Government Working Group #1 Handout

Chickahominy River and Tributaries – Implementation Plan Development

Henrico, Hanover, New Kent, Charles City Counties and City of Richmond, VA

Our Task

Include all governmental agencies in order to develop a plan to install Best Management Plans (BMPs) that will reduce bacteria from entering the impaired water bodies.

Primary Roles of Government Working Group

- Assist in determining cost for each BMP
- Identify economic incentives/hardships with each BMP
- Identify technical and financial resources to carry out implementation plan
- Report findings to Steering Committee

Goals of Meeting

- Review the pollutant reductions that the implementation plan must meet (Table 2b).
- Discuss preliminary estimates of implementation measures that will result in reductions in Agricultural and residential bacterial loads.
- Document existing efforts underway to address bacteria in Agricultural and Residential areas of the watersheds (Table 3 for Ag – need existing Residential BMPs).
- Identify additional/alternative measures or BMPs to reduce the bacteria load that the implementation plan can address.

Discussion

- What constraints to implementation exist?
    - Availability of contractors that would install the BMPs
    - Workload of technical staff within agencies
    - Financial/cultural constraints of stakeholders
    - Discuss informal homework assignment "constraints/solutions"
- Are there local ordinances already in place? – dog waste, residential sewage, enforcement of E&S, & Chesapeake Bay Act
- What are the educational needs?
- What alternative funding sources are available?
- How can we get residents interested in the project? By what "vehicle" should we convey our message?
- Is there anyone missing from this group who should be included?

Total Maximum Daily Load (TMDL) Study Results

Segments on the Chickahominy River, Collins Run, Beaverdam Creek, Boatswain Creek, and Stony Creek do not meet water quality standards (WQS)for bacteria. These standards are designed to identify waters that are not suitable for “primary contact recreation” (swimming) because of the risk of illness. The TMDL study identified the sources of bacteria and how much each source category needs to be reduced to restore water quality. A watershed approach was followed during allocation in determining the needed reductions in bacteria loads to streams in order to meet the water quality standards. In the watershed approach, the same percentage reduction is applied throughout the entire watershed and the resulting improvement in simulated water quality conditions is assessed at all impaired subwatershed outlets. Additional reductions to sources are modeled until simulated water quality conditions meet the standard at all impaired subwatersheds. Simulated water quality conditions were compared to WQS at 11 locations including impaired subwatersheds, previously developed TMDLs, and outlet of entire study area (Table 1). The subwatershed map is shown in the "Maps" section at the end of the document. The area of interest in this IP is the entire drainage area of the **non-tidal** Chickahominy River.

The implementation plan will outline a staged approach to meet the reductions to human, pet, and agricultural sources determined in the TMDL study. Wildlife is considered a background condition and reductions to wildlife bacteria loads are not explicitly addressed in the TMDL implementation plan.

Table 1. Description of locations where allocation was conducted within the Chickahominy River watershed.

Subwatershed	Impairment
18	Collins Run Impairment
19	Collins Run Impairment
25	Beaverdam Creek Impairment
24	Boatswain Creek Impairment
9	Chickahominy River Impairment, Outlet of NTU 103
10	Chickahominy River Impairment
11	Chickahominy River Impairment
1	Main outlet of entire study area, Outlet of NTU 90.1
27	Stony Run Impairment
26	Upham Brook TMDL
22	White Oak Swamp TMDL

Table 2a lists the needed reductions and expected improvement in water quality for several scenarios including the final allocation scenario. A description of scenarios follows:

Scenario 0	a baseline scenario that corresponds to the existing conditions in the watershed.
Scenario 1	reflects the impact of eliminating sanitary sewer overflows (SSOs)
Scenario 2	explores the impact of eliminating all straight pipes
Scenario 3	explores the impact of fencing out all cattle
Scenario 4	shows the impact of reducing load from developed lands by 50%
Scenario 5	shows the impact of reducing load from agricultural lands by 50%
Scenario 6	contribution from land-based dominated by anthropogenic sources was almost entirely eliminated
Scenario 7	impact of reducing loads from direct deposition by wildlife and lands dominated by wildlife sources
Scenario 8	**impact of reducing loads from direct deposition by wildlife and lands dominated by wildlife sources**
Scenario 9	As per request of DCR, bacteria loading from all anthropogenic sources is eliminated while not applying any reductions to SSOs.

Bolded is Final TMDL Scenario

Table 2b. Allocation scenarios for reducing current bacteria in the Chickahominy River watershed.

Scenario	Wildlife Direct	Forest, Wetlands, Barren[1], Comm.	Livestock Direct	Cropland, Pasture, LAX[2]	SSOs[3]	Straight Pipes	Developed	sub27 (%)	Sub26 (%)	Sub25 (%)	Sub24 (%)	Sub22 (%)	Sub19 (%)	Sub18 (%)	Sub11 (%)	Sub10 (%)	Sub9 (%)	Sub1 (%)
0	0	0	0	0	0	0	0	30.73%	19.69%	51.54%	6.49%	32.05%	4.19%	3.35%	6.91%	8.38%	4.54%	0.42%
1	0	0	0	0	100	0	0	29.05%	14.25%	29.54%	6.49%	29.12%	4.19%	3.35%	3.35%	3.84%	1.19%	0.14%
2	0	0	0	0	100	100	0	6.91%	1.40%	1.75%	6.49%	9.08%	4.19%	3.35%	0.56%	0.49%	0.00%	0.00%
3	0	0	100	0	100	100	0	6.56%	1.40%	1.47%	5.94%	8.24%	3.98%	2.86%	0.49%	0.21%	0.00%	0.00%
4	0	0	100	0	100	100	50	5.31%	1.12%	0.98%	4.61%	7.54%	2.44%	2.03%	0.00%	0.00%	0.00%	0.00%
5	0	0	100	50	100	100	50	5.31%	1.12%	0.98%	4.61%	7.54%	2.44%	2.03%	0.00%	0.00%	0.00%	0.00%
6	0	0	100	99	100	100	99	3.70%	0.00%	0.00%	3.35%	6.35%	0.21%	0.35%	0.00%	0.00%	0.00%	0.00%
7	50	50	100	99	100	100	99	0.00%	0.00%	0.00%	2.09%	0.91%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
8[4]	77	77	100	99	100	100	99	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
9	0	0	100	99	0	100	99	4.05%	0.35%	1.96%	3.35%	8.03%	0.21%	0.35%	0.00%	0.00%	0.00%	0.00%

[1]Barren - Areas of bedrock, strip mines, gravel pits, and other accumulations of earthen material. Generally, vegetation accounts for less than 15% of total cover.
[2]LAX - livestock pasture access near flowing streams.
[3]SSOs – Sanitary Sewer Overflows
[4]Final TMDL Scenario

Accounting for BMPs Installed

It is recognized that the SWCDs/NRCS have been working in the watershed to establish Best Management Practices (BMPs) that are both cost-effective and beneficial to the farmer and the environment. Table 3 was created from the DCR Ag BMP database website (http://dswcapps.dcr.virginia.gov/htdocs/progs/BMP_query.aspx). These BMPs are helpful in removal/prevention of bacterial contamination. Costs listed in Table 3 are obtained by averaging costs per practice from the DCR database. Watershed-wide streamside fencing values were accounted for in Table 4.

