HONOR ★ REMEMBER ★ EXPLORE

Arlington National Cemetery Millennium Project Final Environmental Assessment

Lead Agency:
Arlington National Cemetery
Cooperating Agency:
U.S. National Park Service

June 2013

US Army Corps of Engineers ®
Norfolk District

APPENDIX C:

Stream Restoration

DRAFT STREAM RESTORATION ANALYSIS

I. Stream and Resource Protection Area (RPA) Impacts

Pursuant to the jurisdictional determination issued by the U.S. Army Corps of Engineers (COE) dated November 28, 2011 (#NAO-2011-02220), there are Waters of the U.S. (WOUS) present on the Millennium site, as well as RPA's along the perennial stream channels. While no wetland impacts are proposed as part of this project, the proposed plan (dated October 23, 2012) does impact both intermittent and perennial streams and the associated RPA Buffer.

Over the past several years as the development of this project has progressed, reductions in the amount of impacts to these natural resources have been achieved with each subsequent design. The result of these design efforts is a plan that represents the Least Environmentally Damaging Practicable Alternative (LEDPA). A summary of these impact reductions (to both streams and RPA buffers) is provided below in Table 1:

Table 1. Summary of Stream and RPA Impacts

Resource Type	*Impact Lengths for Specified Streams (lf of stream and buffer width for RPA)*				
	Current Condition	*12/01/09*	*07/12*	*09/25/12*	*11/06/12 (Proposed)*
Average RPA Buffer	100	16	40	64	81
Intermittent Stream (R4)	372	370	291	216	148
Perennial Stream (R3)	1,680	758	363	148	140
Total Stream Impact	**0**	**1,128**	**654**	**364**	**288**

A more detailed analysis of the evolution of the Millennium project from the December 1, 2009 plan to the draft layout dated November 6, 2012, as it relates to stream and RPA buffer impacts, is presented in Appendix 1.

To offset the unavoidable proposed impacts to the existing streams and their RPA buffers, the remaining stream channels and buffer will be restored (1,879 linear feet, existing length; 1,754 linear feet, proposed length; and ±0.3 ac of RPA buffer)[1]. The restoration approach is described in detail in the following section.

II. Stream and Buffer Restoration: On Site

As part of the Arlington National Cemetery (ANC) Millennium project the existing stream channels, where not impacted, will be restored and integrated into the overall project as a natural landscape amenity (as shown on the most recent design layout, dated November 6, 2012, Figure 1) where they are severely degraded. Natural Channel Design (NCD) Techniques will be utilized to restore the existing degraded stream channels. Unlike conventional engineering practice, the goal of NCD is not simply the abatement of stream bank erosion or the maximization of channel conveyance (typically done with riprap and concrete), but to restore the balance of flow and sediment in the stream system and to

[1] *Given the site constraints and the dimensions needed to achieve a stable stream pattern, the proposed stream length is shorter than the existing stream length.*

reestablish natural hydraulic and ecologic functions. This is accomplished by mimicking, as much as possible, the characteristics (channel dimension, planform geometry, slopes) of a stable, "natural" system. Further, a stream's floodplain connection is reestablished, allowing large flow events (those equal to or greater than the ±0.8 to 1.5 year storm event) to access, spread out, and slowdown in the floodplain. The reestablished floodplain connection helps reduce downstream water quality by improving nutrient (nitrogen and phosphorus, etc.) and sediment uptake in the floodplain, increasing evapotranspiration, improving riparian habitat, and raising local ground water tables. By establishing a stable channel geometry and reestablishing a floodplain connection, excessive bank and bed erosion can be arrested, in-stream habitat improved, and the downstream transport of pollutants reduced.

In addition to the stream restoration, a small area (approximately 0.3 acre) of the stream RPA buffer that is currently a maintenance yard will be restored and reforested, consistent with the planting guidelines presented in *Riparian Buffer Modification and Mitigation Guidance Manual* prepared by the Virginia Department of Conservation and Recreation Chesapeake Bay Local Assistance, September 2003 – Reprinted 2006.

Based on the existing stream condition and the proposed Millennium project site plan (dated November 6, 2012), the stream restoration can be broken down into the three sections shown in Figure 1. The streams in each section will be restored to varying degrees dependent upon their existing degree of degradation, flow rate, and the proposed adjacent land use.

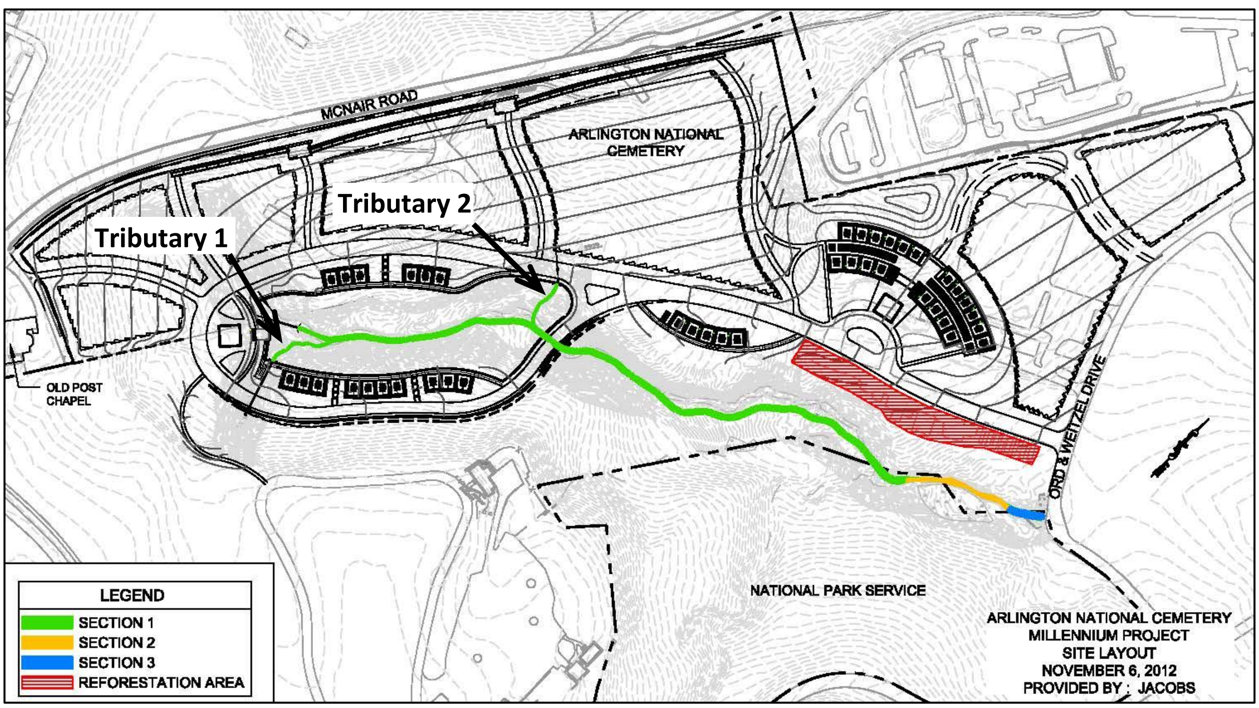

Figure 1. Proposed stream restoration sections and reforestation area in relation to the overall Millennium Project.

