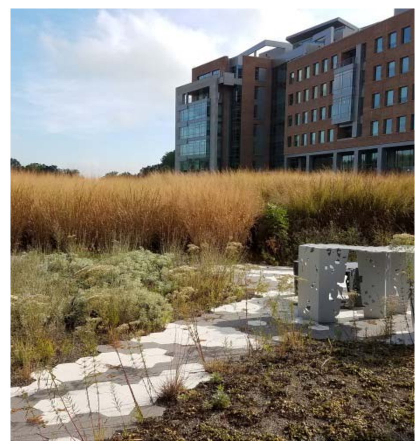

WHITE OAK FOOD & DRUG ADMINISTRATION FACILITY

ANALYSIS AND RECOMMENDATIONS FOR SITE SYSTEMS

March 2018

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U.S. General Services Administration

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EXECUTIVE SUMMARY

The 670-acre White Oak property in Silver Spring, Maryland is a former Navy research facility that is now home to the U.S. Food & Drug Administration (FDA). Beginning with a 1997 Master Plan, the western portion of the site was gradually developed over time to be the consolidated headquarters of the FDA. The FDA campus currently occupies 104 acres, surrounded by 121 acres of natural areas. The areas developed to date primarily utilized a green infrastructure approach for stormwater management. This is in contrast to conventional campuses, which rely strictly on gray infrastructure like storm sewers and underground holding tanks to manage stormwater. Green infrastructure systems on the FDA campus include green roofs, bioretention, sand filters, and naturalized detention basins.

During the period from 2015 to 2018, the Landscape Architecture Foundation and Conservation Design Forum were contracted to study the green infrastructure systems at the FDA facility. The intent of the study was to assess these systems and measure their performance in terms of stormwater runoff reduction and other benefits. The study consisted of stormwater runoff monitoring, a landscape assessment, and a campus-wide assessment of stormwater management performance and irrigation water conservation.

Using instrumentation, stormwater runoff was measured at two locations from February 2017 through January 2018. Runoff flow rates were measured and calculations performed to determine peak flows and runoff volumes for multiple rain events during the monitoring period. The results were then compared to what would be expected for a site with no stormwater controls under the same rainfall conditions. **The monitoring results showed that the White Oak green infrastructure systems reduced peak flows by 80% to 85% and runoff volumes by 40% to 60% for the eight largest rain events.**

HydroCAD modeling was used to extrapolate these monitoring results to the entire 104-acre developed area and compare the performance of the FDA campus to three different development scenarios. The modeling shows that **the current FDA campus produces more runoff volume than the pre-development condition but significantly less than would be expected from a conventionally designed site. The campus also produces lower peak discharge rates than conventional development, even development with conventional detention.**

Performance of the site was also assessed relative to federal sustainability directives, specifically Section 438 of the Energy Independence and Security Act of 2007, which specifies that runoff be retained and no surface runoff be discharged for all events up to and including the 95th percentile event. **Although the green infrastructure practices at the FDA campus significantly reduce runoff, the site does not achieve the EISA 438 standard since even small events produced runoff.** However, it should be noted that a significant portion of the FDA campus was designed and developed prior to EISA's adoption.

A qualitative landscape assessment was conducted for the site, revealing that 121 acres of undeveloped natural area surrounding the developed campus has generally been left in an unmanaged state. This has resulted in the presence of species that are a management concern along with excess woody growth and a lack of ground plain vegetation due to excessive shade. Nonetheless, the natural areas are likely reducing runoff volumes and rates relative to what would be expected if this acreage were developed. **Management of the natural areas, including invasive species control and establishment of native**

ground flora, would improve ecological performance related to biodiversity, soil health, and wildlife habitat.

An analysis of irrigation water use was conducted for the FDA facility. The White Oak site has no permanent irrigation system, and no potable water is used for landscape irrigation. Under a more conventional development scenario, 36.4 acres of the FDA campus would be irrigated, requiring 22.2 million gallons of water annually. **Not having a conventional permanent irrigation system at the FDA campus saves an estimated $181,000 per year in water utility costs.**

The stormwater monitoring, stormwater calculations, and the irrigation water use calculations in this report clearly demonstrate the economic and environmental benefits that have accrued from constructing the site green infrastructure systems and forgoing a permanent irrigation system.

This report includes a number of recommendations for modifications to the existing site to improve ecological performance and to assist with maintenance and operations. The recommendations include:

- Implementation of the originally designed landscape plan for the southeast portion of the site
- Preparation and implementation of a natural areas management plan
- Preparation and implementation of a landscape restoration and management plan for Pond 2
- Continued stormwater and landscape monitoring
- Periodic reporting and documentation of maintenance activities

This report also suggests that **site commissioning be considered for all future phases of development at the White Oak site.** GSA is in the process of updating the master plan to add 1.9 million square feet of office and special use space, reconfigure East Loop Road and add new parking and security measures.

STUDY CONTEXT

Study Purpose

During the period from 2015 to 2018, the Landscape Architecture Foundation and Conservation Design Forum were contracted to study the green infrastructure systems at the White Oak U.S. Food & Drug Administration (FDA) facility in Silver Spring, Maryland. The intent of the study was to assess these systems and measure their performance in terms of stormwater runoff reduction and other benefits. The study consisted of stormwater runoff monitoring, a landscape assessment, and a campus-wide assessment of stormwater management performance and irrigation water conservation. The measured and calculated performance of the White Oak systems were compared to scenarios of more conventional development.

The U.S. General Services Administration (GSA) was interested in measuring the site's performance relative to federal sustainability directives, particularly EISA 438. Section 438 of the Energy Independence and Security Act of 2007 specifies that runoff be retained and no surface runoff be discharged for all events up to and including the 95th percentile event.

This study also supports GSA's efforts related to site commissioning. GSA was one of the earliest entities to develop and adopt a commissioning program, which today is called Total Building Commissioning. This process and commissioning efforts under the U.S. Green Building Council's LEED program have largely focused on buildings rather than sites. However, GSA's adoption of the SITES rating system in 2016 broadened GSA's attention toward commissioning of the sites on which buildings sit in addition to the buildings themselves. The promise of GSA's effort is that the building industry, as a whole, will begin to commission active site systems.

Concurrent with the White Oak FDA site study, GSA assembled working groups and commissioned a study to examine how a measurement and verification framework could be applied to high-performance sites. This effort culminated in the release of GSA's "Site Commissioning White Paper"[1] in July 2017. This report builds on that study.

