5.0 Water Supply and Treatment Facilities

This chapter presents an evaluation of improvement alternatives to meet the projected quantity and quality needs for the planning period.

5.1 Water Production Needs

Water supply and treatment facilities are typically designed to supply the maximum day demand. The development of demand projections for this plan is summarized in Chapter 3, Water Sales Projections. Table 5-1 correlates projected demands to service areas and existing treatment plant capacities based on the current supply-treatment-transmission configuration.

Table 5-1
Demand Allocation to Service Areas and Treatment Plants

Demand Condition/ Service Area	2000 Average Day (mgd)	2000 Maximum Day (mgd)	2020 Average Day (mgd)	2020 Maximum Day (mgd)
Demands by Service Area				
Retail Customers				
660 PP Area[(1)]	88.0	123.2	97.2	126.1
Elevated Service Area[(2)]	37.8	64.3	51.8	88.1
Subtotal – Retail	*125.8*	*187.5*	*149.0*	*224.2*
Wholesale Customers[(3)]				
Connected to 660 PP	1.4	2.2	3.4	3.4
Connected to ESA	1.2	3.2	5.0	5.0
Subtotal – Wholesale	*3.6*	*5.4*	*8.4*	*8.4*
Total	129.4	192.8	157.4	232.6
Demands Assigned to Existing Treatment Plants				
CHWTP[(4)]	89.4	125.4	100.6	139.5
B. E. Payne WTP[(5)]	40.0	67.5	56.8	93.1
Total	129.4	192.8	157.4	232.6

Notes:
[(1)]Includes the 750, 760, 790, 810, 940, and 1030 Pressure Planes within the 660 Plane, as well as Bullitt County.
[(2)]Includes the 770, 820, 860, 940, and proposed 900 and 950 Pressure Planes in eastern Jefferson County and Oldham County.
[(3)]Wholesale demands assigned to 660 PP and Elevated Service Area based on a 40% - 60% allocation. Wholesale demands limited to current maximum contract amounts.
[(4)]Located in the 660 Pressure Plane.
[(5)]Located in the Elevated Service Area.

LWC 2724

Table 5-2 presents an analysis of Crescent Hill Water Treatment Plant (CHWTP) and B. E. Payne Water Treatment Plant (BEPWTP) capacities and their ability to supply the projected treated water demands.

Table 5-2
Analysis of Demands and Current Treatment Plant Capacities

Demand Condition	2000 Average Day (mgd)	2000 Maximum Day (mgd)	2020 Average Day (mgd)	2020 Maximum Day (mgd)
CHWTP Capacity	180.0	180.0	180.0	180.0
660 PP Area Demand	89.4	125.4	100.6	139.5
CHWTP Reserve Capacity	90.6	54.6	79.4	40.5
BEPWTP Capacity(1)	60.0	60.0	60.0	60.0
ESA Demand	40.0	67.5	56.8	93.1
BEPWTP Reserve Capacity	20.0	(7.5)	3.4	(33.1)
Combined Plant Capacity	240.0	240.0	240.0	240.0
Total Demand	129.4	192.8	157.4	232.6
Overall Reserve Capacity	110.6	47.2	82.6	7.4

(1)BEPWTP treatment capacity after current expansion project is completed in 2003.

The following conclusions can be drawn from the information in Tables 5-1 and 5.2:

- The total current plant capacity of 240 mgd exceeds the 2020 maximum day demand of 232.6 mgd, leaving a reserve capacity of 7.4 mgd.
- For the projected 2020 conditions, CHWTP has reserve capacity of 40.5 mgd. BEPWTP has a capacity deficit of 33.1 mgd, assuming no transmission system transfer of treated water between service areas.
- The BEPWTP capacity deficit could be addressed by (1) continuing to pump from the 660 Pressure Plane to the Elevated Service Area, or (2) building new treatment facilities at BEPWTP or elsewhere.
- LWC's 660 Pressure Plane-to-Elevated Service Area inter-transfer approach remains valid.

5.2 Water Quality Issues

LWC does not limit its water quality concerns strictly to regulatory compliance matters, but focuses instead on the overall quality of water delivered to its customers. One of LWC's goals is to achieve certification in the *Partnership for Safe Water* program. In doing so, the quality of the finished water will be substantially better than that required under the current Interim Enhanced Surface Water Treatment Rule and other pending regulations, such as the Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR).

The impact of the Long Term 2 Enhanced Surface Water Treatment Rule on operations at LWC's plants will depend in part on results obtained during required monitoring of the source water for *Cryptosporidium* oocysts. Successful participation in the *Partnership for Safe Water* program would result in plant performance that could enable LWC to earn an additional 0.5-log *Cryptosporidium* removal credit for maintaining the turbidity of the finished water at 0.15 NTU or lower for a minimum of 95% of the monthly compliance samples collected. (A 1.0-log credit could potentially be obtained if individual filter effluent turbidity levels are maintained at 0.15 NTU or lower for a minimum of 95% of the monthly compliance samples.)

Another potential option for responding to the LT2ESWTR would be to take the position that the source water for the BEPWTP is riverbank infiltration (RBI) water after this source is fully developed and capable of providing all of the supply for that plant. It would be necessary to acknowledge that the Ohio River directly influences the quality of the RBI supply. (This would likely require concurrence by the Kentucky Division of Water, and could potentially have ramifications for other entities withdrawing water from alluvial wells along the Ohio River.) If RBI water is considered as the source water being treated by the BEPWTP, and it can be demonstrated through monitoring that the source water is essentially free of *Cryptosporidium* oocysts, no additional removal/inactivation credit for *Cryptosporidium* would be required under the LT2ESWTR.

As discussed above, water quality concerns are not limited to regulatory compliance at LWC; source water acquisition, treatment, and distribution are carried out with the goal of providing safe drinking water that is also aesthetically pleasing. This requires operation to ensure that taste and odor problems are avoided or minimized, that the high quality of the finished water produced at the treatment plants is maintained throughout the distribution system, and that procedures are in place to avoid or mitigate the effects of spills on the Ohio River. At BEPWTP, LWC's concerns for water quality will be met in part through use of riverbank filtration. At the CHWTP, the combination of source water acquisition technique and treatment processes employed will need to be capable of providing finished water of equivalent quality to that produced by the BEPWTP following conversion to full RBI supply.

5.3 Overview of Advanced Treatment Processes

As shown in Table 4-3, Microbial Toolbox, Log Credits, and Design/Implementation Criteria in Chapter 4.0, there are several advanced treatment processes that LWC could implement to achieve overall improvements in finished water quality, and to receive credit for additional removal/inactivation of microbial pathogens. The technologies that are suitable for large plants and are appropriate for consideration in this plan are described below.

5.3.1 Riverbank Infiltration (RBI)

Riverbank infiltration (also referred to as riverbank filtration) is a water purification process that utilizes the natural sands and gravel of an alluvial aquifer as a filtration mechanism. Using a pump and well system, raw water is obtained from a riverbank aquifer, which is recharged by the river and by groundwater recharge in the associated alluvial zone. Riverbank infiltration provides a high-quality raw water source that can reduce the level of treatment required to produce finished water that meets all aesthetic and regulatory compliance requirements.

LWC has had good experience with riverbank infiltration. A 15 mgd demonstration collector well has been in operation at the BEPWTP since 1999. LWC has conducted *Cryptosporidium* monitoring for water supplied by the collector well since late 1999. In 22 samples collected from RBI Lateral 4, no *Cryptosporidium* oocysts and no *Giardia* cysts were detected in samples collected through March 2001. It is also emphasized that the microbial toolbox provisions presented in the preproposal draft of the LT2ESWTR would grant riverbank filtration using vertical wells *Cryptosporidium* removal credits of 0.5-log and 1-log for well setbacks of 25 and 50 feet, respectively. (Similar removal credits are specified for horizontal collector wells with laterals no closer than 25 feet and 50 feet to the bottom of the river channel, respectively.) LWC currently has a project underway to construct an additional 45 mgd of RBI supply at BEPWTP. The combined 60 mgd facilities should be eligible to receive a 1-log *Cryptosporidium* removal credit under the LT2ESWTR (if promulgated as currently drafted). Alternatively, if RBI water is considered by the Kentucky Division of Water (KDOW) as the actual source of water for the BEPWTP, is appears likely that no additional log removal credits would be would be required, as the quality of the RBI water is outstanding with respect to absence of *Cryptosporidium* oocysts, and the absence of *Giardia* cysts reinforces the efficacy of RBI for the removal of protozoa.

Riverbank infiltration has many significant advantages, including:

- More uniform raw water quality characteristics
- Removal of turbidity, organics, microorganisms, and Zebra mussels
- Protective barrier against river spills
- Reduced treatment costs

The capabilities of riverbank infiltration at Louisville were discussed in a paper by Wang, Song, and Hubbs. They compared the quality of Ohio River water and RBI water for several water quality parameters and reported substantial improvements in quality due to riverbank infiltration. In 1995, Dooley, Sweazy, and Wang reported on removal of disinfection by-product precursors by RBI. Information presented in these papers is summarized in Table 5-3.

Table 5-3
Comparison of Ohio River Water and RBI Water

Constituent	Ohio River	RBI Water	RBI Removal
Total Coliform, MPN/100 mL	9 to 33,040	Typ. 1 or less	0.9 to >4.5 log
HPC Bacteria, CFU/mL	10 to 8,800	0 to 420	0.3 to 3.8 log
Turbidity, NTU	<2 to >400	95% < 0.20 NTU Max = 0.57 NTU	-
Total Aerobic Spores, CFU/mL	3,000 to 15,000	1 – 100	>3 log
TOC, mg/L	2.1 – 3.8	1.0 – 2.7	~ 40%
DBP Precursors	-	-	>50%
Atrazine	-	Below Detection	-
Alachlor	-	Below Detection	-
MIB	-	Below Detection	-
Geosmin	-	Below Detection	-
Ammonia	-	Below Detection	-

The efficacy of riverbank filtration as practiced in Germany was reviewed by Kuehn and Muller (2000). Riverbank filtration can provide spill protection by greatly dampening the effect of shock loadings of a single contaminant. By reducing the peak of the organic contaminant spill, RBI can provide the opportunity to obtain further contaminant reduction through application of moderate dosages of powdered activated carbon (PAC) in the treatment process. Without the delay and dampening effect of RBI, a spill could result in a very rapid rise in the concentration of an organic contaminant entering the treatment facility, and subsequently the distribution system. Effective control of very high organic contaminant peak concentrations may require PAC dosages that exceed the capacity of the plant's feed equipment or that would result in excessive carryover of PAC to the filters.

In Germany, RBI water typically tends to contain about 40% of the assimilable organic carbon (AOC) that was present in the river supply prior to infiltration. The removal of AOC by RBI results in a more stable water quality in the distribution system. Waters that are less supportive of biological growth in distribution mains are less likely to contribute to problems related to development and growth of biofilms and/or depletion of disinfectant residuals.

RBI also results in reductions in dissolved organic carbon (DOC) of about 50%, as compared to that of the Rhine River supply. Kuehn and Mueller reported a 99.9% reduction in bacteria colony counts in River Elbe water following bank filtration.

Observations of the efficacy of RBI at Louisville and in Germany indicate that this approach to source water extraction provides a more uniform and much improved quality of water for treatment. However, an important observation by Kuehn and Mueller is that persistent chemicals present in the surface supply that are not biodegradable and are not readily adsorbed on the soil/alluvial materials matrix will be able to pass through the aquifer materials and appear in the RBI filtrate water. Therefore, like other water treatment processes, RBI is not universally effective for removal of all contaminants.

An area of increasing concern for utilities using groundwater supplies are the presence of dense, non-aqueous phase liquids (DNAPLs). These substances are organic compounds which are denser than water, and do not dissolve or mix easily in water. They include chlorinated solvents, coal tar, creosote, and PCB oils. Because of their nature, DNAPLs have unique subsurface migration patterns. When released below ground, DNAPLs migrate downward through unsaturated zones and spread laterally through capillary forces and fractures. Once in the water table, DNAPLs will continue downward until reaching an impermeable layer, such as clay or bedrock. As a result of these patterns, DNAPLs will be present in the alluvial layers as pools and disconnected globules, and are difficult to locate and remediate. They can continue slow dissolution into the contact water for a long period of time, and thereby be a recurring treatment issue. Although there are no known areas of DNAPL contamination within the areas being considered by LWC for installing RBI wells, their potential for long-term groundwater contamination should be recognized. DNAPLs would have to be addressed on a contaminant-specific basis if they are identified in the supply.

5.3.2 Ultraviolet (UV) Disinfection

Ultraviolet (UV) irradiation, historically used in this country primarily to disinfect wastewater effluents, is gaining increased acceptance as a viable disinfectant in the drinking water industry. While use of UV for this purpose in the United States is currently limited, there are reportedly more than 2,000 facilities in Europe utilizing UV for disinfection of public drinking water supplies. Current research is focused primarily on inactivation of *Cryptosporidium* and *Giardia*, and preliminary results suggest that 3-log to 5-log inactivation of these microbial pathogens can be readily achieved.

Benefits of UV disinfection include: (1) significantly lower costs than for comparable microbial control processes (ozone, microfiltration); (2) small facility area requirements; (3) ability to retrofit existing plant facilities; (4) significant reductions in formation of halogenated disinfection by-products (as required free chlorine contact times for disinfection are greatly reduced); and (5) high levels of achievable pathogen inactivation. Potential disadvantages include: (1) potential for fouling/plating of the quartz sleeves which house the UV lamps; (2) reliability/accuracy of the UV sensors used to monitor process effectiveness; (3) difficulties in securing State regulatory approval for disinfection of surface water supplies due to limited full-scale U.S. operating experience; and (4) UV treatment is effective only for inactivation of microorganisms. UV will not remove particulate matter and organic compounds, nor is it effective for improving biological stability of finished water in the distribution system. By itself, UV does not control taste and odor-causing compounds.

LWC should also be aware that one manufacturer of UV systems (Calgon Carbon Corporation) recently obtained a patent for inactivation of *Cryptosporidium* using UV radiation. Calgon will charge water utilities that use UV disinfection a licensing fee equivalent to $0.015 per thousand gallons of water treated. This licensing fee will apply to all utilities that install UV for inactivation of *Cryptosporidium*, regardless of the supplier selected to provide the UV equipment. The licensing fee is scheduled to expire in 2018.

Several states have approved use of UV for disinfection of groundwater supplies, but none have approved its use for utilities treating surface water supplies. The U.S. Environmental Protection Agency (USEPA) intends to address this potential problem by publishing the following concurrent with proposal of the LT2ESWTR:

- Tables specifying required UV radiation dosages to achieve up to 3-log inactivation of *Giardia*, up to 3-log inactivation of *Cryptosporidium*, and up to 4-log inactivation of viruses.
- Minimum standards to determine if UV systems are acceptable for compliance with drinking water disinfection requirements.
- A UV Guidance Manual, the purpose of which is to facilitate design and planning of UV disinfection system installations by familiarizing State/Primacy agencies and utilities with UV system design and operational issues.

UV systems currently being designed include provisions for periodic automated cleaning of the lamp sleeves. It is expected that as additional experience is acquired, state regulatory agencies will be increasingly supportive of the use of UV technology as an alternative to conventional disinfection processes.

Newer UV system designs typically utilize medium-pressure or low-pressure high-intensity lamps enclosed in a stainless steel pipe-type reactor vessel, which facilitates incorporation into existing treatment facilities. Multiple units operating in parallel are typically specified to provide reliability and to ensure continued plant operation should a single unit require servicing. As UV disinfection should be applied to the cleanest possible water in order to maximize effectiveness and minimize operating costs, it would typically be used to treat the filtered water prior to storage/distribution. UV disinfection has also been shown to be relatively ineffective for inactivation of some enteric viruses at dosages typically considered cost-effective for inactivation of *Giardia* and *Cryptosporidium*. Therefore, a brief free chlorine contact period either prior to or following UV disinfection would be required to ensure that conditions for positive inactivation of viruses are provided.

Evaluation of *Cryptosporidium* control requirements for other facilities indicates that both probable construction and annual operating costs associated with UV disinfection would be considerably less than for microfiltration/ultrafiltration membrane treatment or ozone disinfection. For LWC's treatment facilities, UV disinfection facilities could potentially be retrofitted in the existing piping of the South, Old East, and New East filters.

5.3.3 Ozonation

Ozone has been used with increasing frequency for disinfection in U.S. water treatment facilities. In addition to disinfection, potential direct benefits associated with the use of ozone include the following:

- Improvement in filtered water turbidity when applied immediately preceding filtration.
- "Microcoagulation" of dissolved organic contaminants (transformation of soluble organic contaminants into insoluble forms that can be removed by conventional treatment techniques).
- Reduction of tastes and odors. Studies in natural waters have shown that ozone can be effective for treating geosmin and MIB.
- Oxidation of iron and manganese.
- Improved biological stability of water in the distribution system, IF ozone treatment is followed by effective biological filtration. This is most effective if GAC filter beds are used to provide the surfaces on which biofilm bacteria can become established so they can metabolize the smaller organic molecules and molecular fragments resulting from ozonation.

Ozone oxidation must precede filtration to ensure effective removal of the flocculated particles resulting from the partial oxidation of dissolved organic materials. Ozone is applied to the process stream in gaseous form, and because of its instability, is generated onsite. A baffled contact chamber with multiple ozone reaction cells is typically required to achieve optimum ozone utilization and effectiveness and to satisfy disinfection contact time requirements. As ozone treatment does not yield a sustainable disinfectant residual, a secondary disinfectant (typically chloramine) must continue to be added to prevent microbial regrowth within the distribution system. Because of its highly reactive nature, ozone should be applied prior to filtration at a point where water quality is highest (typically immediately upstream of filtration.) This results in maximum disinfection efficiency, lower ozone demands, and minimum formation of potentially undesirable by-products.

Disadvantages of ozone include high construction costs for the generation and contact equipment, and high operating costs attributable to energy consumption rates. Continuing concerns regarding the potential health impacts of bromate (a by-product of ozone oxidation of waters containing low levels of bromide) may also limit application of ozone in some cases, unless effective bromate control measures can be implemented. Recent research data also suggest that inactivation of Cryptosporidium under cold-water conditions may require higher ozone dosages and longer ozone contact periods than originally anticipated, which could reduce the attractiveness of ozone for inactivation of this microbial contaminant. Ozone is generally not a stand-alone process, but must be used in conjunction with other processes in a treatment train. By itself, ozone treatment provides no removal of particulate matter. Ozone would offer little or no protection in the event of spills on the Ohio River, unless the spill consisted of a chemical that could be readily oxidized/degraded by ozone to carbon dioxide and water. Ozone alone increases the assimilable organic carbon concentration of the water treated, and biological filtration following ozone is therefore typically necessary to attain biological stability within the distribution system.

Use of ozone as the primary disinfectant at LWC's treatment facilities would require construction of contact chambers between the existing coagulation/softening basins and filters in order to minimize required ozone dosages and associated generation costs. As ozonation prior to filtration would result in the filters operating in a biologically-active mode, provisions for a short period of free chlorine contact following filtration would be required to ensure effective inactivation of microbes that would be present in the filter effluent. Construction of ozone generation and contact facilities within the confines of the existing CHWTP site would be relatively difficult. It is also emphasized that while ozonation would provide positive inactivation of microbial pathogens, it would be considerably more expensive to implement and operate than newer technologies such as UV disinfection.

While ozonation is not considered a cost-effective option for primary disinfection at LWC, it could be useful as an effective additional tool for dealing with periodic taste and odor episodes. When utilized to control tastes and odors, required ozone dosages and contact times are considerably less than would be required for inactivation of microbial pathogens such as *Giardia* and *Cryptosporidium.*

5.3.4 Membrane Filtration

Microfiltration (MF) and ultrafiltration (UF) are physical processes in which colloidal particles are removed from the water supply by straining through a porous medium. Both processes provide exceptional removal of turbidity (most operating facilities routinely produce treated water with turbidities of less than 0.05 NTU). MF membranes typically used for treatment of surface water supplies are hollow-fiber with a nominal pore size of 0.2 microns. UF membranes used in surface water treatment applications typically exhibit a nominal pore size of 0.04 microns. As these pore sizes are significantly smaller than *Cryptosporidium* oocysts (2 to 7 microns) and *Giardia* cysts (5 to 15 microns), MF and UF provide excellent removal of these microbial contaminants. Removal of *Giardia* cyst-sized particles in excess of 6 to 8 logs (99.9999 to 99.999999 percent) have been demonstrated during pilot-scale testing. Therefore, many states grant 3-log, and, in some cases 4-log removal credits for MF and UF treatment. It should be noted that the Kentucky Division of Water (KDOW) currently does not have a specific position with regard to allowable removal credits for MF/UF.

In its capability to attain very high log removals of particles, including protozoa and bacteria, membrane filtration equals or exceeds the capabilities of RBI. Membrane filtration by MF or UF, however, is a straining process, and none of the potential biological action associated with RBI is expected to occur with membrane filtration. Straining action that is adequate for the removal of protozoa and bacteria will not by itself remove MIB or geosmin, so membrane filtration would not be effective for taste and odor control without addition of PAC ahead of the membranes. MF and UF will not remove dissolved organic carbon or soluble DBP precursor compounds. MF and UF would offer no protection against chemical spills involving dissolved organic or inorganic chemicals, and a severe spill of a compound such as diesel fuel could irreversibly harm the membranes.

Average feedwater pressures for conventional "encased" membrane configurations are 15 to 20 psi. Backwashing of MF/UF modules is typically initiated every 18 to 20 minutes (up to 30 minutes for exceptionally clean feedwaters), and the backwash cycle lasts for 2.5 to 3 minutes. Backwashing typically uses approximately 5 to 7 percent of the feedwater pumped to an MF system; however, recycling of the backwash flow to the plant influent following treatment to remove settleable solids can reduce overall losses to 1 to 2 percent of plant production. Periodic cleaning with citric acid, caustic/hypochlorite solution, and/or proprietary detergent solutions may be required when conventional backwashing can no longer restore differential pressures across the membranes to original levels. Chemical cleaning is typically conducted at 4- week to 6-week intervals.

A relatively new development in MF/UF treatment is the "immersed" membrane configuration. Immersed membrane systems consist of "modules" of membrane fibers suspended in conventional concrete or steel tanks containing the water to be treated. Unlike conventional membrane systems, where the feedwater is pressurized to force it through the membranes, immersed membranes operate under a slight vacuum (typically 6 to 8 psig). Vacuum is produced by pumps located on the product water side of the membranes. The membranes are periodically "backpulsed" using product water to remove deposits on the membrane surfaces; this typically occurs every 15 to 20 minutes for a period of approximately 30 seconds. Immersed membrane system employs injection of air at the floor of the membrane chamber to scour the membrane surfaces and to maintain a homogeneous concentration of suspended solids within the chamber. Periodic chemical cleaning is required to maintain membrane flux rates; this is typically accomplished by backpulsing the membranes at a reduced rate with concentrated cleaning solutions. Cleaning solutions typically include sodium hypochlorite and proprietary detergent solutions. The cleaning process is typically automated to reduce operator labor required. Most existing immersed membrane systems operate at raw-to-product recovery rates of approximately 90 percent. However, through recycling of the membrane reject stream and/or use of "secondary" membrane treatment systems, overall treatment process losses can typically be reduced to 1 to 2 percent of the raw water treated.

As MF and UF treated water exhibits extremely low turbidities, which are difficult to monitor consistently, provisions for continuous monitoring of treated water particle counts are required to ensure that the membranes are operating properly. It is also typically recommended that an air integrity test be conducted at least once per day to ensure that the membranes and associated gaskets/seals are functioning properly, and that individual membrane fibers have not failed. (At least one state currently requires that membrane integrity testing be conducted every 4 hours.)

A potential advantage of immersed membranes is their ability to be located in existing plant structures, such as filter boxes (the membranes would replace the conventional granular media). Minimum required basin depth for the immersed membranes is 10 to 11 feet, and membrane production rates at "conservative" hydraulic loading (flux) rates are approximately 3 to 6 gpm per square foot of basin plan area. (A new product released this year may allow a higher equivalent loading rate.)

As MF/UF would provide positive removal of *Giardia* cysts and *Cryptosporidium* oocysts, only a brief contact period (~3 - 6 minutes) with free chlorine would be required either prior to or following membrane treatment to ensure effective inactivation of viruses. (Viruses are considerably smaller than *Giardia* cysts and *Cryptosporidium* oocysts, and therefore may not be effectively removed by MF/UF.)

5.3.5 Activated Carbon Adsorption

Activated carbon can be used to adsorb organic chemicals, and thus it is often used to cope with spills and to control tastes and odors in drinking water. Activated carbon can also be used to reduce the concentrations of TOC and DBP precursors in drinking water, although utilization for this purpose can be expensive. Three general approaches for using activated carbon are:

- Addition of powdered activated carbon (PAC)
- Granular activated carbon (GAC) filter/adsorbers
- Post-filter GAC contactors

These techniques for using activated carbon are discussed in the following paragraphs.

PAC is used at many water treatment plants, as addition of powdered carbon can be designed and used as a supplemental treatment process. PAC can be used during taste and odor episodes, and if the operating staff is aware of a spill occurrence, PAC can be added as needed to remove organic contaminants associated with the spill. PAC is utilized on a once-through basis, so it is less effective than GAC for adsorbing organic contaminants. As the concentration of organic adsorbed onto PAC increases, the concentration in the process stream, which drives the adsorption process, decreases. Therefore, PAC cannot be loaded with organic compounds to the extent that GAC can be. An additional disadvantage of PAC is that it is used on an ad-hoc basis due to cost, so utility personnel have to be aware of the need to add PAC in order for it to have a chance to work effectively. In spite of these disadvantages, PAC can be more economical to use than GAC, if PAC addition is needed only occasionally and required dosages are not excessive. A potential problem could be experienced if a major spill or taste and odor episode occurred upstream from Louisville on the Ohio River; all of the utilities that rely on PAC for spill and/or taste and odor control would need to feed PAC, and the demand for PAC could exceed the available supply.

GAC filter/adsorbers are commonly used for control of tastes and odors. Typically, GAC is used as a replacement for the anthracite in a dual media filter. The life of GAC filter/adsorbers for taste/odor control may range from 1 to 5 years, depending on the amount of organics that are present in the raw water. GAC bed life is shorter when the source water contains high concentrations of other organics that compete with taste/odor compounds for adsorption sites. GAC filter/adsorbers are not typically used for TOC and DBP precursor removal, as the shallow bed depth and resulting short contact times provided do not favor effective removal of these organics over extended periods. On the other hand, if GAC filter/adsorbers are operated such that they are biologically active (particularly if ozone is used in a pre-filtration mode), the biomass present in the filter/adsorber can effectively remove a fraction of the organic matter and some of the TOC and DBP precursor compounds, in addition to improving the biological stability of the finished water. GAC filter/adsorbers should be as effective as conventional anthracite/sand dual media filters for physical removal of bacteria and protozoa, but no more effective. Because GAC filters are known to exhibit a chromatographic effect when they adsorb organics at very high concentrations, using GAC filter/adsorbers at the peak of a spill might also result in gradual desorption of the organic chemicals after raw water concentrations return to normal levels. (The potential for and extent of this desorption would depend on how strongly an organic chemical is bound to the GAC.)

Post-filter GAC adsorbers are currently used by the Greater Cincinnati Water Works. The GAC adsorbers were installed at significant cost, but have proven effective for the purposes for which they were intended. Cincinnati's GAC adsorbers reduce the TOC in the filtered water, provide 24-hour protection from unknown organics that might be present as a result of spills and by removing assimilable organic matter from the finished water, improve its biological stability. With the relatively long empty bed contact times provided, Cincinnati's GAC adsorbers are also effective for removal of taste and odor compounds. All of this, however, was achieved at high cost, as the GAC adsorbers are located in a new, separate building, and Cincinnati has its own GAC regeneration furnaces. Cincinnati Water Works operating data show that the turbidity of the water following the rapid sand filters is on the order of 0.10 NTU, while turbidity following the post-filter GAC adsorbers is approximately

0.05 NTU. Some small additional filtration benefit is therefore being derived from the post-filter GAC adsorbers.

Use of activated carbon is a relatively expensive but proven technology for coping with taste and odor and chemical spill problems. Use of biologically active carbon filters to remove biodegradable organic matter from drinking water and improve its biological stability is becoming more common in this country.

5.4 Preliminary Considerations

5.4.1 General Guidance

Based on interviews with LWC staff, steering committee meetings, and technical review workshops, the following general guidance is set forth to guide the development of infrastructure alternatives for this plan:

- Economy
  - Capital funds must be used wisely and efficiently.
  - No more infrastructure will be built than is required to meet LWC's goals.
  - New treatment alternatives will be considered if large increments of capacity are required or if economically justified to replace aging infrastructure.
- Water Quality
  - Treated water quality will exceed that required by regulations.
  - Multiple treatment barriers will be provided.
  - Finished water quality produced at all plants will be essentially equivalent.
  - Conventional treatment processes will be optimized to achieve Phase IV Partnership for Safe Water goals.
  - Provisions for effective control of tastes and odors will be included for all alternatives considered.
- Facilities
  - 60 mgd of riverbank infiltration supply will be constructed for BEPWTP.
  - Plate settlers will be evaluated as an alternative to in-kind replacement of coagulation equipment at both plants.
  - Pellet reactors will be considered as an alternative technology for softening.
  - Biologically active up-flow filters ahead of conventional dual media filters will be considered for removal of taste and odors and organics.

5.4.2 Aging Infrastructure at Zorn Pumping Station and CHWTP

Many Zorn Pumping Station and CHWTP facilities are of considerable age, as shown in Table 5-4. (Table 5-4 addresses only major structures, and does not include equipment replacements and upgrades completed on schedule to maintain facilities in reliable operating condition.)

Table 5-4
Approximate Age of Zorn and Crescent Hill Facilities

Facility	Approximate Year Completed	Approximate Structure Age (Nearest 5 Years)
Reservoirs / Gatehouse	1879	120
Zorn Pump Station No. 2	1893	110
North Filters	1909	90
South Filters	1909	90
Clearwell	1909	90
Zorn Intake Tower	1910	90
Zorn Pump Station No. 3	1916	85
High Service Pumping Station	1926	75
Old East Filters	1926	75
Cardinal Hill Reservoir	1932	70
Softening Trains 1and 2	1944	55
New East Filters	1955	45
Softening Trains 3 and 4	1956	45
North Flocculation/Coagulation Basins	1959	40
South Flocculation/Coagulation Basins	1968	35
Softening Trains 5 and 6	1971	30

Based on experience and observations from the 2001 and 2002 Annual Inspections, structures that will exceed 100 years of age during the 2002-2021 planning period should be considered for retirement. Facilities in this category are highlighted in Table 5-4, and their recommended disposition is as follows:

- The North and South Reservoirs and Gatehouse structures are in serviceable condition and play a key role in providing emergency raw water storage. Both reservoirs were cleaned and relined in recent years. A number of gates and valves are inoperable and should be replaced.
- Zorn Pump Station No. 2 has a cypress timber foundation. The foundation cannot be visually inspected. According to construction drawings, the entire foundation is at elevations where it is always submerged. Timber structures submerged in water generally perform well unless subjected to cyclic wetting and drying. Thus, with no visual evidence of extensive cracking or settlement, it appears that the foundation and building continue to be sound. Pump piping systems have been well maintained and are in good operating condition. It appears that this pump station can continue in service.
- Equipment and control/monitoring systems for the North filters are outdated and in need of replacement in order to reliably produce finished water meeting LWC's goals. LWC's 2002 capital program includes a budget item of $3,250,000 to upgrade these filters. Because of the structure age and constricted physical

configuration, it is recommended that these filters not be upgraded, but instead considered for retirement or use for other purposes. Capital funds allocated for this upgrade should instead be allocated toward upgrading the Old East, New East, and South filters to perform at higher filtration rates and to improve finished water turbidity levels at the plant design capacity of 180 mgd.

- The South filters are in serviceable condition and should continue to be used. These filters were upgraded with new underdrains, support gravel, dual media, and air/water backwash systems in the early 1990s. These filters should be kept in service and the gravel replaced with a porous media support cap on the underdrain. This will allow for installation of an additional 10 to 12 inches of dual media, thereby providing a filter configuration more capable of meeting the Phase IV Partnership finished water turbidity goal.
- The Clearwell is in serviceable condition and should continue to be used. In the early 1990s, the structure above the floor was rehabilitated. LWC investigations indicate that treated water may be seeping from cracks in the clearwell rock bottom into the Crescent Hill Pump Station. The 2002 capital program includes a budget item to line the floor in Clearwell Chamber No. 4 to address this concern.
- The Zorn Intake Tower remains in serviceable condition and should continue to be used. The current screens were installed during the 1930s, and although the moving equipment has been well maintained, submerged structural steel components have deteriorated to the point that replacement is needed. It is recommended that all four screens be removed and replaced with new equipment.
- Zorn Pump Station No. 3 appears to be in serviceable condition. The structure shows no significant evidence of failure. Pump Nos. 6 and 7 are well maintained; however, the pump suction and discharge valves do not operate or seal well, and should be replaced.

An outside consultant completed a physical condition survey of the CHWTP buildings in 1999. The results and recommendations derived from this survey are presented in the report Physical Condition Survey and Maintenance Analysis: Louisville Water Company, dated November 11, 1999. The report recommends that structural repairs be made at a cost totaling approximately $2 billion. This item should be included in the budget for improvements to CHWTP.

5.4.3 Feasibility of Riverbank Filtration Supply for CHWTP

LWC has committed to utilizing riverbank infiltration for 60 mgd of water supply at the BEPWTP. RBI supply is also being considered for CHWTP. For this plan, existing technical reports and information were reviewed; based on this review, an opinion regarding the technical feasibility of RBI supply for CHWTP is presented in this section.

Operational experience gained at the collector well at the BEPWTP indicates that riverbank infiltration is a feasible alternative for LWC where geologic conditions are suitable. The initial collector well specific capacity was 505 gpm/ft, but has declined to 363 gpm/ft. It appears that the capacity may be stabilizing. While the exact causes of the reduction in capacity are being investigated, the impacts of the reduced performance must be incorporated into the feasibility analysis of riverbank infiltration for the CHWTP. Factors that impact the yield of collector wells include hydraulic conductivity and saturated thickness of the aquifer, and the efficiency of infiltration of the surface water into the aquifer.

5.4.3.1 Hydraulic Conductivity and Saturated Thickness of the Aquifer

The hydraulic conductivity of the aquifer is a measure of how quickly water can move through it. Factors that impact hydraulic conductivity include the gradation of the aquifer materials and water temperature. Fence diagrams of the aquifer between Zorn Avenue and BEPWTP were reviewed. In general, the fence diagrams show sand and gravel layer at the base of the aquifer. This layer is expected to have a relatively high hydraulic conductivity. However, some data indicate the presence of areas of low hydraulic conductivity values. In general, a hydraulic conductivity value of 750 to 1000 gad/ft or greater indicates a productive aquifer zone. Several areas of low permeability are identified in the reports, particularly from Zorn Avenue upstream approximately 2 miles. Permeability (hydraulic conductivity) less than 500 gad/ft are prevalent in this area. Calibrated modeling results for the Zorn Avenue area and two miles upstream indicate that the hydraulic conductivity of the aquifer is about 750 gad/ft.

In general, the available information indicates that the hydraulic conductivity of the aquifer is highest in the area of the existing collector well at the BEPWTP, but should be suitable in most areas. In the BEPWTP area, the hydraulic conductivity is estimated to be 2,500 - 3,500 gpd/ft. For most of the other areas of the aquifer, hydraulic conductivity is estimated to be 1,000 gpd/ft or less. If the collector wells are to be located in the area northeast of Zorn Avenue to two miles upstream, pumping tests are needed to verify the suitability of this area.

