Connecticut

Jordan Cove Urban Watershed
Section 319
National Monitoring Program Project

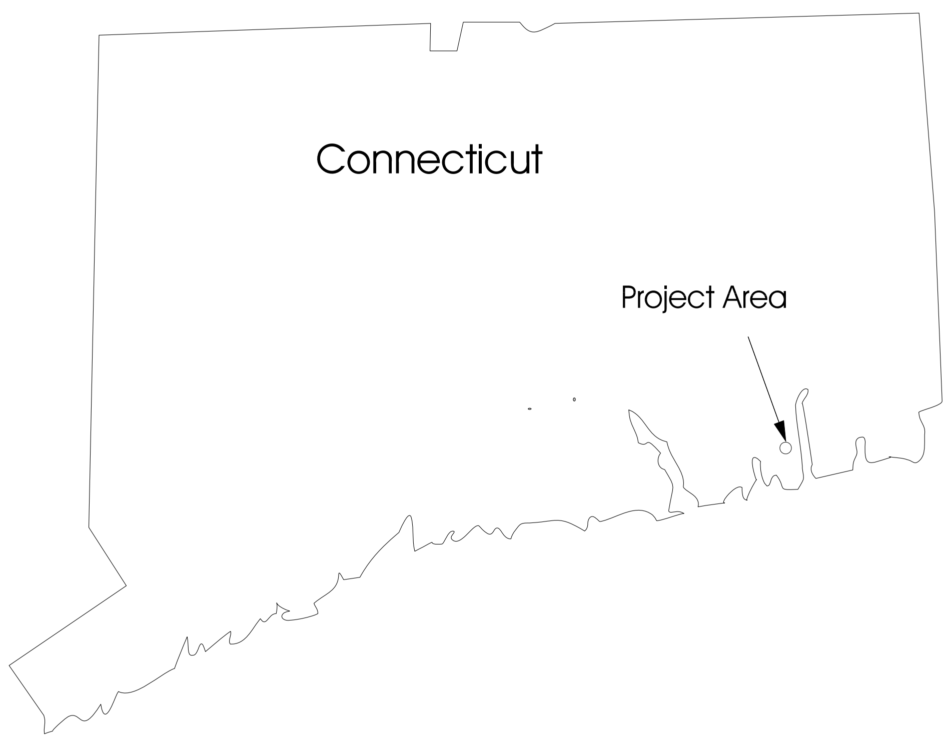
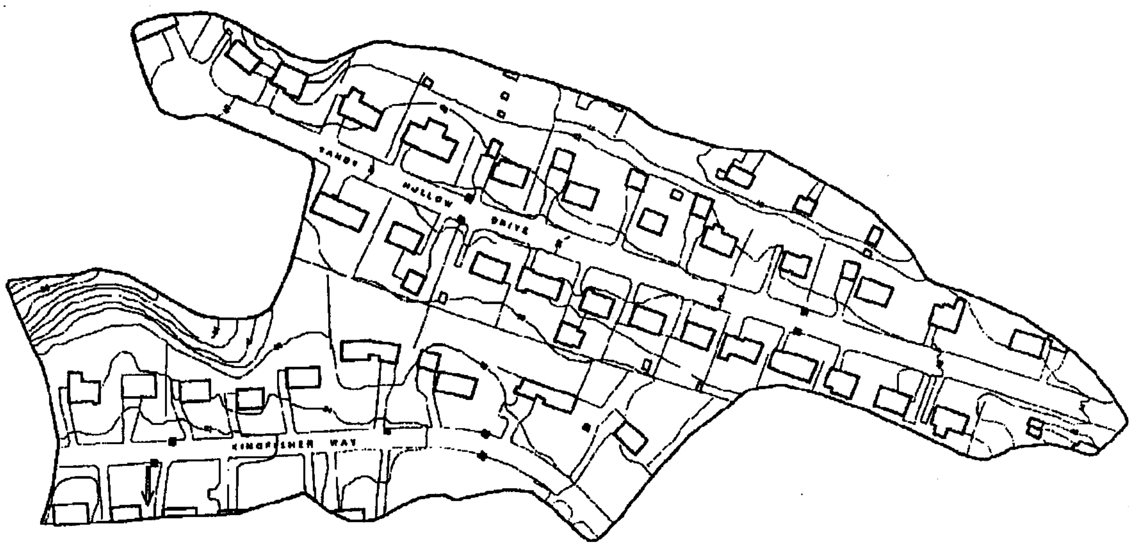
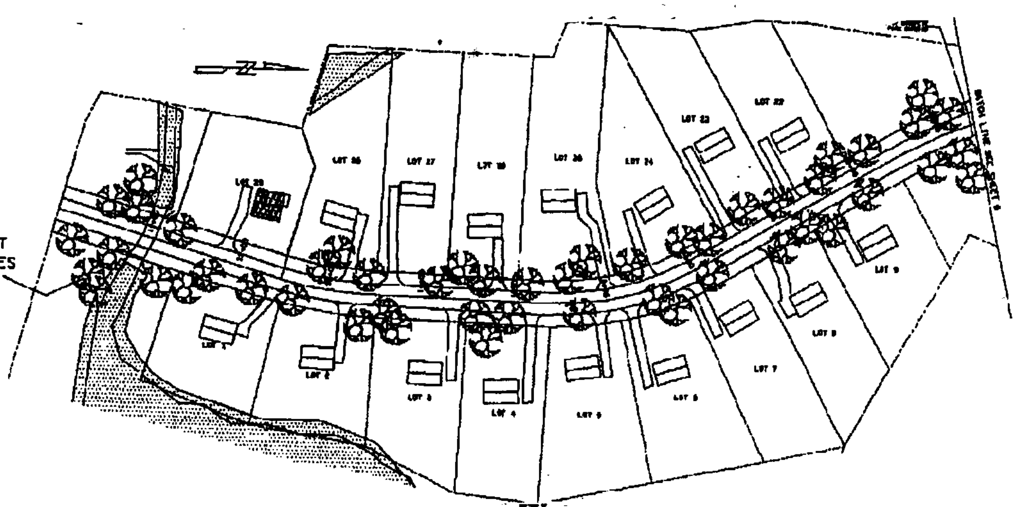


