ESTABROOK DAM REHABILITATION WORKGROUP – ALTERNATIVES MATRIX

ATTACHMENT B

Dam & Impoundment Management Alternative	1. Do-Nothing	2. Short-Term Repairs	3. Short & Long-Term Repairs	4. Dam Removal
Description of Dam Management	* No short or long-term structural repairs are made to the dam.	* Implement STS recommendations	* Implement STS recommendations * Study stabilization of gated spillway for full ice loading. * Stabilize dam.	* Remove the Estabrook Dam including gated control structure and fixed crest spillway.
Description of Impoundment Management	* The current seasonal impoundment fill (approx. May 15 – October 15) and drawdown (approx. October 16 – May 14) operations continue, if allowed by the WDNR.	* Assumes future operational order requires dam and impoundment to be managed as run-of-the river or pool-full. *NOTE: Establishment of operational order requires a more thorough review of operation and management options, including a public review and comment process than could be presented here.*	* Assumes future operational order requires dam and impoundment to be managed as run-of-the river and pool-full. *NOTE: Establishment of operational order requires a more thorough review of operation and management options, including a public review and comment process than could be presented here.*	* Free-flowing river is restored.
Capital Construction Costs [1] [2]	* $ 0 - No short or long-term term capital costs. *NOTE: Assumes deferring the long-term repair or removal. Funding repair or removal is required for compliance with state dam safety regulations.* *$0 - Sediment management. *NOTE: Long-term sediment management costs for dredging accumulating sediment are not included.* Sediment management costs are not bondable * Capital Subtotal $0	*$2,180,000 - ($1,400,000 plus debt service) *NOTE:* Additional major and minor maintenance funding will be necessary to achieve the dam's 20-year life expectancy over and above O&M costs. *(Only Debris removal costs of $270,000 are included in $2.18M above)* *$1,000,000 - Sediment management. *NOTE: Long-term sediment management costs for dredging accumulating sediment are not included.* Sediment management costs are not bondable *Capital Subtotal $3,180,000	*$1,400,000 *NOTE:* Additional major and minor maintenance funding will be necessary to achieve the dam's 20-year life expectancy over and above O&M costs. *(Only Debris removal costs of $270,000 are included in $2.18M above.)* * $ 50,000 - $100,000 – Stabilization study * $ 2,000,000 - $5,000,000 (not including debt service costs) to stabilize dam. *$1,000,000 - Sediment management. *NOTE: Long-term sediment management costs for dredging accumulating sediment are not included and are not bondable.* *Capital Subtotal $ 5,130,000 - $9,550,000 million including debt service on G.O. Bonds.	* $ 675,000 – Dam removal including gated control structure *and* fixed crest spillway. * $ 75,000 - Re-vegetation of exposed sediment * $270,000 – Fixed weir debris removal * $1,000,000 - Sediment management. *(NOTE: Portion of natural debris, rock and concrete from demolition could be re-used on site for habitat enhancement)* Sediment management costs are not bondable *Capital Subtotal $ 2.02 million in cash financing. It is likely that G.O. Bonds cannot be used for demolition.

