data were not provided, EPA obtained a precipitation value from NOAA for the monitoring station nearest the project location, available at http://cdo.ncdc.noaa.gov/cgi-bin/climatenormals/climatenormals.pl?directive=prod_select2&prodtype=CLIM20&subrnum. If the amount of precipitation retained by the pervious pavement was not provided, EPA assumed a retention rate of 80 percent, from The Center for Neighborhood Technology's *The Value of Green Infrastructure*, available at www.cnt.org/repository/gi-values-guide.pdf.

With these assumptions, the following equation was used to calculate stormwater runoff avoided:

$$\text{Runoff Avoided} = \text{Precipitation} \times \text{Feature Area} \times \text{Precipitation Retained} \times \text{Conversion Factor}$$

Where:

Runoff Avoided:	Amount of runoff avoided (gal/yr)
Precipitation:	Average annual precipitation (in)
Feature Area:	Area of porous pavement (ft^2)
Precipitation Retained:	Amount of precipitation retained by the porous pavement (%)
Conversion Factor:	Conversion to gal/yr

2.5.3.5 Riparian Restoration Assumptions and Methodology

Projects that utilized riparian restoration to reduce stormwater runoff represented 18 percent of the total individual green infrastructure projects, including subprojects. To estimate the quantity of stormwater runoff avoided, pollutants reduced, and subsequent energy saved from riparian restoration projects, EPA needed the following information:

- Area of riparian restoration;
- Average annual precipitation; and
- Percent of precipitation retained by the restored area.

If the GPR project file did not provide the restored riparian area, EPA could not evaluate the amount of avoided stormwater runoff associated with the project. If the annual rainfall data were not provided, EPA obtained a precipitation value from NOAA for the monitoring station nearest the project location, available at http://cdo.ncdc.noaa.gov/cgi-bin/climatenormals/climatenormals.pl?directive=prod_select2&prodtype=CLIM20&subrnum. If the amount of precipitation retained by the restored riparian area was not provided, EPA assumed a retention rate of 80 percent. EPA assumed the retention rate would be similar to that of a bioretention area, which has a retention rate of 80 percent, obtained from The Center for Neighborhood Technology's *The Value of Green Infrastructure*, available at www.cnt.org/repository/gi-values-guide.pdf.

With these assumptions, the following equation was used to calculate stormwater runoff avoided:

$$\text{Runoff Avoided} = \text{Precipitation} \times \text{Restoration Area} \times \text{Precipitation Retained} \times \text{Conversion Factor}$$

Where:

Runoff Avoided:	Amount of stormwater runoff avoided (gal/yr)
Precipitation:	Average annual precipitation (in)
Restoration Area:	Riparian restoration area (ft^2)
Precipitation Retained:	Amount of precipitation retained by the riparian restoration area (%)
Conversion Factor:	Conversion to gal/yr

2.5.3.6 Rainwater Harvesting (RW) Assumptions and Methodology

Projects that utilized rain water harvesting to reduce stormwater represented four percent of the total individual green infrastructure projects, including subprojects. To estimate the quantity of stormwater runoff avoided, pollutants reduced, and subsequent energy saved from rainwater harvesting projects, EPA needed the following information:

- Surface area available for rainwater collection (e.g., roof top);
- Precipitation collected;
- Rainwater collection efficiency; and
- Number of rainwater collection devices.

In general, the GPR project files only provided the number of rainwater collection devices distributed and occasionally the roof top collection area. To calculate the environmental benefits associated with rainwater harvesting projects, EPA made some general assumptions, including:

- Rainwater harvesting has an 85 percent collection efficiency, from The Center for Neighborhood Technology's *The Value of Green Infrastructure*, available at www.cnt.org/repository/gi-values-guide.pdf.
- Rainfall is only collected and utilized for the period of March through October (assumed to be the period when precipitation is in the form of rain and when the rainwater would be used as supplemental irrigation). If the precipitation data were not provided, EPA obtained a precipitation value from NOAA, for the monitoring station nearest the project location, available at http://cdo.ncdc.noaa.gov/cgi-bin/climatenormals/climatenormals.pl?directive=prod_select2&prodtype=CLIM20&subrnum.
- For residential applications, the rain barrel volume is 55 gallons.
- For residential applications, the rooftop surface area is 1,200 sq ft roof per home, obtained from the Center for Neighborhood Technology's Green Values Stormwater Management Calculator, available at http://logan.cnt.org/calculator/calculator.php.

However, the roof has four gutters, and the rain barrel is only attached to one gutter for a total collection surface area of 300 feet.

- For non-residential buildings, due to the variety of building sizes (e.g., government, offices, commercial space), EPA did not estimate benefits unless roof size was provided in the GPR project file.

With these assumptions, the following equation was used to calculate stormwater runoff avoided:

$$\text{Runoff Avoided} = \text{Precipitation} \times \text{Roofttop Surface Area} \times \text{Collection Efficiency} \times \text{Units} \times \text{Conversion Factor}$$

Where:

Runoff Avoided:	Amount of stormwater runoff avoided (gal/yr)
Precipitation:	Total precipitation from March to October (in)
Rooftop Surface Area:	Area of the rooftop draining to the rainwater collection device (ft^2)
Collection Efficiency:	Collection efficiency of the rainwater collection device (%)
Units:	Number of rainwater collection devices
Conversion Factor:	Conversion to gal/yr

When calculating energy and cost savings, EPA did not account for savings associated with not using potable water to supply irrigation. Savings only account for not treating the stormwater runoff.

2.5.3.7 Stormwater Pond (SP) Assumptions and Methodology

Projects that utilized stormwater ponds to reduce stormwater runoff represented six percent of the total individual green infrastructure projects, including subprojects. To estimate the quantity of stormwater runoff avoided, pollutants reduced, and subsequent energy saved from stormwater pond projects, EPA required the following information:

- Stormwater pond area;
- Drainage area;
- Average annual precipitation; and
- Amount of precipitation retained and treated by the stormwater pond.

If the GPR project file did not provide the stormwater pond area and the drainage area, EPA could not evaluate the amount of stormwater runoff avoided associated with that project. If the annual rainfall data were not provided, EPA obtained a precipitation value from NOAA for the monitoring station nearest the project location, available at http://cdo.ncdc.noaa.gov/cgi-bin/climatenormals/climatenormals.pl?directive=prod_select2&prodtype=CLIM20&subrnum. If the amount of precipitation retained and treated by the stormwater pond was not provided, EPA assumed a retention rate of 80 percent, taken from The Center for Neighborhood Technology's *The Value of Green Infrastructure*, available at http://logan.cnt.org/calculator/calculator.php.

With these assumptions, the following equation was used to calculate stormwater runoff avoided:

$$\text{Runoff Avoided} = \text{Precipitation} \times \text{Drainage Area} \times \text{Precipitation Retained} \times \text{Conversion Factor}$$

Where:

Runoff Avoided:	Amount of stormwater runoff avoided (gal/yr)
Precipitation:	Average annual precipitation (in)
Drainage Area:	Area drained to the pond (ft^2)
Precipitation Retained:	Amount of precipitation retained by the stormwater pond (%)
Conversion Factor:	Conversion to gal/yr

2.5.3.8 Vegetative Plantings (VP) Assumptions and Methodology

Projects that utilized vegetative plantings to reduce stormwater runoff represented seven percent of the total individual green infrastructure projects, including subprojects. To estimate the quantity of stormwater runoff avoided, pollutants reduced, and subsequent energy saved from vegetative plantings projects, EPA needed the following information:

- Number and type of plantings;
- Average size of planting;
- Climate zone of project location;
- Average annual precipitation; and
- Average annual interception rate.

All of the vegetative planting projects evaluated and included in this model were tree plantings. Therefore, EPA structured the model and made some general assumptions to calculate the environmental benefits specifically associated with trees. If the GPR project file did not provide the number of tree plantings, EPA could not evaluate the amount of avoided stormwater runoff associated with the project. If the average size of the trees planted was not provided, EPA assumed the average tree size was medium. If the climate zone was not provided, EPA assigned the project to a climate zone based upon its location in accordance with climate zones established by the U.S. Forest Service, available at www.fs.fed.us/psw/programs/cufr/tree_guides.php. If the annual rainfall data were not provided, EPA obtained a precipitation value from NOAA for the monitoring station nearest the project location, available at http://cdo.ncdc.noaa.gov/cgi-bin/climatenormals/climatenormals.pl?directive=prod_select2&prodtype=CLIM20&subrnum.

With this information, EPA identified the region-specific average annual interception rates (gallons per tree per year) for the types of trees planted and used the interception rate as the basis for estimating the environmental benefits. Interception rates were obtained from the U.S Forest Service, available at www.fs.fed.us/psw/programs/cufr/tree_guides.php.

With these assumptions, the following equation was used to calculate stormwater runoff avoided:

$$\text{Runoff Avoided} = \text{Interception Rate} \times \text{Trees}$$

Where:

Runoff Avoided:	Amount of stormwater runoff avoided (gal/yr)
Interception Rate:	Average annual interception rate (gal/tree/yr)
Trees:	Number of trees planted

2.5.3.9 Wetlands (WL) Assumptions and Methodology

Projects that utilized constructed wetlands to reduce stormwater runoff represented seven percent of the total individual green infrastructure projects, including subprojects. To estimate the quantity of stormwater runoff avoided, pollutants reduced, and subsequent energy saved from wetland projects, EPA needed the following information:

- Wetland area;
- Average annual precipitation; and
- Percent of precipitation retained by the wetland.

If the GPR project file did not provide the wetland area, EPA could not evaluate the amount of avoided stormwater runoff associated with the project. If the annual rainfall data were not provided, EPA obtained a precipitation value from NOAA for the monitoring station nearest the project location, available at http://cdo.ncdc.noaa.gov/cgi-bin/climatenormals/climatenormals.pl?directive=prod_select2&prodtype=CLIM20&subrnum. If the amount of precipitation retained by wetland was not provided, EPA assumed a retention rate of 80 percent. EPA assumed the retention rate would be similar to that of a bioretention area, which has a retention rate of 80 percent, obtained from The Center for Neighborhood Technology's *The Value of Green Infrastructure*, available at http://logan.cnt.org/calculator/calculator.php.

With these assumptions, the following equation was used to calculate stormwater runoff avoided:

$$\text{Runoff Avoided} = \text{Precipitation} \times \text{Wetland Area} \times \text{Precipitation Retained} \times \text{Conversion Factor}$$

Where:

Runoff Avoided:	Amount of stormwater runoff avoided (gal/yr)
Precipitation:	Average annual precipitation (in)
Wetland Area:	Wetland area (ft^2)
Precipitation Retained:	Amount of precipitation retained by the wetland (%)
Conversion Factor:	Conversion to gal/yr

3. Methodology for Extrapolating Environmental Benefits to All GPR Projects

Once the benefits for the individual project subcategories were calculated, EPA compiled the estimated benefits for all the projects in each subcategory into a summary table to analyze the quantifiable environmental benefits associated with each project (which may have consisted of several subprojects under different subcategories) and the project category as a whole (i.e.,, energy efficiency, water efficiency, green infrastructure). EPA also calculated the total cost savings associated with the project or group of subprojects that comprised the project and the project payback period, based upon the project funding reported in the CBR database.

From the set of modeled benefits, EPA extrapolated and estimated the potential environmental benefits for all GPR projects, based on both the project funding and the number of projects the modeled benefits represented. The extrapolation methodology is outlined in detail below.

