Container Nursery BMPs Demonstration Event

Holly Factory Nursery
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What's in a BMP?

(Copied from preface of 2007 Florida Container Nursery BMP Manual)

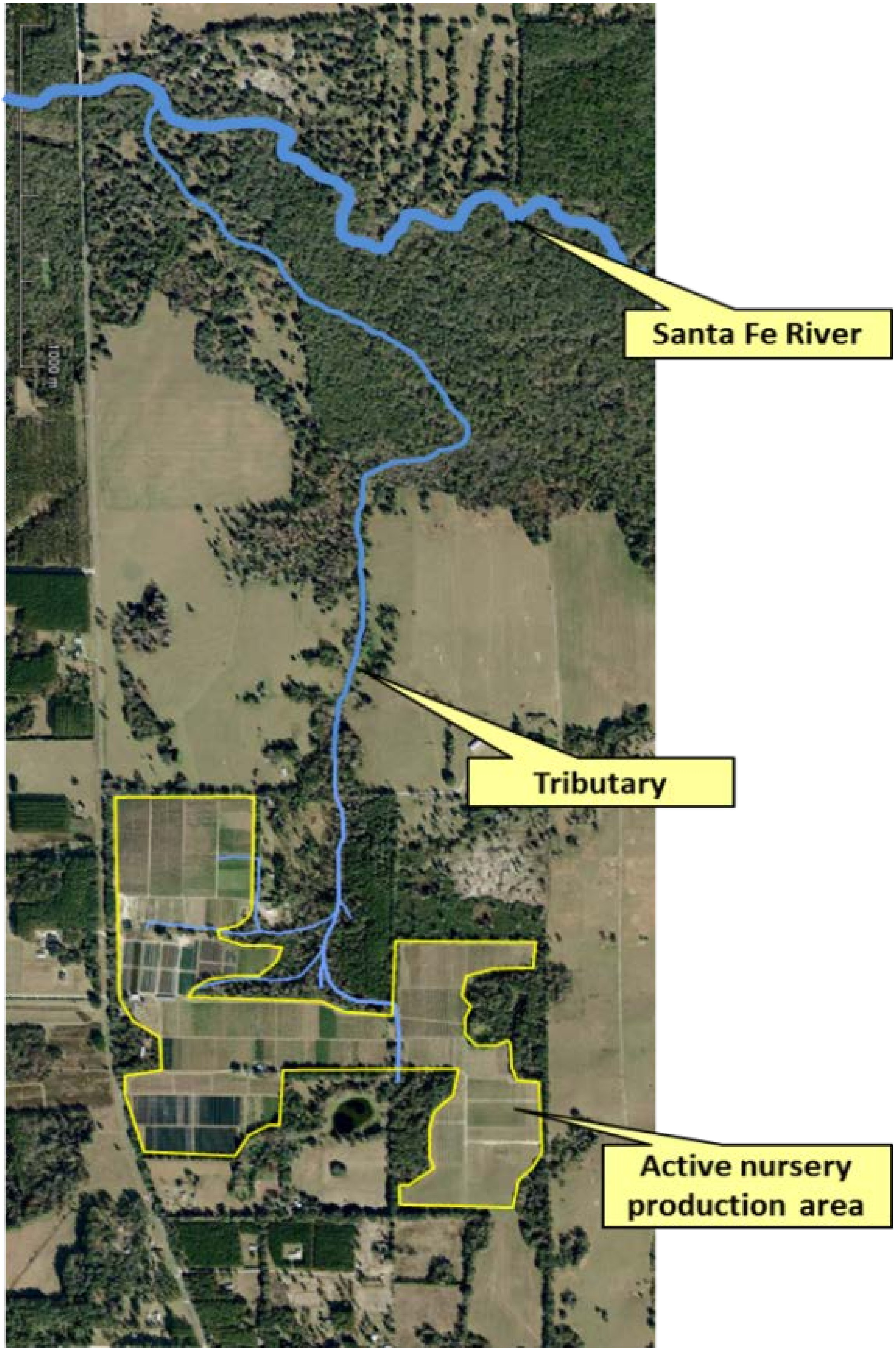
Since 1994, the Florida Department of Agriculture and Consumer Services (FDACS) has been statutorily authorized to assist the agricultural industry with the development and implementation of Best Management Practices (BMPs). As a result, BMPs have become the preferred mechanism for state agencies to address water quality issues related to agricultural discharges, from ground water leaching to surface water runoff. The Florida Department of Environmental Protection (FDEP), the water management districts, the agricultural industry, the academic community, and environmental organizations have endorsed this mechanism. Because of the program's established creditability and the statutory presumption of compliance with state water quality standards for those who implement the BMPs, this is an important program for growers.

The nursery industry made the decision to participate in the BMP program to offer growers an alternative to existing or future water quality regulation and to address specific water quality issues that may arise locally. The industry has demonstrated a willingness to cooperate with university researchers and extension programs by supporting research projects, and by transferring improved technology related to water resource protection to their nursery operations through the development and implementation of BMPs.

