A COMPARATIVE CASE STUDY IN REHYDRATION AS A TOOL IN RESTORATION AND EXOTIC PLANT CONTROL: A TALE OF TWO CITIES

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Introduction

"It was the best of times. It was the worst of times." The self contradicting situation originally described by Charles Dickens still occurs. We working environmental professionals have seen it innumerable times. In this case study, two projects are compared once again reminding us that we must constantly strive for professionalism and a sound scientific foundation in our efforts.

The names, locations, and many of the details of these two cases have been altered, but the pivotal events in the projects have been retained. For example, the projects may have been conducted by other levels of government or even by private sector entities. What remains accurate is that the two types of entity are the same.

Case Comparison Overview

These two cases were chosen for comparison because of a high degree of similarity in the projects at inception and the great divergence which occurred during implementation. For the purposes of our comparison, both projects are government owned public park facilities which include recreational components (e.g. ball fields) and natural components (e.g. nature trails, education centers). Each of these parks have been in existence for similar periods of time, about 40 years, and each enjoys public sector support in the form of citizen based *friends* groups and local sponsors. The natural section of each park is composed of upland, lowland, and flowing water components, totaling approximately sixty acres. The condition of the lowlands and streams has been altered by drainage features and heavy populations of exotic plants.

At the inception of the projects, each municipality had similar goals: Rehydration, restoration, exotic plant control, and a general improvement of the park experience offered to visitors. One government chose to provide solutions based on an extensive ad hoc scientific assessment while the other chose to apply stock, one size fits all, solutions. How these two municipalities approached these goals gives us the foundation for the comparison.

Similarities

In each case, the size of the habitat considered for rehabilitation is approximately 60 acres. Both contain lowlands and uplands, but in different geospatial relationships. These mixtures of Bay-Maple and Oak Hammock habitats are both associated with streams . The hydroperiods have been altered by ditches dug as part of now outmoded practices of mosquito and flood control. Exotic plants occur frequently in both upland and wetland segments of each of the properties.

Dissimilarities

Case A	Case B
* Streams run through the central portion of the wetland.	* Streams flow around margins of wetland.
* Streams provide direct input to the wetland basin.	* Stream input occurs only at high water stages. Direct input from overland flow is minor
* Stream flows continuously.	* Streams flow intermittently.
* Tailwater is a lake controlled by a weir.	* Tailwater is tidal, but weirs separate wetland from tidewaters.
* Impetus from an unanticipated need for mitigation.	* Impetus from a restoration grant.

The greatest dissimilarity, however, is the dynamics of the relationship between engineering practices and ecological goal setting.

Case A

The city in Case A hired an ecological consultant to characterize the existing conditions. The city then devised a rehydration plan which was implemented by city staff. This history, and the related implications, are somewhat abbreviated as it is taken from a sparse set of records. The ecological report was limited in scope to a vegetative characterization and included a variety of questionable statements and inferences. A set of maps was prepared from the vegetative data. These maps are more impressionistic than definitive. In addition to problems with the vegetative characterization, the survey data was incomplete, not all the streams were located, and controlling elevations both within the streams and at critical locations within the swamp were unknown (Figure 1).