For each project subcategory, EPA summed the individual project benefits to obtain a total value for all of the benefits in that subcategory, as illustrated in Table 9 for the water efficiency subcategories.

Table 9. Modeled Environmental Benefits for Water Efficiency Projects

Water Efficiency Subcategory	Water Savings (gal/yr)	Alternative Water Generated (gal/yr)	Embedded Energy Savings (kWh/yr)	Reduced GHG Emissions (MT CO2e/yr)	Total Cost Savings ($/yr)
ME	416,706,440	NA	987,356	672	$473,468
RE	4,234,199,790	4,234,199,790	5,978,005	3,510	$23,858,731
WF	5,769,487	NA	18,462	12	$7,289
Total Benefits Modeled	4,656,675,717	4,234,199,790	6,983,824	4,194	$24,339,487

EPA then determined the total funding and number of subprojects represented in the model for each subcategory, as illustrated in Table 10 for the water efficiency subcategories.

Table 10. Representation of Modeled Water Efficiency Projects by Subcategory

Water Efficiency Subcategory	Total Number of Subprojects	Number Modeled of Subprojects Represented	Percent of Modeled Subprojects Represented	Total Subcategory Dollars Funded	Modeled Subcategory Dollars Represented	Percent of Modeled Subcategory Dollars Represented
ME	13	6	46%	$7,699,876	$5,068,047	66%
RE	50	16	32%	$110,707,113	$24,447,807	22%
WF	3	1	33%	$1,087,500	$675,000	62%

To extrapolate benefits for all of the projects in each project subcategory, EPA divided the modeled benefits (i.e., totals from Table 9) by the percent of funding or projects (i.e., percentages from Table 10) for each subcategory. ERG then added the extrapolated benefits from each subcategory to obtain an estimation of the total benefits for all projects in each category, as illustrated in Table 11 for all water efficiency projects.

Table 11. Extrapolated Environmental Benefits for All Water Efficiency Projects

Water Efficiency Subcategory	Extrapolation Metric	Water Savings (gal/yr)	Alternative Water Generated (gal/yr)	Embedded Energy Savings (kWh/yr)	Reduced GHG Emissions (MT CO2e/yr)	Total Cost Savings ($/yr)
ME	% of Funding	633,101,452	NA	1,500,089	1,021	$719,339
	% of Projects	902,863,953	NA	2,139,272	1,456	$1,025,847
RE	% of Funding	19,173,745,713	19,173,745,713	27,070,226	15,894	$108,039,597
	% of Projects	13,231,874,345	13,231,874,345	18,681,265	10,969	$74,558,534
WF	% of Funding	9,295,284	NA	29,745	19	$11,743
	% of Projects	17,308,460	NA	55,387	36	$21,866

Table 11. Extrapolated Environmental Benefits for All Water Efficiency Projects

Water Efficiency Subcategory	Extrapolation Metric	Water Savings (gal/yr)	Alternative Water Generated (gal/yr)	Embedded Energy Savings (kWh/yr)	Reduced GHG Emissions (MT CO2e/yr)	Total Cost Savings ($/yr)
Total as % of Funding		19,816,142,450	19,173,745,713	28,600,060	16,935	$108,770,679
Total as % of Projects		14,152,046,758	13,231,874,345	20,875,924	12,461	$75,606,247

The extrapolated benefits calculated for all project subcategories are provided in Appendices A, B, and C.

4. SUMMARY OF ENVIRONMENTAL BENEFITS FOR GPR PROJECTS

Tables 12, 13, and 14 show the minimum, maximum, average, and total environmental benefits modeled and the total extrapolated benefits for all energy efficiency, water efficiency and green infrastructure projects, respectively. The individual project benefits from the environmental benefits models, summary of modeled environmental benefits, and the extrapolated environmental benefits are provided in Appendices A, B, and C.

On average, each energy efficiency project is estimated to save over 2 million kWh, 4 million gallons of water (associated with reduced energy use), 1,000 metric tons of greenhouse gas emissions (CO_2 equivalents), and save more than $200,000 per year. Extrapolated to all energy efficiency GPR projects, this equates to savings of approximately 800 million kWh, 1.6 billion gallons of water (associated with reduced energy use), and nearly 400,000 metric tons of greenhouse gas emissions (CO_2 equivalents), and $80 million per year.

On average, each water efficiency project is estimated to save over 200 million gallons of water per year, 300,000 kWh and 180 metric tons of greenhouse gas emissions (CO_2 equivalents) per year by not having to supply and treat the saved water/wastewater, and save more than $1 million per year in cost savings. Extrapolated to all water efficiency GPR projects, this equates to savings of over 14 billion gallons of water, 20 million kWh, 12,000 metric tons of greenhouse gas emissions (CO_2 equivalents), and over $75 million per year.

On average, each green infrastructure project is estimated to reduce stormwater runoff by 22 million gallons, save nearly 4,000 kWh and 2 metric tons of greenhouse gas emissions (from not having to treat the avoided stormwater), reduce total suspended solids, total phosphorous, and total nitrogen loadings by over 7,500 pounds, 10 pounds and 100 pounds, respectively, and save more than $2,500 per year. Extrapolated to all green infrastructure GPR projects, this equates to approximately 6.6 billion gallons of stormwater runoff avoided, a reduction of over 1.3 million kWh and over 600 metric tons of greenhouse gas emissions (by not having to treat the avoided stormwater), reduced loadings of 1.3 million pounds of total suspended solids, 3,000 pounds of total phosphorous, and 32,000 pounds of total nitrogen, and over $800,000 in cost savings per year.

Table 12. Summary of Modeled and Extrapolated Energy Efficiency GPR Project Environmental Benefits

	Project Cost	Energy Savings (kWh/yr)	Alternative Energy Generated (kWh/yr)	Embedded Water Savings (gal/yr)	Reduced GHG Emissions (MT CO_2e/yr)	Total Cost Savings ($/yr)	Payback (yrs)
Modeled Environmental Benefits							
Maximum	$56,151,187	125,923,049	125,923,049	251,846,098	60,840	$12,806,374	2,513
Minimum	$3,366	1,256	11,494	2,529	1	$114	0.2
Average	$2,714,581	2,156,551	5,212,910	4,350,045	1,049	$218,488	96.5
Total	$241,597,699	252,316,518	161,600,213	504,605,246	122,743	$25,563,095	NA
Extrapolated Environmental Benefits							
Total (as % of Funding)		**804,774,811**	**639,301,871**	**1,609,492,606**	**389,900**	**$79,720,247**	**NA**
Total (as % of Projects)	**$613,662,983[3]**	**814,783,439**	**610,630,906**	**1,629,496,849**	**393,370**	**$81,158,345**	**NA**

NA: Not applicable. Did not calculate payback as a total.

Table 13. Summary of Modeled and Extrapolated Water Efficiency Project Environmental Benefits

	Project Cost	Water Savings (gal/yr)	Alternative Water Generated (gal/yr)	Embedded Energy Savings (kWh/yr)	Reduced GHG Emissions (MT CO2e/yr)	Cost Savings	Payback (yrs)
Modeled Environmental Benefits							
Maximum	$5,004,817	2,737,500,000	2,737,500,000	3,832,500	2,712	$15,549,000	252
Minimum	$6,000	219,000	219,000	701	0	$1,807	0.2
Average	$820,780	202,464,162	264,637,487	303,645	182	$1,058,239	27
Total	$13,132,479	4,656,675,717	4,234,199,790	6,983,824	4,194	$24,339,487	NA
Extrapolated Environmental Benefits							
Total (as % of Funding)		**19,816,142,450**	**19,173,745,713**	**28,600,060**	**16,935**	**$108,770,679**	**NA**
Total (as % of Projects)	**$155,553,019[4]**	**14,152,046,758**	**13,231,874,345**	**20,875,924**	**12,461**	**$75,606,247**	**NA**

NA: Not applicable. Did not calculate payback as a total.

[3] The total project cost is not extrapolated. It is the total project costs for all energy efficiency projects as reported in the CBR database.

[4] The total project cost is not extrapolated. It is the total project costs for all water efficiency projects as reported in the CBR database.

Table 14. Summary of Modeled and Extrapolated Green Infrastructure Project Environmental Benefits

	Project Cost	Stormwater Runoff Avoided (gal/yr)	Pollutant Loading Reductions: Total Suspended Solids (lb/yr)	Total Phosphorous (lb/yr)	Total Nitrogen (lb/yr)	Energy Savings (kWh/yr)	Reduced GHG Emissions (MT CO2e/yr)	Cost Savings	Payback (yrs)
Modeled Environmental Benefits									
Maximum	$14,637,485	792,994,574	233,276	251	3,309	91,893	65	$58,738	6,311
Minimum	$18,477	5,913	3.2	0.01	0.04	0.0	0.0	-$1,104	2.8
Average	$931,036	21,959,359	7,507	10	102	3,854	2.3	$2,505	1,421
Total	$63,310,454	1,822,626,825	623,050	832	8,464	319,845	$187	$207,931	NA
Extrapolated Environmental Benefits									
Total (as % of Funding)	**$204,666,942[5]**	**6,589,804,465**	**2,526,223**	**3,894**	**34,569**	**1,301,411**	**685**	**$814,931**	**NA**
Total (as % of Projects)		**6,675,814,327**	**2,388,098**	**3,332**	**32,159**	**1,476,857**	**778**	**$947,522**	**NA**

NA: Not applicable. Did not calculate payback as a total.

[5] The total project cost is not extrapolated. It is the total project costs for all green infrastructure projects as reported in the CBR database.

5. DATA LIMITATIONS

EPA identified and documented data limitations as it collected data, developed the environmental benefits models, and estimated, summarized, and extrapolated the environmental benefits. These data limitations are discussed below.

Modeled Environmental Benefits May Not Be Fully Representative

EPA was able to collect information for 438 of the 641 energy efficiency, water efficiency, and green infrastructure projects; however, only 180, or 28 percent, of the GPR project files provided sufficient information to estimate environmental benefits.

There were several factors that impacted EPA data collection activities and the ultimate representativeness of the modeled dataset. These included:

- Due to time constraints, EPA did not gather GPR project files from every state.
- Several states, including Virginia and Arizona, denied EPA access to the GPR files due to resource constraints.
- Other states, including California, only provided access to a portion of the GPR projects.
- Each state instituted different application requirements, therefore, the type of data contained in GPR project files was highly variable and in some cases insufficient to calculate environmental benefits.

EPA was unable to collect GPR project information for three of the six water efficiency subcategories: water efficient components, water efficient processes, and pipes projects or retrofits. As a result, these projects are not represented in the modeled data set or the extrapolated water efficiency project environmental benefits. In addition, EPA did not collect any GPR projects files for projects completed in Region 7; therefore Region 7 is not represented in the modeled data set or extrapolated environmental benefits.

Benefits Are Anticipated, Not Actual

The environmental benefits modeled are anticipated benefits and not actual benefits realized. In addition, in many cases, EPA relied on the savings projections provided in GPR project files, which provided little to no supporting information.

Environmentally Innovative Projects Were Excluded

EPA did not estimate environmental benefits associated with any of the environmentally innovative projects. These projects, which consisted of biosolids application, decentralized treatment, and a variety of other very unique projects, were not conducive to modeling because they did not have similar data inputs and standard assumptions that EPA could use to estimate the environmental benefits. There were 111 environmentally innovative projects reported in the CBR database, representing approximately 15 percent of the total GPR projects funded.