A. Section 1 (± 1,477 l.f.)

Section 1 contains the most degraded reaches of existing stream and will require the most intensive restoration effort. Currently, the streams in this section are deeply incised (up to 8 feet, preventing storm flows from accessing the floodplain) and have raw, actively, eroding banks. This section includes the restoration of the main stream, from the point where the stream will flow from a proposed pipe on the southeast end of the loop road and will continue to where it ties into a relatively stable section of stream located on National Park Service property. In addition to the restoration of the main stream, this section also includes two tributary streams. Tributary 1 is located at the upstream end of the project and flows from south to north into Reach 1. Tributary 2 is located just upstream of the loop road crossing and flows from northwest to southeast into Section 1.

The reaches in this section will be restored by establishing a stable cross section sized to convey the post-cemetery construction 1.5-year flow rates within its banks. In addition, the restored stream invert will be reconnected to the floodplain. The proposed riffle cross sectional dimensions for Section 1 range from 6.5 feet wide by 0.7 feet deep at the upstream end to 11.0 feet wide by 1.2 feet deep at the downstream end. Tributaries 1 and 2 will be 5 feet wide by 0.6 feet deep. Photos 1 and 2 (below) compare the existing condition to the proposed conditions where the stable stream cross section is raised and reconnected to its floodplain.

Photo 1. Existing stream channel with approximate cross section superimposed

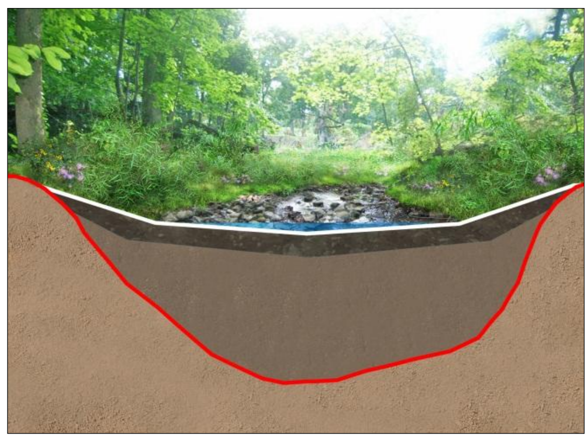

Photo 2. Rendering of proposed condition superimposed on the existing stream channel.

The proposed stream restoration area is located on a headwater stream that begins at the outlets of pipes, the contributing watershed is fully developed, and there is little to no sediment input into the system. In addition, the in-situ stream bed sediment is not of sufficient size to withstand the erosive flows resulting from this urban watershed. As such, the proposed restoration will be designed as a threshold channel to prevent future erosion and ensure long term stability. To achieve the threshold condition, 2 feet (or two times the necessary mean diameter, or D_{50}, of the cobble size, whichever is greater) of reinforced bed material (a mixture of larger cobble, small cobble, gravel, sand, and topsoil) will be placed in the stream channel. The larger cobble component of the material is sized to withstand the sheer stress of the storm flows in the restored stream channel. The smaller material provides added stability by helping to "lock" the larger cobble together and provide filtration, infiltration, and hyporheic flow capacity. In addition, the smaller material is redistributed within the channel by the stream flows, creating a naturally defined thalweg (the deepest part of the channel) and point bars (areas of deposition on the inside of meanders). The cobbles and gravels used in the reinforced bed material will be rounded river washed stone that is brownish/tan in color. When initially installed this material will be "clean" (and thus "whiter" due to quartzite), but will stain over time. In addition to the reinforced bed material, in-stream structures such as step pools, s-vanes, boulder riffles, boulder pools, and modified cross vanes will be utilized to provide energy dissipation, grade control, and reduce the shear stress on the stream banks. Rock used to construct the in-stream structures can similarly be selected from local quarries (diabase), or selected from other sources to obtain colors more compatible with the project architecture and landscape.

Where the stream flows under the loop road, either a bottomless culvert or a depressed box culvert will be utilized for the road crossing to minimize aquatic resource impacts.

Following the restoration of the channel, the area will be replanted with either native riparian plantings (for a forested condition), or with native herbaceous material (for a more manicured condition). The final plant palette will depend on the final overall design plan for the Millennium project, and the specific species will be selected from the published list of recommended plantings provided by Arlington County[2], and consistent with the planting guidelines presented in *Riparian Buffer Modification and Mitigation Guidance Manual* prepared by the Virginia Department of Conservation and Recreation Chesapeake Bay Local Assistance, September 2003 – Reprinted 2006.

B. Section 2 – (± 200 l.f.)

This section of stream is fairly stable with a few areas of stream bank erosion. Section 2, is located from just beyond where the stream flows onto NPS property to just upstream of Ord and Weitzel Drive. Photos 3 and 4 (below) document the existing condition of Reach 2.

Photo 3. Looking downstream at the existing stream channel (maintenance yard off picture to left).

Photo 4. Looking downstream at the existing stream channel (approx. 30 feet downstream of Photo 3).

The restoration concept for this section would be to provide "spot stabilization" improvements of the existing areas of stream bank erosion. Following the restoration of this section, the disturbed areas will be replanted with native riparian plantings. As with Section 1, the final plant palette for this section will be selected from the published list of recommended plantings provided by Arlington County, and

[2] *Simmons, Rod and Zell, Greg. Keeping It Natural: A Local Guide to the Use of Native Plants For Natural Land Restorations and Post-Disturbance Project Plantings Within Natural Woodland Sites, Riparian Buffers and Forest-Edge Ecotones in Arlington County and the City of Alexandria in Virginia. November 24, 2009.*

consistent with the planting guidelines presented in Riparian Buffer Modification and Mitigation Guidance Manual prepared by the Virginia Department of Conservation and Recreation Chesapeake By Local Assistance, September 2003 – Reprinted 2006.

C. Section 3 (± 77 l.f.)

Section 3 is located in the area just upstream of the culvert under Ord and Weitzel Drive. Currently, a headcut is developing as the stream flows into the existing culvert (from a combination of steeper gradient and the culvert's flow concentration) and there is evidence of erosion around the sides and bottom of the culvert. If left unattended, the headcut will progress upstream and threaten the stability of Section 2.

This section will be restored using a series of step pools to stop the head cut and provide a stable and attractive transition between Section 2 and the culvert under Ord and Weitzel Drive. Step pools are series of cascades and pools that provide grade control and energy dissipation. The rock used to construct these structures will be large (Class III size) rock. A naturalized brownish/tan color landscaping quality rock that blends into the landscape could be used as opposed to grey/blue "blocky" diabase rock that is typically seen in many local stream restoration projects[3]. Photo 5 shows the existing condition of the stream channel. Photos 6 and 7 are examples of a step pool system using diabase rock immediately after construction and 3-years post-construction, respectively.