Saturated thickness is also highest in the area of the BEPWTP. The bedrock appears to be about 5 feet lower in this area than the rest of the aquifer. Also, fence diagrams indicate an area where the aquifer is comprised primarily of very fine sediments near Goose Creek.

Some contradictory information is presented in the results of a geophysical investigation conducted for LWC. This investigation indicated that a prime location for a collector well would be at the confluence of Goose Creek and the Ohio River. The geophysical investigation also showed thicker deposits of coarse-grained material than the fence diagram in several areas.

5.4.3.2 Infiltration of Surface Water

Infiltration of surface water into the aquifer is influenced by the grain size of the riverbed and the temperature of the water. A geophysical survey of the riverbed has been conducted; results of this study are a series of cross-sections cut through the river channel through the study area that show the thickness of fine and coarse grained sediments in the riverbed. In general, the cross-sections show the thickness of the fine-grained sediments to be 5 to 10 feet where present. According to the available data, the collector well at BEPWTP is near one of the largest areas of coarse-grained riverbed sediments.

As water temperature decreases, the infiltration rate of water flowing through the riverbed also decreases. This is important, because testing of the collector well has been conducted during periods of relatively high water temperatures. Yields during the late winter and early spring will be reduced by as much as 20 percent when water temperatures are lowest.

5.4.3.3 Collector Well Capacity and Spacing

Available information indicates that the collector well at the BEPWTP is in one of the most productive areas of the aquifer. This site appears to have the best combination of hydraulic conductivity, saturated thickness, and riverbed conditions in the area from Zorn Avenue to BEPWTP. Collector well capacity is apparently stabilizing at approximately 15 mgd during low temperature conditions and 18 to 20 mgd during higher temperature conditions and peak demand periods.

The available information reviewed indicates that collector well capacities of 10 to 15 mgd are more likely in the aquifer between Zorn Avenue and BEPWTP. For planning purposes, an average capacity of 10 to 12 mgd is warranted to ensure that conservative decisions are made. This is based on the 5-foot reduction in saturated thickness and the variability of the riverbed sediments. Additional testing is needed to verify this assumption.

The plot on Figure 5-2 indicates that drawdown was approximately 4 feet at a distance of 1,500 feet from the collector well at the conclusion of the October 2000 test. This indicates that a collector well spacing of at least 1,500 feet should be used. Mutual interference of 5 feet or less between wells is considered acceptable.

The distance between Zorn Avenue and BEPWTP is approximately 28,000 linear feet, which provides space for approximately 19 collector wells. At an average capacity of 10 mgd, the total yield would be 190 mgd, and at 12 mgd average capacity, the total yield would be 228 mgd. Firm capacity is defined as 90 percent of the total capacity, which allows for wells to be out of service for maintenance, and for some reduction in efficiency. Therefore, the firm capacity of the system would be 171 to 205 mgd. This indicates that a riverbank infiltration system is viable if locations for the collector wells can be acquired, given the aforementioned assumptions and conditions.

Additional testing and modeling are recommended to evaluate the aquifer conditions between Zorn Avenue and BEPWTP and to refine overall yield estimates.

5.4.4 Softening

RBI water at BEPWTP has generally exhibited a total hardness between 200 and 230 mg/L as $CaCO_3$ (magnesium hardness reportedly averages 20 mg/L as $CaCO_3$). LWC desires a finished water hardness of 150 to 170 mg/L. RBI water therefore requires softening to achieve the desired finished water hardness goal. The hardness of the Ohio River supply is generally at or below the desired goal, and therefore softening is not typically required. However, during the fall and winter months, the hardness of the Ohio River supply can exceed LWC's finished water hardness goal for extended periods. Therefore, to ensure the ability to provide water of equivalent quality from both treatment facilities, CHWTP treatment alternatives utilizing Ohio River supply should also include provisions for softening as necessary to achieve the finished water hardness goal on a continuous basis.

LWC has conventional precipitative lime softening facilities at both CHWTP and BEPWTP. The softening basins at CHWTP are currently used only for pH adjustment. At BEPWTP, LWC employs split-stream treatment, where combined Ohio River and RBI water is softened in one of three trains and blended with clarified, unsoftened water prior to filtration. The blended softened and unsoftened waters yield a pH that is low enough to preclude the need for further pH adjustment with carbon dioxide (recarbonation). However, for alternatives involving treatment of a 100% RBI supply, a greater percentage of the total plant flow would need to be softened, and recarbonation would therefore be required to produce finished water with a pH that would yield acceptable calcium carbonate precipitation potential (CCPP) concentrations. (Deliver of finished water with high CCPP values can result in excessive deposition of calcium carbonate scale within distribution system piping and appurtenances, with subsequent reductions in hydraulic capacity.) At both plants, the equipment in the softening basins is at or near the end of its useful life, and should be scheduled for replacement if continued use of these basins is envisioned.

Pellet reactors have been used infrequently for softening in the United States and, to some extent, in Europe. Several plants have been constructed in the Netherlands using cylindrical pellet reactors and sodium hydroxide ("caustic soda") addition for softening. Generally these installations are at plants with production capacities much lower than that of LWC's current treatment facilities. Pellet reactors employ a crystallization process whereby calcium carbonate is plated onto fluidized sand grains, producing hard, round pellets. Reported advantages of pellet reactors include production of a smaller quantity of dried solids and lower capital cost when compared to construction of new conventional precipitative lime softening facilities. While the crystallization process can also remove iron and manganese, which are anticipated to be present in RBI water, it does not remove magnesium hardness. Preliminary assessment of this technology suggests that probable construction costs for new pellet reactors would exceed probable costs for rehabilitation of LWC's existing softening basins by a significant margin. Other considerations are the lack of full-scale U.S. operating experience, and the need for construction of multiple reactors to achieve the relatively high treatment capacities required. Based on these considerations, use of pellet softening reactors is not considered economically viable, and was therefore not developed as an alternative to upgrading of LWC's existing softening facilities.

5.4.5 Coagulation Basin Equipment Replacement

Installation of plate settlers in several of the existing CHWTP basins was evaluated as an option to replacement of flocculation and sludge collection equipment in essentially all of the existing basins. Plate settlers improve the efficiency of conventional rectangular settling basins by taking advantage of the theory that settling efficiency depends primarily on available settling area, rather than basin detention time. Typical "effective" plate loading rates (based on total projected plate area) range from 0.3 to 0.7 gpm/sq ft, depending on the settling characteristics of the solids, water temperature, and desired effluent quality. (Most existing installations utilize effective loading rates in the 0.3 to 0.4 gpm/sq ft range.) These rates yield overall sedimentation basin loading rates of 2 to 6 gpm/sq ft (significantly greater than the 0.35 to 0.5 gpm/sq ft rate typically used for conventional sedimentation basins). Evaluation of plate settlers at CHWTP in the existing coagulation basins suggest the following:

- One CHWTP North coagulation basin at 2 gpm/sq ft would have a capacity of 65 mgd.

LWC 2743

- One CHWTP South coagulation basin at 2 gpm/sq ft would have a capacity of 90 mgd.

While it would be feasible to retrofit a portion of the existing CHWTP coagulation basins with plate settling equipment at the loading rates discussed above, available flocculation detention time would then become the limiting factor in determining the capacity of the retrofitted basins. (Flocculation performance has been demonstrated to be a critical factor with respect to efficient operation of high-rate sedimentation facilities.) At the basin hydraulic capacities discussed above, available flocculation detention time would be substantially less than required to ensure the formation of a dense, readily-settleable floc under anticipated raw water quality and temperature conditions. Available flocculation detention time for a plate-equipped North coagulation basin operating at 65 mgd would be only 6.2 minutes, while detention time for a plate-equipped South coagulation basin operating at 90 mgd would be only 12.1 minutes. (For most surface waters, a minimum flocculation detention time of 30 minutes is considered acceptable, and current KDOW requirements specify a "minimum" detention time of 40 minutes for conventional flocculation facilities.) Therefore, any coagulation basin plate settler retrofit would require extensive modifications to and expansion of the preceding flocculation basin to provide the required detention time, and to provide for effective distribution of the flocculated water to the multiple basin influent channels associated with the plate settling equipment. These modifications would also need to be completed while maintaining the remaining coagulation basins in service (as flocculation basin volume would need to be increased, simultaneous removal of two flocculation/coagulation basin trains from service could be required to complete these modifications).

The existing circular sludge collection equipment in basins to be retrofitted with plate settlers would need to be removed, and the basin floors modified to facilitate use of new collection equipment that would be compatible with the plate settling equipment. The need for these extensive modifications would result in probable costs that would exceed those for replacement of existing flocculation and coagulation basin equipment. Therefore, retrofitting of a portion of the existing CHWTP coagulation basins with plate settling equipment would not be a cost-effective alternative to in-kind replacement of equipment in all of the existing basins.

5.4.6 Upflow GAC Filters

Granular activated carbon is typically used as a replacement for anthracite in dual media filters (filter/adsorbers) or in separate post-filter contactors operating in a downflow mode,

LWC 2744

similar to traditional media filters. In the downflow mode, settled or filtered water is applied to the top of the GAC media and flows downward through the media to the underdrain. LWC staff has in the past conducted pilot-scale testing of upflow filters, and reports that this testing indicated that biologically active upflow filters could be effective in reducing tastes and odors and organics associated with continued use of the Ohio River supply. It has been further suggested that upflow filters equipped with GAC media would potentially be used as an intermediate process between the existing coagulation basins and the conventional downflow filtration process by converting a portion of the existing CHWTP softening basins to upflow filters. These filters would be operated in a biologically active mode to remove taste and odor causing compounds and other organic compounds.

Upflow GAC filters have not been used to any extent in large water treatment plants in the United States. Literature does indicate that fluidized bed biofilm upflow reactors have been used in Europe for nitrification in wastewater treatment applications, and that this experience could potentially be applied to potable water production applications. LWC staff intends to conduct further pilot testing of upflow filters. However, prior to any decision to further develop and implement this process on a full-scale basis, available experience should be carefully evaluated to assess associated design and operational risks. Careful attention should be directed to factors such as practical maximum filter area, media volume/contact time requirements, filter shape/configuration, media blinding potential, and media wash requirements. Once these factors are better defined, actual feasibility and probable costs of upflow GAC filtration can be determined.

5.5 BEPWTP with Full RBI Supply

As previously discussed, LWC has committed to construction of additional RBI supply at BEPWTP, which will eliminate the need for direct withdrawal of surface water from the Ohio River. LWC has nearly completed contract documents to construct an additional 45 mgd of RBI capacity at the BEPWTP. The project is based on providing three 15 mgd collector well caissons, or a series of traditional collector wells spaced 1,000 feet apart with interconnecting rock tunnels and a central pumping station on the middle caisson. These new collector wells will be connected with the existing collector well to provide a total 60 mgd RBI supply capacity. Projected treatment requirements following conversion to full RBI supply, and capital improvements needed to meet these requirements and to ensure continued reliable service throughout the plan period are discussed below.

5.5.1 Pretreatment

Pretreatment would consist of addition of powdered activated carbon for taste and odor control on an "as needed" basis, aeration, and chemical oxidation. Current PAC feed capability would be retained, with modifications as necessary to permit addition of PAC slurry into the raw water pipeline upstream of the new aeration system in order to maximize available contact time with the raw water prior to softening/filtration. Provisions for increasing the RBI supply's dissolved oxygen (DO) concentration would be added. (RBI water will enter the plant with a DO concentration of essentially zero.) Preliminary costs assume construction of diffused aeration basins with fine bubble diffusers at the plant influent (15 ft sidewall water depth, approximate total basin volume of 22,500 cubic feet), with sufficient capacity to increase dissolved oxygen concentrations to 4-5 mg/L under maximum flow and water temperature conditions. (A more detailed evaluation of the need for and alternatives to increase the DO of the RBI supply should be conducted prior to full-scale implementation of RBI supply at the BEPWTP.) Potassium permanganate would be fed following aeration to oxidize manganese and any soluble iron remaining after aeration.

5.5.2 Softening / Filtration

As discussed above, the existing collector well at the BEPWTP provides a supply with an average total hardness concentration of approximately 220 mg/L as $CaCO_3$, and softening will therefore be required to achieve LWC's finished water hardness goal of approximately 160 mg/L. The existing precipitative lime softening facilities at the BEPWTP would be retained to provide the required level of softening treatment. An evaluation of lime softening and subsequent pH adjustment ("recarbonation") requirements suggests that the most cost-effective treatment approach under the anticipated raw water quality conditions would be to soften approximately 50% of the total plant flow. However, at plant flows exceeding 45 to 50 mgd, hydraulic loading rates for a single softening basin would exceed typically-recommended levels for acceptable performance with respect to precipitation of floc particles. Therefore, it is recommended that two of the three existing softening basin trains be retained in service (and associated flocculation and sludge collection systems be upgraded as necessary to ensure reliable service over the planning period). Assuming that approximately 1/2 of the total plant flow is softened, the hardness of the softened water would need to be reduced to approximately 100 mg/L to achieve a blended finished water total hardness of 160 mg/L. Carbon dioxide would be added at the existing recarbonation basins at dosages sufficient to produce a blended finished water with a calcium carbonate precipitation potential (CCPP) in the 6 to 10 mg/L range. Preliminary calculations suggest that this would require an average carbon dioxide dosage of 8 to 14 mg/L at the recarbonation basin influent, and result in a finished water pH of approximately 8.1 to 8.2

(following blending with the unsoftened stream). Provisions for addition of ferric chloride as a flocculant aid at the softening basin influent(s) would be retained to assist in maintaining low softened water turbidities.

LWC staff indicates that the BEPWTP facilities are not currently configured to allow raw water to bypass the existing coagulation basins and flow directly to the softening basins or to the filters. Therefore, it is assumed that all of the raw water could continue to flow through the existing coagulation and softening basins following conversion to full RBI supply. However, the current practice of adding a coagulant at the basin influent and providing flocculation and sedimentation would not be required. Flocculation and sludge collection equipment in all of the existing coagulation basins, and in one of the three existing softening basins would therefore not need to be replaced to ensure continued reliable service over the planning period. The existing coagulation basins would likely need to be removed from service periodically and drained/flushed to remove accumulated solids resulting from addition of PAC and from oxidation/precipitation of iron and manganese. (This evaluation assumes that average total organic carbon concentrations for RBI water will continue to be less than 2.0 mg/L, and that provisions for TOC reduction through enhanced coagulation will therefore not be required.)

Improvements to the existing filters and associated backwash and control systems would be made to provide required treatment capacity and to ensure efficient and reliable operation following conversion to full RBI supply. These filter improvements should include recommended modifications presented in an engineering report recently completed by Camp, Dresser & McKee (CDM) for the BEPWTP (new backwash supply pumps, state-of-the-art filtration and backwash systems).

5.5.3 Disinfection, Post-treatment

Chlorine would continue to be used as the primary disinfectant, followed by addition of ammonia to provide a chloramine residual within the distribution system. A free chlorine residual would be maintained across the recarbonation basins and filters to provide the contact time required to comply with current KDOW disinfection CT requirements under the Surface Water Treatment Rule. (As the current RBI supply exhibits very low disinfection by-product formation potential, use of free chlorine for primary disinfection followed by chloramines for residual maintenance within the distribution system should not result in any difficulties in complying with current and anticipated future disinfection by-product regulations.) Following filtration, ammonia (and additional chlorine as necessary) would be added to yield the desired finished water chloramine residual. Provisions for future addition of post-filtration UV disinfection capability should be included in order to address potential future Cryptosporidium inactivation requirements under the Long Term 2 Enhanced Surface Water Treatment Rule. Provisions for continued addition of fluoride (hydrofluosilicic acid) to the filtered water should also be included.

5.5.4 Miscellaneous Improvements

Other improvements recommended at BEPWTP to ensure continued reliable service over the planning period include the following:

- New high service pumps and primary and secondary power systems, as recommended in the recent CDM report on BEPWTP.
- Chemical Feed and Storage Systems: Provide improvements to correct deficiencies as noted in Tables 4-4 and 4-5 of Volume 1 of this report.
- Clearwell: Construct a new 3 million gallon chamber. Total clearwell volume is recommended to be 15% of plant capacity, or 9 million gallons. (Current total clearwell volume is 6 millions gallons.)
- Solids Handling Facilities: Implement selected improvements as recommended in the July 2000 CH2M HILL report Drainage and Solids Management Improvements; Crescent Hill Water Treatment Plant, and report supplement dated April 20, 2001. The improvements include cleaning and rehabilitation of four lagoons and associated piping systems.

5.6 Supply and Treatment Alternatives for CHWTP

Based on considerations previously discussed, and on results of a water treatment workshop conducted with LWC staff during March 2002, several CHWTP supply and treatment alternatives were developed for evaluation. The primary objectives assumed in the formulation of these alternatives were; (1) production of a high-quality finished water that meets or exceeds all applicable current and anticipated future regulatory requirements; (2) ability to produce and deliver finished water that is essentially identical to that produced at the BEPWTP following conversion to full RBI supply; and (3) ability to effectively address aesthetic concerns such as periodic taste and odor occurrences associated with the current Ohio River supply. CHWTP supply and treatment alternatives evaluated are as follows:

- **Alternative C1:** Provide for 180 mgd firm capacity with full RBI (collector well) supply, aeration, and continuous softening of a portion of the total plant flow. With RBI, this alternative provides for advanced treatment and taste and odor control through riverbank infiltration, powdered activated carbon addition, and ultraviolet (UV) disinfection (if required for future regulatory compliance).

LWC 2748

- **Alternative C2:** Provide for 180 mgd firm capacity with Ohio River supply through the Zorn intake, improved conventional treatment, softening of a portion of the total plant flow, taste and odor control with PAC and ozonation, and advanced treatment with biological filtration and ultraviolet (UV) disinfection.
- **Alternative C3:** Provide for 180 mgd firm capacity with Ohio River supply through the Zorn intake, improved conventional treatment, softening of a portion of the total plant flow, conventional filtration, taste and odor control with PAC and post-filter granular activated carbon (GAC), and ultraviolet (UV) disinfection.
- **Alternative C4:** Provide for 180 mgd firm capacity with Ohio River supply through the Zorn intake, high-rate conventional sedimentation, softening of a portion of the total plant flow, and advanced treatment with membrane filtration, post-filter granular activated carbon adsorption, and ultraviolet (UV) disinfection.

The primary components that comprise these alternatives are summarized in Table 5-5, and operational considerations and projected capital improvements that would be required to implement each alternative are discussed in the following sections.

Table 5-5
Supply and Treatment Alternatives for CHWTP

Alternative	Capacity (mgd)	Supply Component	Softening	Advanced Treatment Components	Taste & Odor Control Components
C1	180	Collector Wells	Continuous	RBI, UV	RBI, PAC
C2	180	Zorn PS	As Needed	Ozone, BF, UV	PAC, Ozone
C3	180	Zorn PS	As Needed	GAC, UV	PAC, GAC
C4	180	Zorn PS	As Needed	MF, GAC, UV	PAC, GAC

Abbreviations:
BF – Biologically Active Filtration
GAC – Granular Activated Carbon
MF – Membrane Filtration
PAC – Powdered Activated Carbon
PS – Pump Station
RBI – Riverbank Infiltration
UV – Ultraviolet Disinfection

5.6.1 Zorn Avenue Pumping Station Improvements

For CHWTP alternatives involving continued use of the current Ohio River supply, improvements at the Zorn Avenue Pumping Station would be required to ensure continued reliable service over the entire planning period. Based on recent inspection results, recommended equipment replacements and facility modifications are as follows:

- The current screens were installed in the Intake Tower during the 1940s. A contract diver inspected the screens on August 29, 2001. The inspection report states that the structural main frames for Screen Nos. 2 and 3 are severely corroded and should be replaced. Given the equipment age and the operational and economic advantages of one-time

LWC 2749

replacement, it is recommended that all four screens be replaced with new equipment. In addition, four sluice gates that shut off flow to the 42-inch pipelines to the pump stations are in need of replacement.

- The main electrical switchgear in the boiler house is near the end of its useful life and should be replaced. Spare parts required to maintain the switchgear are becoming increasingly difficult to procure.
- Suction and discharge values on Pumps 6 and 7 are reported to be inoperable or leaking, making pump isolation for maintenance difficult. Replacement of these valves is recommended.
- To facilitate periodic maintenance of the 24-inch sludge line to BEPWTP, the July 2000 CH2M HILL report Drainage and Solids Management Improvements; Crescent Hill Water Treatment Plant recommends construction of a solids storage lagoon at Zorn Pumping Station.

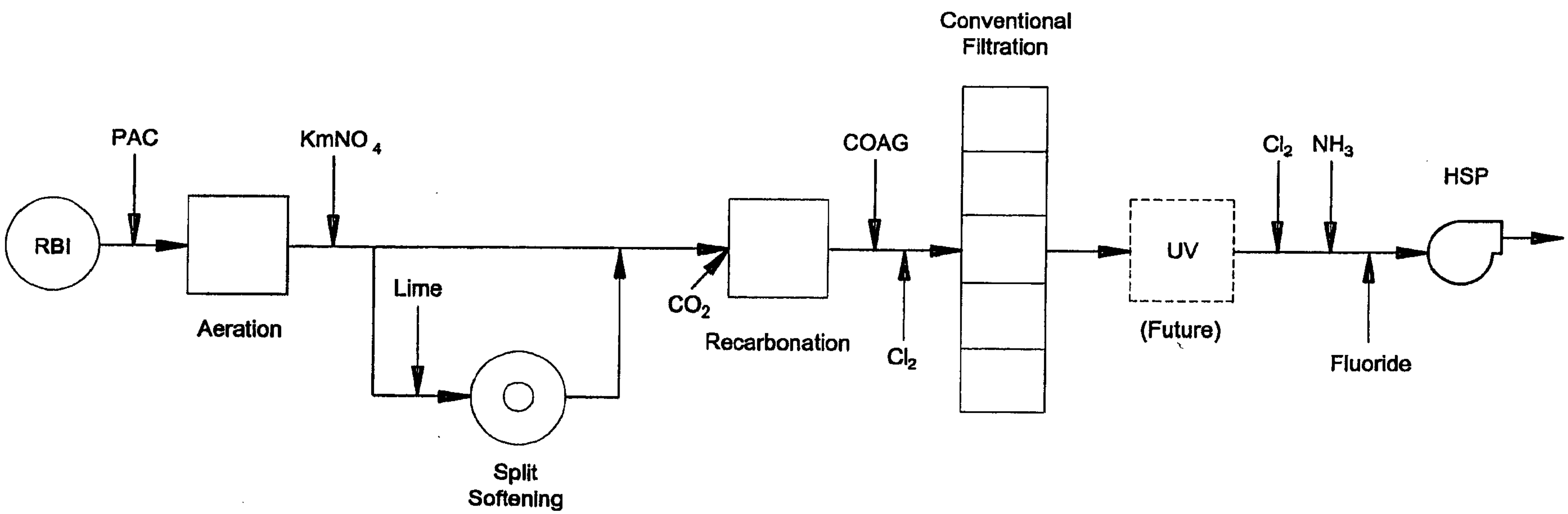
5.6.2 CHWTP Alternative C1 (Full RBI Supply)

This alternative assumes that provisions for full RBI supply would be constructed, utilizing the collector well and tunnel concept developed by LWC. A process schematic for this alternative is shown on Figure 5-1.

5.6.2.1 Pretreatment

Water quality for a new RBI supply serving CHWTP is assumed to be similar to that for the existing RBI supply at the BEPWTP. (Water quality data obtained from a test well located near the Zorn Pumping Station suggests, however, that manganese concentrations for a new RBI supply constructed in this area could be as high as 0.70 mg/L, which is considerably higher than for the existing collector well supply at BEPWTP.) As provisions for chemical coagulation and sedimentation of the RBI supply prior to filtration would not be required, the existing coagulation basins at CHWTP would be bypassed, and raw water would be conveyed directly to the existing softening basin complex. (This evaluation assumes that average total organic carbon concentrations for RBI water will be less than 2.0 mg/L, and that provisions for TOC reduction through enhanced coagulation will not be required.)

Pretreatment would consist of addition of PAC for taste and odor control on an "as needed" basis, aeration, and chemical oxidation. PAC would be added into the raw water pipeline upstream of the new aeration system in order to maximize available contact time with the raw water prior to softening and filtration. The ability to increase the dissolved oxygen concentration of the RBI supply by 4-5 mg/L under maximum flow and water temperature conditions would be provided by constructing new diffused aeration basins within one of the existing softening basins. (A more detailed evaluation of the need for and alternatives to



NOTE:
All chemicals may not be fed to all locations at a given time.

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ALTERNATIVE C1:
RIVERBANK INFILTRATION SUPPLY

Figure 5-1

LWC 2751

increase the DO of the RBI supply should be conducted prior to any full-scale implementation of RBI supply at CHWTP.) Potassium permanganate would be fed following aeration to oxidize manganese and any soluble iron remaining after aeration.

5.6.2.2 Softening / Filtration

As discussed above, provisions for softening would be required to achieve LWC's finished water hardness goal of 160 mg/L. This evaluation assumes that existing softening basins 5 and 6 would be retained in service to soften approximately 50% of the total flow treated. (For basins 5 and 6, flocculation basin detention time at 90 mgd would be approximately 40 minutes; sedimentation basin hydraulic loading rate and detention time at 90 mgd would be 0.78 gpm/sq ft and 2.6 hours, respectively.) The softened water would then be blended with raw water to achieve the desired finished water hardness. Based on a projected average raw water total hardness of 220 mg/L, a softened water total hardness of approximately 100 mg/L would be required to achieve a blended finished water total hardness of 160 mg/L. Ferric chloride would be added as a flocculant aid at the softening basin inlets to assist in the formation of a readily-settleable floc and to reduce the turbidity of the softened water.

Carbon dioxide would be added as necessary to the blended raw/softened waters to reduce its pH to approximately 8.0 to 8.2. Carbon dioxide would be added at the inlet to one or more of the existing recarbonation/reaction basins. Provisions for addition of chlorine at the recarbonation basin inlet would be included to maintain a free chlorine residual across the basins and filters, thereby providing contact time required to comply with current KDOW disinfection CT requirements under the Surface Water Treatment Rule.

The existing South and East filters would be upgraded to improve reliability and performance, and the existing North filters would be removed from service. The filters would be equipped with new underdrains, porous media support cap, and sand/anthracite dual media. All influent and effluent valves in the Old East and New East filter pipe galleries would be replaced. Additional valves would be installed to provide additional operational flexibility, and an air/water backwash system would be installed for the Old East and New East filters. A new filter aid feed system would be provided to replace the existing temporary polyaluminum chloride feed system. The new filter media would be preconditioned prior to startup using concentrated potassium permanganate solution to ensure effective removal of manganese during initial operation of the upgraded filters.

5.6.2.3 Disinfection, Post-Treatment

Chlorine would continue to be used as the primary disinfection (as discussed above, a free chlorine residual would be maintained across the recarbonation/reaction basins and filters), followed by addition of ammonia (and additional chlorine as necessary) at the filter discharge to yield the desired finished water chloramine residual concentration. Provisions for addition of post-filtration UV disinfection capability should be included in order to address potential future Cryptosporidium inactivation requirements under the Long Term 2 Enhanced Surface Water Treatment Rule. (UV disinfection could be installed on the effluent side of the Old East, New East, and South filters by making structural, piping, and power system improvements.) Provisions for continued addition of fluoride (hydrofluosilicic acid) to the filtered water would be included.

5.6.2.4 Miscellaneous Improvements

Other improvements recommended at CHWTP to ensure continued reliable operation over the planning period in conjunction with implementation of Alternative C1 include the following:

- Filter Backwash System: Implement washwater supply improvements as recommended in the October 1993 report Conceptual Design Report for Washwater Supply System; Crescent Hill Water Treatment Plant prepared by Alvord, Burdick and Howson. Recommended improvements include demolition of the two existing washwater tanks and installation of a new 1.5 million gallon washwater storage tank, and installation of combined air and water backwash systems in the Old East and New East filters (as discussed above). In addition, a redundant 36-inch backwash water supply line to the Old East and New East filters is recommended.
- Solids Handling Facilities: Implement selected improvements as recommended in the July 2000 CH2M HILL report Drainage and Solids Management Improvements; Crescent Hill Water Treatment Plant, and report supplement dated April 20, 2001. As indicated in the LWC 2002 budget, proposed improvements include: (1) a second backwash holding tank and dry pit pump station and other improvements, (2) a backwash storage basin and pump station on Reservoir Avenue, and (3) a second 24-inch pipeline crossing at Harrod's Creek.
- Chemical Feed Systems: Provide improvements to correct deficiencies as noted in Tables 4-4 and 4-5 of Volume 1 of this report.
- Clearwell: Install a liner on the floor of Chamber 4 to eliminate leakage into the Crescent Hill Pump Station.
- High Service Pump Station: An inspection was conducted and past reports were reviewed regarding the discharge headers in and yard piping around the Crescent Hill Pump Station. Based on this review, due to pipeline age and potential risk of

failure, the capital project in the budget to replace cast iron 48-inch and 60-inch headers and leaking 60-inch yard piping should be completed.

5.6.3 CHWTP Alternative C2 (Ohio River Supply w/Ozone & UV)

Alternatives C2, C3, and C4 assume continued use of the current Ohio River supply. These alternatives also assume that the existing North and South reservoirs would be maintained in service to provide presedimentation of the river supply and emergency raw water storage. A process schematic for Alternative C2 is shown on Figure 5-2.

5.6.3.1 Pretreatment

Pretreatment would consist of addition of PAC for taste and odor control on an "as needed" basis, and chemical oxidation using potassium permanganate. CHWTP is currently equipped with storage and feed facilities for PAC, which has historically been used primarily to remove taste and odor-causing compounds from the Ohio River supply. LWC reports that taste and odor events of mild to severe nature caused by blue-green algae by-products (2-methylisoborneol (MIB) and geosmin) are experienced, with major events occurring approximately every 10 years. The odor threshold level for detection of these compounds has been reported to be as low as 3 to 5 nanograms per Liter (ng/L). LWC reports mild to moderate taste/odor occurrences (20 to 40 ng/L of MIB) every year. In 1999, a severe event, during which MIB levels reached 122 ng/L, resulted in many customer complaints and heavy use of PAC to control the problem. A PAC dosage of 500 pounds per million gallons treated (60 mg/L) was reportedly required for adequate taste and odor control during this event.

PAC is currently stored in slurry form at the CHWTP and fed prior to the coagulation process. However, provisions for PAC feed at the Zorn intake would take advantage of available mixing and contact time within the pipelines leading to the plant, thereby improving PAC utilization and adsorption efficiency. Addition of a new PAC system at Zorn Pumping Station is therefore assumed for this evaluation; this would include two 60,000 gallon PAC slurry storage tanks, two 1,875 gph peristaltic pumps, two 250 gph peristaltic pumps, dust collection equipment, PAC off-loading station, and associated monitoring/control systems.

5.6.3.2 Enhanced Coagulation

Provisions for feeding chlorine dioxide as a preoxidant/predisinfectant at the existing coagulation basin complex would be added. Provisions for feeding sulfuric acid to optimize coagulation pH for removal of TOC would also be included. (Preliminary costs presented in this document assume addition of sulfuric acid on an "as needed" basis to maintain a

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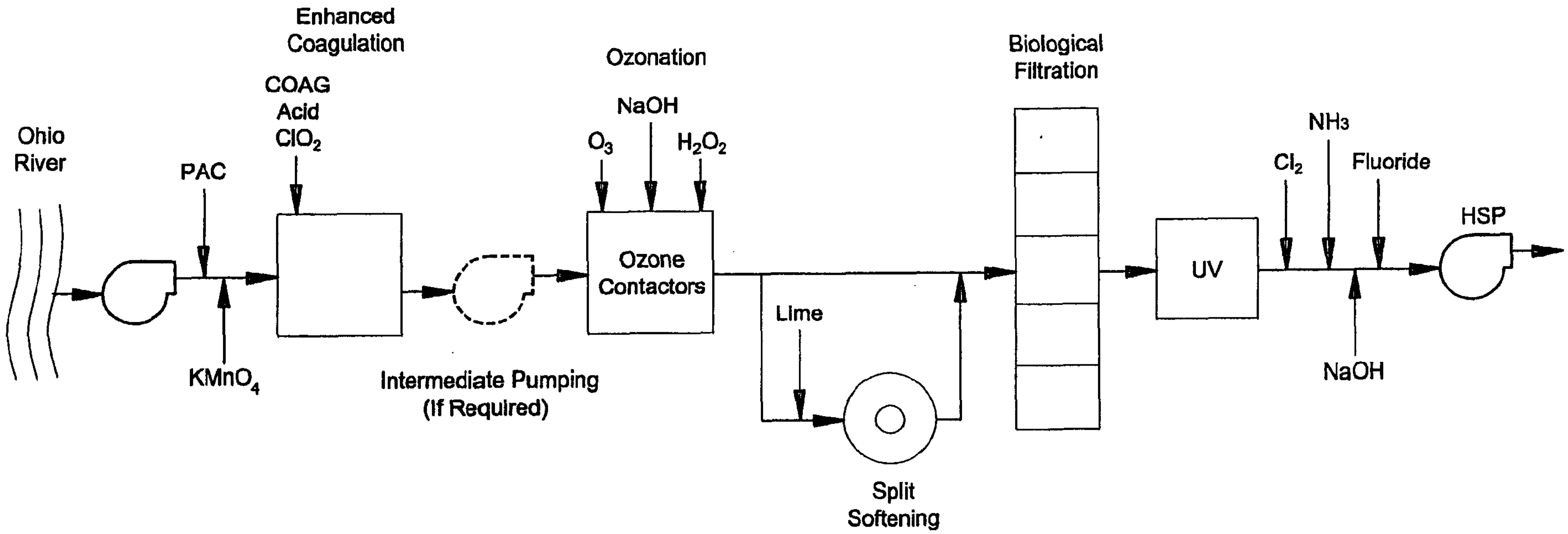

NOTE:
All chemicals may not be fed to all locations at a given time.

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ALTERNATIVE C2:
OHIO RIVER SUPPLY
W/ OZONE AND UV

Figure 5-2

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LWC 2755

coagulation pH of approximately 6.5.) Continued use of ferric chloride as the primary coagulant and cationic polymer as a coagulant aid is assumed.

5.6.3.3 Ozonation

Ozonation capability for control of tastes and odors would be provided through construction of ozone generation and feed facilities, two covered contact basins, contactor off-gas treatment facilities, liquid oxygen storage facilities, and chemical storage and feed facilities for pH adjustment and removal of residual ozone from the contactor discharge. Considering the projected ozone contact time requirement of 5 to 10 minutes for effective taste and odor removal, a portion of one of the existing softening basins could be converted to ozone contactors in order to reduce overall project costs. A sidestream injection system would be utilized to disperse the ozone into the process stream at the contactor inlet. Sodium hydroxide would be added near the contactor discharge to increase the pH of the process stream to approximately 7.0, and hydrogen peroxide would be added following pH adjustment to remove any residual ozone from the process stream prior to softening/filtration. (Provisions for adjustment of pH prior to addition of hydrogen peroxide are recommended to ensure efficient and rapid reaction of the hydrogen peroxide with the ozone residual; this reaction is relatively slow when pH is less than approximately 7.0.)

5.6.3.4 Softening / Filtration

While provisions for precipitative lime softening are in place at CHWTP, softening has not been practiced in recent years due to relatively low raw water hardness levels during most of the year, and to the desire to reduce chemical treatment costs and residuals production. However, a review of recent water quality data for the Ohio River supply indicates that total hardness typically exceeds LWC's current finished water hardness goal of 160 mg/L for 4 to 5 months each year. (This generally occurs during the late fall and winter months.) Therefore, provisions for lime softening to achieve the finished water hardness goal on a continuous basis are assumed in order to provide water from CHWTP equivalent to that from BEPWTP following conversion to full RBI supply.