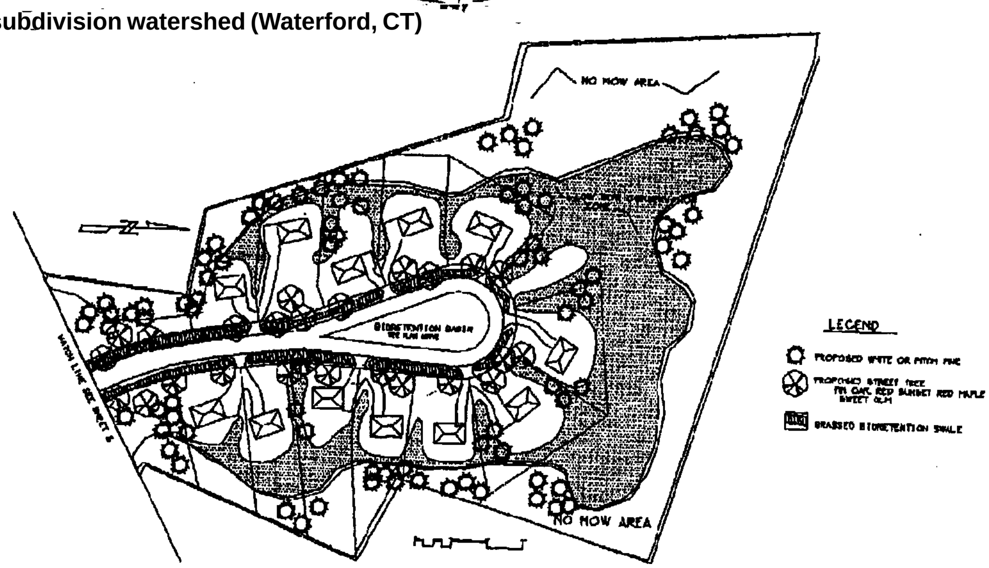
Figure 7: Jordan Cove Urban Watershed (Connecticut) Project Location



