WATER SUPPLY ASSESSMENT AND RANKING OF WATERSHED DAMS IN GEORGIA

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Abstract Jordan, Jones & Goulding, Inc. (JJG, teamed with Schnabel Engineering, LLC) was selected by the Georgia Soil and Water Conservation Commission (Commission) to inventory and evaluate the water supply potential for 166 existing Watershed Dams in Georgia. Because of tremendous growth in the past several decades, water supply sources are increasingly in demand in Georgia, particularly in North Georgia. Also, environmental permitting requirements associated with constructing new reservoirs are increasingly stringent. Expansion of existing reservoir structures may be more acceptable to resource agencies, because many of the environmental impacts associated with existing reservoirs have already occurred.

The Commission wanted a methodology to assess its existing dams and to rank their relative suitability for water supply; but inventory, assessment and ranking of 166 dams and their potential for expansion is no small task. JJG employed a GIS-based approach to the inventory and evaluation process. Available data resources were accessed and pertinent information on many factors was obtained, including wetlands, streams (including trout streams), protected species, cultural resources, numbers of affected structures and roads, impaired streams [303(d) or 305(b) listed], and distance to existing surface water intakes. Use of these data coverages made the organization of this huge amount of information manageable.

The available environmental resource data was compared to potential reservoir yields, potential for pumped-storage operation, and distance/cost of pumping to existing water systems. This information was assembled into an electronic matrix that enabled ranking of the various economic and non-economic factors according to their perceived importance. By iterations of the matrix, sensitivity analyses of the alternatives were done to look at their robustness under various yields and operating conditions.

The top twenty alternatives that emerged from the ranking process were physically surveyed by JJG ecologists and engineers to refine the previously-collected data under “real-world” field conditions. Field data sets were collected using global positioning system (GPS) equipment, enabling the more accurate information to be downloaded directly into the GIS database. This in turn enabled a rapid re-evaluation of the rankings of the 20 most suitable alternatives.

INTRODUCTION

The Commission, in partnership with the Natural Resources Conservation Service (NRCS) and the Georgia Environmental Protect Division (EPD), evaluated the flood control dams designed and constructed under federal laws PL 544 and PL 566, in order to determine which structures could best be modified to serve as water supply reservoirs.

The 352 watershed dams in Georgia were primarily designed and constructed for flood control and as sediment traps. Most of the dams are maintained and operated by Soil and Water Conservation Districts. In a few instances, cities or counties are the easements holders and have the responsibility to operate and maintain the structures. Many of these dams are now in or adjacent to urban areas where flood control is even more relevant but the demand for water is exceeding the developed supply.

The Commission, with assistance from the NRCS and the EPD, performed an initial assessment of the 352 watershed dams. The dams were assessed based on proximity to heavily developed urban areas, and drainage basin or watershed area. Dams with drainage areas less than 4 square miles, and dams located near dense urban environments were eliminated. A small drainage area would not provide a useable water supply, and the dense urban environment would make property acquisition for expanded pools expensive, and probably contentious. The Commission eliminated 186 structures, with 166 dams retained for more detailed assessment.

The Commission retained the professional services of Schnabel Engineering South, LLC (Schnabel) and Jordan, Jones and Goulding (JJG) to further evaluate the remaining l66 structures based upon environmental impacts, infrastructure impacts, and potential yield, with JJG having primary responsibility for environmental impacts and water supply infrastructure impacts, not including the dam footprint. Out of the 166, twenty were selected for even more detailed study, including the potential cost of refurbishing the dam and associated infrastructure to supply a minimum feasible yield.

ENVIRONMENTAL EVALUATION FACTORS

Environmental factors were selected based on the critical impact they would have on the expanded reservoir permitting process and consisted of the following:

- Wetlands
- Streams
- Impaired Streams
- Trout Streams
- Threatened and Endangered Species
- Cultural Resources
- Historic Resources

These factors were deemed to have a significant impact, and in some cases, an absolute barrier to permitting. They were compiled, for the most part, from readily available Internet sources. In most cases, these factors were already in a GIS-based coverage that could be readily overlaid to the expanded reservoir footprints. There were several factors for which GIS coverages were created out of non-GIS readily available sources. The following describes each of the environmental factors used in the reservoir selection process and their sources. The sources are administered entirely by various State of Georgia sponsored agencies.