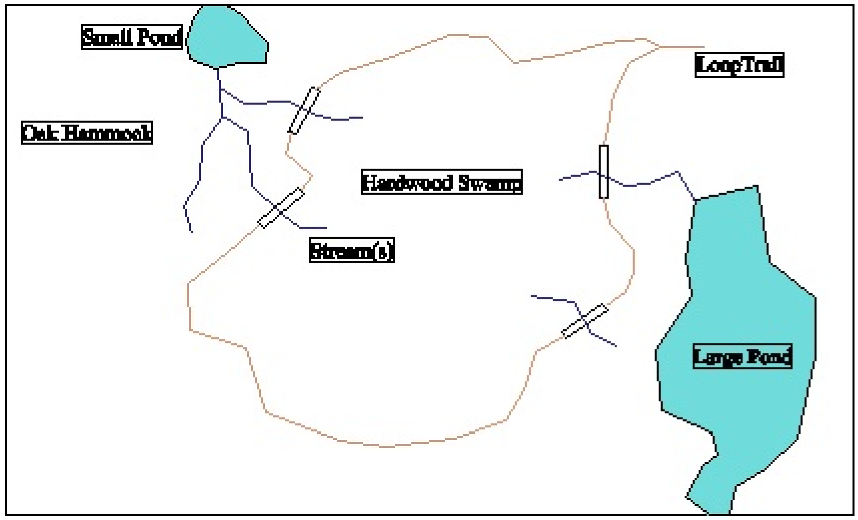

Figure 1. Suspected positions of streams. Connectivity within the swamp was not determined. Elevations were not determined. Flow is from small pond under boardwalks in loop trail and to large pond. Outfall from system was thought to be at the bottom right of the graphic.

The ecological restoration plan was prepared without the assistance of ecologists (Figure 2). The simplistic solution was to place dams in the streams with the intent of backing up the stream flow and flooding the surrounding swamp floor. Many participants felt that this would also eliminate the exotic plants. The city included the promise of the elimination of exotic plants and the rehydration of the swamp in the proposed mitigation. City staff biologists voiced some concerns, but the plans were not modified.

The implementation process went no more smoothly. Of the six planned dams, only five were ever installed. During the first rainy season, four of these five failed. The fifth turned out to be in a stream bed that had been cut off and no longer carried water except in the most severe weather. The four failed dams were replaced during the next dry season and promptly failed again when the rainy season began again.

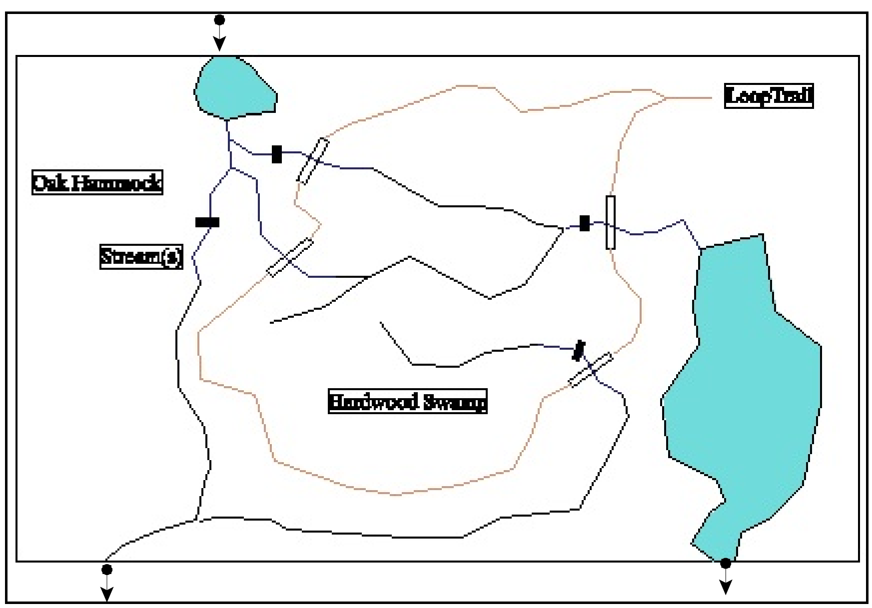

Figure 2. Actual connectivity of streams as determined after failure of the dams, shown as black bars. Note the dual outlet pathways.

An examination of the dams revealed both why they had failed and why they could never have rehydrated the swamp as intended. Each stream bed was incised into the floor of the swamp. The dams (Figure 3) would back up wat within the stream channel as intended. Once the channel was full, the waters simply flowed around sides of the dam instead of backing up and flooding the forest floor. The mass of water now forced around the edge of the dam crest quickly eroded a new channel to the side of the dam, causing failure.