Existing residential control watershed with contours (Waterford, CT)



Traditional subdivision watershed (Waterford, CT)



BMP subdivision watershed (Waterford, CT)

Figure 8: Water Quality Monitoring Stations for Jordan Cove Urban Watershed (Connecticut)

PROJECT OVERVIEW

The Jordan Cove watershed is located along the north or Connecticut side of the Long Island Sound (Figure 7). Jordan Cove is a small estuary fed by Jordan Brook; the estuary empties into Long Island Sound. Water quality sampling had indicated that the Cove did not meet bacteriological standards for shellfish growing and sediment sampling had revealed high concentrations (>20 ppm) of arsenic. Also, short-term monitoring of bottom waters had documented depressed levels of dissolved oxygen.

Land use in the 4,846-acre Jordan Brook watershed is mostly forests and wetlands (74%) along with some urban (19%), and agricultural (7%) uses. The project was located in a residential section of the watershed. The project plan was to develop a 10.6-acre area following traditional subdivision requirements and another 6.9-acre area of housing using best management practices (BMPs). A third drainage area consisting of 43 lots on 13.9 acres, which was developed in 1988, was used as a control.

The project incorporated the paired watershed monitoring design for the three study areas. Monitoring included precipitation, air temperature, and grab and storm-event sampling for solids, nutrients, metals, fecal coliform, and biochemical oxygen demand (BOD). Additionally, monitoring of selected individual BMPs was conducted.

The 10-year project is completed. Monitoring concluded in June 2005. The 2007 Final Report is on the web: http://www.jordancove.uconn.edu/jordan_cove/publications/final_report.pdf.

PROJECT BACKGROUND

Project Area

The project was located within the Town of Waterford, CT near Long Island Sound. The two developments designated as treatment watersheds together covered about 17.5 acres and the residential control watershed was approximately 13.9 acres.

Relevant Hydrological, Geological, and Meteorologic Factors

The average annual precipitation was 49.8 inches, including 35 inches of snowfall. Soils on the study areas were mapped as Canton and Charlton, which are well-drained soils (hydrologic soil group B). The surficial geology is glacial till and stratified drift. Bedrock is composed of gneiss originating from Avelonia. Bedrock is typically at a depth greater than 60 inches and the water table is located below six feet.

Land Use

Land use in the area to be developed using traditional requirements was poultry farming; the area designated for development using BMPs was a closed-out gravel pit. The control drainage area of 13.9 acres had 43 residential lots, ranging in size from 15,000 square feet to 20,000 square feet, which were developed in 1988. The traditional watershed had 15 developed 0.3 acre lots. The BMP watershed had 12 developed lots. Imperviousness in the traditional watershed increased from 4 to 11%.

Water Resource Type and Size

Water resources of concern were Jordan Brook, Jordan Cove estuary, and Long Island Sound. The cove is a long and narrow estuary consisting of a 390-acre inner cove and an 100-acre outer cove. Because the project sampled only overland runoff, no water resource was monitored.

Water Uses and Impairments

The Jordan Cove estuary did not meet bacteriological standards for shellfish growing. Sediment sampling had revealed high concentrations (>20 ppm) of arsenic.

Pollutant Sources

Primary pollutant sources were construction and later urban runoff from residences.

Pre-Project Water Quality

Semi-annual sampling at eight locations along Jordan Brook had documented average concentrations of total phosphorus less than 0.03 mg/l and nitrate less than 1 mg/l. Water samples from inner Jordan Cove have had fecal coliform counts with a geometric mean ranging from 26 to 154 cfu/100ml.

