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ENGINEERING • PLANNING
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TO: Town of Norwich, VT
Norwich Pool Dam: Engineering Evaluation Results

Date: November 7, 2012

## I. Background:

The purpose of this memorandum is to summarize the engineering evaluation of the Norwich Pool Dam and provide recommendations to reestablish the dam and the pond it impounds. The dam was built in 1944 for community recreation, and created an approximate 0.5-acre pond at the normal pool level.

The dam suffered extensive damage during the August 28, 2011 Tropical Storm Irene. The damage included erosion and failure of the right abutment, which caused the draining of the pond, extensive gravel and sediment deposition in the pond area, and loss of the platform and related public amenities. The dam requires reconstruction in order to reestablish and safely impound the pond.

The Town's objective is to reconstruct the dam and reestablish the pond with construction tentatively planned for 2013. In May 2012, the Town hired Dubois & King, Inc. (D&K) to lead the planning, permitting and engineering effort and to assist with the management and oversight of construction.

As part of the planning phase, D&K conducted an engineering analysis to evaluate the existing dam and determine if it can be rehabilitated or requires a new structure be built. This memorandum documents and summarizes those analyses and provides recommendations our action by the Town.

## II. Regulatory Jurisdiction:

The Norwich Pool Dam, which impounds approximately 4-acre-feet of water, falls significantly under the minimum 11.45 acre-feet threshold that triggers jurisdiction of the State Department of Environmental Conservation (DEC), Dam Safety Section (Chapter 43, 10 V.S.A.). However, any work below the top of the riverbank does fall under the jurisdiction of the DEC River Management Section, and approval from River Management is required. Part of the project review and approval through River Management is comments and requirements from the State Fish and Wildlife Department, normally through their regional fisheries biologist.

An initial meeting was held at the dam site on June 20, 2012 with Mr. Barry Cahoon, P.E., the regional VT River Management Engineer to discuss the project and standards required for repairing or replacing the dam. Mr. Cahoon clearly stated the Town will be required to meet the

same level standard of design as required by the VT Dam Safety Section under Chapter 43, 10 V.S.A.

Mr. Cahoon also indicated the potential permitting challenges in obtaining fisheries clearances. Mr. Cahoon provided us with a copy of a letter dated February 8, 2012, from the VT Department of Fish and Wildlife to the regional VT River Management Engineer, which indicates that F&W would not support reestablishment of the Norwich Pool, at least unless several key conditions are implemented into the design.

Because of this, the issues identified in the letter served as guidance when evaluating potential alternatives. Design elements were added to the alternatives to specifically address those issues. One key design element includes the passage of fish. D&K understands the State's position is if a permit is to be issued, then they will likely require the incorporation of a fish passage device and a sediment management plan. A second expected condition is any repaired or replacement dam must have enough spillway hydraulic capacity to pass significant flood events in order to minimize the potential for future washout of the dam.

In addition, the U.S. Army Corps of Engineers has jurisdiction on work in the waterways and rivers, and Section 401 clearances will be required through the New England Division's Vermont Regulatory Field Office. However, we believe the project should be considered to be a maintenance project, which is consist with their prior conclusions on similar projects, as long as it is repaired or replaced in the existing footprint, and the water levels do not change.

## III. Existing Conditions:

To establish the existing (post Irene) conditions at the site, D&K conducted several site visits / inspections, and conducted a topographical survey and several soil test pits. The formal site inspection was conducted on June 1, 2012, and was led by Shawn Patenaude, P.E. Because the pond was empty, much of the remnants of the dam were exposed, and we were able to view quite a bit of it.

There are no known records of the original construction of the dam, or any documentation, such as engineering plans or material specifications. The following conclusions were based on D&K's visual observations.

The floodwaters from T.S. Irene overwhelmed the hydraulic capacity of the spillway, and during the flood, water rose high enough to where it started flowing over the right abutment area (the land beyond the side of the concrete dam). This abutment area consists of earth material, and is easily eroded during severe flood conditions. An approximate 20-ft wide section of this abutment area eroded down to the base of the dam, and the brook now flows around the right side of the dam.

An observer, who was at the dam area during the flood, captured some of the dam failure on video. This video illustrates the floodwaters rising up on the dam, and the subsequent destruction of the former dock.

Much of the original dam survived the flood. The right concrete abutment wall, stop log section, both spillway bays, the left abutment and the walkway over the dam survived largely intact. However, much, if not all of the remaining dam is in poor condition. This is not caused so much by Irene, but rather by its progressive deterioration over the 67 years since it was originally constructed.

During the site inspection, D&K's survey crew conducted a topographic survey of the dam and surrounding area. This survey was used in our hydraulic and alternatives analysis, and will also

be used in developing the final design of the new dam. In addition, the Town provided a backhoe to dig test pits along the foundation of the dam and in the impoundment. Results of this are discussed below.