Benefits May Be Underestimated

In some cases, the project descriptions provided in the CBR database were vague and insufficient for EPA to be able to classify the project into a particular subcategory. The projects that EPA could not classify into a subcategory ("NC"), including green infrastructure projects classified as unspecified green stormwater improvement projects or other BMPs ("BM"), were not specifically targeted for data collection. As a result, these projects were not included in the environmental benefits models. Further, EPA did not extrapolate environmental benefits for these projects because it had no basis with which to assume and apply average environmental benefits values to estimate their total benefits. Non-categorized projects comprised 18 percent of the subcategorized energy efficiency projects, 28 percent of the subcategorized water efficiency projects, and 12 percent of the subcategorized green infrastructure projects. Because these projects were excluded, total extrapolated benefits may be underestimated.

In addition, the environmental benefits included in the models represent those benefits that could be quantified based on information typically available in the GPR project files. EPA is aware of other environmental benefits, particularly for the green infrastructure projects, that were not included in the models because they are either qualitative in nature or the GPR project files did not have sufficient information with which to estimate the benefits. As a result, the modeled environmental benefits may be underestimated. Some additional environmental benefits provided by green infrastructure projects but not accounted for in the environmental benefits model include:

- Reduced flooding;
- Increased available water supply/groundwater recharge;
- Improved air quality;
- Reduced urban heat island effect;
- Energy saved from building heating and cooling affects;
- Vegetation carbon sequestration;
- Improved aesthetics;
- Increased recreational opportunities; and
- Improved habitat.

Project Payback May Be Underestimated

EPA used the project funding reported in the CBR database to calculate project payback periods, however, this funding was not appropriated based on the individual subprojects that may have been completed as part of a funded project. In some instances, EPA only estimated environmental benefits for a portion of the subprojects, therefore, the payback period calculated may be underestimated, as EPA could not account for the environmental benefits and cost savings associated with all portions of the project.

Project Modifications Not Captured

Sometimes project documentation was submitted prior to final project funding approval. As a result, EPA could not capture changes resulting from any project or funding modifications that may have occurred.

APPENDIX A: ENERGY EFFICIENCY

Table A-1. Summary of Modeled Environmental Benefits by State for Energy Efficiency GPR Projects

Location	Project Description	Subcategory	Project Cost	Total Project Benefits: Energy Savings (MWh/yr)	Alternative Energy Generated (MWh/yr)	Embedded Water Savings (gal/yr)	Reduced GHG Emissions (MT CO2e/yr)	Total Cost Savings ($/yr)	Payback (yrs)	Notes
Alabama										
Town of Moundville	Sanitary sewer collection system and improvements	ER	$52,318	262	NA	524,000	179	$26,645	2.0	
City of Childersburg	Replacement & rehab of sewer outfall line, lift stations, and pipe segments	EC		26	NA	51,326	18	$2,610		
		ER	$291,451	66	NA	131,506	45	$6,687	31.3	
Decatur Utilities	Design & construction of biological nutrient removal system at WWTP	EC		10,899	NA	21,797,158	7,658	$925,392		
		GP		4,105	4,105	8,209,066	2,884	$344,781		
		ER		3,981	NA	7,962,846	2,798	$334,440		
		EP	$905,750	41	NA	81,295	29	$3,948	0.6	
City of Montevallo Water & Sewer	Sanitary sewer collection and WWTP improvements	EC		1,899	NA	3,797,384	1,295	$132,908		
		EP	$2,388,408	2,035	NA	4,069,684	1,388	$142,633	8.7	
City of Pell City	Sanitary sewer collection system improvements	ER	$681,753	585	NA	1,170,920	399	$25,272	27.0	
Alaska										
City of Palmer	WWTP improvements - subsurface drainage system (insulated covers on two lagoons and aeration blower upgrades)	EP	$2,500,000	252	NA	504,758	147	$25,667	97.4	Originally categorized as a GI project in the CBR database. Complete funding applies to EE. Reclassified as an EE project.
Arkansas										
City of Batesville	Replace a pump station and force main with gravity line and tunnel	EP	$10,000,000	692	NA	1,384,854	317	$70,420	142.0	
California										
Inland Empire Utilities Agency	Replacement of belt press system that supports dewatering, resulting in reduced weight of material hauled to composting facility	EP	$14,823,874	17,843	NA	35,685,420	5,532	$1,814,604	8.2	
Colorado										
Georgetown	Wind turbine and energy efficiency improvements	EC		118	NA	235,004	102	$11,950		
		WI		243	243	485,000	211	$24,662		
		OR		800	800	1,600,000	695	$81,360		
		EP	$3,131,000	40	NA	80,600	35	$4,099	25.6	
Florida										

Table A-1. Summary of Modeled Environmental Benefits by State for Energy Efficiency GPR Projects

Location	Project Description	Subcategory	Project Cost	Total Project Benefits: Energy Savings (MWh/yr)	Alternative Energy Generated (MWh/yr)	Embedded Water Savings (gal/yr)	Reduced GHG Emissions (MT CO2e/yr)	Total Cost Savings ($/yr)	Payback (yrs)	Notes
Alachua	Construction of 1.5 MGD BNR and existing land application system expansion ; construction of 5MG reclaimed water ground storage tank	EP	$10,000,000	131	NA	261,294	73	$13,718	729.0	
Hawaii										
County of Maui	Pump replacement with efficient ones	EC	$5,050,316	26	NA	51,600	16	$8,308	607.9	
Idaho										
City of Coeur d'Alene	Sludge digester and gas handling	GP	$4,167,767	2,888	2,888	5,776,671	1,131	$79,742	52.3	Could not calculate all project benefits. Only the GP component of the project included in payback.
		EC		NC	NC	NC	NC	NC		
Indiana										
Angola	WWTP and sewer improvements	EC	$452,000	138	NA	276,600	98	$12,000	37.7	
Auburn	WWTP improvements for CSO abatement	EC	$3,636,464	797	NA	1,594,302	564	$81,070	44.9	
Darlington	WWTP expansion from .11 to .13 mgd, WWTP improvements, collection system improvements	EC	$78,000	71	NA	142,240	50	$3,709	21.0	
Jeffersonville	CSO elimination and sewer improvements	EC	$44,450	71	NA	141,907	50	$7,095	6.3	
Lafayette	Improvements to WWTP and collection system	EC	$646,000	2,534	NA	5,068,000	1,793	$257,708	2.5	
Mishawaka	Juday Creek force main and WWTP improvements	EC	$197,900	428	NA	856,486	303	$29,977	6.6	
Newburgh	Expand WWTP from 4.6 to 7.4 mgd	EC	$618,400	707	NA	1,413,207	500	$49,462	12.5	
Peru	WWTP upgrade	EC	$477,000	1,575	NA	3,149,220	1,114	$204,699	2.3	
Rensselaer	WWTP improvements to meet agreed LTCP	EC	$353,500	22	NA	43,260	15	$1,774	199.3	
Walton	Rehab of collection system and WWTP to abate I/I and eliminate SSO 002	EC	$53,000	18	NA	35,433	13	$1,329	39.9	Could not calculate all project benefits. Only the EC component of the project included in payback.
		ER		NC	NC	NC	NC	NC		
Richmond	Improvements at WWTP, tertiary bldg; LTCP/CSO impacts	EC	$119,200	6	NA	11,000	4	$559	213.1	
Carmel	WWTP improvements	EC	$343,965	153	NA	306,172	108	$1,530,862	0.2	
Kentucky										
Ky. Dept. of Parks	Construction of new WWTP and demolition of old one	EC	$340,000	56	NA	111,320	39	$5,566	61.1	

Table A-1. Summary of Modeled Environmental Benefits by State for Energy Efficiency GPR Projects

				Total Project Benefits						
Location	**Project Description**	**Subcategory**	**Project Cost**	**Energy Savings (MWh/yr)**	**Alternative Energy Generated (MWh/yr)**	**Embedded Water Savings (gal/yr)**	**Reduced GHG Emissions (MT CO2e/yr)**	**Total Cost Savings ($/yr)**	**Payback (yrs)**	**Notes**
City of Sacramento	Gravity sewer, force main, submersible pump station	EC	$287,000	2	NA	3,665	1	$114	2,513.1	
City of Prestonburg	New treatment units	EP	$803,000	729	NA	1,458,724	513	$50,326	16.0	
Maryland										
Talbot County	Solar panels, use of waste grease for energy, and wind turbines	SO		150	150	300,000	72	$15,255		Could not calculate all project benefits. Only the SO and WI component of the project included in payback.
		WI		464	464	928,932	224	$47,236		
		GP	$3,800,000	NC	NC	NC	NC	NC	60.8	
Michigan										
Genesee	WWTP upgrades	EC	$2,361,087	1,351	NA	2,702,294	1,018	$94,580	25.0	
Minnesota										
City of Big Lake	WWTP improvements	EP	$4,000,000	990	NA	1,979,224	778	$35,586	112.4	
City of Grand Rapids	Relocate primary treatment facilities	EP		332	NA	663,370	261	$32,216		
		EC	$4,022,709	176	NA	352,000	138	$17,899	80.3	
Mississippi										
City of Clinton	Sludge pumping dredge, holding tanks, dewatering and storage facility; solar drying greenhouses	EP	$1,900,000	2,200	NA	4,400,000	1,006	$223,740	8.5	
City of Natchez	Replacement of return activated sludge pumps; construction of sludge dewatering facility and solar drying chamber	EP	$4,318,000	902	NA	1,804,760	615	$91,772	47.1	
Montana										
City of Laurel	New energy recovery ventilator system	EP	$60,000	29	NA	58,730	11	$2,937	20.4	
New Jersey										
Long Branch SA	Installation of microturbine at WWTP	EC		1,268	NA	2,536,896	613	$193,819		
		GP	$2,500,000	876	876	1,752,000	423	$133,853	7.6	
Bayonne MUA	Construction of wind turbine for power	WI	$5,045,400	3,380	3,380	6,760,000	1,633	$338,000	14.9	
Middlesex County U.A.	Replacement of electrical system at WWTF	GP		125,923	125,923	251,846,098	60,840	$12,806,374		
		EP	$7,500,000	14	NA	NC	7	$115,924	0.6	
Passaic Valley Sewage Commission	Clean and remove liner of heat treatment plant supernatant return line from Zimpro sludge treatment	EC	$5,000,000	1,258	NA	2,516,632	608	$161,064	31.0	

Table A-1. Summary of Modeled Environmental Benefits by State for Energy Efficiency GPR Projects