For cost development purposes, it was assumed that softening would typically be required at CHWTP four to five months per year to maintain a maximum finished water total hardness of 160 mg/L, with raw water total hardness averaging approximately 185 mg/L during this period. Approximately one-third of the total plant flow (60 mgd max) would be softened, using existing softening basin trains 5 and 6. In addition to lime, preliminary calculations suggest that addition of sodium carbonate (soda ash) for removal of noncarbonate hardness may be required at times to achieve the desired finished water total hardness. Assuming adjustment of ozone contactor effluent pH to approximately 7.0, provisions for recarbonation to reduce the pH of the blended softened and unsoftened process streams would not be required. During periods when lime softening is not practiced, adjustment of treated water pH using sodium hydroxide would be required to provide a stable, non-aggressive finished water.

The existing East filters would be modified to accommodate use of approximately 6 feet of GAC media, which would provide an empty-bed GAC contact time of approximately 10 minutes at the plant design flow of 180 mgd. Maintaining the filters in a biologically-active mode would provide for removal of assimilable organic carbon (AOC) and potential ozonation by-products, and the GAC media would provide additional removal of taste and odor compounds that may not be fully removed during ozonation. Recommended filter modifications would consist of raising the existing filter box walls approximately 3 feet, and addition of new underdrains equipped with a porous plate-type media support cap and air scour capability. The existing North and South filters would be removed from service, and the resulting hydraulic loading rate for the converted East filters would be approximately 4.25 gpm/sq ft with one filter out of service for backwashing. Provisions for backwashing with non-chlorinated filtered water would be included to prevent excessive loss of biomass from the filters during backwashing.

Filter modifications to accommodate to deeper GAC media would impact the overall plant hydraulic gradient, and the need for intermediate pumping would need to be evaluated prior to implementation of Alternative C2. For this evaluation, provisions for low-lift intermediate pumping between the existing softening/recarbonation basins and the modified East filters have been assumed.

5.6.3.5 Disinfection, Post-Treatment

Provisions for using UV as the primary disinfectant are assumed for this evaluation, based on anticipated future regulatory requirements and the desire to provide "multiple treatment barriers" to minimize the potential for presence of viable Giardia cysts and/or Cryptosporidium oocysts in the finished water produced at the CHWTP. UV disinfection would be provided following the modified East filters, and a design UV dosage of 40 mJ/cm^2 is assumed for cost development purposes. (UV disinfection could be installed on the effluent side of the modified East filters by making structural, piping, and power system improvements.) Provisions for a brief period of free chlorine contact (3 to 5 minutes) following filtration would be included to ensure positive inactivation of microbes that may be present in the biofilter discharge. Ammonia would then be added to convert the free chlorine residual to the chloramine form prior to distribution of the finished water. Provisions for continued addition of fluoride (hydrofluosilicic acid) to the filtered water would be included.

5.6.3.6 Miscellaneous Improvements

In addition to the miscellaneous plant improvements listed under Alternative C1 (section 5.6.2.4), the following improvements should be made to ensure reliable service over the planning period:

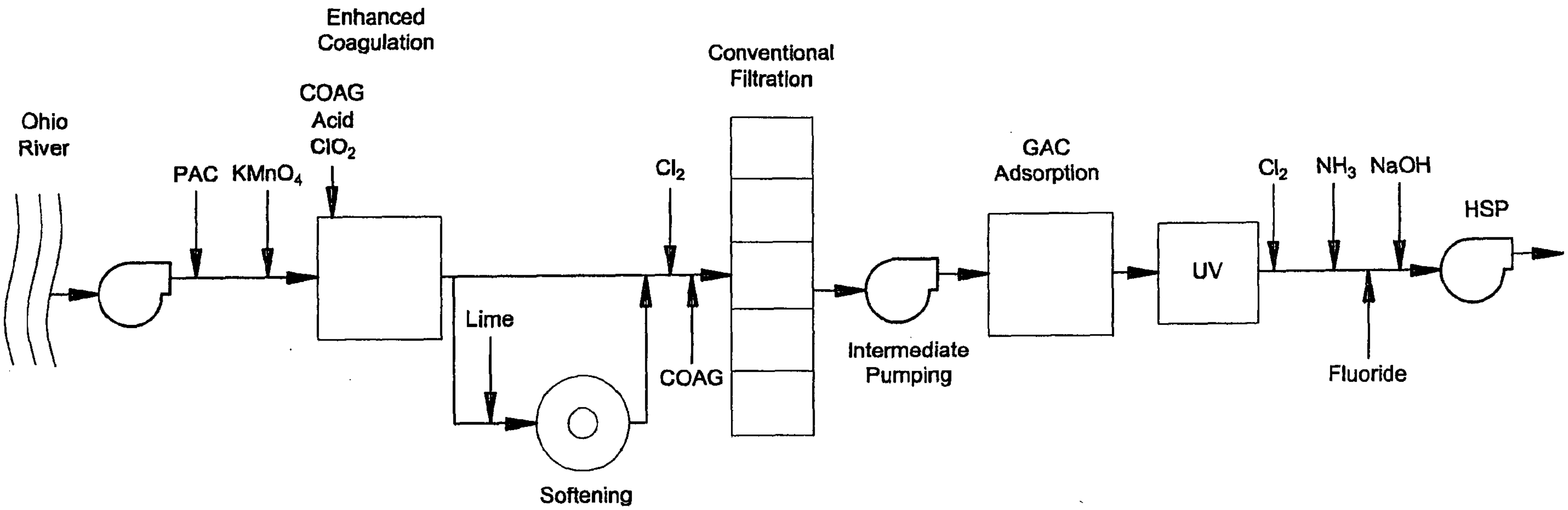
- North, South Reservoirs: Replace influent and effluent gates and valves at the Gatehouse.
- Coagulation Basins: For all basins, replace existing sludge collection equipment and miscellaneous metals and influent and effluent gates. In the South basins, complete repairs on the two remaining flocculators, and re-grout the floors.
- Towers: Replace flow control valves.

5.6.4 CHWTP Alternative C3 (Ohio River Supply w/GAC & UV)

This alternative would be identical in most respects to alternative C2. However, control of taste and odors would be accomplished through a combination of powdered activated carbon addition and post-filter GAC adsorption contactors, and provisions for ozonation would not be included. (As ozonation for taste and odor control would not be included, biologically-active filtration would not be required.) A process schematic for Alternative C3 is shown on Figure 5-3.

As for alternative C1, the existing South and East filters would be upgraded to improve reliability and performance, and the existing North filters would be removed from service. The filters would be equipped with new underdrains, porous media support cap, and sand/anthracite dual media. All influent and effluent valves in the Old East and New East filter pipe galleries would be replaced. Additional valves would be installed to provide additional operational flexibility, and an air/water backwash system would be installed for the Old East and New East filters. A new filter aid feed system would be provided to replace the existing temporary polyaluminum chloride feed system. The new filter media would be preconditioned prior to startup using concentrated potassium permanganate solution to ensure effective removal of manganese during initial operation of the upgraded filters.

Provisions for intermediate pumping to convey the filtered water to the new GAC contactors would be required. GAC adsorption would provide positive control of tastes and odors, in addition to protection against organic spills on the Ohio River. Provisions for onsite thermal



NOTE:
All chemicals may not be fed to all locations at a given time.

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ALTERNATIVE C3: OHIO RIVER SUPPLY W/ GAC AND UV

Figure 5-3

regeneration of the GAC would be included. Preliminary design parameters assumed in evaluating probable costs for post-filter GAC adsorption are summarized in Table 5-6 below.

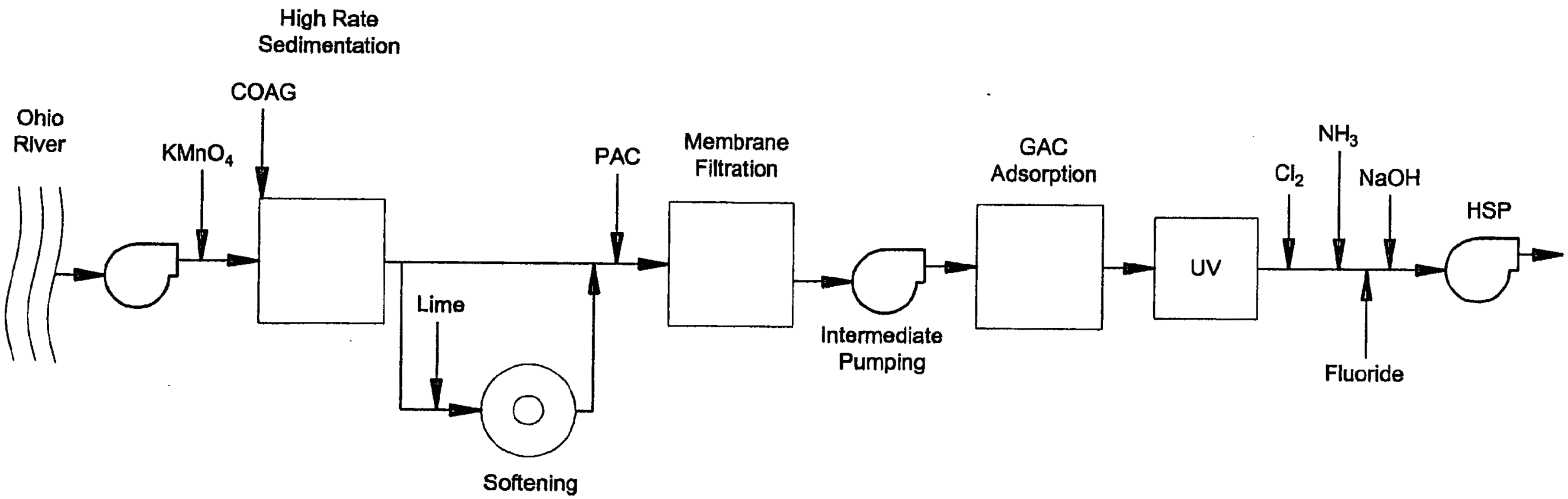
Table 5-6
Preliminary Design Parameters for Post-Filter GAC Adsorption

GAC Empty Bed Contact Time, minutes @ 180 mgd	15
Contact Hydraulic Loading Rate, gpm/sq ft @ 180 mgd	5.5
Number of GAC Contactors	
Online	11
Standby	1
GAC Bed Depth, feet	~11
Projected GAC regeneration interval, months	6
GAC Regeneration	
No. of furnaces	2
Regeneration capacity per furnace, pounds GAC per day	45,000

5.6.5 CHWTP Alternative C4 (Ohio River w/Membranes, GAC, & UV)

This alternative would be similar in most respects to alternative C3. However, a portion of the existing coagulation basins would be equipped with inclined plates to provide high-rate conventional sedimentation, and granular media filtration would be replaced by an immersed membrane filtration process to provide enhanced particle removal. A process schematic for Alternative C4 is shown on Figure 5-4.

Retrofitting of all of the existing South coagulation basins with inclined plates is assumed for this evaluation. (As continued use of the existing North flocculation/coagulation basins would not be required for Alternative C4, replacement of the sludge collection and flocculation equipment in these basins would also not be required.) A portion of the inlet zone of the existing coagulation basins would be modified to ensure equal distribution of flocculated water to the multiple influent flow channels associated with the inclined plate system. Hydraulic detention time for the four existing South flocculation basins would be approximately 24 minutes at the plant design capacity of 180 mgd. This is considerably less than the current KDOW requirement of 40 minutes for conventional flocculation basins, and could therefore require pilot-scale demonstration testing to obtain KDOW approval. However, as the high-rate flocculation/sedimentation system would be followed by highly-efficient membrane filtration rather than conventional granular media filters, the ability to consistently maintain very low settled water turbidities would not be as critical for this alternative as for alternatives C1, C2, and C3. KDOW may therefore be more amenable to approving a flocculation system that does not meet the minimum 40 minutes detention time requirement. Continued use of ferric chloride as the primary coagulant and cationic polymer



NOTE:
All chemicals may not be fed to all locations at a given time.

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ALTERNATIVE C4:
OHIO RIVER SUPPLY W/
MEMBRANES, GAC AND UV

Figure 5-4

as a flocculant aid, and an effective plate hydraulic loading of 0.30 to 0.35 gpm/sq ft were assumed in developing probable construction and operating cost data for this alternative.

For this evaluation, it is assumed that all of the existing Old East and New East filters and a portion of the existing South filters would be retrofitted with immersed ultrafiltration (UF) membranes; the North filters would be removed from service. (Media and underdrains would be removed from the existing filter boxes to provide the depth required for efficient operation of immersion-type UF membranes.) Feasibility of this approach has been confirmed on a preliminary basis by one of the primary manufacturers of submerged UF membrane systems.

5.6.6 Present Worth Evaluation for CHWTP Alternatives

The total costs associated with constructing and operating each of the CHWTP treatment alternatives discussed above can be compared by adding the probable project capital costs for the treatment facilities (less the present worth of their remaining value at the end of the planning period) to the present worth of their respective annual operation and maintenance costs over an extended period of time. For the comparison presented below, a planning period of 20 years and an interest rate of 7.5 percent was assumed. Present worth costs for each alternative are summarized in Table 5-7.

Table 5-7
Present Worth Cost Comparison for CHWTP Treatment Alternatives

Alternative	Probable Capital Cost, $	Projected Annual O&M Cost, $/yr	Present Worth, $*
C1A: RBI Supply w/UV	116,000,000	2,290,000	129,000,000
C1B: RBI Supply wo/UV	103,000,000	1,770,000	111,000,000
C2: Ohio River w/Ozone	70,000,000	6,570,000	154,000,000
C3: Ohio River w/GAC	114,000,000	6,880,000	174,000,000
C4: Ohio River w/membranes & GAC	204,000,000	5,270,000	254,000,000

*20 years, 7.5% interest rate; includes present worth of projected remaining value of facilities at end of planning period.

Annual O&M costs presented in Table 5-7 do not include projected costs for raw and treated water pumping. (As these costs would be similar for all of the alternatives evaluated, their inclusion in the present worth comparison would not impact the relative alternative ranking with respect to overall cost.) O&M costs assume operation of the CHWTP at an annual average production rate of 95 mgd. Water quality assumptions for determination of softening requirements are summarized in Table 5-8.

Table 5-8
Water Quality Assumptions for Determination of Softening Requirements

Parameter	Average Value		
	RBI Supply (Alt. C1)	Ohio River Supply (Alts. C2-C4)	
		4.5 months/year	7.5 months/year
Hardness, mg/L as $CaCO_3$			
Total	220	185	150
Calcium	200	170	140
Magnesium	20	15	10
Total Alkalinity, mg/L as $CaCO_3$	165	120[1]	85[1]
pH, units	7.8[2]	7.0[3]	7.0[3]

[1]Raw water alkalinity; concentrations would be lower following enhanced coagulation.
[2]After aeration.
[3]After enhanced coagulation and ozonation (Alt. C2). For Alts. C3 & C4 (no ozone), pH would be approx. 6.5.

Cost analysis results summarized in Table 5-7 indicate that Alternatives C1A and C1B (RBI supply without and with UV disinfection, respectively) would be the most desirable options strictly from an overall project cost perspective.

5.6.7 Comparison of Relative Benefits for CHWTP Alternatives

A comparison of the relative benefits of the various alternatives with respect to several performance- and operations-related criteria is summarized in Table 5-9. (This summary was developed based on input from both Black & Veatch and LWC staff during a March 2002 water treatment workshop.) For the comparison summarized in Table 5-9, alternatives that exhibit no clear advantage or benefit with respect to a given criterion were assigned a value of 0, while alternatives that exhibit a clear benefit or advantage were assigned values of +1 (beneficial) or +2 (clearly superior). If an alternative was determined to be clearly inferior or less desirable than other alternatives with respect to a given criterion, it was assigned a value of –1.

Results of the relative benefits comparison summarized in Table 5-9 suggest that Alternative C1 would be the most desirable, but by a relatively small margin.

Table 5-9
Comparison of Relative Performance/Operations Benefits
For CHWTP Treatment Alternatives

Criteria	Relative Rating of Alternative			
	C1 RBI w/UV	C2 Ozone+UV	C3 GAC+UV	C4 UF+GAC+UV
Particle Removal	+1	+1	+1	+1
Microbial Pathogen Removal	+1	+1	+1	+1
DBP Precursor Removal	+1	+1	+1	+1
Taste & Odor Removal	+1	+1	+1	+1
Spill Mitigation	+2	+1	+2	+1
Iron/Manganese Removal	-1	+1	+1	0
SOC Removal	+1	+1	+1	+1
AOC/BDOC Removal	+1	0	+1	+1
Nitrification Control	+2	+1	+1	+1
Finished Water Temperature	+1	0	0	0
Process Operability	+2	0	0	+1
Residuals Management	0	0	0	+1
Multiple Treatment Barriers	+2	+2	+2	+2
Reduced Chemical Addition	0	0	0	+1
Totals:	+14	+10	+12	+13

5.6.8 Risks / Unknowns

A number of relative risks were identified during the development and evaluation of the various CHWTP treatment alternatives. Relative risks associated with each of the CHWTP treatment alternatives are summarized in Table 5-10.

5.6.9 Conclusions

The following conclusions can be drawn from the information presented above:

- Alternative C1 (RBI supply with or without UV disinfection) is the least-cost alternative when both probable initial capital and projected annual operating costs over the planning period are considered.
- Alternative C2 (Ohio River supply with ozone and UV disinfection) is the least-cost alternative strictly from a probable initial construction cost perspective.
- An evaluation of overall performance- and operations-related factors indicates that Alt. C1 would be preferable to Alternatives C2, C3, and C4 by a slight margin. However, additional evaluation is recommended to address sustainable capacity and related cost/risk concerns prior to any large-scale commitment to RBI supply at CHWTP.

Table 5-10
Risks Identified for CHWTP Treatment Alternatives

Treatment Alternative	Risks
C1A, C1B: RBI Supply	(1) Sustainable Well Capacity (2) Uncertain Geological Conditions (3) Right of Way Issues (Cost Impacts) (4) Well Contamination (short vs. long term impact Of spills)
C2: Ohio River w/ozone, UV	(1) Bromate Production (2) Chlorite / Chlorate Production (3) Possible Need for Intermediate Pumping
C3: Ohio River w/GAC, UV	(1) Increased GAC Regeneration Frequency
C4: Ohio River w/membranes, GAC, UV	(1) Membrane Replacement Frequency (2) Membrane Biofouling Potential

5.7 Recommended Supply and Treatment Approach

As previously discussed in this section of the report, LWC's governing objective is to continue providing its customers the highest quality of water at an economical cost. Consistent with this objective, LWC also strives to maintain comparable or equivalent water quality throughout its distribution system, so that consumers essentially receive the same product regardless of location. This philosophy was key in developing the recommended approach to treatment for the Crescent Hill and B. E. Payne plants.

LWC has already committed to converting the BEPWTP to a full RBI supply within the foreseeable future. Therefore, it is incumbent that the recommended treatment plan incorporate that decision, and be designed to achieve a similar level of water quality from the Crescent Hill plant to that which will be produced at B. E. Payne. Fortunately, LWC can meet this goal with the CHWTP treatment alternative that proved to be most advantageous and least costly from the analysis; Alternative C1. That alternative, as described in this chapter is the basis for the recommended approach.

The resulting recommended supply and treatment recommendation for LWC is summarized below. Key points are highlighted along with relevant elements associated with those points.

➢ **Adopt Alternative C1A as the treatment improvement plan for CHWTP.**

- Investigate and confirm the sustainable RBI capacity for CHWTP. Using RBI as the supply source for Crescent Hill will be dependant upon ensuring that adequate volumes of water are available.

- Verify that LWC's assumptions regarding geology and property acquisition are correct for the areas where collector wells are proposed. These aspects of the RBI plan are important for assessing the scope, limitations, and cost of this approach.

- Confirm process design assumptions for CHWTP through pilot testing. Although LWC has some operational experience with RBI supply at BEPWTP, it would be useful to determine more accurately the effects and operational adjustments associated with changing the plant's source of supply.

➢ **Coordinate installation of UV at CHWTP with conversion of BEPWTP to full RBI supply.**

- In order to satisfy LWC's goal of avoiding any disparity in finished water quality between the two plants, it is recommended that ultraviolet disinfection systems be incorporated into Crescent Hill simultaneously with B. E. Payne switching to total RBI supply. Current projections are that the additional RBI wells will be operational about 2007. Although installing UV at CHWTP will not make the resulting treated water a duplicate of that from BEPWTP, it will represent a considerable improvement and provide some of the same benefits as RBI.

➢ **Plan completion of the RBI supply source for CHWTP to coincide with installing UV systems at BEPWTP.**

- When RBI is ready for CHWTP, install UV at BEPWTP. When this step is completed, the two plants will effectively produce identical quality finished water.

6.0 Delivery and Storage Facilities

This chapter covers the review, evaluation, and recommendations for pumping, storage, and transmission improvements to meet water system demands for the 2002-2021 planning period.

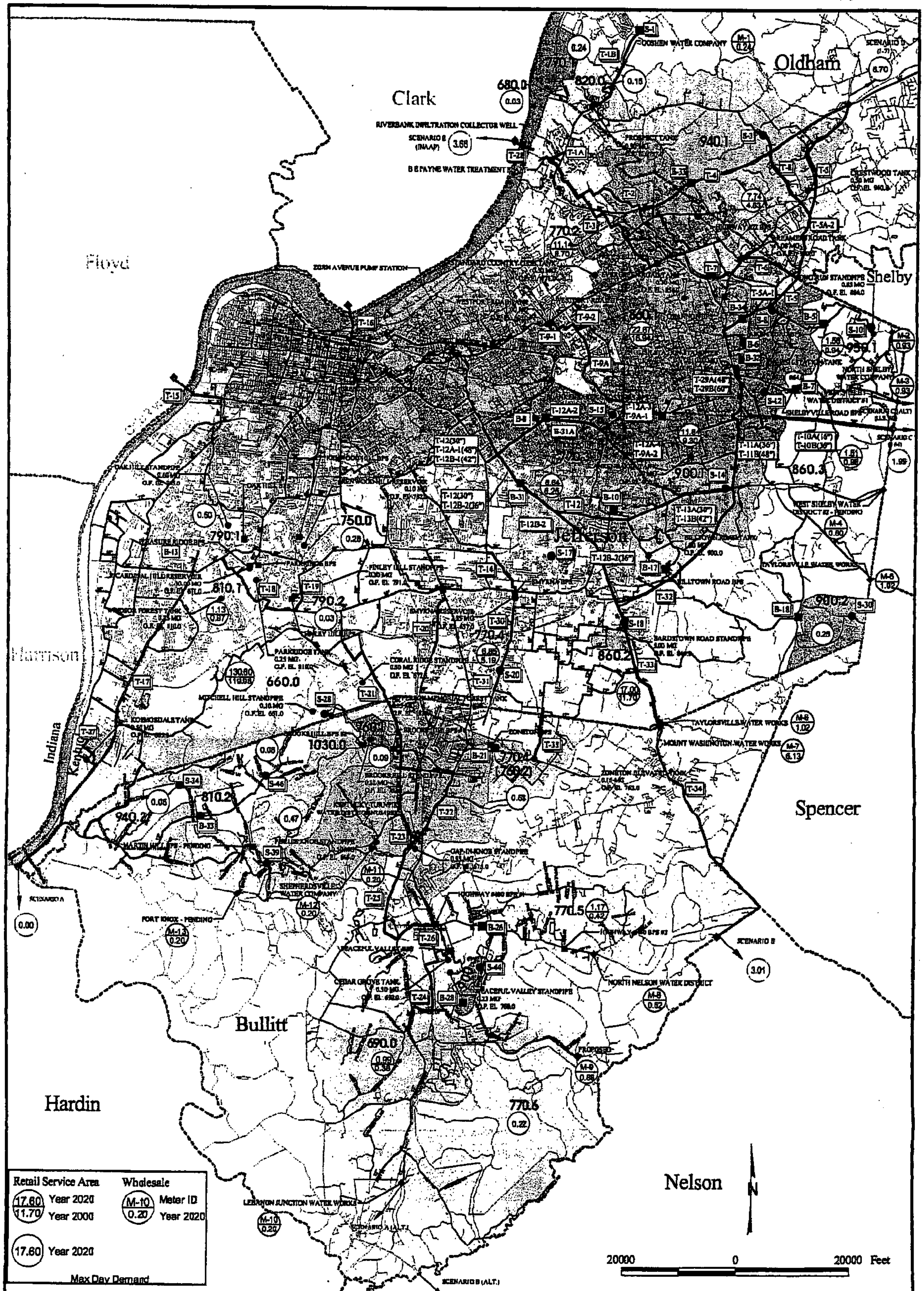
The review considered the current transmission system facilities, existing and projected water demands, supply and treatment capacities, prior planning reports, and additional plans and concepts suggested by the Infrastructure Planning Business System. Prior planning reports included the *1995-2015 Facilities Plan*, the 1996 Distribution System Hydraulic Master Plan, the year 2000 Billtown and Long Run Hydraulic Update, and the 2001 Creation of a New 900.1 Pressure Plane Report. The currently planned capital improvements were based on the 2002-2006 proposed capital expenditures for Budget Item BI 14 – Booster Pressure System, Item BI 15 – Storage Facilities, and Item BI 65 – Transmission Mains.

During the course of the *2002-2021 Facilities Plan* review, meetings with LWC staff and with the Technical Review Committee were held to present recommendations, secure LWC input, and achieve consensus. Potential improvements that were considered, including alternatives, are shown on Figure 6-1. The Figure also indicates whether each potential improvement was proposed for the recommended Capital Improvements Program, was not proposed, or is a future main dependent on implementation of a regionalization scenario.

Proposed capital improvements should be confirmed by computerized hydraulic modeling prior to final design and construction, to ensure they are adequately sized and located for LWC's system.

6.1 Delivery and Storage Unit Costs

Table 6-1 provides planning level unit construction costs for storage, pumping and transmission facilities. Costs are used to compare alternatives and to prepare the recommended capital improvements program. All costs represent fourth quarter 2001 price levels. Probable capital costs are estimated as the construction costs plus a 30 percent total allowance for contingencies and engineering, legal, and administrative costs. Costs for land, rock excavation, or rights of way are not included. Some cost variations for certain storage tanks, as appear elsewhere in this section, are due to the style of construction anticipated for the particular geographic area (pedestal, column, etc.) or anticipated unique geological engineering concerns.



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POTENTIAL IMPROVEMENTS

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Figure 6-1

Table 6-1
Delivery and Storage Unit Costs

Size and Cost Units	Size	Construction Costs ($)	Construction Unit Cost ($ per Unit)
Contingency			15%
Design and Administration			15%
Ground Level Storage Reservoirs			
MG, $/Gallon	0.25	$550,000	$2.20
	0.5	$675,000	$1.35
	1	$1,100,000	$1.10
	2	$1,800,000	$0.90
	3	$2,400,000	$0.80
	5	$3,500,000	$0.70
	10	$5,000,000	$0.50
	20	$8,000,000	$0.40
Elevated Storage Tanks			
MG, $/Gallon	0.25	$750,000	$3.00
	0.5	$885,000	$1.77
	1	$1,000,000	$1.00
	2	$2,000,000	$1.00
	3	$2,850,000	$0.95
	4	$3,600,000	$0.90
Booster Pumping Stations			
Total Capacity (MGD), $/MGD	0.1	$130,000	$1.30
	0.5	$160,000	$0.32
	1	$192,500	$0.19
	2	$300,000	$0.15
	3	$330,000	$0.11
	5	$1,700,000	$0.34
	10	$2,700,000	$0.27
	20	$3,850,000	$0.1925
	30	$4,500,000	$0.15
	40	$5,000,000	$0.125
Pipelines (Cost Per Foot)			
Diameter (inch), $/Diameter-inch Foot	8	$46.40	$5.80
	12	$69.60	$5.80
	16	$92.80	$5.80
	18	$104.40	$5.80
	20	$116.00	$5.80
	24	$139.20	$5.80
	30	$174.00	$5.80
	36	$208.80	$5.80
	42	$243.60	$5.80
	48	$278.40	$5.80
	54	$313.20	$5.80
	60	$348.00	$5.80

6.2 Delivery Needs

As previously discussed, the nominal production capacity from CHWTP is up to 180 mgd and from BEPWTP is up to 60 mgd once the current project underway is completed in 2003. The total treated water supply of 240 mgd satisfies the projected year 2020 maximum daily demand of 239.5 mgd, including an allowance for potential new regional wholesale customers.

Figure 6-2A, 6-2B, and 6-2C provide a simplified flow schematic of the existing and proposed transmission systems for years 2000, 2005, and 2020, respectively. The schematics show the maximum day water demands in each service area, the required flow transfers between areas to meet these demands, and the required production from the water treatment plants.

6.3 Storage Needs

Storage facilities in a transmission system serve multiple purposes. Without water storage, the LWC supply, pumping, and transmission facilities would need to deliver instantaneous peak demands (maximum hour). The availability of sufficient water storage at appropriate locations reduces the maximum demand on the supply, pumping and transmission facilities to the maximum day rate.

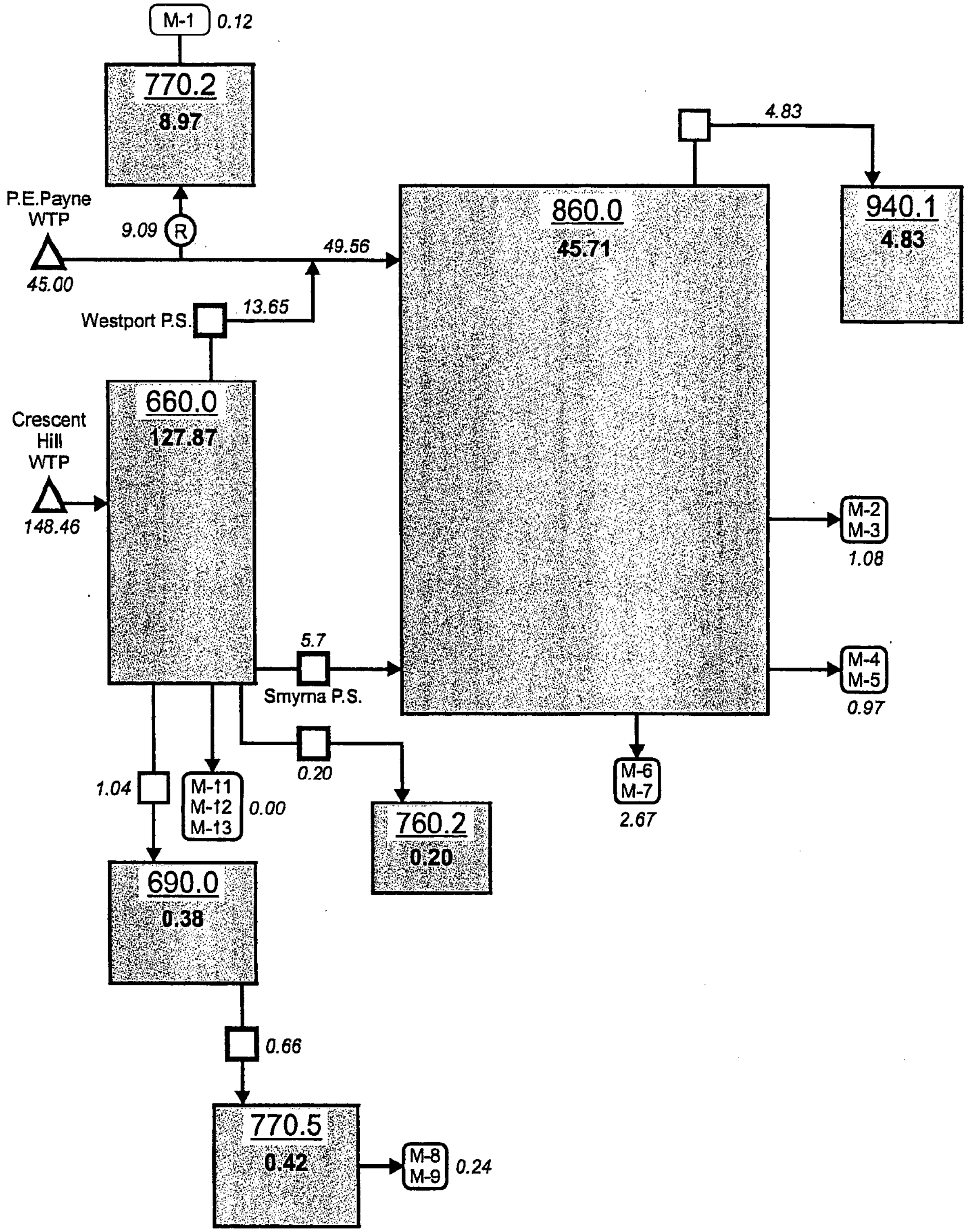
Storage needs are determined for each service area as the total of the volume needs for equalization, fire reserve and emergency supply. The available storage in each area should also be not less than twice the equalization volume, to avoid drafting reservoirs by more than one-half during normal demands. These criteria have been utilized in prior LWC planning work and are consistent with American Water Works Association (AWWA) Manual M32.

6.3.1 Equalization Storage

Equalization storage should be adequate to supply the maximum hour rate in excess of the maximum day rate for at least a 6-hour peak period. For the LWC demand ratios, this equates to 11.25 percent of the maximum day use in the areas supplied by the CHWTP (660 Pressure Plane) and 13.25 percent of the maximum day use in the Elevated Service Area. The 6-hour peak period criterion was confirmed by reviewing the hourly demand patterns for the historical maximum use day. On a maximum demand day, storage facilities will generally contribute water when demands are greater than the instantaneous average daily rate and will refill when demands are less than the instantaneous average daily rate.

6.3.2 Fire Storage

Fire storage is based on supplying fire flow for the required duration. The Insurance Services Office (ISO) grades municipal fire defense capabilities for insurance rating purposes. Part of the



Note:
Pressure Zones 660.0, 770.2 and 860.0 include dependent zones.
Demands and Flows are in mgd.

M-1 Wholesale Meter (typ.)