Photo 5. Looking downstream at the culvert under Ord and Weitzel Drive.

[3] *Quarried diabase rock typically used in stream restoration projects in this region tends to be rectangular with sharp edges versus rounded in shape, and is not weathered. Due to its rectangular shape and stark color contrast between the blue/grey rock and the surrounding landscape, it can take several years for the natural appearance of a restoration project to fully develop (i.e. the rock to weather and the surrounding vegetation to mature). By utilizing a more weathered rock with a brown/tan coloring, the natural appearance could be achieved immediately following the completion of construction if project budget restrictions can be met.*

Photo 6. Step pool example (after construction).

Photo 7. Step pool system (same as Photo 6), 3-Years post-construction.

III. Stream Impacts: Permitting

Through the iterative design process, proposed impacts to WOUS have been reduced to the point where they can be permitted using a State Programmatic General Permit (SPGP), or a combination of an SPGP and Nationwide Permit #27. No compensatory mitigation will be required given the minimal proposed impacts (<300 lf). This result was achieved through the Design Team's efforts to comply with the Clean Water Act Section 404(b)(1) Guidelines that require the following three step process be followed in order to achieve a permittable plan: 1) avoid impacts to the maximum extent practicable[4], 2) minimize unavoidable impacts to the maximum extent practicable, and 3) provide compensatory mitigation for those unavoidable impacts that exceed de minimis thresholds under the Clean Water Act and Virginia Water Protection Permit program. By following this procedure and achieving significant reductions in proposed impacts to WOUS for the project, representatives of the Corp of Engineers (COE) and Virginia Department of Environmental Quality (DEQ) stated at a pre-application meeting held to present the proposed plan that it is reasonable to assume it can be permitted as currently proposed.

IV. Stream Restoration: Water Quality Benefits

A. Estimate of Pollution Reduction from Stream Restoration

With the exception of Section 2 (described above), the streams located on the Millenium project site are deeply incised (preventing storm flows from accessing the floodplain) and have raw, actively, eroding banks. In their current state, they are effectively serving as conduits - transporting and providing

[4] *The term "practicable" is defined in EPA's Section 404(b)(1) Guidelines (40 CFR §§ 230.1-230.80) as "available and capable of being done after taking into consideration cost, existing technology, and logistics in light of overall project purposes".*

pollutants (i.e. total nitrogen, total phosphorus, and total suspended solids) to downstream receiving waters. Through the use of NCD techniques, the proposed stream restoration component of this project will restore a stable cross section and planform, resulting in approximately 1,501 linear feet of restored stream channel (this length does not include the 200 linear foot section of spot improvements) of a unnamed tributary to the Potomac River, reconnect it to its floodplain, and reduce the pollutant load. The Chesapeake Bay Program's Chesapeake Bay Phase 5.3.2 Community Watershed Model (CBCWM)[5] presents pollutant removal rates (CBP 2003)[6] achieved through stream restoration.

Since the publication of CBP 2003, the scientific community has performed additional research showing that these removal rates are significantly (i.e. orders of magnitude) underestimated. In August 2011, the Chesapeake Stormwater Network (CSN) published "CSN Technical Bulletin No. 9 Nutrient Accounting Methods to Document Local Stormwater Load Reductions in the Chesapeake Bay Watershed" (CSN 2011) which proposed interim pollutant removal rates.[7] Per CSN 2011, these rates are to be used until the University of Maryland completes the stream restoration research review, and the BMP Expert Panel has an opportunity to review its findings (ongoing). Table 1 compares the pollutant load reductions resulting from stream restoration as presented in CBP 2003 and CSN 2011:

Table 2. Comparison of CBP 2003 and CSN 2011 Stream Restoration Pollutant Load Reduction Rates

Pollutant	***CBP 2003 Removal Rate***	***CSN 2011 Removal Rate***
Total Nitrogen	0.02 lb/lf-yr	0.2 lb/lf-yr
Total Phosphorus	0.0035 lb/lf-yr	0.068 lb/lf-yr
Total Suspended Solids	2.55 lb/lf-yr	310 lb/lf-yr

Despite the "interim" label, it is justifiable to use the CSN 2011 values in order to determine the pollutant removal benefit of the proposed stream restoration. First, the CSN recommended the use of these rates until a final determination is made by the University of Maryland panel currently reviewing them[8]. Second, when the CSN 2011 TSS load reductions are converted to a stream bed and bank erosion rate, they indicate a yearly erosion rate that, anecdotally, is consistent with stream bank erosion witnessed throughout Fairfax County.[9] The CSN 2011 removal rates estimate a reduction of 2.4 inches per year of stream bed and bank erosion in Snakeden Branch while the CBP 2003 removal rates estimate less than 0.2 inches per year of stream bed and bank erosion.

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[5] *U.S. EPA, 2010. Chesapeake Bay Phase 5 Community Watershed Model In preparation EPA XXX-X-XX-010 Chesapeake Bay Program Office, Annapolis, Maryland. December 2010.*

[6] *Urban Stormwater Workgroup. "Stream Restoration in Urban Areas Crediting Jurisdictions for Pollutant Load Reductions." Chesapeake Bay Program. 26 June 2009. Available at: http://archive.chesapeakebay.net/pubs/subcommittee/nsc/uswg/BMP_Stream_Restoration_and_Pollutant_Load_Reductions.PDF.*

[7] *Chesapeake Stormwater Network. "CSN Technical Bulletin No. 9: Nutrient Load Accounting Methods to Document Local Stormwater Load Reductions in the Chesapeake Bay Watershed. 15 August 2011. Available at: http://www.chesapeakestormwater.net/whatsnew/new-release-technical-bulletin-no-9.html.*

[8] *Per email correspondence (dated November 7, 2012) between Scott Petrey (WSSI) and William P. Stack (CWP), the stream restoration panel expects to complete their review in mid-2013.*

[9] *Staley, Nathan. Wetland Studies and Solution, Inc. Memorandum – Chesapeake Bay Watershed Model – Update on Pollutant Reductions for Stream Restoration. January 24, 2012.*

Table 3 presents a summary of the total pollutant load reduction resulting from the stream restoration.