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Operation & Maintenance Costs	$50,000/year - Cleaning debris and vegetation control for dam icebreakers. * O&M Subtotal = 50,000/year * Amortized O&M $1,000,000 over 20-yr	* $ 50,000/yr - Cleaning debris and vegetation control for dam *and* fixed crest spillway. * $ 25,000/year – Mechanical & structural for dam *and* fixed crest spillway. * O&M Subtotal = $ 75,000/year * Amortized O&M $ 1,500,000 over 20-yr	* $ 50,000/year - Cleaning debris and vegetation control for dam *and* fixed crest spillway. * $ 25,000/year – Mechanical & structural for dam *and* fixed crest spillway. * O&M Subtotal = $ 75,000/year * Amortized O&M $ 1,500,000 over 20-yr	* $ 0 – Dam is removed with no short or long-term operation and maintenance costs. * O&M Subtotal = $ 0/year * Amortized O&M $0 over 20-yr
Life Cycle Costs 20-yr	**Capital $ 0** **O&M $_1,000,000____** **Sediment Management $0** **TOTAL $_1,000,000____**	**Capital $ _2,180,000__** **O&M $__1,500,000__** **Sediment Management $1,000,000** **TOTAL $__4,680,000 _**	**Capital $ _5,130,000-9,550,000** **O&M $__1,500,000___** **Study $ 100,000** **Sediment Management $1,000,000** **TOTAL $__7,730,000-12,150,000__**	**Capital $ _1,020,000__** **O&M $ 0** **Sediment Management $1,000,000** **TOTAL $ _2,020,000__**
Flooding, Hydraulics & Hydrology [3] [4]	**(+ / -)** 100-yr flood on Lincoln Cr. & Milwaukee R. (worst case scenario) – Seasonal impoundment at full pool or drawdown provide *no* protection against over bank flooding along Lincoln Cr. or the Milwaukee R. since the dam is submerged. Similarly, while stormsewer outlets are partially or fully submerged, operating the impoundment at drawdown does not exacerbate drainage problems along Lincoln Creek or the Milwaukee River.[3, 4] **(+ / -)** 2-yr to 10-yr flood on Lincoln Cr. – With the dam gates <u>open</u>, flood elevations along Lincoln Creek are *reduced* between 0.1-ft and 0.6-ft. [3] Although submerged, the stormsewer capacities would not be significantly compromised.[4]	**(+ / -)** 100-yr flood on Lincoln Cr. & Milwaukee R. (worst case scenario) – Dam gates closed and impoundment at full pool provide *no* protection against over bank flooding along Lincoln Creek or the Milwaukee River. Similarly, while stormsewer outlets are partially or fully submerged, operating the impoundment at draw down does not exacerbate drainage problems along Lincoln Creek or the Milwaukee River.[3, 4]	**(+ / -)** 100-yr flood on Lincoln Cr. & Milwaukee R. (worst case scenario) – Dam gates closed and impoundment at full pool provide *no* protection against over bank flooding along Lincoln Creek or the Milwaukee River.	**(+ / -)** 100-yr flood on Lincoln Cr. & Milwaukee R. (worst case scenario) – Dam removal will *not* have any negative impacts on current flood elevations or drainage problems along Lincoln Creek or the Milwaukee River. Removal provides the greatest reduction in flood elevations along Lincoln Cr. and the Milwaukee R., compared to other alternatives however; the reductions and benefits may not be significant.[3]

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Flooding, Hydraulics & Hydrology (continued)	(+ / -) Full array of 2, 10 and 100-yr flood on Lincoln Cr. & Milwaukee R. - With the dam gates open, flood elevations are *reduced* between 0.14-ft to 0.36-ft. on Lincoln Cr. at Green Bay Ave.; between 0.08-ft to 1.26-ft at the Lincoln Cr./Milwaukee R. confluence in Lincoln Park; and between 0-ft and 2.21 ft on the Milwaukee R. at Hampton Ave. [3] **(-)** Based on hydrologic and hydraulic modeling results, operation of the dam to maximize the conveyance of floodwaters would not reduce upstream the 2-yr through 100-yr flood stages significantly along the reach of Lincoln Cr. [3] The County's current practice and attendant costs for partially or completely drawing down the impoundment during flood events would continue despite this action providing *no* benefit for controlling floods or drainage problems.			**(+)** Removing the dam will *not* have any negative impact on current flood elevations or drainage problems along Lincoln Cr. or the Milwaukee R. Compared to the other alternatives, dam removal would result in the greatest reduction in flood elevations along Lincoln Cr. and the Milwaukee R. The current costs for manipulating the dam gates and water level would be eliminated.
Environmental Impacts [5] [6]	**(-)** Sediment Quality & Quantity – Annual scour and flushing of accumulated polluted sediment would continue. **(-)** Water Quality – Turbid and eutrophic (e.g., algae blooms) during pool-full	**(-)** Sediment Quality & Quantity - Annual scour and flushing of accumulated polluted sediment would be greatly reduced. In the long-term, polluted sediment will accumulate in the impoundment at increasing rates. **(-)** Water Quality – Turbid and eutrophic (e.g., algae blooms) during pool-full	**(-)** Sediment Quality & Quantity - Annual scour and flushing of accumulated polluted sediment would be greatly reduced. In the long-term, polluted sediment will accumulate in the impoundment at increasing rates. **(-)** Water Quality – Turbid and eutrophic (e.g., algae blooms) during pool-full	**(+ / -)** Sediment Quality & Quantity – In the short-term, impacts will be similar to "Do-Nothing" as previously accumulated sediment is scoured. In the long-term, upstream sources of sediment would be transported through the former impoundment or deposited above the bank-full elevation creating new river bank and floodplain. **(+ / -)** Water Quality – Less turbid and eutrophic (e.g., algae blooms) during