Background

The 670-acre White Oak property was formerly occupied by the Navy as a research facility. Areas of development on the site are separated by eight wooded stream courses, the largest of which is Paint Branch, which bisects the site from north to south. Beginning with a 1997 Master Plan, the western portion of the site was and continues to be configured as the consolidated headquarters of the Food and Drug Administration. Building 1 at the entrance to the property is the only building that remains from the original Navy facility.

Since 2003, the site has gradually been transformed into the 104-acre FDA campus that exists today. The campus includes administrative offices, labs, and employee amenities such as a cafeteria, indoor and

[1] *Site Commissioning White Paper*, U.S. General Services Administration, Public Buildings Service, Office of the Chief Architect. July 2017

outdoor seating, and gathering areas. As of 2016, 9 of the 10 planned office buildings had been constructed. About 10,500 FDA staff and contractors work in about 3.8 million square feet, which is 27% more staff than originally planned for the completed buildings.

Further consolidation is planned, with FDA proposing to locate an additional 5,900 staff at White Oak by 2020. GSA is in the process of updating the master plan for the site to accommodate a total workforce population of 18,000 by adding 1.9 million square feet of office and special use space, reconfiguring the East Loop Road and adding new parking and security measures. As of this writing, the density and scale of new buildings is being considered as part of the Environmental Impact Statement process.

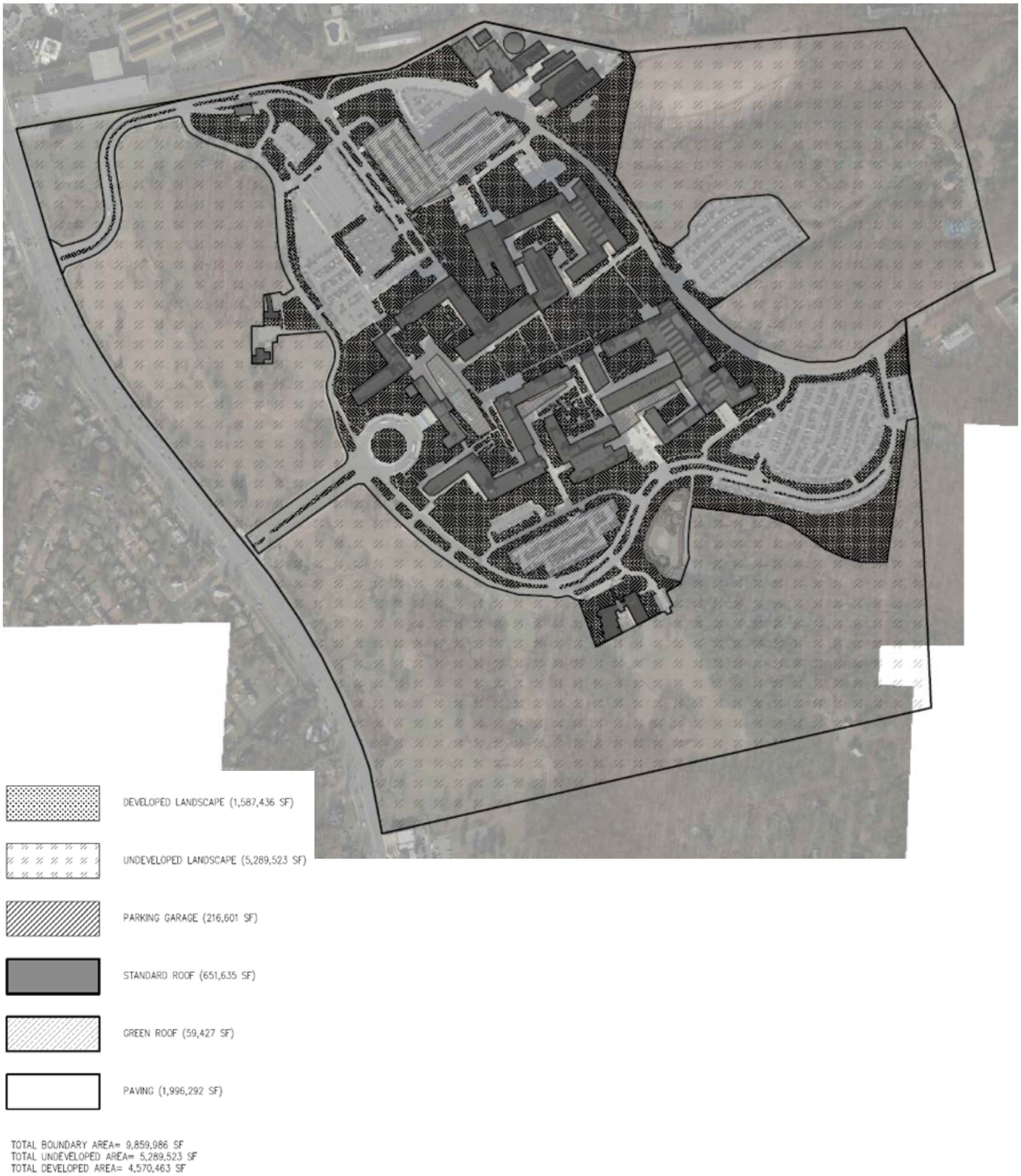
Site System Design

The plan for the existing FDA campus preserved large contiguous natural areas[2] surrounding the developed area. This study focuses on the 225 acres that are the current FDA campus and surrounding natural area. The study boundary is depicted in Figure 1. Within the developed area, the design plan called for a range of landscapes with some turf and trees but mostly more naturalized landscapes with native and adapted species integrated into the site.

The site includes a large number of integrated stormwater green infrastructure practices that are designed to mimic natural hydrologic and water quality conditions. Some of the roof areas have green (vegetated) roofs, some loading dock areas include sand filters, most all the roof areas drain to bioretention systems integrated into the landscape, and naturalized detention basins have been installed around the perimeter of the site. The perimeter roads and parking lots are largely served by storm sewers that drain directly to the detention basins. Some of the detention basins include internal landscaped bioretention/sand filters.

[2] The term “natural area” as used in this document refers to the undeveloped landscapes, totaling approximately 121 acres, located across the west, south, and east portions of the White Oak FDA facility (see Figure 1). These undeveloped landscapes include both wooded and non-wooded acreage.