## IV. Preliminary Evaluation:

Our preliminary evaluation considered three (3) primary areas of engineering: geotechnical and foundation conditions, structural and material condition, and hydrology and hydraulics.

### Geotechnical and Foundation Conditions

The purpose of the test pits was to estimate the foundation conditions adjacent to the dam and establish a distance to bedrock. A total of three test pits were dug. In each test pit bedrock was found between 4 and 6 feet below the existing ground surface (BGS). In Test Pit #1, located immediately upstream of the flashboard section of the spillway, a 1-foot thick concrete footing was found at 5 feet below BGS. This indicates that the dam was likely founded on bedrock, which would help explain its stability during T.S. Irene.

Two conclusions resulted from the test pits effort: the existing dam is founded on bedrock and because the bedrock is close to the surface any new construction should be founded on bedrock. This is significant because of the increased stability of any new structure. It also indicates a cost savings by avoiding large and complicated footings or foundation elements.

### Material / Structural Evaluation

D&K evaluated the structural elements of the existing dam, including the flashboard system and the material condition of the concrete, as well as an overall evaluation of the remaining components of the structure.

A deficiency identified during our site inspection was the flashboard system, which is the timber boards that extend above the concrete crest, and increases the depth of impounded water. The timber boards are held in place with steel posts. A properly designed flashboard system yields during periods of high flows, which in turn, increases the hydraulic capacity of the spillway, and begins to lower the water level in the pond. Because the steel posts at the Norwich Pool dam did not yield, (perhaps because they were not designed to do so, were too strong, etc), the water continued to rise, resulting in the flood damages.

Original design calculations were not available for this analysis; and we suspect the existing flashboard system was intended to hold the timber board in place without regard to yielding during a flood event. The support braces are configured in a manner that maximizes their strength and are able to withstand a height of water significantly higher that the top of dam elevation. This makes the flashboard system non-operable during a flood event and they do not contribute to additional hydraulic capacity of the spillway.

Regarding the concrete portions of the dam, we found significant cracking, and overall deterioration of the material. This deterioration is most clearly seen in the condition of the concrete elements. There is significant cracking and section loss throughout the concrete elements of the dam, where whole sections are separated from the main dam or completely missing.

Additionally, there is significant efflorescence on the training wall and stop log section support, including significant cracking on the underside of the support members. Efflorescence is the white powdery substance that follows cracks, which represents the leaching of lime and calcium from the cement. While efflorescence itself is not a problem, it indicates a potential structural

deficiency, especially in a freeze/thaw environment.

### Hydrology & Hydraulics

D&K conducted a hydrological and hydraulic analysis (H&H) of the watershed and dam. The hydrologic analysis consisted of preparing a rainfall-runoff model using the HydroCad computer program. The model was used to develop runoff hydrographs into the pond during the 1-percent exceedance frequency. This information was then used to evaluate the hydraulic capacity of the existing dam.

The drainage area of the Charles Brown Brook that flows through the Norwich Pool Dam pond is approximately 5.6-square miles (3,597 acres). This area was delineated on a digitized 1:24000 USGS topographic map with 20-foot contours using the USGS Streamstats program.

The hydrocad model representing existing conditions for the 1-percent exceedance frequency storm indicate a peak inflow discharge of 2,553-cubic feet per second (cfs). This value correlates well with published FEMA publications. Additional exceedance frequency storms were evaluated and will be used as part of the new design.

The estimated hydraulic capacity of the dam, under full pond, normal water conditions (with flashboards in place) is approximate 200-cfs.

The H&H analysis indicates the hydraulic capacity of the existing dam is significantly less than the required capacity. The dam has been, and would remain vulnerable to overtopping and associated damages during significant storm events.

## V. Alternatives Analysis:

D&K has evaluated three (3) alternatives to reconstruct or replace the dam. D&K has prepared engineering sketches of each alternative. These sketches are attached to this memo. The following is a discussion of each alternative.

### Alternative #1: Reconstruct & Repair the Existing Dam.

Alternative #1 involves rehabilitating the existing structure. The remaining elements of the structure, including the spillway and left earth embankment require rehabilitation but can be repaired and put back in service. The primary components of this alternative include:

- Place articulated concrete blocks as overtopping protection on the left embankment.
- Reconfigure the flashboards to yield during the design storm event.
- Construct a concrete overflow section in the right abutment breach area, resulting from the flooding during Tropical Storm Irene. This section will provide additional hydraulic capacity to the dam.
- Raise the right earth abutment to add freeboard and prevent the potential for overtopping during the design storm event.
- Repair the deteriorating sections of concrete on the existing structure.
- Replace the stop log section with a rising stem sluice gate.

To address the State's concern over fish passage and sediment transport a fish ladder will be constructed and a sediment management will be required. The specifics of each will be outlined in the permit requirements, which have not been established.