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Environmental Impacts (continued)	summer recreating period, less severe during coldwater and drawdown periods. **(-)** Wetlands – Negative impact on wetlands by seasonal alteration of hydrology. **(-)** Wildlife – Negatively impacts herptiles and invertebrates by desiccation and freeze-out. **(-)** Fish – Negative *seasonal* impact on fish passage by river and L. Michigan fish populations during pool-full periods (June – October) and (September – October). Diversity and abundance of fish reduced. **(-)** Due to seasonal fish barrier and poor habitat, fish diversity will be lower and recreational fishing opportunities would be dominated by tolerant species (e.g., carp).	summer recreating period, and less severe during coldwater periods. **(+)** Wetlands – Pool-full condition maintains local wetland hydrology. No net gain or loss in wetland acreage. **(+)** Wildlife – Pool-full condition prevents herptiles and invertebrates from desiccation and freeze-out. **(-)** Fish – Negative *year-around* impact on fish passage by river and L. Michigan fish populations for all periods and life stages. Diversity and abundance of fish reduced. **(-)** Due to permanent fish barrier and poor habitat, fish diversity will be lower and recreational fishing opportunities would be dominated by tolerant species (e.g., carp).	summer recreating period, and less severe during coldwater periods. **(+)** Wetlands – Pool-full condition maintains local wetland hydrology. No net gain or loss in wetland acreage. **(+)** Wildlife – Pool-full condition prevents herptiles and invertebrates from desiccation and freeze-out. **(-)** Fish – Negative *year-around* impact on fish passage by river and L. Michigan fish populations for all periods and life stages. Diversity and abundance of fish reduced. **(-)** Due to permanent fish barrier and poor habitat, fish diversity will be lower and recreational fishing opportunities would be dominated by tolerant species (e.g., carp).	summer recreating period compared to impounded condition, and less severe during coldwater periods. **(+)** Wetlands – Free-flowing riverine environment will maintain natural wetland hydrology. Potential net gain for wetland acreage as exposed banks and sediment flats are re-vegetated. **(+)** Wildlife – Natural riverine hydrology will not negatively impact herptiles and invertebrates from desiccation and freeze-out. **(+)** Fish – All barriers to fish movement along the Milwaukee R., estuary and Lake Michigan are removed. Fish diversity and abundance increase. **(+)** Fish passage and enhanced habitat will increase fish diversity and provide more quality recreational fishing opportunities for preferred game fishes.
Riparian Ownership Rights & Land Values [7] [8] [9] [10]	**(+)** Ownership rights *unchanged* – Those who own land abutting the river also own to the middle of the impoundment or free-flowing riverbed. **(-)** Potential responsibility for polluted sediment and soil. **(+)** Land value *unchanged* – Previous economic studies concluded that residential property in the vicinity of a free-flowing stream is more valuable than identical	**(+)** Ownership rights *unchanged* – Those who own land abutting the river also own to the middle of the impoundment. **(-)** Potential responsibility for polluted sediment and soil. **(+)** Land value *unchanged* – Previous economic studies concluded that residential property in the vicinity of a free-flowing stream is more valuable than identical	**(+)** Ownership rights *unchanged* – Those who own land abutting the river also own to the middle of the impoundment. **(-)** Potential responsibility for polluted sediment and soil. **(+)** Land value *unchanged* – Previous economic studies concluded that residential property in the vicinity of a free-flowing stream is more valuable than identical	**(+)** Ownership rights *unchanged* – Those who own land abutting the river also own to the middle of the free-flowing riverbed. **(-)** Potential responsibility for polluted sediment and soil. **(+)** Land value *unchanged* – Previous economic studies concluded that residential property in the vicinity of a free-flowing stream is more valuable than identical