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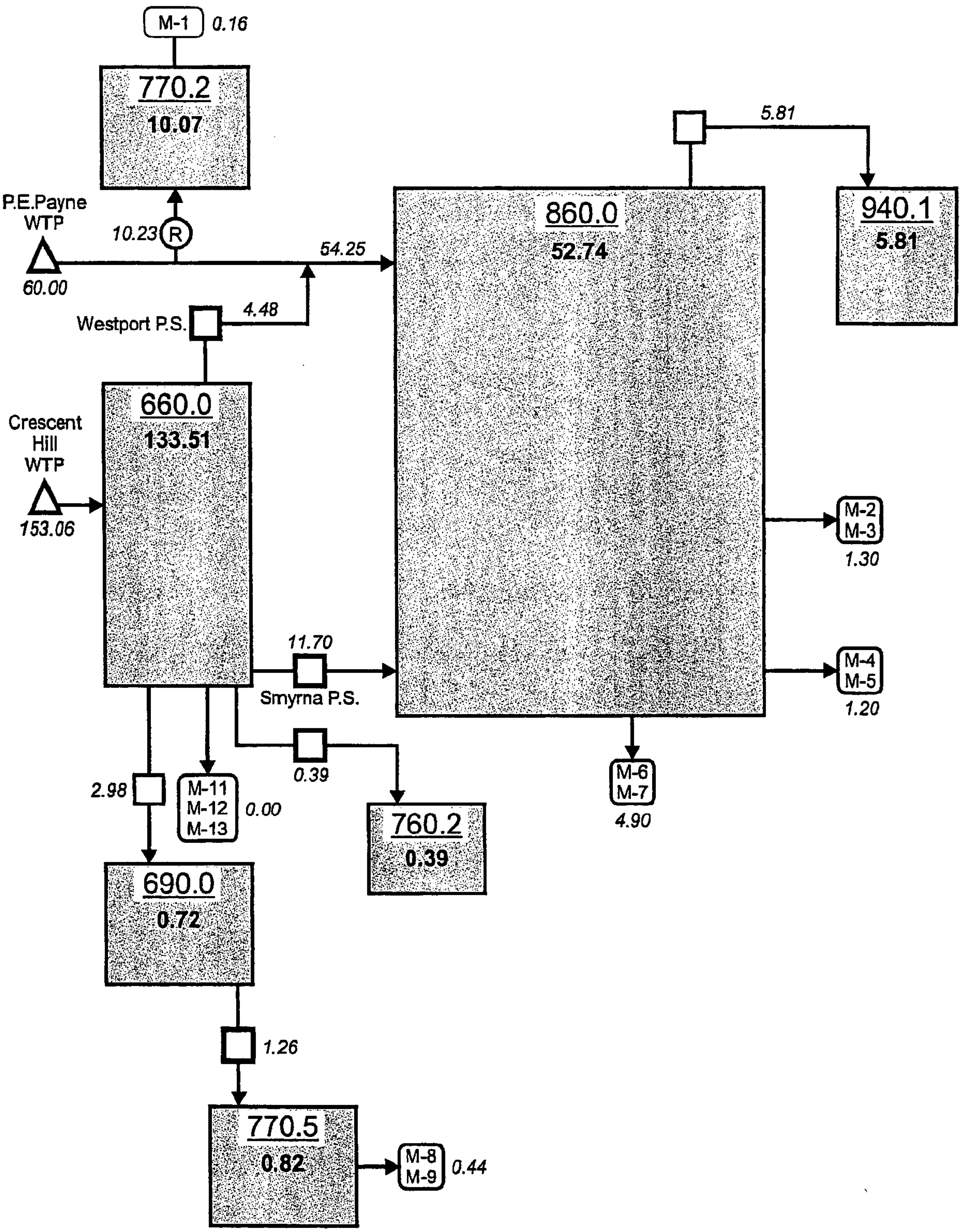
EXISTING SYSTEM FLOW SCHEMATIC
YEAR 2000 MAXIMUM DAY DEMANDS

Figure 6-2A

CYGNET 12/26/01
66603-1000-WTUP-C-N000011VH



Note:
Pressure Zones 660.0, 770.2 and 860.0 include dependent zones.
Demands and Flows are in mgd.

M-1 Wholesale Meter (typ.)

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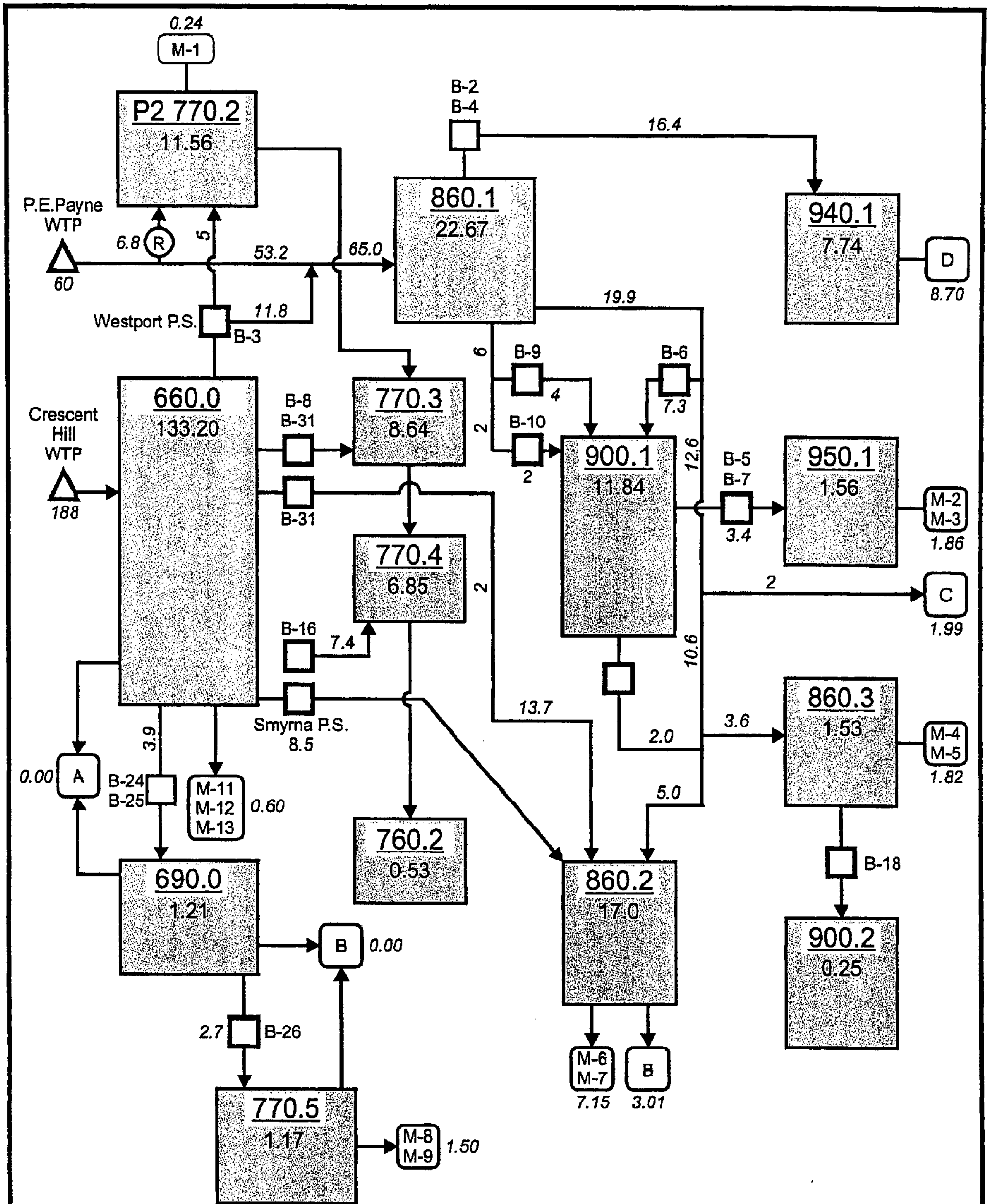
Louisville Water Company
Louisville, Kentucky
2002 - 2021 Facilities Plan

EXISTING SYSTEM FLOW SCHEMATIC
YEAR 2005 MAXIMUM DAY DEMANDS

Figure 6-2B

CYGNET 12/26/01
66603-1000-WTUP-C-N0000130H



Note:
Pressure Zones 660.0, 770.2 and 860.0 include dependent zones.
Demands and Flows are in mgd.

M-1 Wholesale Meter (typ.)

B Regionalization Scenario (typ.)

BLACK & VEATCH Corporation

Louisville Water Company
Louisville, Kentucky
2002 - 2021 Facilities Plan

PROPOSED SYSTEM FLOW SCHEMATIC
YEAR 2020 WITH REGIONALIZATION
MAXIMUM DAY DEMANDS

Figure 6-2C

CYGNET 12/26/01
66603-1000-WTUP-C-N00001VJ

ISO evaluation consists of determining needed and available fire flows at various locations throughout a water utility's system. The needed fire flow is calculated based on the size, construction, occupancy, and exposure of each building or complex. Needed fire flows can range from 500 to 12,000 gpm. A flow of 1,000 gpm is generally sufficient for fighting fires in residential structures no higher than two stories if they are more than 10 feet apart. The fire flow is required for a specified duration, generally 2 to 3 hours, at a residual pressure of 20 psi. The system should be capable of supplying the required fire flow during maximum day demand conditions.

For insurance rating purposes, 3,500 gpm for a 3-hour duration is the maximum fire flow required to be supplied by a municipal water system in accordance with ISO Schedule and AWWA M31. This rate would require fire storage of 0.63 MG. Fire flow requirements in excess of 3,500 gpm that cannot be met by the water system may affect the rating of an individual building; however, the overall municipal rating will not be affected.

Each pressure plane was assigned a fire flow volume for the storage evaluation, corresponding to Table 6-2 and an assessment of the typical development. Generally, a 3,500 gpm rate was assigned to pressure planes that include industrial or heavy commercial areas; 2,500 gpm to areas with commercial land use; and 1,500 gpm to all other areas.

Table 6-2
Fire Storage Volume Criteria

Fire Flow Rate (gpm)	Duration (hours)	Volume (MG)
3,500	3	0.63
2,500	2	0.30
1,500	2	0.18

6.3.3 Emergency Storage

Emergency storage provides a reserve supply in the event that the water supply is disrupted for any reason. These may include major water main breaks, equipment failures, power outages, or natural disasters. Providing emergency storage is a LWC policy issue, which should consider the risk of supply disruption and the desired degree of reliability. The volume required to meet demands during an outage depends on the system demand and the duration of the outage. The *1995-2015 Facilities Plan* evaluated a range of emergency storage criteria, and concluded emergency storage volumes would be sufficient for LWC's system if they could supply the average annual day demand rate for a 6-hour period. This criterion remains appropriate for LWC given the redundancy available in the system and the types of emergency events that have occurred.

Since emergency storage is not an absolute requirement of a water utility, some flexibility in applying the criteria is appropriate. As stated in AWWA M32, "Unlike equalization and fire storage, which should be available at all system storage sites, emergency storage may be included at only one or a few of the storage sites."

6.3.4 Total Storage Requirements

In general, the storage assigned to each purpose should be allocated in terms of its position in the storage reservoir. Equalization storage represents the top portion of a reservoir, since this portion fills and drains during a typical day and the fire and emergency volumes are held in reserve. Also, equalization storage should not be less than about one half of the total storage volume. The middle portion of the reservoir is the fire volume, and emergency storage is the bottom section. The importance of designating levels for the different types of storage allocation is to ensure that the storage volume has the correct hydraulic grade line for the intended purpose. For example, fire storage may be required at a time when the equalization storage has been depleted. System analysis should ensure that fire storage is available at the hydraulic grade line equal to the "bottom" of fire storage volume allocation. Storage levels would vary from full to depletion-of-equalization volume (or half full) as demand varies throughout the day.

Table 6-3 presents the calculation of storage requirements for the pressure planes served by each reservoir and for the total system, based on year 2005 demands. Table 6-4 presents the storage requirements for year 2020 demands. The tables indicate that additional storage of 7.56 MG by year 2005 and 13.73 MG by year 2020 would be needed to fully satisfy the storage criteria in all pressure planes.

Table 6-3
Year 2005 Storage Volume Requirements

Pressure Plane	Existing Volume (MG)	MD (mgd)	Equalization Volume (MG)	Fire Volume (MG)	6-hr AD Emergency Volume (MG)	Total Required Volume (MG)	Additional Volume Requirement (MG)
Elevated Service Area Pressure Planes							
680.0	0.00	0.02	0.00	0.18	0.00	0.19	0.19
770.1	0.00	0.18	0.02	0.18	0.03	0.23	0.23
770.2	1.00	9.76	1.34	0.63	1.43	3.41	2.41
770.3	0.00	7.21	0.81	0.30	1.06	2.17	2.17
770.4	0.00	5.95	0.82	0.30	0.87	1.99	1.99
820.0	0.00	0.11	0.02	0.18	0.02	0.21	0.21
860.1	10.80	19.32	2.66	0.63	2.84	6.13	-4.67
860.2	5.00	13.75	1.89	0.63	2.02	4.54	-0.46
860.3	0.00	1.20	0.17	0.30	0.18	0.64	0.64
900.1	2.00	10.43	1.43	0.63	1.53	3.60	1.60
900.2	0.00	0.20	0.03	0.18	0.03	0.24	0.24
940.1	1.50	5.81	0.80	0.30	0.85	1.95	0.45
950.1	0.50	1.25	0.17	0.30	0.18	0.66	0.16
Subtotal	**20.80**	**75.18**	**10.16**	**4.74**	**10.87**	**25.95**	**5.15**
660 Pressure Plane and Dependent Planes							
770.6	0.00	0.17	0.02	0.18	0.03	0.23	0.23
1030.0	0.15	0.38	0.04	0.18	0.07	0.29	0.14
660.0	35.25	124.39	13.99	0.63	22.21	36.84	1.59
690.0	0.50	0.72	0.08	0.30	0.13	0.51	0.01
750.0	0.10	0.25	0.03	0.18	0.05	0.25	0.15
760.1	0.35	0.07	0.01	0.18	0.01	0.20	-0.15
760.2	0.15	0.39	0.04	0.18	0.07	0.29	0.14
770.5	0.23	0.82	0.09	0.30	0.15	0.54	0.31
790.1	0.60	0.49	0.06	0.18	0.09	0.32	-0.28
790.2	0.30	0.03	0.00	0.18	0.00	0.19	-0.11
810.1	0.50	1.04	0.12	0.18	0.19	0.48	-0.02
810.2	0.00	0.06	0.01	0.18	0.01	0.20	0.20
960.2	0.00	0.04	0.01	0.18	0.01	0.19	0.19
Subtotal	**38.13**	**128.86**	**14.50**	**3.03**	**23.01**	**40.54**	**2.41**
Total Existing Retail Service Area							
Total	**58.93**	**204.05**	**24.65**	**7.77**	**33.88**	**66.49**	**7.56**

Table 6-4
Year 2020 Storage Volume Requirements

Pressure Plane	Existing Volume (MG)	MD (mgd)	Equalization Volume (MG)	Fire Volume (MG)	6-hr AD Emergency Volume (MG)	Total Required Volume (MG)	Additional Volume Requirement (MG)
Elevated Service Area Pressure Planes							
680.0	0.00	0.03	0.00	0.18	0.00	0.19	0.19
770.1	0.00	0.24	0.03	0.18	0.04	0.25	0.25
770.2	1.00	11.14	1.53	0.63	1.64	3.80	2.80
770.3	0.00	8.64	1.19	0.30	1.27	2.76	2.76
770.4	0.00	6.85	0.94	0.30	1.01	2.25	2.25
820.0	0.00	0.15	0.02	0.18	0.02	0.22	0.22
860.1	10.80	22.67	3.12	0.63	3.33	7.08	-3.72
860.2	5.00	17.00	2.34	0.63	2.50	5.47	0.47
860.3	0.00	1.51	0.21	0.30	0.22	0.73	0.73
900.1	2.00	11.84	1.63	0.63	1.74	4.00	2.00
900.2	0.00	0.25	0.03	0.18	0.04	0.25	0.25
940.1	1.50	7.74	1.06	0.30	1.14	2.50	1.00
950.1	0.50	1.56	0.21	0.30	0.23	0.74	0.24
Subtotal	**20.80**	**89.61**	**12.32**	**4.74**	**12.95**	**30.01**	**9.21**
660 Pressure Plane and Dependent Planes							
770.6	0.00	0.22	0.02	0.18	0.04	0.24	0.24
1030.0	0.15	0.47	0.05	0.18	0.08	0.32	0.17
660.0	35.25	130.60	14.69	0.63	23.32	38.64	3.39
690.0	0.50	0.99	0.11	0.30	0.18	0.59	0.09
750.0	0.10	0.26	0.03	0.18	0.05	0.25	0.15
760.1	0.35	0.09	0.01	0.18	0.02	0.21	-0.14
760.2	0.15	0.53	0.06	0.18	0.09	0.33	0.18
770.5	0.23	1.17	0.13	0.30	0.21	0.64	0.41
790.1	0.60	0.50	0.06	0.18	0.09	0.33	-0.27
790.2	0.30	0.03	0.00	0.18	0.01	0.19	-0.11
810.1	0.50	1.13	0.13	0.18	0.20	0.51	0.01
810.2	0.00	0.08	0.01	0.18	0.01	0.20	0.20
960.2	0.00	0.05	0.01	0.18	0.01	0.20	0.20
Subtotal	**38.13**	**136.13**	**15.31**	**3.03**	**24.31**	**42.65**	**4.52**
Total Existing Retail Service Area							
Total	**58.93**	**225.74**	**27.64**	**7.77**	**37.26**	**72.66**	**13.73**

LWC 2777

6.4 Water Quality Considerations

Chloramines are presently employed by LWC as a secondary disinfectant for maintaining a residual in the distribution system. Chloramine is a more stable, longer lasting disinfectant than chlorine, and it has limited reactions with organic compounds that form disinfection byproducts. It is also effective in controlling the growth of existing biofilms on the pipe walls. These benefits will better enable the LWC to expand the transmission and distribution systems and remain in compliance with regulatory requirements. However, as experienced by LWC, use of chloramines as a disinfectant residual poses some risks associated with nitrification in the distribution system.

One of the key factors in successfully using chloramines is the proper ratio of chlorine and ammonia. If the ratio is not optimal, free ammonia conditions can occur and trigger nitrification episodes in the distribution system; or the speciation can shift from the desirable mono-chloramine to di- and tri-chloramines. The presence of these two compounds can result in taste and odor complaints, and, therefore, should be avoided. Given the need to achieve the proper chemical balance, boosting the residual at stations in the distribution system is generally not recommended.

Ten States Standards, Article 4.3.3, states that "Minimum combined residuals, if appropriate, should be 1.0 to 2.0 milligrams per liter at distant points in the distribution system." For comparison, the minimum residual for free chlorine is 0.2 mg/L. As chloramines are not as strong an oxidant as free chlorine, a higher combined chlorine concentration is recommended to provide protection against microbial regrowth. If the target residual cannot be maintained to the ends of the distribution system, then increasing the concentration leaving the plant will be necessary. The maximum residual disinfectant level for chloramines is 4.0 mg/L. The system needs to mutually satisfy both the minimum and maximum residual levels permissible, which may be a constraint on the amount of system expansion.

If the residual can be maintained in the system through optimized treatment and distribution system operations, then susceptibility to nitrification needs to be considered. In addition to maintaining the proper chlorine-to-ammonia ratio, other factors important in nitrification susceptibility include system residence time, temperature, and pH, as well as the physical conditions in the pipe such as sediment, tuberculation, and biofilms. Operation strategies to avoid nitrification problems include maximizing water circulation and tank turnover rates. Vigilant monitoring can indicate that conditions are conducive for a nitrification episode, allowing a swift response. Having a plan in-place for controlling nitrification is needed, which may include flushing to reduce water age in localized areas or temporarily feeding free chlorine as a system-wide control measure. Extended travel distance within a lengthy transmission and distribution system can result in prolonged residence time, which corresponds to a loss of chlorine residual when high temperature and slow circulation conditions exist simultaneously. In such instances involving significant geographical area coverage, it may be necessary to consider chloramine re-injection to assure a disinfection residual, where the balance of the transmission and distribution system can be functionally isolated from the rest of the system. In such circumstances, tight process controls to assure the proper chlorine-to-ammonia ratio must be instituted in addition to providing site safety controls for chlorine and ammonia storage at the chloramines re-injection location.

LWC has established operational criteria to help prevent nitrification in stored water. Nitrification can generally occur at temperatures over 12 degrees Centigrade (54 degrees Fahrenheit). The rule of thumb is to turn over one-third of the tank volume each day to avoid nitrification in the stored water. This ratio exceeds the allocated flow equalization volume. Therefore, in actual operation of problematic reservoirs, LWC may chose to cycle a portion of the fire and emergency volumes each day to minimize nitrification potential. In addition, after nitrification occurs in a reservoir, increased daily cycling is needed to eliminate the problem.

To avoid nitrification, construction of future reservoirs in developing areas should be delayed until development has created a sufficient water demand. Provision of adequate transmission main looping, and avoidance of long dead-end mains can help avoid nitrification in pipelines. Chapter 4 of Volume 1 identifies some recommendations for cycling and main looping for existing storage tanks that currently experience nitrification problems.

6.5 Delivery and Storage Alternatives Evaluation

This section includes evaluation and recommendations for storage, pumping, and transmission facilities. For brevity, all facilities are referred to by reference the facility ID numbers that are shown on Figure 6-1.

6.5.1 Storage Facility Evaluation and Recommendation

Several existing and new pressure planes will require new storage tanks to meet equalization, fire, and emergency storage requirements. Tables 6-3 and 6-4 presented the calculation of storage requirements by pressure plane for year 2005 and 2020 demands. The development of storage recommendations is presented in Table 6-5.

Table 6-5 Storage Evaluation and Recommendations							
Pressure Plane	Existing Volume (MG)	2020 MD (mgd)	Storage Deficiency (MG)	CIP No.	Facility Name	CIP Volume (MG)	Recommended Volume (MG)
Elevated Service Area Pressure Planes							
680.0	0	0.03	0.19				0
770.1	0	0.24	0.25				0
770.2	1	11.14	2.80				0
770.3	0	8.64	2.76	S-15	Hikes Point	0.50	1
				S-17	High-View	0.50	1
770.4	0	6.85	2.25	S-20	Heritage	0.50	1
820.0	0	0.15	0.22	S-1	Hillcrest	1.00	0.50
860.1	10.8	22.67	-3.72	S-14	Tucker Station Rd.	5	0
860.2	5	17.00	0.47	S-18	Bardstown Rd.	1.50	1.5
860.3	0	1.51	0.73				0
900.1	0	11.84	2.00	S-8	Old Henry Rd.	1.00	1
				S-12	English Station / Alt. Old Henry	1.00	1
900.2	0	0.25	0.25	CS-30	Dryridge	0.25	0.25
940.1	1.5	7.74	1.00	S-3	Highway #329 – Applepatch	0.75	1
950.1	0.5	1.56	0.24	CS-10	Long Run	1.00	1
Subtotal	**18.8**	**89.61**	**9.44**			**13.00**	**9.25**
660 Pressure Plane and Dependent Planes							
770.6	0.15	0.47	0.17				0
1030.0	0.15	0.47	0.31	S-28	Jefferson County Memorial Forest II	0.15	0.15
				S-39	Gospel Kingdom	0.25	0.25
660.0	35.3	130.60	3.39	S-48	Cardinal Hill Reservoir Improvements	0	0
690.0	0.5	0.99	0.09		I-65 Undesignated	0.50	0.50
750.0	0.1	0.26	0.15				0
760.1	0.35	0.09	-0.14				0
760.2	0.15	0.53	0.18				0
770.5	0.23	1.17	0.41	S-38	Ridge Rd. / Hwy. 480	0.50	0.50
790.1	0.6	0.50	-0.27				0
790.2	0.3	0.03	-0.11				0
810.1	0.5	1.13	0.01				0
810.2	0	0.08	0.20	S-46	Sugar Tree	0.25	0.25
900.3	0	0.05	0.20	S-44	Ram's Run	0.25	0.25
960.1	0	0.05	0.20	S-34	Barralton Hill	0.25	0.25
Subtotal	**38.33**	**136.42**	**4.79**			**2.15**	**2.15**
Total Existing Retail Service Area							
Total	**57.1**	**226.03**	**14.23**			**15.15**	**11.4**

Table 6-5 recommendations consider the following:

- A 660.0 PP shortage is avoided using emergency criteria of 5.4 hours.
- Provide smaller pressure planes with peak pumping capacity instead of storage. These include the 680.0, 820.2, 770.6, 750.0, 760.2, and 810.2 Pressure Planes.
- Excess 860.1 PP storage meets 770.2 PP and 860.3 PP deficiencies.
- The 950.1 PP existing standpipe (currently 860.3 PP) will be retired. The proposed Elevated Tank will meet the total requirement.
- The 770.3 PP and 770.4 PP storage requirements will be supplemented via PRV's from the 24-inch Cross County Highway transmission main.
- Although no additional Bullitt County storage is recommended in PP 690.0 and limited storage in PP 770.5, LWC should monitor possible pressure stabilization needs in extended portions of the service areas.

Recommendations for new storage tanks listed below are discussed in the following paragraphs. The potential tanks discussed are listed in Table 6-6.

Table 6-6
New Storage Tank Identification Numbers

S-1	S-28
S-3	S-30
S-8	S-34
S-10	S-38
S-12	S-39
S-14	S-44
S-15	S-45
S-17	S-46
S-18	S-47
S-20	S-48

6.5.1.1 S-1 (Hillcrest) Elevated Storage Tank

S-1 (Hillcrest) Elevated Storage Tank is recommended to meet storage requirements in the 820.0 Pressure Plane. A minimum capacity of 500,000 gallons is required. It is recommended to provide a capacity of 1.0 MG to provide service to the 820.0 Pressure Plane and the entire Goshen Utilities service area demand.

6.5.1.2 S-3 (Highway 329 - Applepatch) Elevated Storage Tank

S-3 (Highway 329 - Applepatch) Elevated Storage Tank is recommended to supplement existing storage in the 940.1 Pressure Plane. This storage was previously recommended by the PDR Facilities Report prepared for the former OCWD No. 1.

6.5.1.3 S-8 (Old Henry Road) and S-12 (English Station)

The expanded 900.1 Pressure Plane preliminary engineering report recommended either the S-8 or S-12 elevated tank be constructed to meet storage requirements for the 900.1 Pressure Plane. However, after evaluation of storage requirements for the area, both tanks are recommended to meet year 2020 water demands. It is recommended that S-8 be constructed first. LWC staff have determined that when the S-8 storage facility is in service, there will be sufficient elevated storage in the vicinity to permit the English Station Standpipe to be removed from service for needed maintenance. S-8 and S-12 storage tanks should each have a storage volume of 1.0 MG with an overflow at elevation 900 feet.

6.5.1.4 CS-10 (Long Run)

Elevated storage is recommended for construction based on a special report (*Long Run Hydraulic Update*) prepared for LWC. The existing standpipe will be replaced with a 1.0 MG elevated tank (CS-10) with an overflow elevation of 950 feet msl.

6.5.1.5 S-14 (Tucker Station)

The previous facilities plan recommended a new 5.0 MG tank be constructed near the Snyder Freeway and Taylorsville Road. This facility is superseded with creation of the expanded 900.1 Pressure Plane; therefore, the S-14 (Tucker Station) facility is not recommended. This location could be considered as an alternate site to the recommended S-12 (English Station) 1.0 MG elevated storage tank.

6.5.1.6 S-15 (Hikes Point), S-17 (High-View), and S-20 (Heritage)

Elevated tanks were recommended in the previous facilities plan to meet the storage requirements for the newly created 770 Pressure Plane. The modification of the 660 and 860 Pressure Planes to create the new 770 Pressure Plane will improve customer service by eliminating low and high pressure areas from portions of the former 660 and 860 Pressure Planes. The 770.3 and 770.4 Pressure Plane storage requirements will be supplemented by flows through pressure reducing valves from the 24-inch Cross County Highway transmission main. The actual demands and corresponding pumping and storage needs for the areas to be converted to these new pressure planes should be determined after the final boundaries are defined. In the interim, LWC should plan for 1.0 MG storage at each site (S-15, S-17, and S-20)

6.5.1.7 S-18 (Bardstown Road)

The previous Facilities Plan recommended a 1.5 MG elevated tank be constructed at an overflow elevation of 865 feet msl to improve system flow and pressure in the south-central county area for the 860.3 Pressure Plane. The existing 5 MG Bardstown Road Standpipe has an overflow elevation of 844 feet msl that will be 21 feet below the overflow of the S-18 Tank. Prior to construction, a re-evaluation should be made to study the opportunity to extend the 900.1 Pressure Plane to address customer low pressure concerns needs by constructing this elevated tank at a 900 msl. With increased transmission capacity being recommended along the Snyder Freeway between the English Station Standpipe with an overflow elevation of 864 feet msl and the Bardstown Road Standpipe, it is believed the Snyder Freeway transmission main could be better supported with the existing Bardstown Road Standpipe serving in a transmission storage capacity for the 860.2 Pressure Plane.

6.5.1.8 S-28 (Jefferson Memorial Forest)

The previous Facilities Plan recommended a second 150,000 gallon elevated tank be constructed to meet storage requirements for the 1030 Pressure Plane.

6.5.1.9 CS-30 (Dry Ridge Road)

This elevated tank is recommended to provide system storage for the 900.2 Pressure Plane. The volume should be 250,000 gallons with an overflow elevation of 900 feet msl.

6.5.1.10 S-34 (Barralton)

This elevated tank is recommended to provide system storage for the 940.2 Pressure Plane. The volume should be 250,000 gallons.

6.5.1.11 S-38 (Ridge Road / Highway 480)

This elevated tank is recommended to provide system storage for the 770.5 Pressure Plane in support of the Bullitt County Extension Program in eastern Bullitt County. The volume should be 500,000 gallons.

6.5.1.12 CS-39 (Gospel Kingdom)

This elevated tank is recommended to provide system storage for the southern portion of the 1030 Pressure Plane. The volume should be 250,000 gallons.

6.5.1.13 S-44 (Ram's Run)

This elevated tank is recommended to supplement existing storage in the 900.3 Pressure Plane. The volume should be 250,000 gallons.

LWC 2783

6.5.1.14 S-45 (I-65 Transmission Corridor: Undesignated)

This elevated tank is recommended to provide system storage for the 690.1 Pressure Plane in support of the Bullitt County Extension Program in southern Bullitt County. The volume should be 1.0 million gallons.

6.5.1.15 S-46 (Sugar Tree)

This elevated tank is recommended to provide system storage for the 810.2 Pressure Plane in support of the Bullitt County Extension Program in western Bullitt County. The volume should be 250,000 gallons.

6.5.1.16 S-47 (860 Pressure Plane: Undesignated)

This elevated tank serves as a placeholder to provide system storage for the 860.1 Pressure Plane if deficient capacity is determined, given the backup backflow from the 900.1 Pressure Plane storage through the interconnect design with check valves and pressure sustaining valves.

6.5.1.17 S-48 (Cardinal Hill Reservoir Improvements)

This 30.0 MG reservoir is in need of significant improvements and recoating of certain structures to extend their useful life. These improvements include, but are not limited to piping, structure renovation, and security related items.

6.5.2 Booster Pumping Facility Evaluation and Recommendation

Several of the potential transmission main improvements will require booster pumping to deliver water supply to higher pressure planes. New booster pumping stations are listed in Table 6-7 along with existing stations to be modified. The new and modified stations listed below are discussed in the following paragraphs.

Table 6-7
Booster Pumping Facility Identification Numbers

New		Modified
B-6	B-28	B-7
CB-10	RB-31	B-8
B-13	RB-31A	B-9
B-17	B-32	
CB-18	RB-33	
B-21	B-34	
B-26	B-35	

6.5.2.1 B-7 (Shelbyville Road BPS)

B-7 (Shelbyville Road BPS) pumps will be modified by changing impellers to allow pumping to the 950.1 Pressure Plane from the newly created 900.1 Pressure Plane. The total firm capacity from

Shelbyville Road BPS and the existing Aiken Road BPS should be equal to 2400 gpm. It was previously recommended to provide 2100 gpm at Aiken Road BPS and 1000 gpm at Shelbyville Road BPS.

6.5.2.2 B-8 (Hikes Point BPS)

B-8 pumps will be modified by changing impellers to allow pumping to the expanded 770.3 Pressure Plane and a new elevated tank (Hikes Point S-15). This station has total and firm capacities of 7.5 and 5.0 mgd, respectively.

6.5.2.3 B-9 (Blankenbaker Crossing BPS)

The two existing B-9 pumping units provide firm and total capacities of 1.15 mgd and 2.30 mgd, respectively. To meet the expanded and new 900.1 Pressure Plane water demands, a third unit should be installed to provide firm capacity of 1.82 mgd, and a total capacity of 3.30 mgd.

6.5.2.4 RB-31 BPS or B-31A BPS

RB-31 or B-31A is to meet increased demand should Regionalization Scenario B or Regionalization Scenario C come to fruition. Though its capacity would not be used to solely supply those regionalization scenarios, it would supply areas in the 770.3 Pressure Plane and a new elevated tank (Highview S-17) as well as the Snyder 860 Pressure Plane Transmission System. Funding is not included for either of these stations, as the Regionalization Scenario business cases will provide for the required funding. If B-31 Station is not constructed, then pressure reducing valves off the 24-inch Cross County Highway main could supplement the water demands in the 770.3 Pressure Plane. Also, the 770 pumps installed in the Smyrna BPS could serve the 770.3 and 770.4 Pressure Planes and the High-View Tank (S-17). As shown on Figure 6-1, B-31A BPS is not recommended.

6.5.2.5 B-6 (Tucker Station Road BPS)

This station will provide water supply to the new 900.1 Pressure Plane. This station should have a firm capacity of 2.0 mgd to meet the projected year 2020 water demands. The location for this BPS will match the 990 PP tank locations of either S-12 (English Station) or S-14 (Tucker Station). This station will meet residential and commercial demand in this area as well as address low pressure complaints along Taylorsville Road near I-265 and Tucker Station Road.

6.5.2.6 CB-10 (Shady Acres BPS) and B-17 (Billtown Road BPS)

CB-10 (Shady Acres BPS) and B-17 (Billtown Road BPS) are new or pending booster pumping stations that will discharge to the new 900.1 Pressure Plane. It was previously recommended that each station should have a capacity of 1400 gpm for a total of 2800 gpm. The Shady Acres BPS should have an extra pumping unit, to provide firm capacity with one pumping unit out of service.

6.5.2.7 B-13 (Pleasure Ridge Park II BPS)

B-13 (Pleasure Ridge Park II BPS) is recommended to provide a redundant supply to the 810.1 Pressure Plane in the area of the Cardinal Hill Reservoir for reliability purposes. The firm capacity of the station is recommended to be 2.0 mgd.

6.5.2.8 CB-18 (Dry Ridge BPS)

CB-18 (Dryridge BPS) is recommended to provide supply to the 900.2 Pressure Plane and the new elevated tank (S-30). The total and firm capacity of the station should be 300 gpm and 200 gpm, respectively.

6.5.2.9 B-21 (Zoneton BPS)

B-21 (Zoneton BPS) is planned as a new station that will replace the existing station with two 300 gpm units. However, with the expanded 770 Pressure Plane as shown on Figure 6-1, it is recommended that B-21 not be constructed and instead a new 12 inch main (T-35) be extended from the 770.4 Pressure Plane to the existing Zoneton elevated tank. This raises the hydraulic gradient elevation from 760 to 770 feet.

6.5.2.10 B-26 (Ridge Road / Highway 480 BPS)

B-26 (Ridge Road BPS) is a new station to provide water supply to the 770.5 Pressure Plane and an elevated tank (S-38). The firm capacity of this station is recommended to be 2.84 mgd.

6.5.2.11 B-28 (Ram's Run BPS)

B-28 (Ram's Run BPS) is a new station to provide water supply to the 900.3 Pressure Plane and an elevated tank (S-44). The firm capacity of this station is recommended to be 1.0 mgd.

6.5.2.12 B-32 (English Station Standpipe BPS)

To fully utilize the 10 MG stored in the standpipe, a 20 mgd booster station should be constructed near the base of the standpipe to discharge to the English Station Elevated Tank and the 60 inch transmission main. The top 20 feet of the standpipe would float with the existing elevated tank. When the water level falls below 20 feet, then the booster pumping station would take suction from the remaining volume. It is assumed that about 5 MG or 45 feet would be available for pumping at a rate of 20 mgd for 6 hours. Replenishment of the standpipe would be through a pressure reducing valve at a controlled rate of about 10 mgd over a period of 12 hours.

6.5.2.13 B-33 (Knob Creek Road BPS)

B-33 (Knob Creek Road BPS) is a new 1.0 mgd station to supply Sugar Tree Tank in western Bullitt County along Knob Creek Road (Hwy. 1526) and the lower portion of Martin Hill Road due to hydraulic constraints. It will serve the 810.2 Pressure Plane created by the tank.