Table 3. BMPs Already Installed.

BMP name	BMP Code	Units	# Units Installed	Average Acres Benefited	Average System Cost $
Animal waste control facilities	WP-4	system	1		18,516
Continuous No-Till System	SL-15A	acre	2283	23	2,260
Grass filter strips	WQ-1	acre	20	1	307
Long Term Continuous No-Till Planting System	CCI-CNT	Acre	3241	54	1,350
Permanent Vegetative Cover on Cropland	SL-1	Acre	268	11	1,838
Protective cover for specialty crops	SL-8	Acre	320	13	281
Reforestation of erodible crop and pastureland	FR-1	Acre	2	2	403
Sediment retention, erosion or water control structures	WP-1	System	1	14	23,895

Animal waste control facilities: A planned system designed to manage liquid and/or solid waste from areas where livestock and poultry are concentrated. This practice is designed to provide facilities for the storage and handling of livestock and poultry waste and the control of surface runoff water to permit the recycling of animal waste onto the land in a way that will abate pollution that would otherwise result from existing livestock or poultry operations.
Continuous No-Till System: This practice will implement continuous no-till systems and nutrient management technologies resulting in the reduction of non-point source pollution to state waters from nutrients and sediments. It will also increase biomass/soil quality and recognize nutrient management indicators and manage the movement of nitrogen, phosphorus, sediments and runoff with the use of no-till planting.
Grass filter strips: Grass filter strips are vegetative buffers that are located along the banks of water courses to filter runoff, anchor soil particles, and protect banks against scour and erosion.

Long Term Continuous No-Till Planting System: This practice will implement a continuous no-till system and nutrient management planning technologies that result in the reduction of non-point source pollution to state waters from nutrients and sediments. To increase biomass/soil quality and manage the residue to reduce the movement of nitrogen, phosphorus, sediments and runoff with the use of no-till planting systems.
Permanent Vegetative Cover on Cropland: Grass and/or legume vegetation will be established on cropland with existing cover of less than 60% converting it to pasture or hay land to reduce soil erosion and enhance water quality.
Protective cover for specialty crops: This practice will provide an incentive to keep a cover on cropland when it is not being used after harvest of a specialty crop cost-share and tax credit are provided to establish vegetative cover on specialty cropland.
Reforestation of erodible crop and pastureland: This practice will plant trees (hardwoods and/or conifers) on land currently used as cropland or pastureland in order to make a permanent land use conversion to forest.
Sediment retention, erosion or water control structures: This practice will promote structures that will collect and store debris or control the grade of drainage ways.

Streamside Fencing for Cattle

In order to reduce direct bacteria from livestock, some form of livestock stream exclusion is necessary. Streamside fencing eliminates direct livestock bacteria loads, prevents livestock from eroding the stream bank, provides a buffer for capturing pollutants in runoff from pasture, and establishes (with the growth of streamside vegetation) one of the foundations for clean water. The inclusion of a buffer helps to reduce bacteria, as well as other possible pollutants, in runoff. The incorporation of effective buffers could reduce the need for more costly control measures.

To estimate fencing requirements, the stream network was overlaid with land use. Stream segments that flowed through or adjacent to pasture were identified. If the stream segment flowed through the land-use area, it was assumed that fencing was required on both sides of the stream, while if a stream segment flowed adjacent to the pasture area; it was assumed that fencing was required on only one side of the stream. Not every land-use area identified as pasture has livestock on it at any given point in time. However, it is assumed that all pasture areas have the potential for livestock access. This may result in fencing needs estimated in an area that does not have cattle on it. Two options are given here in terms of the class of streams that need fencing. In Option 1, only named streams were used while in option 2, all streams were used including intermittent streams.

Types:

- The SL-6 and LE-1T systems include streamside fencing, interior fencing, alternative watering system, and require a 35-ft buffer from the stream. The SL-6 practice offers a cost-share up to 75%, whereas the LE-1T practice offers a maximum of 85%.
- The LE-2T system is similar to the LE-1T, except that it only requires a 10-ft buffer and offers a maximum of 50% cost-share.
- The WP-2T system includes streamside fencing, hardened access/crossing options, requires a 35-ft buffer, and offers a 75% cost-share. In cases where a watering system already exists, a WP-2T system is a more appropriate choice.
- 7% of the total fencing needed was calculated as fence maintenance needed during the project.

- **Table 4. Total watershed Estimated Stream Fencing Installed and Needed.**

Option	Estimated Fence Length Needed (ft)	Cost-Share Fence installed (ft)	Total Fence Length Needed (ft)	Fence Maintenance (7% annually) (ft)	Streamside Fencing Systems Needed (LE-1T, LE-2T, SL-6 or WP-2T)
Option (1): Using named perennial streams	**55,497**	**3,235**	**52,262**	**3,658**	**62**
Option (2): Using all streams, perennial and intermittent	**238,021**	**3,235**	**234,786**	**16,435**	**276**

Table 5. Subwatershed-level estimated needed fencing length (ft).

Sub-watershed	Needed fencing length Option (1) (ft)	Needed fencing length Option (2) (ft)	Dairy Repla-cements	Horse	Sheep	Hog	Beef	Beef Calves
1	374	7,309	0	63	0	0	15	22
2		1,980	0	26	0	0	6	8
3		620	0	0	0	0	0	1
4		304	0	0	0	0	1	2
5	315	3,067	0	36	0	0	12	19
6	1,858	14,587	0	124	0	0	33	47
7		5,818	0	110	5	0	24	25
8	188	5,021	0	101	7	0	43	32
9		2,308	0	30	0	0	6	5
10	791	12,897	0	164	6	0	71	52
11		278	0	8	0	0	3	3
12	258	5,021	0	35	1	0	17	15
13		4,243	0	22	2	0	6	4
14	2,572	6,888	0	63	5	0	30	23
15	1,153	6,681	0	54	4	0	23	18
16	15,307	57,836	0	236	9	0	76	56
17	229	229	0	0	0	4,440	0	0
18	135	135	0	0	0	0	1	1
19		477	0	0	0	0	2	3
20			0	0	0	0	1	1
21	3,450	7,798	0	82	0	0	19	25
22	1,523	20,551	0	231	19	0	49	39
23	211	6,951	0	48	0	0	10	8
24		261	0	24	2	0	4	3
25	4,538	11,264	0	116	9	0	19	14
26	15,545	29,894	0	141	0	0	29	28
27	7,050	25,603	30	147	11	0	24	18
Total	**55,497**	**238,021**	**30**	**1,861**	**80**	**4,440**	**524**	**472**

To relate the area of interest, subwatersheds in the current project have been broken down to the 14-digit HUC. A correlation table is given with the proposed length of stream fencing by the 14-digit HU abbreviation and the project's subwatershed map division number (Table 6).

Table 6. Stream fencing needed by hydrologic unit.

14-Digit HU	Chickahominy Subs	Needed fencing length Option (1) (ft)	Needed fencing length Option (2) (ft)
JL16	16	15,307	57,836
JL17	13-14-15-27	10,775	43,415
JL18	26	15,545	29,894
JL19	9-10-11-12-24-25- upper part 8	5,775	37,050
JL20	7-23-lower part 8	211	12,769
JL21	22	1,523	20,551
JL22	6	1,858	14,587
JL23	2-3-4-5-21	3,765	13,769
JL24	1-17-18-19-20	738	8,150
Total		**55,497**	**238,021**

Questions for the group:

- Which fencing option is more realistic? Option 1 with fencing only named streams or option 2 which calls for fencing all streams including intermittent streams?
- What is the breakdown of exclusion systems that are expected for each: SL-6, LE-1T, LE-2T or WP-2T?