The total approximate construction cost of Alternative #1 is $324,000 without the fish passage element. The fish passage costs will range between $50,000 and $100,000, depending on the specific device/approach chosen. D&K is prepared to discuss the specifics of these devices with Town officials.

**Alternative #2: Ogee Spillway and Articulated Concrete Blocks.**

Alternative #2 involves removing the existing structure and replacing it with a new, 50-foot span ogee-shaped, concrete spillway. This type of spillway maximizes the hydraulic capacity within the area between the right abutment and the left earthen embankment. However, given the design storm requirements, overtopping protection of the left embankment will still be required. The primary components of this alternative are as follows:

- Place articulated concrete blocks as overtopping protection on the left embankment.
- Construct a 50 foot ogee spillway with a steel pedestrian bridge.
- Install a rising stem sluice gate in the spillway.
- Raise the right earth abutment to add freeboard and prevent the potential for overtopping during the design storm event.

To address the State's concern over fish passage and sediment transport a fish ladder will be constructed and a sediment management will be required. The specifics of each will be outlined in the permit requirements, which have not been established.

The total approximate construction cost of Alternative #2 is $456,000 without the fish passage element. The fish passage costs will range between $50,000 and $100,000, depending on the specific device/approach chosen. As with Alternative 1, D&K is prepared to discuss the specifics of these devices with Town officials.

**Alterative #3: Labyrinth Weir and Articulated Concrete Blocks.**

Alternative #3 involves removing the existing structure and replacing it with a 40 foot, 3 cycle labyrinth weir spillway. Because of design storm requirements, overtopping protection of the left embankment will still be required with this alternative. The primary components of this alternative are as follows:

- Place articulated concrete blocks as overtopping protection on the left embankment.
- Construct a 40 foot, 3 cycle labyrinth weir spillway with a steel pedestrian bridge.
- Install a rising stem sluice gate in the spillway.
- Raise the right earth abutment to add freeboard and prevent the potential for overtopping during the design storm event.

To address the State's concern over fish passage and sediment transport a fish ladder will be constructed and a sediment management will be required. The specifics of each will be outlined in the permit requirements, which have not been established.

The total approximate construction cost of Alternative #3 is $375,000 without the fish passage element. The fish passage costs will range between $50,000 and $100,000, depending on the specific device/approach chosen. As with Alternatives 1 and 2, D&K is prepared to discuss the specifics of these devices with Town officials.

For comparison purposes the following table depicts the anticipated construction costs. Please note that the fish passage costs are interchangeable between alternatives and the final costs may be lower if different combinations are chosen.

| Anticipated Construction Costs | | | |
|---|---|---|---|
| **Cost Elements** | **Alternative #1: Rehabilitate Existing Dam** | **Alternative #2: New Ogee Spillway** | **Alternative #3: New Labyrinth Weir** |
| **Dam Construction Costs (Without Fish Passage)** | **$324,000** | **$456,000** | **$375,000** |
| **Fish Passage Construction** | **$100,000** | **$50,000** | **$100,000** |
| **Engineering Costs (12% of anticipated construction cost)** | **$50,880** | **$60,720** | **$57,000** |
| **Total** | **$474,880** | **$566,720** | **$532,000** |

## VI. Public Informational Meeting:

Shawn Patenaude presented these alternatives to the Town at a Public Informational Meeting on August 20, 2012. The meeting was well attended by the public and a very productive discussion ensued.

The evaluation approach was outlined and each alternative was discussed. Based upon the feedback during the meeting, the public seemed to be open to each alternative, but the overall preference appeared to be a new dam, and not to repair or rehabilitate the existing one. The reasons stated for this preference was a new dam would provide a longer service life. Alternative 3 appeared to D&K to be the public's top choice of the alternatives.

## VII. Recommendations and Next Steps:

As a result of our analysis and evaluations and based upon the input we received during the public informational meeting in August, D&K recommends the Town select Alternative #3. While this alternative is slightly higher in initial capital costs than Alternative #1, this alternative will provide the best least cost and long-term design for the Town of Norwich.

The Town's objective is to reconstruct the dam and restore the pond and public area during the 2013 construction season. To accomplish this, the Town will need to select an alternative to serve as the basis for the design and construction documents. Once the Town selects the alternative, D&K will complete the design and prepare bid documents suitable for competitive

bidding by qualified contractors. We expect the project to be bid for construction in the first quarter of 2013.

DuBois & King understands that the Town's objective is to have a full impoundment for the 2013 recreation season. To accomplish this construction would be expected to commence as early as practical and as conditions allow during the spring of 2013. For our part, D&K has initiated the design process, evaluating design elements common to all of the alternatives with the goal of having a construction bid package ready by mid-January 2013. Our design plans will contain the basis for any design alternative selected. They will serve as exhibits for the regulatory agencies to review and provide comment.