6.5.2.14 RB-33 (T-4 Alternative) and RB-34 (T-5 Alternative)

One of these new stations will be needed to meet the projected increased water demands in the 940.1 Pressure Plane and regionalization demand for Scenario D should this regionalization scenario come to fruition. Because the T-5 Alternative is not recommended, the B-34 station would not be required.

6.5.3 Transmission Main Evaluation and Recommendations

Several of the proposed improvements shown on Figure 6-1 are alternatives to one another. The alternatives were evaluated based on implementation, staging potential, and capital costs. The alternatives are listed below and discussed in the following paragraphs.

- B. E. Payne 60-inch Pipeline Reliability Connection; Pipelines T-2 versus T-3.
- Regionalization Scenario D Supply; Pipelines T-4 versus T-5. Pipelines T-4 or T-5 will require a booster pumping station B-33 or B-34, respectively.
- Crescent Hill to ESA Reliability Connection; Pipelines T-9 Segment 1, T-9A, T-9A1 and T-9A2 versus T-12A1, T-12A2, T-12A3, and T-12A4.
- Southern 860 Pressure Plane Supply; Pipelines T-29A, T-11A, T-13A, 12-B1 and 12-B2 versus T-29B, T-11B, T-13B, and T-32. T-12 and T-12B, or T-12A will require a booster pumping station B-31 and B-31A, respectively.
- Scenario C/Bluegrass Pipeline, T-10A versus T-10B.
- Scenarios A and B Supplies; Pipelines T-34 and T-17.

6.5.3.1 B. E. Payne 60-inch Pipeline Reliability Connection

Pipelines T-2 and T-3 are alternative improvements that provide a parallel redundant main to the B. E. Payne 60-inch transmission main, between the plant and Westport Road. Both routes were reviewed based on implementation and costs. The existing main has a history of leaks as discussed previously, with the majority of leaks located west of Highway 71.

The required flow through the parallel pipeline was determined to be 30 mgd based on the 112 mgd year 2020 maximum day demand for the elevated service area plus wholesale and regionalization scenario demands, less 72 mgd supply from the Westport, Smyrna, and a future B-31 pumping station discussed later.

The current high service pump operation is limited to 60 mgd and about 209 psi discharge pressure to avoid over-pressurizing the 60-inch pipeline. LWC indicated that the pumps could be operated at about 10 psi additional head when pumping to the parallel main with the 60-inch main out of service.

The T-2 alignment offers a first connection to the 60-inch main at 12,500 feet from the B. E. Payne plant. This connection would provide redundancy for the most problematic portion of the 60-inch main. A 36-inch pipe is required to convey 30 mgd to this location with the available pump discharge head. The 36-inch pipe could deliver up to 42 mgd.

The T-3 alignment would connect to the 60-inch main at 21,900 feet from the plant. This pipeline would also be 36-inch, but would deliver up to 31 mgd with the available head.

T-2 has the higher capital cost for the total project, at about $9,600,000 compared to about $7,540,000 for T-3. T-3 is the recommended alternative, based on lower costs for the project.

6.5.3.2 Regionalization Scenario D Supply, T-4 Versus T-5

T-4 and T-5 are alternative improvements that provide water supply to the 940.1 Pressure Plane and Scenario D. Both improvements require a new pumping station to booster the hydraulic gradient from the 860 Pressure Plane to the 940 Pressure Plane. T-4 has the lowest capital cost of about $10,800,000 compared to about $13,000,000 for T-5. T-4 is recommended based on cost. (Note: T-4 is not included in Table 6-10 because it is a Regionalization transmission main and does not have capital funding.)

6.5.3.3 Crescent Hill to ESA Reliability Connection; Pipelines T-9 Segment 1, T-9A, T-9A1 and T-9A2 versus T-12A1, T-12A2, T-12A3, and T-12A4

The first alternative improvement (T-9 series) consists of a 42-inch transmission main from the Westport Booster Pumping Station to the existing 36-inch main in Linn Station Road at Hurstbourne Parkway (Cross County Header). A second section of the first alternative would consist of a new 36-inch main across Interstate 64 along the Cross County Header to Taylorsville Road, then along Taylorsville Road to the Snyder Freeway. The second alternative improvement (T-12A series) consists of a 48-inch transmission main from the 60-inch main at Bon Air Avenue to Hikes Lane, then a 42-inch main along Hikes Lane to Taylorsville Road, then in Taylorsville to the Cross County Header, then a new 36-inch to the existing 36-inch main in Linn Station Road. The second part of this alternative would be a 36-inch main from the Cross County Header along Taylorsville Road to the Snyder Freeway. These two alternatives provide a reliability connection to the 60-inch transmission main in English Station Road from the BEPWTP.

Based on 2001 capital costs, the first alternative (T-9 series) would be about $20,000,000, whereas the second alternative (T-12A series) would be about $20,800,000. It should be recognized the second alternative would require a booster pumping station (B-31A) at a cost of $3,780,000 for a total $23,780,000 capital cost. The first alternative is recommended since it allows for staged improvements and provides for an initial connection to the Cross County Header 24-inch and 36-inch mains at Linn Station Road. The second parts of both alternatives are future improvements.

T-12 was the improvement initially developed to provide a reliability connection to the 60-inch main in English Station Road as a 30-inch transmission main. As shown in Figure 6-3, T-12 represents realignment of the T-12B segment that would direct flows to Snyder Freeway and Taylorsville Road, rather than to Snyder Freeway and Bardstown Road. To provide equivalent hydraulic capability as T-12B, segment T-12 would need to be the same diameter (36-inch), and T-13 and T-32 on Snyder Freeway would need to be 42-inch. Therefore, any alternative utilizing the T-12 alignment is less efficient at meeting the projected southern 860 Pressure Plane demands. T-12 is not recommended. T-12 could be reconsidered if Scenario C demands are significantly increased or if the Bluegrass Pipeline project is reactivated.

6.5.3.4 Southern 860 Pressure Plane Supply, Pipelines T-29A, T-11A, T-13A, T-12B1, and T-12B2 versus T-29B, T-11B, T-13B, and T-32

T-29A, T-11A, T-13A, T-12B-1, and T-12B-2 versus T-29B, T-11B, T-13B, and T-32 are alternative improvements to provide water supply to Regionalization B, Regionalization C and the 860.2 Pressure Plane. The first alternative improvements provide water supply from both the BEPWTP and CHWTP, whereas, the second alternative improvement provides water supply only from the BEPWTP. The first alternative improvements allow staging whereas the transmission along Snyder Freeway would be constructed first. The transmission main along Bardstown Road would be constructed when increased transmission capacity is required to meet additional water demands in the 860.2 Pressure Plane and the Taylorsville and Mount Washington Water Works wholesale water customers.

Based on 2001 capital costs, the first alternative would be about $24,700,000 plus $3,780,000 for a booster pump station (B-31) a total $28,580,000 capital cost. The second alternative along Snyder Freeway has a cost opinion of $20,300,000. However, the first alternative is recommended since it provides two sources of supply and allows for staging.

6.5.3.5 Scenario C/Bluegrass Pipeline; T-10A and T-10B

T-10A is an improvement to provide water supply to the 860.3 Pressure Plane and Regionalization Scenario C wholesale customers. T-10B is an alternative improvement to provide a future supply to the Kentucky-American Water Company service area in addition to the T-10A demand. T-10A is a 16-inch main and T-10B is a 36-inch transmission main with probable capital costs of about $4,008,960 and about $8,700,000, respectively.

All other mains shown on Figure 6-1 and Table 6-7A are recommended to meet projected water demands for the planning period.

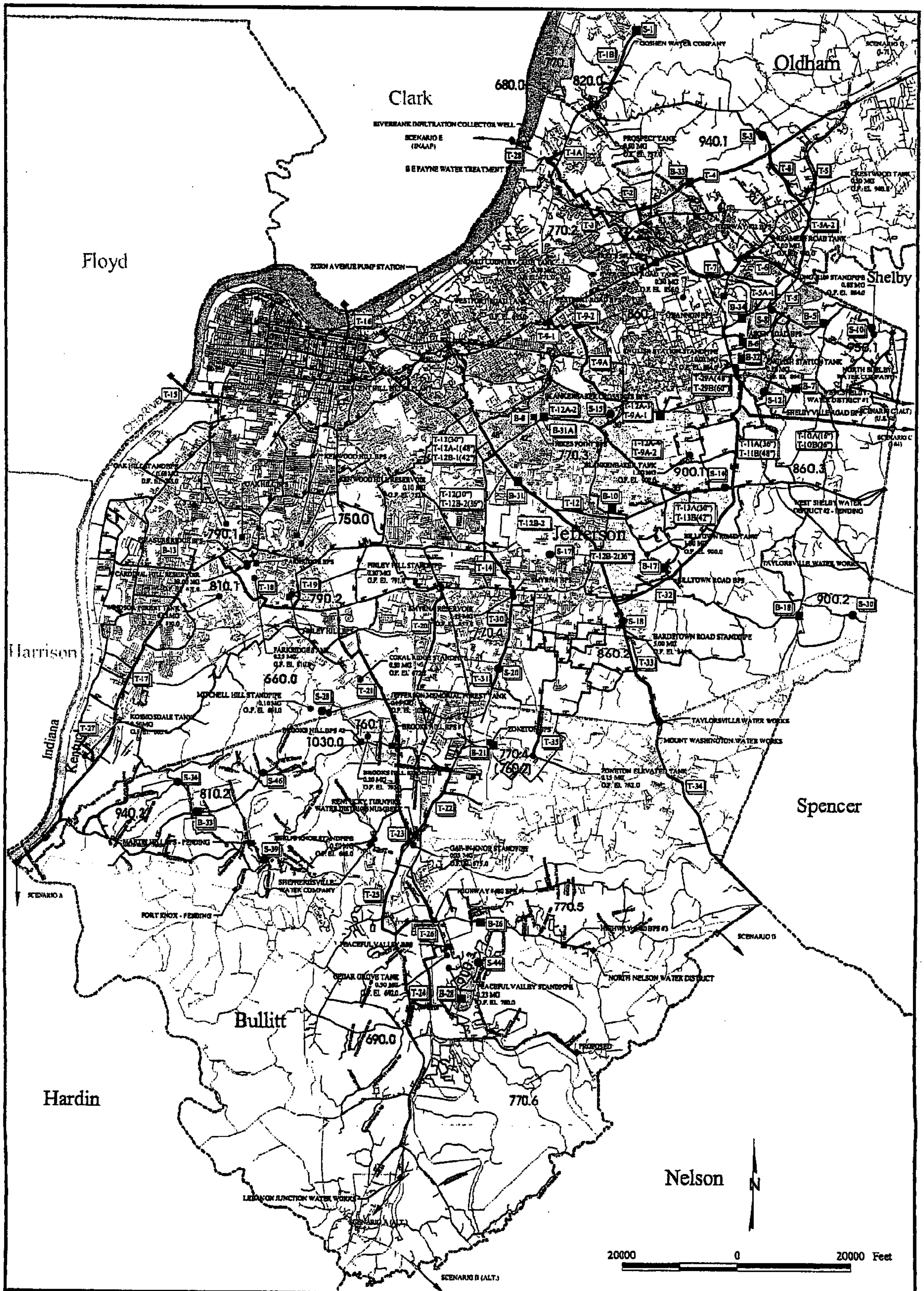
6.5.3.6 Scenarios A and B Supplies; Pipelines T-34 and T-17.

Alternative locations for supply connections to Regionalization Scenarios A and B were considered, as shown on Figure 6-1. Scenario A could be provided water either on Dixie Highway and the Jefferson County Line, or farther south at Highway 65 at the southern Bullitt County Line. Pipeline T-17 would supply the Dixie Highway connection. A comparable pipeline through Bullitt County Pressure Plane 690.0 plus increased capacity for mains in southern Pressure Plane 660.0 would be needed for the southern connection. The T-17 improvement requires significantly less pipeline length and is recommended. (Note: T-17 is not included in Table 6-10 because it is a Regionalization transmission main and does not have capital funding.)

Similarly, Scenario B could be supplied from either near the Nelson and Spencer County Lines, or Highway 65 at the southern Bullitt County line. Pipeline T-34 supplies the northern connection. For Scenario A, using the southern connection would require a comparable main through the 690.0 Pressure Plane plus increased capacities within southern 660.0. The T-34 improvement is recommended.

6.6 Recommended Delivery and Storage Capital Improvements Plan

Figure 6-3 shows the Capital Improvements Plan for the recommended delivery and storage facilities. The proposed system flow schematic with 2020 maximum day demands and regionalization flows was provided in Figure 6-2C. Tables 6-8, 6-9, and 6-10 list the recommended storage, pumping, and transmission mains, respectively, along with the capital costs.



Legend

Proposed Water Mains
- Proposed
- Regionalization
- Not Proposed

Existing Water Mains
- 8" - 10"
- 12" - 72"

Proposed Facilities
- Pumping Station
- Storage
- Meter
- Regionalization Meter

750 Pressure Plane
- Storage Facility
- Supply Facility
- Pumping Station
- Master Meter

County Boundary
Streets

Loulsville Water Company
2002-2021 Facilities Plan

POTENTIAL IMPROVEMENTS

BLACK & VEATCH

Figure 6-3

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Table 6-8 Recommended Storage Facilities						
ID Number	Storage Facility Name	Pressure Plane	Req'd Volume (MG)	Unit Rate ($/gal)	Construction Costs ($)	Capital Costs ($)
S-1	Hillcrest	820.1	1	1.15	$1,150,000	$1,500,000
S-3	Highway 329 - Applepatch	940.1	0.5 – 0.75	1.18	$885,000	$1,150,000
S-8	Old Henry Road	900.1	1	1.00	$1,000,000	$1,300,000
CS-10	Long Run	950.1	1	1.00	$1,000,000	$1,300,000
S-12	English Station Road	900.1	1	1.00	$1,000,000	$1,300,000
S-15	Hikes Point	770.3	1	1.00	$1,000,000	$1,300,000
S-17	High View	770.3	1	1.25	$1,250,000	$1,600,000
S-18	Bardstown Road	900.1	1.5	0.925	$1,385,000	$1,800,000
S-20	Heritage	770.4	1	0.925	$925,000	$1,200,000
S-28	Jefferson County Memorial Forest II	1030.0	0.15	3.20	$480,000	$625,000
CS-30*	Dry Ridge	900.2	0.25	1.38	$345,000	$450,000*
S-34	Barralton Hill	940.2	0.25	3.00	$750,000	$975,000
S-38	Ridge Road/Hwy. 480	770.5	0.5	1.77	$885,000	$1,150,000
CS-39*	Gospel Kingdom	1030.0	0.25	1.38	$345,000	$450,000*
S-44	Ram's Run	900.3	0.25	3.00	$750,000	$975,000
S-45	I-65 Transmission Corridor: Undesignated	690.1	1	1.15	$1,150,000	$1,500,000
S-46	Sugar Tree	810.2	0.25	3.00	$750,000	$975,000
S-47	860 PP: Undesignated	860.1	1	1.25	$1,250,000	$1,600,000
S-48	Cardinal Hill Improvements	660.0	30	-	$1,845,000	$2,400,000
Total			**42.9 – 43.15**		**$18,145,000**	**$23,550,000**

* = These facilities have already been funded and costs should not be included in future budget calculations.

Table 6-9
Recommended Booster Pumping Facilities

ID Number	Pumping Station Name	Pressure Plane Supplied	Req'd Total Capacity (mgd)	Unit Rate ($/mgd)	Construction Costs ($)	Capital Costs ($)
B-8	Hikes Point (Rebuild)	770.3	5.00	34,000	170,000	250,000
B-26	Ridge Rd. / Hwy. 480	770.5	2.84	108,450	308,000	400,000
CB-10*	Shady Acres	900.1	2.00	115,000	230,000	300,000*
B-13	PRP II	810.1	2.00	115,000	230,000	300,000
B-17	Billtown Rd.	900.1	2.00	135,000	270,000	350,000
B-6	Tucker Station Rd.	900.1	2.00	135,000	270,000	350,000
B-9	Blankenbaker Crossing (Modify)	900.1	2.00	115,000	230,000	300,000
CB-18	Dry Ridge	900.2	0.29	448,275	130,000	170,000
B-7	Shelbyville Rd. (Modify)	950.1	1.00	115,000	115,000	150,000
B-28	Ram's Run	900.3	1.00	192,500	192,500	250,000
B-32	English Station SP	860.1	20.00	192,300	3,846,000	5,000,000
B-33	Knob Creek Road	810.2	1.00	192,500	192,500	250,000
	Total				**6,184,000**	**8,070,000**
Future Booster Pumping Facilities Dependent on Regionalization						
RB-31	T-12 PS to ESA	770.3,860	18.00	140,000	2,520,000	3,780,000
RB-33	T-4 PS to 940.1	940.1	12.00	140,000	1,680,000	2,520,000
	Total				**4,200,000**	**6,300,000**

* = These facilities have already been funded and costs should not be included in future budget calculations.

Table 6-10
Recommended Transmission Pipeline Facilities

CIP Project No.	Description	Pressure Plane	Diameter (in)	2020 MD Flow (mgd)	Length (ft)	Unit Cost ($/ft)	Construction Costs ($)	Capital Costs ($)
Proposed 2002-2021 Transmission Mains								
T-1A	River Rd., B. E. Payne to US Hwy 42	770.2	16	0.7	3,300	92.80	306,000	459,000
T-1B	Prospect Tank to Hillcrest Tank along Hwy. 42	820.0	16		16,000	92.80	1,484,800	2,227,000
T-3	I-265 Transmission: Wolf Pen Branch to Westport Rd. (Alt. 2)	860.0, ESA	36	30	30,700	163.75	5,027,000	7,540,000
T-5A, Segment 2	Reamer Rd. at Ash Ave. to Hwy. 329	940.1	16	3.2	11,600	92.80	1,081,000	1,622,000
T-6	Old Floydsburg Rd./Reamers Rd. to Ash Ave.	940.1	16	2	11,600	92.80	1,081,000	1,622,000
T-7	Chamberlain Ln./Lagrange Rd.: 60" at Ford KTP to Reamers Tank	940.1	24	0	8,500	139.20	1,186,000	1,779,000
T-8	Hwy. 329 Fox Hollow at Hwy. 329 to Applepatch Tank (S-3), south to Spring Hill Development	940.1	16	2	10,000	92.80	928,000	1,392,000
T-9, Segment 1	Westport BPS to Lake Ave. at Herr Ln. and Lyndon Ln.	860.0	42	20	6,700	226.85	1,520,000	2,280,000
T-9, Segment 2	Lake Ave. at Herr Ln. and Lyndon Ln. to Ormsby Ln.	860.0	24	20	2,300	139.20	316,000	474,000
T-9A	Lake Ave. at Herr Ln. and Lyndon Ln. to Linn Station/Ellingsworth 36"	860.0	42	20	14,300	226.85	3,251,000	4,876,000
T-10A	US Hwy. 60: English Station Rd. to Jefferson/Shelby County Line	860.0 / 950.1	16	2	28,800	92.80	2,672,640	4,009,000
T-11A	Snyder Transmission 48", I-64 to Taylorsville Rd.	Southern 860	36	10.6	13,300	225.56	3,000,000	4,500,000
T-13A	Snyder Transmission 36": Taylorsville Rd. to Billtown Rd.	Southern 860	30	7	18,300	182.15	3,334,000	5,000,000
T-14	Fern Valley Rd. 30": Fern Valley Rd. to Smyrna BPS	860.0	30	15	9,200	174.00	1,595,000	2,393,000
T-18	Cardinal Hill Reservoir Secondary Supply: St. Andrews and New Cut	660.0	30	20	20,600	229.29	4,724,000	7,085,000
T-19	New Cut Rd.: West Indian Trail to Outer Loop	660.0	24	9	4,600	139.20	637,000	956,000
T-20	Blue Lick Rd.: Preston Hwy. to Jefferson County Line	660.0	16	2.5	10,200	23.20	236,640	355,000
T-21	National Turnpike/South Park Fairdale Rd. to N. Lakeview Dr.	660.0, 690.0, 770.3	16	2.4	26,800	75.55	2,025,000	3,037,000
T-22	I-65 Transmission: Hwy. 61 from Hebron to Gap in Knob Tank (S-41)	660.0, 690.0, 770.3	16	2.5	15,000	23.20	348,000	522,000

LWC 2794

Table 6-10
Recommended Transmission Pipeline Facilities

CIP Project No.	Description	Pressure Plane	Diameter (in)	2020 MD Flow (mgd)	Length (ft)	Unit Cost ($/ft)	Construction Costs ($)	Capital Costs ($)
T-23	I-65 Transmission: Coral Ridge Rd. from Blue Lick to Hwy. 61	660.0, 690.0, 770.3	16	2.5	6,400	92.80	591,000	887,000
T-24	I-65 Transmission: Cedar Grove 16" to Chapeze to Hwy. 61 to KY Hwy. 245	690.0	16	0.99	21,900	92.80	2,032,000	3,048,000
T-25	I-65 Transmission: Hwy. 61 from Gap in Knob Tank (S-41) to Hwy. 480 Bypass	690.0, 770.3	16	2.5	18,600	46.40	863,040	1,295,000
CT-26	I-65 Transmission: Hwy. 480 BPS (B-24) to Hwy. 480 Bypass	690.0, 770.3	16	2.5	10,500	0	0	0
CT-27	Rogers St./Henderson Ave. Gridtie	660.0	16	1.5	5,900	0	0	0
T-29	Snyder Transmission: English Station Tank to I-64 (either T-29 or T-29A, sum T-29A only)	Southern 860	36	7.1	8,100	208.80	1,691,280	2,537,000
T-29A	Snyder Transmission: English Station Tank to I-64 (either T-29 or T-29A, sum T-29A only)	Southern 860	48	12.6	8,100	253.50	2,053,000	3,080,000
T-30	Manslick Rd. to Proposed Heritage Tank (S-20)	770.4	12	2.5	11,300	69.60	786,480	1,180,000
T-31	Cooper Rd. (S-20) to Mt. Washington Rd.	770.4	12	2.5	3,600	69.60	250,560	376,000
T-33	Bardstown Rd., Bardstown Rd. Tank to County Line	860.2, M-6, M-7	24-30	2.0 – 2.9	18,000	174.00	3,132,000	4,698,000
CT-35	Cedar Creek Rd., Mt. Washington Rd. to Zoneton Elevated Tank	760.2	12	0.9	8,400	0	0	0
T-36	Hwy. 1020, Lakeview Dr. to Hwy. 1526	660.0	16		8,000	92.80	742,400	1,114,000
T-37	Bells Ln.: Hwy 61 to Floyd's Fork	660.0	12		7,000	69.60	487,200	731,000
T-38	Pendleton/Pauley's Gap: Mendoza to County Line	660.0	12		5,000	69.60	348,000	522,000
T-39	US Hwy. 31W: St. Andrews Church Rd. to Bethany Ln.	660.0	16		21,000	92.80	1,948,800	2,923,000
T-40	US Hwy. 31W: Gagel to St. Andrews Church Rd.	660.0	30		13,000	174.00	2,262,000	3,393,000
T-41	Greenbelt Hwy.: Tradeport Rd. to Bethany Ln.	660.0	16		9,500	92.80	881,600	1,322,000
T-42	Newcut Rd./Manslick Rd.: I-265 to Fairdale Ln.	660.0	12		8,000	69.60	556,800	835,000
T-43	Hubbards Ln.: Shelbyville Rd. to Browns Ln.	660.0	12		4,000	69.60	278,400	418,000
T-44	900 PP Expansion & Interconnect – Glenmary/ Bardstown Rd. Area	900.0					350,000	500,000

Table 6-10
Recommended Transmission Pipeline Facilities

CIP Project No.	Description	Pressure Plane	Diameter (in)	2020 MD Flow (mgd)	Length (ft)	Unit Cost ($/ft)	Construction Costs ($)	Capital Costs ($)
T-45	900 PP Expansion & Interconnect – Billtown, Jeffersontown & Blankenbaker Area	900.0					245,000	350,000
T-46	900 PP Expansion & Interconnect – Middletown/ Old Henry Rd. Area	900.0					350,000	500,000
Total							51,935,360	81,837,000
Future Transmission Mains Dependent on Regionalization								
T-4	I-71 Transmission: 60" main at I-71 to Hwy. 146 at I-71 (Alt. 1)	940.1	30	11.2	41,400	174.00	7,212,000	10,818,000
T-9A, Segment 1	Cross County Hwy. to Ellingsworth Rd.	860.0, ESA	36	-	6,800	208.80	1,428,000	2,142,000
T-9A, Segment 2	Cross County Hwy. to Snyder Freeway	860.0, ESA	36	-	28,300	208.80	5,899,000	8,849,000
T-10B	Bluegrass Pipeline: I-64 at I-265 to Jefferson/Shelby Co. line	Scenario C	36	15	27,800	208.80	5,799,000	8,699,000
T-12B, Segment 1	60" Main at Bon Air to Hikes Ln.	860.0, ESA	42	13.7	5,400	243.60	1,308,000	1,962,000
T-12B, Segment 2	Hikes Ln. along Bardstown Rd. to Snyder Freeway	860.0, ESA	36	13.7	34,000	208.80	7,109,000	10,664,000
T-15	Southern Indiana: Algonquin Parkway / Bells Lane Route	Indiana	24	NA	8,800	139.20	1,230,000	1,845,000
T-16	Southern Indiana: Preston/ Hancock Route	Indiana	20	NA	5,000	116.00	575,000	863,000
T-17	Hardin County: Hwy 31W Route, Greenwood Rd. south	660.0, Scenario A	30	0	61,000	174.00	10,607,000	15,911,000
T-28	Southern Indiana: B. E. Payne Route	Indiana	36	3.7	3,200	208.80	666,000	999,000
T-34	Bardstown Rd., County Line to Scenario B Meter	Scenario B	16	2.9	46,900	92.80	4,352,000	6,528,000
Total					268,600		46,185,000	69,280,000

6.7 Regional Distribution Center

As discussed in Chapter 2, distribution system operations and maintenance activities are mostly all based out of the Allmond Avenue Distribution Center. LWC staff reports that the current facility has reached or exceeded its capacity to support the operations housed there. The Center is located just west of the Louisville Airport and, from 1967 to 1972, was built and located based on serving customers mainly in the 660 Pressure Plane. Since that time LWC has constructed the B. E. Payne plant and expanded service regionally to eastern Jefferson County and to the south in Bullitt County. Travel times to work sites for distribution O&M staff have increased steadily over the years. This Facilities Plan shows that LWC will continue to expand regionally and, thus the Allmond Avenue Center will continue to become more pressed. Therefore, it is recommended that LWC evaluate and develop a plan for its long-term operations and maintenance support needs. To this end, provisions for implementation of a plan are included in the Recommended Capital Improvements Program. A preliminary capital cost of $15,200,000 for a regional distribution center. This cost assumes a concept of providing a facility half the size of the Allmond Avenue Center at another site, such as on the LWC's 10-acre property at the Middletown Service Center.

7.0 Capital Improvements Program

This chapter presents a recommended Capital Improvements Program (CIP) for the *2002-2021 Facilities Plan.* Annually in the third quarter LWC prepares a coming year budget for review and approval by the Board of Water Works and the City of Louisville. The preliminary budget for 2002 was published in October 2001. Each annual budget document presents capital and operating budgets for the next 20 years. For this plan, a proposed capital program will be presented in terms of terms of modifications to the most recent (2002) budget. Projected impacts on annual operating and maintenance expenses will also be discussed.

7.1 2002-2021 Annual Capital Budget

7.1.1 Capital Budget Items

Based on the findings for this *2002-2021 Facilities Plan,* recommended improvements and associated costs are shown as revisions to the 2002-2021 capital budget recently completed by LWC staff and reviewed by Black & Veatch. To incorporate this plan into the budgeting process, it is anticipated that the following Budget Items will be modified:

BI:11 SOURCE OF SUPPLY (ZPS)
BI:12 ZORN PUMPING STATION (ZPS)
BI:13 CRESCENT HILL PUMP STATION
BI:14 BOOSTED PRESSURE SYSTEM
BI:15 STORAGE FACILITIES
BI:16 CRESCENT HILL FILTRATION PLANT (CHFP)
BI:18 B. E. PAYNE WTP
BI:22 DISTRIBUTION BUILDINGS/FACILITIES IMPROVEMENTS
BI:63 MAIN REHABILITATION AND REPLACEMENT PROGRAM
BI:65 TRANSMISSION IMPROVEMENTS

7.1.2 Capital Budget Summary Table

The modified 2002-2021 Capital Budget is summarized in Table 7-1. This table includes the following:

- The first page shows the overall Total Capital Budgets (Gross and Net) and individual selected Budget Item (as listed in 7.1.1 above) Subtotals, as duplicated from the 2020-2021 budget document. It also shows the Budget Item Totals as modified by recommendations in this report, and the associated variances from the 2002-2021 Capital Budget.

- Subsequent Tables 7-2 through 7-11 show the recommended capital programs and budgets for each of the modified Budget Items listed in 7.1.1 above.

It is important to note that for simplicity and clarity, Budget Items that are not explicitly impacted by this plan's recommendations are listed separately as a combined subtotal. Variances are shown only for the modified Budget Items and the Overall Total Budget.

7.1.3 Recommended Capital Improvements Program

Recommended capital improvements were described in Chapter 5, Supply and Treatment Facilities and Chapter 6, Delivery and Storage Facilities. Project description summaries are included under the respective Budget Items in Table 7-1. The more notable projects (construction cost $2 million or greater) are also listed in Table 7-12 below.

To facilitate implementation and project management, recommended capital projects in this plan have been compiled, prioritized, and scheduled based on the following:

- Reliability related improvements are generally are set aside as separate capital projects and are assigned an early schedule.
- Regulatory related improvements are bundled by plant and scheduled to achieve start-up well ahead of required compliance dates.
- Supply and treatment improvements are bundled by such factors as plant location, common process area, economy of scale, anticipated design entity (LWC or consultant), work sharing,
- Delivery and storage projects are compiled based on design, construction and operational dependencies and scheduled on a "when needed" basis.
- Capital projects already in progress are maintained as separate budget items.

Table 7-1
Capital Improvements Program
2002-2021 Facilities Plan

Budget Area	Budget Item No.	Prior	2002	2003	2004	2005	2006	2002-2006	2007 - 2011	2012 - 2021	2002 - 2021
2002 Preliminary Budget											
Totals (Gross)			$74,214,807	$70,316,741	$69,086,572	$61,213,926	$54,017,426	$328,849,472	$252,592,190	$0	$581,441,662
Totals (Net)			$50,873,015	$47,874,918	$49,661,127	$40,704,906	$36,169,558	$225,283,524	$166,676,888	$0	$391,960,412
Comparison of 2002 Preliminary Budget Costs and 2002 - 2021 Facilities Plan Recommendation Costs											
Source of Supply											
2002 Preliminary Budget	11	$1,800,000	$5,650,000	$5,300,000	$15,000,000	$11,400,000	$12,000,000	$49,350,000	$48,400,000	$0	$97,750,000
2002-2021 Facilities Plan	11	$1,250,000	$1,800,000	$2,250,000	$2,150,000	$4,700,000	$17,500,000	$28,400,000	$79,500,000	$14,000,000	$121,900,000
Variance			($3,850,000)	($3,050,000)	($12,850,000)	($6,700,000)	$5,500,000	($20,950,000)	$31,100,000	$14,000,000	$24,150,000
Zorn Pumping Station											
2002 Preliminary Budget	12	$0	$225,000	$550,000	$150,000	$1,700,000	$0	$2,625,000	$0	$0	$2,625,000
2002-2021 Facilities Plan	12		$0	$445,000	$580,000	$2,015,000	$0	$3,040,000	$0	$750,000	$3,790,000
Variance			($225,000)	($105,000)	$430,000	$315,000	$0	$415,000	$0	$750,000	$1,165,000
Crescent Hill Pump Station											
2002 Preliminary Budget	13	$205,000	$275,000	$225,000	$225,000	$200,000	$1,800,000	$2,725,000	$0	$0	$2,725,000
2002-2021 Facilities Plan	13		$75,000	$200,000	$225,000	$425,000	$2,000,000	$2,295,000	$0	$0	$2,295,000
Variance			($200,000)	($25,000)	$0	$175,000	$200,000	$430,000	$0	$0	$430,000
Boosted Pressure System											
2002 Preliminary Budget	14	$0	$235,000	$800,000	$50,000	$300,000	$0	$1,385,000	$250,000	$0	$1,635,000
2002-2021 Facilities Plan	14		$70,000	$1,150,000	$0	$850,000	$0	$2,070,000	$950,000	$5,000,000	$8,020,000
Variance			($165,000)	$350,000	($50,000)	$550,000	$0	$685,000	$700,000	$5,000,000	$6,385,000
Storage Facilities											
2002 Preliminary Budget	15	$230,000	$3,895,000	$4,110,000	$3,250,000	$3,475,000	$1,275,000	$16,005,000	$6,575,000	$0	$22,580,000
2002-2021 Facilities Plan	15		$2,125,000	$4,725,000	$3,250,000	$2,500,000	$400,000	$13,000,000	$8,700,000	$5,200,000	$26,900,000
Variance			($1,770,000)	$615,000	$0	($975,000)	($875,000)	($3,005,000)	$2,125,000	$5,200,000	$4,320,000
Crescent Hill Filtration Plant											
2002 Preliminary Budget	16	$2,350,000	$2,845,000	$4,585,000	$5,735,000	$5,135,000	$1,285,000	$19,585,000	$8,550,000	$0	$28,135,000
2002-2021 Facilities Plan	16		$2,115,000	$5,215,000	$3,865,000	$7,865,000	$12,645,000	$31,705,000	$11,895,000	$10,350,000	$53,950,000
Variance			($730,000)	$630,000	($1,870,000)	$2,730,000	$11,360,000	$12,120,000	$3,345,000	$10,350,000	$25,815,000
B. E. Payne Water Treatment Plant											
2002 Preliminary Budget	18	$500,000	$6,220,000	$7,200,000	$3,700,000	$210,000	$3,780,000	$21,110,000	$15,550,000	$0	$36,660,000
2002-2021 Facilities Plan	18		$2,100,000	$13,815,000	$6,880,000	$1,230,000	$4,625,000	$28,650,000	$21,300,000	$5,000,000	$54,950,000
Variance			($4,120,000)	$6,615,000	$3,180,000	$1,020,000	$845,000	$7,540,000	$5,750,000	$5,000,000	$18,290,000
Distribution Buildings/ Facilities Improvement											
2002 Preliminary Budget	22	$150,000	$327,500	$352,500	$27,500	$27,500	$27,500	$762,500	$137,500	$0	$900,000
2002-2021 Facilities Plan	22		$328,000	$853,000	$1,328,000	$1,328,000	$1,663,000	$5,498,000	$3,638,000	$275,000	$9,410,000
Variance			$500	$500,500	$1,300,500	$1,300,500	$1,635,500	$4,735,500	$3,500,500	$275,000	$8,510,000
Main Replacement & Rehabilitation Program											
2002 Preliminary Budget	63	$0	$10,500,000	$10,500,000	$10,500,000	$4,500,000	$4,500,000	$40,500,000	$24,500,000	$50,000,000	$115,000,000
2002-2021 Facilities Plan	63		$8,500,000	$8,500,000	$8,500,000	$7,000,000	$7,000,000	$39,500,000	$35,000,000	$58,500,000	$133,000,000
Variance			($2,000,000)	($2,000,000)	($2,000,000)	$2,500,000	$2,500,000	($1,000,000)	$10,500,000	$8,500,000	$18,000,000
Transmission Improvements (Gross)											
2002 Preliminary Budget	65	$2,333,500	$2,729,400	$4,996,100	$6,580,000	$10,412,000	$7,810,000	$32,527,500	$47,254,000	$0	$79,781,500
2002-2021 Facilities Plan	65		$5,369,000	$6,534,000	$9,948,000	$16,072,000	$10,103,000	$48,026,000	$38,319,000	$14,062,000	$100,407,000
Variance			$2,639,600	$1,537,900	$3,368,000	$5,660,000	$2,293,000	$15,498,500	($8,935,000)	$14,062,000	$20,625,500
Variance Totals (Gross)			($10,419,900)	$5,068,400	($8,491,500)	$6,575,500	$23,458,500	$16,469,000	$48,085,500	$63,137,000	$127,690,500
Revised Budget											
Totals (Gross)			$63,794,907	$75,385,141	$60,595,072	$67,789,426	$77,475,926	$345,318,472	$300,677,690	$63,137,000	$709,132,162