Figure 1: White Oak FDA facility study boundary and land cover



ANALYSIS

Site Observations

Conservation Design Forum, Versar (CDF's runoff monitoring consultant), the Landscape Architecture Foundation, GSA Office of the Architect staff, and White Oak Facility staff from GSA's Region 11 met at the site on October 12, 2016 to assess the rainwater management systems and their landscapes and to select monitoring locations. During the visit, a number of observations were made:

1) The majority of the landscape plan indicated on the construction drawings was not installed. Instead, landscape areas were planted by GSA facilities staff. There are no records of what was planted.
2) There is reported to be no irrigation occurring on the site.
3) The landscape was generally limited to turf and trees throughout most of the site except for some of the stormwater management areas and a few other select areas.
4) The landscape within the stormwater facilities varied significantly. Many of the bioretention areas designed to capture roof runoff were vegetated with turf while others included more natural landscapes. The larger detention areas that receive runoff from larger areas of the campus, including the discharge from the bioretention areas, varied significantly in their landscape typology. Some were wet ponds, others were naturalized, and still others were mostly turf.
5) It was reported that the undeveloped natural areas surrounding the developed portion of the site are not actively managed by GSA facilities staff.
6) The roof runoff from the majority of the buildings is managed within bioretention features. These features include a surface depression, topsoil, and underdrains.
7) Runoff from roads is mainly managed using open swale drainageways adjacent to the roads.
8) Runoff from parking areas appears to mainly managed by storm sewers.

Stormwater Management Monitoring and Assessment

Methods

With a limited budget and the desire to extrapolate the results to the broader campus, two stormwater treatment locations were selected for flow monitoring to evaluate the performance of the green infrastructure practices in reducing the volume and rate of runoff from the developed portion of the property. The two locations are described below.

1) <u>Pond 2</u>: Pond 2 on the south side of the property was selected since it is the ultimate discharge point for a large portion of the developed campus. It is also the most recently developed portion of the campus that is served by the most comprehensive system of stormwater green infrastructure features. It receives runoff from a relatively large drainage area (38 acres) that hosts a number of green infrastructure practices including a green roof, bioretention systems, and naturalized detention basin. The drainage area is shown in Figure 2.

2) Bioretention 3: A bioretention location was selected to isolate the performance of that specific practice from the performance of the overall system. Of the green infrastructure practices on the property, bioretention is the most prevalent practice and likely the most effective in terms of runoff volume and peak flow reduction. A number of different bioretention areas on the property were considered but many of them had conditions that would “muddy” the data. For example, one located in the Pond 2 drainage area was first considered but it had significant condensate flow, which would make it difficult to differentiate between the stormwater flow and condensate flow during events. Another bioretention area had two outlets which would have required monitoring of both. Bioretention Area 3 was selected because it has only one outflow and its drainage area could be determined with relative accuracy. The drainage area is shown in Figure 3.

Figure 2: Pond 2 drainage area

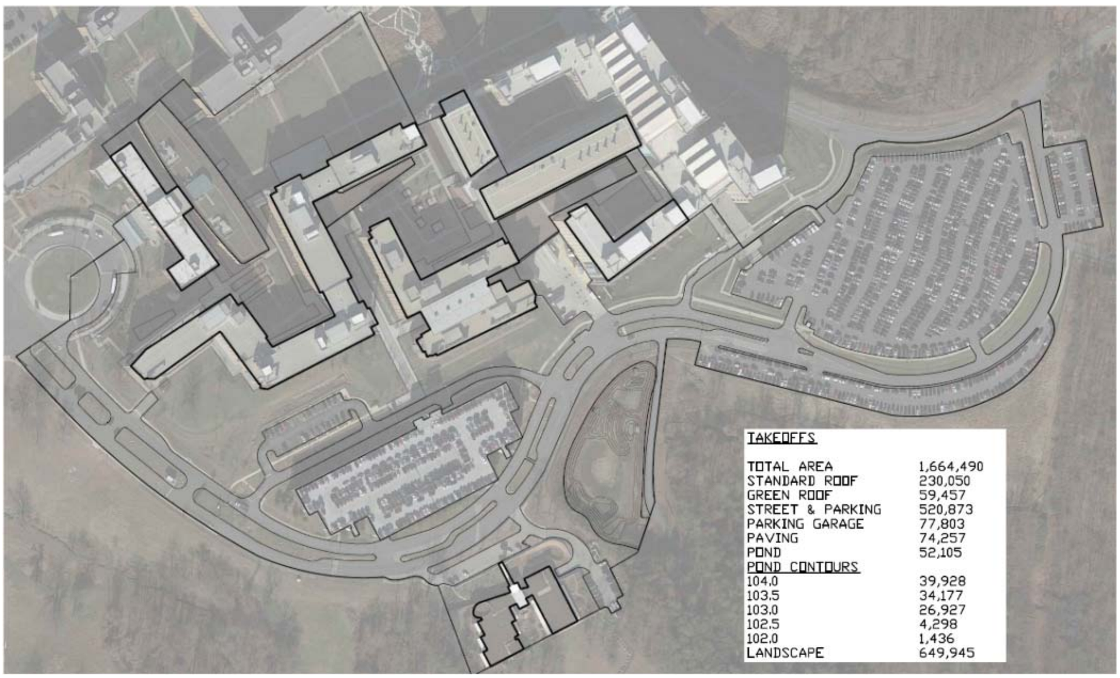


Figure 3: Bioretention 3 drainage area

These two locations are drained by outlet structures with storm sewer outfalls that have relatively free discharges. Thus, in selecting monitoring equipment, the potential impact of backwater conditions did not need to be considered. Below is a list of the equipment used.

1) Thelmar Weirs: The weirs were inserted in the outlet pipes of Pond 2 and Bioretention 3 to provide a control and allow accurate conversion from measured stage to flow.
2) Isco 730 Bubbler Flow Module: The bubblers were used to measure water level stage on the upstream side of the Thelmar weirs.
3) Marsh-McBirney Flo-Mate: The bubblers were connected to this device to continuously measure stage and calculate flows. The flow was calculated from the rating curves of the Thelmar weirs. The rain gage listed below is also connected to the Flo-Mate to record precipitation.
4) Onset HOBO RG3 Rain Gage: This is used to measure rainfall and the rainfall is recorded with the Flo-Mate.

The monitoring equipment was installed in February 2017 and monitoring continued through January 2018 to obtain approximately one year of data. The data collected included flow and precipitation data collected at 5-minute intervals at each location.