Agricultural BMPs Needed

Through modeling (Table 2b), it was concluded that fencing out livestock will not be enough to meet the water quality standard at all impaired segments. In order to meet the water quality standards, additional BMPs are needed that treat or prevent bacteria from traveling to surface waters. Table 7 shows the estimated needs of agricultural BMPs in the watershed.

agricultural BMPs in the watershed.

Table 7. Estimated Agricultural land-based BMPs Needed.

Control Measure	Unit	Units Needed	Cost per Unit ($)	Source of Cost estimate
Conservation Tillage - Cropland	acre	210	$100	James River/Richmond IP
Retention Ponds - Cropland	acre	3,000	$200	Previous IPs (low?)
Vegetated Buffer - Cropland	acre	3.4*	$360	James River/Richmond IP
Composting for 20 Dairy Replacements	Systems	2	$3,000	James River/Richmond IP
Composting - for waste of 1050 horses*	Systems	?*	$3,000	James River/Richmond IP
Improved Pasture Management	acre	12,552	$150	James River/Richmond IP
Retention Ponds - pasture	Acre - treated	20,110	$200	Previous IPs (low?)
Stream Exclusion With Grazing Land Management	systems	62 (or 276)	$7,800	DCR database average
Fence Maintenance	Foot/year	3,658	$3.5	James River/Richmond IP

* any help in determining how many horses we should assume per facility to help identify the number of units needed since we estimated the total number of horses for which waste should be composted?

Questions for the group:

- Cost estimate for exclusion system may seem low but this is the estimate from the DCR database by averaging the cost per system. Other IPs have used number much higher than this figure and around $25,000 per system. Which should we use considering an average length per system of 840 ft?
- Are the cost estimates in Table 7 valid for this watershed?
- Any other suggested measures?

Residential BMPs Needed

In order to meet the water quality standards, residential BMPs are needed in residential areas that treat or prevent bacteria from traveling to surface waters (Table 8). Some of the measures deal with addressing failing septic systems and straight pipes while other measures deal with other sources of bacteria within residential areas. Bacteria accumulated on the ground surface from human, pet, and wildlife sources travels with runoff through backyards to nearby streams and water bodies. Therefore, reducing runoff from backyards through rain gardens and rain barrels reduces the amount of bacteria transported to streams.

Table 8. Estimated Residential land-based BMPs Needed.

Control Measure	Unit	Units Needed	Cost per Unit ($)	Source of Cost estimate
Straight Pipe Corrections:		**35**		
Sewer Connection	system	25	$6,000	James River/Richmond IP
Alternative Waste Treatment System Installation (RB-5)	system	2	$20,000	James River/Richmond IP
Septic System Installation/Replacement (RB-4)	system	8	$8,000	James River/Richmond IP
Failing Septic Systems Corrections:		**387**		
Septic System Installation/Replacement (RB-4)	system	57	$8,000	James River/Richmond IP
Septic System Repair (RB-3)	system	100	$3,500	James River/Richmond IP
Sewer Connection	system	230	$6,000	James River/Richmond IP
Bioretention	Acre-treated	200	$19,000	James River/Richmond IP
Rain Garden	Acre-treated	1,000	$19,000	James River/Richmond IP
Vegetated Buffer	acre	1.4	$360	James River/Richmond IP
Retention Ponds	Acre-treated	10,000	$200	Previous IPs (low?)
Pet Waste Composter	#	10,000	$50	James River/Richmond IP
Pet Litter Control Program	program	1	$15000	
Baggy, Sign and Waste Basket Station	Station	30	$170	James River/Richmond IP
Bag Refills	Each	300,000	$0.10	James River/Richmond IP
Mailings (to each household)	Each	102,145	$0.36	James River/Richmond IP
Overflow correction	program	1	?	

To better illustrate the locations of needed BMPs related to home-owners, a breakdown is given in Table 9 for straight pipes and failing septic systems by subwatershed.

Table 9. Home owners' related potential BMPs by subwatershed (columns 6 and 7).

Sub-watershed	Human Population	Housing Units	Homes with Sewer	Homes with Septic	Estimated Homes with Failing Septic System	Estimated Homes with Straight Pipes
1	696	333	6	326	11	1
2	181	73	1	72	2	0
3	108	45	0	45	1	0
4	254	100	0	100	3	0
5	1,192	471	0	469	16	2
6	4,522	1,823	27	1,794	60	2
7	2,770	1,133	21	1,111	37	1
8	1,502	618	225	393	13	0
9	3,356	1,523	1,428	95	3	0
10	13,995	5,502	4,592	909	30	1
11	5,820	2,211	2,169	42	1	0
12	12,658	5,656	5,592	63	2	1
13	4,839	1,833	1,689	144	5	0
14	12,135	5,306	5,051	254	8	1
15	1,525	670	255	413	14	2
16	34,755	13,285	12,095	1,187	40	3
17	2	1	0	1	0	0
18	14	6	0	6	0	0
19	315	152	0	152	5	0
20	75	28	0	28	1	0
21	596	267	0	267	9	0
22	6,126	2,507	2,330	171	6	6
23	876	434	416	17	1	1
24	307	136	0	136	5	0
25	20,769	8,100	6,930	1,167	39	3
26	101,467	47,745	46,398	1,341	45	6
27	5,296	2,187	1,295	887	30	5
Total	**236,151**	**102,145**	**90,520**	**11,590**	**387**	**35**

Questions for the group:

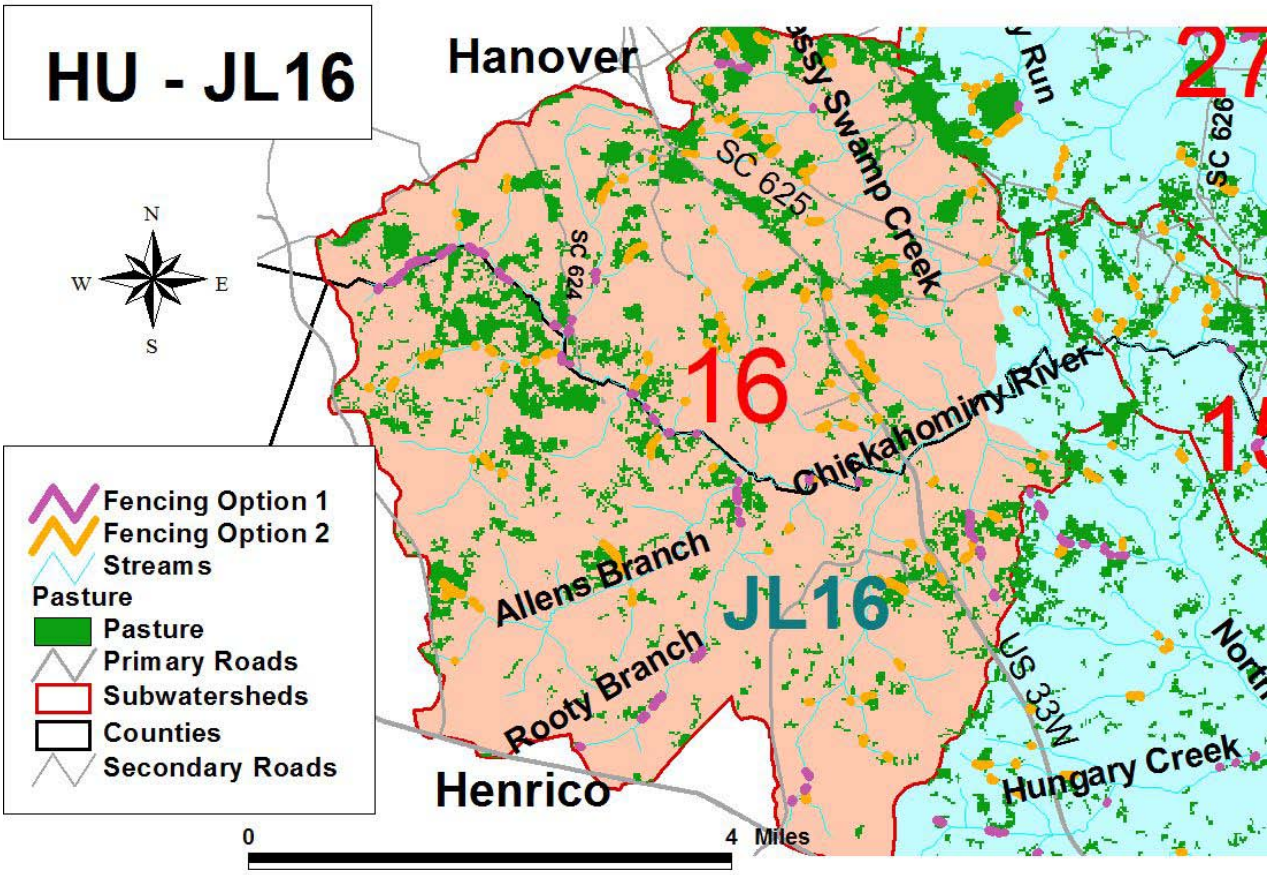
- Are the cost estimates in Table 8 valid for this watershed?
- Where do we start with the issue of sanitary sewer overflow correction? Potential cost? Time line?
- Any other suggested measures?

Steering Committee Representation

So far, we have the following volunteer(s): (Mr. Houston) houston4@comcast.net; (Sharon Conner – Hanover SWCD) slconner@hanovercounty.gov; mark.alling@deq.virginia.gov; ram.gupta@dcr.virginia.gov; Megan.Sommers@dcr.virginia.gov; (**James. Beckley** - citizen) James.Beckley@deq.virginia.gov; Margaret.smigo@deq.virginia.gov; (Major Mansfield) jeanandmajor@aol.com; (**Jody Bryan**) jmb823@gmail.com; (**Olivia Hall**) hal57@co.henrico.va.us. The name in bold are folks who volunteered for the Gov't WG and then also volunteered to be on the steering committee. Please provide your telephone # on the sign-in sheet and check your email above.

Maps – 9 maps exist in this section corresponding to the hydrologic units explained in Table 6 above.

Option 2 fencing on maps shows fencing needs beyond option 1.