Location	Project Description	Subcategory	Project Cost	Total Project Benefits: Energy Savings (MWh/yr)	Alternative Energy Generated (MWh/yr)	Embedded Water Savings (gal/yr)	Reduced GHG Emissions (MT CO2e/yr)	Total Cost Savings ($/yr)	Payback (yrs)	Notes
Mount Laurel Twp MUA	Design and construction of photovoltaic system to provide power for on-site sanitary sewer pumping station	SO	$3,328,800	660	660	1,320,000	319	$67,122	49.6	
Bayshore Regional SA	Construction of wind turbine for power	WI	$5,775,000	3,500	3,500	7,000,000	1,691	$355,950	16.2	
New York										
Town of LaGrange	Efficiency upgrades at WTTP	EC	$405,900	323	NA	646,230	101	$38,774	10.5	
Village of Canastota	Planning, design, and rehab of treatment facility and construction of storage tank for wet weather flows	EC		356	NA	712,000	111	$49,840		
		SO	$1,514,619	29	29	57,606	9	$6,432	26.9	
Village of Elba	Installation of solar units, energy efficient lighting, effluent powered heat pump, automated DO sensors, VFDs, and pipeline leak detection equipment	EC		32	NA	64,980	10	$2,843		There were 12 subprojects in all. Insufficient information to calc benefits for rain barrels heat pump, infrared heater, insulation, effluent quality control, pump station monitoring, pipeline inspection equipment, vehicle retrofit. Payback does not include these benefits.
		SO	$275,119	40	40	80,000	12	$3,600	42.7	
Village of Ellenville	Installation of solar panels	SO		112	112	224,000	35	$16,800		Project also includes a geothermal heat pump recovery system. Not enough info to calculate benefits for this subproject. Not included in payback.
		OR	$341,970	NC	NC	NC	NC	NC	20.4	
Town of Catskill	Design and construction of collection system improvements to address inflow & infiltration	EC	$39,175	15	NA	29,624	5	$1,777	22.0	
Cedarhurst	High efficiency lighting, premium efficiency motors and VFDs for pumps at pump stations	EC		1,219	NA	2,438,600	788	$131,309		
		EP	$80,385	344	NA	688,990	223	$37,894	0.5	
Village of Cuba	Improvement of collection system to correct inflow	EC	$536,397	232	NA	463,464	72	$35,918	14.9	
Village of Granville	WWTP upgrade that will allow better treatment and efficiency - installation of premium efficiency motors and lighting	EC	$566,637	33	NA	66,652	10	$6,116	92.7	
City of Hudson	Design & improvement of WWTP and pump station for efficiency	EC	$3,201,863	621	NA	1,241,994	193	$68,310	46.9	
Nassau County	Design and construction of collection system, pump station, and force main to replace failed septic systems	EC	$3,366	1	NA	2,529	1	$278	12.1	

Table A-1. Summary of Modeled Environmental Benefits by State for Energy Efficiency GPR Projects

Location	Project Description	Subcategory	Project Cost	Total Project Benefits					Payback (yrs)	Notes
				Energy Savings (MWh/yr)	Alternative Energy Generated (MWh/yr)	Embedded Water Savings (gal/yr)	Reduced GHG Emissions (MT CO2e/yr)	Total Cost Savings ($/yr)		
Town of North Salem	Design and construction of collection system, pump station, and treatment plant	EC	$79,147	198	NA	395,149	62	$24,376	3.2	
NYCMWFA	Replacement of primary settling tank influent gates, sludge pumps, degritting and collection system	EC	$1,827,361	588	NA	1,175,536	188	$51,724	35.3	
NYCMWFA	Construction of 3 new sludge ships for transport = ~1000 fewer trips/year	EC	$56,151,187	6,383	NA	12,766,039	2,045	$640,740	87.6	
Town of Brookhaven	Energy efficiency tertiary treatment	EP	$170,515	243	NA	486,440	157	$36,726	4.6	
Town of Greenville	Design and construction improvements to WWTP - high efficiency lighting, high efficiency blowers, building insulation	EP		14	NA	27,742	4	$1,803		
		EC	$84,705	99	NA	198,524	31	$12,904	5.8	
Town of Greenport	Planning and refurbishment of treatment plant	EC	$1,276,135	632	NA	1,263,936	197	$66,357	19.2	
NYCMWFA	Upgrade of sludge digesters for additional energy	EC	$4,187,146	6,407	NA	12,813,694	2,053	$383,876	10.9	
Village of Lyons	Energy efficiency and renewable energy improvements	EC		193	NA	386,845	60	$17,215		There are 12 subprojects funded under EE. Could not calc benefits for rainwater harvesting, green roof, sludge dewatering, vehicle retrofits pump station monitoring, manhole monitoring, pipeline inspection. Benefits are underestimated.
		SO	$546,575	80	80	160,000	25	$7,120	22.5	
Village of Medina	Installation of energy efficient lighting, solar units, effluent-powered heat pumps, biogas powered CHP units, and pipeline leak inspection equipment	EC		357	NA	714,751	111	$34,308		There are 12 projects subfunded under EE. Could not calc benefits for rainwater harvesting, green roof, weather monitoring station, vehicle retrofit, water meters and pipeline inspection.
		SO		230	230	460,000	72	$22,080		
		GP	$1,260,486	100	100	200,000	31	$10,170	18.9	
City of Ogdensburg	Upgrades to aeration system and anaerobic digester	EC		406	NA	811,050	126	$52,718		
		GP	$1,061,752	40	40	80,000	12	$5,200	18.3	
Village of Richfield Springs	Refurbishment of WWTP	EC	$665,185	20	NA	40,176	6	$2,149		
		EP		7	NA	13,118	2	$699		
		SO		22	22	44,566	7	$2,384	127.1	
Town of Southeast	Design and construction of collection system, pump station, and treatment plant	EC	$27,807	198	NA	395,149	62	$24,375	1.1	
Town of Ticonderoga	Treatment plant and sewer upgrades	EC	$917,091	23	NA	45,666	7	$2,854	321.3	

Table A-1. Summary of Modeled Environmental Benefits by State for Energy Efficiency GPR Projects

Location	Project Description	Subcategory	Project Cost	Total Project Benefits: Energy Savings (MWh/yr)	Alternative Energy Generated (MWh/yr)	Embedded Water Savings (gal/yr)	Reduced GHG Emissions (MT CO2e/yr)	Total Cost Savings ($/yr)	Payback (yrs)	Notes
Village of Weedsport	Rehab of sanitary sewer system and treatment upgrades	EC	$977,586	194	NA	387,867	60	$13,799	60.3	
		ER		20	NA	39,102	6	$1,428		
		EP		10	NA	20,190	3	$989		
Westchester County	Design & construction of biological nutrient removal system at WWTP	EC	$2,928,111	3,331	NA	6,662,978	1,067	$333,149	4.4	
		EP		3,331	NA	6,662,978	1,067	$333,149		
Village of Hoosick Falls	Installation of solar panels	SO	$92,914	98	98	195,968	31	$15,677	5.9	
Village of Port Byron	Installation of solar panels at WTF	SO	$131,306	11	11	22,988	4	$2,388	55.0	
Town of Williamson	Solar units and energy efficient replacements	SO	$664,793	80	80	160,000	25	$8,400	79.1	Could not calculate all project benefits. Only the SO component of the project included in payback.
		EC		NC	NC	NC	NC	NC		
Rockland County	Upgrades to WWTP and pump station	EC	$125,270	67	NA	133,448	21	$7,340	17.1	
NYCMWFA	Repair of anaerobic digesters to generate additional gas for energy	GP	$7,051,000	6,592	6,592	13,183,646	2,112	$199,509	35.3	
Albany County	Installation of CHP system	GP	$5,868,742	6,231	6,231	12,461,665	1,941	$470,000	12.5	
Village of Oakfield	Construction of reed bed at WWTP	EP	$135,000	38	NA	75,442	12	$3,664	36.8	
Oklahoma										
Duncan Public Utilities Authority	WWTP improvements (improved energy efficiency aerators with variable frequency drives)	EC	$304,135	594	NA	1,187,370	439	$39,005	7.8	
Ohio										
Clark County (OH)	Utility energy efficiency improvements	EC	$53,278	294	NA	587,474	208	$29,873	1.8	
City of Delphos	Install solar panels at the wastewater treatment plant	EC	$1,109,450	548	NA	1,096,264	388	$55,745	19.9	
City of Delphos	Replacement of aeration blowers with turbo blowers	SO	$635,316	93	93	186,976	66	$9,508	66.8	
Northeast Ohio Regional Sewer Dist.	Southerly WWTC CVI lift station imps	EC	$6,586,267	783	NA	1,566,446	554	$79,654	82.7	
Summit County	Pump Station #51 replacement	EC	$184,651	43	NA	86,606	31	$4,404	41.9	
Tri-Cities North Regional Wastewater	WWTP pump building equipment	EC	$3,539,000	298	NA	596,000	211	$30,307	116.8	
Village of Bradner	Solar powered water circulators	SO	$144,498	842	842	1,684,568	596	$85,660	1.7	

Table A-1. Summary of Modeled Environmental Benefits by State for Energy Efficiency GPR Projects

Location	Project Description	Subcategory	Project Cost	Total Project Benefits: Energy Savings (MWh/yr)	Alternative Energy Generated (MWh/yr)	Embedded Water Savings (gal/yr)	Reduced GHG Emissions (MT CO2e/yr)	Total Cost Savings ($/yr)	Payback (yrs)	Notes
Village of Chickasaw	WWTP improvements	SO	$151,794	842	842	1,684,568	596	$85,660	1.8	
Middleport Village	Wastewater treatment lagoon improvements	SO	$181,402	1,096	1,096	2,192,800	776	$111,504	1.6	
Village of Sherwood	Sherwood WWTP improvements	SO	$251,391	1,430	1,430	2,860,800	1,012	$145,472	1.7	
Pennsylvania										
Borough of Huntingdon	WWTP improvements to reduce P and N outputs & development of Class A biosolids product	EC	$3,774,298	902	NA	1,804,031	436	$72,161	52.3	
Bedford Borough Municip.	WWTP upgrade	EC	$3,202,600	289	NA	578,279	140	$28,914	21.5	
		EP		686	NA	1,372,342	332	$68,617		
		GP		517	517	1,033,868	250	$51,693		
Texas										
City of McAllen	New 15MGD treatment process	EP	$9,880,499	4,516	NA	9,032,402	2,576	$361,296	27.3	
Washington										
City of Richland	Update treatment system	EC	$3,049,304	966	NA	1,932,891	378	$38,658	78.9	
Wisconsin										
City of Evansville	Replacement of lagoon system with vertical loop reactor treatment	WI	$2,925,287	124	124	248,640	96	$12,432	112.1	
		EP		137	NA	273,180	105	$13,659		
West Virginia										
Corporation of Shepherdstown	Elimination of pump station and installation of gravity sewer line	EP	$375,772	3	NA	5,562	2	$289	1,299.6	
		Maximum	**$56,151,187**	**125,923**	**125,923**	**251,846,098**	**60,840**	**$12,806,374**	**2,513**	
		Minimum	**$3,366**	**1**	**11**	**2,529**	**1**	**$114**	**0.2**	
		Average	**$2,714,581**	**2,157**	**5,213**	**4,350,045**	**1,049**	**$218,488**	**96.5**	
		Total	**$241,597,699**	**252,317**	**161,600**	**504,605,246**	**122,743**	**$25,563,095**	**NA**	

NA: Not applicable
NC: Not calculated

Table A-2. Energy Efficiency GPR Environmental Benefits Model Notes and Assumptions

Summary

- Costs were obtained from the Clean Water Benefits Report (CBR) database, http://66.148.13.226/cwapplications/. Not modified per contract documents. Costs cannot be divided among individual subcategorized projects completed under the discrete energy efficiency funding provided to a particular location.
- Payback calculated using simple payback method (initial cost/annual savings). For discretely funded projects comprised of multiple project subcategories, annual savings for payback is based upon all quantifiable savings for the individual subcategorized projects added together. In some instances not all subcategorized projects have quantifiable benefits. In these cases, the savings are denoted with an "NC" and the "Note's column indicates that payback may be underestimated.
- Converted all Energy Savings and Alternative Energy Generated to kWh/yr for direct comparison.
- In some instances, an energy efficiency project was incorrectly classified in the CBR as a green infrastructure project. If the entire project was comprised of energy efficiency subprojects, reclassified the project as an energy efficiency project.