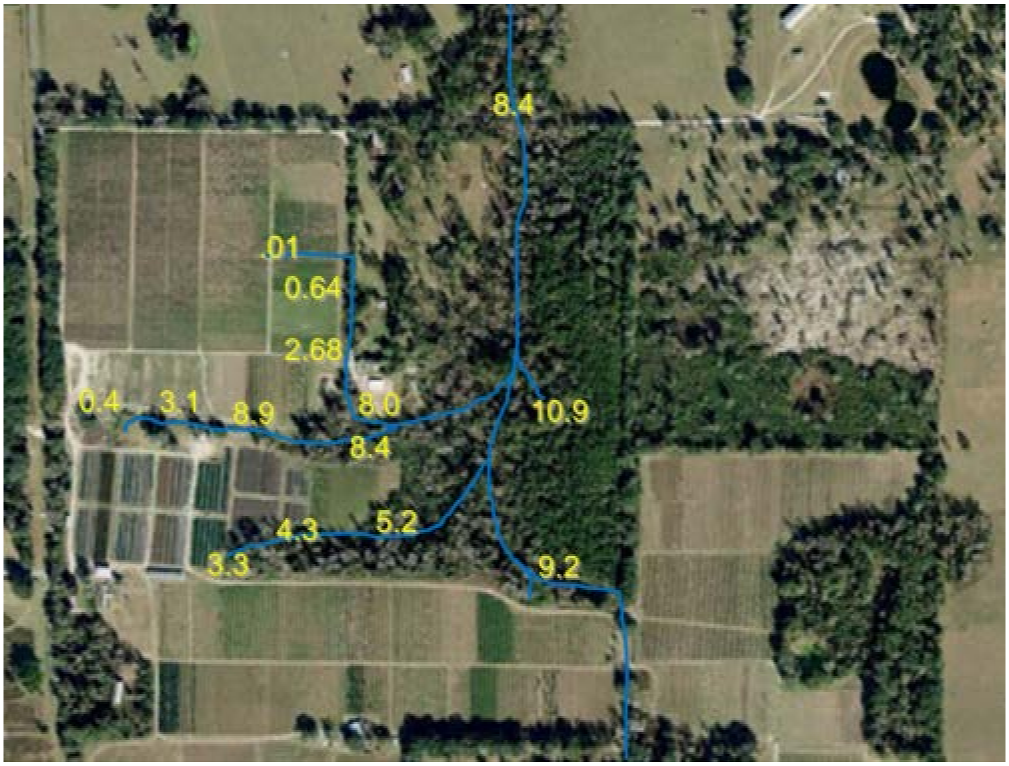
Consistent with the intent of the authorizing legislation, growers and interested parties have had full opportunity to participate in the development of the individual practices contained in the BMP guide, and will have the same opportunity should modifications to the BMP guide be necessary based on new information. Many nursery growers have provided invaluable input throughout the development of this guide. This has enabled the industry to achieve a balance between water resource protection and technically and economically feasible BMPs.

Benefits of Enrolling in the Nursery BMP Program

- Recognition that you are a responsible citizen doing your part as an environmental steward.
- Participants establish eligibility for federal and state cost-share dollars for the implementation of specific practices.
- The implementation of improved management practices for nutrient and irrigation inputs can reduce production costs.
- Grower participation signifies a strong preference for voluntary, consensus-based programs (implementing BMPs) as opposed to the traditional regulatory and/or permitting approach.
- Under the Florida Watershed Restoration Act (s. 403.067, F.S.), implementation of BMPs that FDEP has verified as effective in reducing target pollutants and that FDACS has adopted by rule provides a presumption of compliance with state water quality standards. FDEP is then precluded from recovering costs or damages for contamination related to the target pollutants. Maintaining BMPs is part of implementation.