HU - JL16
Hanover
Henrico
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Fencing Option 1
Fencing Option 2
Streams
Pasture
Pasture
Primary Roads
Subwatersheds
Counties
Secondary Roads
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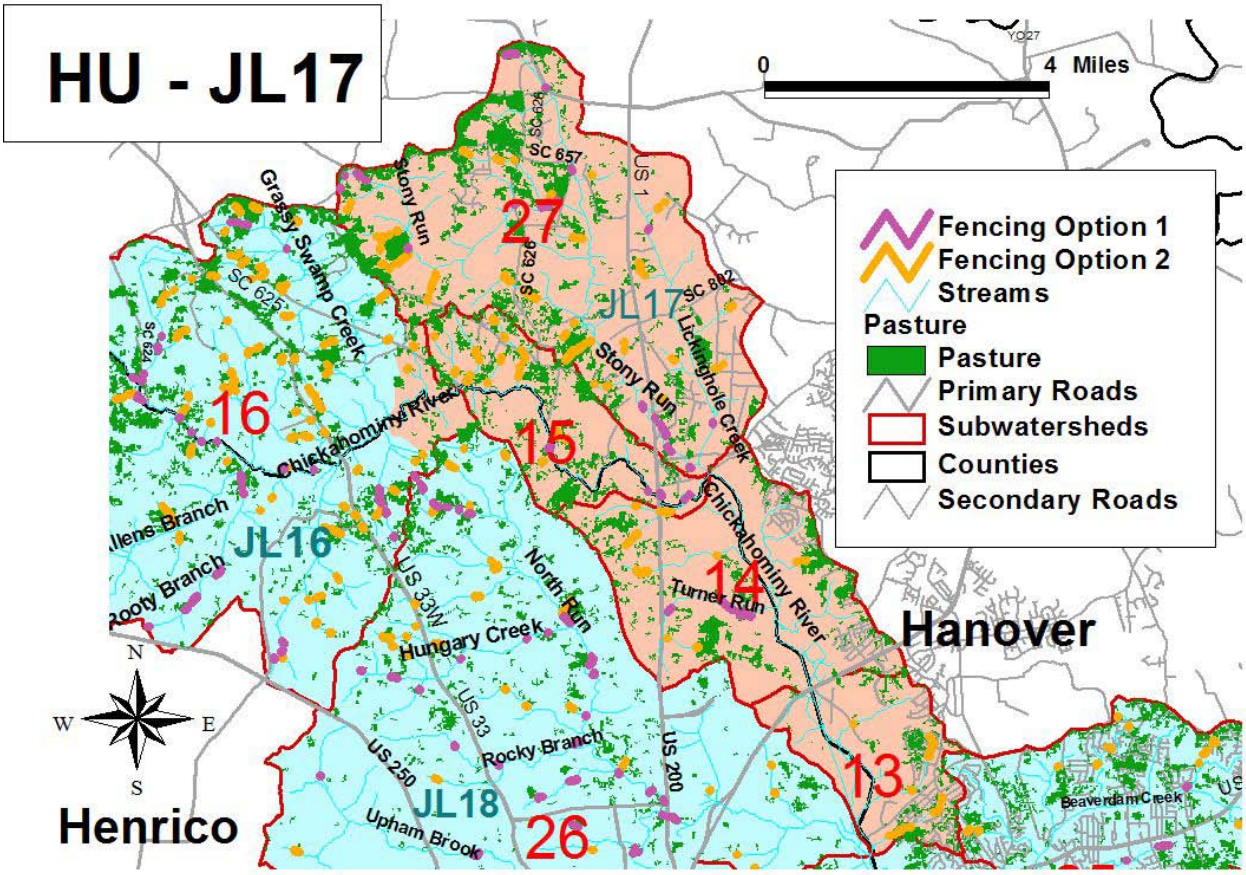
4 Miles
16
JL16
27
Grassy Swamp Creek
SC 625
SC 624
SC 626
Chickahominy River
Allens Branch
Rooty Branch
US 33W
Hungary Creek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4 Miles
Fencing Option 1
Fencing Option 2
Streams
Pasture
Pasture
Primary Roads
Subwatersheds
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Henrico
Hanover
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16
15
14
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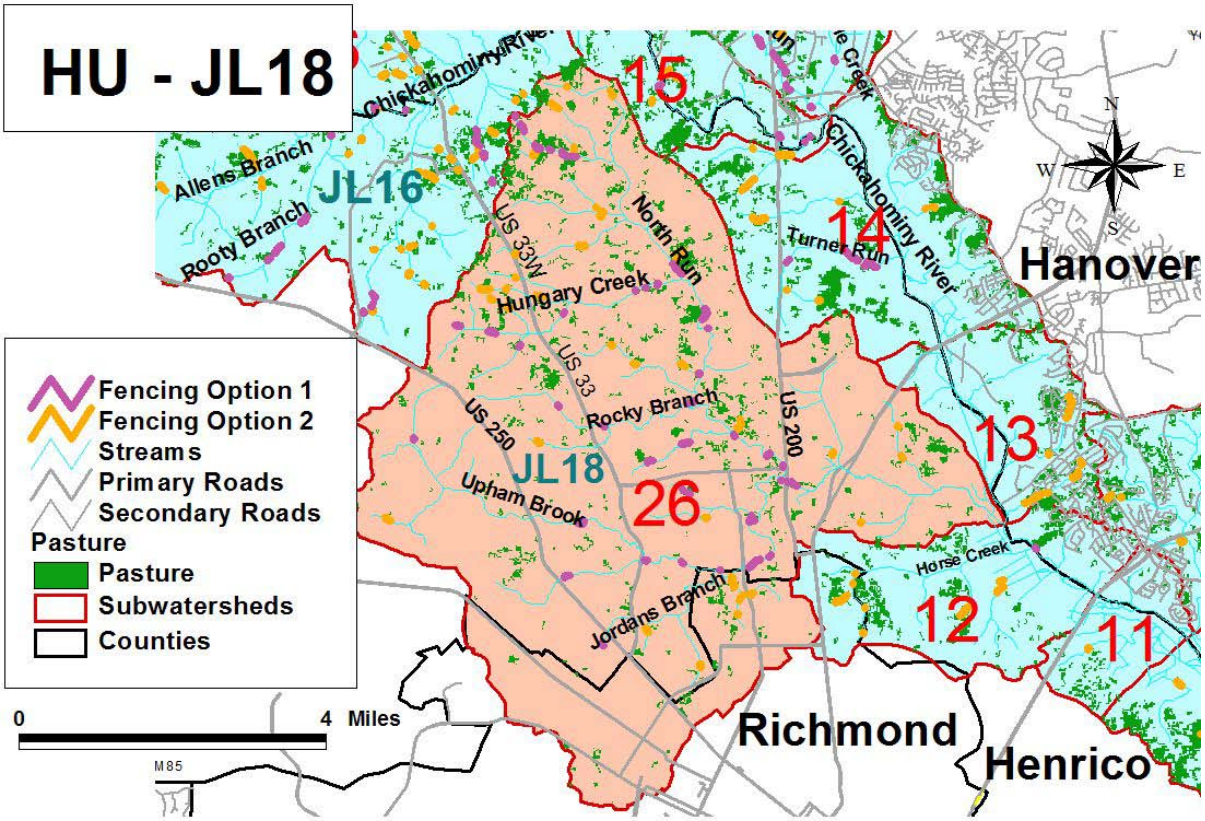
26
JL17
JL16
JL18
Grassy Swamp Creek
SC 625
SC 624
SC 626
SC 628
SC 657
SC 882
Stony Run
Lickinghole Creek
Chickahominy River
Allens Branch
Rooty Branch
US 33W
Hungary Creek
North Run
Turner Run
US 33
Rocky Branch
US 250
US 200
Upham Brook
Beaverdam Creek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Chickahominy River