LWC 2800

Table 7-2
Source of Supply Capital Improvements Program (BI:11)
2002 – 2021 Facilities Plan

CIP Title	ID No.	Description	Prior	2002	2003	2004	2005	2006	2002-2006	2007-2011	2012-2021	2002-2021
Advanced Treatment Technology Phase II	99-402	Construct RBI well at BEP to provide total supply of 60 mgd	$1,250,000	$1,250,000	$1,250,000	$1,250,000	$4,000,000	$14,000,000	$21,750,000	$8,000,000		$29,750,000
Long-Term RBI Supply		Long-term replacement of CHWTP facilities with new plant		$500,000	$500,000	$500,000	$700,000	$3,500,000	$5,700,000	$71,500,000	$14,000,000	$91,200,000
Zorn Intake Improvements		Replace existing traveling screens; improve access bridge; replace 48-inch sluice gates.		$50,000	$500,000	$400,000			$950,000			$950,000
Totals			$1,250,000	$1,800,000	$2,250,000	$2,150,000	$4,700,000	$17,500,000	$28,400,000	$79,500,000	$14,000,000	$121,900,000

Table 7-3
Zorn Pumping Station Capital Improvements Program (BI:12)
2002 – 2021 Facilities Plan

CIP Title	ID No.	Description	2002	2003	2004	2005	2006	2002-2006	2007-2011	2012-2021	2002-2021
Upgrade Solids Lagoon		Augment existing earthen berm and replace inflow and outflow structures		$200,000	$350,000			$550,000			$550,000
Replace Incoming Electrical Service		Replace aging electrical service equipment including 480-volt transformers			$150,000	$1,700,000		$1,850,000			$1,850,000
Pumping Unit Overhaul Program	02-600	Overhaul ZPS pumping units including motor rewind, pump rebuild, and valve rebuild or replacement		$225,000				$225,000		$750,000	$975,000
Chemical Feed System Improvements		Powdered activated carbon storage and feed and new potassium permanganate system		$20,000	$80,000			$100,000			$100,000
Pump Nos. 6 and 7 Valve Replacements		Replace suction and discharge valves				$315,000		$315,000			$315,000
Totals				$445,000	$580,000	$2,015,000		$3,040,000	$0	$750,000	$3,790,000

Table 7-4
Crescent Hill Pumping Station Capital Improvements Program (BI:13)
2002 – 2021 Facilities Plan

CIP Title	ID No.	Description	2002	2003	2004	2005	2006	2002-2006	2007-2011	2012-2021	2002-2021
Replace Pump Discharge Valves	00-580	Replace failing pump discharge valves that have been in service since 1948	$45,000					$45,000			$45,000
Pump Unit Overhaul Program	02-402	Overhaul CHPS pumping units including motor rewind and pump rebuild		$200,000	$225,000	$225,000		$650,000			$650,000
Header and Yard Piping Improvements		Replace 48" CI headers with single 60" header and extend existing 72" header to outside yard piping; replace leaking yard piping				$200,000	$2,000,000	$2,200,000			$2,200,000
Install Housing for 13.8 kV Switchgear		Install housing for 13.8 kV switchgear to protect from roof leaks and other elements	$30,000					$30,000			$30,000
Totals			$75,000	$200,000	$225,000	$425,000	$2,000,000	$2,295,000	$0	$0	$2,925,000

LWC 2801

Table 7-5
Booster Pressure System Capital Improvements Program (BI:14)
2002 – 2021 Facilities Plan

CIP Title	ID No.	Capacity	2002	2003	2004	2005	2006	2002-2006	2007-2011	2012-2021	2002-2021
Tucker Station Rd. PS	B-6	2 mgd						$0	$350,000		$350,000
Shelbyville Rd. BPS	B-7	1 mgd				$150,000		$150,000			$150,000
Hikes Point BPS	B-8	5 mgd							$250,000		$250,000
Blankenbaker Crossing BPS	B-9	2 mgd				$300,000		$300,000			$300,000
Shady Acres BPS	CB-10	2 mgd									$0
PRP II BPS	B-13	2 mgd	$50,000	$250,000				$300,000			$300,000
Billtown Rd. BPS	B-17	2 mgd							$350,000		$350,000
Dry Ridge BPS	CB-18	0.3 mgd	$20,000	$150,000				$170,000			$170,000
Ridge Rd. BPS	B-26	2.84 mgd				$400,00		$400,000			$400,000
Ram's Run BPS	B-28	1 mgd		$250,000				$250,000			$250,000
English Station SP BPS	B-32	20 mgd								$5,000,000	$5,000,000
Knob Creek Rd.	B-33	1 mgd		$250,000				$250,000			$250,000
Install Bullitt County Booster Re-Chloramination Station by Hwy. 480 BPS		3 mgd		$250,000				$250,000			$250,000
Totals			$70,000	$1,150,000	$0	$850,000	$0	$2,070,000	$950,000	$5,000,000	$8,020,000

Table 7-6
Storage Facilities Capital Improvements Program (BI:15)
2002 – 2021 Facilities Plan

CIP Title	ID No.	Volume	2002	2003	2004	2005	2006	2002-2006	2007-2011	2012-2021	2002-2021
Hillcrest Tank	S-1	1 MG	$100,000	$750,000	$650,000			$1,500,000			$1,500,000
Highway 329 Tank	S-3	0.5 to 0.75 MG	$500,000	$650,000				$1,150,000			$1,150,000
Old Henry Rd. Tank	S-8	1 MG							$1,300,000		$1,300,000
Long Run Tank	CS-10	1 MG	$500,000	$800,000				$1,300,000			$1,300,000
English Station Road	S-12	1 MG					$200,000	$200,000	$1,100,000		$1,300,000
Hikes Point Tank	S-15	1 MG					$200,000	$200,000	$1,100,000		$1,300,000
Highview Tank	S-17	1 MG								$1,600,000	$1,600,000
Bardstown Rd. Tank	S-18	1.5 MG							$1,800,000		$1,800,000
Heritage Tank	S-20	1 MG			$300,000	$900,000		$1,200,000			$1,200,000
Jefferson County Memorial Forest II Tank	S-28	0.15 MG	$325,000	$300,000				$625,000			$625,000
Dry Ridge Tank	CS-30	0.25 MG									$0
Barralton Tank	S-34	0.25 MG	$75,000	$900,000				$975,000			$975,000
Gospel Kingdom Tank	CS-39	0.25 MG									$0
Ridge Rd. / Hwy. 480	S-38	0.5 MG							$1,150,000		$1,150,000
Rams' Run Tank	S-44	0.25 MG		$475,000	$500,000			$975,000			$975,000
I-65 Transmission Corridor	S-45	1 MG							$1,500,000		$1,500,000
Sugar Tree	S-46	0.25 MG		$475,000	$500,000			$975,000			$975,000
860 PP: Undesignated	S-47	1 MG								$1,600,000	$1,600,000
Cardinal Hill Reservoir Improvements	S-48		$25,000	$75,000	$1,000,000	$1,300,000		$2,400,000			$2,400,000
Sandblast/Recoat	02-611		$600,000	$300,000	$300,000	$300,000		$1,500,000	$750,000	$2,000,000	$4,250,000
Totals		10.7 MG	$2,125,000	$4,725,000	$3,250,000	$2,500,000	$400,000	$13,000,000	$8,700,000	$5,200,000	$26,900,000

Table 7-7
Crescent Hill Filtration Plant Capital Improvements Program (BI:16)
2002 – 2021 Facilities Plan

CIP Title	ID No.	Description	2002	2003	2004	2005	2006	2002-2006	2007-2011	2012-2021	2002-2021
CHFP Reservoir Improvements Phase III – Site Improvements	02-618		$175,000	$200,000				$375,000			$375,000
Replace Clearwell Floor at CHFP	02-619		$150,000	$1,000,000	$1,000,000			$2,150,000			$2,150,000
Water Quality Equipment	02-427	Annual allowance to replace miscellaneous laboratory equipment	$25,000	$25,000	$25,000	$25,000	$25,000	$125,000	$125,000	$250,000	$500,000
Tools and Safety Equipment	02-426	Annual allowance to replace and update tools and safety equipment for all production facilities	$10,000	$10,000	$10,000	$10,000	$10,000	$50,000	$50,000	$100,000	$200,000
Alternative Disinfection Process		Install alternative disinfection process to treat 180 mgd				$3,000,000	$10,000,000	$13,000,000			$13,000,000
Contingency Funding		Annual allowance for unidentified projects									$0
Replace Ion Chromatograph	02-621	Replace existing equipment due to age and discontinuation of support services in 2002	$25,000					$25,000			$25,000
Drainage and Solids Handling Improvements	99-416	Construct facilities to improve handling and transport of solids and existing drainage collection system	$250,000	$1,600,000		$2,000,000		$3,850,000	$350,000		$4,200,000
Plant Control and Telemetry Systems Upgrade	99-418	Replace SCADA process and operational control hardware, software, and devices at both plants and replace communications equipment for distribution system facilities	$950,000					$950,000			$950,000
Flocculation and Sedimentation Basin Renovation	02-625	Renovate South Flocculation Basins 6 and 7, South Coagulation Basins 5 – 8, with Plate Settlers; Slow Mixing Basins 5 and 6, Softening Basins 1 – 6									
Purchase Portable Pump	02-631	Purchase portable pump to supply underserved areas, to be used in emergency supply situations, and for dewatering transmission mains after main breaks	$30,000					$30,000			$30,000
Aeration for Iron and Manganese Removal from RB1 Supply									$1,380,000		$1,380,000
Filter and Backwash Systems Renovation		Upgrade Old East, New East, and South Filters with state-of-the-art filter and backwash systems, including new 1.5 MG elevated tank		$200,000	$1,000,000	$1,000,000	$1,000,000	$3,200,000	$4,100,000		$7,300,000
Chemical Feed System Improvements		Provide chemical feed system upgrades per 2002 – 2021 Facilities Plan; replace ammonia storage system; install coagulation mixing; fluoride storage tanks; polyaluminum chloride feed system; lime feed system upgrades		$480,000	$130,000	$130,000	$660,000	$1,400,000	$140,000		$1,540,000
Caustic Soda Feed System		Install caustic soda feed system for pH control							$750,000		$750,000
		Chemical Feed System improvements for security		$200,000	$200,000	$200,000	$200,000	$800,000			$800,000
Contingency Projects		Annual allowance for unidentified capital projects							$5,000,000	$10,000,000	$15,000,000
Totals			$2,115,000	$5,215,000	$3,865,000	$7,865,000	$12,645,000	$31,705,000	$11,895,000	$10,350,000	$53,950,000

Table 7-8
B. E. Payne Water Treatment Plant Capital Improvements Program (BI:18)
2002 – 2021 Facilities Plan

CIP Title	ID No.	Description	2002	2003	2004	2005	2006	2002-2006	2007-2011	2012-2021	2002-2021
Solids Lagoon Renovations	02-632	Removal of treatment plant residuals, construction of new diversion structures, renovation of earthen berms and inflow and outflow structures	$50,000	$300,000			$3,300,000	$3,650,000	$14,300,000		$17,950,000
Expansion and Reliability Improvements	00-418	Increase firm high service pumping capacity to 60 mgd, renovate filters and backwash, and provide primary and secondary power supplies	$2,050,000	$12,770,000	$5,680,000			$20,500,000			$20,500,000
Contingency Funding	18.10	Annual allowance for unidentified projects							$2,500,000	$5,000,000	$7,500,000
Coagulation and Softening Basin Renovation Program	02-636	Replace coagulation collectors with plate settlers and replace softening equipment		$700,000	$700,000	$700,000		$2,100,000			$2,100,000
Chemical Feed System Upgrades		Miscellaneous chemical feed improvements per 2002 Annual Inspection; install recarbonation system; and replace ammonia storage system		$45,000		$30,000	$525,000	$600,000			$600,000
Alternative Disinfection Process		Install alternative disinfection process to treat 60 mgd							$4,500,000		$4,500,000
Expand Clearwell		Construct 3 MG additional clearwell capacity			$500,000	$500,000	$800,000	$1,800,000			$1,800,000
Totals			$2,100,000	$13,815,000	$6,880,000	$1,230,000	$4,625,000	$28,650,000	$21,300,000	$5,000,000	$54,950,000

Table 7-9
Distribution Buildings / Facilities Improvement Capital Improvements Program (BI:22)
2002 – 2021 Facilities Plan

CIP Title	Description	2002	2003	2004	2005	2006	2002-2006	2007-2011	2012-2021	2002-2021
Total Improvements as Referenced from 2002 Preliminary Annual Budget		$328,000	$353,000	$28,000	$28,000	$763,000	$1,498,000	$138,000	$275,000	$1,910,000
Security Program			$500,000	$1,300,000	$1,300,000	$900,000	$4,000,000			$4,000,000
Middletown Distribution Operations Building	Construction 30,000 square foot area building to support distribution system operations							$1,500,000		$1,500,000
Bullitt County Distribution Operations Building	Construction 30,000 square foot area to support distribution system operations							$2,000,000		$2,000,000
Totals		$328,000	$853,000	$1,328,000	$1,328,000	$1,663,000	$5,498,000	$3,638,000	$275,000	$9,410,000

Table 7-10
Main Replacement and Rehabilitation Program Capital Improvements Program (BI:63)
2002 – 2021 Facilities Plan

CIP Title	2002	2003	2004	2005	2006	2002-2006	2007-2011	2012-2021	2002-2021
Infrastructure Renewal Program After 2007							$20,000,000	$50,000,000	$70,000,000
Water Main Replacement Program 2000 - 2007	$4,000,000	$4,000,000	$4,000,000	$5,000,000	$5,000,000	$22,000,000			$22,000,000
Water Main Rehabilitation Program 2000 - 2004	$4,000,000	$4,000,000	$4,000,000			$12,000,000			$12,000,000
Lead Service Renewal	$500,000	$500,000	$500,000	$2,000,000	$2,000,000	$5,500,000	$15,000,000	$8,500,000	$29,000,000
Totals	$8,500,000	$8,500,000	$8,500,000	$7,000,000	$7,000,000	$39,500,000	$35,000,000	$58,500,000	$133,000,000

Table 7-11

Transmission Improvements Capital Improvements Program (BI:65)

2002 – 2021 Facilities Plan

CIP Title	ID No.	Description	2002	2003	2004	2005	2006	2002-2006	2007-2011	2012-2021	2002-2021
T-1A		River Rd., B. E. Payne to US Hwy. 42			$459,000			$459,000			$459,000
T-1B		Prospect Tank to Hillcrest Tank along Hwy. 42								$2,227,000	$2,227,000
T-10A		US Hwy. 60: English Station Rd. to Jefferson / Shelby County Line		$500,000	$1,500,000	$2,009,000		$4,009,000			$4,009,000
T-11A		Snyder Transmission 48": I-64 to Taylorsville Rd.					$1,500,000	$1,500,000	$3,000,000		$4,500,000
T-13A		Snyder Transmission 36": Taylorsville Rd. to Billtown Rd.	$40,000	$260,000	$1,000,000	$3,700,000		$5,000,000			$5,000,000
T-14		Fern Valley Rd. 30": Fern Valley Rd. to Smyrna BPS							$2,393,000		$2,393,000
T-18		Cardinal Hill Reservoir Secondary Supply: St. Andrews and New Cut	$1,525,000	$1,560,000	$2,000,000	$2,000,000		$7,085,000			$7,085,000
T-19		New Cut Rd.: West Indian Trail to Outer Loop				$191,000	$765,000	$956,000			$956,000
T-20		Blue Lick Rd.: Preston Hwy. to Jefferson County Line			$355,000			$355,000			$355,000
T-21		National Turnpike / South Park Fairdale Rd. to N. Lakeview Dr.	$1,500,000	$1,537,000				$3,037,000			$3,037,000
T-22		I-65 Transmission: Hwy. 61 from Hebron to Gap in Knob Tank (S-41)			$522,000			$522,000			$522,000
T-23		I-65 Transmission: Coral Ridge Rd. from Blue Lick to Hwy 61		$177,000	$710,000			$887,000			$887,000
T-24		I-65 Transmission: Cedar Grove 16" to Chapeze to Hwy. 61 to KY Hwy. 245				$1,500,000	$1,548,000	$3,048,000			$3,048,000
T-25		I-65 Transmission: Hwy. 61 from Gap in Knob Tank (S-41) to Hwy. 480 Bypass							$1,295,000		$1,295,000
CT-26		I-65 Transmission: Hwy. 480 BPS (B-24) to Hwy. 480 Bypass									$0
CT-27		Rogers St. / Henderson Ave. Gridtie									$0
T-29		Snyder Transmission: English Station to I-64							$2,537,000		$2,537,000
T-29A		Snyder Transmission: English Station Tank to I-64							$3,080,000		$3,080,000
T-3		I-265 Transmission: Wolf Pen Branch to Westport Rd. (Alt. 2)	$300,000	$2,000,000	$1,300,000	$2,000,000	$1,940,000	$7,540,000			$7,540,000
T-30		Manslick Rd. to Proposed Heritage Tank (S-20)		$400,000	$780,000			$1,180,000			$1,180,000
T-31		Cooper Rd. (S-20) to Mt. Washington Rd.				$100,000	$276,000	$376,000			$376,000
T-33		Bardstown Rd., Snyder Hwy. to County Line								$4,698,000	$4,698,000
CT-35		Cedar Creek Rd., Mt. Washington to Zoneton Elevated Tank									$0
T-5A, Segment 2		Reamers Rd. at Ash Ave. to Hwy. 329								$1,622,000	$1,622,000
T-6		Old Floydsburg Rd./Reamers Rd. to Ash Ave.								$1,622,000	$1,622,000
T-7		Chamberlain Ln./Lagrange Rd.: 60" at Ford KTP to Reamers Tank	$1,779,000					$1,779,000			$1,779,000
T-8		Hwy. 329, Fox Hollow at Hwy. 329 to Apple Patch Tank (S-3), south to Spring Hill Development							$1,392,000		$1,392,000
T-9, Segment 1		Westport BPS to Lake Ave. at Herr Ln. and Lyndon Ln.				$1,140,000	$1,140,000	$2,280,000			$2,280,000
T-9, Segment 2		Lake Ave. at Herr Ln. and Lyndon Ln. to Ormsby Ln.				$1,200,000	$1,243,000	$2,443,000	$2,433,000		$4,876,000
T-9A		Oxmoor: Lake Ave. to Linn Station / Ellingsworth 36"							$474,000		$474,000
T-36		Hwy. 1020, Bardstown Rd. Tank to County Line			$500,000	$614,000		$1,114,000			$1,114,000
T-37		Bells Ln.: Hwy. 61 to Floyd's Fork							$731,000		$731,000
T-38		Pendleton/Pauley's Gap: Mendoza to County Line				$300,000	$222,000	$522,000			$522,000
T-39		US Hwy. 31W: St. Andrews Church Rd. to Bethany Ln.							$2,923,000		$2,923,000
T-40		US Hwy. 31W: Gagel to St. Andrews Church Rd.								$3,393,000	$3,393,000

LWC 2805

Table 7-11
Transmission Improvements Capital Improvements Program (BI:65)
2002 – 2021 Facilities Plan

CIP Title	ID No.	Description	2002	2003	2004	2005	2006	2002-2006	2007-2011	2012-2021	2002-2021
T-41		Greenbelt Hwy.: Tradeport Rd. to Bethany Ln.			$622,000	$700,000		$1,322,000			$1,322,000
T-42		Newcut Rd./Manslick Rd.: I-265 to Fairdale Ln.				$400,000	$435,000	$835,000			$835,000
T-43		Hubbards Ln.: Shelbyville Rd. to Browns Ln.			$200,000	$218,000		$418,000			$418,000
T-44		990 PP Expansions & Interconnect – Glenmary/Bardstown Rd. Area								$500,000	$500,000
T-45		990 PP Expansions & Interconnect – Billtown, Jeffersontown and Blankenbaker Area					$350,000	$350,000			$350,000
T-46		990 PP Expansions & Interconnect – Middletown/Old Henry Rd. Area								$500,000	$500,000
	01-744	Kentucky/Glenmary/Oak 48" Transmission Main Replacement & Rehabilitation	$100,000					$100,000	$15,170,000		$15,270,000
	99-471	Rehabilitate 60"/48" Cardinal Hill Primary Supply					$684,000	$684,000	$1,116,000		$1,800,000
		CHPS Yard Piping	$125,000	$100,000				$225,000	$1,275,000		$1,500,000
Totals			$5,369,000	$6,534,000	$9,948,000	$16,072,000	$10,103,000	$48,026,000	$38,319,000	$14,062,000	$100,407,000

Table 7-12
Recommended Capital Projects over $2,000,000
Years 2002-2021 Costs

Project Description	$
BI:11 Source of Supply	
Advanced Treatment Technology Phase II (BEPWTP RBI)	29,750,000
Long-Term RBI Supply (CHWTP)	91,200,000
BI:13 Crescent Hill Pump Station	
Header and Yard Piping Improvements	2,200,000
BI:14 Booster Pressure System	
B-32 English Station Standpipe Booster Pump Station	5,000,000
B:15 Storage Facilities	
Cardinal Hill Reservoir Improvements	2,400,000
Sandblast / Recoat Storage Facilities	4,250,000
B:16 Crescent Hill Filter Plant	
Replace Clearwell Floor at CHFP	2,150,000
Alternate Disinfection Process	13,000,000
Drainage and Solids Handling Improvements	4,200,000
Filter and Backwash Systems Renovation	7,300,000
BI:18 B. E. Payne WTP	
Solids Lagoon Renovations	17,950,000
Expansion and Reliability Improvements	20,500,000
Coagulation and Softening Basin Renovation Program	2,100,000
Alternative Disinfection Process	4,500,000
BI:22 Distribution Buildings/Facilities Improvements	
Security Program	4,000,000
Bullitt County Distribution Operations Building	2,000,000
BI:63 Main Replacement and Rehabilitation Program Capital Improvements Program	
Water Main Replacement Program (Annual, through 2004)	4,000,000
Water Main Replacement Program (Annual, 2005 and 2006)	5,000,000
Water Main Rehabilitation Program (Annual, through 2004)	4,000,000
BI:65 Transmission Improvements Capital Improvements Program	
T-1B Prospect Tank to Hillcrest along Highway 42	2,227,000
T-10A US Highway 60: English Station Rd. to Jefferson / Shelby County Line	4,009,000
T-11A Snyder Transmission 48": I-64 to Taylorsville Rd.	4,500,000
T-13A Snyder Transmission 36": Taylorsville Rd. to Billtown Rd.	5,000,000
T-14 Fern Valley Rd. 30": Fern Valley Rd. to Smyrna BPS	2,393,000
T-18 Cardinal Hill Reservoir Secondary Supply: St. Andrews and New Cut	7,085,000
T-21 National Turnpike / South Park Fairdale Rd. to North Lakeview Dr.	3,037,000
T-24 I-65 Transmission: Hwy 61 from Gap in Knob Tank to Highway 480 Bypass	3,048,000
T-29 Snyder Transmission: English Station to I-64	2,537,000
T-29A Snyder Transmission: English Station to Tank to I-64	3,080,000
T-3 I-265 Transmission: Wolf Pen Branch to Westport Rd.	7,540,000
T-33 Bardstown Road, Snyder Highway to County Line	4,698,000
T-9, Segment 1 Westport BPS to Lake Ave. at Herr Lane and Lyndon Lane	2,280,000
T-9A Oxmoor: Lake Avenue to Linn Station / Ellingsworth 36"	4,876,000
T-39 US Highway 31W: St. Andrews Church Road to Bethany Lane	2,923,000

Table 7-12 Recommended Capital Projects over $2,000,000 Years 2002-2021 Costs	
Project Description	**$**
T-40 US Highway 31W: Gagel to St. Andrews Church Road	3,393,000
01-744 Kentucky / Glenmary / Oak 48" Transmission Main Rehabilitation and Replacement	15,270,000

Appendix

"Economic, Demographic, and Water Sales Forecasts
2000 to 2025
for the Louisville Economic Area"

Economic, Demographic, and Water Sales Forecasts
2000 to 2025
for the Louisville Economic Area

for

The Black and Veach Corporation

and

The Louisville Water Company

by

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November 30, 2001

Economic, Demographic, and Water Sales Forecasts 2001 to 2025 for the Louisville Region

November 30, 2001

Executive Summary

The first national recession in a decade has just been declared. Analysts point to March of 2001 as the beginning date, but also claim that without the terrorist attacks of September 11 the economy would likely to have recovered in the third and fourth quarter of this year, thus avoiding a recession. Certainly, the manufacturing sector has been in decline for over a year and is only now showing signs of bottoming out. Nearly all factors point to a short downturn and a solid recovery next year. Monetary and fiscal policy are stimulative. Fuel and commodity prices are low. Inventories of many goods have been depleted, and fresh orders for manufacturing operations are in the pipeline. Stock prices are headed back up, and consumer confidence seems to have recovered as the war in Afganistan has gone well, and security measures are taken around the US.

The Louisville area economy has felt the national downturn, with a net loss of about 4,000 manufacturing jobs in the last year. Modest growth in other sectors has kept the local economy growing, if not at the rate of the past few years. Indeed, the last decade was a particularly strong one for the Louisville economy. The metro economy out-performed the US economy during the first half the 1990s, and grew in stride during the second half. Manufacturing expansions led to employment increases at area factories, even as the US economy was shedding workers in that key industry. UPS's international air freight hub in Louisville has added over 10,000 workers in the last ten years. While the lack of a strong local presence in the tech sector hurt our ability to generate wealth during the dot com boom, it also insulated us from the current tech bust that has tripped up economies such as Austin, Seattle and Portland.

The relatively strong economic growth has caused a turnaround in the demographic outlook for the Louisville area. The Louisville Metropolitan Statistical Area (MSA) added around 75,000 persons between the 1990 and 2000 Census, after posting zero net growth during the 1980s. Jefferson County, the central county and the prime customer base for the Louisville Water Company and LGE, added 28,000 residents during the last decade, just offsetting the two previous decades of population decline. The steady economic and demographic growth, combined with low interest rates, has led to a strong market for new housing in Louisville - our area has added more new homes every year this decade than any year last decade.

Finally, this solid economic and demographic growth has enlarged the geographic footprint of the area economy. We now consider the labor market to include the twenty-three counties in the Louisville Economic Area, as defined by the US Bureau of Economic Analysis. This larger area contains over 1.4 million residents, and is essentially coterminus with the the regional labor, housing, retail, entertainment, and media markets. Indeed, it is only by zooming out to a larger geographical area that one can reasonably explain how jobs have been filled in the economic core. Thousands of new households have been set up in the metro core, but also in the exurban counties as low interest rates, low gasoline prices, better fuel economy, higher highway speed limits, and the opening of several new interstate interchanges in the region have made it economically feasible to buy a new home and commute within a fifty mile radius of downtown Louisville

This is the general backdrop for the current long-term forecasts for the Louisville area. This forecast updates the one published in November 1999*. In this report, we take account of two more years of data and a new national outlook to produce a fresh forecast of economic and demographic activity in the region. We use the fourth quarter 2000 national forecast produced by the WEFA Group.

* "Economic, Demographic, and Water Sales Forecasts 1999 to 2020 for the Louisville Region," by Nan-Ting Chou, Paul Coomes, and Barry Kornstein, November 1999.

LWC 2811

The analysis also covers the sixteen Kentucky and Indiana counties surrounding the seven-county Louisville MSA. In percentage terms, the greatest demographic growth is occurring in the ring, or exurban, counties. The counties outside of Jefferson, and within a commuting distance of the Louisville core, offer the greatest sales growth potential for Louisville-based utilities. For the most important variables - population, jobs, income - we provide forecasts for each of the twenty-three counties of interest to the research sponsors.

Finally, we have updated and revised our previous model of water usage by LWC customers, and used it to forecast annual water sales through the year 2025. We examined 30 years of water usage for four customer classes - residential, commercial, industrial, and wholesale. For each customer class we attempted to explain usage by demographic and economic variables. A set of regression models accounts for all but a few percentage points of annual water sales by customer class over the last thirty years.

Among the most important and interesting forecast results are:

» Assuming good economic conditions, we forecast that the Louisville area will add 290,000 jobs between 2000 and 2025. This will spur the net attraction of 291,000 residents and 141,000 households.

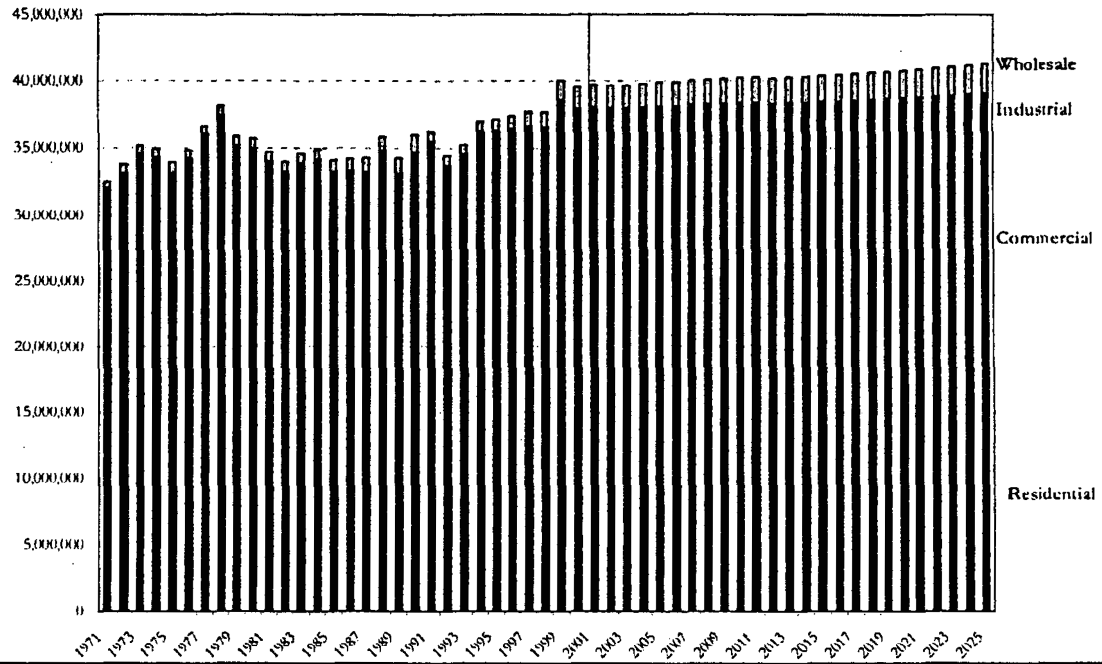
» We forecast that Jefferson County, the core service area for the Louisville Water Company, will gain 26,000 households over the next quarter century.

» Other counties expected to add a large number of households are: Bullitt (13,000), Oldham (10,000), Clark (9,000), and Nelson (7,000). The fastest growing counties in percentage terms are expected to be Spencer, Shelby, Bullitt, and Trimble.

» Total annual water sales are likely to grow from the current level of about 38.5 billion gallons to about 41.3 billion gallons over the next two and one-half decades, assuming no net declines in residential and commerical customer usage due to federally-mandated water-conserving appliances.

» The largest increase in water sales is expected to be from commercial customers. In percentage terms, LWC is likely to see the fastest growth from wholesale customers. Their share of total water sales is expected to rise from the current 4.3 percent to 5.5 percent by the year 2025.

Water Sales by Type (000 gallons)
Louisville Water Company



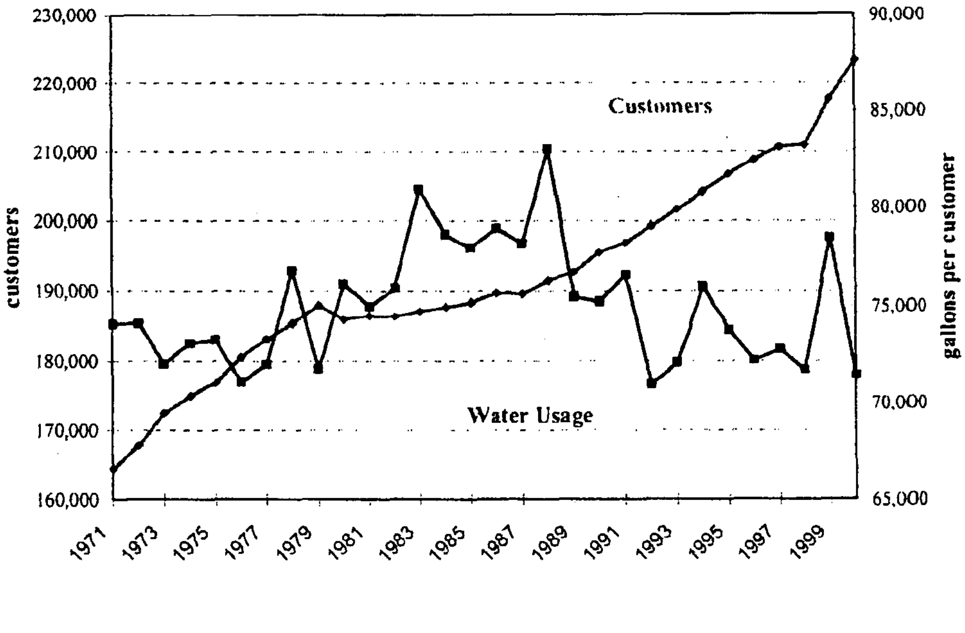
Water Sales History, Models, and Forecasts

The Louisville Water Company (LWC) serves approximately 245,000 customers in Jefferson County, Kentucky. Total water sales have grown modestly during the past thirty years. Total annual water sales have averaged 35.7 billion gallons of water during this time, with a low of 32.6 billion gallons in 1971 and a high of 40.1 billion gallons in 1999. LWC sold 39.5 billion gallons of water in 2000, which represents a four percent increase over the average of the previous five years. Gains in the number of residential and commercial water customers have offset declines in industrial usage per customer. The number of industrial customers continues to decline, however at a slower pace. Water usage per residential customer have been steady for last few years. Sales to customers outside Jefferson County, while still a small fraction of total sales, have been the fastest growing component for the Company*.

The charts below summarize important trends in the number of water customers and their usage, by customer class.

We have constructed a simple model that relates LWC water sales to economic and demographic developments in the Louisville area. We then used the model to prepare forecasts of annual water sales by customer class. Our forecasts for Louisville area economic and demographic variables were prepared using a model linked to national economic conditions. The regional economic model, its structure and forecast results, are described later in this report. A summary forecast of water sales by class is provided in the chart on the facing page. See Appendix A for water forecast values.