General

- Where both calculated and reported values are available, the calculated value is used to determine key savings.
- Project Description obtained from the CBR database, http://66.148.13.226/cwapplications/.
- Embedded Water Savings calculated assuming 2 gallons/kWh, from http://www.nrel.gov/docs/fy04osti/33905.pdf.
- Reduced Greenhouse Gas Emissions factors obtained from region-specific eGRID 2007 data. Accounts for CO2, methane, and nitrous oxide emissions and converts to CO2 equivalents. See http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html.
- Unless specified in project files, assume average electricity cost is $.1017/kWh for commercial end use, from http://www.eia.gov/cneaf/electricity/epa/epat7p4.html.

EC (high efficiency components)

- No additional assumptions.

EP (energy efficient processes)

- Unless specified in project files, assume average national diesel price assumed to be $3.948/gallon, based on data obtained 6/1/11 for the week of 5/30/11 from http://www.eia.gov/oog/info/wohdp/diesel.asp.

ER (pipes/retrofits)

- No additional assumptions.

GP (reclaimed gas power generation)

- Assume that using the reclaimed gas as alternative energy does not in itself add or reduce GHG emissions since the gas is either flared or combusted to generate energy, therefore the greenhouse gas emissions reduction is solely related to the amount of energy substituted by the gas.
- Unless specified in project file, assume cost of natural gas taken from http://www.eia.gov/dnav/ng/ng_pri_sum_a_EPG0_PCS_DMcf_a.htm. Used state specific rates for the commercial sector.

OR (other renewable energy projects)

- No additional assumptions.

SO (solar)

- Unless savings is provided in project file or otherwise indicated, assume a daily average of 7 hours of sunlight.

WI (wind)

- No additional assumptions.

Table A-3. Summary of Extrapolated Energy Efficiency GPR Environmental Benefits

	Energy Savings (1000 kWh/yr)		Alternative Energy Generated (1000 kWh/yr)		Embedded Water Savings (1000 gal/yr)		Reduced GHG Emissions (MT CO2e/yr)		Total Cost Savings ($/yr)	
	% Cost	**% Project**	**% Cost**	**% Project**	**% Cost**	**% Project**	**% Cost**	**% Project**	**% Cost**	**% Project**
EC										
Modeled	50,243		NA		100,485		26,291		$6,116,224	
Extrapolated	86,245	107,663	NA	NA	172,489	215,326	45,131	56,339	$10,498,864	$13,106,194
EP										
Modeled	35,559		NA		71,091		15,193		$3,486,374	
Extrapolated	72,958	89,610	NA	NA	145,858	179,150	31,172	38,287	$7,153,024	$8,785,662
ER										
Modeled	4,914		NA		9,828		3,427		$394,472	
Extrapolated	6,271	6,880	NA	NA	12,542	13,760	4,373	4,797	$503,367	$552,261
GP										
Modeled	147,272		147,272		294,543		69,625		$14,101,322	
Extrapolated	590,148	572,723	590,148	572,723	1,180,297	1,145,445	279,003	270,765	$56,507,021	$54,838,475
OR										
Modeled	800		800		1,600		695		$81,360	
Extrapolated	4,747	6,400	4,747	6,400	9,494	12,800	4,125	5,561	$482,773	$650,880
SO										
Modeled	5,817		5,817		11,635		3,656		$605,063	
Extrapolated	30,305	14,544	30,305	14,544	60,611	29,087	19,047	9,141	$3,152,015	$1,512,656
WI										
Modeled	7,711		7,711		15,423		3,855		$778,280	
Extrapolated	14,101	16,965	14,101	16,965	28,202	33,930	7,050	8,481	$1,423,183	$1,712,217
Total										
Modeled	252,317		161,600		504,605		122,743		$25,563,095	
Extrapolated	804,775	814,783	639,302	610,631	1,609,493	1,629,497	389,900	393,370	$79,720,247	$81,158,345

APPENDIX B: WATER EFFICIENCY

Table B-1. Summary of Modeled Environmental Benefits by State for Water Efficiency GPR Projects

Location	Project Description	Subcategory	Project Cost	Total Project Benefits: Water Savings (1000 gal/yr)	Alternative Water Generated (1000 gal/yr)	Embedded Energy Savings (kWh/yr)	Reduced GHG Emissions (MT CO2e/yr)	Total Cost Savings ($/yr)	Payback (yrs)	Notes
California										
Inland Empire Utilities Agency	Recycled water pipeline	RE	$3,107,326	437,618	437,618	612,666	149	$2,485,673	1.3	
Inland Empire Utilities Agency	Construction of recycled water pump station	RE	$5,004,817	3,500	3,500	4,900	1	$19,880	251.8	
Inland Empire Utilities Agency	Construction of recycled water pump station	RE	$4,446,949	339,211	339,211	474,896	116	$1,926,720	2.3	
Inland Empire Utilities Agency	Recycled water pipeline	RE	$1,562,991	65,170	65,170	91,238	22	$370,167	4.2	
Literacy for Environmental Justice	LID demonstration project	RE	$116,720	219	219	701	0	$1,807	64.6	
Delaware										
Town of Millsboro	Water reuse at parks and ballfields	RE	$250,000	83,547	83,547	116,966	57	$474,547	0.5	
Georgia										
Paulding County (GA)	Construction of reuse pump station and transmission line	RE	$1,174,965	270,000	270,000	378,000	258	$1,533,600	0.8	
Summerville	Reuse pump station and force main	RE	$395,664	91,250	91,250	127,750	90	$278,313	1.4	
Louisiana										
City of Carencro	Water meter leak detection program	ME	$599,475	52,865	NA	72,800	52	$80,355	7.5	
City of Youngsville	Advanced meter system	ME	$750,000	72,783	NA	101,896	72	$99,485	7.5	
West Monroe	WWTP upgrade	RE	$4,750,000	2,737,500	2,737,500	3,832,500	2,712	$15,549,000	0.3	
Montana										
City of Hamilton	Upgrade headworks, solids handling, and add potable water system	RE	$149,925	6,000	6,000	19,200	15	$49,500	3.0	
Conrad	Pumping System, heat recovery, and instruments and controls	RE	$19,300	5,200	5,200	9,360	7	$23,764	0.8	
New Mexico										
City of Santa Rosa	WWTF improvements	RE	$100,000	72,000	72,000	100,800	25	$408,960	0.2	Originally categorized as a GI project. Complete funding applies to WE.
Town of Taos	WWTP improvements (treatment of water for unrestricted reuse)	RE	$2,438,850	98,000	98,000	137,200	33	$556,640	4.4	

Table B-1. Summary of Modeled Environmental Benefits by State for Water Efficiency GPR Projects

Location	Project Description	Subcategory	Project Cost	Total Project Benefits: Water Savings (1000 gal/yr)	Alternative Water Generated (1000 gal/yr)	Embedded Energy Savings (kWh/yr)	Reduced GHG Emissions (MT CO2e/yr)	Total Cost Savings ($/yr)	Payback (yrs)	Notes
New York										
City of Hudson	Design & improvement of WWTP and pump station for efficiency	RE	$76,800	16,172	16,172	51,750	16	$133,419	0.6	
Suffolk County Community College	Installation of water saving appliances throughout campus	WF	$675,000	5,769	NA	18,462	12	$7,289	93	
Town of Greenport	Planning and refurbishment of treatment plant	RE	$6,000	4,306	4,306	13,778	4	$35,521	0.2	
Village of Sackets Harbor	Replacement of WWTP & portions of collection system - replacing old water meters	ME	$395,000	45,000	NA	63,000	20	$112,500	3.5	
Tennessee										
Franklin (TN)	Recycled water distribution and collection	RE	$847,500	4,506	4,506	6,300	4	$11,220	76	
Maryville	Water meter replacements and an unaerated composting/solar drying system at the WWTP	ME	$960,000	140,000	NA	328,720	231	$132,367	7.3	
Maynardville	Automatic read meters and sewer system Tving, cleaning, and mapping	ME	$380,722	12,410	NA	17,374	12	$8,191	46.5	Originally categorized as an EE project. Complete funding applies to WE.
West Virginia										
City of Lewisburg	Water meters with leak detection	ME	$1,982,850	93,648	NA	403,566	286	$40,570	49	
		Maximum	**$5,004,817**	**2,737,500**	**2,737,500**	**3,832,500**	**2,712**	**$15,549,000**	**252**	
		Minimum	**$6,000**	**219**	**219**	**701**	**0**	**$1,807**	**0.2**	
		Average	**$820,780**	**202,464**	**264,637**	**303,645**	**182**	**$1,058,239**	**27**	
		Total	**$13,132,479**	**4,656,676**	**4,234,200**	**6,983,824**	**4,194**	**$24,339,487**	**NA**	

NA: Not applicable

Table B-2. Water Efficiency GPR Environmental Benefits Model Notes and Assumptions

Summary

- Costs were obtained from the Clean Water Benefits Report (CBR) database, http://66.148.13.226/cwapplications/. Not modified per contract documents. Costs cannot be divided among individual subcategorized projects completed under the discrete water efficiency funding provided to a particular location.
- Payback calculated using simple payback method (initial cost/annual savings). For discretely funded projects comprised of multiple project subcategories, annual savings for payback is based upon all quantifiable savings for the individual subcategorized projects added together. In some instances not all subcategorized projects have quantifiable benefits. In these instances, the savings are denoted with an "NC" and the "Note's column indicates that payback may be underestimated.
- In some instances, a water efficiency project was incorrectly classified in the CBR as a green infrastructure or energy efficiency project. If the entire project was comprised of water efficiency subprojects, reclassified the project as a water efficiency project.

General

- Where both calculated and reported values are available, the calculated value is used to determine key savings.
- Project Description obtained from the CBR database, http://66.148.13.226/cwapplications/.
- Unless otherwise specified, assume the cost of water is $3.68/1,000 gal and wastewater is $4.57/1,000 gal for a total of $8.25/1,000 gal, from Raftelis Financial Consulting. *Water and Wastewater Rate Survey. American Water Works Association, 2010.*
- Unless otherwise specified, assume embedded energy for pumping and treating water and wastewater is 3.2 kWh/1,000 gal for a 10 MGD water and wastewater treatment plant, from Electric Power Research Institute's (EPRI) *Water & Sustainability (Volume 4): U.S. Electricity Consumption for Water Supply & Treatment - The Next Half Century*, March 2002, based on:
  - Water supply (surface water) including treatment and distribution requires on average 1.4 kWh/1,000 gal from 0.1205 kWh/1,000 gal for raw water pumping, 0.0997 kWh/1,000 gal for treatment, and 1.2055 kWh/1,000 gal for distribution.
  - Wastewater treatment requires on average 1.8 kWh/1,000 gal.
- Reduced Greenhouse Gas Emissions obtained from region-specific eGRID 2007 data. Accounts for CO2, methane, and nitrous emissions and converts to CO2 equivalents. See http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html.

ME (meters)

- Assume Embedded Energy Savings come only from not having to produce and distribute the lost water (i.e., 1.4 kWh/1.000 gal unless actual energy requirements for water production are provided).
- Unless energy costs for producing and distributing the lost water are provided, energy cost savings is not calculated and are not included in total cost savings. Do not have adequate information to assume a standard energy cost for water production and distribution.