Data Analysis

The monitoring equipment described above was used to measure stormwater flows at the two locations. These flows were used to calculate runoff volumes and peak flows for a number of larger rainfall events that occurred during the monitoring period. From those numbers, runoff volume and peak flow runoff coefficients were calculated. The coefficients indicate the proportion of total rainfall that became runoff (runoff volume coefficient) and the ratio of the peak flow to peak rate of runoff (peak flow coefficient).

To provide a basis of comparison, expected flows for a conventional development with no runoff controls were calculated based on the precipitation, drainage area, land cover, and estimated time of concentration for the two locations. The flows were calculated using the rational formula. Based on the land cover of the area tributary to Pond 2 and Bioretention 3, the rational formula runoff coefficients for the two locations were calculated to be 0.69 and 0.78, respectively.

During the period of monitoring, the data was analyzed on a roughly quarterly basis and quarterly reports prepared. The quarterly reports are provided in Appendix 1. The results are presented in the form of hydrographs depicting the measured flow, the calculated conventional flow (flows that would be expected if the site were designed as a typical campus with no stormwater controls), and precipitation. In addition to the full period, hydrographs are provided for selected large events.

Results

During the monitoring period, eight large events were identified. For each of the events, hydrographs were plotted and statistics were calculated in terms of runoff volumes and rates. The measured flow rates and volumes were also compared to calculated volumes and rates that would be expected from conventional developments with no runoff controls. Tables 1 and 2 below show the results for the eight events.

Table 1: Pond 2 stormwater runoff monitoring results

Rain Events			Runoff				Runoff Coefficient			
Date	Measured Rainfall		Peak (cfs/ac)		Total Runoff (in)		Peak		Volume	
	Total (in)	Peak hr (in/hr)	White Oak	Conv	White Oak	Conv	White Oak	Conv	White Oak	Conv
Apr 6-9	1.47	0.64	0.07	0.45	0.81	1.02	0.11	0.70	0.55	0.69
Apr 20-23	1.31	0.79	0.01	0.55	0.39	0.91	0.01	0.70	0.30	0.69
Jul 1-2	0.77	0.77	0.01	0.54	0.15	0.53	0.01	0.70	0.19	0.69
Jul 22-25	2.21	0.74	0.02	0.52	0.51	1.53	0.03	0.70	0.23	0.69
Jul 28-29	4.91	1.23	0.46	0.86	2.37	3.40	0.37	0.70	0.48	0.69
Sep 5-7	1.18	0.63	0.01	0.44	0.42	0.82	0.02	0.70	0.36	0.69
Oct 9-10	0.75	0.51	0.02	0.36	0.24	0.52	0.04	0.70	0.32	0.69
Oct 12-13	0.87	0.69	0.02	0.48	0.42	0.60	0.03	0.70	0.48	0.69
Event weighted averages:			0.11	0.56	0.66	1.17				
Reduction from improvements:			80%		43%					

White Oak runoff values are based on measured flows at the discharge point of Pond 2.
Conventional (Conv) runoff values are based on the land cover of the site and an assumed Time of Concentration of 60 minutes.

Table 2: Bioretention Area 3 stormwater runoff monitoring results

Rain Events			Runoff				Runoff Coefficient			
Date	Measured Rainfall		Peak (cfs/ac)		Total Runoff (in)		Peak		Volume	
	Total (in)	Peak 15min (in/hr)	White Oak	Conv	White Oak	Conv	White Oak	Conv	White Oak	Conv
Apr 6-9	1.47	0.88	0.08	0.69	0.33	1.14	0.10	0.78	0.22	0.78
Apr 20-23	1.31	2.84	0.09	2.23	0.11	1.02	0.03	0.78	0.08	0.78
Jul 1-2	0.77	3.04	0.25	2.38	0.41	0.60	0.08	0.78	0.53	0.78
Jul 22-25	2.21	1.52	0.44	1.19	0.55	1.71	0.29	0.78	0.25	0.77
Jul 28-29	4.91	2.60	0.48	2.04	2.07	3.85	0.18	0.78	0.42	0.78
Sep 5-7	1.18	1.52	0.21	1.19	0.15	0.92	0.14	0.78	0.13	0.78
Oct 9-10	0.75	0.92	0.06	0.72	0.07	0.58	0.07	0.78	0.09	0.77
Oct 12-13	0.87	1.28	0.18	1.00	0.20	0.67	0.14	0.78	0.23	0.77
Event weighted averages:			0.25	1.71	0.49	1.31				
Reduction from improvements:			86%		63%					

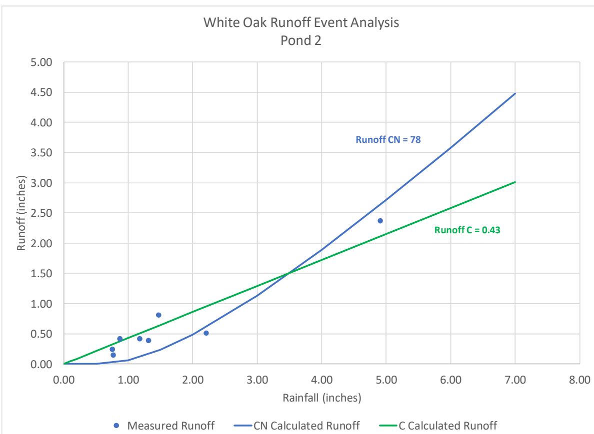
White Oak runoff values are based on measured flows at the discharge point of Bioretention 3.
Conventional (Conv) runoff values are based on the land cover of the site and an assumed Time of Concentration of 15 minutes.

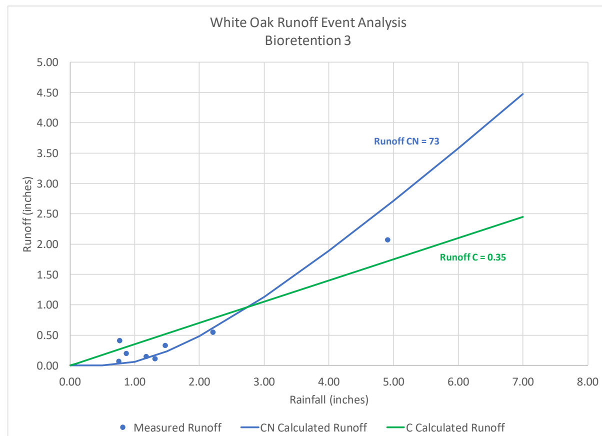
Tables 1 and 2 show that runoff volumes and rates measured at the two White Oak locations are substantially lower than would be expected from a more conventional site with no stormwater controls. **Runoff volumes were reduced for every event and the reduction in average runoff was 63% at Bioretention 3 and 43% at Pond 2. Peak flows were reduced to an even greater degree with reductions in event-size weighted peak flow of 86% at Bioretention 3 and 80% at Pond 2.** Because Pond 2 is the ultimate discharge point for this part of the developed campus, it represents the cumulative performance of all the stormwater green infrastructure practices within its drainage area.