Water Quality Objectives

Retain sediment on site during construction and reduce nitrogen, bacteria, and phosphorus export by 65, 85, and 40 percent, respectively. Maintain post-development runoff peak rate and volume and total suspended solids load to pre-development levels.

Project Time Frame

1996 to 2005

PROJECT DESIGN

Nonpoint Source Control Strategy

The management practices were applied to the BMP treatment drainage area only and varied with two time phases. The first phase was during construction (18 months). During this phase, nonstructural practices such as phased grading, immediate seeding of stockpiled topsoil, maintenance of a vegetated open space perimeter, and immediate temporary seeding of proposed lawn areas and structural practices, including sediment detention basins and sediment detention swales, was employed.

Post-construction practices included implementation of fertilizer and pesticide management plans, animal (pets) waste management, and plant waste pick-up. Structural practices such as grassed swales, detention basins, roof runoff rain gardens, pervious access road and driveways, and the minimization of impervious surfaces were used. The goal was to implement BMPs on 100% of the lots in the BMP study area.

Project Schedule

Site	Calibration	Construction	Post-Construction
BMP	1/96-3/99	3/99-8/02	8/02-6/05
Traditional	8/96-10/97	10/97-6/03	6/03-6/05
Control	11/95	N/A	

Water Quality Monitoring

The study design was the paired watershed approach using one control and two treatment watersheds. The calibration period was about two years, during which time land use management remained unchanged. The treatment period included two phases: an 18-month construction phase and a long-term post implementation monitoring phase.

Variables Measured

Biological

Fecal coliform (FC)

Chemical and Other

Total suspended solids (TSS)
Total phosphorus (TP)
Total Kjeldahl nitrogen (TKN)
Ammonia (NH_3)
Nitrate + nitrite ($N0_3 + N0_2$)
Biochemical oxygen demand (BOD)
Copper (Cu), lead (Pb), and zinc (Zn)

Covariates

Runoff
Precipitation
Air temperature

Sampling Scheme

Flow-weighted composite samples were collected during storm-events and analyzed for solids and nutrients. Bacteria and BOD analyses were conducted on grab samples collected manually when flow was occurring during weekly visits to the site. Portions of storm samples were saved and combined into a monthly composite sample that were analyzed for metals.

Monitoring Scheme for the Jordan Cove Urban Watershed 319 National Monitoring Program Project

Design	Sites or Activities	Primary Parameters	Covariates	Frequency of WQ Sampling	Frequency of Habitat/Biological Assessment	Duration
Paired	BMP watershed Traditional watershed Control watershed	TSS TP TKN NH_3 NO_3+NO_2	Rainfall Air temperature Runoff	Storm-event		2-3 yr calibration 3-5 yr construction 3 yr post-BMP

Land Treatment Monitoring

In addition to annual household surveys, weekly observations were made of earth-moving and construction activities in the traditional and BMP watersheds.

Modifications Since Project Start

In August 1996, Monitoring Station 544 at the traditional site was abandoned and replaced with Monitoring Station 545 at a different location at the site. This resulted from the concern that water quality at the old station location (Sta. 544) may be contaminated with high organic nitrogen and total phosphorus associated with past chicken house cleaning practices. In May 1998, the station was moved again to sample exports from the traditional site which now largely leave via a paved street. The new station sampled the stormwater sewer. For 2 months in Spring 1998, monitoring was halted in the traditional watershed as the station was connected to the stormwater sewer which was being constructed at the same time. The BMP station was bermed off in June through July 1999 and received no flow.

Progress to Date

Tradition Watershed: Construction was complete in the traditional watershed.