Proximity of Nursery to Santa Fe River

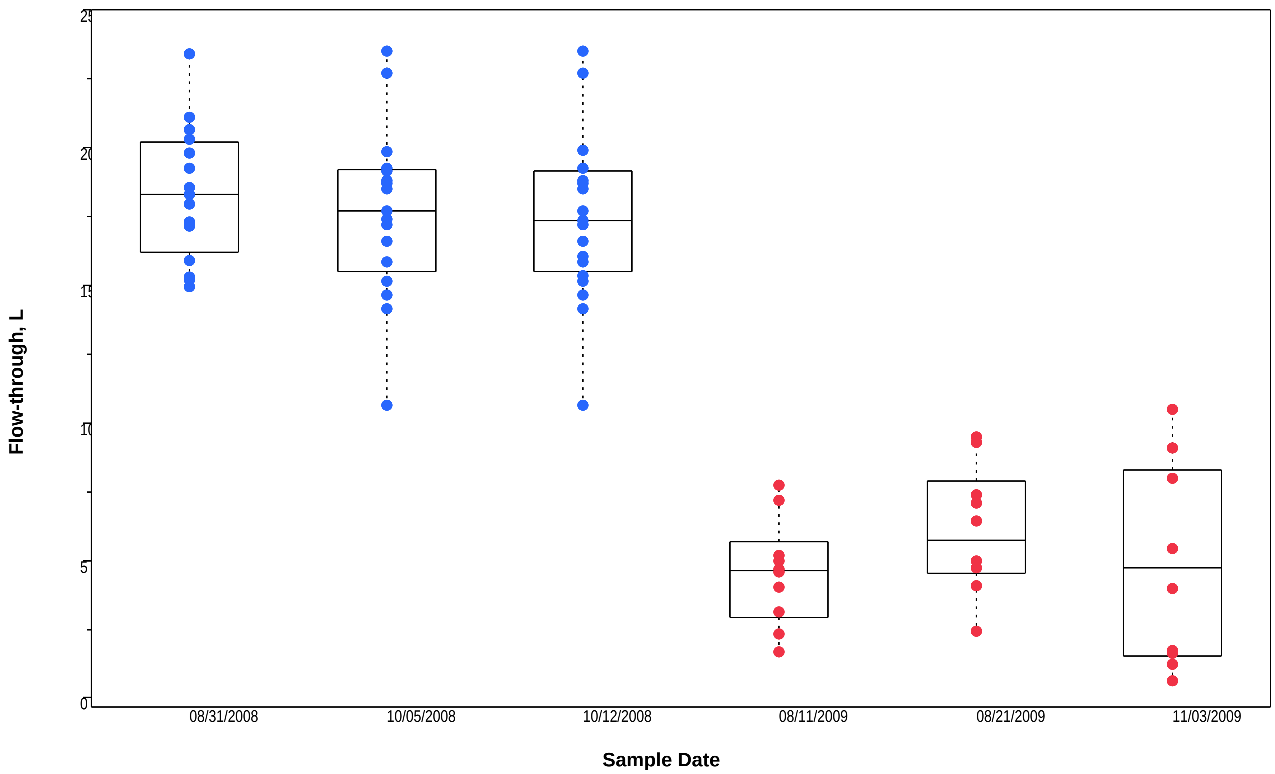


Surface water Nitrate-Nitrogen concentrations (mg L^{-1}) collected in January 2006 from subtributaries and seeps near nursery.

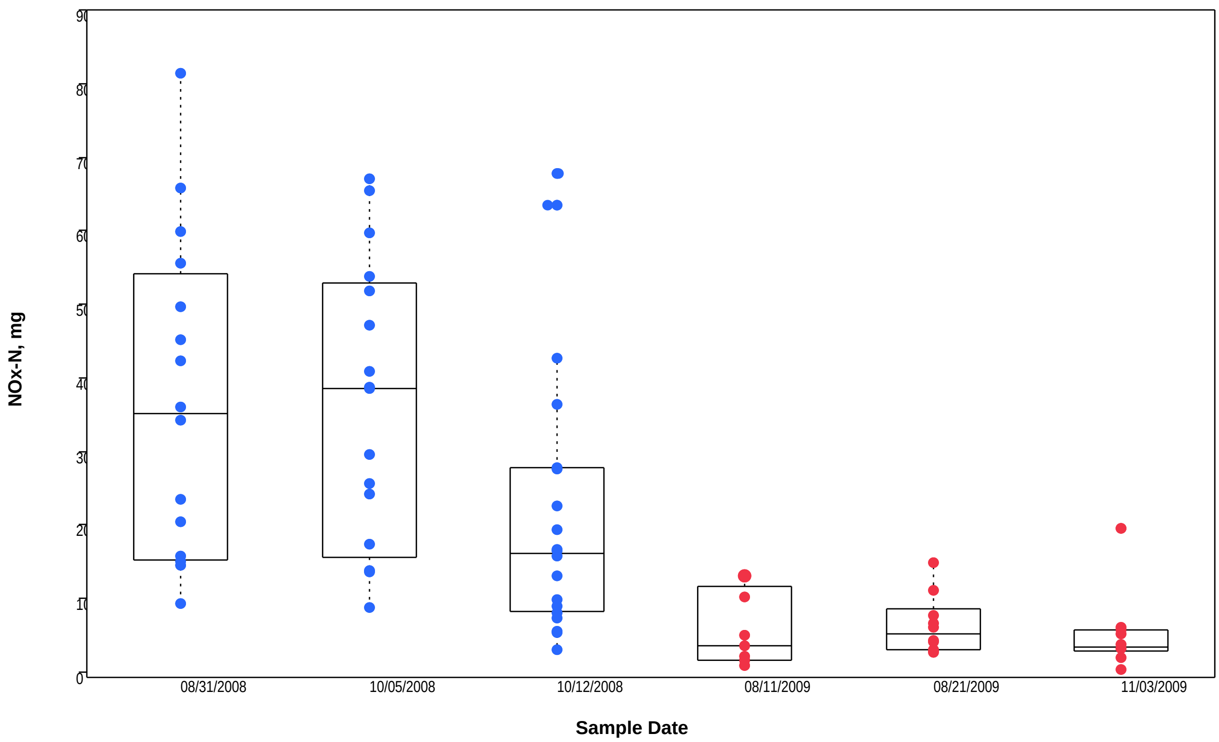
Layout of nursery showing irrigated areas using overhead irrigation (red) and those areas using microirrigation (yellow)