To allow extrapolation of the monitoring results to design storms and to the entire White Oak campus, the event results data was analyzed to determine equivalent runoff coefficients (C) and runoff curve numbers (RCN) for the two locations. The rainfall and runoff measurements for Pond 2 and Bioretention 3 were plotted in the graphs below and fitted with C and RCN curves.

As can be seen from the graphs, the equivalent runoff coefficients (C) for the Pond 2 and Bioretention 3 drainage areas are 0.43 and 0.35, respectively. (C values range from 0.00 to 1.00, with lower numbers indicating lower runoff potential.) These are significantly lower than the values of 0.69 and 0.78 calculated based on land cover, **demonstrating that the green infrastructure interventions for the site are providing a significant stormwater benefit.**

Figures 4 and 5: Runoff coefficient (C) and runoff curve number (RCN) curve fits





Runoff curve numbers (RCN) were calculated in addition to runoff coefficients since that is the method used by many practitioners and the method used by the Maryland Department Environment regulatory program. Based on the measured values, the equivalent RCNs were determined to be 78 and 73 for the Pond 2 and Bioretention 3 drainage areas, respectively. (RCNs range from 30 to 100 for landscapes found in North America, with lower numbers indicating lower runoff potential.) As with the runoff coefficients, these are significantly lower than the values calculated based on land cover. (87 for Pond 2 and 93 for Bioretention 3)

Landscape Assessment

Land Cover and Qualitative Assessment

Based on analysis of aerial photography, the western portion of the White Oak property was categorized in terms of land cover and generally divided between the developed and undeveloped portions of the property. The analysis is shown in Figure 1, and the land cover statistics are shown in Table 3 below. In total, this portion of the property covers an area of 225 acres, 54% of which (121 acres) is undeveloped open space. The developed portion of the property covers 104 acres, 65% of which is paving and roofs, surfaces that are typically impervious. However, 1.36 acres of roof area on the FDA site are green (vegetated) roof, which has a runoff response more like that of landscape areas than of impervious surfaces. The percent of impervious coverage on the developed portion of the property is typical of commercial office campuses.

Table 3: Land cover statistics for the western portion of the White Oak Property

Land Cover	Area
Undeveloped Landscape	**121.43**
Developed Area	**103.56**
Developed Landscape	36.44
Parking Garage	4.97
Standard Roof	14.96
Green Roof	1.36
Paving	45.83
Total Area	**224.99**

The site includes approximately five acres of parking garage. The parking garages average five floors, which reduces the parking footprint by 20 acres relative to what would have been necessary to provide those spaces as surface parking. **The decision to build parking garages reduces impervious cover on the site and prevented a loss of 20 acres of natural open space.**

A unique aspect of the FDA campus is that over half of the land on this portion of property has been left in an undeveloped state. As undeveloped landscape, this acreage provides natural habitat for wildlife, offers passive recreational opportunities for federal employees and surrounding residents, reduces stormwater runoff and associated urban pollutants, and affords carbon sequestration.

It was reported that the 121 acres of undeveloped landscape / natural areas outside the developed portion of the campus are not being managed. Although a detailed survey was not conducted for the natural areas, a qualitative review revealed a presence of species of management concern and, in the wooded portions, a lack of ground plain, herbaceous vegetation due to excessive shading. The natural areas would benefit from invasive species control, establishment of native ground plain vegetation, and management through prescribed burns. **Because the natural areas are essentially left as is and in an unmanaged state, they are not meeting their full potential in terms of ecological performance related to biodiversity, soil health, and wildlife habitat.**

It was also reported that for the most recently developed southeast portion of the site, little of the landscape shown in the construction drawings was installed, and instead turf was planted throughout. **As a result, much of the native and adapted landscape that would have required less mowing is not present.** Although calculations were not performed, carbon emissions from mowing could be reduced significantly if the original landscape plan were implemented.

Trees and other landscape plants have been installed over time by a GSA staff members assigned part-time to “steward” the White Oak FDA site. The steward has a good understanding of landscape ecology and appears to have taken significant personal interest in managing the site to improve ecological function and to oversee the large number of stormwater features. However, the site is very large and managing the entire landscape with a part-time steward presents a significant challenge. The steward provided significant assistance for this study.

Pond 2 Vegetation Assessment and Recommendations

An assessment of the vegetation within one of the detention basins was conducted. Pond 2 was chosen because it was selected for stormwater monitoring and because Pond 2 was the most "naturalized" of the large detention basins. The full landscape assessment of Pond 2 is in Appendix 2. Key findings are:

- Other than some pine trees, it appears that little to none of the planting or seeding specified in the landscape plan was completed for the Pond 2 basin.
- It appears that there has been minimal effort to manage the basin slopes and bottom for weeds or to enhance these landscapes with appropriate native species.
- As would be expected given these conditions, the vegetation across the stormwater detention basin is indicative of a landscape that is of low quality in terms of the conservatism and diversity of species. The basin is dominated by weedy and invasive species.

In light of these conditions, **a landscape restoration and management plan should be prepared for Pond 2**, and that plan should be responsive to the expected hydrologic conditions within the basin. The management plan should outline strategies for retrofitting the basin with native prairie and wetland species. The plan should consider the presidential memorandum on 'Supporting the Health of Honey Bees and Other Pollinators' and incorporate its guidance on plant selection and landscape management principles.

Campus Water Analysis and Scenario Comparison

Campus-wide water analyses were conducted for both stormwater performance and irrigation water conservation. The stormwater analysis extrapolates the results from the stormwater monitoring to the entire 104-acre developed area and compares it to three different development scenarios. The water conservation analysis examines site water usage (irrigation) for the FDA campus relative to what might be expected for a more typical development.