Table 3. Pollutant Removal Rates (Per 2011 CBWM)

Pollutant	*Removal Rate*	*Restored Stream Length*	*Total Pollutant Load Reduction*	*TSS Load Reduction (by Volume)**
Total Nitrogen	0.2 lb/lf/yr	1,554 lf	311 lb/yr	---
Total Phosphorus	0.068 lb/lf/yr	1,554 lf	106 lb/yr	---
Total Suspended Solids	310 lb/lf/yr	1,554 lf	481,740 lb/yr	198 (cy/yr)
**Based on an assumed soil density of 90 lb/cf*				

B. Phosphorus Loading Analysis – The Keystone Pollutant in the Chesapeake Bay Preservation Act

To determine the overall effect of the portion of the proposed project related to streams and RPA buffers on water quality, an analysis of the proposed project's effect on the net total phosphorus (the keystone pollutant in the Chesapeake Bay Preservation Act) loading was performed. By comparing the increases in loading from the proposed land use changes in the RPA (both land use change and buffer encroachment) to the decreases in loading fom the stream restoration, the project's overall environmental benefit can be determined. Enclosures 1 and 2 depict the existing and proposed land uses, respectively, within the 100 foot RPA Buffer on the Arlington National Cemetery Millennium Project site. Total phosphorus loading rates from the CBCWM were used. As discussed in the previous section, the total phosphorus removal rates for stream restoration from CSN 2011 were used. The Buffer Equivalency calculation from the Chesapeake Bay Local Assistance Department (CBLAD) Information Bulletin 3, dated March 1991 was used to determine the impact of encroachments into the 100 foot RPA buffer.

Table 4 is a summary of the net phosphorus loading calculation. A detailed calculation is presented in Appendix 2. **As summarized by Table 4, the proposed project yields a net reduction in total phosphorus loads which will result in improved water quality in the Millennium project stream and downstream receiving waters, even with the construction of the proposed cemetery expansion.**

Table 4. Phosphorus Loading Summary (lb of TP/yr)

Phosphorus Load Changes			*Net Phosphorus Load*
From Change in Land Use	*From Buffer Reduction*	*From Stream Restoration*	
1.98	0.29	(106)	**(103.4)**

V. RPA Buffer Impacts: Approval Process

Pursuant to the Coastal Zone Management Act, in 1986, the National Oceanic and Atmospheric Administration (NOAA) approved Virginia's Coastal Zone Management Program (CZM Program). As a result, any proposed federal activity that is likely to affect any coastal land, water or natural resources of Virginia's designated coastal resources management areas, must be consistent, to the maximum extent practicable, with the enforceable policies of Virginia's CZM Program. In Virginia, the Coastal Lands Management program is an enforceable policy administered by CBLA through the Bay Act and the Regulations.

NOAA has determined that the Coastal Zone Management Act does not grant states regulatory authority over activities on federal lands, so there are no Chesapeake Bay Preservation Areas (CBPAs) designated on federal lands located in Virginia and projects proposed on federal lands are not directly subject to the Bay Act. However, while CBPAs are not locally designated on federal lands, pursuant to the Coastal Zone Management Act of 1972, as amended, federal activities affecting Virginia's coastal resources must be consistent with the Bay Act and the Regulations as one of the enforceable programs of Virginia's CZM Program. Thus, federal agencies have the responsibility to be consistent with the provisions of the Regulations, § 9 VAC 10-20-10 et seq., including adherence to the performance criteria applicable to lands within locally designated CBPAs. As a result, projects on federal lands that include land disturbing activity must adhere to the general performance criteria, especially with respect to minimizing land disturbance (including access and staging areas), retaining indigenous vegetation and minimizing impervious cover.

Through the iterative design process that has been followed for the ANC Millennium Project, these performance criteria are being met. A summary of the extent to which impacts to the RPA buffer have been reduced is contained in this document. Detailed computations demonstrating compliance with the Bay Act through the following steps:

- Preparation of an RPA Plan (using the restored stream alignment as a core RPA component),
- Preparation of an RPA Exception Request (that documents the changes made during design development to comply with the Bay Act Regulations),
- And preparation of an associated Water Quality Impact Assessment (WQIA) prepared in accordance with state regulations.

In accordance with CZM Program, the above documents will be submitted for review, comment, and approval by the appropriate ANC Officer. Arlington County will serve as a coordinating and commenting agency, but will not have regulatory authority over the approval of these documents related to ANC Compliance with the Bay Act.

As demonstrated in the previous section, the WQIA will clearly demonstrate a net improvement of water quality resulting from the proposed actions in the RPA.

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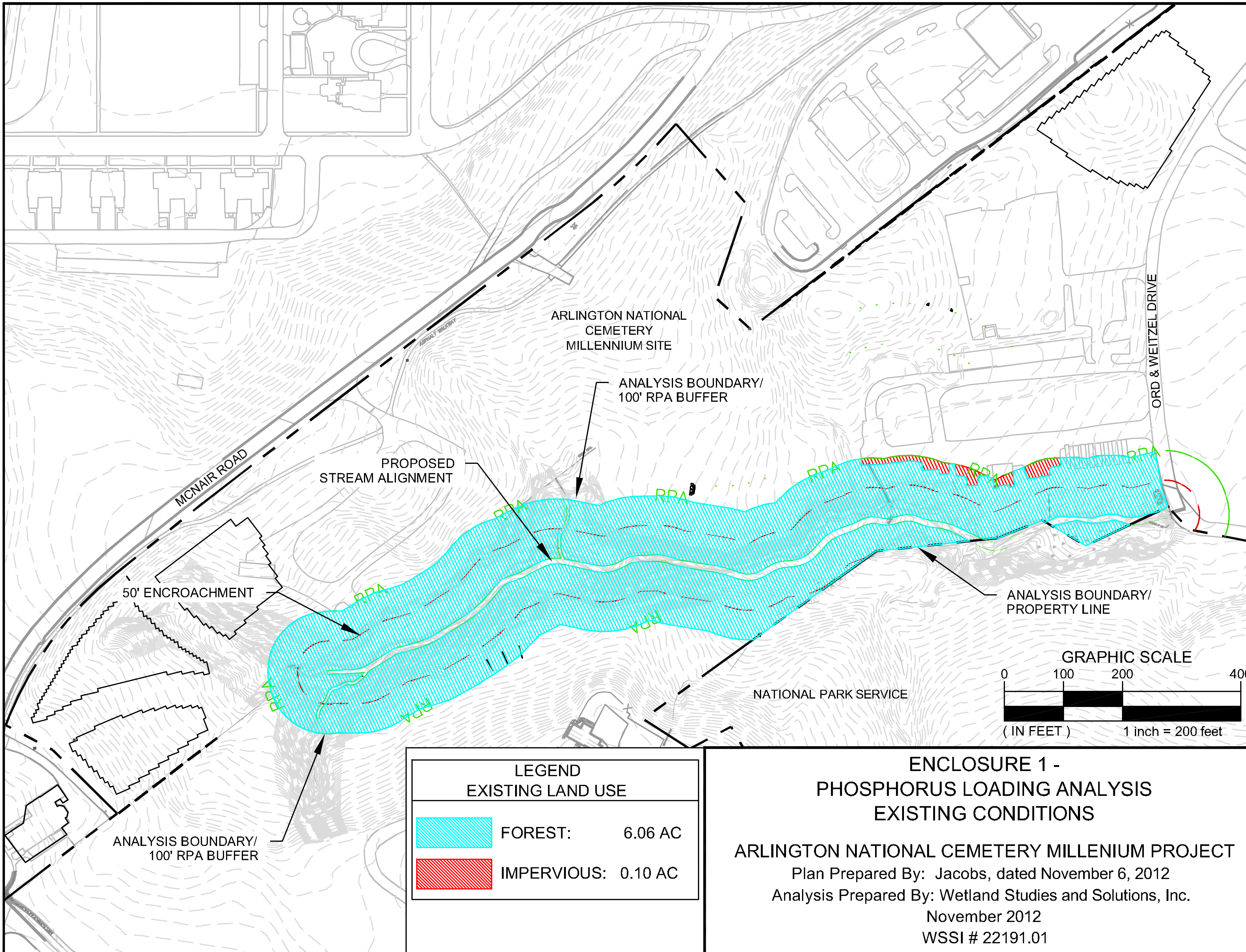
APPENDIX 1