BMP Watershed: BMPs installed during construction included earthen berms, temporary seeding, bioretention cul-de-sac, swales, and access road using pervious concrete pavers. Twelve homes with residential rain gardens were constructed. Two replicates of three driveway types were constructed and monitored. The three driveway treatments were asphalt, concrete paver, and crushed stone. Water quality monitoring was completed June 2005.

DATA MANAGEMENT AND ANALYSIS

Data Management and Storage

Quarterly and annual reports were prepared and submitted according to Section 319 National Monitoring Program procedures.

NPSMS Data Summary

STATION TYPE: CONTROL/504 **STUDY TYPE:** Paired

CHEMICAL PARAMETERS

Season / Parameter Name	QUARTILE VALUES -75-	-50-	-25-		Counts/ 1997	1998
BOD (MG/L)	6.4	2.0	1.7	Highest		
				High	1	2
				Low		
				Lowest	1	2
NITROGEN, AMMONIA, TOTAL (MG/L)	.47	.19	.06	Highest	21	15
				High	6	6
				Low	7	4
				Lowest	1	7
NITROGEN, KJELDAHL, TOTAL (MG/L)	1.9	1.2	.6	Highest	10	15
				High	9	6
				Low	13	5
				Lowest	2	5
PHOSPHORUS, TOTAL (MG/L)	.353	.183	.103	Highest	8	6
				High	4	7
				Low	4	8
				Lowest	18	10
FECAL COLIFORM (CFU/100ML)	110	37	4	Highest	1	1
				High		
				Low	1	1
				Lowest		
COPPER, TOTAL (MG/L)	.018	.011	.006	Highest	2	2

				High	1	6
				Low	4	4
				Lowest	5	0
LEAD, TOTAL (MG/L)	.013	.009	.005	Highest	1	2
				High	3	5
				Low	2	1
				Lowest	6	4
ZINC, TOTAL (MG/L)	.061	.035	.013	Highest	4	7
				High	3	5
				Low	2	
				Lowest	3	
NITRATE + NITRATE (MG/L)	.5	.3	.1	Highest	23	12
				High	13	4
				Low		8
				Lowest		10
TOTAL SUSPENDED SOLIDS (MG/L)	67.2	29.5	12.0	Highest	6	7
				High	4	7
				Low	11	11
				Lowest	10	9

STATION TYPE: TRADITIONAL/545

CHEMICAL PARAMETERS

Season Parameter Name	QUARTILE VALUES -75-	-50-	-25-		Counts/ 1997	1998
BOD (MG/L)				Highest		
				High		
				Low		
				Lowest		
NITROGEN, AMMONIA, TOTAL (MG/L)	.26	.15	.03	Highest	2	6
				High		3
				Low		8
				Lowest		2
NITROGEN, KJELDAHL, TOTAL (MG/L)	7.2	5.7	4.6	Highest		
				High		
				Low	1	1
				Lowest		19
PHOSPHORUS, TOTAL (MG/L)	3.288	2.902	1.461	Highest		
				High		1
				Low	1	2
				Lowest	1	17
FECAL COLIFORM (CFU/100ML)				Highest		
				High		
				Low		
				Lowest		
COPPER, TOTAL (MG/L)	.034	.018	.011	Highest		2
				High		3
				Low		1
				Lowest	2	1
LEAD, TOTAL (MG/L)	.035	.023	.013	Highest		
				High	1	3
				Low		2
				Lowest	1	2
ZINC, TOTAL (MG/L)	.100	.090	.077	Highest		5
				High		
				Low		
				Lowest	2	2
NITRATE + NITRATE (MG/L)	.32	.17	.1	Highest	1	18
				High		
				Low		
				Lowest	1	1
TOTAL SUSPENDED SOLIDS (MG/L)	353	257	93	Highest		4
				High		1
				Low		4
				Lowest	1	11

STATION TYPE: BMP/537 **STUDY TYPE:** Paired

CHEMICAL PARAMETERS

Season Parameter Name	QUARTILE VALUES -75-	-50-	-25-		Counts/ 1997	1998
BOD, (MG/L)				Highest	2	0
				High		2