15
Allens Branch
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Rooty Branch
US 33W
North Run
Hungary Creek
Turner Run
14
Chickahominy River
Hanover
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US 33
Rocky Branch
US 250
JL18
Upham Brook
26
US 200
13
Horse Creek
12
11
Jordans Branch
Richmond
Henrico
M85
Fencing Option 1
Fencing Option 2
Streams
Primary Roads
Secondary Roads
Pasture
Pasture
Subwatersheds
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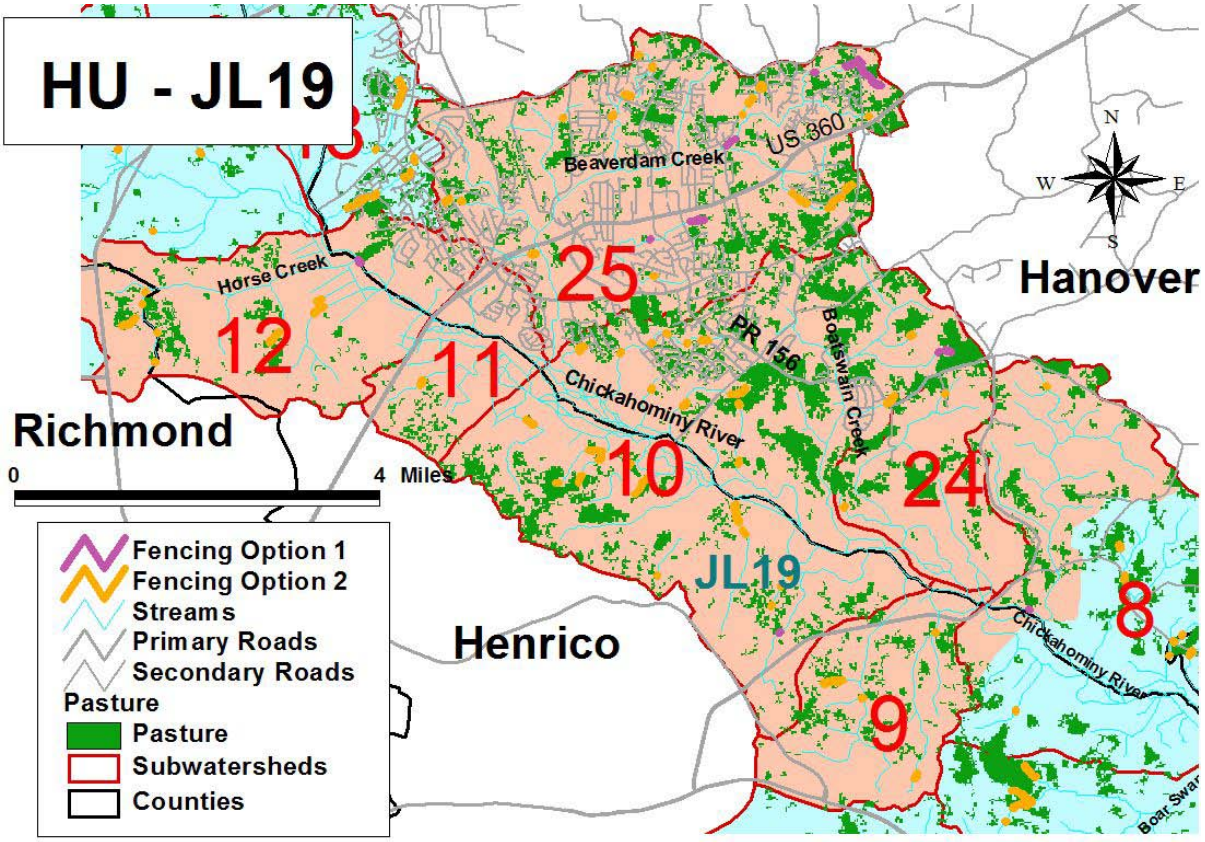
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Beaverdam Creek
US 360
N
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Hanover
Horse Creek
25
12
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PR 156
Boatswain Creek
Chickahominy River
Richmond
10
24
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4 Miles
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Fencing Option 1
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Streams
Primary Roads
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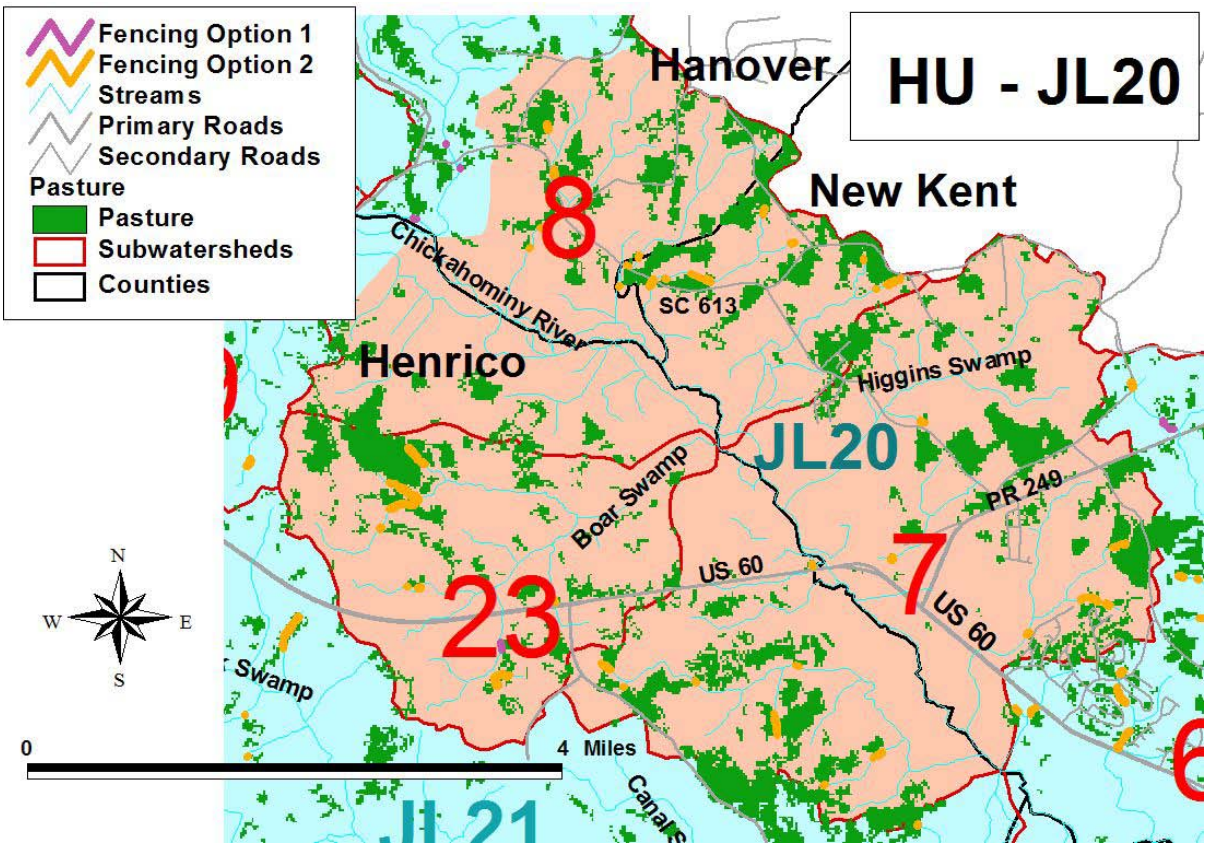
Counties