Campus Stormwater Assessment

Based on the results from the stormwater flow monitoring, a campus-wide assessment was conducted to estimate the difference in runoff response of the current FDA campus relative to a more typical office campus. For the conventional development, two scenarios were considered: (1) the FDA site with no stormwater controls and (2) the FDA site with controls that just meet the minimum Maryland Department of the Environment (MDE) Unified Stormwater Sizing Criteria (USSC), which is required of all new development in the state. The criteria require the use of the RCN calculation method and therefore that approach was used here.

The analysis was conducted for the approximately 104-acre developed portion of the campus. A HydroCAD[3] stormwater model was created for each of the scenarios. The HydroCAD model develops hydrographs from rainfall time series based on the RCN for the drainage area along with a time of concentration that defines how quickly the system responds to rainfall input. The model can also route runoff hydrographs through storage systems to represent detention and retention facilities. The paragraphs below briefly describe the assumptions for each scenario.

[3] HydroCAD version 10.00-20 by HydroCAD Software Solutions LLC

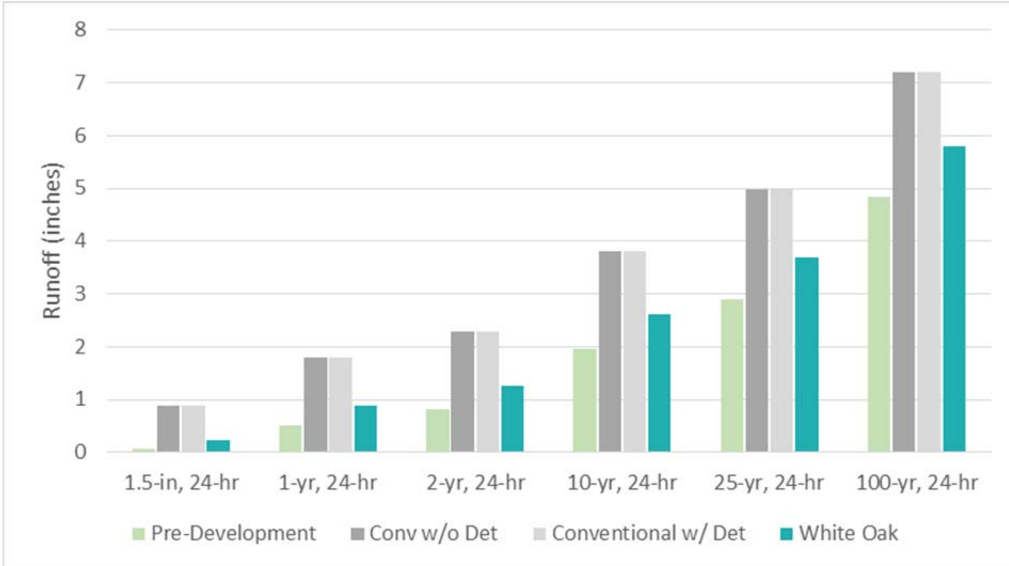
1) Pre-development: Based on standard RCN tables published by the Natural Resources Conservation Service (NRCS), the RCN for woodland on hydrologic soil group C soils is 70. This value along with a time of concentration of 60 minutes was used to determine the expected runoff response of the site prior to any development.
2) Conventional development without detention: The standard NRCS tables were used to determine the area weighted RCN for the 104-acre developed portion of the property. A time of concentration of 15 minutes was assumed because typical storm sewer systems move water more quickly than natural drainage.
3) Conventional development with detention: The same RCN was used here as above, but the model included a hypothetical stormwater detention system designed to meet the Maryland Unified Sizing Criteria, which includes a water quality volume (0.9-inch event), a channel protection volume (one-year event), and an overbank flood protection volume (10-year event).
4) Current FDA campus (White Oak): The RCN that was calculated based on the Pond 2 monitoring data was used. The design drawings were used to develop a model of the hydraulics of Pond 2. The results from this modeling were then scaled by the ratio of the area of the developed campus to the drainage area of Pond 2 to produce results representing the entire 104-acre developed portion of the White Oak site.

Using the HydroCAD models developed for each of the scenarios, runoff volumes and peak flows were determined for a range of event sizes from a 1.5-inch event to the 100-year event. All events were modeled as 24-hour duration events using the NRCS Type 2 rainfall distribution. The 1.5-inch event was used to represent the 95th percentile event as specified in EISA 438. The results of the analysis are depicted in the bar charts below.

The Runoff Volume Comparison Chart shows the total runoff volume (in drainage area-inches) resulting from each of the scenarios. Since conventional detention systems do little to reduce runoff volumes, the volume results are identical for the two conventional development scenarios. The chart shows that while the runoff volume from the FDA campus is low (0.23 inches) for the 1.5-inch 95th percentile event, the campus is not achieving zero discharge for this event as specified by EISA 438. However, the model results show that even the pre-development site would produce some runoff for this event (0.08 inches). **The modeling for the 1.5-inch event shows that the current FDA campus produces more runoff than the pre-development condition but significantly less runoff than would be expected from a conventionally designed site.** For the larger events, the pattern continues, with the FDA campus producing more runoff than the pre-developed condition but less than from a conventionally designed site.

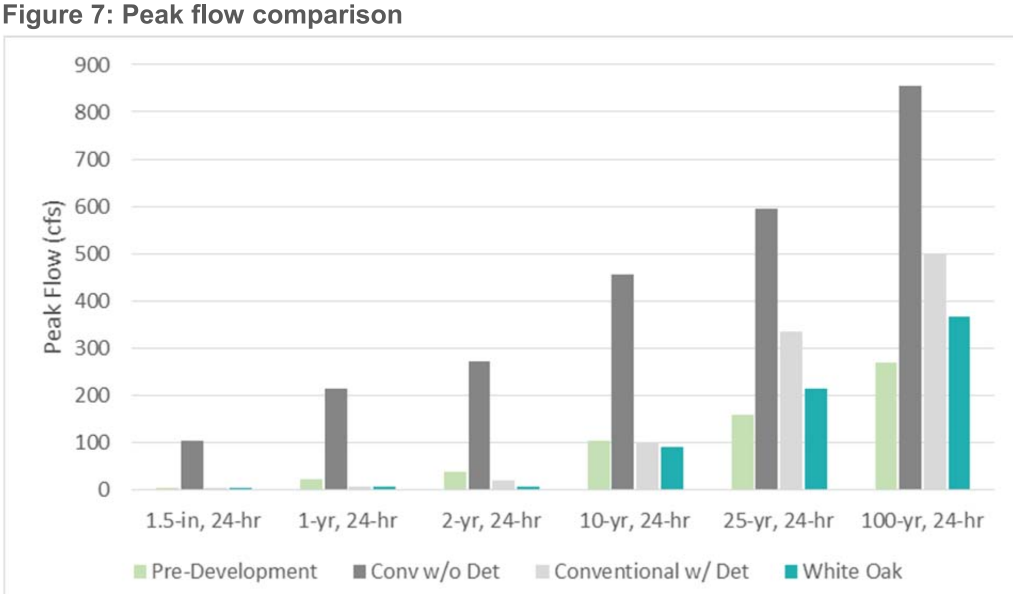
Though not modeled, the FDA campus is likely meeting the Sustainable Site Initiative (SITES v2) Prerequisite 3.1 of retaining the precipitation volume from the 60th percentile rainfall event. It is close but likely not achieving Credit 3.3: Manage Precipitation Beyond Baseline, which grants 4 points for retaining the 80th percentile event (and more points for the 90th and 95th percentile events.) In April 2016, GSA adopted the SITES rating system for its capital construction program.