RE (reuse/reclamation/recycling)

- For projects that supply municipally reclaimed/treated wastewater for reuse in non-potable applications, assume that the embedded energy savings comes only from not having to supply potable water (assume 1.4 kWh/1,000 gal unless actual energy requirements are provided in project file). Assume no net energy impact from treating and redistributing the reclaimed water.
- For projects that reuse wastewater onsite from one process as a water supply for another process, assume energy savings comes both from not having to supply the process with water or treat the wastewater discharged from the previous process (3.2 kWh/1,000 gal unless actual energy requirements are provided in project file).
- Unless otherwise specified, assume the cost of recycled water is on average $2.00/1,000 gal. This average comes from San Diego's reclaimed water rate of $1.91/1,000 gal and El Paso's rates of $2.16/1,000 gal.
- Assume cost to supply reused water is negligible.

WF (high-efficiency fixtures)

- No additional assumptions

Table B-3. Summary of Extrapolated Water Efficiency GPR Environmental Benefits

	Water Savings (1000 gal/yr)		Alternative Water Generated (1000 gal/yr)		Embedded Energy Savings (MWh/yr)		Reduced GHG Emissions (MT CO2e/yr)		Total Cost Savings ($/yr)	
	% Cost	**% Project**	**% Cost**	**% Project**	**% Cost**	**% Project**	**% Cost**	**% Project**	**% Cost**	**% Project**
ME										
Modeled	416,706		NA		987		672		$473,468	
Extrapolated	633,101	902,864	NA	NA	1,500	2,139	1,021	1,456	$719,339	$1,025,847
RE										
Modeled	4,234,200		4,234,200		5,978		3,510		$23,858,731	
Extrapolated	19,173,746	13,231,874	19,173,746	13,231,874	27,070	18,681	15,894	10,969	$108,039,597	$74,558,534
WF										
Modeled	5,769		NA		18,462		12		$7,289	
Extrapolated	9,295	17,308	NA	NA	30	55	19	36	$11,743	$21,866
Total										
Modeled	4,656,676		NA		6,983,824		4,194		$24,339,487	
Extrapolated	19,816,142	14,152,047	19,173,746	13,231,874	28,600	20,876	16,935	12,461	$108,770,679	$75,606,247

APPENDIX C: GREEN INFRASTRUCTURE

Table C-1. Summary of Modeled Environmental Benefits by State for Green Infrastructure GPR Projects

				Total Project Benefits								
					Pollutant Loading Reductions							
Location	Project Description	Subcategory	Project Cost	Stormwater Runoff Avoided (1000 gal/yr)	Total Sediment (lbs/yr)	Total Phosphorus (lbs/yr)	Total Nitrogen (lbs/yr)	Avoided Energy Use (kWh/yr)	Reduced GHG Emissions (tons CO_2/yr)	Total Cost Savings ($/yr)	Payback (yrs)	Notes
California												
Literacy for Environmental Justice	LID demonstration project	GR	$116,720	27	15	0.0	0.2	38	0.01	$24.46	4,771	Insufficient information to calculate all project benefits. Payback based on GR.
		RG		NC	NC	NC	NC	NC	NC	NC		
American Rivers	Green stormwater management	RG	$375,000	727	433	1.0	6.2	0	0.00	$0.00	NMB	Community doesn't treat stormwater via a CSO. No monetary benefits.
		SW		575	291	0.3	8.1	0	0.00	$0.00		
Association of Bay Area Government	Trash capture devices for use and evaluation	RG	$392,000	687	409	0.9	5.8	0	0.00	$0.00	NMB	Project includes the construction of 2 rain garden CBR database project description. Community doesn't treat stormwater via a CSO. No monetary benefits.
Georgia												
Jefferson	Pervious pavement and grass filter strips for civic center	PP	$425,863	1,979	1,177	2.1	27.1	0	0.00	$0.00	NMB	Community doesn't treat stormwater via a CSO. No monetary benefits.
Illinois												
Aurora	Bioinfiltration facility	BI	$34,869	440	262	0.6	3.7	619	0.44	-$1,104.07	NMB	No monetary benefits due to negative cost savings.
Massachusetts												
Lowell Regional Wastewater Utility	Green roof installation	GR	$714,380	516	278	0.5	3.3	727	0.57	$464.67	1,537	
Maryland												
Prince Georges County	Design and construction of shallow marsh and gabion dam in drainage area	WL	$216,800	2,460	1,170	2.0	12.3	0	0.00	$0.00	NMB	Community doesn't treat stormwater via a CSO. No monetary benefits.
Chesapeake Bay Trust	Green street with bioretention areas, street swales, street trees, and permeable pavement	BI	$1,100,000	NC	NC	NC	NC	NC	NC	NC	NMB	Community doesn't treat stormwater via a CSO. No monetary benefits.
		SW		NC	NC	NC	NC	NC	NC	NC		
		VP		12	7	0.0	0.1	0	0.00	$0.00		
		PP		114	68	0.1	1.6	0	0.00	$0.00		
Chesapeake Bay Trust	3 acre wetland offshore on West River	WL	$811,000	2,847	1,354	2.3	14.3	0	0.00	$0.00	NMB	Community doesn't treat stormwater via a CSO. No monetary benefits.

Table C-1. Summary of Modeled Environmental Benefits by State for Green Infrastructure GPR Projects

Location	Project Description	Subcategory	Project Cost	Total Project Benefits: Stormwater Runoff Avoided (1000 gal/yr)	Pollutant Loading Reductions: Total Sediment (lbs/yr)	Total Phosphorus (lbs/yr)	Total Nitrogen (lbs/yr)	Avoided Energy Use (kWh/yr)	Reduced GHG Emissions (tons CO_2/yr)	Total Cost Savings ($/yr)	Payback (yrs)	Notes
Dorchester County Council	Low profile stone containment structure and marsh plantings for living shoreline	RR	$2,670,250	29,162	15,697	28.7	185.0	0	0.00	$0.00	NMB	Community doesn't treat stormwater via a CSO. No monetary benefits.
Howard County	Change stormwater detention facility to shallow wetland pond, incorporating forebays, water quality column, and channel protection volume	RR	$174,000	NC	NC	NC	NC	NC	NC	NC	NMB	Community doesn't treat stormwater via a CSO. No monetary benefits.
		WL		760	362	0.6	3.8	0	0.00	$0.00		
Inner Harbor West, LLC	Capping of shoreline and creation of tidal wetlands	WL	$620,500	337	160	0.3	1.7	475	0.23	$303.37	2,045	
Kent County (MD)	Construction of terminal groins, breakwaters, beachfill, planting marsh grasses, and installing wildlife nesting boxes	RR	$420,100	76	41	0.1	0.5	0	0.00	$0.00	NMB	Community doesn't treat stormwater via a CSO. No monetary benefits.
Queen Anne's County	Installation of permeable parking lot	PP	$200,000	268	160	0.3	3.7	0	0.00	$0.00	NMB	Community doesn't treat stormwater via a CSO. No monetary benefits.
City of Takoma Park	Green roof installation	GR	$69,500	80	43	0.1	0.5	0	0.00	$0.00	NMB	Community doesn't treat stormwater via a CSO. No monetary benefits.
Washington County (MD)	Placement of imbricated riprap, trees, shrubs, love fascines, and live stalks	RR	$191,700	NC	NC	NC	NC	NC	NC	NC	NMB	Community doesn't treat stormwater via a CSO. No monetary benefits.
		VP		25	15	0.0	0.2	0	0.00	$0.00		
Waterfowl Festival, Inc.	Installation of stormwater BMP facility	WL	$332,000	1,196	569	1.0	6.0	0	0.00	$0.00	NMB	Community doesn't treat stormwater via a CSO. No monetary benefits.
Maine												
South Portland	Pump system replacement and collection system upgrade	PP	$301,000	242	144	0.3	3.3	341	0.27	$218.03	1,381	Insufficient information to calculate all project benefits. Payback based on PP.
		BI		NC	NC	NC	NC	NC	NC	NC		
Michigan												
Allen Creek	Stormwater	BI	$4,435,000	NC	NC	NC	NC	NC	NC	NC	NMB	Underground infiltration

Table C-1. Summary of Modeled Environmental Benefits by State for Green Infrastructure GPR Projects

Location	Project Description	Subcategory	Project Cost	Total Project Benefits: Stormwater Runoff Avoided (1000 gal/yr)	Pollutant Loading Reductions: Total Sediment (lbs/yr)	Pollutant Loading Reductions: Total Phosphorus (lbs/yr)	Pollutant Loading Reductions: Total Nitrogen (lbs/yr)	Avoided Energy Use (kWh/yr)	Reduced GHG Emissions (tons CO_2/yr)	Total Cost Savings ($/yr)	Payback (yrs)	Notes
Drainage District	management practices at Pioneer High School, including underground infiltration basin, treatment units, infiltration, and cleaning	SP		236,504	69,573	75.0	986.8	0	0.00	$0.00		basins were considered SP. Community doesn't treat stormwater via a CSO. No monetary benefits.
Auburn Hills	Stormwater BMPs including bioinfiltration areas, infiltration trench, level spreader, rain cisterns	RG	$215,000	1,964	1,168	2.6	16.7	2,765	2.08	$1,767.52	108	Bioretention area used interchangeably with infiltration trench.
		BI		202	120	0.3	1.7	285	0.21	$182.14		
		RW		55	33	0.1	0.5	78	0.06	$49.66		
Pinckney	Stormwater BMPs	BI	$1,135,000	243	145	0.3	2.1	0	0.00	$0.00	NMB	Community doesn't treat stormwater via a CSO. No monetary benefits.
		PP		1,335	794	1.4	18.3	0	0.00	$0.00		
North Carolina												
City of Fayetteville	Drainage improvements along roadway	SP	$500,095	35,305	10,386	11.2	147.3	0	0.00	$0.00	NMB	Community doesn't treat stormwater via a CSO. No monetary benefits.
City of Fayetteville	Stormwater detention basins	SP	$539,261	13,971	4,110	4.4	58.3	0	0.00	$0.00	NMB	Community doesn't treat stormwater via a CSO. No monetary benefits.
Town of Highlands	Installation of stormwater treatment hydrodynamic separator and underground stormwater detention system	SP	$746,517	27,734	8,159	8.8	115.7	0	0.00	$0.00	NMB	Community doesn't treat stormwater via a CSO. No monetary benefits.
City of Asheville	Creation of wetland and streambank stabilization	WL	$263,403	811	386	0.7	4.1	0	0.00	$0.00	NMB	Community doesn't treat stormwater via a CSO. No monetary benefits.
		RR		NC	NC	NC	NC	NC	NC	NC		
Town of Black Mountain	Construction of stormwater impoundment and creation of stormwater wetland	WL	$384,385	3,044	1,448	2.5	15.2	0	0.00	$0.00	NMB	Community doesn't treat stormwater via a CSO. No monetary benefits.
Town of	Stormwater retention	SP	$1,686,234	185,475	54,561	58.8	773.9	0	0.00	$0.00	NMB	Community doesn't treat

Table C-1. Summary of Modeled Environmental Benefits by State for Green Infrastructure GPR Projects