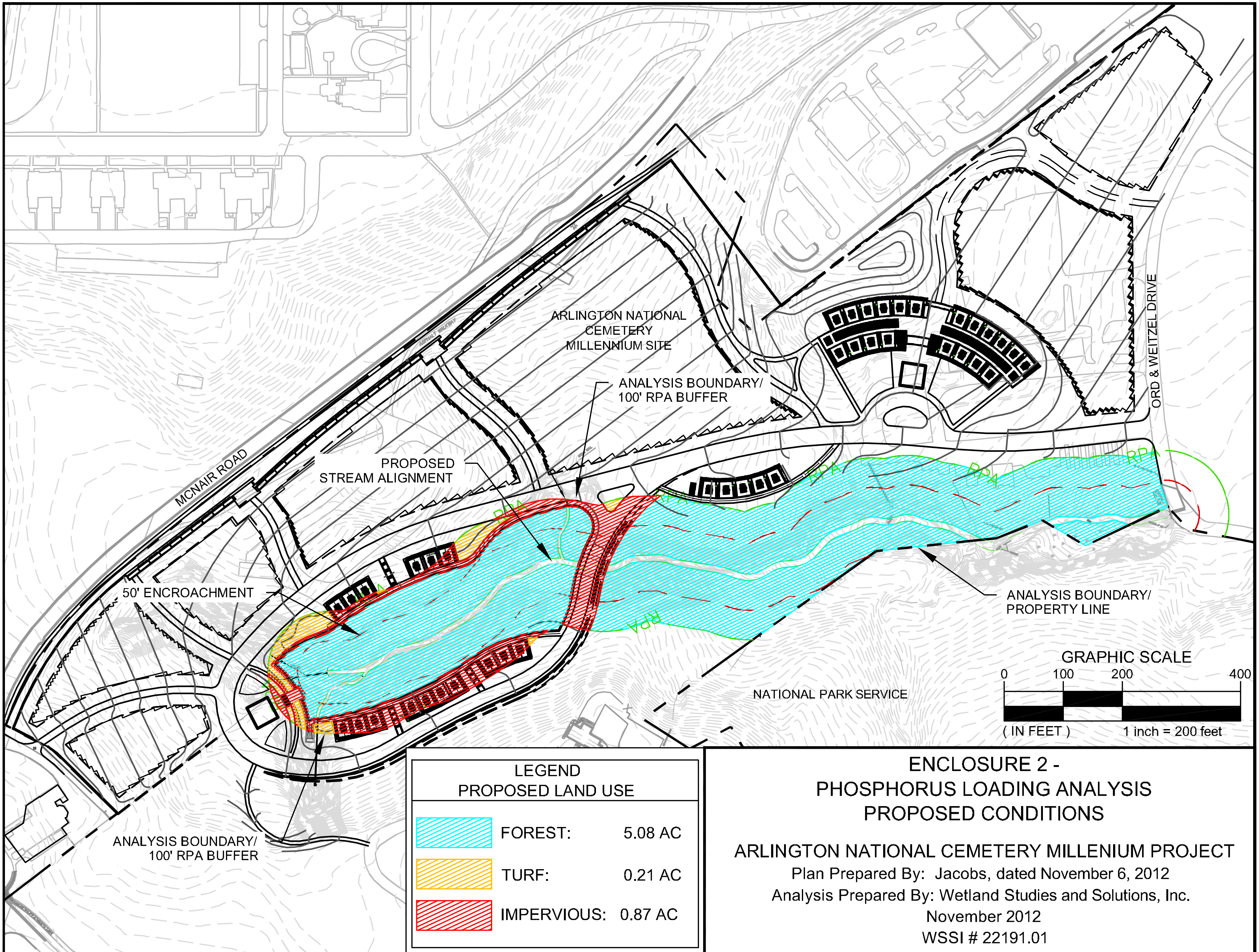


LEGEND
EXISTING LAND USE

FOREST:		6.06 AC
IMPERVIOUS:		0.10 AC

ENCLOSURE 1 -
PHOSPHORUS LOADING ANALYSIS
EXISTING CONDITIONS

ARLINGTON NATIONAL CEMETERY MILLENIUM PROJECT
Plan Prepared By: Jacobs, dated November 6, 2012
Analysis Prepared By: Wetland Studies and Solutions, Inc.
November 2012
WSSI # 22191.01