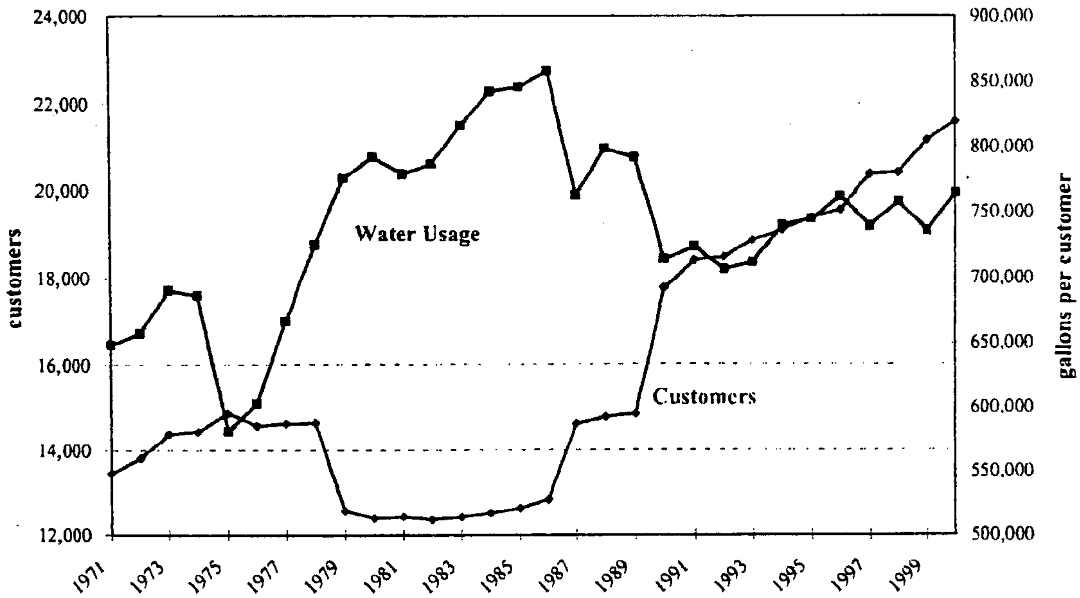
Residential Customers & Water Usage: 1971-2000
Louisville Water Company



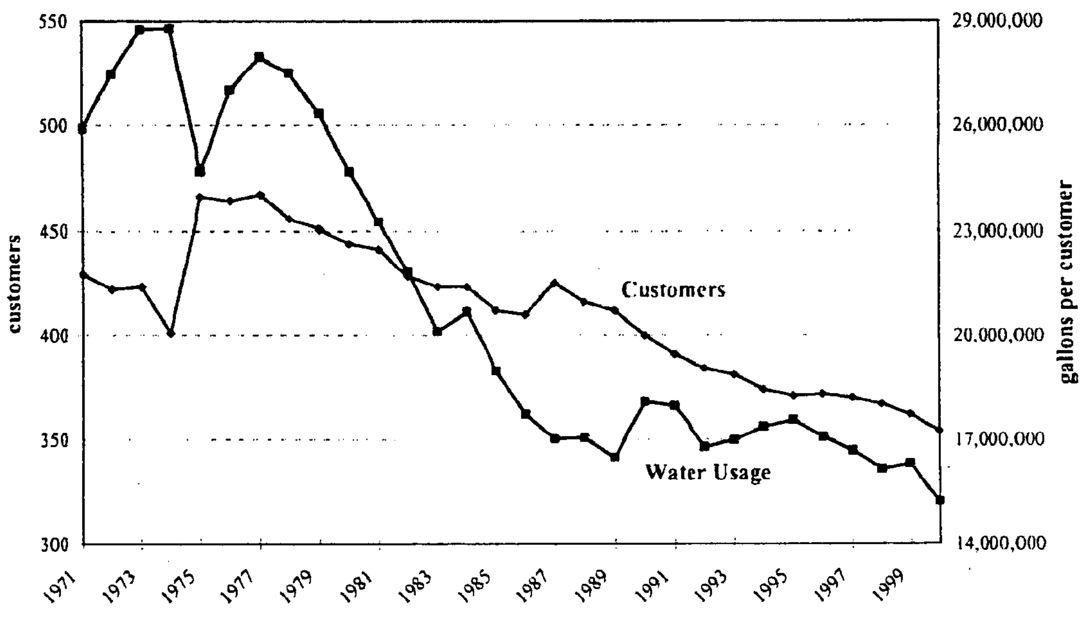
*Data on sales to wholesale customers would be higher, and data on sales to Jefferson County customers would be lower, if historical data were adjusted to more accurately account for customers in leased districts in Oldham and Bullitt counties. The Water Company believes that around 6,000 residential customers in the Crestwood (Oldham) and Kentucky Turnpike (Bullitt) water districts have been counted as Jefferson County residential customers. Sales and customers in these districts have been growing at a faster rate than in Jefferson County.

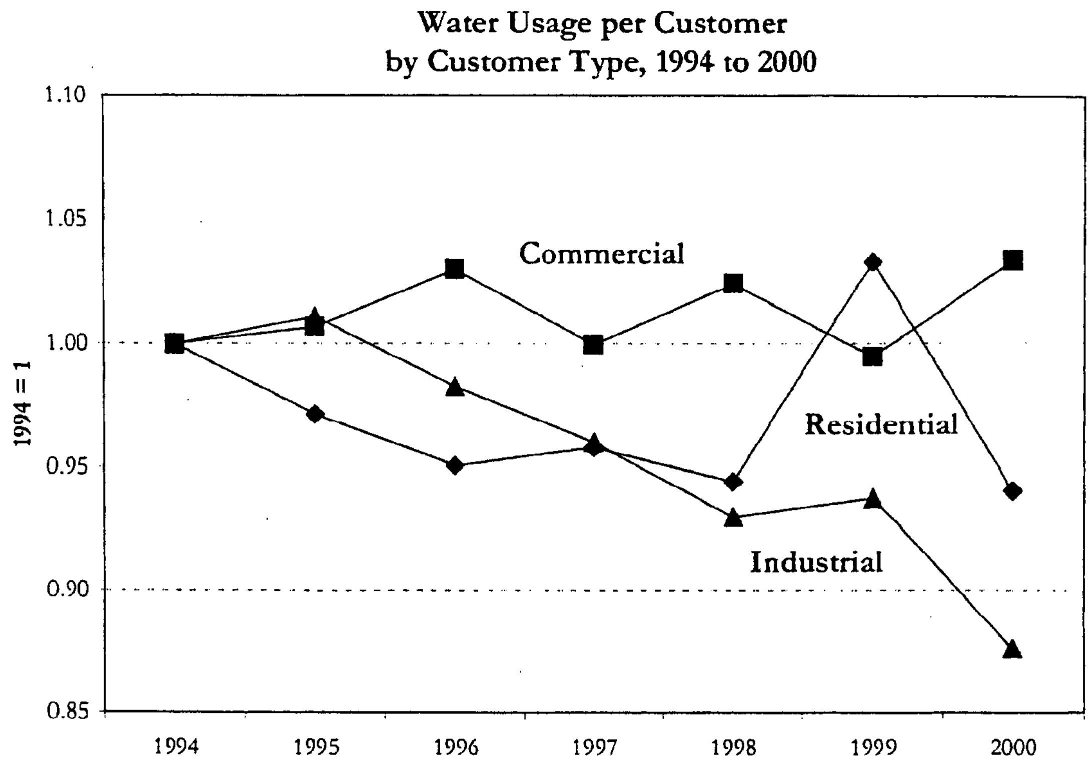
LWC 2813

Commercial Customers & Water Usage: 1971-2000
Louisville Water Company



Industrial Customers & Water Usage: 1971-2000
Louisville Water Company





In a departure from our previous forecasting exercises for LWC, we have dropped the simulation of various conservation assumptions on the forecasts. These assumptions were developed from engineering studies that measure the decreased water usage from new federally-mandated appliances. All new construction was assumed to use the water-conserving fixtures and appliances; and existing structures would slowly change out their old fixtures to modem water-saving devices.

Despite the change in federal law, water usage per residential and commercial customer has remained roughly constant, suggesting that the conservation requirements are being skirted or that an increasing amount of water is being used for irrigation and other purposes that do not go through the affected appliances. The accompanying chart shows that water usage per commercial customer has actually risen since 1994, while residential usage has fallen slightly. We do not have end use survey information, or other research, to determine why the federal conservation laws have had so little effect in Louisville. So, in this forecasting exercise, we have held residential and commercial water usage per customer constant at their 2000 levels. For industrial customers, we have allowed usage per customer to fall annually at the compound annual growth rate (-1.7%) observed during the previous decade.

Water Sales Model

The forecasts presented here have been developed using regression models. Some of the details are discussed further in subsequent sections of this report. The forecast steps include:

1. We used linear regression to explain the number of residential water customers from 1971 through 2000 by the number of households in Jefferson County.
2. We used linear regression to explain the number of commercial water customers from 1971 through 2000 by the growth in service sector jobs in Jefferson County. The service sector as defined here includes the following industries: transportation, communications, public utilities, wholesale and retail trade, finance, insurance, real estate, services, and government. These industries accounted for close to eighty-percent of all jobs in Jefferson County in 1999 (the latest available data).

3. We used linear regression to explain the number of industrial water customers from 1975 through 2000 by the growth in manufacturing jobs in Jefferson County.
4. Projections of households and jobs in Jefferson County are described elsewhwere in this report. These were used to generate trend projections of water customers by category.
5. Although we have done some research about the wholesale customers, the exact mix of ultimate customers among the seven wholesale customers is not known. LWC officials believe that 90 percent or more of the ultimate customers in the wholesale category are residential. Usage per customer by type is assumed to be the same as for in-County customers by type.

Regressions

We have used data on annual water sales by type, and on economic and demographic variables to fit relationships used in the forecasts. A time trend variable (YEAR) was also included to model the long-term declines in jobs per establishment for commercial and industrial customers. All regression coefficients are significant at the 95% confidence level; all R^2 are adjusted for degrees of freedom.

Residential. The number of residential water customers (C^R) in Jefferson County is closely related to the number of households over the period 1971 to 2000. The coefficient on YEAR is not statistically significant in the regression. There appears to be a very stable relationship between the number of households and the number of residential meters in Jefferson County.

$$C^R = 5{,}800.5 + .764\ HH \qquad R^2 = .96$$

Commercial. The number of commercial water customers (C^C) is related to service sector jobs (J^S) in Jefferson County over the period 1971 to 2000.

$$C^C = 462{,}602 + .074\ J^S - 236.7\ YEAR - 2{,}324\ DUMMY \qquad R^2 = .94$$

A dummy variable was used to model the reclassifications which occurred in 1979 to 1986 (see historical points in above chart of commercial water customers).

Industrial. The number of industrial water customers (C^I) is related to manufacturing jobs (J^M) in Jefferson County over the period 1975 to 2000. (Data for industrial water customers for 1971 through 1974 show a large drop, presumably due to a major reclassification; hence we omit these years from the regression).

$$C^I = 8514 + .00037\ J^M - 4.09\ YEAR \qquad R^2 = .97$$

Wholesale Water Customers and Usage

In 2000, the Company sold approximately 1.7 billion gallons of water to "wholesale" customers in surrounding counties, 4.3 percent of total water sales by LWC. The wholesale category is the fastest growing component of LWC sales, and is likely to remain so. We predict that the surrounding Kentucky counties will all grow at a faster rate than Jefferson County in terms of population, households, service sector jobs and manufacturing jobs. (See Economic and Demographic Forecast section of this report). For example, the number of households in Spencer, Oldham, Shelby, Bullitt, and Trimble nties are each projected to grow by at least 2.0 percent per year, compared to only 0.4 percent per year in Jefferson County.

Variously denoted "wholesale" or "utility," the category includes customers in Bullitt, Oldham, Shelby and Spencer counties. The historical data include six wholesale customers[1]: North Shelby Water Company, West Shelby Water District, City of Taylorsville, City of Mount Washington, Shepherdsville Water District, and Kentucky Turnpike Water Company District #2. The North Shelby district also purchases water from Frankfort, but about 30 percent of its water is purchased from LWC. The West Shelby district purchases about 40 percent of its water from LWC. The City of Taylorsville supplies much of its own water. The Kentucky Turnpike Water Company District #2 (Salt River Water District) historically has purchased almost all its water from LWC.

[1]In 2000, the Louisville Water Company acquired the Kentucky Turnpike Divisions I and II customers. Another customers in a surrounding county is the Oldham Water District #1, a so-called "leased" districts. LWC reads the individual customers' meters and handles billing. These customers and their sales are actually counted in Jefferson County sales. Around 6,000 customers are involved, but the residential/commercial mix is unknown - they are all counted as residential customers.

Customer Mix Comparison: All Customers vs. Four Wholesale Customers, 1997

	All Customers	North Shelby	West Shelby	KY Turnpike Water District	City of Shepherdsville
Water Sales (000 gallons)					
Residential	15,641,715	264,243	69,913	89,215	3,692
Commercial	14,528,729	40,537	24,720	104,024	6,784
Industrial	6,318,517	185	74,514	0	NA
Number of Customers					
Residential	207,352	3,356	944	1,607	845
Commercial	19,770	57	94	242	222
Industrial	364	1	12	0	NA
Sales per Customer (gallons)					
Residential	75,435	78,737	74,060	55,516	4,369
Commercial	734,883	711,175	262,979	429,851	30,556
Industrial	17,369,872	185,000	6,209,500	NA	NA

Sources: Louisville Water Company and "Statistics for Utilities Under Kentucky P.S.C. Jurisdiction for the Calendar Year Ending December 31, 1997," Kentucky Public Service Commission, 1998.
The most recent available data for North Shelby, West Shelby, and KY Turnpike is for the year of 1997.

The ultimate usage of the water sold to wholesale customers is not completely known. That is, LWC does not know how much of the wholesale water is used by industrial, commercial, or residential customers. However, based on public records and survey information, it appears that the ultimate customer mix and usage patterns of wholesale customers is not very different than that for LWC's Jefferson County customers.

The North Shelby, West Shelby, and Salt River districts are regulated by the Kentucky Public Service Commission, and their sales records are available to the public. These three districts account for about 37 percent of all LWC wholesale water sales[2,3]. About 63 percent of their ultimate water sales are to residential customers, compared to only 43 percent for LWC's Jefferson County customers. They have a particularly low water usage by industrial customers. On the other hand, the municipal customers (Mt. Washington, Shepherdsville, and Taylorsville) are likely to have a much higher usage by commercial customers - they serve a more urbanized geography.

We know from survey information that the City of Sheperdsville sells 65 percent of its water to commercial customers, compared to only 41 percent for LWC's Jefferson County customers. Hence, based on information on four of the six wholesale customers, it appears that the mix of ultimate usage is not dramatically different from that of LWC's traditional customers.

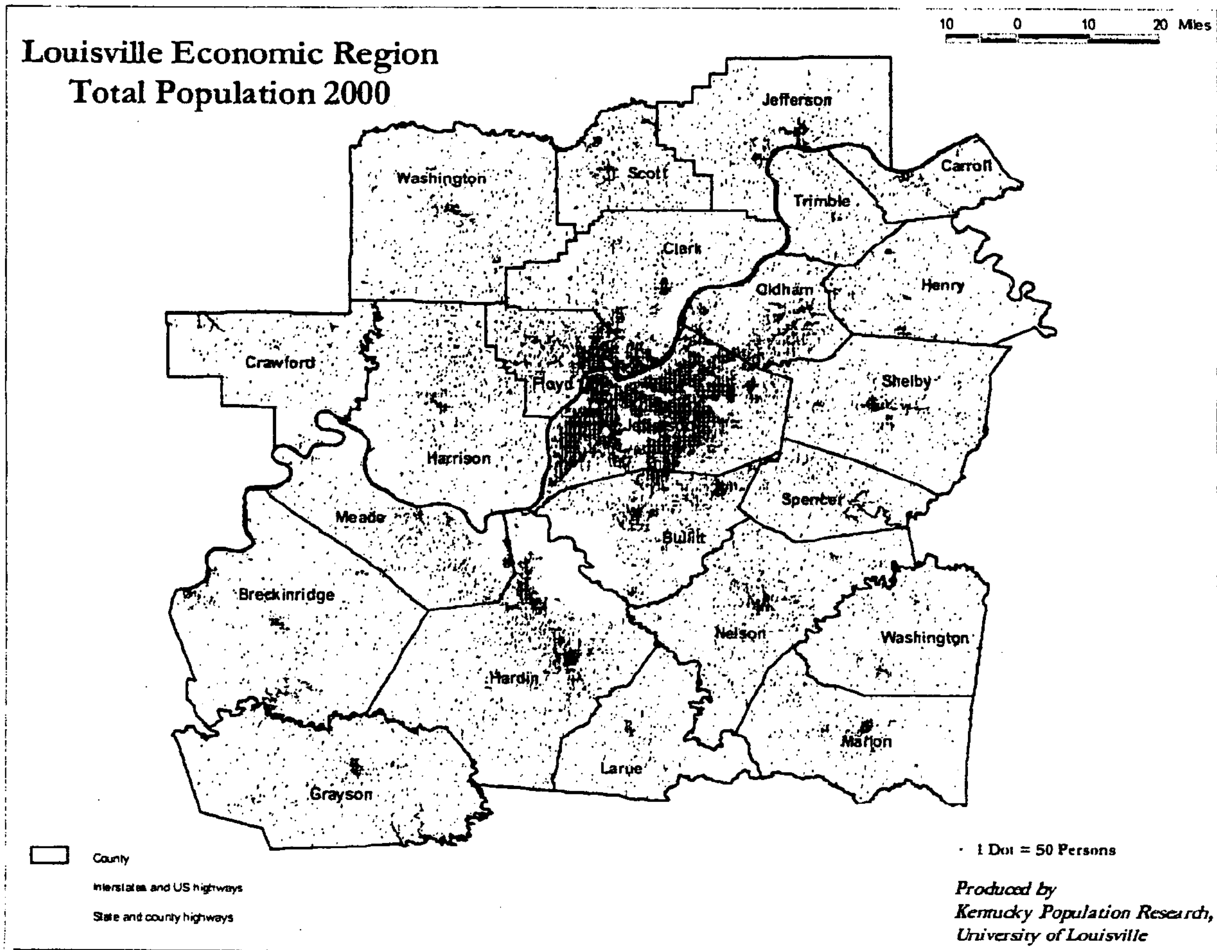
[2] The municipal water districts owned by the cities of Mt. Washington, Shepherdsville, and Taylorsville are not regulated by the Public Service Commission, and hence do not file annual reports of sales.

[3] Included in the historical data through 1990 for the wholesale category are sales to the Jeffersontown water district - a district in Jefferson County. LWC acquired the Jeffersontown district in 1990 and the one wholesale customer was converted to 3,588 residential, 606 commercial and 39 fire service customers.

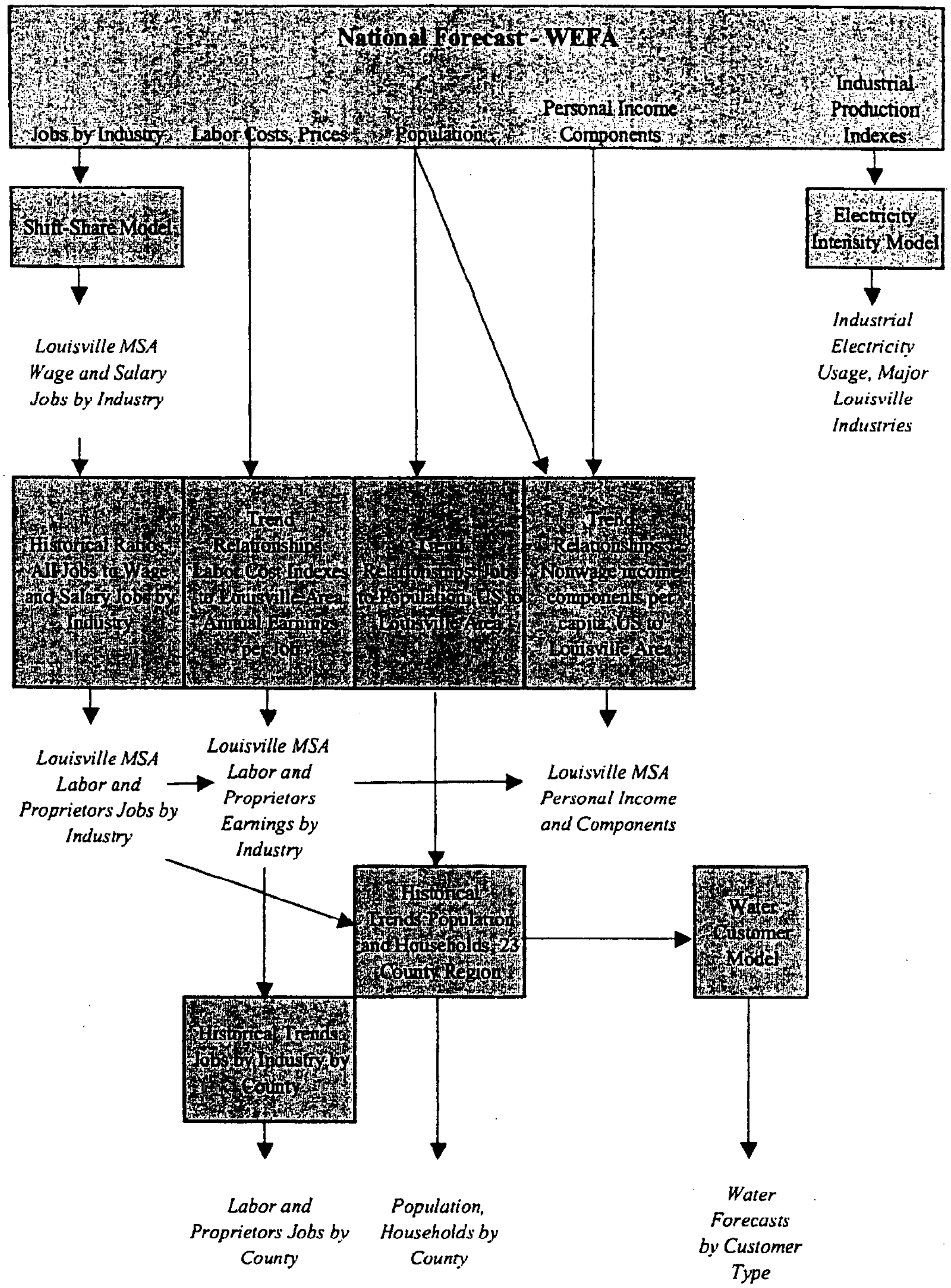
Economic and Demographic Forecasts Methodology, and Detailed Results

The economic and demographic forecasts have been prepared using simple techniques and straightforward assumptions. The methods used are dictated largely by data constraints. Unlike at the national level, there are no regular detailed county or MSA-level estimates of industrial output, wage rates, product prices, household formation, labor force participation, or commuting patterns. Regional analysts must try to use what clean data they can obtain to produce useful and consistent forecasts, given a national scenario and their knowledge of the local economy.

The steps used in this forecast are outlined below. We perform a shift-share analysis of Louisville metro area wage and salary job growth over the last forty years. We use this information, along with forecasts of the number of wage and salary jobs by industry for the United States provided by the WEFA Group, to produce a forecast of Louisville's growth rate for wage and salary jobs by industry. We then use historical relationships to construct a forecast of all jobs, including the self-employed. Next we model and forecast earnings per job in each industry, based upon trend relationships between Louisville area and national earnings. This becomes the foundation for a forecast of the personal income - wages, salaries, dividends, interest, rent, transfer payments - of Louisville area residents. Finally, we examine the historical relationship between MSA activity and that in the twenty-three counties of the regional economy. We examine trends in jobs, population and households over the past thirty years, and forecast these key variables for each of the twenty-three counties.



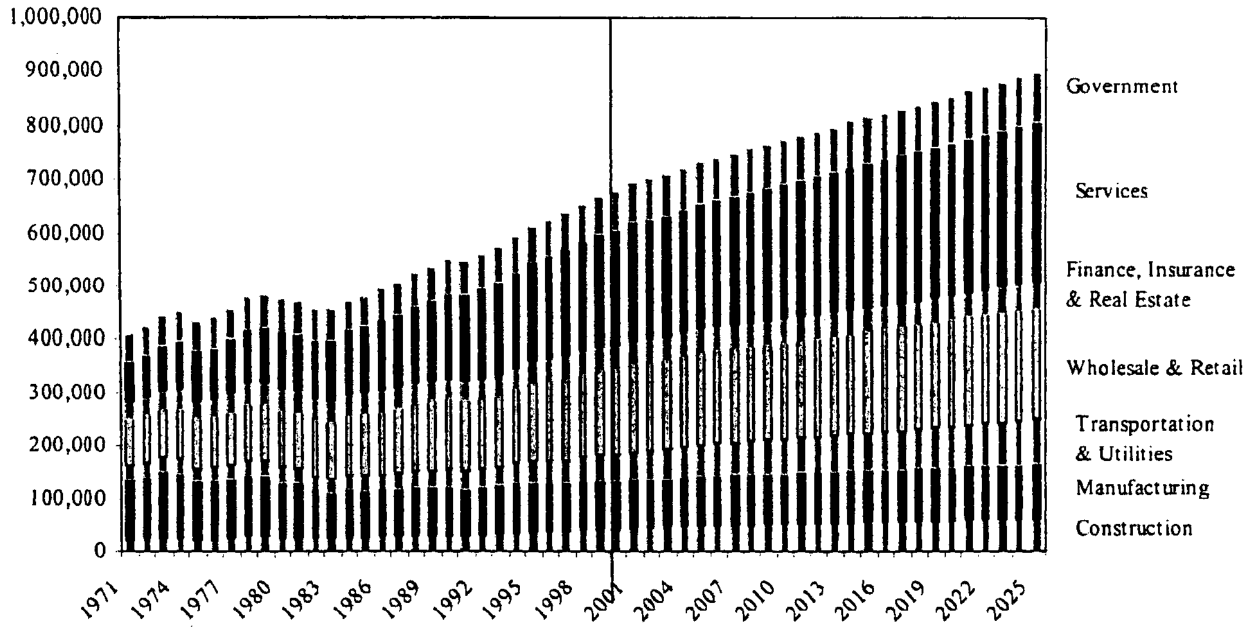
LWC 2819



Most of LWC's customers are in Jefferson County. However, it is important to understand economic and demographic trends throughout the region. We learned during the last decade that the Louisville economy extends well beyond the seven county metropolitan statistical area (MSA). The MSA includes Bullitt, Jefferson, and Oldham counties in Kentucky; and Clark, Floyd, Harrison, and Scott counties in Indiana. The geography most coterminus with the full economic market is the Louisville Economic Area as defined by the US Bureau of Economic Analysis. The LEA is defined by commuting patterns of workers and as such is closely aligned with labor, housing, media, retail, and transportation markets. Because more detailed data is available at the MSA level, we perform much of our economic analysis first in terms of the MSA, and then in terms of the other county's shares of, or ratios to, that economic activity.

LWC 2820

Labor and Proprietors Jobs by Industry, Louisville MSA



Several of the exurban counties have had strong population growth during the last decade and are the source of many of the long-distance commuters who are filling jobs in the central county. Hence, we have also developed forecasts of population and jobs for the sixteen Kentucky and Indiana counties outside the MSA.

Moreover, we take advantage of the recent release of demographic and housing data from the 2000 Census. Block and census-tract level data on persons and households were released in the summer of 2001. We have examined the demographic developments for each of the 330 Census tracts in the twenty-three county area, and have prepared basic forecasts at the tract level for the next two decades. The tract-level forecasts were controlled to county-level forecasts linked to our economic forecasts, but take into account small area information about land availablility and recent growth trends. We now examine the forecast steps in more detail.

Wage and salary jobs by industry for the Louisville MSA were forecast using the results of a shift-share analysis over the last fortyyears of data on Louisville and US job growth. We used 24 industrial categories. The growth in jobs in each Louisville industry was decomposed into three components: national growth, industry mix, and local competitiveness.

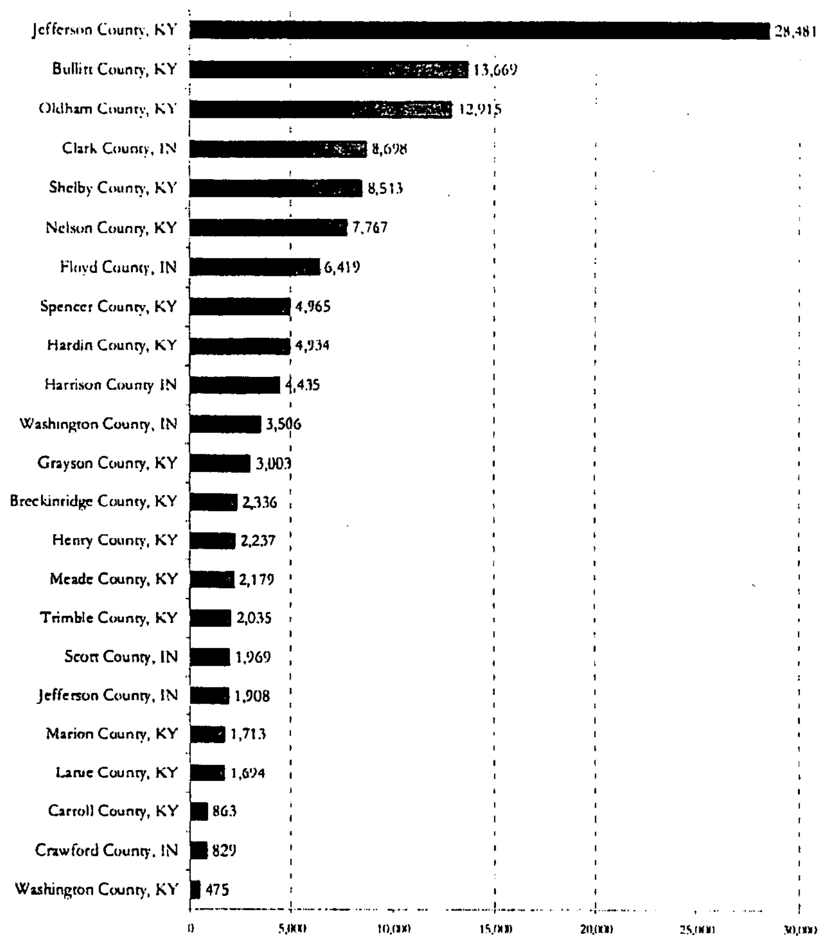
The national component quantifies the extent to which the growth of the region may be attributed simply to the fact that the nation is growing. The industry mix component can be attributed to the mix of industries in the region. If the region happens to have more than its share of fast or slow growth industries, its growth rate will be greater than or less than that of the nation. The competitive component recognizes that local firms may grow faster or slower than other firms in their industries located outside the region. WEFA forecasts of national job growth by industry were used to forecast the first two components. We then applied our subjective estimates of future local competitiveness per industry to arrive at our final forecasts of wage and salary job growth in the Louisville MSA. See Appendix B, Table 1, for our estimate of the competitive components, as well as the forecasted distribution of jobs by industry. *Excel spreadsheet name: Shift-Share W&S Job Forecast.*

The competitive components for manufacturing sectors derived from the shift-share analysis indicate that Louisville is most competitive in the other nondurables, transportation & public utilities, transportation equipment, furniture and fixtures, and printing & publishing industries. Consistent with strong national trends, Louisville's manufacturing industries are expected to account for only 12.8 percent of area wage and salary jobs in twenty years, down from 14.9 percent today.

Appendix B, Table 2, provides our forecast of job levels by industry for the Louisville MSA. Keep in mind that the job estimates are on a place-of-work basis, and may be filled by nonresident commuters as well as the MSA resident workforce. Also, multiple job holders are double (and triple) counted; this is a job forecast, not a forecast of employed persons.

Labor and proprietors jobs by industry for the Louisville MSA were forecast using ratios of total jobs to wage and salary jobs for each industry. This allows us to account for all jobs, including the roughly 84,000 proprietors in the MSA, and to make our forecast definitionally equivalent to the comprehensive database produced by the US Bureau of Economic Analysis for all counties. The ratios of labor and proprietors jobs to wage and salary jobs by industry are fairly constant and predictable over time. Appendix B, Table 3, provides forecast data at the major industry level, as portrayed in the accompanying chart. *Excel spreadsheet name: Jobs - Labor&Proprietors.*

Growth in Population, 1990 to 2000
Counties in Louisville Economic Area



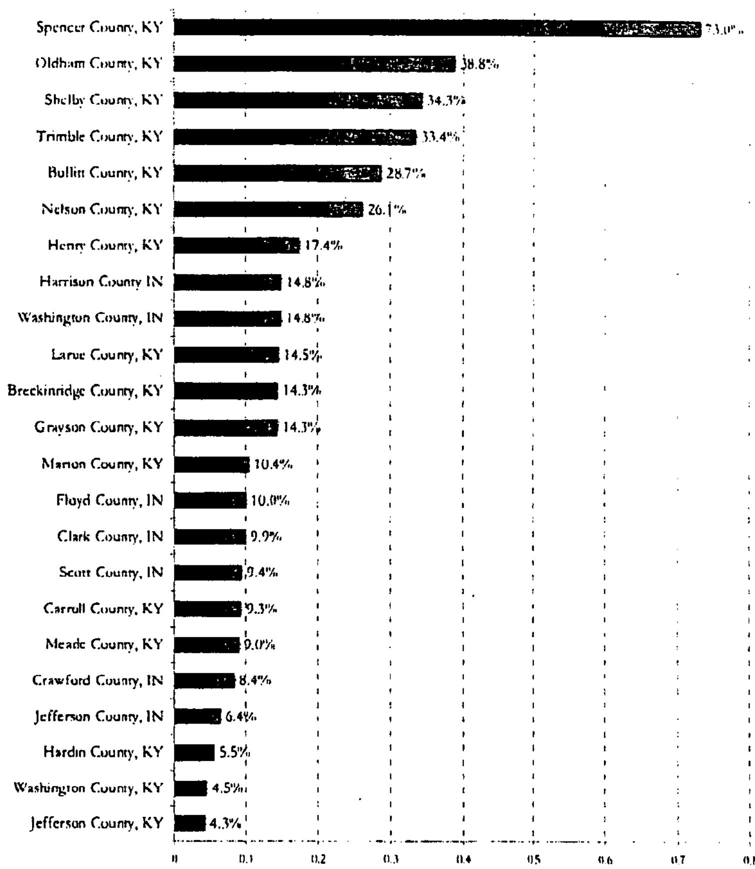
Finally, we forecast the total number of jobs in the twenty-three county economic area as a ratio to the forecast for the seven county MSA, as the relationship has held steady over time. For each county, we forecast its share of manufacturing and nonmanufacturing jobs in the region using an extrapolation of historical trends computed over the past decade *Excel spreadsheet name: BEA County Jobs 23.xls.*

Population and household forecasts. We use the national forecasted ratio of people to jobs to forecast the total population of the Louisville twenty-three county labor market. The regional ratio of people to jobs nicely tracks the national ratio. The job forecast was multiplied by the forecasted ratio of people to jobs to arrive at a total regional population forecast. *Excel spreadsheet name: Census 2000.*

The population of each of the twenty-three counties was forecast as a share of the total, using an extrapolation of trends from 1970 to 2000. Similarly, we forecast the number of households in each county, using the county population forecasts and trend forecasts of the number of people per household. Tables showing county population, households, and household size for the last four decennial censuses are provided in Appendix C, Tables 1 to 3. *Excel spreadsheet name: Census 2000.*

Finally, we prepared forecasts of population and households by census tract for the twenty-three counties. There are 330 tracts. For each tract we examine data on the number of households, the household population, and the group quarters population as reported in the 1990 and 2000 censuses. We computed the number of persons per household in 1990 and 2000, and calculated each tract's share of county household population in both census years. We forecast each tract's share of county household population in 2010 by extrapolating the change from 1990 to 2000 to the period 2000 to 2010. We then hold constant the 2010 share through 2020. We multiply these shares times the forecasted county household population to obtain a forecast each tract's household population, 2001 to 2020. We forecast the number of households in each tract by dividing each tract's forecasted household population by the forecasted number of persons per household in each tract. The forecasts of household size are extrapolated from 2000, using the damped change in household size between the 1990 to 2000 censuses*. *Excel spreadsheet name: Census Tracts.xls.*

% Growth in Population, 1990 to 2000
Counties in Louisville Economic Area



We provide some summary census and forecast information in the exhibits on the next two pages. The chart of persons per household per census tract shows both the wide range of household size around the region and also the reduction in household size between the last two censuses. A table identifies the tracts we believe will attract the most new households over the next twenty years. Finally, two maps show the change in households over the last decade, plus our forecast of net household growth by census tract.