Wetland Impacts

The Georgia GIS Clearinghouse contains wetland coverages for the entire State developed from the National Wetland Inventory (NWI) digital data files. These files are records of wetlands locations and classifications as developed by the U.S. Fish & Wildlife Service. The files are both linear, representing streams, and polygonal, representing wetland areas and other jurisdictional features, such as ponds. It was discovered early in the collection process that the NWI streams were not as comprehensive as the USGS quadrangle streams also from the Clearinghouse. Therefore, the linear NWI coverages were not used in assessing the stream impacts; the U.S.G.S. streams were used for this purpose. However, the polygonal coverages were used to assess wetland and associated jurisdictional impacts.

The polygonal features were separated into two categories, palustrine (wetlands, marshes, etc.) and lacustrine (ponds and lakes). It was opined during project team discussions that palustrine impacts would be a more critical factor so separating into two categories would allow application of more weight to the palustrine impacts.

Wetland impacts were measured based on the amount of acres within the expanded reservoir footprint.

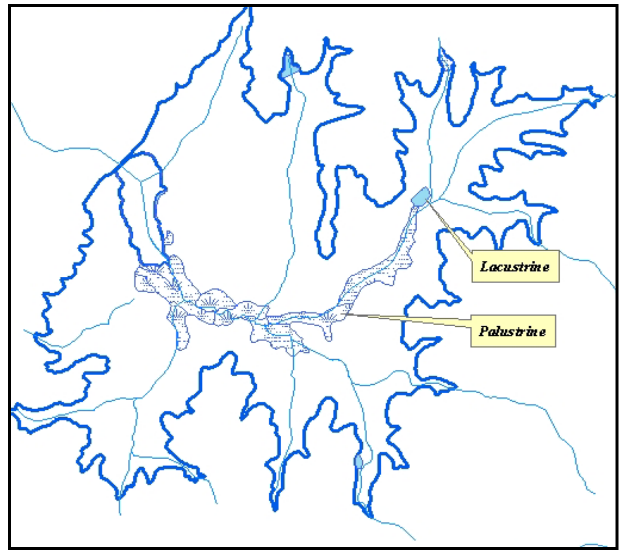

Figure 1. Example, Wetland Impacts

Stream Impacts

The Georgia GIS Clearinghouse contains stream coverages developed from the latest United States Geological Survey (USGS) 7.5 minute quadrangles. The coverages are specific to each Georgia county and represent both the perennial and intermittent "blue-line" streams shown on the quadrangle maps. The streams from each county that contained at least one of the 166 reservoir locations were downloaded from the Clearinghouse.

Stream impacts were measured based on the number of linear feet of stream within the expanded reservoir footprint.