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Riparian Ownership Rights & Land Values (continued)	property in the vicinity of a small impoundment, and the shoreline frontage along small impoundments confers no increase in residential property value compared to frontage along a free-flowing stream. (+) Land value *increase* -- Previous study concluded an increase in property value following sediment remediation. (-) Does *not* address the DNR short-term dam maintenance requirements. (Not applicable)	property in the vicinity of a small impoundment, and the shoreline frontage along small impoundments confers no increase in residential property value compared to frontage along a free-flowing stream. (+) Land value *increase* -- Previous study concluded an increase in property value following sediment remediation. (+) Addresses the DNR short-term dam maintenance requirements. (-) Does *not* address long-term stability of the dam due to ice loading.	property in the vicinity of a small impoundment, and the shoreline frontage along small impoundments confers no increase in residential property value compared to frontage along a free-flowing stream. (+) Land value *increase* -- Previous study concluded an increase in property value following sediment remediation. (+) Addresses the DNR short-term dam maintenance requirements. (+) Addresses long-term stability of the dam due to ice loading.	property in the vicinity of a small impoundment, and the shoreline frontage along small impoundments confers no increase in residential property value compared to frontage along a free-flowing stream. (+) Land value *increase* -- Previous study concluded an increase in property value following sediment remediation. (+) Addresses DNR requirement for abandoning a dam. (+) Addresses DNR requirement for abandoning a dam.
Compliance with State Regulations	(-) Operational order for impoundment water level has not been established. For planning purposes, the DNR would issue an Administrative Order directing the dam owner to comply with orders for repair or abandonment because the dam cannot remain in a state of disrepair or abandoned in-place. As such, the "Do-Nothing" alternative is not a viable alternative from a regulatory endpoint.	(+) This alternative assumes that an operational order for establishing an impoundment water level has been established (as pool-full and run-of-the-river). *NOTE: For planning purposes, a study identifying socio-economic and environmental costs and benefits of various water level will be required and could take 2-3-yrs to complete.*	(+) This alternative assumes that an operational order for establishing an impoundment water level has been established (as pool-full and run-of-the-river). *NOTE: For planning purposes, a study identifying socio-economic and environmental costs and benefits of various water level will be required and could take 2-3-yrs to complete.*	(+) Operational order for free-flowing river is not needed.
Impact on River Recreation	(-) Recreational fishing would continue to be limited due to poor habitat and *seasonal* barrier to fish passage between lower river, estuary and Lake Michigan. (+) Non-motorized watercraft use would continue in deeper parts of impoundment scoured by flushing.	(-) Recreational fishing would continue to be limited due to poor habitat and *year-around* barrier to fish passage between lower river, estuary and Lake Michigan. (+) Non-motorized watercraft use would continue.	(-) Recreational fishing would continue to be limited due to poor habitat and *year-around* barrier to fish passage between lower river, estuary and Lake Michigan. (+) Non-motorized watercraft use would continue.	(+) Recreational fishing would improve in the free-flowing river as habitat improves and barrier to fish passage between lower river, estuary and Lake Michigan is removed. (+) Non-motorized watercraft use would continue.