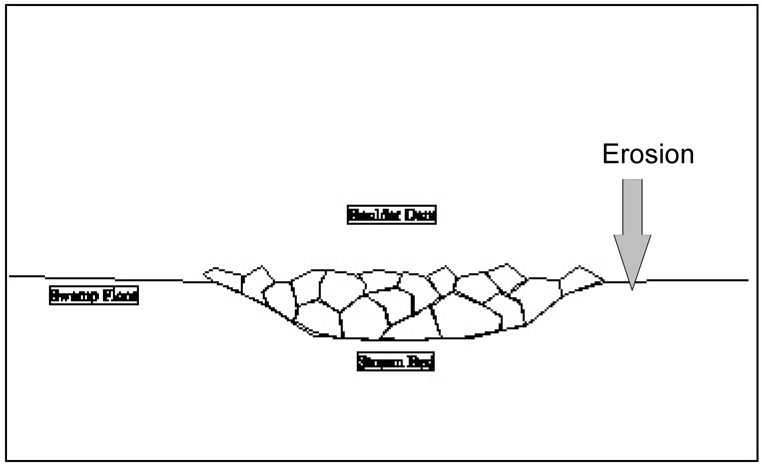

Figure 3. Cross section through dam. The intent to back up water only created heavy erosional force at the edge of the structure. All dams failed in the same manner. Even if erosion had not occurred, the water levels behind the dam would be insufficient to mimic natural hydroperiods and amplitudes.

This case has been officially determined to be a failure. It is in redesign. If the new design cannot achieve the intended mitigation alternatives must be identified.

Case B

Differences in Case B were apparent from the outset. Instead of retaining a consultant to conduct a simple vegetative assessment, City B formed a team of scientists, engineers, and managers. The team included ecologists, geologists, hydrologists, engineers, city park staff and city managers. The ecological assessment was augmented with geological studies and an engineering assessment of stream hydraulics. The resulting restoration plan was developed jointly by the team members. A hierarchical system of goals was used to help assure success.

At the outset, case B had some of the same problems that were present in case A. The most notable of these was an incomplete topographic survey. In case B, however, the team was encouraged to define the survey needs and acquire the necessary data. In case B, the stream channels were surveyed and were modeled in accordance with the existing county flood models. The controlling elevations within the system were meticulously determined. Ecological data on the soils and the flora were correlated with geological data in order to determine the condition of the swamp prior to the dehydration. Historic aerials were consulted to increase the confidence of the interpretations. A brief overview of the methods is presented in the following paragraphs.

A series of planned observation points was established using a 150 foot grid (Figure 4). These were connected to form transit lines to be walked by the field team. At each point the team would collect a soil sample and take notes on flora in accordance with standard point observation techniques. Notes were collected on canopy, mid level, and ground level flora. Notes were also taken on fauna or faunal trace. A hand held GPS unit was carried for navigation and recording purposes. The actual grid was not as uniform as the planned grid because of field conditions, but the GPS points allowed for proper adjustments to be made. When flora was thick or views were blocked, roving around the central point was used to assure that the floral records were complete.

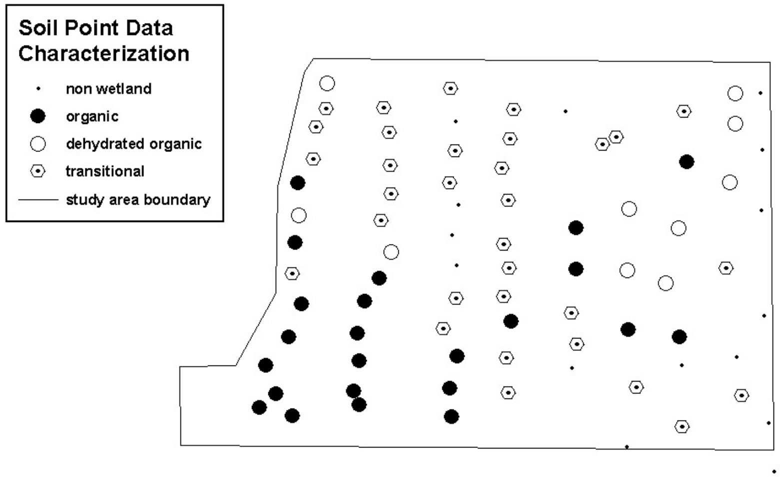

Figure 4. Soils characterized at each of the observation stations. The most severe dehydration has occurred in the upper right quadrant.