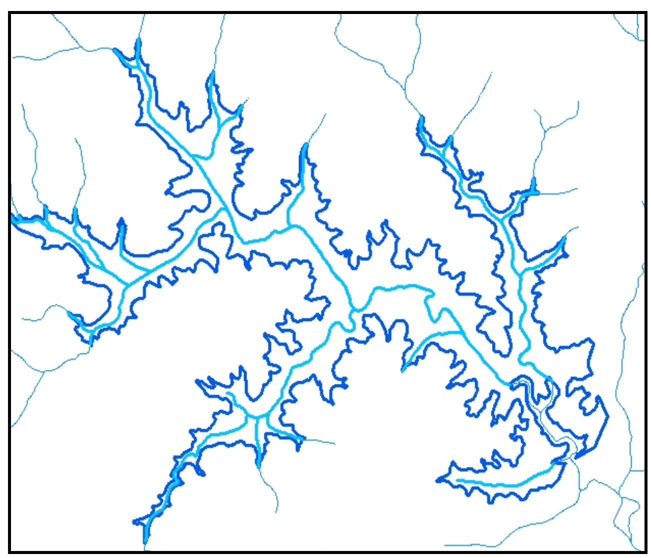

Figure 2. Example, Stream Impacts reservoir footprint

Impaired Streams

The Georgia Environmental Protection Division (EPD) has responsibility for maintaining a list of water quality impaired streams in the State, the 303(d) list. This list is updated every two years, with 2002 being the first year the list was formulated. The list was updated in 2004 and 2006. Only the 2002 list had been placed by EPD into a GIS coverage. This 2002 list coverage was downloaded along with the table listings for 2004 and 2006. The 2002 GIS coverage was manually adjusted using the 2004 table listings to formulate a GIS coverage for the 2004 list. This 2004 GIS coverage was then manually adjusted using the 2004 table listings to formulate a 2006 GIS coverage. Finally, the 2006 GIS coverage was used to determine listed streams that would be impacted by the expanded reservoirs.

Impaired stream impacts were measured based on the number of linear feet of impaired stream within the expanded reservoir footprint.

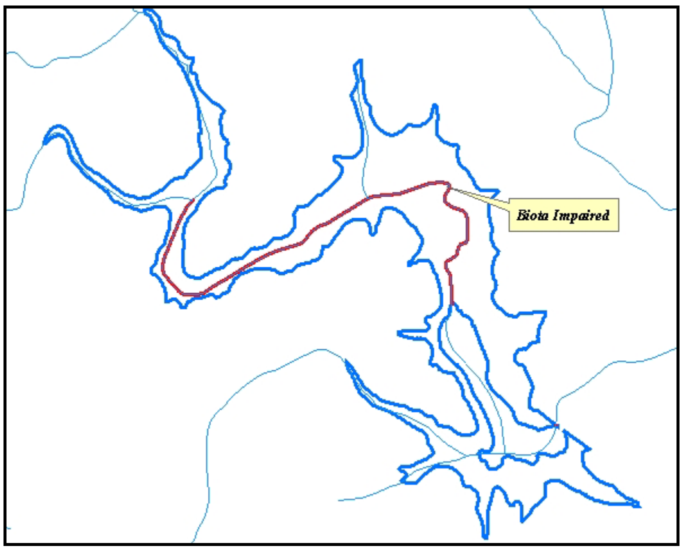

Figure 3. Example, Impaired Stream

Trout Streams

The Georgia DNR maintains designated trout stream maps in a PDF format on its website. These maps are specific to counties containing trout streams. Examination of the maps suggested that they were created using a GIS and therefore the trout stream GIS coverage might be available. JJG contacted DNR personnel knowledgeable about the GIS trout stream coverage and obtained an electronic copy of the GIS coverage. That data was used to assess impacts to trout streams from the expanded reservoir footprints.

Potential impacts were assessed for both primary and secondary trout streams. Trout stream impacts were measured based on the number of linear feet of trout stream within the expanded reservoir footprint.

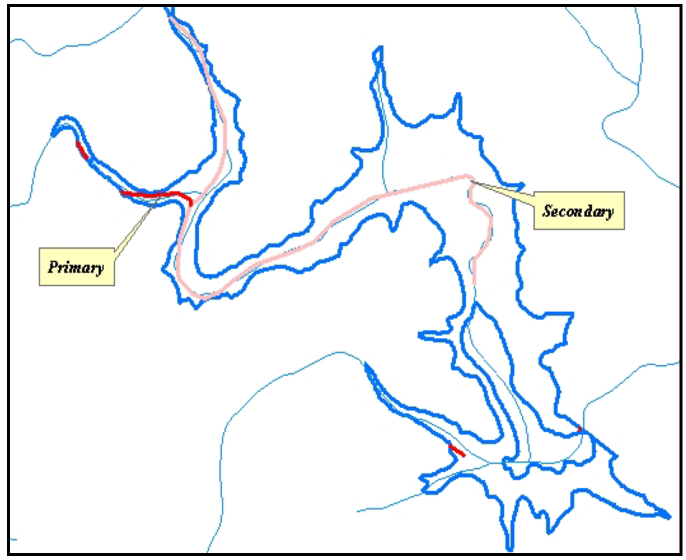

Figure 4. Example, Trout Stream Impact

Threatened and Endangered Species

The Clearinghouse maintains a statewide GIS coverage of threatened and endangered species. The coverage is not a geo-database that contains locations of specific known occurrences. It is, rather, data that is attached to the 3.75-minute quarter-quad grid for the State of Georgia. The potential threatened and endangered species that may be encountered within the specific quarter-quad area are associated to the specific graphic grid shape.