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Impact on River Recreation (continued)	(+ / -) In the short-term, motorized watercraft use would continue in deeper areas of the impoundment on a seasonal basis during pool-full conditions, and cease during drawdown conditions. (+ / -) In the long-term, motorized watercraft would use would continue in deeper areas as the impoundment is flushed of accumulating sediment on a seasonal basis. (+ / -) In the long-term, the quality and frequency of water-based recreational uses (e.g., swimming, non-motorized navigation, seasonal motorized navigation, wading and fishing) would be unchanged beyond existing conditions as sediment are routinely flushed on an annual basis. (-) On-going conflict between some user groups. (+ / -) On-going conflict between aesthetic preferences for a reflecting pool versus free-flowing stream.	(+ / -) In the short-term, motorized watercraft use would continue in deeper portions of impoundment. (-) In the long-term, additional areas would become increasingly difficult to navigate with continuing sedimentation and lack of sediment scouring events, in particular backwater areas, middle and lower reaches of the impoundment. (-) In the long-term, the quality and frequency of water-based recreational uses (e.g., swimming, motorized and non-motorized navigation, wading and fishing) would diminish as polluted sediment continues to fill the impoundment. (-) On-going conflict between some user groups. (+ / -) On-going conflict between aesthetic preferences for a reflecting pool versus free-flowing stream.	(+ / -) In the short-term, motorized watercraft use would continue in deeper portions of impoundment. (-) In the long-term, additional areas would become increasingly difficult to navigate with continuing sedimentation and lack of sediment scouring events, in particular backwater areas, middle and lower reaches of the impoundment. (-) In the long-term, the quality and frequency of water-based recreational uses (e.g., swimming, motorized and non-motorized navigation, wading and fishing) would diminish as polluted sediment continues to fill the impoundment. (-) On-going conflict between some user groups. (+ / -) On-going conflict between aesthetic preferences for a reflecting pool versus free-flowing stream.	(-) In the short and long-term, motorized watercraft use would cease during base- and low-flow periods. May be navigable by small, shallow drafting motorized craft during high flow periods. (+) In the long-term, the quality and frequency of water-based recreational uses (e.g., swimming, non-motorized navigation, wading and fishing) would improve as free-flowing riverine habitat and morphology are restored, and sediment inputs reach equilibrium (e.g., no net accumulation or loss of stored sediment). (-) On-going conflict between some user groups. (+ / -) On-going conflict between aesthetic preferences for a reflecting pool versus free-flowing stream.
Liability & Safety [11] [12]	(-) Liability and safety issues of owning and operating a dam continue. (-) To the extent that WDNR or USEPA remediate sediment, *moderate* potential for seasonal dermal exposure to polluted soils when sediment is exposed during seasonal drawdown.	(-) Liability and safety issues of owning and operating a dam continue. (-) To the extent that WDNR or USEPA remediate sediment, *limited* potential for dermal exposure to polluted soils, as sediment is continuously flooded as a result of pool-full.	(-) Liability and safety issues of owning and operating a dam continue. (-) To the extent that WDNR or USEPA remediate sediment, *limited* potential for dermal exposure to polluted soils, as sediment is continuously flooded as a result of pool-full.	(+) No liability or safety issues following dam removal. (-) To the extent that WDNR or USEPA remediate sediment, *moderate* potential for dermal exposure to polluted soils when sediments were exposed following dam removal.

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Liability & Safety (continued)	(-) Potential dermal exposure to sediment by wading during pool-full and exposed soils during drawdown. (-) The extent and likelihood of indemnification by regulatory agencies unknown due to continuing accumulation of polluted sediment following proposed remediation by WDNR and USEPA is unknown. (-) The current practice of seasonal or temporary flood driven drawdown will remain a safety and liability issue for recreational users downstream of the dam; and potential conflict for pool-full recreational users upstream of the dam.	(-) Potential dermal exposure to flooded sediment by wading at pool-full. (-) The extent and likelihood of indemnification by regulatory agencies unknown due to continuing accumulation of polluted sediment following proposed remediation by WDNR and USEPA is unknown. (+ / -) Run-of-the-river operation, significantly reduces, but does not eliminate, safety and liability issues associated with downstream and upstream recreational users.	(-) Potential dermal exposure to flooded sediment by wading at pool-full. (-) The extent and likelihood of indemnification by regulatory agencies unknown due to continuing accumulation of polluted sediment following proposed remediation by WDNR and USEPA is unknown. (+ / -) Run-of-the-river operation, significantly reduces, but does not eliminate, safety and liability issues associated with downstream and upstream recreational users.	(-) Potential dermal exposure to sediment by wading and exposed soils during drawdown. (+) Potential indemnification by regulatory agencies following proposed remediation by WDNR and USEPA comparable to that provided public and private cooperating landowners along the former North Avenue impoundment. (+) Eliminates all safety and liability concerns associated with owning and operating a dam.
External Funding Opportunities [13]	(-) No known federal, state or non-profit funding available. County likely to assume all or majority of O&M costs.	(-) No known federal, state or non-profit source of funding available. County likely to assume all or majority of capital, and O&M costs.	(-) No known federal, state or non-profit source of funding available. County likely to assume all or majority of capital, and O&M costs.	(+) Variety of federal, state and non-profit sources available especially for fish barrier removal available. County likely to receive significant assistance toward abandoning dam.