				Low		2
				Lowest		3
NITROGEN, AMMONIA, TOTAL (MG/L)	.36	.10	.005	Highest	10	5
				High	7	0
				Low	8	6
				Lowest		11
NITROGEN, KJELDAHL, TOTAL (MG/L)	1.85	.70	.40	Highest	2	6
				High	12	10
				Low	10	3
				Lowest		3
PHOSPHORUS, TOTAL (MG/L)	.093	.025	.009	Highest	6	2
				High	3	11
				Low	9	6
				Lowest	6	3
FECAL COLIFORM (CFU/100ML)	330	20	7	Highest	2	1
				High		3
				Low		
				Lowest		1
COPPER, TOTAL (MG/L)	.013	.009	.003	Highest	1	
				High	1	4
				Low	7	2
				Lowest		
LEAD, TOTAL (MG/L)	.006	.004	.003	Highest	1	2
				High		1
				Low	1	
				Lowest	7	3
ZINC, TOTAL (MG/L)	.074	.044	.034	Highest	2	4
				High	2	1
				Low	1	1
				Lowest	4	
NITRATE + NITRATE (MG/L)	.4	.2	.1	Highest	13	2
				High	5	2
				Low	4	5
				Lowest	2	13
TOTAL SUSPENDED SOLID (MG/L)	8.9	5	3	Highest	5	3
				High	7	5
				Low	1	5
				Lowest	12	9

Final Results

Calibration Period

Concentrations of pollutants in runoff from the existing residential control were somewhat lower when compared to event mean concentrations from the Nationwide Urban Runoff Program. Runoff from the BMP site exhibited lower concentrations of most water quality variables than the control site.

Calibration for flow were conducted between the control and BMP watershed. In order to develop the regression between runoff from the two sites, hydrograph separation of stormflow and baseflow was necessary for the BMP site due to the ground water inputs. The regression between the two sites was significant ($F=83.0$, $p=<0.001$, $R^2=0.62$). The median runoff from the existing residential control was about 10 times that from the BMP site. Significant ($p=0.05$) calibration regressions were established for TSS, TP, BOD, FC, Cu, and Pb concentrations; and the mass export of NH_3, TKN, TSS, and TP. Calibration of the control and traditional sites has been completed.

Construction Period

During the construction period on the traditional watershed, no samples were collected until May 1998 even though the construction period began October 1997. The lack of runoff occurred because construction activities, including silt fence installation, divided the watershed into smaller pieces.

In the traditional watershed, weekly flow (34,930%) and peak discharge significantly ($p<0.05$) increased due to land development. Concentrations of TKN decreased 63% and TP increased 51% ($p<0.05$). TSS, nitrate, ammonia, copper, lead, and zinc concentrations did not change. Mass export (kg/ha/yr) increased for NO_3-N (7,525%), NH_3-N (1,958%), TKN (6,928%), TP (9,914%), and TSS

(11,620%) ($p<0.05$) in accord with the increases of flow. Export of copper (19,412%), lead (3,644%), and zinc (7,208%) also increased ($p<0.05$) during the construction period. These results suggest that hydrologic response, rather than erosion and sediment, is the cause of increased pollutant export from this construction site. Changes in geomorphic land forms likely influenced the hydrologic response at this site.

In the BMP watershed during construction weekly stormflow decreased ($p<0.05$) by 97% and peak discharge also decreased. The earthen berm, basement excavations and permeable fill all contributed to the runoff. However, concentrations of TSS (1,575%), TP (3,870%), NH_3-N (414%), TKN (256%) increased ($p<0.05$) in runoff. The mass export (kg/ha/yr) of TSS and TP also increased. Fertilization influenced N and P results. Time plots suggest that activities early in the construction period produced peak concentrations of TSS, N and P.