Species were categorized as flora, fauna, or natural communities, as defined in the geo-database. It was opined during team discussions that flora would present a less permitting difficulties than fauna. Separating into categories allowed different weightings to be applied to any category. Threatened and endangered species impacts were measured based on the number of potential occurrences in the quarter-quad area within which the expanded reservoir footprint is found.

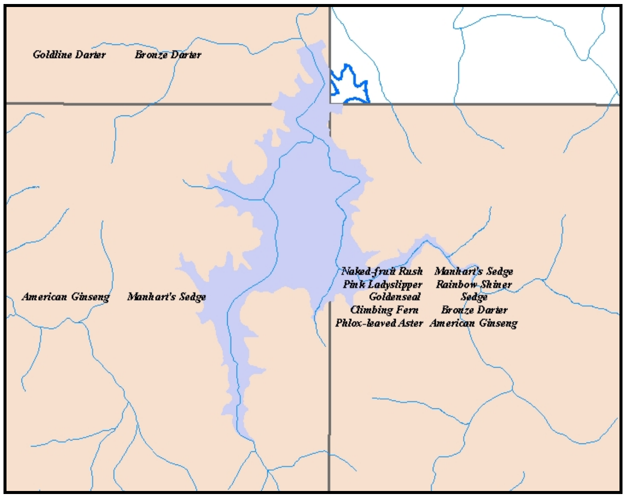

Figure 5. Example, Threatened and Endangered Species

Cultural Resources

The Clearinghouse has GIS coverages specific to each county that contain point locations of named features located throughout Georgia. This data is an extract from the Geographic Names Information System (GNIS) compiled by the USGS. The information has been typically used in emergency preparedness, marketing, site-selection and analysis, genealogical and historical research, and transportation routing applications. It therefore has an excellent capacity for application as an environmental factor in reservoir selection. Cultural resources consist of human-created features such as airports, schools, churches, cemeteries, etc.

Cultural resource impacts were measured by the number found within the expanded footprint of the reservoir.

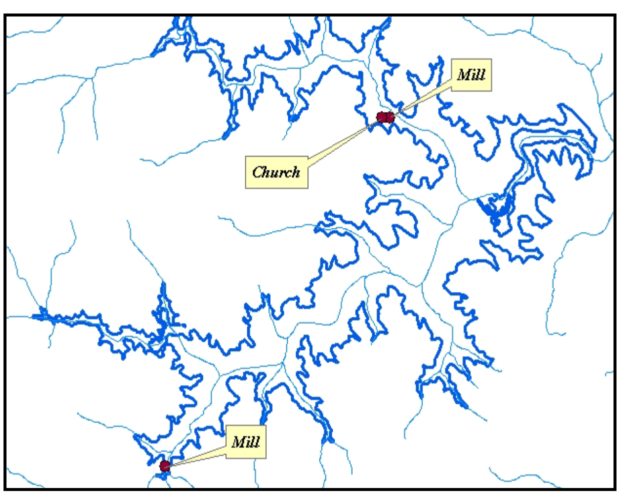

Figure 6. Example, Cultural Resources Impacts

Historic Resources

Georgia's Natural, Archaeological, and Historic Resources GIS (NAHRGIS) is a geographical information system designed to catalog information about the natural, archaeological, and historic resources of Georgia. In its current, initial phase of development, NAHRGIS contains information about Georgia's archaeological and historic resources. Historic resources include buildings, structures, historic sites, landscapes, and districts included in the Historic Preservation Division's Historic Resources Survey or listed in the National Register of Historic Places. This information has been compiled by the Historic Preservation Division of the DNR-Georgia's state historic preservation office-in collaboration with the Georgia Archaeological Site File at the University of Georgia. The historic resource GIS coverage was downloaded and overlaid to the expanded reservoir footprints. Archaeological site locations were requested but they were not provided.