Cyclical Irrigation

During production, most nurseries irrigate on a daily basis (except when rain supplies adequate moisture) in which the daily water allotment is applied in a single application (continuously). An alternative approach to help increase the water holding capacity is cyclic irrigation in which the daily water allotment is applied in more than one application with timed intervals between applications. For example, if the plant need were 0.3 inch of water per day, then for continuous irrigation, 0.3 inch would be applied in a single, one hour application. For cyclic irrigation, 0.1 inch would be applied in 20 minutes; one hour later 0.1 inch would be applied again; one hour later the last 0.1 inch would be applied. Thus, with cyclic irrigation, the 0.3 inch irrigation is applied over a three hour period compared to the one hour period for continuous irrigation. Other cycle durations and intervals might be used, but compared to continuous irrigation, cyclic irrigation has been shown to reduce the volume of irrigation runoff by 30% and the amount of nitrate leached from containers by as much as 41% (Fare et al., 1994). Cyclic irrigation can be used with overhead and microirrigation but automation with controllers and solenoid valves is necessary. Otherwise, cyclic irrigation is too cumbersome.



Flow-through irrigation volume collected during three sampling periods before cyclical irrigation BMPs were implemented (blue) and after cyclical application and lower volumes were implemented (red).



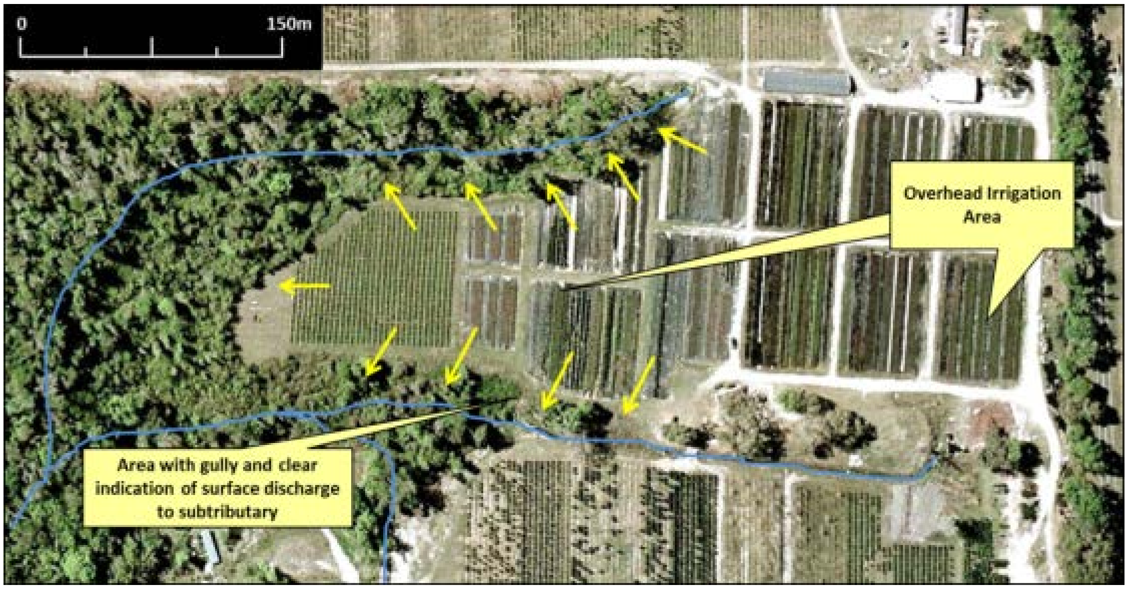
Nitrate-Nitrogen loads in irrigation flow through water from 15 gal containers under preBMP (blue) and postBMP (red) irrigation regimes and fertilizer application rate.

Summary table of PreBMP and Post BMP flow-through volume, nutrient concentration and loads.