Figure 6: Runoff volume comparison



The Peak Flow Comparison chart below shows that the model results for peak flows are more varied. For the smaller 1-year through 10-year events within the design range of the MDE requirements, both the *conventional development with detention* scenario and the FDA campus (*White Oak* scenario) reduce peak flows relative to even pre-development conditions. However, for larger events beyond the design range, all three developed scenarios produce larger peak flows than pre-development. Based on the results, it would appear that the FDA campus detention was designed using the MDE criteria since its peak flows are similar to the *conventional development with detention* scenario for the two design events (1-year and 10-year). As expected, the *conventional site without detention* scenario produces significantly higher peak flows than the other scenarios, and the relative difference is most pronounced for the smaller events. The chart shows that **for both smaller and larger events, the FDA campus produces lower peak discharges than conventional development, even with detention.**

Figure 7: Peak flow comparison



Although the FDA campus is not meeting the EISA 438 standard, it is clear that the system of green infrastructure practices at the site results in significantly improved performance relative to what would be expected for a more conventionally developed site. It is also clear that for events within the design range, the MDE requirements are sufficient to control peak flows.

While this analysis only considers the 104 developed acres, the 121 acres of surrounding natural area are likely performing similar to the pre-development scenario modeled here. **Therefore, the runoff volumes and rates from the undeveloped portion of the site are less than would be expected if these areas were developed, even if they included an advanced green infrastructure system.**

Campus Irrigation Assessment

For many commercial and institutional developments, irrigation accounts for a significant portion of potable water use. In fact, for developments with no lab or kitchen uses, irrigation is often the largest source of demand for water. At the White Oak site, there is no permanent irrigation system, and it has been reported that no irrigation has occurred outside of the initial landscape establishment period. This has resulted in a significant water savings. Although it has been reported that the turf areas have browned out and gone dormant during extended dry periods, no lawns or other landscape areas have required replacement.

For the developed FDA campus, the landscape area that would typically be irrigated under a more conventional development scenario is 36.4 acres. The irrigation demand for typical commercial landscapes is one inch per week for the 18-week period from mid-May through mid-September. For most conventional developments, the irrigation system is on a timer that does not adjust irrigation based on rainfall, so an irrigation rate of one inch per week was assumed for the entire 18-week period. Finally, 1.25 inches of water is typically required to achieve one inch of full coverage over the landscape due to overspray onto pavement areas and overlap between irrigation heads.

Using the assumptions above, the annual irrigation water demand for the White Oak development under a conventional irrigation scenario would be 22.2 million gallons, which equates to 175,000 gallons per day from mid-May to mid-September). Assuming that other campus water uses are sufficiently high (greater than 9,000 gallons per day) to reach the maximum billing rate of $8.16[4] per 1,000 gallons, the conventional irrigation usage level would result in an annual irrigation water cost of $181,000 per year. **Not having a conventional permanent irrigation system at the FDA campus saves an estimated $181,000 per year in water utility costs.**

[4] Washington Suburban Sanitary Commission rate per 1,000 gallons is $8.16 for daily usage levels exceeding 9,000 gallons. This is the cost for water alone and does not include sewer cost, which typically is not charged when irrigation is separately metered.

RECOMMENDATIONS

Maintenance and Operations

Design Considerations

Planning for maintenance and operations should begin early in the programming and design phase of a project. An understanding of the current and potential maintenance capabilities of the owner (GSA, in the case of this project) is essential to designing a system that will meet the performance goals of the project in both the short term and long term. During exploration of design alternatives, the maintenance and operations implications should be well defined and communicated to the owner and their facilities management team. When current maintenance and operations capabilities are inadequate for a given design alternative, strategies for enhancing capabilities should be explored. Capabilities can be enhanced through training of existing staff, acquisition of staff with the required expertise, or through use of outside support from maintenance contractors and/or from vendors that may provide maintenance contracts.

As an element of the design, system complexity should be considered. In the case of the White Oak site, the stormwater systems are all passive, gravity systems that require no automation or human intervention beyond basic inspections. Thus, the stormwater system has relatively low complexity. However, on sites with water harvesting or other non-passive systems that require automation, complexity is greater and adequate staffing and training should be part of the design considerations.

The originally planned landscape systems at White Oak that were composed of traditional turf, natural meadows in ornamental and stormwater settings, and preserved natural areas that have a higher level of complexity than a conventional landscape composed of turf and trees. The greater level of complexity does not necessarily translate into greater cost. However, a greater level of expertise is required to monitor and manage this broad range of landscapes. Assignment of a site steward, as was done at the White Oak facility, is the preferred strategy for management when there are a range of landscapes. The site steward can monitor the landscapes and oversee facilities staff and/or private contractors to manage the various landscapes.

Design and as-built drawing files as well as narrative descriptions of the design and intended function should be prepared and provided to facilities staff to ease ongoing commissioning and to facilitate adaptive management of the systems and trouble shooting in the event of system malfunction.

Maintenance and Operations Recommendations

The format of the maintenance and operations program should be responsive to the design and complexity of the system. The simpler the system, the more it can be operated and monitored using existing facilities staff. The more automated and complex the system, the greater the need for expert assistance.

The following recommendations are intended to improve the ecological performance of the White Oak site and aid in the monitoring and management of the broad range of landscapes and on-site stormwater systems.