Historic resources were measured based on the number of sites found within each expanded reservoir footprint.

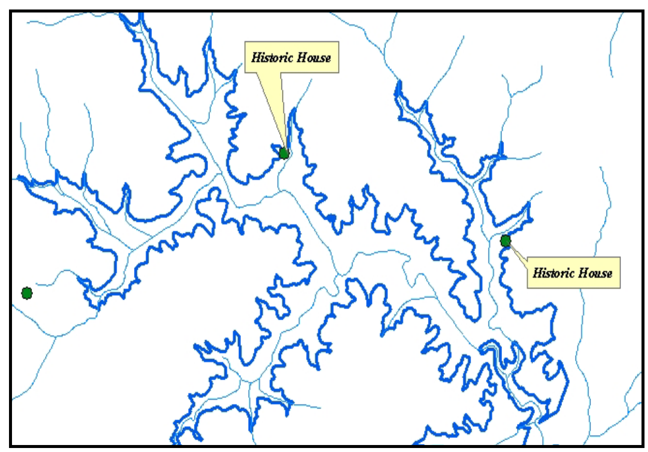

Figure 7. Example, Historic Resources

ENGINEERING FACTORS

Several engineering factors were also used to assess the watershed dams and included the following:

- Approximate Yield
- Reservoir Fill Time
- Pumping Distance – Pumped storage facilities only, non-pumped storage facilities were automatically given a default advantage in this category with a distance of zero.
- Streets
- Structures
- Distance to Downstream Intake

Distance to Downstream Intake

Several GIS coverages were required to quantify this factor. The same USGS stream coverages described in the environmental stream impact section were used here as well. The downstream path from each reservoir was extracted. In some cases, additional county stream coverages were required to contiguously map the stream path from the dam to the downstream intake.

There was not a readily available GIS coverage of existing intake locations. A GIS coverage from an older issue of the Digital Environmental Atlas of Georgia CD set was available. In addition, a GIS coverage of water supply watersheds was available from the Georgia Clearinghouse. GIS points were created at the most downstream limit of the water supply watersheds. These points were combined with the older Atlas intake locations to produce a single coverage of intake locations. The combined locations were compared to locations described in the document "Water Use in Georgia by County for 2000, Information Circular 106, Julia Fanning, USGS, Atlanta, 2003". New locations were created or existing locations moved as required resulting in a final intake location point coverage.

The downstream contiguous stream paths from each dam to the nearest downstream intake location were extracted for each dam. Impacts were measured as the linear stream distance in feet from the dam to the intake location. Those dams that did not have a downstream intake location were given a distance equal to twice the distance of the longest actual measured distance in order to quantify a disadvantage to those dams.

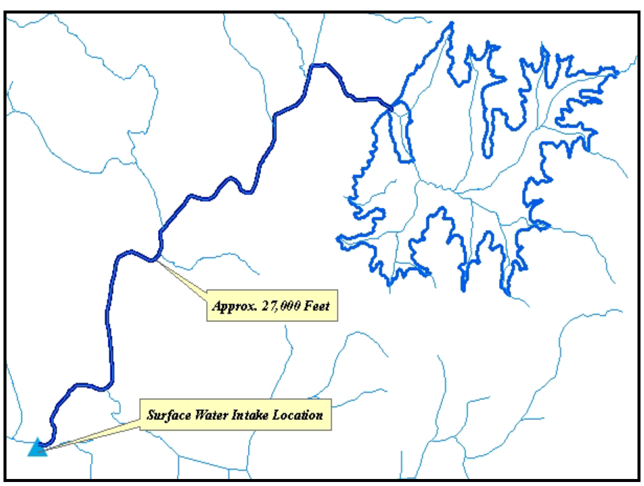

Figure 8. Example, Distance to Downstream Intake

GIS IMPACTS ANALYSIS

The impacts analysis was developed using the coverages described previously. The first step in this process was to eliminate the area of the existing NRCS lake within each reservoir footprint. This was accomplished so that no impacts would be measured from the existing normal pool of each lake.