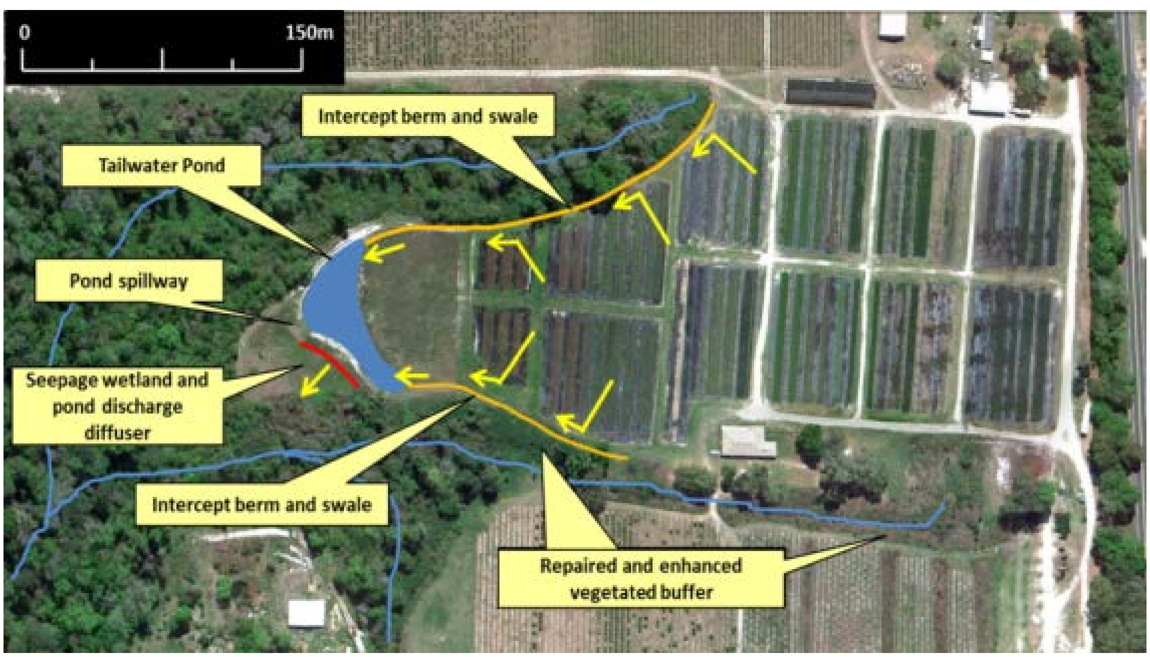
	30 min x 1 application	6 min x 3 applications	% reduction
Irrigation applied	22.9 ± 2.42	8.40 ± 3.74	63.3
Flow-through, L	17.8 ± 2.81	5.13 ± 2.67	71.2
Flow-through, % of irrigatic	87.2 ± 12.8	59.4 ± 17.8	31.9
Flow-through concentration			
TP, mg L^{-1}	4.63 ± 3.77	4.14 ± 4.09	10.6
NOx-N, mg L^{-1}	17.5 ± 11.9	15.1 ± 17.4	13.7
TKN, mg L^{-1}	8.46 ± 5.04	7.06 ± 7.84	16.5
TN, mg L^{-1}	26.0 ± 14.5	22.2 ± 21.1	14.6
Flow-through mass			
TP, mg day^{-1}	80.2 ± 65.3	29.0 ± 40.0	63.8
NOx-N, mg day^{-1}	306 ± 207	57.6 ± 46.7	81.2
TKN, mg day^{-1}	148 ± 82.1	38.6 ± 41.1	73.9
TN, mg day^{-1}	454 ± 251	96.2 ± 78.0	78.8