Location	Project Description	Subcategory	Project Cost	Total Project Benefits: Stormwater Runoff Avoided (1000 gal/yr)	Pollutant Loading Reductions: Total Sediment (lbs/yr)	Total Phosphorus (lbs/yr)	Total Nitrogen (lbs/yr)	Avoided Energy Use (kWh/yr)	Reduced GHG Emissions (tons CO_2/yr)	Total Cost Savings ($/yr)	Payback (yrs)	Notes
Carolina Beach	ponds; removal and replacement of pavement, roadways, driveways; sedimentation and erosion control	BM		NC	NC	NC	NC	NC	NC	NC		stormwater via a CSO. No monetary benefits.
City of Charlotte	Stream/wetland restoration; creation of wildlife habitat; removal and replacement of sidewalks, pavement, roadways; sedimentation and erosion control	BM	$1,570,740	NC	NC	NC	NC	NC	NC	NC	NMB	Community doesn't treat stormwater via a CSO. No monetary benefits.
		WL		5,765	2,742	4.7	28.9	0	0.00	$0.00		
		RR		NC	NC	NC	NC	NC	NC	NC		
City of Charlotte	Construction of 3.5 mg reuse pond; sedimentation and erosion control devices	SP	$316,442	156,890	46,153	49.8	654.6	0	0.00	$0.00	NMB	Community doesn't treat stormwater via a CSO. No monetary benefits.
		BM		NC	NC	NC	NC	NC	NC	NC		
City of Raleigh	Construction of rainwater harvesting systems and bioretention areas	BI	$279,517	NC	NC	NC	NC	NC	NC	NC	NMB	Community doesn't treat stormwater via a CSO. No monetary benefits.
		RG		NC	NC	NC	NC	NC	NC	NC		
		RW		2,028	1,206	2.7	17.3	0	0.00	$0.00		
City of Burlington	Installation of 12,000 gallon underground stormwater collection system for irrigation	RW	$65,000	74	44	0.1	0.6	0	0.00	$0.00	NMB	Community doesn't treat stormwater via a CSO. No monetary benefits.
New York												
Village of Greenwood Lake	Reduction of impervious surfaces and construction of rain garden and bioswales	RG	$417,965	110	65	0.1	0.9	0	0.00	$0.00	NMB	Community doesn't treat stormwater via a CSO. No monetary benefits.
		PP		289	172	0.3	4.0	0	0.00	$0.00		
		BM		NC	NC	NC	NC	NC	NC	NC		
		SW		491	249	0.3	6.9	0	0.00	$0.00		
Village of Greenwood Lake	Improvements to riparian buffer	RR	$18,477	50	27	0.0	0.3	0	0.00	$0.00	NMB	Community doesn't treat stormwater via a CSO. No monetary benefits.
Chemung County Library District	Installation of green roof at library	GR	$821,527	327	176	0.3	2.1	460	0.14	$294.10	2,793	
City of Utica	Installation of tree	RW	$646,641	1,943	1,155	2.6	16.5	2,736	0.85	$1,748.70	320	

Table C-1. Summary of Modeled Environmental Benefits by State for Green Infrastructure GPR Projects

Location	Project Description	Subcategory	Project Cost	Total Project Benefits: Stormwater Runoff Avoided (1000 gal/yr)	Pollutant Loading Reductions: Total Sediment (lbs/yr)	Total Phosphorus (lbs/yr)	Total Nitrogen (lbs/yr)	Avoided Energy Use (kWh/yr)	Reduced GHG Emissions (tons CO_2/yr)	Total Cost Savings ($/yr)	Payback (yrs)	Notes
	pits, tree planting, and use of rain barrels	VP		304	181	0.4	2.6	428	0.13	$273.78		
Onondaga County	Provide rain barrels to homeowners and businesses	RW	$256,834	2,712	1,613	3.6	23.1	3,819	1.19	$2,441.09	105	
Lindenhurst Memorial Library	Installation of green parking lot	PP	$198,111	119	71	0.1	1.6	0	0.00	$0.00	NMB	Community doesn't treat stormwater via a CSO. No monetary benefits.
		SW		182	92	0.1	2.6	0	0.00	$0.00		
NYS Office of Parks	Installation of pervious pavement and bioretention areas in parking lot	PP	$556,200	951	566	1.0	13.0	1,675	1.32	$1,070.95	519	Insufficient information to calculate all project benefits. Payback based on PP.
		BI		NC	NC	NC	NC	NC	NC	NC		
Monroe County	Green roof construction	GR	$4,715,123	1,166	627	1.1	7.4	0	0.00	$0.00	NMB	Community doesn't treat stormwater via a CSO. No monetary benefits.
Roeliff Jansen Community Library	Installation of vegetated swale, rain garden, etc.	PP	$320,000	714	425	0.8	9.8	0	0.00	$0.00	NMB	Community doesn't treat stormwater via a CSO. No monetary benefits.
		BI		318	189	0.4	2.7	0	0.00	$0.00		
		SW		NC	NC	NC	NC	NC	NC	NC		
		RG		NC	NC	NC	NC	NC	NC	NC		
Town of Amherst	Reduction of impervious surfaces and construction of rain garden	BM	$129,328	NC	NC	NC	NC	NC	NC	NC	NMB	Community doesn't treat stormwater via a CSO. No monetary benefits.
		RG		1,269	755	1.7	10.8	0	0.00	$0.00		
City of North Tonawanda	Installation of raingardens and bioretention cells in parking lot	BI	$267,100	47	28	0.1	0.4	66	0.02	$42.32	6,311	Insufficient information to calculate all project benefits. Payback based on BI.
		RG		NC	NC	NC	NC	NC	NC	NC		
NYC Dep't of Parks & Rec	Greenstreet	VP	$2,000,000	334	198	0.4	2.8	406	0.32	$300.25	4,172	
		SW		199	101	0.1	2.8	242	0.19	$179.18		
NYCMWFA	Restoration of 38 acres of wetlands and grasslands next to CSO facility	WL	$14,637,485	38,118	18,132	31.2	190.9	46,352	36.42	$34,306.64	427	Insufficient information to calculate all project benefits. Payback based on WL.
		BI		NC	NC	NC	NC	NC	NC	NC		
City of Rome	Tree planting	VP	$250,000	507	301	0.7	4.3	0	0.00	$0.00	NMB	Community doesn't treat stormwater via a CSO. No monetary benefits.
Village of	Replacement of	PP	$95,000	55	33	0.1	0.8	144	0.04	$49.91	1,904	Insufficient information to

Table C-1. Summary of Modeled Environmental Benefits by State for Green Infrastructure GPR Projects

Location	Project Description	Subcategory	Project Cost	Total Project Benefits: Stormwater Runoff Avoided (1000 gal/yr)	Pollutant Loading Reductions: Total Sediment (lbs/yr)	Total Phosphorus (lbs/yr)	Total Nitrogen (lbs/yr)	Avoided Energy Use (kWh/yr)	Reduced GHG Emissions (tons CO_2/yr)	Total Cost Savings ($/yr)	Payback (yrs)	Notes
Sackets Harbor	WWTP & portions of collection system - porous pavement and rain gardens installed at WWTP	RG		NC	NC	NC	NC	NC	NC	NC		calculate all project benefits. Payback based on PP.
Tioga County Soil & Water Conservation	Construction and restoration of wetlands	WL	$736,131	20,989	9,984	17.2	105.1	29,552	9.21	$18,889.92	39	
Ohio												
Columbus & Franklin Co	Restoration of tributary and construction of 78 acres of wetland	WL	$2,244,781	65,265	31,045	53.4	326.8	91,893	65.02	$58,738.33	38	Insufficient information to calculate all project benefits. Payback based on WL.
		RR		NC	NC	NC	NC	NC	NC	NC		
Oklahoma												
Owasso PWA	Stormwater detention basin	SP	$75,925	792,995	233,276	251.5	3,308.9	0	0.00	$0.00	NMB	Community doesn't treat stormwater via a CSO. No monetary benefits.
OK Conservation Commission	Green roof at the National Weather Center in Norman	GR	$86,500	18	10	0.0	0.1	0	0.00	$0.00	NMB	Community doesn't treat stormwater via a CSO. No monetary benefits.
Pennsylvania												
Chesapeake Bay Foundation	Riparian buffers with other BMPs	RR	$4,370,378	40,700	21,908	40.1	258.1	57,306	27.69	$36,630.10	119	BM does not fall under green infrastructure categories. Payback based on RR.
		BM		NC	NC	NC	NC	NC	NC	NC		
Factoryville Borough	Green parking lot	PP	$85,600	506	301	0.5	6.9	0	0.00	$0.00	NMB	Community doesn't treat stormwater via a CSO. No monetary benefits.
Lehigh City - County Environment al	County Environmental Center	GR	$40,000	6	3	0.0	0.0	0	0.00	$0.00	NMB	Community doesn't treat stormwater via a CSO. No monetary benefits.
		RG		NC	NC	NC	NC	NC	NC	NC		
		RW		NC	NC	NC	NC	NC	NC	NC		
PA Environment al Council	Installation of pervious pavement, rain barrels, and cistern	PP	$1,312,718	492	293	0.5	6.7	693	0.49	$443.20	2,962	Insufficient information to calculate all project benefits. Payback based on PP.
		RW		NC	NC	NC	NC	NC	NC	NC		
Pennsylvania Horticultural Society	Tree plantings	VP	$1,655,249	2,487	1,479	3.3	21.2	0	0.00	$0.00	NMB	Community doesn't treat stormwater via a CSO. No monetary benefits.
Snyder CCD	Riparian stream buffer tree planting	RR	$119,833	47,970	25,821	47.2	304.2	67,541	32.63	$43,172.71	3	No benefits from VP. Payback based on RR.
		VP		5,712	3,397	7.6	48.6	0	0.00	$0.00		

Table C-1. Summary of Modeled Environmental Benefits by State for Green Infrastructure GPR Projects

Location	Project Description	Subcategory	Project Cost	Total Project Benefits: Stormwater Runoff Avoided (1000 gal/yr)	Pollutant Loading Reductions: Total Sediment (lbs/yr)	Pollutant Loading Reductions: Total Phosphorus (lbs/yr)	Pollutant Loading Reductions: Total Nitrogen (lbs/yr)	Avoided Energy Use (kWh/yr)	Reduced GHG Emissions (tons CO_2/yr)	Total Cost Savings ($/yr)	Payback (yrs)	Notes
Standing Stone Township	Road bank stabilization w/super nails and mesh	RR	$128,653	12	6	0.0	0.1	0	0.00	$0.00	NMB	Community doesn't treat stormwater via a CSO. No monetary benefits.
Standing Stone Township	Road bank stabilization w/super nails and mesh	RR	$101,462	20	11	0.0	0.1	0	0.00	$0.00	NMB	Community doesn't treat stormwater via a CSO. No monetary benefits.
		BI		1,001	595	1.3	8.5	0	0.00	$0.00		
Towamencin Township	Permeable parking lot with bioretention areas	PP	$281,964	291	173	0.3	4.0	0	0.00	$0.00	NMB	Community doesn't treat stormwater via a CSO. No monetary benefits.
Western Pennsylvania Conservancy	Tree plantings along commercial & residential areas	VP	$2,400,000	6,338	3,768	8.5	53.9	8,923	6.31	$5,703.75	421	
		BM		NC	NC	NC	NC	NC	NC	NC		
		VP		406	241	0.5	3.5	571	0.28	$365.04		
PA Cleanways	Cobbscreek-West Phila-SW mitigation	RR	$136,429	NC	NC	NC	NC	NC	NC	NC	374	Insufficient information to calculate all project benefits. Payback based on VP.
Tredyffrin Twp	Maude-Lisa-Vincent drainage improvement	BI	$523,974	48,265	28,698	64.4	410.8	0	0.00	$0.00	NMB	Community doesn't treat stormwater via a CSO. No monetary benefits.
		RW		4,959	2,949	6.6	42.2	0	0.00	$0.00		
Villanova University	Removing impervious surface	RG	$55,912	908	540	1.2	7.7	0	0.00	$0.00	NMB	Community doesn't treat stormwater via a CSO. No monetary benefits.
		SP		NC	NC	NC	NC	NC	NC	NC		
		WL		2,944	1,400	2.4	14.7	0	0.00	$0.00		
Lehigh County Conservation District	Retrofit existing stormwater basin with additional capacity	RR	$100,000	6,796	3,658	6.7	43.1	0	0.00	$0.00	NMB	Community doesn't treat stormwater via a CSO. No monetary benefits.
Township of Whitemarsh	Construction of stormwater basin for wetland	WL	$618,485	6,900	3,282	5.6	34.5	0	0.00	$0.00	NMB	The reported value for stormwater runoff avoided was used as the calculated value was not able to be determined.
Pennsylvania Urban & Comm'y Forestry	Tree plantings along streets	VP	$300,000	1,014	603	1.4	8.6	986	0.48	$912.60	329	
		VP		514	305	0.7	4.4	723	0.51	$462.24		
Friends of Pittsburgh Urban Forest	Trees, landscaping, permeable pavement	PP	$274,393	NC	NC	NC	NC	NC	NC	NC	594	Insufficient information to calculate all project benefits. Payback based on VP.
Texas												