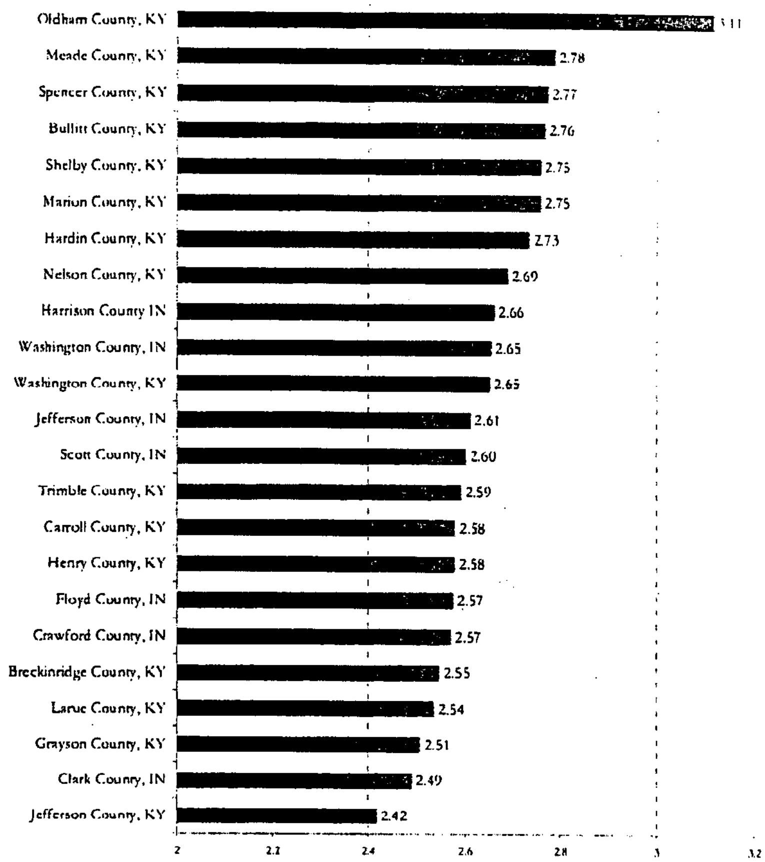
Earnings per labor and proprietors job by industry in the Louisville MSA were forecast using relationships to national compensation measures. WEFA forecasts hourly earnings in a number of important industrial categories. For other industries, such as Trade and Government, we used WEFA's forecast of a national index of labor compensation per hour. Earnings per job were multiplied by jobs to arrive at a forecast of total labor and proprietors earnings in the Louisville MSA on a

*Adjustments were made to the methodology as follows. For Hardin County, the Census Bureau split tow 1990 tracts for 2000 (9.01 and 9.02, 10.01 and 10.02); we held their household population shares constant at 2000 levels in forecast. For Jefferson County tract 14 (Russell), we kept the tract's share of County household population constant at 2000 share. For Jefferson County tract 119.01 (Airport), we reduce the household population by 100 per year in forecast. For Jefferson County tract 117.03, we add 100 persons per year to share forecast; MSD and LWC new facilities will raise density. For Meade County tracts 97.02 and 97.03 (Ft. Knox), we kept tracts' shares of County household population constant at 2000 share.

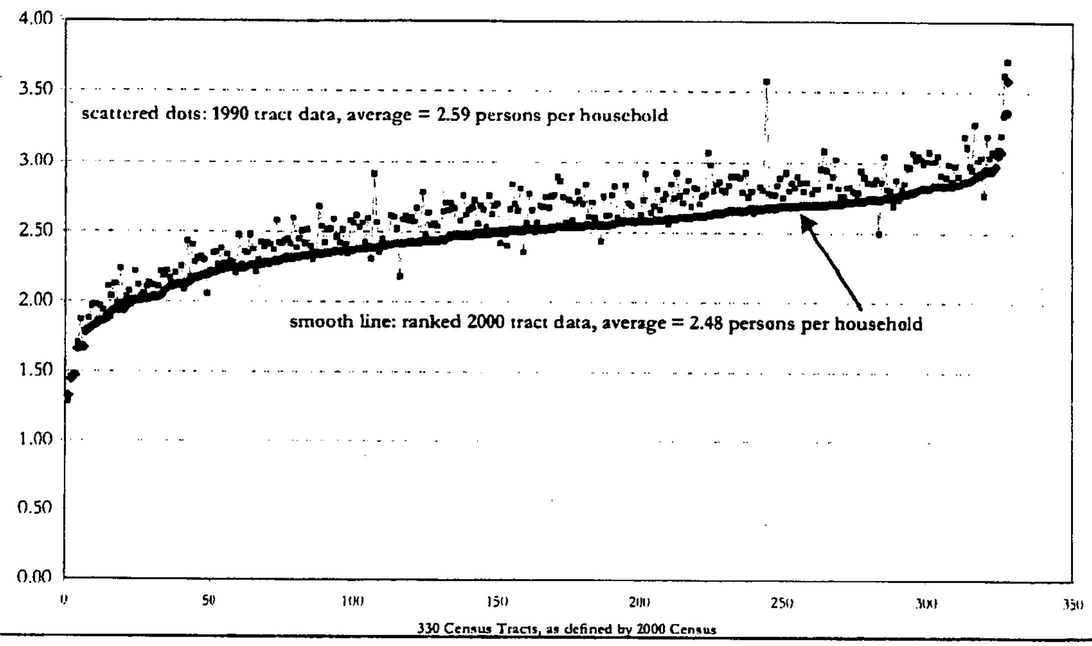
place of work basis. *Excel spreadsheet name: Earnings and Income.*

<u>The components of personal income</u> for Louisville MSA residents were forecast using historical relationships between Louisville and national measures. For example, employee contributions to social insurance programs (primarily Social Security) in Louisville are tightly related to the comparable national measure. Similarly, income per Louisville resident derived from transfer payments, dividends, interest, and rent are closely related to the national measures. WEFA forecasts these components and we apply these to the Louisville forecast on a per capita or per dollar basis. The result is a total personal income forecast for Louisville MSA residents. The accompanying table provides the forecast details for personal income and its components. *Excel spreadsheet name: Earnings and Income.*

Persons per Household, 2000
Counties in Louisville Economic Area



Persons per Household, 1990 and 2000 Census
330 Census Tracts in 23-County Louisville Area Economy



LWC 2824

Highest Growth Areas in Louisville Economic Area (23 counties)
Forecast: 2000 to 2020

Census Tract Descriptor	Forecast Growth in Households
Spencer County, Taylorsville Road	3,466
Nelson County, north Bardstown	3,004
Floyd County, Grant Line Road	2,295
Oldham County, Highway 22 - Ballardsville	2,265
Bullitt County, Mt. Washington	2,208
Bullitt County, Shepherdsville	2,158
Jefferson County, Hurstbourne-Fern Creek	2,036
Clark County, north of Jeffersonville, east of I-65	1,907
Jefferson County, Hurstbourne-Taylorsville Road	1,741
Bullitt County, south of Highway 44 between Mt. Washington and Shepherdsville	1,683
Shelby County, Shelbyville	1,639
Shelby County, KY 53 south of Shelbyville	1,594
Jefferson County, Lagrange Road east of I-265	1,587
Oldham County, KY 329	1,574
Bullitt County, south of Mt. Washington	1,572
Clark County, northeast of Jeffersonville, IND 62	1,538
Bullitt County, Hillview exit of I-65	1,506
Shelby County, KY 53 and KY 55, north of Shelbyville	1,483
Shelby County, KY 55, Simpsonville and Finchville	1,481
Oldham County, LaGrange	1,472
Jefferson County, Westport Road west of I-265	1,382
Jefferson County, northwest corner of Bardstown Road and I-265	1,370
Jefferson County, south of Taylorsville Road inside I-265	1,352
Jefferson County, Westport Road at Oldham County line	1,349
Oldham County, KY 22 south of Crestwood	1,302
Trimble County, closest to I-71	1,285
Meade County, Brandenburg	1,253
Shelby County, far east side	1,235
Washington County IN: New Pekin	1,232
Nelson County, east of Bardstown	1,196
Nelson County, Fairfield, Cox's Creek	1,172
Clark County, Hamburg Pike	1,168
Jefferson County, Middletown south	1,138
Bullitt County, Hillview east of Preston Highway	1,135
Jefferson County, Pleasure Ridge Park	1,123
Jefferson County, southwest corner of Bardstown Road and I-265	1,120
Jefferson County, north of I-265 and Westport Road	1,103
Jefferson County, Floyd's Fork between Taylorsville and Bardstown Roads	1,074
Jefferson County, southeast of intersection of KY 42 and I-265	1,053

Source: Paul Coomes and Michael Price, University of Louisville, October 2001.

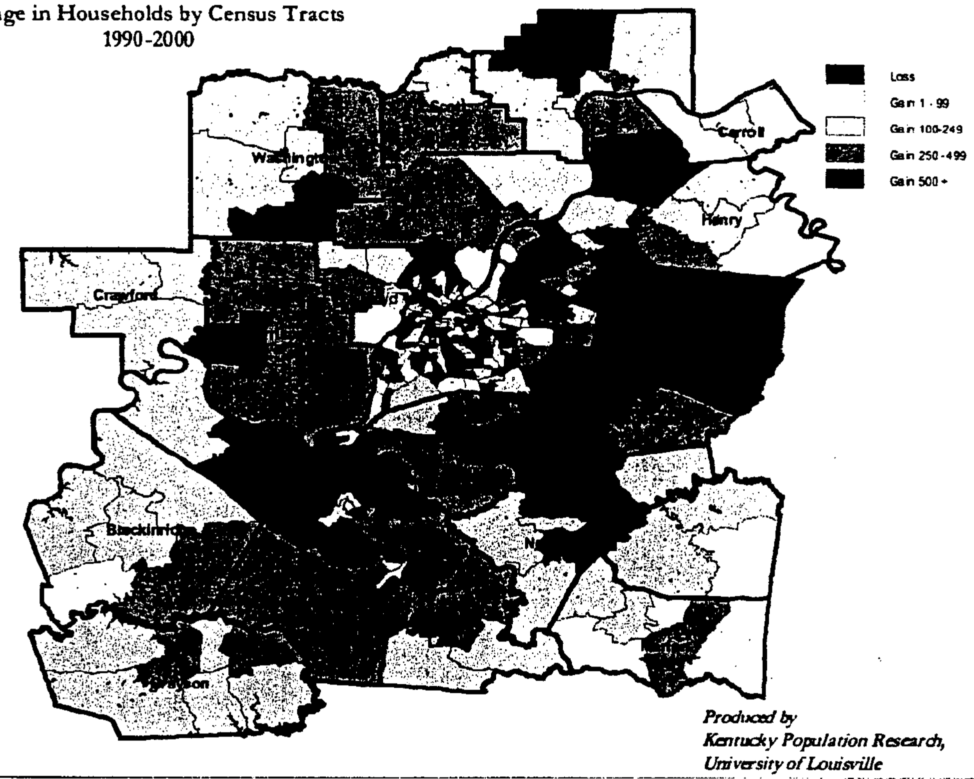
Forecast: above tracts to see a total of 61,000 new homes (out of a total growth of 113,000 for 23-county region).

Components of Personal Income: Louisville MSA and United States (Baseline)

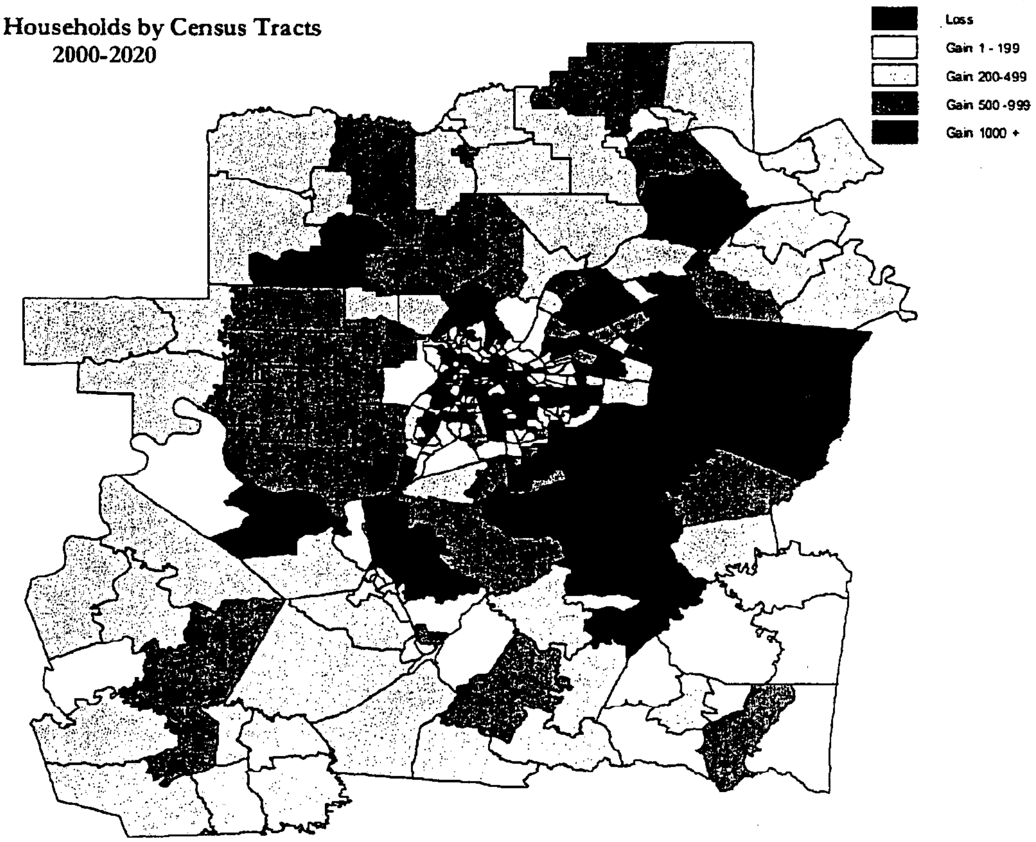
	1970	1980	1990	2000	2010	20
Louisville MSA						
Earnings by Place of Work ($000)	$3,057,418	$7,301,911	$13,243,273	$22,678,445	$35,216,456	$57,810,55
- Personal Contributions for Social Insurance	$110,437	$338,370	$802,539	$1,453,513	$2,028,535	$3,217,28
- Adjustment to Place of Residence Basis	$70,757	$227,722	$356,656	$684,162	$1,284,267	$2,410,7
= Net Earnings by Place of Residence	$2,876,224	$6,735,819	$12,084,078	$20,540,769	$31,903,655	$52,182,52
+ Dividends, Interest and Rent Income	$449,646	$1,405,722	$3,807,965	$6,159,001	$8,158,386	$13,227,76
+ Transfer Payments	$272,903	$1,133,287	$2,263,643	$3,908,096	$6,686,146	$12,108,62
= Total Personal Income of Residents ($000)	$3,598,773	$9,274,828	$18,155,686	$30,607,866	$46,748,186	$77,518,90
Population	906,870	953,944	950,488	1,025,334	1,096,748	1,155,2
Per Capita Income	$3,968	$9,723	$19,101	$29,852	$42,624	$67,10
Average Compound Growth Rate		9.37%	6.99%	4.57%	3.63%	4.64
United States						
Earnings by Place of Work ($000)	$666,477,000	$1,729,911,000	$3,508,380,000	$6,003,575,000	$9,516,040,875	$16,002,925,27
- Personal Contributions for Social Insurance	$22,345,000	$76,988,000	$202,934,000	$360,700,000	$509,969,400	$826,404,57
- Adjustment to Place of Residence Basis	$175,000	$454,000	$737,000	$50,000	$75	$
= Net Earnings by Place of Residence	$643,957,000	$1,652,469,000	$3,304,709,000	$5,642,825,000	$9,006,071,400	$15,176,520,62
+ Dividends, Interest and Rent Income	$116,085,000	$381,662,000	$986,055,000	$1,570,475,000	$2,108,946,875	$3,519,393,45
+ Transfer Payments	$74,413,000	$279,790,000	$594,761,000	$1,067,700,000	$1,851,827,300	$3,451,751,32
= Total Personal Income of Residents ($000)	$834,455,000	$2,313,921,000	$4,885,525,000	$8,281,000,000	$12,966,845,575	$22,147,665,40
Population	203,798,722	227,224,719	249,464,396	274,520,875	297,685,450	322,744,0
Per Capita Income	$4,095	$10,183	$19,584	$30,165	$43,559	$68,62
Average Compound Growth Rate		9.54%	6.76%	4.41%	3.74%	4.65

Source: Historical data from the US Bureau of Economic Analysis, "Local Area Personal Income, 1969-98", June 2000.
Forecast data for the United States from WEFA Group "U.S. Long-Term Economic Outlook", Trend Scenario, First Quarter 2001.

Change in Households by Census Tracts
1990-2000



Change in Households by Census Tracts
2000-2020



LWC 2827

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LWC 2828

Appendix A

Annual Water Sales: Forecast and Recent History (000 gallons)

	Residential	Commercial	Industrial	Wholesale	Total
1994	15,505,661	14,122,909	6,496,332	860,947	36,985,849
1995	15,253,010	14,420,893	6,514,208	964,847	37,152,958
1996	15,074,752	14,898,875	6,348,264	1,077,452	37,399,343
1997	15,324,804	15,072,760	6,171,064	1,137,398	37,706,026
1998	15,120,651	15,457,818	5,927,904	1,174,684	37,681,057
1999	17,071,857	15,562,681	5,893,433	1,527,158	40,055,129
2000	15,937,596	16,498,751	5,387,815	1,709,445	39,533,607
2001	15,993,799	16,737,738	5,245,463	1,744,680	39,721,679
2002	16,050,199	16,747,104	5,095,098	1,755,364	39,647,766
2003	16,106,799	16,816,267	4,950,817	1,772,682	39,646,565
2004	16,163,598	16,960,727	4,814,526	1,798,380	39,737,231
2005	16,220,597	17,132,158	4,678,226	1,827,293	39,858,274
2006	16,277,798	17,263,172	4,543,123	1,852,007	39,936,100
2007	16,335,200	17,399,469	4,409,073	1,877,537	40,021,278
2008	16,392,805	17,519,068	4,278,375	1,901,418	40,091,666
2009	16,450,612	17,631,626	4,151,047	1,924,711	40,157,997
2010	16,508,624	17,755,527	4,026,745	1,949,502	40,240,398
2011	16,529,331	17,868,673	3,905,395	1,966,331	40,269,730
2012	16,483,235	17,952,817	3,787,083	1,967,485	40,190,620
2013	16,553,987	18,050,541	3,671,765	1,991,874	40,268,167
2014	16,619,871	18,141,387	3,559,218	2,014,747	40,335,223
2015	16,684,474	18,233,161	3,449,412	2,037,656	40,404,704
2016	16,748,162	18,325,941	3,342,390	2,060,675	40,477,167
2017	16,809,849	18,424,089	3,238,083	2,084,108	40,556,129
2018	16,871,986	18,521,014	3,136,281	2,107,646	40,636,927
2019	16,931,948	18,621,298	3,037,069	2,131,324	40,721,640
2020	16,989,687	18,726,106	2,940,390	2,155,268	40,811,451
2021	17,044,007	18,833,916	2,846,192	2,179,053	40,903,169
2022	17,096,215	18,940,096	2,754,267	2,202,371	40,992,949
2023	17,146,802	19,049,496	2,664,699	2,225,897	41,086,894
2024	17,193,922	19,164,193	2,577,437	2,249,512	41,185,064
2025	17,238,172	19,285,404	2,492,422	2,273,481	41,289,479

Appendix B

Table 1

Estimated "Competitive Component" Used in Shift-Share Forecast

Industry (SIC)	This Forecast	2000 Forecast	1999 Forecast	LOUISVILLE % of Total Jobs 2000	LOUISVILLE % of Total Jobs 2025	U.S. % of Total Jobs 2000	U.S. % of Total Jobs 2025
Contract Construction (15 to 17)	0.0018	0.0021	0.0021	5.18%	5.43%	5.07%	5.32%
Mining (10 to 14)	0.0080	0.0000	0.0000	0.12%	0.10%	0.41%	0.33%
Total Manufacturing				14.91%	12.76%	13.97%	10.31%
Nondurable Manufacturing				6.33%	4.69%	5.57%	3.76%
Food and Kindred Products (20)	-0.0012	-0.0011	-0.0063	1.65%	1.08%	1.27%	0.92%
Tobacco Products (21)	-0.0525	-0.0314	-0.0298	0.21%	0.02%	0.03%	0.01%
Apparel and Other Finished Textile Products (23)	0.0060	0.0078	0.0000	0.26%	0.08%	0.49%	0.13%
Printing and Publishing (27)	0.0075	0.0026	0.0022	1.66%	1.24%	1.18%	0.78%
Chemicals and Allied Products (28)	-0.0202	-0.0216	-0.0228	0.94%	0.53%	0.78%	0.80%
Other Nondurables (22,26,29,30,31)	0.0255	0.0205	0.0155	1.61%	1.74%	1.83%	1.13%
Durable Manufacturing				8.57%	8.07%	8.40%	6.55%
Lumber and Wood Products (24)	-0.0050	-0.0067	-0.0076	0.67%	0.37%	0.62%	0.41%
Furniture and Fixtures (25)	0.0090	0.0008	0.0007	0.49%	0.37%	0.42%	0.27%
Stone, Clay and Glass (32)	0.0032	0.0033	0.0008	0.40%	0.31%	0.43%	0.33%
Fabricated Metal Products (34)	-0.0079	-0.0079	-0.0150	1.32%	0.69%	1.16%	0.79%
Nonelectrical Machinery (35)	0.0008	-0.0003	-0.0006	1.42%	1.21%	1.61%	1.44%
Electrical Machinery (36)	-0.0376	-0.0355	-0.0325	1.36%	0.52%	1.29%	1.29%
Transportation Equipment (37)	0.0377	0.0317	0.0023	2.32%	4.18%	1.40%	1.05%
Other Durables (33,38,39)	0.0050	0.0020	0.0048	0.58%	0.42%	1.47%	0.97%
Transportation and Public Utilities (40 to 49)	0.0157	0.0142	0.0139	7.93%	9.69%	5.30%	4.72%
Wholesale and Retail Trade (50 to 59)	0.0019	0.0003	0.0004	24.03%	22.78%	22.87%	22.04%
Finance, Insurance and Real Estate (60 to 68)	-0.0043	-0.0063	-0.0054	5.89%	4.71%	5.77%	5.50%
Services (70 to 89)				29.20%	32.62%	31.04%	36.62%
Health Services (80)	-0.0003	-0.0011	0.0023	7.63%	7.66%	7.68%	8.29%
Business Services (73)	-0.0033	-0.0054	-0.0008	7.65%	7.59%	7.38%	8.43%
Other Services (70,72,75 to 79,81 to 89)	0.0019	0.0014	0.0010	13.92%	17.37%	15.98%	19.90%
Federal Government (91)	0.0028	0.0009	-0.0029	2.23%	1.85%	2.10%	1.78%
State and Local Governments (92,93)	0.0011	0.0012	0.0009	10.52%	10.05%	13.47%	13.38%

Table 2

Wage and Salary Jobs by Industry, Louisville MSA (Baseline)

Major Industries (SIC Code)	1970	1980	1990	2000	2010	2020	2025
Mining	594	545	527	683	758	820	854
Construction	15,933	17,550	23,836	30,658	37,785	42,376	44,729
Total Manufacturing	118,658	100,333	87,736	88,192	96,723	101,933	105,190
Nondurable Manufacturing	47,057	41,742	40,864	37,475	40,087	39,511	38,670
Food and Kindred Products (20)	13,448	10,483	10,200	9,775	9,455	8,926	8,930
Tobacco Products (21)	10,292	8,367	4,400	1,267	544	221	139
Apparel and Other Finished Textile Products (23)	2,426	2,317	2,700	1,533	1,216	810	654
Printing and Publishing (27)	7,577	7,342	8,400	9,792	11,840	11,158	10,224
Chemicals and Allied Products (28)	9,609	8,825	7,400	5,567	5,108	4,648	4,365
Other Nondurables (22,26,29,30,31)	3,705	4,408	7,764	9,542	11,925	13,747	14,358
Durable Manufacturing	71,602	58,592	46,873	50,717	56,635	62,422	66,520
Lumber and Wood Products (24)	3,951	3,983	3,922	3,992	4,068	3,514	3,043
Furniture and Fixtures (25)	2,615	1,408	2,122	2,883	3,320	3,228	3,022
Stone, Clay and Glass (32)	2,542	2,625	2,122	2,358	2,508	2,550	2,574
Fabricated Metal Products (34)	9,286	9,408	7,822	7,825	7,486	6,322	5,699
Nonelectrical Machinery (35)	12,904	11,991	6,822	8,425	8,977	9,699	9,954
Electrical Machinery (36)	16,260	17,800	12,822	8,067	6,380	4,790	4,293
Transportation Equipment (37)	7,842	7,425	7,722	13,717	20,280	28,818	34,490
Other Durables (33,38,39)	16,200	3,950	3,522	3,450	3,616	3,502	3,445
Transportation and Public Utilities (40 to 49)	22,750	24,292	30,855	46,933	59,719	72,528	79,885
Wholesale and Retail Trade (50 to 59)	69,008	88,975	119,027	142,133	160,297	178,431	187,753
Finance, Insurance and Real Estate (60 to 68)	16,667	23,433	27,664	34,842	35,181	37,444	38,813
Services (70 to 89)	47,666	75,391	125,455	172,742	210,984	248,130	268,886
Health Services (80)	12,740	24,459	40,315	45,158	51,264	58,032	63,169
Business Services (73)	6,801	11,642	26,215	45,233	52,280	59,121	62,550
Other Services (70,72,75 to 79,81 to 89)	28,126	39,290	58,924	82,350	107,441	130,977	143,167
All Government	43,792	61,033	64,427	75,375	83,517	92,840	98,093
Federal Government (91)	11,861	12,437	12,464	13,167	13,145	14,451	15,253
State and Local Governments (92,93)	31,931	48,597	51,964	62,208	70,372	78,389	82,840
Total Nonagricultural Wage and Salary Jobs	335,067	391,552	479,527	591,558	684,965	774,502	824,203

Note: Historical data from the US Bureau of Labor Statistics. Estimates exclude proprietors and other self-employed persons.
Jobs are on a place of work basis and are NOT full-time equivalents; double-counting occurs for person holding two jobs. See the monthly BLS publication, "Employment and Earnings", for details.

Table 3

Labor and Proprietors Jobs by Industry, Louisville MSA (Baseline)

Major Industries (SIC Code)	1970	1980	1990	2000	2010	2020	2025
Mining	859	844	738	922	1,017	1,091	1,130
Construction	22,853	25,545	31,439	41,878	51,419	57,505	60,623
Total Manufacturing	122,166	104,227	89,548	89,204	96,956	101,273	103,988
Transportation and Public Utilities (40 to 49)	25,326	27,223	33,661	50,758	63,863	76,463	83,589
Wholesale and Retail Trade (50 to 59)	85,805	105,593	130,836	160,736	181,052	200,748	210,761
Finance, Insurance and Real Estate (60 to 68)	29,494	41,751	40,694	46,080	45,836	47,483	48,486
Services (70 to 89)	75,554	105,813	159,435	218,058	254,140	283,402	298,755
All Government	48,408	62,502	62,100	72,151	78,719	85,889	89,900
Federal Government (91)	11,603	12,848	12,665	13,244	13,156	14,305	15,004
State and Local Governments (92,93)	36,805	49,654	49,435	58,908	65,563	71,584	74,896
Total Nonagricultural Labor and Proprietors Jobs	410,465	473,498	548,451	679,788	773,003	853,855	897,232
+ Ag. services, forestry, fishing, and other	851	1,922	3,644	5,014	6,014	7,014	7,514
+ Farm employment	6,686	7,387	5,632	4,755	4,755	4,755	4,755
= Total Labor and Proprietors Employment (BEA)	422,313	487,127	563,002	689,557	783,772	865,624	909,501

LWC 2832

Appendix C

Table 1

Population of Louisville Economic Area

					Census Estimates	
	1970	1980	1990	2000	change, 1990 to 2000	% change, 1990 to 2000
Breckinridge County, KY	14,789	16,861	16,312	18,648	2,336	14.3%
Bullitt County, KY	26,090	43,346	47,567	61,236	13,669	28.7%
Carroll County, KY	8,523	9,270	9,292	10,155	863	9.3%
Clark County, IN	75,876	88,838	87,774	96,472	8,698	9.9%
Crawford County, IN	8,033	9,820	9,914	10,743	829	8.4%
Floyd County, IN	55,622	61,205	64,404	70,823	6,419	10.0%
Grayson County, KY	16,445	20,854	21,050	24,053	3,003	14.3%
Hardin County, KY	78,421	88,917	89,240	94,174	4,934	5.5%
Harrison County IN	20,423	27,276	29,890	34,325	4,435	14.8%
Henry County, KY	10,910	12,740	12,823	15,060	2,237	17.4%
Jefferson County, IN	27,006	30,419	29,797	31,705	1,908	6.4%
Jefferson County, KY	695,055	685,004	665,123	693,604	28,481	4.3%
Larue County, KY	10,672	11,922	11,679	13,373	1,694	14.5%
Marion County, KY	16,714	17,910	16,499	18,212	1,713	10.4%
Meade County, KY	18,796	22,854	24,170	26,349	2,179	9.0%
Nelson County, KY	23,477	27,584	29,710	37,477	7,767	26.1%
Oldham County, KY	14,687	27,795	33,263	46,178	12,915	38.8%
Scott County, IN	17,144	20,422	20,991	22,960	1,969	9.4%
Shelby County, KY	18,999	23,328	24,824	33,337	8,513	34.3%
Spencer County, KY	5,488	5,929	6,801	11,766	4,965	73.0%
Trimble County, KY	5,349	6,253	6,090	8,125	2,035	33.4%
Washington County, IN	19,278	21,932	23,717	27,223	3,506	14.8%
Washington County, KY	10,728	10,764	10,441	10,916	475	4.5%
TOTAL - 23 County	1,198,525	1,291,243	1,291,371	1,416,914	125,543	9.7%
Louisville MSA	904,897	953,886	949,012	1,025,598	76,586	8.1%

Source: US Bureau of the Census

Table 2

Households in the Louisville Economic Area

				Census Estimates		
	1970	1980	1990	2000	change, 1990 to 2000	% change, 1990 to 2000
Breckinridge County, KY	4,617	5,881	6,159	7,324	1,165	18.9%
Bullitt County, KY	7,215	12,944	15,965	22,171	6,206	38.9%
Carroll County, KY	2,755	3,377	3,505	3,940	435	12.4%
Clark County, IN	23,249	31,021	33,292	38,751	5,459	16.4%
Crawford County, IN	2,643	3,462	3,660	4,181	521	14.2%
Floyd County, IN	17,571	21,459	24,085	27,511	3,426	14.2%
Grayson County, KY	5,193	7,228	7,991	9,596	1,605	20.1%
Hardin County, KY	17,050	24,610	29,358	34,497	5,139	17.5%
Harrison County IN	6,208	9,085	10,618	12,917	2,299	21.7%
Henry County, KY	3,628	4,564	4,896	5,844	948	19.4%
Jefferson County, IN	7,890	10,288	10,897	12,148	1,251	11.5%
Jefferson County, KY	216,160	250,569	264,138	287,012	22,874	8.7%
Larue County, KY	3,334	4,268	4,503	5,275	772	17.1%
Marion County, KY	4,379	5,599	5,688	6,613	925	16.3%
Meade County, KY	5,335	7,165	8,080	9,470	1,390	17.2%
Nelson County, KY	6,218	8,650	10,417	13,953	3,536	33.9%
Oldham County, KY	3,798	8,026	10,673	14,856	4,183	39.2%
Scott County, IN	5,132	6,728	7,593	8,832	1,239	16.3%
Shelby County, KY	5,954	7,859	9,048	12,104	3,056	33.8%
Spencer County, KY	1,641	2,026	2,451	4,251	1,800	73.4%
Trimble County, KY	1,696	2,124	2,246	3,137	891	39.7%
Washington County, IN	6,069	7,556	8,664	10,264	1,600	18.5%
Washington County, KY	3,120	3,482	3,709	4,121	412	11.1%
TOTAL - 23 County	360,855	447,971	487,636	558,768	71,132	14.6%
Louisville MSA	279,333	339,832	366,364	412,050	45,686	12.5%

Source: US Bureau of the Census

Table 3

Population per Household in the Louisville Economic Area

Census Estimates

	1970	1980	1990	2000	change, 1990 to 2000	% change, 1990 to 2000
Breckinridge County, KY	3.20	2.87	2.65	2.55	-0.102	-3.9%
Bullitt County, KY	3.62	3.35	2.98	2.76	-0.217	-7.3%
Carroll County, KY	3.09	2.75	2.65	2.58	-0.074	-2.8%
Clark County, IN	3.26	2.86	2.64	2.49	-0.147	-5.6%
Crawford County, IN	3.04	2.84	2.71	2.57	-0.139	-5.1%
Floyd County, IN	3.17	2.85	2.67	2.57	-0.100	-3.7%
Grayson County, KY	3.17	2.89	2.63	2.51	-0.128	-4.8%
Hardin County, KY	4.60	3.61	3.04	2.73	-0.310	-10.2%
Harrison County IN	3.29	3.00	2.82	2.66	-0.158	-5.6%
Henry County, KY	3.01	2.79	2.62	2.58	-0.042	-1.6%
Jefferson County, IN	3.42	2.96	2.73	2.61	-0.125	-4.6%
Jefferson County, KY	3.22	2.73	2.52	2.42	-0.101	-4.0%
Larue County, KY	3.20	2.79	2.59	2.54	-0.058	-2.3%
Marion County, KY	3.82	3.20	2.90	2.75	-0.147	-5.1%
Meade County, KY	3.52	3.19	2.99	2.78	-0.209	-7.0%
Nelson County, KY	3.78	3.19	2.85	2.69	-0.166	-5.8%
Oldham County, KY	3.87	3.46	3.12	3.11	-0.008	-0.3%
Scott County, IN	3.34	3.04	2.76	2.60	-0.165	-6.0%
Shelby County, KY	3.19	2.97	2.74	2.75	0.011	0.4%
Spencer County, KY	3.34	2.93	2.77	2.77	-0.007	-0.3%
Trimble County, KY	3.15	2.94	2.71	2.59	-0.121	-4.5%
Washington County, IN	3.18	2.90	2.74	2.65	-0.085	-3.1%
Washington County, KY	3.44	3.09	2.82	2.65	-0.166	-5.9%
TOTAL - 23 County	3.32	2.88	2.65	2.54	-0.112	-4.2%
Louisville MSA	3.24	2.81	2.59	2.49	-0.101	-3.9%

Source: US Bureau of the Census