Intercept Berms, Swales and Tailwater Ponds

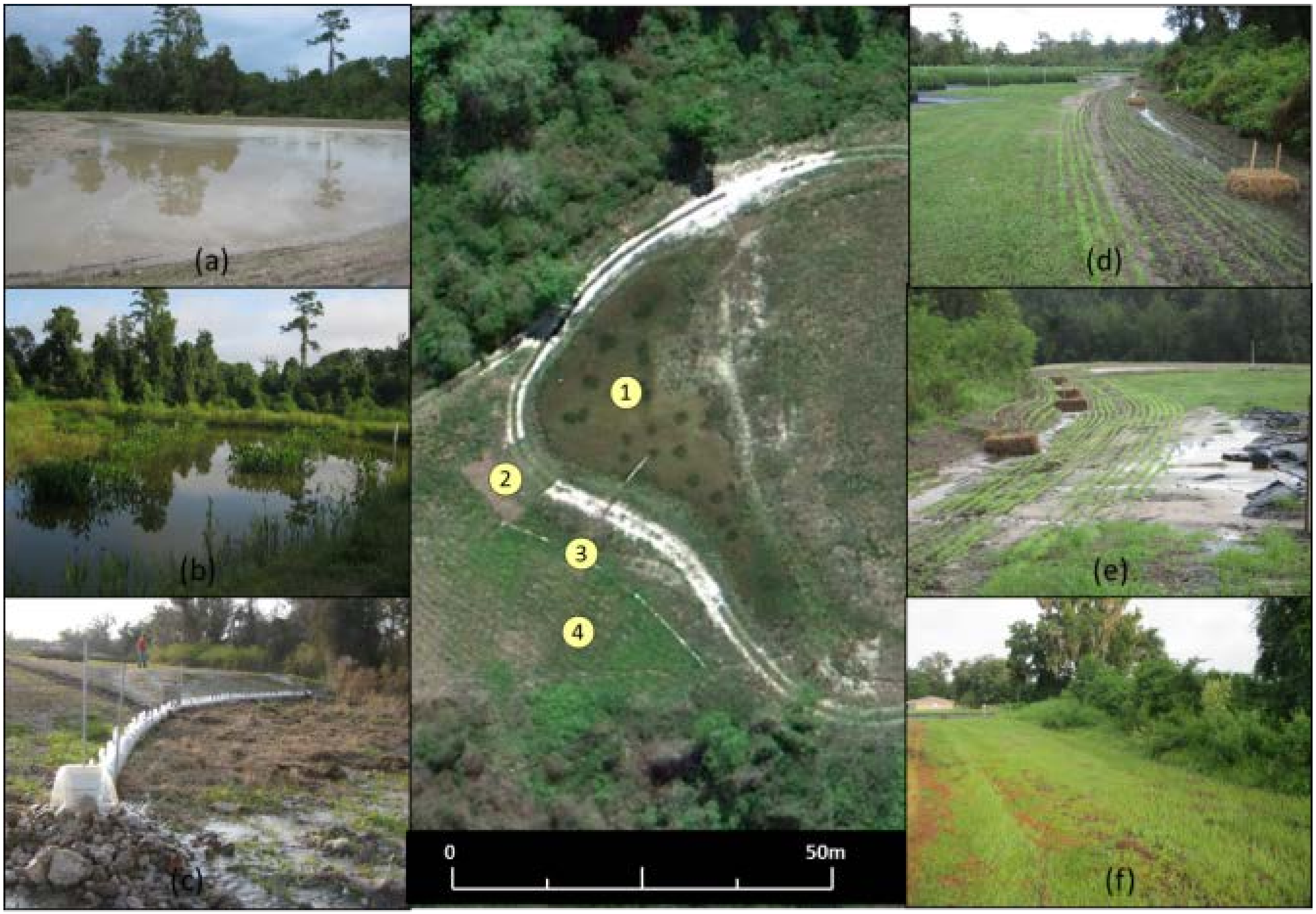
Berms and swales can be used to effectively intercept surface runoff from excess irrigation and storm events and convey the water to a storage area (tailwater pond) for reuse, treatment or discharge to areas with lower impacts.



2006 aerial image of the nursery showing the area of overhead irrigation, overland flow vectors and two subtributaries that receive surface runoff



BMP modifications added to address surface runoff from overhead irrigation area. Post implementation overland flow is intercepted by berms and directed via swales to a tailwater pond. Water detained in the pond is released at a controlled rate to a seepage wetland and eventually flows back to the tributary.



Images of BMPs and other practices integrated into the overhead irrigation area to intercept and treat overland flows previously being discharged directly to the tributary or via vegetated buffers. Center image shows 1) tailwater pond, 2) spillway, 3) pond discharge diffuser pipe and 4) seepage slope/wetland area. Images starting in upper left show a) tailwater pond shortly after first rainfall event, b) tailwater pond nine months after construction, c) tailwater pond discharge diffuser, d and e) intercept berm and swale on south and north side of overhead irrigation area shortly after construction and f) north side berm and swale nine months after construction.