The second step was to extract each of the environmental factors that were found within the expanded pool of each reservoir. The extraction was accomplished so that the dam name would be associated with reservoir specific factors. In this way the summing of factor measurements would be facilitated for each reservoir. This second step created a "one to many" coverage with many database entries associated with one reservoir. For example, several USGS stream reaches were associated with one dam. This "one to many" format was created in this second step for all the environmental factors. Since the summing of the factors was to be accomplished in a spreadsheet environment, a third step was necessary to "dissolve" all specific reservoir factors for each environmental category into one database entry for each reservoir. This third step "dissolves" the numerous environmental factor database entries for each reservoir into one entry for each environmental category. The description of each individual impact is lost in this third step, but the "multipart" nature of the dissolve result means that the graphic representations are found in one database entry, thus facilitating a calculation of the length, area, or number of each environmental impact for each reservoir. The databases created from this third step were imported directly into a spreadsheet for comparison of the impacts from all 166 reservoirs.

DECISION MATRIX SPREADSHEET

Upon development of the GIS database, the sums of the various environmental and engineering impacts from the 166 dams were imported into a spreadsheet for evaluation. The spreadsheet was formatted as a decision matrix so that rankings could be developed to facilitate selection of the top 20 dams. The decision matrix consisted of three ranking procedures, each independent of the other so that comparison of the methods could be made. Each ranking procedure also included two iterations, one ranking with no pumped-storage facilities and one ranking that included all pumped-storage facilities. Within each procedure, the individual factors were ranked. The sums of these individual rankings were used to extract the dams with highest overall rank.

The following is the list of each ranking category and the raw ranking unit:

- Cultural Resources – Number of sites impacted
- Historic Resources – Number of sites impacted
- Trout Streams – Linear feet impacted
- USGS Streams – Linear feet impacted
- Impaired Streams – Linear feet impacted
- Lacustrine Wetlands – Acres impacted
- Palustrine Wetlands – Acres impacted
- Surface Water Intakes – Linear feet to nearest downstream intake
- Threatened and Endangered Species – Number of fauna impacted
- Threatened and Endangered Species – Number of flora impacted
- Threatened and Endangered Species – Number of natural communities impacted
- Streets – Number of streets impacted
- Structures – Number of structures impacted
- Approximate Yield – In MGD
- Reservoir Fill Time – In years
- Pumping Distance – In miles, for pump-storage facilities only, non-pump storage facilities were automatically given a default advantage with a distance of zero.

Ranking Matrix 1

The initial ranking matrix consisted of the raw values of environmental and engineering factors without regard to the relative magnitude of each category. For example, the number of cultural resources impacted by an expanded reservoir would be typically less than 10, while the distance to the nearest downstream intake would be in thousands of feet. This automatically placed more weight on those values with higher relative magnitudes of values. Accordingly, a weighting factor was included for each category so that some normalization could occur between factors without regard to the relative magnitude of each. However, we realized that this weighting factor was serving both for normalization and weighting, which in reality needs to be two unique values.

The ranking was formulated simply by adding the raw values including any weights given to specific categories. Ranking Matrix 1 data resulted from a cumbersome process with a wide fluctuation in weighting factors to normalize the data. It was retained in the decision matrix simply as comparison to the other two ranking matrices.