The results suggest a trade-off between traditional construction practices and low-impact development (LID). Stormflow increased during traditional construction but decreased during LID construction. However, increased erosion and nutrient concentrations occurred during LID construction, as compared to traditional construction, perhaps due to the lack of an impervious road.

Post-Construction Period

BMP Watershed: The volume of stormwater runoff from the BMP Watershed decreased during the construction period and continued to decrease by 74% during the post-construction period. Peak flow did not change significantly from predevelopment conditions which was a goal. During the post-construction period, the peak discharge actually declined by 27% based on the calibration prediction. Following construction, TSS, TP, NO_3 and TKN concentrations were higher than predicted by calibration. Exports generally declined in the post-construction period, except for TP and TSS which increased. Metals export declined following construction.

Traditional Watershed: The volume of stormwater runoff increased 600 times during the post-construction period; peak discharge increased 30 times. Concentrations of TKN, TP, TSS and BOD have all declined compared to calibration but mass exports of all pollutants have increased from 65 to 76,361% depending on the pollutant, except Pb.

Driveway Study

Stormwater runoff was significantly different among each driveway type; the order of decreasing runoff was asphalt>paver>stone. Average infiltration rates were 0, 11.2 and 9.0 cm/hr fro asphalt, paver, and crushed stone driveways, respectively. Both paver and crushed stone driveways reduced stormwater runoff as compared to asphalt driveways. Runoff from paver driveways contained significantly lower concentrations of all pollutants measured than runoff from asphalt driveways. However, runoff from crushed stone driveways was similar in concentrations to runoff from asphalt driveways, except for TP concentrations, which were lower in runoff from crushed stone driveways than runoff from asphalt driveways. The mass export of measured pollutants followed the relative differences in stormwater runoff, rather than differences in concentrations.

Lawn Nutrient Study

NO_3-N desorbed from AEM strips, soil water NO_3-N concentrations and plant reflectance all indicate that the BMP lawns being monitored have lower values than the non-BMP lawns. Soil P concentrations in the BMP watershed were ranked medium during the study.

Household Survey

The survey of residents in the three watersheds revealed little differences among their behaviors. BMP residents mulch their leaves and mow their own lawns compared to the control watershed. No differences in fertilizer habits were observed. There were also no differences in behaviors across years within each watershed.

Conclusions and Recommendations

The BMPs used were able to keep runoff volume and peak at predevelopment levels, which was a project goal. Reduced N and P export goals were also met but TSS export goals were not met. For future projects, cluster designs, LID-based regulations and stormwater disconnects are recommended. Future construction projects should control compaction, maximize undisturbed soils, and use on-site supervision. Earthen berms were an effective BMP. Sediment control for swales and following soil test recommendations are important. Following construction, maintenance of bioretention areas, infiltrating pavers, turf dams, and appropriate grass mixes is needed. Further study is needed of groundwater effects, behavioral social indicators, the economics of LID, and soil testing.

INFORMATION, EDUCATION, AND PUBLICITY

Each household in the three study watersheds were surveyed annually for the purpose of obtaining survey information related to factors influencing nutrient and bacteria losses. Interaction during these visits helped answer questions about residents' habits that affect nutrient and bacteria deposition and educated residents about reducing nonpoint source pollution.

TOTAL PROJECT BUDGET

The estimated budget for several elements of the Jordan Cove Urban Watershed National Monitoring Program project for the life of the project was:

Project Element	Funding Source ($)			
	Federal	State	Local	Sum
Proj Mgt	48,400	NA	6,600	55,000
I & E	NA	NA	NA	NA
L T	151,882	NA	106,675	258,557
WQ Monit	779,718	540,058	NA	1,319,776
TOTALS	980,000	540,058	113,275	1,633,333

Source: Jack Clausen, Personal Communication (2007)

IMPACT OF OTHER FEDERAL AND STATE PROGRAMS

Unknown.

OTHER PERTINENT INFORMATION

None.

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