Fencing Option 1
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Subwatersheds
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New Kent
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Chickahominy River
SC 613
Henrico
Higgins Swamp
JL20
Boar Swamp
PR 249
US 60
7
23
US 60
Swamp
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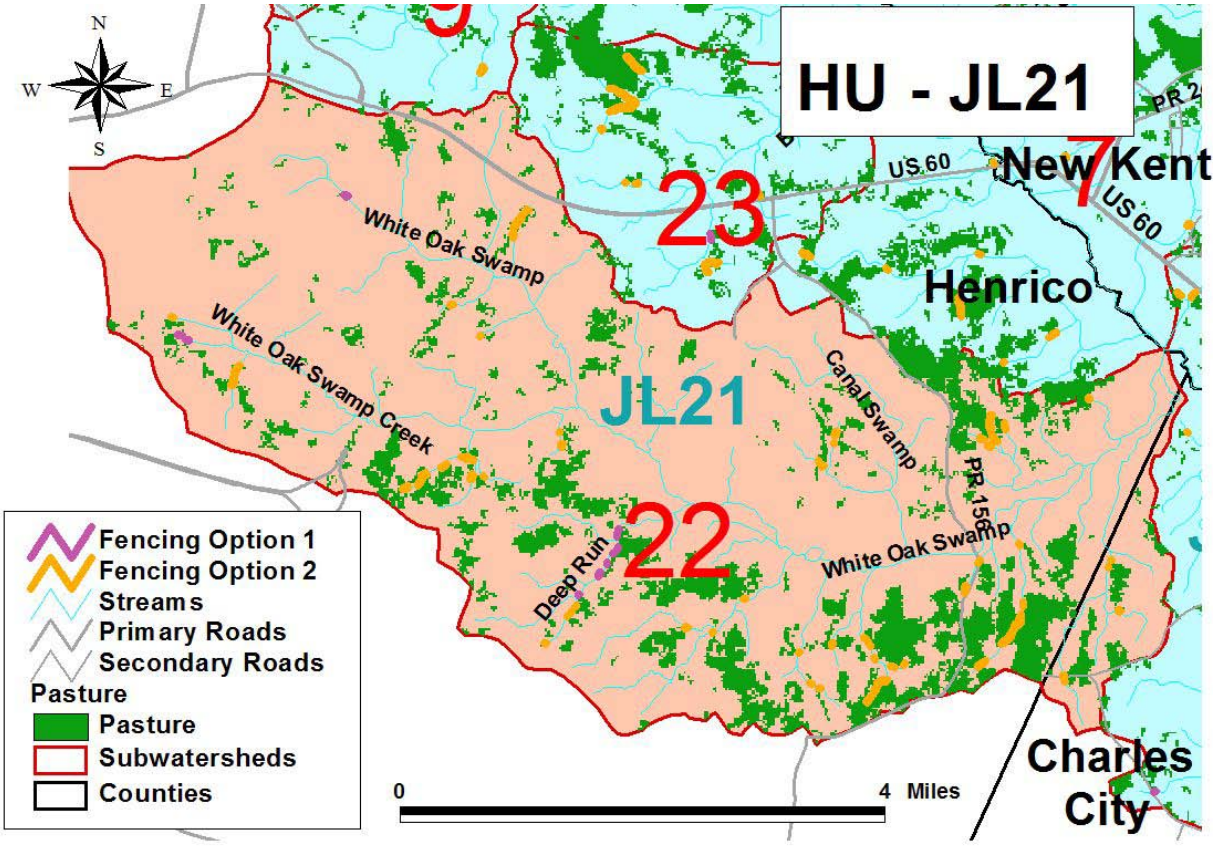
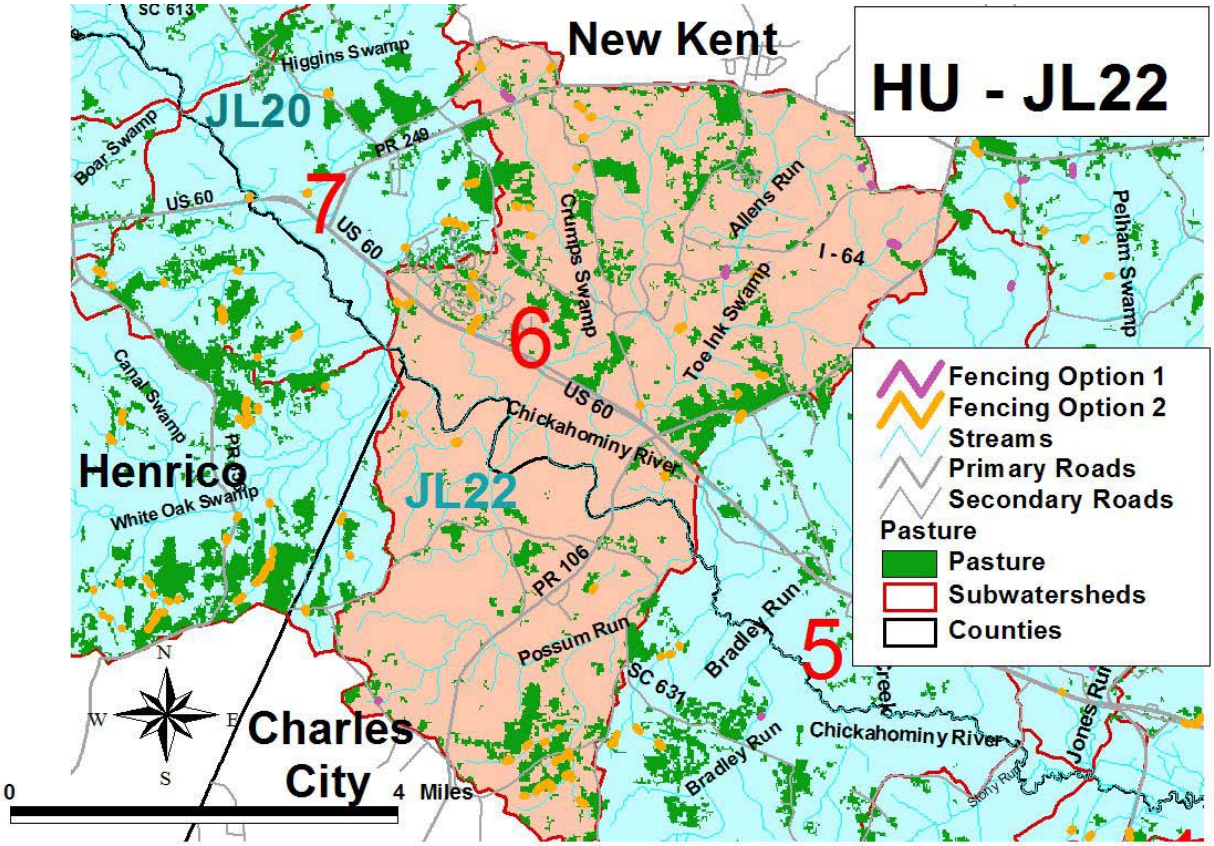
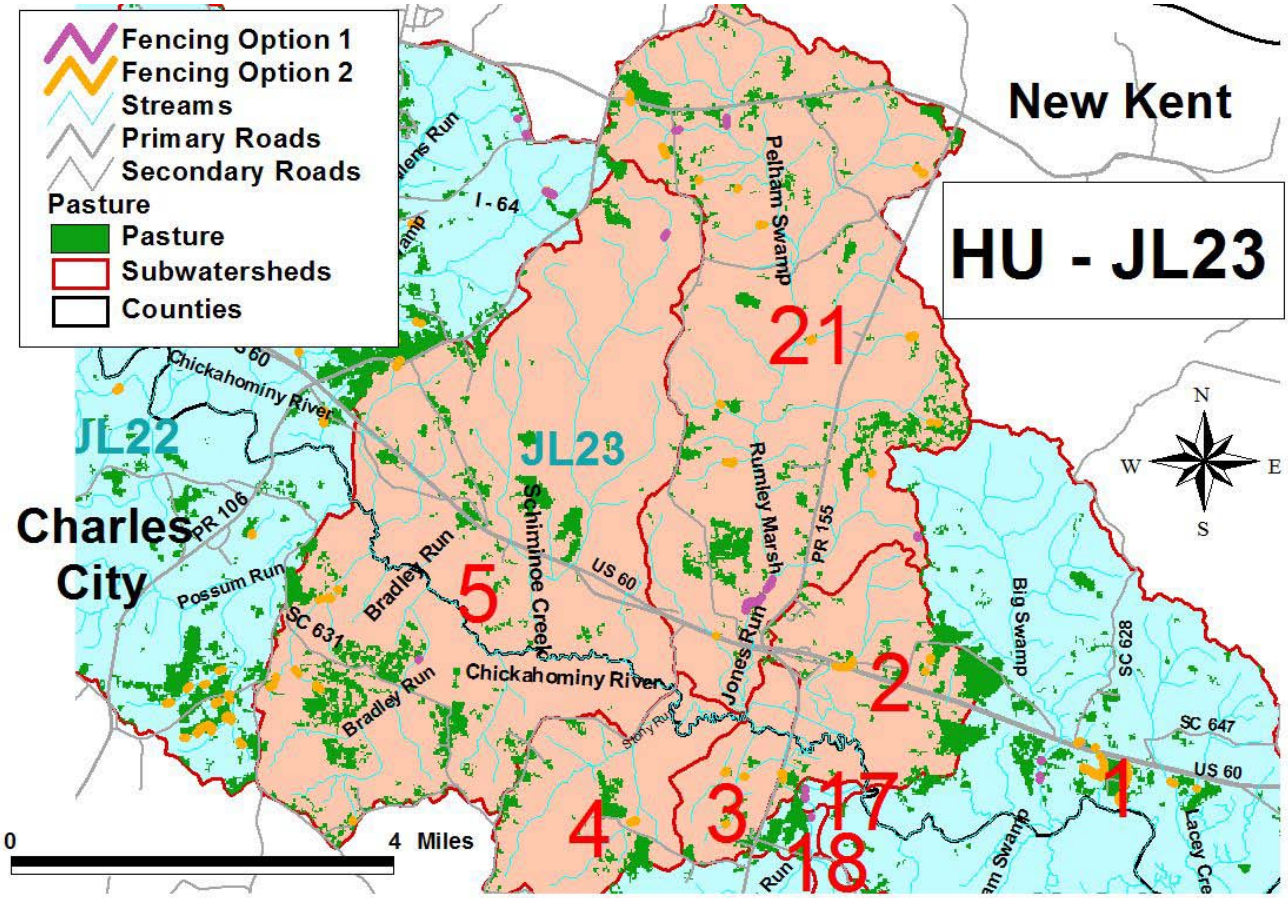
0
4 Miles
Canal S
JL 21