LEGEND
PROPOSED LAND USE

	FOREST:	5.08 AC
	TURF:	0.21 AC
	IMPERVIOUS:	0.87 AC

ENCLOSURE 2 - PHOSPHORUS LOADING ANALYSIS PROPOSED CONDITIONS

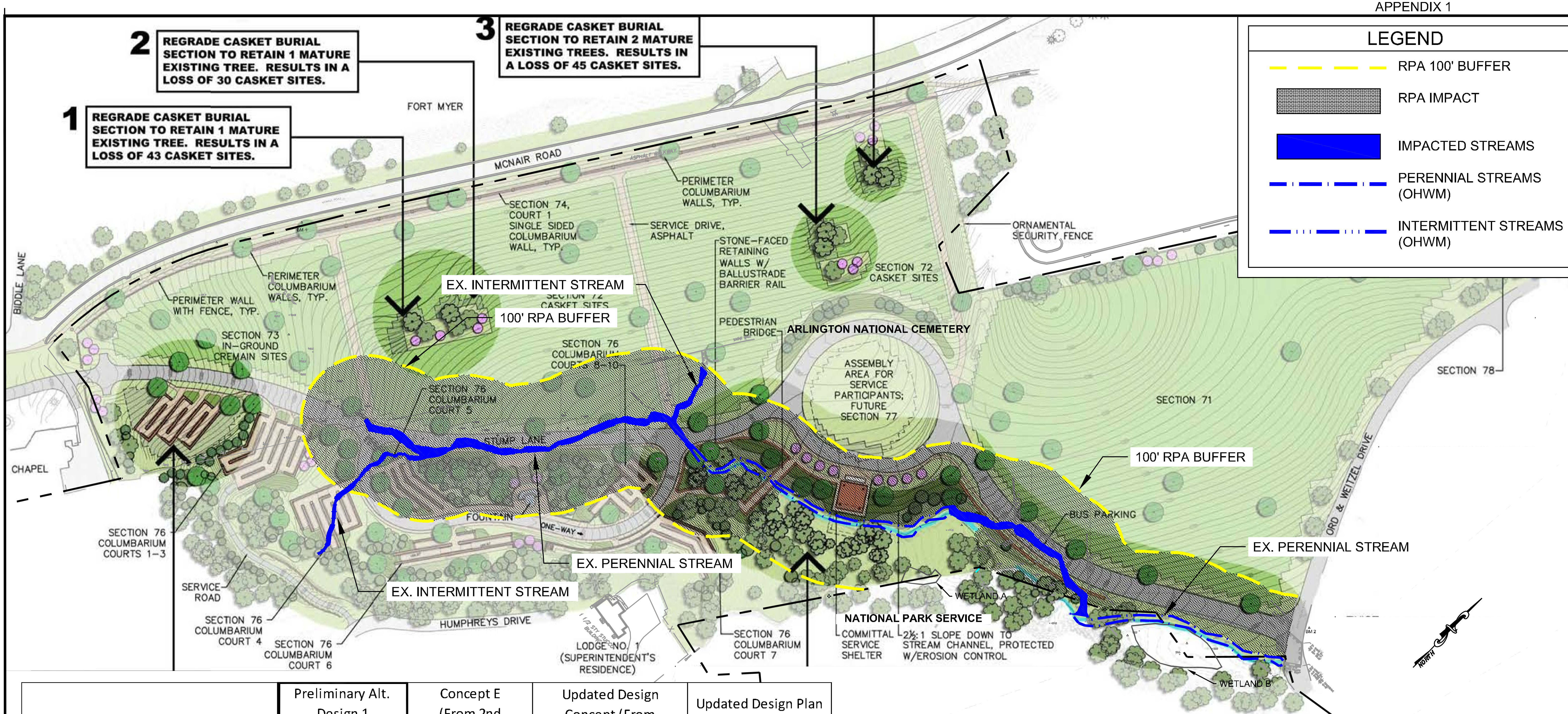
ARLINGTON NATIONAL CEMETERY MILLENIUM PROJECT

Plan Prepared By: Jacobs, dated November 6, 2012

Analysis Prepared By: Wetland Studies and Solutions, Inc.

November 2012

WSSI # 22191.01



Parameter		Preliminary Alt. Design 1 (Dec. 1, 2009)	Concept E (From 2nd Charrette Report, dated July 2012)	Updated Design Concept (From Charrette Report, dated Sept. 25, 2012)	Updated Design Plan -Proposed RPA (Nov. 6 , 2012)
Ex. Intermittent Stream	ft	372	372	372	372
Ex. Perennial Stream	ft	1,680	1,680	1,680	1,680
Intermittent Stream Impact	ft	370	291	216	148
Perennial Stream Impact	ft	758	363	148	140
Area RPA $_{Existing}$	sf	319,572	319,572	319,572	283,867
Area RPA $_{Impacted}$	sf	267,244	192,965	115,434	52,977
Area RPA $_{Undisturbed}$	sf	52,328	126,607	204,138	230,890
Resultant Average Buffer Width*	ft	16	40	64	81

*Resultant Average Buffer Width = $\frac{Area\ RPA_{Undisturbed}}{Area\ RPA_{Existing}}$ X 100' Buffer Width

RPA AND STREAM IMPACT ANALYSIS

EXHIBIT 1 - PRELIMINARY ALT. DESIGN 1

(Plan Prepared By: STV Inc., The LA Group, & CDM, From DEQ File, dated December 1, 2009)

ARLINGTON NATIONAL CEMETERY MILLENIUM PROJECT

WSSI# 22191.01

ANALYSIS PREPARED BY: WETLAND STUDIES AND SOLUTIONS, INC.

NOVEMBER 2012

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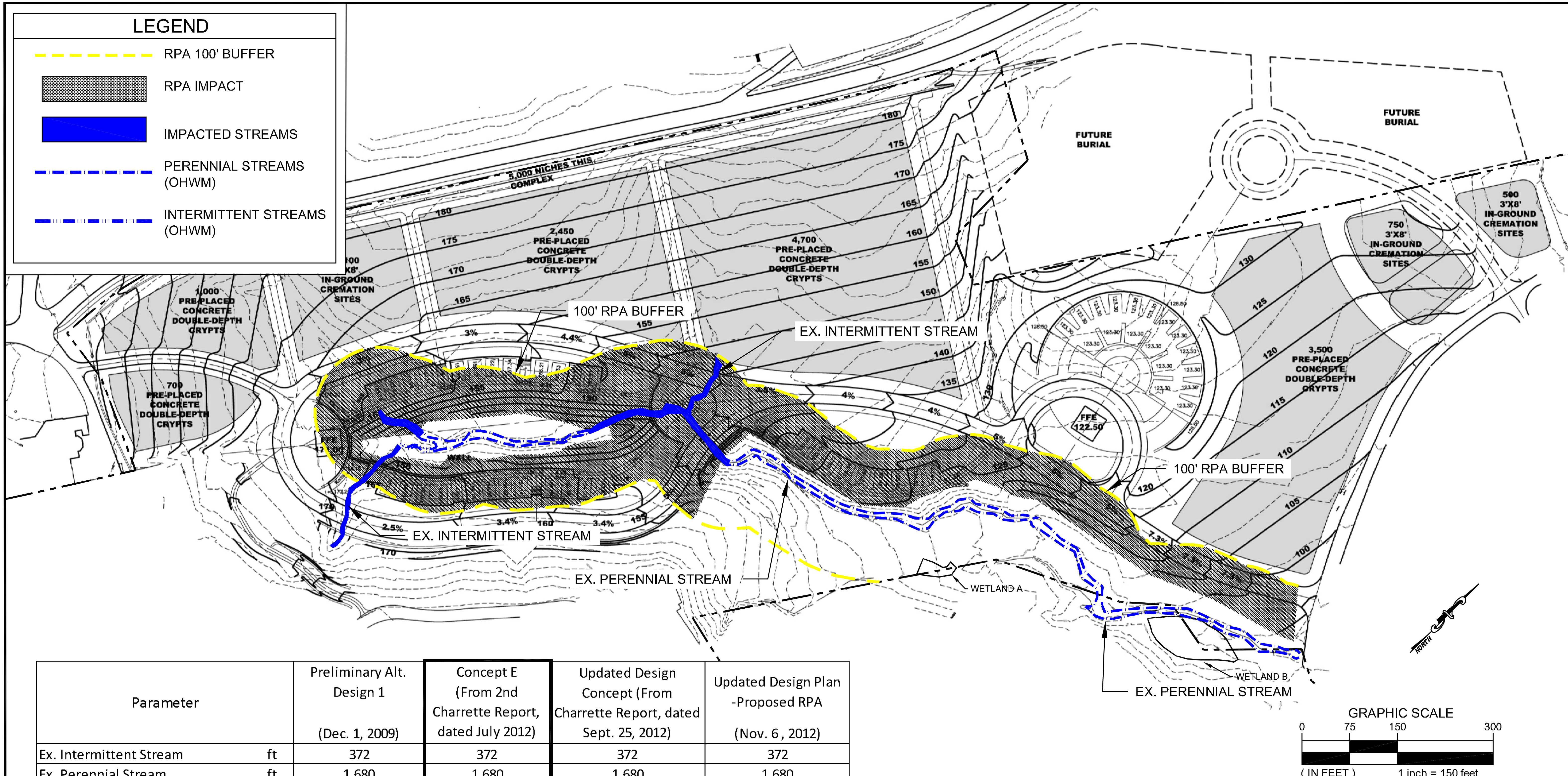