This method resulted in 81 observation stations. Almost all areas within the system were visible from at least one of these observation stations.

Soils collected from these points were classified into very general groupings based on gross conditions. These are: Organic, dehydrated organic, transitional, and non wetland. Simple contouring of these spatially referenced soil types produced a map of upland and wetland soils but also showed where the wetland soils had been most severely dehydrated.

Vegetative data were filtered so that only the oldest trees were included and subjected to clustering analyses. Dominant vegetative indicators were refined into hardwood associations and these were superimposed on the soil and topography maps (Figure 5). The high degree of consistency between the soil and vegetation maps allowed for historic pool and flood elevations to be selected from the topographic layer. An extensive literature review was used to validate and refine these field interpretations. The water depths (hydroperiods) from the literature would be applied to existing topography within each habitat type to generate targets in the engineering design phase.

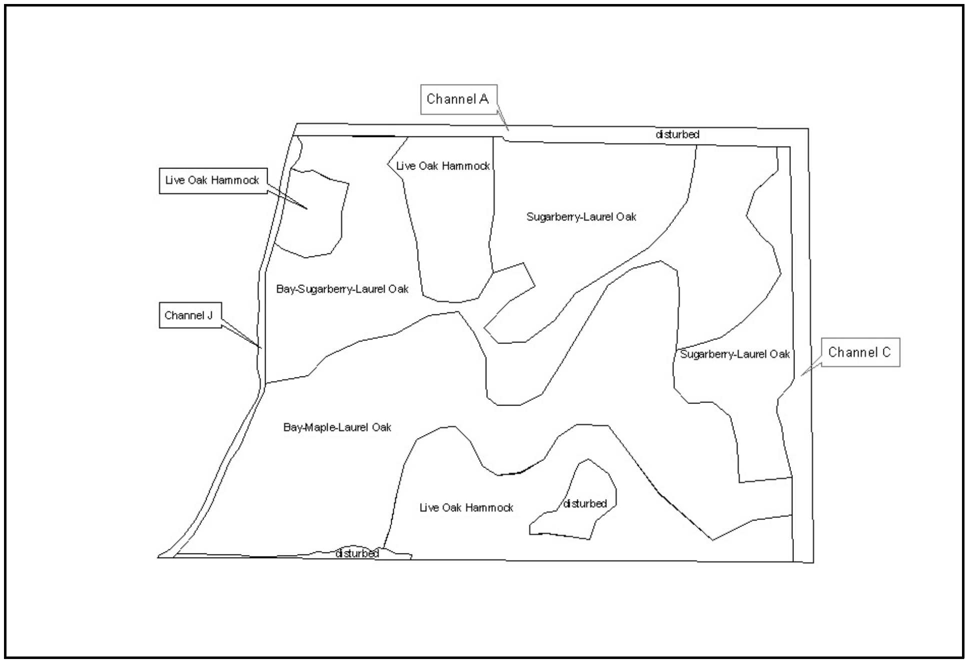

Figure 5. Habitat map created from the dominant vegetation.

The combined analyses of vegetation, soils, topography, and history allowed for a deeper understanding of the internal surface flows and their relationships with source waters and discharge points. The results were significant for numerous reasons, but the most unsuspected was that the swamp was differentiated into two separate swamp systems connected by a high water overflow (Figure 6). The eastern system was considerably higher in elevation and had a greater amplitude in the hydroperiod. The differences would require a much more complex rehydration plan.