1) **Prepare and Implement a Restoration Management Plan for the Natural Areas**
The undeveloped portion of the property is not actively managed. As a result, there are species of management concern, including invasive species, and in the wooded portions there is a limited ground plain flora due to inadequate sunlight, resulting in poor soil health and soil erosion. A restoration management plan should be prepared for the undeveloped portions of the site. The plan should include identification and delineation of plant communities, identification of specific short-term and long-term management activities, and restoration monitoring protocols. Further plan development could include preparation of specifications and bid documents for the initial restoration work and for long-term management activities. This plan should be prepared by an outside consultant and should include participation from the White Oak site steward.

2) **Implement the Designed Landscape Plan**
The landscape plan in the construction drawings for the most recently developed southeast portion of the FDA campus should reviewed and modified / updated as necessary, then implemented in its entirety. This plan would significantly reduce the amount of turf that requires mowing, which would reduce carbon and other pollutant emissions from mowing while increasing plant biodiversity and insect and bird habitat within the developed portion of the property. Implementing the plan should also improve soil health and reduce stormwater runoff.

3) **Prepare and Implement a Landscape Restoration and Management Plan for Pond 2**
Little to none of the planting or seeding specified in the landscape plan was completed for the Pond 2 basin. As a result of this and minimal management, the basin is dominated by weedy and invasive species indicative of a low quality landscape. A plan should be prepared to retrofit the basin with native prairie and wetland species that are appropriate to the hydrologic conditions and consider the presidential memorandum on ‘Supporting the Health of Honey Bees and Other Pollinators’.
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4) **Budget for and Acquire Adequate Staffing to Manage the Landscapes.**
The current site steward has a good understanding of the property’s landscapes and is committed to improving the ecological health of the property, but he is under-staffed and potentially under-resourced. This limits his ability to implement the two previous recommendations.

5) **Develop an Inspection and Maintenance Plan for the Stormwater Systems.**
Although the stormwater systems at the White Oak site are all passive systems without automation, there are a very large number of stormwater features. There is a need to identify those structures and prepare a schedule for inspection and maintenance of those structures. Records should be kept of inspections as well as necessary maintenance activities required to address obstructions, sediment accumulations, and other needs. The records will assist in budgeting for future needs and aid when staff transitions occur.

6) **Consider Continued Stormwater Monitoring**
Even though the landscape of Bioretention 3 is turf, it is performing well in terms of reducing runoff volumes and rates. However, it could potentially perform better with deeper rooted native species that should improve soil organic carbon and the water holding capacity of the soil. Continued monitoring while transitioning the turf landscape to a native landscape would provide an ideal opportunity to assess the influence of native landscapes on bioretention system stormwater performance.

7) **Quarterly Reporting**
It is recommended that quarterly reports be prepared to document implementation of the recommendations in this report. The reports would include ongoing natural areas stewardship activities, landscape and stormwater inspection activities, and monitoring findings. The reporting frequency could be reduced to annual or semi-annual after the initial restoration of the natural areas and installation of the developed-area landscape plan.

8) **Site Commissioning**
The designed landscape was not installed per plan due to budget constraints that apparently arose during the construction process. Had site commissioning been a requirement of GSA and/or a source of points under LEED, it is less likely that elements of the landscape plan would have been eliminated from the project. To reduce the potential for future deviations from designed landscape plans during construction, it is recommended that site commissioning be incorporated into GSA requirements. Site Commissioning would also help to ensure that landscape systems, including preserved natural areas, are managed to meet long-term ecological goals. Site Commissioning is further described in the next section.

Commissioning

Site Commissioning

GSA published its “Site Commissioning White Paper” in July 2017. The paper highlights both the increasing level of ecosystem services that we are demanding from our landscape systems and the greater complexity of those systems necessitated by that demand. Because of the higher expectations and greater complexity, there is an increasing need to ensure that the systems are functioning in a manner consistent with the design intent. Building commissioning has been part of the delivery process for high performance buildings for quite some time. Commissioning ensures that the building systems are performing in a manner consistent with the design intent, primarily from the perspective of energy use and HVAC systems. However, commissioning for site systems is a relatively new concept. Analogous to building commissioning, site commissioning is intended to ensure that landscape, stormwater, and site water conservation systems are performing as intended. The “Site Commissioning White Paper” articulates the need for and value of site commissioning, discusses the hurdles, and then presents a process for implementing a site commissioning system for GSA projects.

The White Paper recommends four core commissioning areas: (1) soil, (2) water, (3) vegetation, and (4) materials and three supporting commissioning areas: (1) climate, (2) habitat and (3) human health + well-being. For each of the commissioning areas, there are three tier performance levels with Tier 1 being the minimum level of performance and Tier 3 being the highest level of performance.

The White Paper also recommends two phases of post-construction commissioning and monitoring. Site Commissioning would end two years after construction completion at the end of a typical plant establishment period. The Long-Term Management phase includes monitoring / adaptive management and commissioning to formalize a process for identifying, reporting, and remediating site system performance deficiencies. Recommissioning would occur every three to five years to ensure the site is continuing to perform as designed.

Commissioning Recommendations for the White Oak Site

The GSA "Site Commissioning White Paper" includes recommended actions specific to site commissioning that can be inserted into GSA's existing commissioning process. Since the existing FDA campus projects were completed over time without site commissioning, the opportunity to complete the actions for the Planning/Pre-Design through Post-Construction phases has passed. However, there continues to be an opportunity to apply the construction/post construction site commissioning recommendations to some aspects of the site, as well as the long-term monitoring /adaptive management and recommissioning recommendations. This would include the following:

Construction and Post-Construction Phases

1) The landscape plan that was prepared for the southeast portion of the site should be reviewed, modified as necessary given current conditions, and implemented.
2) A restoration management plan should be prepared and implemented for the undeveloped portions of the site.

Long-Term / Recommissioning Phase

The Maintenance and Operations Recommendations detailed in the previous section should be implemented to facilitate continuous monitoring and recommissioning of the stormwater systems and other site components.

1) Evaluate landscape and stormwater components per the recommendations in the "Site Commissioning White Paper".
2) Implement a long-term natural areas management plan.

Because the White Oak site will be further developed to address current capacity and security issues and accommodate an additional 5,900 staff, **site commissioning should be included along with Total Building Commissioning as part of GSA's process for all future phases.**