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RPA AND STREAM IMPACT ANALYSIS

EXHIBIT 2 - CONCEPT E
(From 2nd Charrette Report, dated Sept. 25, 2012)
(Plan Prepared By: STV INC. & THE LA GROUP)

ARLINGTON NATIONAL CEMETERY MILLENIUM PROJECT
WSSI# 22191.01
PREPARED BY: WETLAND STUDIES AND SOLUTIONS, INC.
NOVEMBER 2012
SHEET 2 of 4

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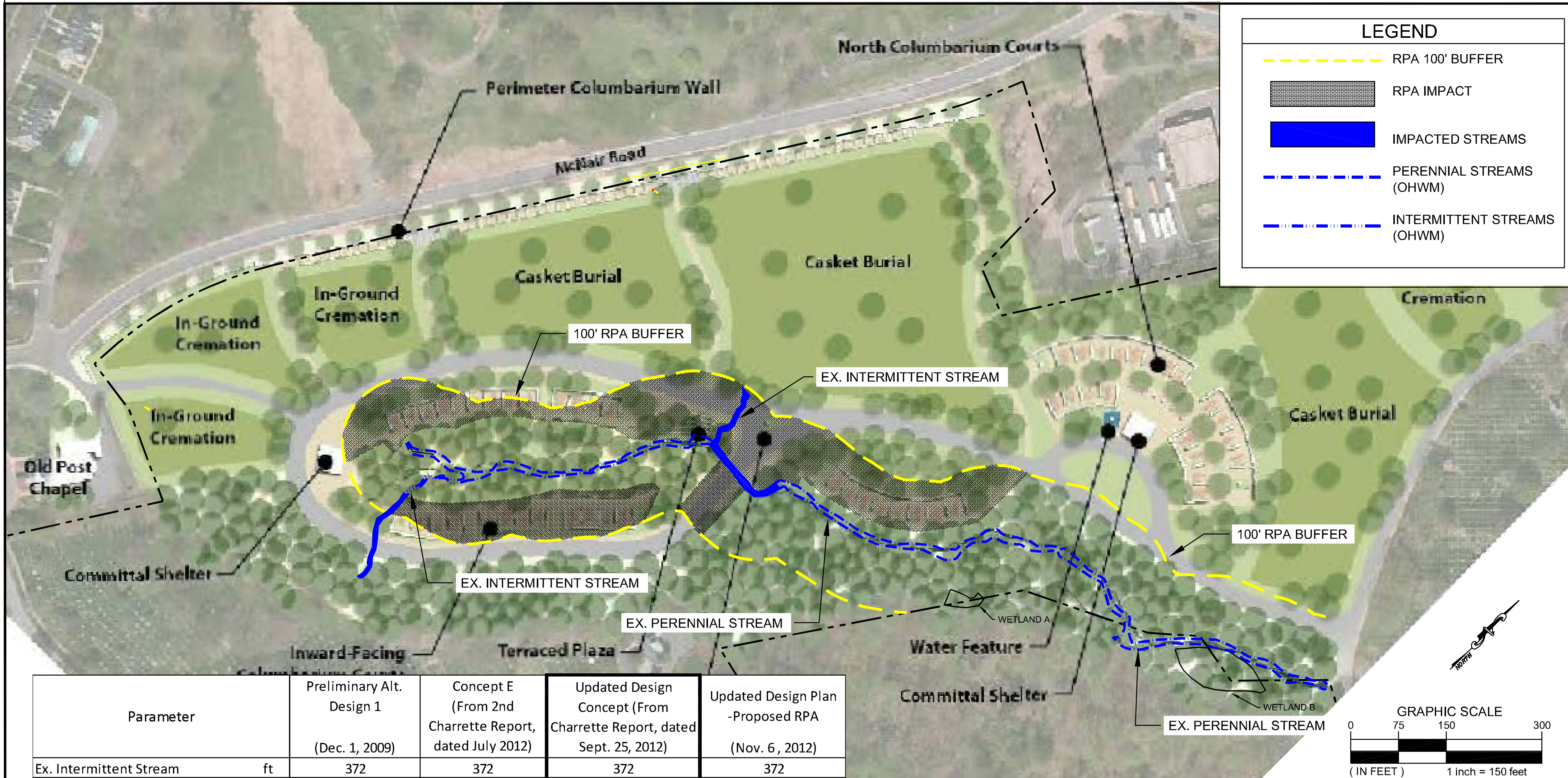

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*Resultant Average Buffer Width = $\frac{Area\ RPA_{Undisturbed}}{Area\ RPA_{Existing}}$ X 100' Buffer Width

RPA AND STREAM IMPACT ANALYSIS

EXHIBIT 3 - UPDATED DESIGN CONCEPT (From Charrette Report dated Sept. 25, 2012)

ARLINGTON NATIONAL CEMETERY MILLENIUM PROJECT
WSSI# 22191.01
PREPARED BY: WETLAND STUDIES AND SOLUTIONS, INC.
NOVEMBER 2012
SHEET 3 of 4