Groundwater levels are known to play a major role in hardwood systems dominated by Bay trees. Concurrent with the field investigations of soils and flora, nine shallow wells were installed. Boring logs were kept from each of these to validate and give depth to the 81 surface soil samples. Four of these wells were equipped with water level data loggers (Figure 7). The other four were inspected weekly and levels recorded. A water level data logger was also

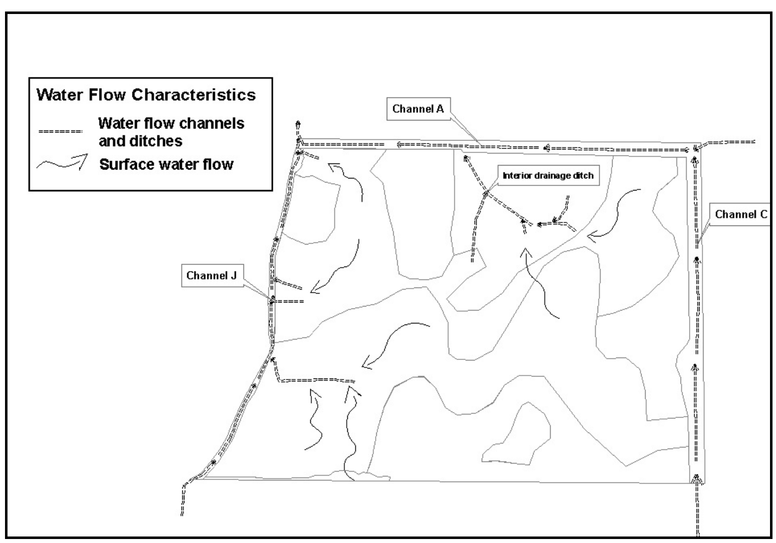

Figure 6. Surface water flow pattern.

installed at the face of the weir in the main discharge channel of the swamp system. A tipping bucket rain gauge and logger was installed on site. Conventional techniques often rely on weekly records to establish relationships between groundwater, stream flow, and rainfall. The hourly records of the data loggers provided a much greater insight into these dynamics.

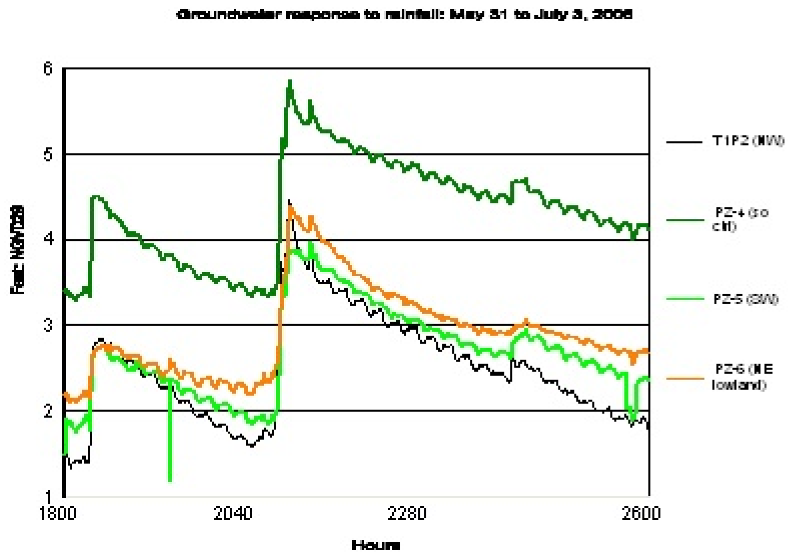

Figure 7. Typical data set from 4 wells. Low spike at 2010 is record taken during maintenance and is an anomaly. Groundwater response to two major rain events and one minor one are seen. Groundwater is seen to respond very rapidly to rain and discharge slopes are different in each.. Hourly records allow for direct measurement of the effects of transpiration: inferred from the 24 hour oscillations apparent in the graph.

By modeling the water level in each well against each of the others, recharge and discharge patterns assisted in determining the best locations and volumes of water needed (Figure 8). The modeling revealed, for example, that when water levels rose in well T1P2, water backed up in well PZ6 (which had no surface source) but only to a point. At a distinct elevation, the water in PZ6 ceased responding to the levels in T1P2 indicating a different discharge pathway had been activated.