(+) On balance positive impacts

(-) On balance negative impacts

(+ / -) Positive and negative impacts *or* no change in existing condition

[1] Debris & sediment management construction costs – Range of costs assumes: A minimum requirement to remove debris along fixed crest spillway to an elevation ~ 3-ft below crest only with no sediment removal. A maximum cost to remove all of the comingled debris and sediment to an elevation ~ 5-ft below the fixed crest spillway and bedrock.

[2] Sediment accumulation rates for the former North Avenue Impoundment were previously estimated at up to 14-ft over 150-yrs, or 1-inch per year. See Woodward-Clyde

[3] Camp Dresser & McKee. 1998. Hydraulic Evaluation of the Lincoln Creek – Milwaukee River Confluence Area.

[4] Southeastern Wisconsin Regional Planning Commission. 2001. Correspondence to Susan Baldwin, Director Milwaukee County Department of Parks, Recreation and Culture. SEWRPC Community Assistance Report No. CA 410-235, March 26, 2001.

[5] Hirethota, P.S., T.E. Burzynski and B.T. Eggold. 2005. Changing Habitat and Biodiversity of the Lower Milwaukee River and Estuary. Wisconsin Department of Natural Resources PUB-FH-511-2005. http://dnr.wi.gov/fish/lakemich/MILWAUKEE_RIVER_rpt_Final.pdf

[6] Steuer, J.S., S.A. Fitzgerald, and D.W. Hall 1999. Distribution and Transport of Polychlorinated Biphenyls and Associated Particulates in the Milwaukee River System, Wisconsin, 1993–95. U.S. Geological Survey, Water-Resources Investigations Report 99–4100. http://wi.water.usgs.gov/pubs/WRIR-99-4100/wrir-99-4100.pdf

[7] Provencher, B., H. Sarakinos, and T. Meyer. 2006. Does Small Dam Removal Affect Local Property Values? An Empirical Analysis. University of Wisconsin-Madison Agricultural & Applied Economics Staff Paper Series. http://www.aae.wisc.edu/pubs/sps/pdf/stpap501.pdf

[8] Olson, C.G. 1994. Fair Market Value Report for the Village of Shorewood's Hubbard Park: Milwaukee River North Avenue Dam Feasibility Study. C.G. Olson, Real Estate Consultant, 15835 Ridgefield Ct., Brookfield, WI.

[9] Born, S.M., K.D. Genskow, T.L. Filbert, N. Hernandez-Mora, M.L. Keefer, and K.A. White. 1998. Socioeconomic and institutional dimensions of dam removals – The Wisconsin experience. Environmental Management 22(3), 1998: 359-370. http://www.aae.wisc.edu/pubs/sps/pdf/stpap501.pdf

[10] Braden, J.B., L.O. Taylor, D.H. Won, N. Mays, A. Cangelosi, A.A. Patunru. 2006. Economic Benefits of Sediment Remediation. Final Report for Project GL-96553601, Great Lakes National Program Office, U.S. Environmental Projection Agency, Chicago, IL http://www.nemw.org/Econ%20Ben%20Report06%20braden.pdf

[11] Wisconsin Department of Natural Resources. 1997. Correspondence from Gloria McCutcheon, WDNR Southeast Region Director to Susan Baldwin, Director Milwaukee Co. Dept. Parks, Recreation and Culture June 1, 1997.

[12] Correspondence Michael Morgan, Commissioner, Milwaukee Department of Development to Susan Baldwin, Director Milwaukee Co. Dept. Parks, Recreation and Culture September 30, 1997 referring to Exhibit B: Riverbank stabilization, access and maintenance easement Milwaukee County (Grantor) for City of Milwaukee (Grantee). Milwaukee Co. Register's Office, recorded August 7, 1997: reference Document No. 7403735 Reel 4112 Image 41.

[13] River Aliance of Wisconsin. Financial and Technical Assistance: How can we fund a river restoration/protection project in our community? http://www.wisconsinrivers.org/index.php?page=content&mode=view&id=8