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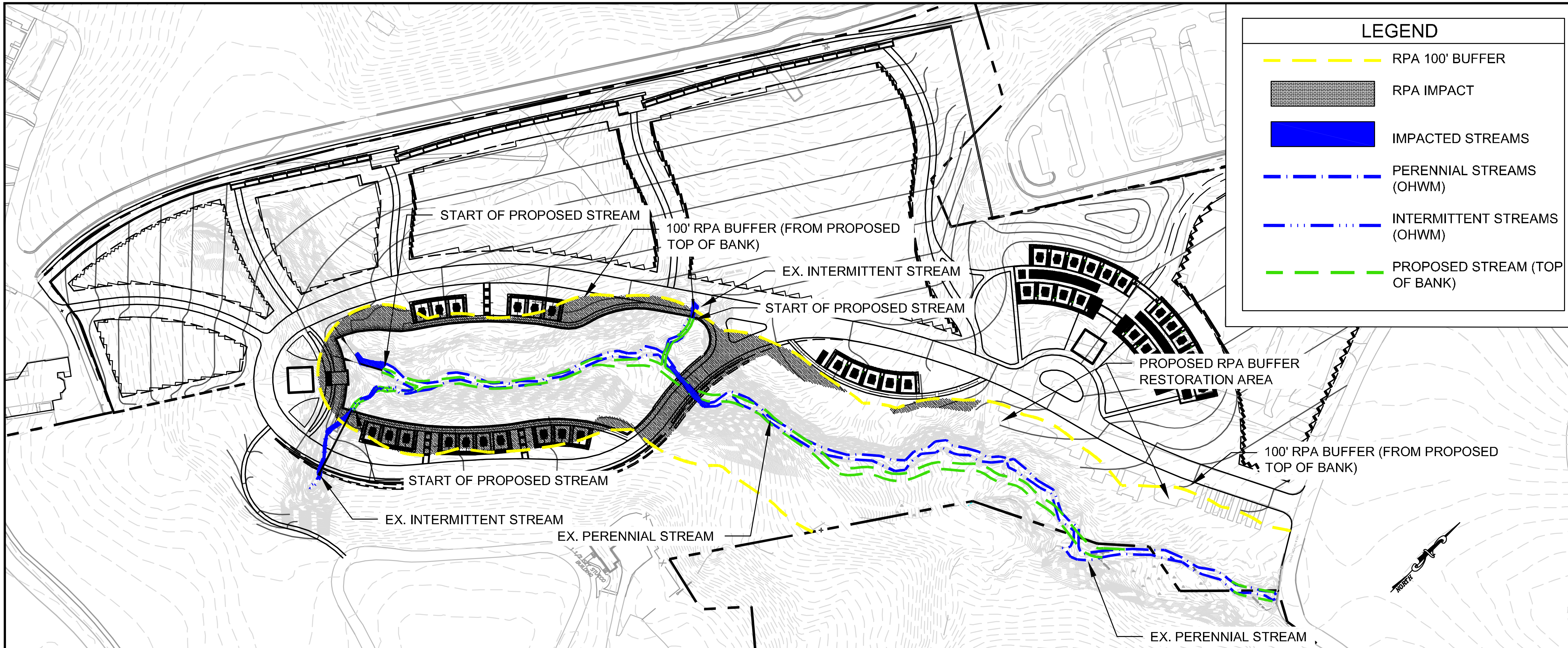

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GRAPHIC SCALE

0 75 150 300

(IN FEET) 1 inch = 150 feet

RPA AND STREAM IMPACT ANALYSIS

EXHIBIT 4 - UPDATED DESIGN PLAN - PROPOSED RPA

(Plan Prepared by Jacobs dated, November 6, 2012)

ARLINGTON NATIONAL CEMETERY MILLENIUM PROJECT

WSSI# 22191.01

ANALYSIS PREPARED BY: WETLAND STUDIES AND SOLUTIONS, INC.

NOVEMBER 2012

SHEET 4 of 4

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APPENDIX 2: NET PHOSPHORUS LOADING CALCULATIONS

Step 1: Determine the Change in Pollutant Load based on the pollutant loading rates found in the Chesapeake Bay Phase 5.3.2 Community Watershed Model (CBCWM), page 10-7, Table 10-2.

Table A-1. Phosphorus loading analysis using the CBCWM

Proposed Conditions				Existing Conditions				
Land Use	**Area**	**Pollutant Loading Rate**	**Total Pollutant Load**	**Land Use**	**Area**	**Pollutant Loading Rate**	**Total Pollutant Load**	**Change In Pollutant Load**
Forested[1]	5.08 ac	0.13 lb/ac-yr	0.66 lb/yr	Forested[1]	4.98 ac	0.13 lb/ac-yr	0.65 lb/yr	
---	---	---	---	Impervious[3]	0.1 ac	2.49 lb/ac-yr	0.25 lb/yr	
Subtotal	**5.08 ac**		**0.66 lb/yr**		**5.08 ac**		**0.90 lb/yr**	**(0.24) lb/yr**
Turf[2]	0.21 ac	0.89 lb/ac-yr	0.19 lb/yr	Forested[1]	0.21 ac	0.13 lb/ac-yr	0.03 lb/yr	0.16 lb/yr
Impervious[3]	0.87 ac	2.49 lb/ac-yr	2.17 lb/yr	Forested[1]	0.87 ac	0.13 lb/ac-yr	0.11 lb/yr	2.06 lb/yr
Totals	**6.16 ac**		**3.02 lb/yr**		**6.16 ac**		**1.04 lb/yr**	**1.98 lb/yr**
[1] Pollutant loading rate from Chesapeake Bay Phase 5.3 Community Watershed Model, Page 10-7, Table 10-2, "Forest, woodlots, and wooded".								
[2] Pollutant loading rate from Chesapeake Bay Phase 5.3 Community Watershed Model, Page 10-7, Table 10-2, "high intensity pervious urban".								
[3] Pollutant loading rate from Chesapeake Bay Phase 5.3 Community Watershed Model, Page 10-7, Table 10-2, "high intensity impervious urban".								

Step 2: Use the Buffer Equivalency Calculation[1] to determine the effect of the buffer encroachment (i.e. proposed cemetery infrastructure) on the reduction of total phosphorus.

Determine pollutant load (L) generated by the buffer (pre-development):

L = 0.000047 (lb/in-ft) x annual rainfall (in) x lot width (ft)
L = 0.000047 lb/in-ft x 40 in x 3,125 ft[2]
L = 5.88 lb

Determine the maximum load (R_{MAX}) capable of being removed by the full buffer:

R_{MAX} = L x 0.4
R_{MAX} = 5.88 x 0.4
R_{MAX} = 2.35 lb

Determine the actual load (R_{ACT}) removed by the remaining buffer (in this case 20' encroachment):

R_{ACT} = L x EFF
R_{ACT} = 5.88 x .35
R_{ACT} = 2.06 lb

[1] Chesapeake Bay Local Assistance Department. "Information Bulletin #3: Draft Buffer Equivalency". March 1991.
[2] Computed as a baseline length along the stream channel and multiplied by 2 (buffer exists on each side).

Where,

EFF = Removal efficiency of the remaining buffer

Determine the net effect on the load (RR) by the proposed buffer encroachment:

$RR = R_{MAX} - R_{ACT}$
RR = 2.35 lb - 2.06 lb
RR = 0.29 lb

Step 3: Determine the total change in pollutant load (TL) from the proposed project.

TL = Change in Pollutant Load (From Step 1,Table A-1) + RR (From Step 2)
TL = 1.98 lb/yr + 0.29 lb/yr
TL = 2.27 lb/yr

Step 4: Determine total phosphorus load reduction ($TP_{REMOVED}$) the pollutant load reduction rates for stream restoration from CSN 2011.

Table A-2. Pollutant Removal From Proposed Stream Restoration

Parameter	Quantity	TSS Load Reduction (by Volume)*
Stream Rest. Length (ft)	1,554	---
TN (lb/yr)	311	---
TP (lb/yr)	106	---
TSS (lb/yr)	481,740	198 (cy/yr)
*Based on an assumed soil density of 90 lb/cf		

Step 5: Determine net effect of the proposed project on the total phosphorus load (NP).

$NP = TL - TP_{REMOVED}$
NP = 2.27 lb/yr - 105.67 lb/yr
NP = (103.40) lb/yr