Table C-1. Summary of Modeled Environmental Benefits by State for Green Infrastructure GPR Projects

Location	Project Description	Subcategory	Project Cost	Total Project Benefits: Stormwater Runoff Avoided (1000 gal/yr)	Pollutant Loading Reductions: Total Sediment (lbs/yr)	Total Phosphorus (lbs/yr)	Total Nitrogen (lbs/yr)	Avoided Energy Use (kWh/yr)	Reduced GHG Emissions (tons CO_2/yr)	Total Cost Savings ($/yr)	Payback (yrs)	Notes
City of El Paso	Stormwater improvements, including deepening of stormwater basins which will create a wetland	WL	$1,030,000	983	468	0.8	4.9	0	0.00	$0.00	NMB	Community doesn't treat stormwater via a CSO. No monetary benefits.
		Maximum	**$14,637,485**	**792,995**	**233,276**	**251**	**3,309**	**91,893**	**65**	**$58,738**	**6,311**	
		Minimum	**$18,477**	**5.9**	**3.2**	**0.01**	**0.04**	**0.0**	**0.0**	**-$1,104**	**2.8**	
		Average	**$931,036**	**21,959**	**7,507**	**10**	**102**	**3,854**	**2.3**	**$2,505**	**1,421**	
		Total	**$63,310,454**	**1,822,627**	**623,050**	**832**	**8,464**	**319,845**	**$187**	**$207,931**	**NA**	

NA: Not applicable
NC: Not calculated

Table C-2. Green Infrastructure GPR Environmental Benefits Model Notes and Assumptions

Summary

- Costs were obtained from the Clean Water Benefits Report (CBR) database, http://66.148.13.226/cwapplications/. Not modified per contract documents. Costs cannot be divided among individual subcategorized projects completed under the discrete energy efficiency funding provided to a particular location.
- Payback calculated using simple payback method (initial cost/annual savings). For discretely funded projects comprised of multiple project subcategories, annual savings for payback is based upon all quantifiable savings for the individual subcategorized projects added together. In some instances not all subcategorized projects have quantifiable benefits. In these cases, the savings are denoted with an "NC" and the "Note's column indicates that payback may be underestimated.

General

- Where both calculated and reported values are available, the calculated value is used to determine key savings.
- Project Description obtained from the CBR database, http://66.148.13.226/cwapplications/.
- Benefits calculated assuming the existing/previous conditions were 100% impervious unless otherwise noted and necessary data is provided.
- Total average annual and March through October rainfall data were obtained from NOAA: http://cdo.ncdc.noaa.gov/cgi-bin/climatenormals/climatenormals.pl?directive=prod_select2&prodtype=CLIM20&subrnum.
- Certain benefits (i.e., avoided Energy Savings, Reduced Greenhouse Gas Emissions, Avoided Stormwater Treatment Costs, and Payback) are calculated assuming stormwater would otherwise be treated at a wastewater treatment plant. This assumption is only valid for areas where stormwater is handled via a combined sewer system, not by a municipal separate storm sewer system (MS4). According to EPA, as of February 2009, 800 cities have active permits for combined sewer overflows. If a project location was not on the list of 800 combined sewer cities provided by EPA, it was assumed that the project location was not serviced by a combined sewer and none of the previously mentioned benefits were calculated.
- Unless otherwise specified, assume the marginal cost to treat stormwater is $0.9/1,000 gal. This number is provided by FEMA in its treatment cost calculation (source cited in City of North Tonawanda NY's application, but could not find actual source to verify).
- Assume avoided energy use is energy saved from reduced stormwater treatment needs. Unless otherwise specified, assume the energy usage for stormwater treatment is equivalent to that of a 10 MGD advanced wastewater treatment plant without nitrification. From the Center for Neighborhood Technology's *The Value of Green Infrastructure*, a 10 MGD advanced wastewater treatment plant without nitrification will use 1,408 kWh/million gal. If size or type of treatment is specified, the energy usage provided in the Center for Neighborhood Technology's The Value of Green Infrastructure that is associated with a plant with the specified characteristics is used.
- Reduced Greenhouse Gas Emissions factors obtained from region-specific eGRID 2007 data. Accounts for CO2, methane, and nitrous emissions and converts to CO2 equivalents. See http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html.
- Reduced Greenhouse Gas Emissions do not account for carbon sequestration.

BI (biorention)

- Assume 80% retention unless otherwise specified, from The Center for Neighborhood Technology's *The Value of Green Infrastructure.*

GR (green roofs)

- Assume 60% retention unless otherwise specified, from The Center for Neighborhood Technology's *The Value of Green Infrastructure.*
- Energy savings does not account for the cooling effect the green roof may have on the building.

PP (pervious pavement)

- Assume 80% retention unless otherwise specified, from The Center for Neighborhood Technology's *The Value of Green Infrastructure.*

RG (rain gardens)

- Assume 80% retention unless otherwise specified, from The Center for Neighborhood Technology's *The Value of Green Infrastructure.*

RR (riparian restoration)

- Assume 80% retention (similar to a bioretention area) unless otherwise specified.

RW (rainwater harvesting)

- Unless otherwise specified, assume that the rain barrel volume is 55 gallons.
- Assume 1200 sq ft roof per home for residential areas (source: http://logan.cnt.org/calculator/calculator.php), but that the roof has 4 gutters and the rain barrel is only attached to one gutter for a total collection surface area of 300 square feet.
- Due to the variety of non-residential building sizes (e.g., government, offices, commercial space), no assumption can be made regarding non-residential roof sizes at this time. Therefore, rainwater harvesting benefits will not be calculated for non-residential projects unless roof size is provided in the project information.
- Assume 85% collection efficiency unless otherwise specified, from The Center for Neighborhood Technology's *The Value of*

Table C-2. Green Infrastructure GPR Environmental Benefits Model Notes and Assumptions

Green Infrastructure

- Assume rainfall is only collected and utilized from March through October (during the warmer months). For rainwater harvesting only, total March through October rainfall is used instead of total annual rainfall to calculate Stormwater Runoff Avoided.
- Did not account for savings to the homeowner associated with not having to use potable water to supply irrigation. Savings only accounts for the costs associated with not having to treat the stormwater.

SP (stormwater pond projects)

- Assume 80% retention unless otherwise specified, from The Center for Neighborhood Technology's *The Value of Green Infrastructure.*

SW (swale)

- Assume 80% retention unless otherwise specified, from The Center for Neighborhood Technology's *The Value of Green Infrastructure.*

VP (vegetative plantings)

- Climate zone determined from http://www.fs.fed.us/psw/programs/uesd/uep/tree_guides.php.
- Region specific interception rates for various trees can be obtained from the Center for Urban Forest Research of the US Forest Service, www.fs.fed.us/psw/programs/cufr/tree_guides.php.

WL (wetlands)

- Assume 80% retention (similar to a bioretention area) unless otherwise specified.

Table C-3. Summary of Extrapolated Green Infrastructure GPR Environmental Benefits

	Stormwater Runoff Avoided (gal/yr)		Total Sediment (lbs/yr)		Total Phosphorus (lbs/yr)		Total Nitrogen (lbs/yr)		Avoided Energy Use (kWh/yr)		Reduced GHG Emissions (tons CO_2/yr)		Total Cost Savings ($/yr)	
	% Cost	**% Project**	**% Cost**	**% Project**	**% Cost**	**% Project**	**% Cost**	**% Project**	**% Cost**	**% Project**	**% Cost**	**% Project**	**% Cost**	**% Project**
BI														
Modeled	50,517		30,038		67		430		971		1		-$880	
Extrapolated	823,883	216,502	489,882	128,732	1,100	289	7,013	1,843	15,829	4,160	11	3	-$14,346	-$3,770
GR														
Modeled	2,140		1,152		2		14		1,225		1		$783	
Extrapolated	2,476	3,057	1,333	1,646	2	3	16	19	1,418	1,750	1	1	$906	$1,119
PP														
Modeled	7,357		4,375		8		101		2,854		2		$1,782	
Extrapolated	30,437	15,847	18,098	9,422	33	17	417	217	11,806	6,147	9	5	$7,372	$3,838
RG														
Modeled	5,666		3,369		8		48		2,765		2		$1,768	
Extrapolated	82,564	26,710	49,093	15,882	110	36	703	227	40,296	13,036	30	10	$25,757	$8,333
RR														
Modeled	124,785		67,168		123		791		124,847		60		$79,803	
Extrapolated	906,117	1,076,273	487,737	579,327	892	1,060	5,747	6,826	906,566	1,076,806	438	520	$579,481	$688,299
RW														
Modeled	11,772		6,999		16		100		6,632		2		$4,239	
Extrapolated	91,137	33,353	54,190	19,832	122	45	776	284	51,349	18,792	16	6	$32,822	$12,012
SP														
Modeled	1,448,873		426,217		459		6,046		0		0		$0	
Extrapolated	4,392,593	4,967,566	1,292,176	1,461,317	1,393	1,575	18,329	20,728	0	0	0	0	$0	$0
SW														
Modeled	1,447		733		1		20		242		0		$179	
Extrapolated	8,571	12,538	4,343	6,353	6	9	118	173	1,434	2,097	0	0	$1,061	$1,551
VP														
Modeled	17,652		10,496		24		150		12,037		8		$8,018	
Extrapolated	39,455	43,327	23,460	25,762	53	58	336	369	26,906	29,545	18	20	$17,921	$19,680
WL														
Modeled	145,518		72,502		125		763		168,272		111		$112,238	
Extrapolated	212,570	280,643	105,910	139,826	182	240	1,115	1,472	245,808	324,524	162	214	$163,955	$216,460
Total														
Modeled	1,815,727		623,049		832		8,463		319,845		187		$207,930	

Table C-3. Summary of Extrapolated Green Infrastructure GPR Environmental Benefits

	Stormwater Runoff Avoided (gal/yr)		Total Sediment (lbs/yr)		Total Phosphorus (lbs/yr)		Total Nitrogen (lbs/yr)		Avoided Energy Use (kWh/yr)		Reduced GHG Emissions (tons CO_2/yr)		Total Cost Savings ($/yr)	
	% Cost	**% Project**	**% Cost**	**% Project**	**% Cost**	**% Project**	**% Cost**	**% Project**	**% Cost**	**% Project**	**% Cost**	**% Project**	**% Cost**	**% Project**
Extrapolated	6,589,804	6,675,814	2,526,223	2,388,098	3,894	3,332	34,569	32,159	1,301,411	1,476,857	685	778	$814,931	$947,522