N
W
E
S
HU - JL21
PR 2
US 60
New Kent
7
US 60
23
White Oak Swamp
Henrico
White Oak Swamp Creek
JL21
Canal Swamp
PR 156
22
Deep Run
White Oak Swamp
Fencing Option 1
Fencing Option 2
Streams
Primary Roads
Secondary Roads
Pasture
Pasture
Subwatersheds
Counties
0
4 Miles
Charles City


HU - JL22
New Kent
Henrico
Charles City
JL20
JL22
7
6
5
Higgins Swamp
Boar Swamp
Canal Swamp
White Oak Swamp
Crumps Swamp
Allens Run
Toe Ink Swamp
Pelham Swamp
Chickahominy River
Possum Run
Bradley Run
Jones Run
Stony Run
US 60
PR 249
PR 106
SC 631
I - 64
SC 613
Fencing Option 1
Fencing Option 2
Streams
Primary Roads
Secondary Roads
Pasture
Pasture
Subwatersheds
Counties
0
4 Miles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New Kent
Charles City
JL22
JL23
21
5
2
1
4
3
17
18
Pelham Swamp
Rumley Marsh
Schiminoe Creek
Chickahominy River
Bradley Run
Possum Run
Jones Run
Stony Run
Big Swamp
Lacey Creek
PR 106
PR 155
US 60
SC 631
SC 628
SC 647
I - 64
Fencing Option 1
Fencing Option 2
Streams
Primary Roads
Secondary Roads
Pasture
Pasture
Subwatersheds
Counties
0
4 Miles

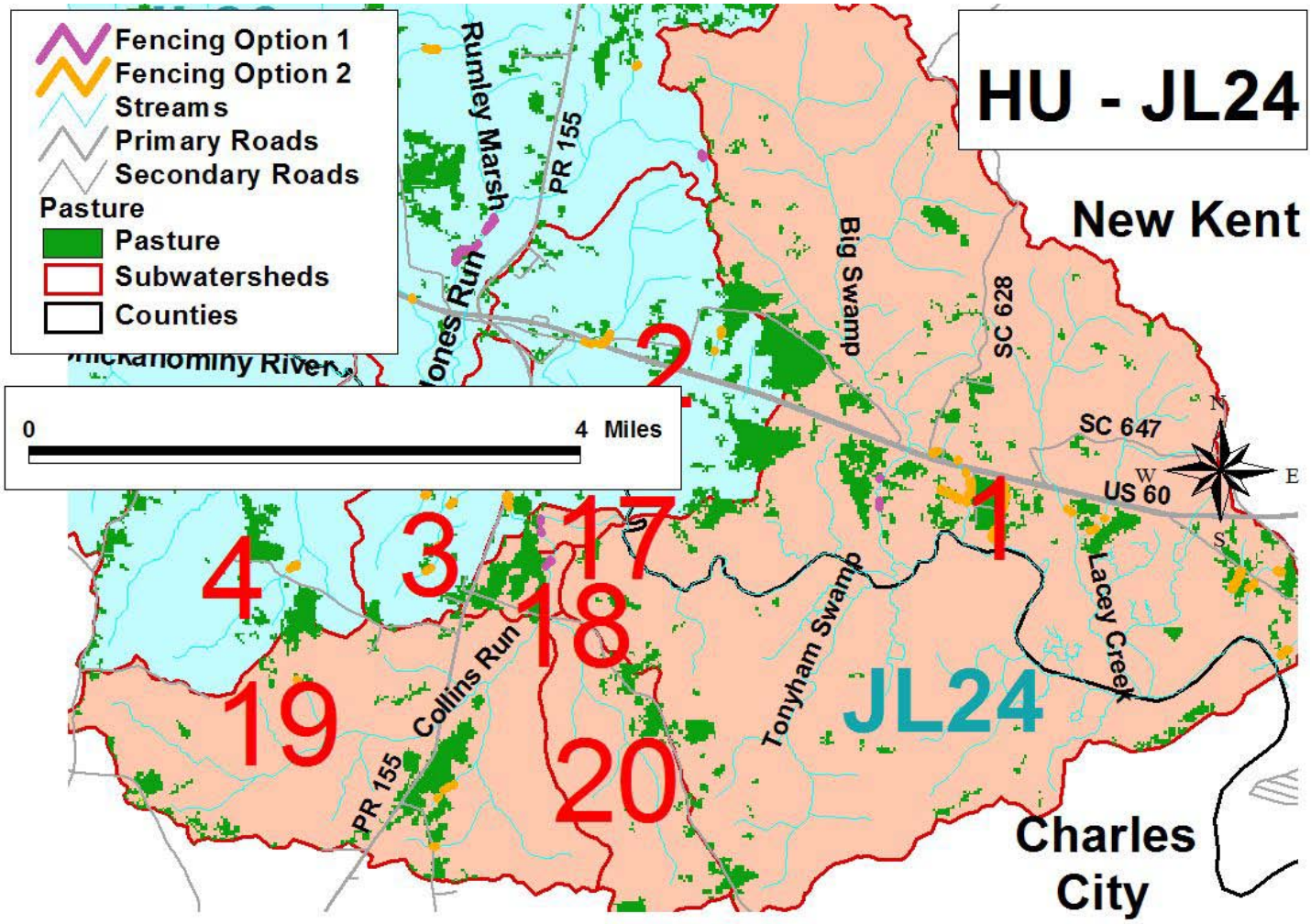
HU - JL24
Fencing Option 1
Fencing Option 2
Streams
Primary Roads
Secondary Roads
Pasture
Pasture
Subwatersheds
Counties
0
4 Miles
New Kent
Charles City
Rumley Marsh
PR 155
Big Swamp
SC 628
SC 647
US 60
Lacey Creek
Tonyham Swamp
Collins Run
PR 155
JL24
1
2
3
4
17
18
19
20

Table 10. Estimated domestic animal populations in areas contributing to impaired segments in the Chickahominy River and Tributaries watershed study area.

Sub-watershed	Dogs	Cats
1	178	199
2	39	44
3	24	27
4	53	60
5	252	282
6	973	1,090
7	605	678
8	330	370
9	813	911
10	2,938	3,290
11	1,181	1,322
12	3,020	3,382
13	979	1,096
14	2,833	3,173
15	358	401
16	7,094	7,944
17	1	1
18	3	4
19	81	91
20	15	17
21	143	160
22	1,339	1,499
23	232	260
24	73	81
25	4,325	4,844
26	25,496	28,552
27	1,168	1,308
Total	**54,546**	**61,086**

Table 11. Volume of sanitary sewer overflows reported within the study area between October 2002 and March 2011.

Subwatershed	Volume (1,000 Gallon)
8	13
9	10,737
10	25
11	108
12	121,164
13	182
14	8
15	2
16	265
22	504
25	2,205
26	8,626
27	154
Total	143,993

Table 12. Application of biosolids within the Chickahominy River study area (2003 – 2010).

Year	Wet Tons (as is)
2003	660
2008	6,223
2009	821
2010	324
Total	8,028