Ranking Matrix 2

Ranking matrix 2 separated the normalization and weighting factors into two unique elements. The normalization factor was simply the ratio of the number of values (166 for the non-pumped-storage list, 195 for the pumped-storage list) in each category to the maximum ranking value in each category. The impact assessment for each category was conducted on the normalized values. Each category therefore had a normalized ranked structure reflective of a spread from either 1 to 166 or 1 to 195, depending on which list was examined. Without this normalization, the ranking spread would be inconsistent between categories. For example, only 23 dams had cultural resource impacts. Without the normalization factor the ranking spread would be from 1 to 24, instead of 1 to 166. This would produce the same problem found in Ranking Matrix 1, with the higher relative magnitude factors controlling the rankings. By taking the highest number of cultural resource impacts on an individual dam, in this case 9, and dividing it into either 166 or 195, the ranking spread would reflect a range either 1 to 166 or 1 to 195. Doing this with each ranking category produced rankings across all categories using consistent ranking ranges.

This simplified the weighting values because no more than a two digit integer would be required for any weighting value. If any category were believed to be say, twice as important as the others, it could be given a weight of two. By the same token, if a category were deemed 10 times more important than the others, it could be given a weight of 10.

Ranking Matrix 3

Ranking Matrix 3 changed the normalization factor in Ranking Matrix 2. Instead of using a ranking spread of either 1 to 166 or 1 to 195, the ranking spread was normalized to 0 to 1. This was accomplished by dividing each value in the category by the highest value in the category such that each ranking is a fraction of the maximum value in its specific category. This also allowed a simplified weighting factor in the same way as Ranking Matrix 2.

FINAL SELECTION PROCESS

Once the matrix selection spreadsheet had been developed, the project team met to pare down the list to the final selected 20 dams for which more detailed analysis would be conducted. The team initially concluded that even if some dams had very favorable environmental settings and a minimal number of impacts, there would be no incentive to invest in retrofitting for water supply if there were not a reasonable yield to be expected. Therefore, the initial selection consisted of all dams with a yield of at least 1 MGD, since this was considered a minimal yield for investment incentive. This initial selection whittled the list down to 85 dams.

The issue of fill time then became of interest because even if the yield was attractive, an excessively long fill time would mean the yield could never be practically realized. The list of 85 dams was reduced to 55 by using a maximum fill time of 10 years. The 10-year limit was selected by the project team as a convenient maximum in order to eliminate impractical dams from further consideration.

The selection process was then adjusted based on research conducted by the project team. For instance, it was known that some areas where dams were located did not have a compelling need for water supply, or already had major projects underway not related to watershed dam sites. In addition, dams from the list that were physically near dams with higher yields were eliminated because the financial investment in a given area could be expected on the higher yield facilities. Using these rationales, the list was reduced to twenty dams with 2 selected as alternates.

SELECTED FINAL TWENTY DAMS

The final twenty selected dams were assessed in more detail. The environmental factors were field checked, although a fully detailed field study appropriate for Section 404 permit submittal was not done. The purpose was to identify whether the databases from the various sources were appropriately accurate for determining the conceptual costs of expanding a given dam and reservoir.

In addition, more detailed yield studies were completed by Schnabel at other potential elevations to optimize the yield with fill-time. In some cases, this reduced the footprint of the dam, and therefore reduced the ranking factors. The magnitude of impacts was appropriately reduced for the purpose of developing conceptual cost estimates.

JJG also developed conceptual pipeline routes for the pumped storage facilities and associated conceptual costs. Conceptual costs were also developed for intake structures and reservoir discharge structures.

For each of the twenty dams, a report was prepared outlining and describing the effort in developing all the conceptual parameters for water supply, including embankment size and cost, outlet structure costs, permitting costs, land acquisition costs, and associated infrastructure costs (intake, pipeline, and reservoir supply discharge). These reports were made available to communities in which the dams were located to inform them of the potential supply capability and the potential cost to develop that capability.

CONCLUSION

The 166 dams identified by the Georgia Soil and Water Conservation Commission were assessed and ranked in terms of relative impact to the environment. Potential yield and other engineering factors were calculated and used to select the twenty most feasible locations for water supply. A report was prepared for each of the final twenty dams that including potential costs for achieving the final calculated yield.

The result of this effort is documentation of the most feasible watershed dams for water supply. In this way, the expansion of an existing dam, which already impacts various environmental factors, could be a less strenuous and more timely permitting effort. The twenty individual reports provide local communities with a foundational road map for developing needed water supply in the north Georgia area.