These relationships allowed the engineering team to determine that the best plan was to elevate groundwater by additions to the western lobe first. The eastern lobe would not require as much augmentation as initially thought, because it was reacting to the western lobe. The design resulted in a less

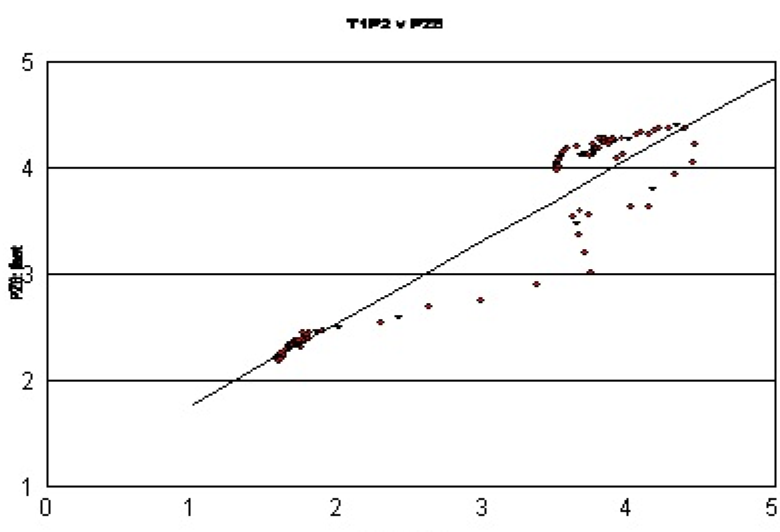

Figure 8. Relationship between water levels in two of the wells.

expensive proposal which retains the elevational differences between the lobes.

In summary, the original concept of a single dehydrated swamp had been refined. The system is a set of two swamps, one staged slightly above the other. The western system is fed by both groundwater and a small remnant stream. When wet, the western system will create a back pressure head in the groundwater that will elevate ground water levels beneath the east system, but not to the point of hydrating the surface soils. The engineering solution needed to consider the severance of normal groundwater flow by the deeply incised channel C and provide a surface input to the eastern lobe while not over hydrating the western one.

The data collected was used to define the system in terms of geology, groundwater, source water, soils, existing vegetation, and old growth vegetation. Both an historic condition and an existing condition were identified. The field data and an exhaustive literature review gave the biologists the information needed to develop target levels for standing water in wet weather, amplitudes of fluctuations, high water discharge levels and rates, and dry weather dessication rates. These targets were then given to the engineering team. The engineers, using the stream models, were able to determine the modifications needed to divert high water flows to the swamp system providing the water levels and amounts requested by the biologists. By capturing only the high water stream flows, the inundation of the swamp is tied directly to rainfall events, providing a degree of uncertainty and unpredictability that mimics natural conditions.

In Summary the restoration plan focused on incorporating natural semi stochastic events. Major plan goals are:

- Hydration is tied to natural events introducing unpredictability
- Planned but unpredictable wet and dry seasons
- Flood water retention during the wet season but with fluctuating water levels
- Floodwater discharge and dessication during dry season
- Adjustable controls during first years to allow for fine tuning
- Continuous multi year monitoring and analysis of performance
- Back up plan: augmentation is available if needed

Hydration as a method of exotic plant control

During the vegetative assessment conducted in the first stages of Case B, detailed notes on exotic plants were collected and converted into maps (Figures 9, 10). Data were collected on canopy, mid strata, and ground level plants.

Exotic plants in the canopy layer were infrequent, but were large specimens. Exotics in the mid stratum were widely dispersed, occurring at almost every observation point, but they were not dominant. From these a threat matrix was developed indicating where and approximately when the exotics in the mid canopy would become dominant.