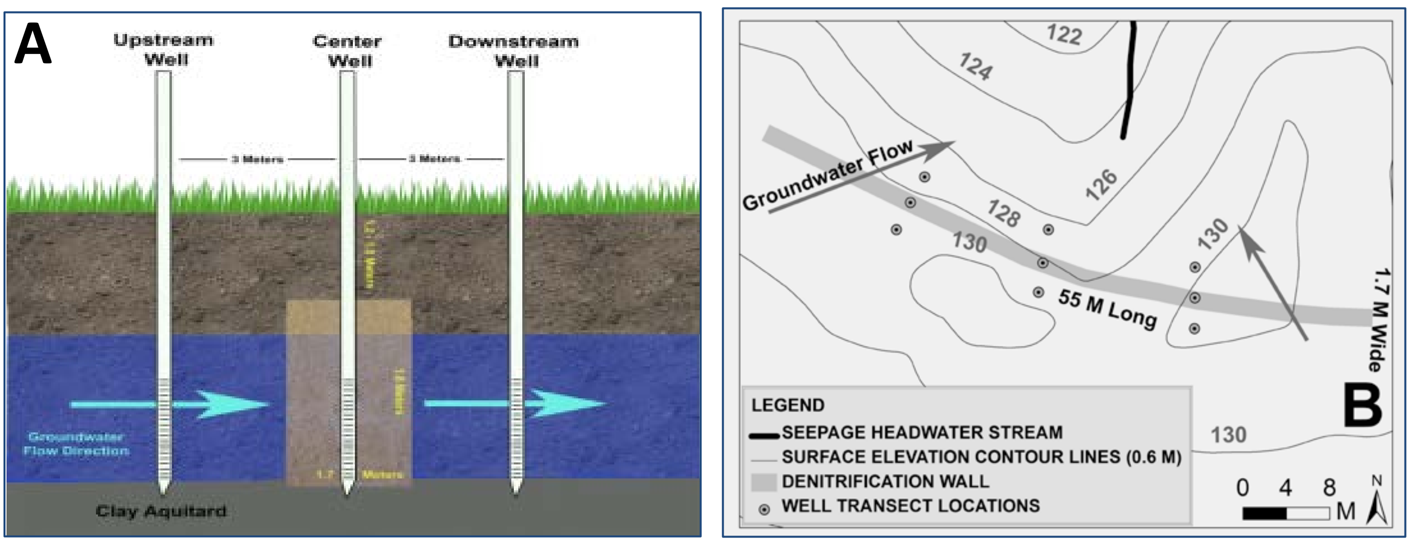
To estimate the benefit of the pond and berm/swale infrastructure to reduce downstream loads, nutrient concentrations in the pond immediately following several storm events were multiplied by the volume of water intercepted by the pond. Using this approach, annualized NOx-N loads intercepted by the pond were 15.7 $\pm$ 5.83 kg N yr^{-1} and 28.5 $\pm$ 9.49 kg N yr^{-1}. If water intercepted by the pond were detained at least one to two weeks, NOx-N levels were almost completely assimilated into plant material or denitrified in the sediments and released to the atmosphere. It is estimated that upwards of 70% of the TN load intercepted by the tailwater pond (19.4 kg annualized) is removed. Additional removal may also be occurring in the seepage slope/wetland area; however, reductions in nitrogen load from this practice have not yet been quantified.

Denitrification Wall

A denitrification wall bioreactor is a permeable reactive barrier that is used to remove Nitrate from groundwater by enhancing a natural process called denitrification. A large denitrification wall was installed at the Holly Factory Nursery to determine if this was an effective means to reduce surface groundwater nitrate pollution from entering a tributary that flowed into the Santa Fe River.

<u>What is Denitrification?:</u> Nitrate is removed in these barriers through a natural process called denitrification. Denitrification is an anaerobic (no oxygen) respiration reaction where bacteria gain energy from consuming organic carbon (leaf litter, sawdust, wood chips etc.), and predominantly convert nitrate to harmless Nitrogen gas (N_2). For denitrification to occur you need an bioavailalble organic carbon source and waterlogged soils to reduce oxygen levels. These conditions can be created by mixing wood chips, sawdust, or another amendment in to soils that are permanently in contact with high nitrate groundwater.

<u>Denitrification Wall Hydrology and Site Selection</u>: Groundwater travels horizontally from high water table elevation to low elevation and to ditches, streams and wetlands. To intercept and treat groundwater, the wall should be installed at the edge of the field, perpendicularly to the predominant flow direction.



(A) A side-view and (B) an overhead view of the wall indicating the hydrology. In this case the wall is installed down to a clay layer and approximately perpendicularly to the groundwater flow direction.

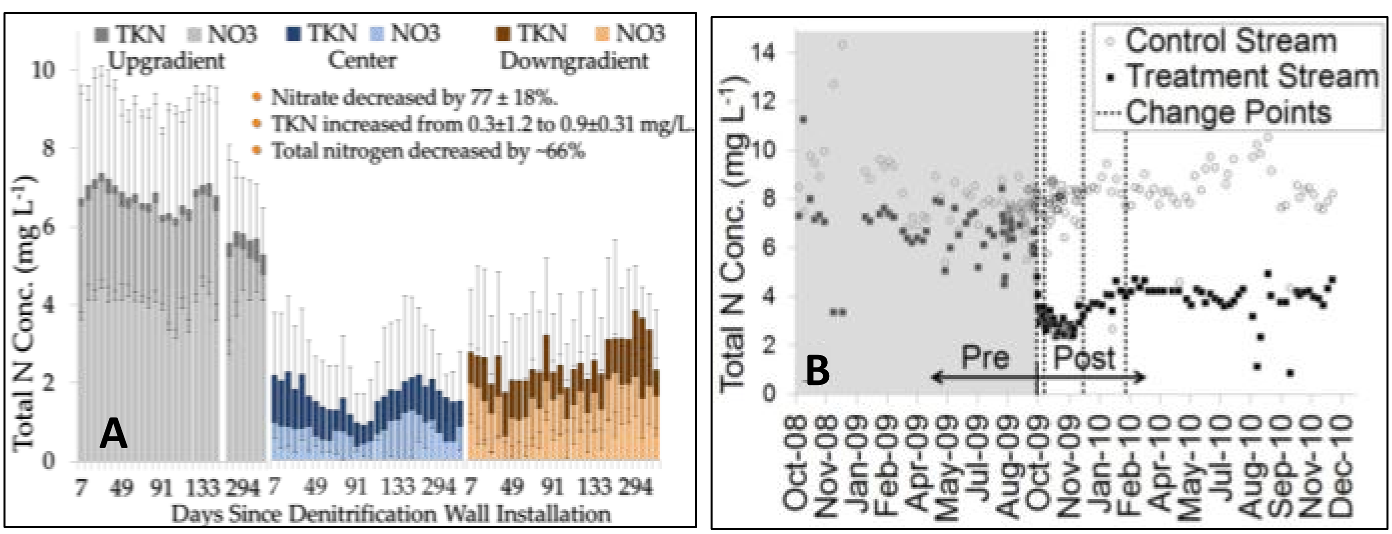
The location and the size of the wall is dependent on the groundwater hydrology and the amount of Nitrate in the water. Below are several factors to consider when evaluating use of a Denitrification Wall:

- The groundwater table should be near the surface to keep the wall media underwater most of the year and reduce construction costs.
- Hydraulic conductivity through the wall must be greater than through the surrounding soil or water must be forced through the wall.
- The detention time of water within the wall must be long enough to create anaerobic conditions and reduce excess Nitrate, this will determine the required width of the wall.
- Locating the wall at strategic locations where groundwater flows are concentrated will result in more effect overall treatment of downstream waters.

Denitrification Wall Installation: The Holly Factory denitrification wall was installed on September 30th, 2009 and it is one of the largest walls in the world. The wall was installed by: mixing pine sawdust with sand in a 50:50 ratio above ground, excavating a trench to the desired depth, adding the sand-sawdust mixture and repeating the process until the full length was completed. The native soils were then backfilled to the surface.

Figure 2 – (A) An image of the sand and sawdust used in the wall. (B) A trench was excavated to the desired depth and was immediately backfilled with the sand and sawdust mixture. (C) the final trench before backfill of surface soils.

Denitrification Wall Results: The wall was evaluated using wells where nitrate was measured upgradient, within (center) and downgradient from the wall. Additionally, to determine if the nitrate was reduced in a stream receiving groundwater from the wall, nitrate concentrations were measured in the receiving 'treatment' stream and an adjacent 'control' stream. The nitrate concentration declined in the groundwater and stream. We estimate that this denitrification wall will last approximately 23 years and it is cost-effective treatment option compared to other methods (treatment wetlands, riparian buffers, industrial treatment).



(A) Nitrate concentration in the groundwater upgradient, within (center) and downgradient from the wall. (B) Nitrate concentration in the receiving (treatment) and control stream pre and post wall installation. Nitrate reductions were significant in both the groundwater and the stream.

Overall Assessment of Nutrient Load Reduction Resulting from Implementation of Container Nursery BMPs

BMP's implemented in conjunction with this project

- <u>1.B.1 Retain rainwater</u> – intercept berm, swale and tailwater pond
- <u>1.B.5 Buffers used</u> – enhanced 25' undisturbed buffer or natural forested buffer around tributaries.
- <u>1.D.2 Runoff captured</u> – intercept berm, swale and tailwater pond
- <u>2.C.5 Minimize off-site nutrient loss</u> – intercept berm, swale and tailwater pond
- <u>3.C.1 Fertilizer Rate</u> – approximate 20% reduction in application of fertilizer to 15 and 30 gal nursery stock on microirigation
- <u>6.A.5 Cyclic irrigation</u> – applied to all nursery irrigation as described in section 2
- <u>8.B.1 Water retained</u> – intercept berm, swale and tailwater pond

Location (above) and photo (below) of main monitoring station used to assess overall efficacy of BMP implementation.

Summary of discharge, nitrogen concentration and load data for the main watershed.

Year	TN Conc (mg/L)	Discharge Ave. (L/s)	Annual TN Load Estimate (kg)	Total Rain (mm)	Rain Rate (mm/d)	Ave Rain intensity (mm/min)	Net Storm Runoff (m3)	Net Storm Runoff Load (kg)	Baseflow (10th Percentile) (L/s)
2008*	7.6 ± 0.9	16.8	4206		1.3	0.05	1674		13.2 ± 1.2
2009	6.6 ± 1.2	19.8	4294	1386	3.8	0.17	27005	173.3	11.3 ± 4.3
2010	6.4 ± 0.9	10.0	2097	827	2.3	0.21	26197	162.8	5.57 ± 1.9
2011*	5.5 ± 0.7	8.44	1525		3.2	0.11	1170		5.41 ± 0.05

**2008 and 2011 were only sampled for approximately 3 and 7 months respectively. As such, total rainfall is not indicated, although the rainfall rate is indicated. Additionally, the annual TN load is estimated by extrapolating existing data collection to the entire year.*