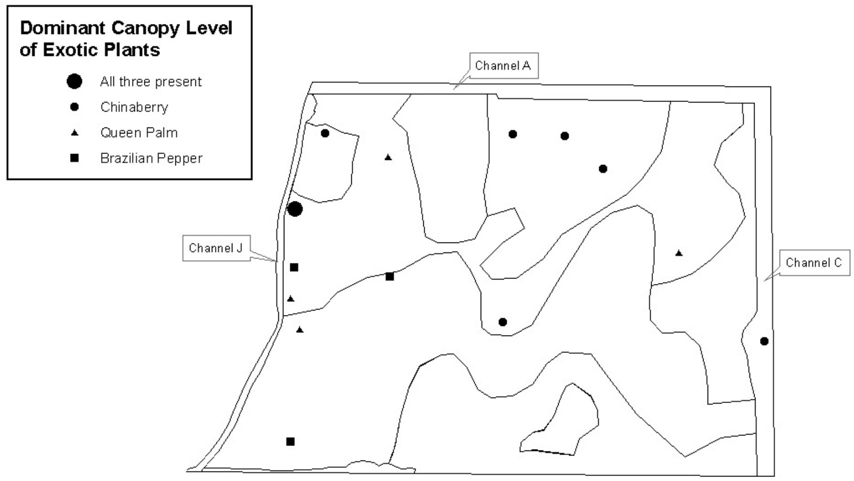

Figure 9. Exotic plants in the canopy level.

In Case B, the exotic plants were predominantly species invading uplands and transitional areas rather than deep swamp areas. In Case A, the exotic plants included those in both uplands and wetlands. Wild Taro, Primrose Willow, and others were abundant. It is apparent that rehydration of a system already heavily populated with hydrophilic exotic plants would do little to reduce their population. Rehydration in the absence of exotic control programs will only result in a shift from one set of exotic plants to another. Active management is required.

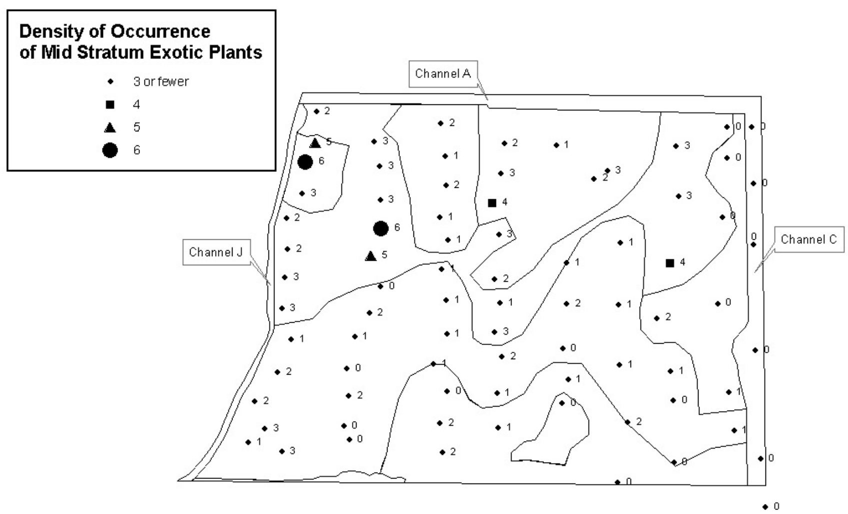

Figure 10. Exotic plants in the mid stratum.

The initial reaction from managers in these cases was that a one time removal of the plants would suffice. An educational effort has been successful in both cases. Managers in both Case A and B understand that all exotic plant programs require three stages to be successful:

- Remove existing biomass or standing crop creating space for native recruitment
- Eliminate recruitment of exotics from the seed bank by frequent maintenance

- Control immigrant recruits

These stages must occur sequentially. Standing crop plants must not be allowed to reach maturity and initiate internal recruitment.

Conclusion

Case A was a total failure. The City spent five years in a failed attempt to provide mitigation and exotic plant control. The City is now hiring a team to prepare and implement the mitigation plan the way it should have been done. In short, the attempt to reduce costs resulted in a five year delay, the loss of the original investment, and an overall cost increase. Managers in Case B conducted a focused scientific study which provided engineers with specific ecological targets in terms of water delivery and discharge. This project is not yet complete. Even though managers in Case A had commenced the project using faulty science, both sets of managers were receptive to well founded, scientific consultation. The study, once again, emphasizes the need for a priori collaboration among a team of professionals basing plans and decisions in good science.